V. V. Dokuchaev

RUSSIAN CHERNOZEM

Selected Works of V. V. Dokuchaev

Volume I

TRANSLATED FROM RUSSIAN

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(Russkii chernozem)

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(Izbrannye sochineniya)

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Glossary of Russian Terms

(The exact definitions of most of these terms vary in different localities of Russia. We have endeavored, as far as possible, to provide the explanation most applicable in the context.)

Balka	a steppe valley; a type of gully which is no longer growing, usually dry, with gently sloping sodded sides, and overgrown with vegetation.
Bor	a type of sparse pine forest growing on sandy soil, dunes, etc.
Dutik	a calcareous concretion in loess.
Guberniya	in pre-Revolutionary Russia, an administrative province, corresponding to the present-day District.
Izd.	Izdatel'stvo = Publishing House.
Khak	patch of saline mud.
Kolok (kolki)	a small isolated grove of aspen or birch on the forest-steppe.
Liman	(1) a shallow steppe depression in arid regions of the USSR, periodically wetted by snowmelt. In spring, limans usually become pools, drying up in summer. They range in area from a few dozen square meters to a few square kilometers. (2) river estuary drowned by the sea.
Mochara/ mochevina	patch of land permanently wet due to the outflow of underground water.
Polesie.	extensive tract of wet forest land; sometimes used as a proper name in the northwestern Ukraine, Belorussia and Poland.
Plavni	lowlying portions of valleys of the lower reaches of some Russian rivers, waterlogged and flooded, overgrown by trees and reeds.
Sel'ga.	(1) ridge of any origin (Finland). (2) forest clearing.
Stanitsa	a large Cossack village.
Suglei	a variety of glei; a pale bluish-white finely graded, very viscous mass, similar to northern podzol.
Sukhovei	strong, hot, dry eastern wind, causing crop failures, mostly along the middle and lower reaches of the Volga; similar to winds which raise dust storms in the USA "Dust Bowl".
Syrt	a level clay area, usually elevated.

VEO	Vol'noe Ekonomicheskoe Obshchestvo = Free Economic Society.
Volost'	smallest administrative division in rural areas of pre-Revolutionary Russia, several "volost's" forming a "uezd"; no corresponding unit exists in the USSR today.
Zaklech'	a kind of heavy soil with dark brown, extremely viscous, very marly clay.
Zapadina.	a rounded, shallow, nearly flat depression in the steppe zone, formed by soil-forming processes or ground subsidences, due to leaching or eluviation of the underground rocks; depth a few meters at the most, often less than 1 m; horizontal dimensions of the order of a few meters, sometimes considerably larger; often only distinguishable by the color of the vegetation (usually very lush, since the "zapadina" is moister than the surrounding country).
Zemstvo	in pre-Revolutionary Russia, an elected rural administrative body with very limited authority.
Zhuravchik	a calcareous nodule in loess.

Geographic Glossary

Akkerman	Bel'gorod Dnestrovskii
Aleksandrovsk	Zaporozh'e
Bakhmut	Artemovsk
Batalpashinsk	Cherkessk
Birzula	Kotovsk
Chembar	Belinskii
Derpt	Tartu
Ekaterinburg	Sverdlovsk
Ekaterinoslav	Dnepropetrovsk
Elisavetgrad	Kirovograd
Golodaevka	Kuibyshevo
Hapsal	Haapsalu
Iletskaya	Sol-Iletsk
Kerensk	Vadinsk
Khasar-Yurt	Khazavyurt
Knyaginin	Knyaginino
Konstantinograd	Krasnograd
Kozlov	Michurinsk
Laishev	Laishevo
Livland, Kurland, Estland, the Ostsee Territory	The Baltic Provinces
Mariupol	Zhdanov
Nizhni-Novgorod	Gorki
Novo-Cherkassk	Novocherkassk
Ol'viopol	Pervomaisk
Orenburg	Chkalov
Orlov	Khalturin
Pereyaslav	Pereyaslav-Khmel'nitskii
Petrovsk	Makhachkala
Proskurov	Khmel'nitskii
Ranenburg	Chaplygin
Samara	Kuibyshev
Sergievskii Posad	Zagorsk

Sergiopol	Ayaguz
Simbirsk	Ul'yanovsk
Spassk-Tatarskii	Kuibyshev
Spassk	Bednodemyanovsk
Spassk (Ryazan Province)	Spassk-Ryazanskii
Stavropol	Tol'yatti
Tsarevosanchursk	Ioshkar-Ola
Turkestan	Soviet Central Asia
Tver	Kalinin
Uryupinskaya	Uryupinsk
Ust Medveditskaya	Serafimovich
Varnavin	Varnavino
Vyatka	Kirov

Old Russian Weights and Measures

1 arshin (arshine) (16 vershoks)	28 in (71.1 cm)
1 centner	100 kg
1 chetvert	1.96 bushels (2.099 hectoliter)
1 dessiatine (desyatina)	2.7 acres (1.09 hectares)
1 liniya	$^1/_{10}$ in
1 sazhen (sajen) (3 arshins)	7 ft (2.134 m)
1 cu. sazhen	343 cu. ft (9.71 m^3)
1 vedro	3.25 US gallons (12.3 liters)
1 vershok	$1^3/_4$ in (4.445 cm)
1 verst (500 sazhens)	0.66 miles (1.07 km)
Mapping scale:	
1 verst to the inch	1:42,000
2 " " " "	1:84,000
3 " " " "	1:126,000

V. V. DOKUCHAEV

1846 — 1903

PUBLISHER'S PREFACE

V. V. Dokuchaev, one of the founders of Russian classical agronomy, was an outstanding, versatile scientist with a very wide range of scientific interests. He was the author of fundamental works on the origin and properties of soils and their role in the economy. Dokuchaev was opposed to all forms of abstract research unconnected with the urgent needs of the people. His lifetime of intense labor and creative investigations was dedicated to serving Russian agriculture.

The Russian people were cruelly afflicted by the periodic droughts and crop failures which desolated many agricultural areas. One of the most severe and memorable droughts was that of 1891 which affected almost the entire Russian chernozem zone, causing famine. In several provinces, the peasant population of entire villages and districts starved to death.

Together with the leading intellectuals of his time, Dokuchaev was roused to action by the suffering of the people. In 1892, he published his famous work "Russian Steppes in the Past and Present" (Nashi stepi prezhde i teper) in which he sought to answer the question whether droughts could be prevented or at least moderated by a system of timely measures. This necessitated thorough studies of the climate, soil, vegetation and topography of the chernozem steppes as well as of the entire history of steppe agriculture. Undaunted by the magnitude of the task, Dokuchaev collected and painstakingly analyzed an enormous amount of data, in order to be able to trace the process of desiccation in the Russian steppes, explain the increasing incidence of steppe droughts, and to point out measures for the prevention of droughts and crop failures.

Dokuchaev was among the first scientists to determine the effect of vegetation on the hydrological conditions of virgin steppes. This grassy vegetation, like the arboreal vegetation of forests, is a powerful agent enhancing the accumulation of atmospheric moisture in the soil. He proved (contrary to the opinions held by many of his contemporaries) that the depletion of groundwaters in the steppe zone, and the frequent crop failures caused by the droughts were totally unrelated to climatic changes and were entirely due to changes in the steppe surface caused by uncontrolled plowing and by the compaction of the ground. He established that the content of soil moisture was dependent on the topography almost as much as on the quantity of atmospheric precipitation.

In collaboration with his closest friend and assistant A. A. Izmail'skii, Dokuchaev used the materials of extensive experiments to prove that the increase of moisture reserves in soil could be ensured mainly by measures inhibiting the surface runoff of atmospheric waters and facilitating their percolation into the soil, as well as by measures protecting the soil surface against desiccation; a favorable combination of such conditions causes a considerable rise in the water table.

In his extensive research works, Dokuchaev laid special emphasis on the strong effect of forests on the water economy of the steppes, and stressed the necessity for large-scale afforestation and the planting of shelterbelts in the drought areas. He predicted a catastrophic deterioration in steppe agriculture in the absence of energetic and decisive measures of amelioration.

Dokuchaev was well aware of the enormous difficulties involved in the transformation of steppe agriculture, which, in his words, "... is already generally recognized to be a kind of speculation the hazards of which are certain to increase each year". He understood the impossibility of implementing the measures he delineated under the socio-economic condition existing in Tsarist Russia, with private ownership of land, millions of petty peasants' farms primitively equipped, and subsistence of the peasantry on the verge of starvation.

Dokuchaev was a true innovator in linking his research work to the urgent needs of agriculture. He strongly opposed the uncritical application of West European systems of agronomy to Russian soil. In contrast to the subservient attitude of the Tsar's high officials, Dokuchaev openly and boldly stated: "We should be ashamed of having applied German agronomy in Russia to true Russian chernozem, without taking account of conditions of climate, vegetation and soil conditions..." According to Dokuchaev, "... specific Russian agronomic techniques and methods must be evolved for the individual soil zones of Russia, in strict accordance with local pedological, climatic, as well as socio-economic conditions. The time has long been overdue!"

This "zonal" approach to the advancement of agriculture and to the institution of agricultural experimentation did not receive due recognition in Tsarist Russia.

Dokuchaev himself saw no assistance forthcoming for steppe agriculture which could lead the enormous peasant population of the main agricultural areas toward economic and cultural prosperity.

In his famous work "Agrarian Program of the Social Democracy during the First Russian Revolution of 1905—1907" (Agrarnaya programma sotsialdemokratii v pervoi russkoi revolyutsii 1905—1907 godov) V.I. Lenin (Vol. 13, 6th ed.) pointed out that vast stretches of land were deemed unsuitable for cultivation not so much because of their natural properties as because of the character of agriculture in Russia which did not allow for advancement in agricultural techniques. Lenin also pointed out the futility of making an estimate of areas which could be converted from "nonarable" to arable land in Russia, stating that these many millions of dessiatines in Turkestan and several other areas of Russia were ripe not only for irrigation and various measures of meliorations, but also for the liberation of the Russian agricultural population from the relics of serfdom.

Peasant farming could be made less dependent on the weather by the introduction of new agricultural techniques. Yet, as pointed out by Lenin, this in turn necessitated reformation of the entire system of primitive, ignorant farming practiced by peasants on their allotments.* The 3-field crop rotation system had to be immediately rejected, as did the primitive

* [At that time village lands were communal property, and were periodically redistributed among the peasant families, more or less in accordance with the number of workers. The property could not be sold, but only farmed by the family to which it had been allotted. As a rule, one allotment did not represent a single area, but consisted of isolated strips of land of various qualities situated at different localities around the village.]

agricultural implements, the patriarchal nonmonetary subsistence farming, the routine methods of livestock breeding, and the naive ignorance of the conditions and requirements of the market.

This was an impossible task under the conditions of Tsarist Russia, but could be realized under the Soviet regime.

V. V. Dokuchaev's recommendations for the improvement of steppe agriculture, combating droughts and crop failures, were well received within the socialist system of agriculture. Modern tools and equipment made it possible to implement the achievements of advanced Russian agronomic science, according to a unified all-national plan, and within a relatively very brief period of time.

A vivid example of the new social structure was the decision of the Council of Ministers of the USSR and the Central Committee of the CPSU, on the 23 October 1948, concerning the planting of shelterbelts, the introduction of a grass-arable system of crop rotation, and the construction of ponds and reservoirs. It was pointed out that in order to ensure high and stable yields of agricultural crops in the steppe and forest-steppe regions of the USSR, kolkhozes and sovkhozes would need to adopt a system of agronomic measures aimed at the improvement of agriculture. This system was based on the theory developed by the most prominent Russian agronomists, V. V. Dokuchaev, P. A. Kostychev and V. R. Vil'yams, and has been the object of many years of scientific research starting from 1949.

The decision under consideration specified the following aspects of the grass-arable system of agriculture:

a) planting of shelterbelts on water divides, along the boundaries of fields under crop rotation, on the sides of gullies and ravines, along river banks and lake shores, around ponds and reservoirs, as well as the afforestation and stabilization of sands;

b) introduction of grass-arable crop rotation for grain and fodder crops, and rational utilization of the various farmlands;

c) correct system of cultivation of the soil and crops, in particular through the extensive use of bare fallow, fall plowing, and stubble cleaning;

d) correct use of organic and mineral fertilizers;

e) sowing of selected seeds of high-yield varieties adapted to local conditions;

f) development of irrigation, utilizing local runoff, by constructing ponds and reservoirs.

The decision of the Council of Ministers of the USSR and of the Central Committee of the CPSU cited the achievements of the Scientific Research Institute of Agriculture for the Central Chernozem Zone im. Prof. V. V. Dokuchaev (the former Kamennaya Step' Experimental Station), as an example of the most consistent implementation of the grass-arable system of agriculture.

The history of this station is very interesting and instructive.

In his studies of the nature of the Russian arid steppes and of the causes of droughts and crop failures, and in the attempt to develop a suitable system for the advancement of steppe agriculture, Dokuchaev provided a convincing proof of the necessity for a large network of experimental stations. It was clear to him that in a country like Russia, with its vast expanses and many different types of soil, climate, and forms of agriculture, experimental stations were extremely important for developing the best techniques for the cultivation of agricultural crops as well as for livestock breeding, taking full account of local conditions.

In 1892, a special expedition was organized, at the initiative of Dokuchaev and under his guidance, for studying the Russian steppe zone. The expedition aimed at producing experimental proof of the possibility of obtaining high and uniform crop yields in arid regions. The following three experimental sites were selected: the Velikii-Anadol plot, situated between the Dnieper and Donets rivers, the Starobel'sk plot, situated on the divide between the Donets and Don rivers, and the Kamennaya Step', situated on the divide between the Don and Volga rivers. The work planned by Dokuchaev began with meteorological observations, investigation and description of soils, compilation of soil maps, studies of the steppe flora and fauna, and the development of methods for regulating the water economy.

The expedition completed its work in 1899. It had instituted an afforestation site in Kammenaya Step', which subsequently became (in 1911) the Kamennaya Step' Agricultural Experimental Station. The experiments were of tremendous scientific and practical importance in elucidating the causes of crop failures and in elaborating a suitable system of farming in arid steppes.

However, this broad plan of work could neither be brought to completion nor exhaustively evaluated under the conditions prevailing in Tsarist Russia. Even within Dokuchaev's lifetime, the work of the Kamennaya Step' Experimental Station was reduced to that of mere forestry, thus thwarting the very aim of a comprehensive study.

The Kamennaya Step' Station began to flourish only under the Soviet regime. The Soviet government supplied the experimental station with tractors, combines, and other modern machinery, and allocated a very large budget for the expansion of research and the full-scale implementation of Dokuchaev's ideas.

In 1946 the Council of Ministers of the USSR passed a decision to convert the Kamennaya Step' Experimental Station into the Scientific Research Institute of Agriculture for the Central Steppe Zone im. Prof. V.V. Dokuchaev.

The work carried out at the Kamennaya Step' Experimental Station clearly demonstrated that the prerequisites for a rapid improvement in the water balance of arid steppes, and for obtaining high and uniform crop yields under any weather conditions, were the creation and systematic maintenance of a strong crumb soil structure, large-scale ameliorative agrosilviculture, and the construction of ponds and water reservoirs in steppe hollows and depressions. The efficency of measures to combat drought and to ensure stable high productivity on arid steppes, as originated by V.V. Dokuchaev and subsequently developed by Academician V.R. Vil'yams, was experimentally proven.

The introduction of V.R. Vil'yams' system of grass-arable crop rotation on the fields of the Kamennaya Step' Experimental Station has doubled the yields of grain and leguminous crops in the course of the last 10 years, to reach over 20 centners per hectare.

The acid test for Kamennaya Step' was the drought of 1946 which was unparalleled within the past fifty years. Nevertheless, the following yields were obtained at Kamennaya Step' from fields which had passed the stage of bare fallow, and had been sown with perennial grasses and properly cultivated (per hectare): winter wheat, 16.52 centners; winter rye, 14.97 centners; spring wheat, 10.62 centners; oats, 15.75 centners; millet, 16.43 centners; sunflower seed, 21.20 centners.

By consistent implementation of the grass-arable system, many kolkhozes, sovkhozes, and machine-tractor stations achieved high crop yields in arid steppes where stable agriculture had been deemed impossible only a short while before.

The first volume of V.V.Dokuchaev's "Selected Works" includes his fundamental monograph "Russian Chernozem" (Russkii chernozem), first published in 1883. The significance of this work, as well as of all Dokuchaev's activities, was vividly described by Academician V.R. Vil'yams in his introduction to "Russian Chernozem", published originally in 1936 and included in the present volume.

In the history of pedology, this was the first complete work which not only contained a vast amount of data, but was also presented on a high theoretical level. "Russian Chernozem" provided the first proof that soil is a peculiar natural body which must be studied by an independent branch of science. In this work, Dokuchaev gave a final answer to the age-old arguments regarding the origin of chernozem, and systematically described the soils of the entire chernozem zone of European Russia. He collected and discussed in detail a great deal of factual material on vegetation, parent rocks, topography, and climate.

Subjects covered by Dokuchaev, which have remained significant even in the present time, include the origin of vegetal-terrestrial soils, the structure of chernozem, its thickness and relation to topography, the age of chernozem and the causes for its absence from northern and southeastern Russia. Dokuchaev solved many controversial problems regarding the origin and development of Russian chernozem, thus laying a strong foundation for the subsequent development of the science of rational agriculture.

However, Dokuchaev's concept of the soil-forming process was erroneous insofar as it did not take into account human activities as one of the soil-forming agents. This omission partly interfered with the correct evaluation of the conditions of soil fertility and to a certain extent invested Dokuchaev's studies of the Russian chernozem with a somewhat contemplative character.

Like Charles Darwin, Dokuchaev mistakenly believed that "Natura non facit saltos". A consistent evolutionist, Dokuchaev elaborated the scientific foundations for the correct understanding of the geological and soil-forming processes. He denied any sudden arbitrary transformations, and explained geological and soil-forming processes by the gradual modification of the earth and of the entire plant and animal world. Yet, he overlooked certain fundamental quantitative and qualitative changes which constitute a part of this same evolution.

Despite these errors, Dokuchaev's work "Russian Chernozem" remains one of tremendous scientific and practical value to the present day.

"Selected Works" are being published according to the original sources. The monograph "Russian Chernozem", included in Volume 1, was reproduced from the edition of 1883. The second and third volumes include Dokuchaev's principal works on geology, agriculture, soil cartography, soil genesis and soil zonality.

The present publication (including Volumes 1 — 3) faithfully reproduces Dokuchaev's original texts. For the reader's convenience, metric measures have been inserted in square brackets following the original Russian measures. Editor's remarks and bibliographical footnotes likewise appear in square brackets.

The author's footnotes are indicated by small Arabic numbers, while editor's footnotes are marked by asterisks.

The third volume of "Selected Works" includes the bibliography of Dokuchaev's works as well as the subject and the authors' indexes for all three volumes.

V. V. DOKUCHAEV'S ROLE IN THE DEVELOPMENT OF SOIL SCIENCE

Academician V. R. Vil'yams

Vasilii Vasil'evich Dokuchaev was one of the most outstanding scientists of the late nineteenth century. His work laid the foundations of the vast and important branch of knowledge known as the genetic pedology.

It should not be assumed, however, that he founded a completely new branch of science. Prior to Dokuchaev's work, a great deal of varied information had been collected on soils and soil fertility. The early investigators included among their number such outstanding scientists as Fallou, Pallas, Liebig, Murchison, Eichwald, Schloesing, Deherain, Schübler, Wollny, and others.

Two principal trends in pedology, which exist even at the present time, were already evident before Dokuchaev'e time: 1) studies of soil genesis and 2) studies of the physical and chemical properties of soils. During the second half of the nineteenth century, the properties of soils had been so thoroughly studied that Karl Marx in "Das Kapital" was able to refer to the absence of natural soils, i.e., soils which had not been modified by human activities, and the differences between the natural and the effective fertility of soils.

Dokuchaev's historic achievement was making soil genesis the central target of pedological investigations and evolving the theory of soil as a peculiar natural body which develops under the combined influence of natural agents. This theory replaced the previously current arbitrary notions regarding processes of soil formation and on soil-forming agents, as well as the earlier empirical studies of isolated properties of soils. Dokuchaev's work developed pedology into a broad scientific discipline.

Dokuchaev pointed out the error made by agronomists and geologists in regarding soil only as a medium, to be utilized for the maximum possible profits. He emphasized that the soil is a natural independent body which, like any other natural body or organism, has a specific origin, history of development, and external appearance. He stressed the primary importance of a scientific approach to soil studies, and pointed out that one of the principal reasons why pedology had not yet gained the status of a true science, was that it often resorted to methods of trial and error, adopting a purely empirical approach in its attempt to solve even the most urgent and important problems of agriculture.[1]

V. V. Dokuchaev was a scientist with a very wide range of interests and he left an enormous literary heritage. The principal subjects with which he was concerned were: 1) the origin, properties and agricultural significance of soils; 2) the structure and origin of river valleys and other aspects

[1] V. V. Dokuchaev. Khod i glavneishie rezul'taty... issledovaniya russkogo chernozema (The Progress and the Principal Results... of Studies of Russian Chernozem). 1881.

of dynamic geology; 3) hydrology; 4) agricultural experimental stations; and 5) agricultural education. He wrote 129 works,* and was the initiator and editor of many others. Most outstanding among his numerous works are the following: 1) "Formation of River Valleys in European Russia" (Sposoby obrazovaniya rechnykh dolin Evropeiskoi Rossii), 1878; 2) "Russian Chernozem" (Russkii chernozem), 1883; 3) "Geological Characteristics of Soils in the Nizhni Novgorod Province. Materials for Land Valuation in the Nizhni Novgorod Province" (Geologicheskie osobennosti pochv Nizhegorodskoi gubernii. Materialy k otsenke zemel' Nizhegorodskoi gubernii), issue No. 14, 1886 (containing "Classification of Soils"); 4) "Russian Steppes in the Past and Present" (Nashi stepi prezhde i teper'), 1892; and 5) the introduction to "Works of the Expedition Organized by the Forestry Department under the Guidance of Prof. Dokuchaev" (Trudy ekspeditsii, snaryazhennoi Lesnym departamentom pod rukovodstvom prof. Dokuchaeva), 1894 (written in collaboration with N. M. Sibirtsev, describing the motives for the organization of the expedition, its tasks and structure, and the plan of experimental work).

The sequence and contents of Dokuchaev's works show that he began with studies of geological problems, then turned to pedology which he reorganized and actually instituted as a new scientific discipline, subsequently concerned himself with geobotanical questions, and finally became involved in the struggle for high and uniform crop yields. His plan of agrosilvicultural melioration in the steppe zone (which included even snow retention) was wholly appreciated, elaborated and will be implemented under a socialist regime.

The wide range of Dokuchaev's scientific interests, far from covering an arbitrary selection of subjects, possessed a logic of its own. Moreover, Dokuchaev had the gift of selecting his collaborators and of arousing their interest in his ideas, which he pursued and implemented with an iron will. In this respect, Dokuchaev strikingly resembled the immortal Louis Pasteur who, advancing from chemistry to studies of microorganisms in fermentation processes and decay processes of organic substances, created the science of microbiology, and finally became engaged in the treatment of rabies, and blazed new trails in the history of medicine.

Both scientists were regarded with distrust by their contemporaries, made many enemies against whom they were ever compelled to struggle, yet did not relinquish their ideas and activities in the face of inimical opposition.

Dokuchaev's last works were the planning of measures of agricultural melioration to achieve high and uniform crop yields, and the organization of three experimental plots to test his plan: the Khrenovo plot which included the Khrenovskoi (Khrenovo) coniferous and the Shipov deciduous forests, the Starobel'sk plot and the Velikii Anadol plot. In his last years of work Dokuchaev showed himself a man far ahead of his time; though he inured himself to the capitalist conditions under which he lived and sought to improve by his work, his scientific inferences and practical proposals conflicted with the existing system. He was well aware of the irreconcilable contradictions between his recommendations for the reorganization of steppe agriculture in order to achieve high and uniform crop yields, and capitalistic demands and the resulting conditions. His pessimism regarding the

* [A revised list of works by Dokuchaev contains over 200 items (see "V. V. Dokuchaev" in "Bibliographic Materials on USSR Scientists (Materialy po bibliografii uchenykh SSSR)), published by the Academy of Sciences of the USSR in 1948". Ed.]

possibility of realizing his plans was in full evidence, when he wrote that Russian agriculture could be placed on a solid basis, no longer to resemble a game of chance by being adapted to local physiographic (as well as historic and economic) conditions, which in turn necessitated a comprehensive study of these conditions and their interrelationships.[1]

Thus, Dokuchaev clearly perceived the abyss separating his desire to raise the crop yield in the steppe zone by overcoming the elemental vicissitudes from the possibility of implementing the necessary measures. Obviously, Dokuchaev could not clearly evaluate the socioeconomic conditions of his time; nevertheless, his plan — the only feasible one — for improving the crop yields in the chernozem steppe zone constituted a challenge to prevalent ideas. He brought his plan to the attention of the ruling circles, yet declared his disbelief in the sincerity of their intention to raise steppe agriculture to the necessary level.

Dokuchaev's name deservedly ranks among the greatest in the natural sciences. The importance of his works is tremendous. Many are almost as valuable today as they were forty or fifty years ago, at the time of publication; such works include "Russian Chernozem".

The most important aspect of Dokuchaev's theory of soil is the concept of soil as a peculiar natural body, differing from rocks though developing from them. Present-day genetic pedology, which plays such an important role in the planned socialist agricultural production of the USSR and in the improvement and maintenance of soil fertility, could not have developed prior to the formulation of this principle. "Russian Chernozem" contained further elaboration of Dokuchaev's concept of soil.

Before Dokuchaev's time, there existed a relatively rich literature on chernozem soils, and a multitude of theories were advanced to explain the origin of these soils. Yet, the very concept of "chernozem soils" as well as ideas concerning their properties, geographic distribution, origin, and reasons for their high fertility, remained unclear, since all of Dokuchaev's predecessors based their conclusions on a limited amount of information which was often incidental, legendary, or purely local. Their main failure was studying isolated properties of these soils in no way connected with other properties and the phenomena which conditioned them.

Dokuchaev was the first to carry out a detailed and systematic investigation of the entire zone of chernozem soils, and to provide a comprehensive description of the individual natural regions of this zone; he was also the first to study the morphology, chemical and physical properties of different chernozems, and to examine critically the previously accumulated materials on chernozem soils. The publication of "Russian Chernozem" put an end to further conjecture regarding the origin of chernozem, established the generally accepted view of chernozem as a vegetal-terrestrial soil formed under grassy meadow-steppe vegetation (Ruprecht's theory), and simultaneously instituted a new phase in the studies of chernozem: investigation of the conditions governing the development, loss, and recovery of fertility by these soils (P. A. Kostychev, V. V. Dokuchaev, P. F. Barakov, A. A. Izmail'skii, V. S. Bogdan, and others).

"Russian Chernozem" merits attention in the following five respects: 1) its aims; 2) methods of investigation; 3) the comprehensive nature of the studies; 4) the factual materials and the conclusions; and 5) the attitude

[1] V. V. Dokuchaev and N. M. Sibirtsev. Vvedenie (Motivy)... (Introduction: Motives...). — In: "Trudy ekspeditsii, snaryazhennoi Lesnym departamentom". 1894.

of scientists (Dokuchaev's contemporaries) and other persons whose activities were related to agriculture.

The aims of Dokuchaev's investigation of chernozem soil were defined in his introduction to "Russian Chernozem", where he stated that he was concerned only with fundamental aspects, and strove, insofar as possible, to study chernozem from the viewpoint of natural sciences, etc. In another place, he wrote: "I was faced with the following basic problems: what, generally, is to be termed as soil? What are the thickness, structure, and position and which should be accepted as normal? What is implied by the very term "chernozem"? Into what natural types can it be subdivided? In the scientific description and classification of chernozem (as well as other soils), should one also take into account incidental, as it were abnormal, soils of secondary occurrence and strongly modified properties? What general laws govern the distribution of chernozem and other soils over European Russia? What principles should govern the compilation of chernozem maps? How did this soil originate, and what are the causes for its absence over the vast expanses of northern, central, and southeastern Russia? What gives rise to the truly remarkable fertility of chernozem?"[1]

The problems confronting Dokuchaev in his research on chernozems were characteristic of the level of the development of soil science at that time, and the reader of "Russian Chernozem" can judge the extent to which the investigation methods were suited to the tasks, and the author's attainment of his aims.

Dokuchaev made use of geographical morphologic methods in his work. He divided the entire chernozem zone into a number of areas, in each of them collecting detailed information on soils (color, thickness, and other characteristics), geology, topography, vegetation, climatic conditions, crop yields, etc. A considerable portion of his samples was subjected to chemical analysis. Dokuchaev then proceeded to group all his materials according to similarities or differences, and drew general conclusions. This method was completely novel as compared to those previously used in research on the same subject. For the first time in the history of soil science, an entire vast natural zone was systematically and comprehensively investigated. Dokuchaev was not concerned with isolated arbitrary soil samples, nor with individual factors in the development of soils, but with the sum-total of these factors. He was in no way confused by the large amount of data; on the contrary, as the information became more abundant, his ideas were broadened and confirmed, and the regularities established by him could be substantiated.[2] Although Dokuchaev did not quote Darwin or Lyell, there was an undoubted similarity in their methodologies and in their views of the nature of investigated objects. They played similar roles in the development of modern natural sciences; Darwin and Lyell, respectively, founded modern biology and modern geology, while Dokuchaev was the founder of modern genetic pedology.

In "Russian Chernozem", Dokuchaev proved the feasibility of drawing broad theoretical generalizations on the formation of soils and their fertility, on the basis of geographic-morphologic and chemical studies. Another method, different from the morphologic-geographic one, was applied

[1] V. V. Dokuchaev. Khod i glavneisnie rezul'taty... issledovaniya russkogo chernozema (The Progress and the Principal Results ... of Studies of Russian chernozem). 1881.

[2] V. V. Dokuchaev and N. M. Sibirtsev. Vvedenie. Trudy ekspeditsii, snaryazhennoi Lesnym departamentom (Introduction. Works of Expedition Organized by the Forestry Department). 1894.

to studies of the fertility of chernozem soils by another outstanding scientist, P. A. Kostychev. Thus, Dokuchaev and Kostychev were the first to elaborate methods of research on the genesis and fertility of soils, and at the same time they demonstrated the need to adapt research methods to the specific purposes of the task. However, pedologists subsequently accepted the geographic-morphologic research method applied by Dokuchaev in his studies of chernozems and of soils in the former Nizhni Novgorod Province as the universal method suitable for all pedologic investigations, despite the fact that it no longer served its purpose in the transition from geographic themes to questions of soil fertility.

The natural factors of soil formation had been identified by Dokuchaev's predecessors. Dokuchaev's contribution consisted in taking account of the combined effect of the five natural factors, considering them in isolation.

Ever since crops have been cultivated on the land, Man has interfered with the natural course of soil processes. Depending on the socio-economic conditions of a country, Man may either enhance or destroy the soil's fertility which is known to be one of its essential properties. Like cultivated plants and domestic animals, soil is a natural factor in agriculture, but it has been so strongly modified by cultivation that today it is impossible to speak of the natural development of soil as unconnected with human activities.

A shortcoming of Dokuchaev's concept of the soil-forming process was his not taking account of the activities of Man among the soil-forming factors. Because of this, Dokuchaev could not reach a correct understanding of the questions of soil fertility, and his concept retained a natural-philosophic, contemplative character.

From the wealth of material presented in "Russian Chernozem", in this brief essay we shall single out the following three topics: 1) parent rocks of the chernozem zone; 2) classification of chernozem soils; and 3) variations in the vegetation and climate of the chernozem zone. The treatment of these three subjects has remained unsatisfactory up to the present time and must be reviewed.

"Russian Chernozem" cited many examples of finds of crystalline boulders among the so-called loesses and loess-like rocks of the chernozem zone. In this work, Dokuchaev did not arrive at a definite conclusion regarding the glacial origin of these so-called loesses and loess-like rocks, because at that time he did not yet completely accept the glacial theory. At that stage, his views on the formation of the parent rocks in the chernozem zone seemed to be inconsistent with terminology he used. On the one hand, he used the term "diluvium", "diluvial deposits", and mentioned the drift of icebergs and the transport of boulder deposits by icebergs over the Russian plain; on the other, he also spoke of glaciers. However, we are primarily interested in the facts, which included the presence of boulders in the so-called loesses and loess-like rocks.

In subsequent works, Dokuchaev repeatedly returned to the problem of these loesses and loess-like rocks, and with the ever-increasing amount of data available, he became progressively more convinced of the glacial origin of these rocks.

For instance, in his description of rocks in the former Poltava Province, Dokuchaev mentioned instances of loesses underlain by boulder clays and loess overlain by boulder deposits. In his paper "The Last Word in the Geology of Russia in General, and of the Southern Steppes in Particular"

(Poslednaya stranichka v geologii Rossii voobshche i yuzhnykh stepei v osobennosti) based on material supplied by workers of the expedition for the investigation of the Poltava Province, he returned to this subject, giving instances of erratic boulders and pebbles found in the lower horizons of the so-called typical loess, as well as providing other general characteristics of loess and of typical boulder formations. Dokuchaev thus concluded that loess is a glacial formation. Finally, he expressed the same views in his paper "The Origin of Russian Loess" (K voprosu o proiskhozhdenii russkogo lessa). In subsequent works on this subject, begining with "Russian Chernozem" and ending with his last papers, one can see a considerable modification of Dokuchaev's views; nevertheless, already in "Russian Chernozem", he stated his disagreement with the aeolian hypothesis of the origin and mechanical transfer of the so-called loesses, which was based on studies of Chinese loesses, without a critical evaluation. It is true that Dokuchaev did not extend his views on the glacial origin of loess to all the regions of occurrence of south Russian loess; he admitted the possibility of their aeolian formation, but only within a strictly-limited area. It should be noted that Dokuchaev also admitted the possibility of marine, lacustrine-fluvial, eluvial, and deluvial formation of loesses. Accepting the typical fine granular loesses as being of exclusively glacial formation, Dokuchaev considered that they were produced by the settling of fine suspensions from glacial waters.

Even at present, there is no generally accepted theory regarding the origin of the so-called loesses and certain loess-like rocks. Certain facts which became known after Dokuchaev's lifetime, such as the four-stage occurrence of loesses, their content of coarse sand, the presence of loess-like rocks in indubitably glacial areas (Belorussia etc.), facts which cannot be explained by the aeolian hypothesis, as well as facts pointed out by Dokuchaev himself, lead us to the acceptance of the glacial origin of the so-called loesses, although not in the same meaning as accepted by Dokuchaev. The over-enthusiastic acceptance of the aeolian hypothesis by some geologists and pedologists merely served to accelerate the refutation of this hypothesis. Today, the number of those who accept the aeolian hypothesis is progressively diminishing.

The second essential subject is the classification of chernozem soils. The Russian chernozem zone occupies a large territory, within which the chernozem soils differ according to the areas of their occurrence; obviously, these differences must be reflected in the soil nomenclature so that chernozem soils must be subdivided into species and varieties. Yet, even today a considerable number of pedologists make use of a classification of chernozems (northern, rich, deep, ordinary, southern, Azovian) attributed to G. Tumin; actually it was drawn up by Chaslavskii, as can be seen from "Russian Chernozem". In turn, Chaslavskii gathered his data from official materials on land taxation, and from colloquial usage, making use of the external features of chernozem soils such as color, thickness, etc. This approach is only satisfactory in the early stages of the development of any science. Even the present-day classification of chernozem soils resembles those used for animals or plants, according to color, size, etc.

Dokuchaev was obviously dissatisfied with Chaslavskii's classification and in "Russian Chernozem" he detailed the principles of classification for chernozems, based on the properties of the parent rocks; at a later stage, in "Materials for Land Valuation in the Nizhni Novgorod Province" (Materialy k otsenke zemel' Nizhegorodskoi gubernii) he introduced the topographic situation of soils as yet another criterion in the classification of chernozem.

Today, we possess sufficient data and adequate theoretical principles for the development of a genetic classification of chernozem soils which would be more suited to the present-day level of pedology and the requirements of the socialist agricultural production.

The last subject is the evolution of the plant cover and the climate in the chernozem zone, or the formation and development of the Russian steppes. In "Russian Chernozem" a large number of data indicate the wider occurrence of forest in the past periods in the steppes than at present. Abundant materials are furnished by Dokuchaev on this subject in his other works also, including "Russian Steppes in the Past and Present" (Nashi stepi prezhde i teper'). There can be no doubt that larger areas of the Russian steppes were formerly covered by forests, which later gave way to the advancing steppes; This process subsequently became even more intensive owing to the felling of trees; a great deal of information on this subject can be found in works by Dokuchaev, A. A. Izmail'skii and others, not to speak of earlier authors. Dokuchaev was nevertheless of the opinion that the present-day chernozem zone was a steppe throughout the entire period of the formation of chernozems and that the climate was generally the same as it is now. It is important to emphasize that Dokuchaev spoke only in general terms and only with regard to the formation of chernozem. This approach was not identical to that of certain later workers who accepted the "eternal nature of steppes". However, we must accept that the steppes underwent, and are undergoing, a number of changes within the period of the formation of chernozems. On the whole, Dokuchaev in "Russian Chernozem" disagreed with the notion of the primordial (eternal) nature of the steppes, and any statement to the contrary is a falsification of Dokuchaev's ideas. This subject will be thoroughly covered in the preface to Dokuchaev's work "Russian Steppes in the Past and Present" which is scheduled for republication by "Sel'khozgiz" in the series "Classics of Natural Sciences".

Dokuchaev had a tremendous influence on the development of an entire complex of natural sciences (geology, silviculture, geobotany, pedology) and that of practical measures for the development of agriculture (afforestation of steppes for drought control, stabilizing crop yields in southern Russia, etc.). He played the difficult role of the reformer of at least a part of the natural sciences related to the development of agriculture in Russia which at that time had just abolished serfdom and entered a period of capitalist development. It was only natural that he should have made both friends and foes along the way; he was vehemently disliked by some and highly revered by others. The heated arguments which raged over his ideas certainly contributed to his scientific work, and thus could not be forgotten or ignored. His theories were subsequently developed, and their value has already become evident.

It is to be hoped that the republication of Dokuchaev's most outstanding works will provide an impetus for the revision of very many aspects of present-day pedology, geobotany, and certain other disciplines, and that it will serve to acquaint our young generation of scientists with the classical literature in natural sciences, helping them towards developing the correct world outlook.

In Memory of ALEKSEI IVANOVICH KHODNEV

INTRODUCTION

> The boundless extent of chernozem makes it scarcely possible, within a human lifetime, to investigate thoroughly and describe all the lithological combinations and transitions of this group of soils, taking into account local peculiarities, variations in fertility, subsoils, sedimentation, etc.
>
> Wangenheim von Qualen

In November 1876, at the suggestion of the late A.I. Khodnev and Prof. A.V. Sovetov, the first division of the Free Economic Society* appointed a special commission to draw up a program of research into Russian chernozem. In addition to Khodnev and Sovetov, Prof. M.N. Bogdanov and the present author were also included in the commission. Following a special report by one of its members, the commission recognized the necessity of subdividing the work planned into two completely independent parts, 1) the geologic-geographic investigations and 2) the physicochemical investigations. The first part, which was to be entrusted to an expert geologist, comprised the following tasks: a) visiting, insofar as possible, most of the territories to be investigated, to complete the geological and geographical information regarding the territories indicated in the report; b) traversing the most typical areas within the chernozem zone of European Russia from north to south and again from east to west; c) collecting a sufficient number of samples of typical chernozem from various localities; d) collecting samples of all soils transitional between true chernozem and forest, peaty, and solonchak soils, as well as samples of the latter, indicated by their local names; e) making a complete collection of samples of the various chernozem subsoils; and f) collecting all the available information regarding the depletion of chernozem in the various localities, as well as gathering information on the cereal crops which are the most suited to the specific chernozem.

This research plan was approved by the first division, by the Council and by the General Assembly of the Free Economic Society without modifications or alterations, and a decision was taken on 24 February 1877 that the work should begin in the summer of the same year. The Council saw fit to entrust the author of this work with the execution of the first half of the program (geologic-geographic research) and expressed the desire that the investigations be completed within the period of two summer vacations, a total of approximately eight months.

The extent of the chernozem zone of Russia is 80—90 millions dessiatines. In order to fulfil the task even in general outlines, (visiting the most important sites in the investigated territory), the author had to travel about 10,000 versts in the course of the eight summer months.

Due to the vastness of the territory to be investigated, despite the assistance (in 1878) of candidate P.A. Solomin of the St. Petersburg University, it was physically impossible for the author to make a detailed examination of chernozem during his excursions; obviously, it was beyond

* [So called because this was a voluntary public organization, as opposed to a government institution. Translator.]

his means to solve many practical problems which—though possibly of importance—were certainly of a local nature. He was concerned only with general tasks and strove, as far as possible, to study chernozem scientifically from the standpoint of natural history. This seemed to be the only possible basis for devising various practical measures for raising the level of agriculture in the Russian chernozem zone, and such a basis had to be comprehensively and scientifically substantiated ...

The task was completed by the end of 1878, and in Octobe of that same year the Society received my soil-sample collections and preliminary report.

While processing the collected materials (1878—1880) the author arrived at certain conclusions concerning the soils of southwestern Russia. These conclusions did not conform with the generally accepted notions on the chernozem of the locality; in fact, they were so unexpected, and difficult to explain, and of such practical and scientific significance (pp. 200—209) that the author decided, in the summer of 1881, to revisit southwestern Russia and inspect even those areas to which access was most difficult. This excursion was deemed so important that the St. Petersburg Society of Naturalists undertook to finance the project out of its very limited funds. Throughout almost the entire excursion the author was accompanied by Candidate agronomist A.I.Kytmanov, whose assistance and partially also financial aid made possible the investigation of larger areas.

Almost immediately following the completion of this work, in the winter of 1881, the Nizhni Novgorod provincial "zemstvo" decided to institute detailed soil and geological investigations within the province, in order to establish a basis for the "zemstvo" land taxation. The execution of this extensive project, which represented quite a novel undertaking in Russia, was entrusted by the "zemstvo" to the present author. He was very willing to undertake the work, particularly since it provided him with the opportunity of investigating in detail one of the most interesting areas of the northern boundary of chernozem; the findings were certain to represent a considerable contribution to those of previous general investigations. In the summer excursions of 1882 in the Nizhni Novgorod Province, the author was accompanied by his pupils P.A.Zemyatchenskii, N.M.Sibirtsev and A.R. Ferkhmin.

The above circumstances were partly responsible for the delay in the publication of the author's complete report, which thus appears only now. Besides the vast scope of the task and the extensive territory investigated, an equally important factor hindering the completion of the work was the collection and evaluation of a great amount of diverse data, mostly from publications by persons who did not specialize in pedological subjects. However, the special nature of our investigation was possibly the greatest stumbling block. Soils are the products of the extremely complex interaction of the effects of local climate, plant and animal organisms, composition and structure of the parent rocks, topography and, finally, the age of the country, and therefore it is only natural that the investigator must constantly excurse into various branches of science ...

In concluding this brief forward, the author wishes to express his gratitude to the Free Economic Society, and the Naturalists Society of the St. Petersburg University, for their financial support, as well as to his young assistants for their energetic work.

31 October 1883 V. Dokuchaev

Chapter I

HISTORIC REVIEW OF THE GEOGRAPHY OF RUSSIAN CHERNOZEM

The geography of chernozem has been one of the favorite subjects of nearly all the investigators of the chernozem zone of European Russia. This preference is understandable. Not only is the soil itself of great practical importance, but its distribution is also of a prime scientific significance. Precise knowledge of the geography of chernozem is prerequisite for establishing its origin; its geography is related to the distribution of certain wild plants and animals in Russia; finally, we shall see later that the geography of chernozem is genetically closely related to the climate of the country and partly also to its recent geological history.

A fairly detailed historical account of the study of the geography of Russian chernozem appeared in a previous publication[1]; we shall therefore only touch on the highlights of the subject in this work.

As far as we know, the systematic collection of geographical data on Russian chernozem dates back to the very end of the 18th century when it was carried out by Storch[2], a statistician by profession. According to his data, chernozem was already known in the Kharkov, Kursk, Orel, Kazan, Penza, Voronezh, Perm, Podol'sk provinces, in the southern parts of the Tambov and Ryazan provinces and in certain localities in the Kaluga, Vyatka, and Taurida provinces[3]. Moreover, Storch recognized the very high fertility of the soil (which he apparently distinguished from nonchernozem soil) in the Novgorod-Seversk, Simbirsk, Ufa, Kiev, and Saratov (on the right-hand bank of the Volga), and in certain parts of the Ekaterinoslav, Irkutsk, Kolyvan, Caucasus (especially along the Terek River) viceregencies, in the Mozdok Territory, in the territory of the Don Cossacks, and in the Ochakov Region[3].

Unfortunately, Storch's work did not include a description of Russian chernozem; he merely distinguished chernozem from bog areas and from northern clays, sands, etc. He also did not define even the approximate boundaries of chernozem. This omission was remedied only in 1842 in the "Economic Map of European Russia" (Karta promyshlennosti Evropeiskoi Rossii) specially compiled by the Ministry of Finance. The map delineated the following boundaries of the Russian chernozem zone.

The northern boundary begins at Volochisk, and continuing in the northeastern direction, passing northwest of Zhitomir and east of Novograd-Volynskii towards Chernigov, reaches Bryansk along the Desna; from here it continues almost due east, passing through Bolkhov and Bogoroditsk and

[1] Dokuchaev. Kartografiya russkikh pochv (Cartography of Russian Soils). St Petersburg. 1879.
[2] Storch. Statistische Übersicht der Statthalterschaften des Russischen Reichs, [Riga]. 1795.
[3] Storch. Ibidem, pp. 29–38, 50. 58–103. See also Georgi. Geographisch - physikalische und naturhistorische Beschreibung des Russischen Reichs, B. II and III, [Königsberg.] 1798–1800.

nearly reaching the Oka in the vicinity of Spassk, whence it turns southeast, almost up to Morshansk; it then again makes another abrupt turn in the northeastern direction, passing through Kerensk and Sergach, reaching Vasil'sursk on the Volga, which it then follows to Kazan. Somewhat south of Kazan, the boundary crosses to the left bank of the Volga and continues eastward along the right banks of the Kama and the Belaya, at a small distance from these rivers, somewhat north of Birsk and Ufa.

The southern boundary (according to the same map of 1842) begins at Kabul*, passes near Bendery and continues northeast toward Olviopol, turns due east to Ekaterinoslav, then southeast to the Azov Sea which it reaches between Berdyansk and Mariupol. This boundary then follows the northern shore of the Azov Sea and the Don River approximately until the mouth of the Sal River. At this point, it makes an abrupt turn northwest, along the northern Donets up to the latitude of Slavyanoserbsk, then again turns northeast, proceeding through Boguchar towards the Uryupinskaya "stanitsa". Assuming a due eastward course, the boundary reaches the Volga (halfway betw[illegible]vshin and Saratov), crosses to the left bank of the Volga along whi[illegible]s towards the mouth of the Bol'shoi Irgiz in the form of a very narrow strip. Before reaching this last point, the boundary turns eastward, reaches the Ural River in the vicinity of the mouth of the Utva, then follows the right bank of the Ural almost to Orenburg and then to Obshchii Syrt** (see general map)[1]. The map of 1842 did not feature any soils other than chernozems.

Only in 1851 was the first general soil map of entire European Russia published by the Department of Agriculture. For this purpose a detailed (100 sheets ?) map of Russia was sent to every province, addressed to the commissions for the equalization of taxes† from State-owned peasants†† in provinces where cadastral work was performed, while in the remaining provinces it was addressed to offices for the administration of State properties. These institutions instructed the officials most familiar with the area to mark the soils on the maps. These maps were returned to the Department of Agriculture where they were checked and corrected against the information on the files; the maps were also examined by a special committee of the Ministry and the Central Commission for the Equalization of Money Taxes, and were moreover compared against published works by various scientists who had traveled in Russia, such as Pallas (for the southern provinces), Ozeretskovskii (in the Olonets Province), Rychkov (in the Orenburg Province), Popov (in the Perm Province), Murchison and Blasius (for the chernozem zone), Gebel (in the Saratov Province), Eichwald (for the western provinces) and many others. Thus checked and corrected, the maps were sent to farm managers, associate members of the special committee and to certain well-known owners of agricultural properties, to the economic societies and to survey managers for a

* [Not to be confused with the capital of Afghanistan. Translator.]

** [Highland lying east of the Volga. Translator.]

1 Our general map only shows the northern and the southern boundaries of the chernozem zone by means of lines of five different colors; the same color is used where the latest boundaries coincide with the former ones. For obvious reasons, the boundaries shown are only approximate. In order to simplify the map, I also omitted the geographical data provided by Murchison and Petzholdt.

† [As opposed to levies in kind, at that period of subsistence farming. Translator.]

†† [State-owned peasants, as opposed to the serfs of private landlords (before the abolition of serfdom in Russia). Translator.]

second check on site.[1] "Special Instructions" were also forwarded, compiled by the Ministry, which apparently prescribed a rigid scheme for the grouping of soils, as follows: a) chernozem; b) clayey soil; c) sand; d) loam or sandy loam; e) silty soil; f) solonetses; g) chalky soils; and h) stony soil; the "Instructions" detailed a number of definite symbols to be used to designate these soils. These data were used by Academician Veselovskii when compiling, in 1849, the first general soil map of Russia, which was published in 1851 in a special agricultural atlas. Academician Veselovskii's work clarified the following principal points:

1. The chernozem zone is not continuous, as shown on the map of 1842, but interrupted by nonchernozem soils (clayey, loamy, and stony patches); such interruptions are particularly numerous in the Voronezh Province, as well as in the northeastern and southwestern corners of the chernozem area.

2. The northern and the southern boundaries of chernozem in Russia have shifted markedly, in some places southward, in others northward. The boundaries became discontinuous (see general map).

3. The map of 1851 was the first to show several chernozem "islands" (patches) along the lower reaches of the Northern Dvina and the Onega.

This soil map was reprinted by the Ministry of State Properties in 1852 and in 1857, the second time with very considerable alterations. The most important changes were as follows: In the area northwest of Ryazan, chernozem was shown to reach the Oka River in the form of five small "islets" in the corner between the Moskva and the Oka rivers; the northern boundary was shifted nearer to Kiev, along the right bank of the Desna, reaching Chernigov. There were changes in the distribution of chernozem between Glukhov, Orel and Kursk, as well as in the vicinity of the mouth of the Sura.

This was the level of knowledge of the geography of the chernozem zone before 1866, the year of publication of Academician Ruprecht's new map. Most of the alterations concerned the northern boundary (2/3 of its total length), for the simple reason that only this boundary had been personally investigated by the author of the map. It will be seen from the general map that Academician Ruprecht shifted the northern boundary of chernozem between Zlatoust and Sarapul considerably southeast (in comparison to the map of 1851), on the other hand, between Sarapul and the mouth of the Vyatka river he showed the boundary along the southern bank of the Kama, almost reaching the Volga; coming within 30 versts of the Volga, the boundary was shown to turn due south, continuing in this direction approximately to the latitude of Simbirsk. Further west, Ruprecht traced the boundary from Simbirsk to Buinsk (somewhat south), Pochinki, Ardatov, Narouchat, Sapozhok and Ryazhsk. From this point almost due north, but terminating considerably short of Zaraisk, the boundary was traced southward almost along a straight line through Tula and Glukhov to Kiev. The rest of the map compiled by Ruprecht is fairly similar to the map of 1857, with the exception of a certain difference regarding the right bank of the Volga between the Samara bend and Saratov, as well as south of the Don.

Moreover, the author did not show chernozem "islands" along the bank of the Northern Dvina and the Onega, and reduced their number between the Oka and the Moskva rivers. On the other hand, he depicted other chernozem

[1] Veselovskii [K.S.] Khozyaistvenno statisticheskii atlas Evropeiskoi Rossii (Economic-Statistical Atlas of European Russia). 1851. [Published by Department of Agriculture of the Ministry of State Properties, St. Petersburg: 2nd edition in 1854, 3rd edition in 1857 and 4th edition in 1869.]

"islands" between Kazan and Malmyzh, north of Vladimir (on the Klyazma) and Novogorod-Seversk, between this town and Chernigov; a long, isolated chernozem "island" was likewise shown along the right bank of the Desna River. Two such "islands" were marked by the author in the Stavropol Province also.

In 1869, the Ministry of State Properties published a new soil map of Russia (edited by Vil'son). In a special memoir accompanying the map, Vil'son remarked[1] that the former map had been corrected according to subsequent descriptions. For instance, in the case of certain provinces the changes were made on the basis of the completed work of cadastral commissions, including the Vladimir, Moscow, Kostroma, Nizhni Novgorod, Yaroslavl, Kherson, Smolensk, Saratov, Kursk, Tambov, Taurida, and Pskov provinces. For other provinces, the earlier map was checked and in places corrected according to the provincial descriptions published by the general staff, according to the geographical dictionary published by the Russian Geographical Society, as well as certain specific descriptions and papers. In view of the undoubted reliability of the detailed maps compiled by the cadastral commissions, they were used in their entirety.

On the whole, Vil'son's work most closely resembled the maps of 1851 and 1857, and any differences are fairly clearly indicated on our general map. Furthermore, the Onega chernozem and the "islands" shown by Ruprecht in the vicinity of Novgorod-Seversk and Starodub were removed. On the other hand, "islands" of the same kind were marked in the following places: a) at the middle reaches of the Lovat (two "islands"); b) at the upper reaches of the Msta (two "islands"); c) in the upper reaches of the Suda, a tributary of the Sheksna (one "island"); d) at the mouth of the Kostroma (one "island"); e) between Suzdal and Yur'ev (one large "island"); f) southwest of Kaluga (one "island"); and g) along the Tesha, between Arzamas and Ardatov. Undoubtedly, the most important changes introduced by Vil'son in his map were the data with respect to soils lying along the Volga between Samara and Tsaritsyn; the map of 1869 depicts this region as one of nearly continuous chernozem, although on the left bank of the Volga chernozem merely forms a narrow strip between Tsaritsyn and the Irgiz River. Nevertheless, the authors of the 1869 map were well aware of the temporary nature of their alterations, and therefore continued to apply themselves to the replenishment of data concerning the soil. For this purpose, in 1873 the Department of Agriculture and Rural Industry instructed the managers of State properties to supply the Ministry with new soil maps. The instructions were addressed to managers in Arkhangelsk, Vitebsk, Vologda, Vyatka, Grodno, Kovno, Livonia, Kurland, Estonia, Minsk, Mogilev, Poltava, Olonets, Orel, Perm, St. Petersburg, Tambov, Tula, Ufa, Orenburg, and Chernigov. All the managers with the exception of those at St. Petersburg and Tambov[2] complied with the instruction, and some also submitted special brief explanatory memoirs.

For the same purpose, the junior editor at the statistical department of the Ministry of State Properties, V.I. Chaslavskii, reviewed the soil material available to the postal and military authorities, studied reports of grain agencies [Khlebnaya ekspeditsiya] and the soil maps of certain rural banks, and personally visited central and southwestern Russia and even Serbia.

[1] Vil'son [I.] Ob'yasneniya k khozyaistvenno-statisticheskomu atlasu Evropeiskoi Rossii (Explanation of the Economic-Statistical Atlas of European Russia). [St. Petersburg], p. 5. 1869.

[2] At least, I did not succeed in finding these maps in the Ministry archives. Author.

and Rumania. Finally, as far as possible, Chaslavskii painstakingly reexamined the pedological literature, paying special attention to the well-known works on chernozem by Ruprecht and Levakovskii. On the basis of this work a new soil map was compiled in 1879, in which the distribution of chernozem was shown as follows:[1] The northern boundary of chernozem was traced approximately through Kremenets, Zaslav, Vasil'kov, somewhat northwest of Pereyaslavl and slightly east of Kozelets, through Chernigov, Gorodnya, Sosnitsa, Dmitrovsk, Bolkhov, Odoev, Zaraisk, Ryazan, southeast of Sapozhok and Elat'ma, through Spassk (of the Tambov Province), Temnikov, Krasnoslobodsk, Pochinki, Perevoz, Knyaginin, Yadrin, Tsivil'sk, Spassk, along the left bank of the Kama almost to the mouth of the Vyatka, Menzelinsk, and the water divide between the Kama's tributaries, Bui and Takyp.

According to Chaslavskii's map, the southern boundary of chernozem is formed by the Black and Azov seas; the map depicts loams and sandy loams only immediately adjacent to the shores of these seas and along the lower reaches of the Dnieper River from Aleshki southward. "Along the eastern shore of the Azov Sea chernozem occurs at a small distance from the sea, reaching the very foothills of the Caucasus, and proceeds along the boundaries of these foothills (Maikop, Batalpashinsk, Pyatigorsk, Mozdok, Kizlyar), down to the Caspian lowlands; it then follows the water divide between the Volga and the Don up to Tsaritsyn, along the Volga and the Irgiz, towards Orenburg. South of this southeastern boundary fertile loamy soils, with a considerable admixture of chernozem particles (gray soils), occur in the southern part of the Samara Province, continuing into the lands belonging to the Kirgizes of the Bukeevskaya Horde".[2]

Other important features of Chaslavskii's map include the following: Firstly, in addition to the chernozem "islands" depicted by Vil'son and Ruprecht, Chaslavskii showed some in the Vyatka, Perm, Kovno, Suvalki, and Grodno provinces in the vicinity of Vladimir-Volynsk and in certain other places. Secondly, he was the first to mark, along the boundaries of chernozem, a "transitional belt several dozen versts wide in some places, where chernozem forms a gradual and often imperceptible transition to the surrounding soils with which it merges";[3] these soils were named gray soils by Chaslavskii. Thirdly, chernozem itself was subdivided into nine varieties which were marked on the maps separately.

In concluding this review of the most important Russian maps of chernozem, I would add that hardly any of them, beginning with the map of 1851, depict chernozem as a continuous belt, but show numerous patches of nonchernozem soils, sands, clays, loams, etc. The various authors differ considerably with respect to the dimensions of the majority of these "islands" as well as in regard to the nature of their soil.

Comparison of all these maps brings to light not only a number of seemingly strange differences in the opinions of the various authors, but also many factual discrepancies; it is remarkable that such controversial areas

[1] Dokuchaev. Doklad obshchemu sobraniyu Vol'nogo ekonomicheskogo obshchestva 17 dekabrya 1881 g., SPb (Report to the General Assembly of the Free Economic Society, 17 December 1881, at St. Petersburg). [Schematic Soil Map of the Chernozem Zone of European Russia, St. Petersburg. 1882; ditto – Trudy Vol'nogo ekonomicheskogo obshchestva, volume 1, No. 4. 1882.]

[2] This is a quotation from Chaslavskii's paper "Pochva" (The Soil) which was printed but not published.

[3] Chaslavskii. Ibid.

sometimes comprise entire provinces. This is illustrated by the following instances.

In the area of the Volga basin, between Vasil'sursk and Kazan, the northern boundary of chernozem was depicted on the 1842 map as passing along the right bank of the Volga, from Vasil to Kazan. The famous Murchison, who studied Russian geology in 1840—1841, shifted the northern boundary of chernozem in this area to lie on the left bank of the Volga, tracing it approximately along the 57° latitude from Nizhni Novgorod to Kazan.[1] Veselovskii's map of 1851 reinstated the boundaries shown in the map of 1842 almost entirely. In contrast, Academician Ruprecht, in 1866, shifted the northern boundary markedly southward; on his map, this boundary was shown passing south of 55°N. from Tetyushi to Pochinki. Vil'son's map of 1869 again shifted chernozem to the left bank of the Volga, its boundaries closely coinciding with those shown by Murchison. Finally, in 1879, Chaslavskii drew the northern boundary of chernozem along the right bank of the Volga at a considerable distance from the river itself, north of Yadrin, Tsivil'sk and Tetyushi.

A similar example is the case of the right bank of the Kama, between the Volga and the Vyatka, from Kazan to Mamadysh. In this area, the map of 1842 showed a fairly wide strip of chernozem, while the maps of 1851 and 1866 depicted clays and loams; the map of 1869 again showed chernozem, and finally Chaslavskii's map featured loams.

There were equally great discrepancies among the maps with respect to the Tsna basin and the right bank of the Volga between Saratov and Tsaritsyn, as well as many other localities. These cannot be attributed exclusively to a subjective approach, and, so to speak, carelessness on the part of the geographer. We must therefore conclude that the differences stem from certain general causes, and this is actually confirmed by a careful study of the literature published on this subject. In the first place, the geographers of Russian chernozem, until very recently, held undefined and very controversial views of chernozem itself and its relationship to associated soils. Indeed, as we shall see later, certain scientists (Strangweis, Murchison, Petcholdt, Agapitov, and others) regarded chernozem as a perfectly uniform body of uniform structure over enormous areas of European Russia, while other scientists (German and Borisyak) recognized significant dissimilarities in the composition and structure of chernozems from different localities. Finally, there were those (Chaslavskii and others) who acknowledged the existence of a certain true chernozem as opposed to clayey, sandy, and other kinds of chernozems. For understandable reasons, proponents of the marine origin of the Russian chernozem (Murchison and others) could not and did not recognize any relationship and gradual transition between these and other, associated northern sod soils; in contrast, proponents of the terrestrial-vegetal origin of chernozem (Eversmann and others) recognized such transitions over a fairly wide range. G. Bogdanov, and to a certain extent Alenitsyn also, readily recognized the affinity and transitions between bog* and forest soils on the one hand and

[1] Murchison. A Geologic Description of European Russia, Part 2, p. 539. [R. I. Murchison, E. Verneil and A. Keiserling. A Geologic Description of European Russia and the Ural Divide. Translated into Russian by A. Ozerskii, Parts 1 and 2. St. Petersburg, 1849.]

* [There is but one Russian expression "boloto" corresponding to the English terms bog, marsh, swamp, moor, etc. Translator.]

chernozem on the other; however, Ruprecht and his followers refused to consider such a relationship. Certain workers (Ruprecht) related the geographical distribution of chernozem to that of steppe vegetation, while others relate it to the occurrence of arboreal vegetation. Some regard chernozem as an aquatic (marine or freshwater) formation, others consider that it originates in marshes (Eichwald), still others believe in its forest and steppe origin (Bogdanov). According to certain authors (Murchison), normal chernozem may reach a thickness of 10 or 20 feet [3.05 – 6.10 m], others (Bogdanov) apply the term "chernozem" even to soils which are less than 1 foot [30 cm] thick and which are brown or even red in color; others still (Meller), do not recognize as true chernozem even those dark-colored sod soils the thickness of which exceeds 2 feet [61 cm]. There is a similar controversy regarding the so-called gray soils which sometimes occur along the chernozem boundaries.

Naturally, people who are not acquainted with such investigations find the concept of chernozem particularly confusing. During my pedological excursions I realized that the population of certain localities applied the term chernozem to any vegetal soil, especially if it contained farmyard manure; in other localities this term was generally applied to all dark-colored soils of whatever origin; finally, soils of whatever color, which generally yielded good crops, were also sometimes called chernozem. We see, therefore, that both in the literature and in everyday life the term chernozem was arbitrarily used. It is obvious that under such conditions the geographical distribution of chernozem could not possibly be established. This work was hindered by many additional factors.

In branches of science other than pedology, studies of the distribution of organisms, research on the local conditions of their life, etc., are conducted a) by specially qualified persons and b) according to generally accepted accurate methods. The history of studies of the geography of Russian chernozem is very different. As already mentioned, practically all the material regarding the distribution of chernozem was collected by officials of the Ministry of State Properties with the assistance of the local population; naturally, most of the investigators were totally unqualified for work of this kind. It is true that several first-rate scientists have participated in studies of the boundaries of the chernozem zone, but even they, with very few exceptions,[1] did not deem it necessary to adhere to work methods which are generally obligatory in accurate investigation. This is confirmed, for instance, by the following three facts:

a) Until very recently, investigators of the geography of chernozem did not assemble a single soil collection, and thus their findings could not be checked.

b) Neither physical or chemical soil analyses have been performed to substantiate the maps of 1851, 1857, 1869, and 1879.[2]

c) The soils were marked on the maps according to information supplied either by local inhabitants or personal observations, but the latter were usually limited to noting the color of soil in the field.

The tremendous detrimental effects of the first two factors (items a and b) are evident, and I shall therefore only discuss item c.

[1] The most noteworthy among them Academician Ruprecht and Prof. Levakovskii.

[2] The only exception was Ruprecht's map in connection with which 11 analyses were performed by Borshchev; naturally, the analytic results have since become obsolete.

Obviously, both the interrogation of the local population and personal observations of soil color in the fields are subject to severe criticism. Indeed, one of the circumstances to which Academician Veselovskii ascribed the imperfections of his map of 1851, was that the same soil may be known by totally different names in the various localities in Russia. As an instance one may cite the fine-sandy, and therefore fairly compact soils which in many areas are known as podzol, in other localities as loam, and elsewhere still simply as sand.

However, the reverse even more frequently occurs, when essentially ~~different soils are known by the same name. This statement is borne out~~ by the following few examples. As we know, steppe chernozem and bog soils are entirely different soils, and yet the latter are known in many localities of central Russia, and even in certain parts of the Arkhangelsk and the Olonets provinces, as chernozem.

Further examples are the podzols in the north and solonetses in the south. There is no longer any doubt that both these terms are collective and designate totally dissimilar soils in different areas of Russia; the only common feature of these soils is their unfertile character.

A third instance is provided by loams, which were shown on the map of 1879 within the chernozem zone, sometimes amidst the most typical chernozem. My personal examination of some of these loamy "islands", and detailed questioning of local inhabitants, revealed that these loams are in no way identical to those of northern Russia. Loams amidst chernozem are actually chernozems on ridges, "syrts" and hills, which had been eroded by atmospheric waters and are therefore somewhat poorer in humus and richer in undecomposed particles of parent rocks[1] than are the chernozems of the surrounding plains and lowlands. Such are, for instance, loams of the northern and central parts of the Samara Province.

Moreover, the scientific names of certain soils are unknown in many localities of Russia, and are substituted by various local terms, for instance "glei", "paglinok", "oglinok", "chernishche", "ilovka", "luda-podzol", etc., "earth with belina", "zaklech", and other terms; the meaning of those terms is impossible to determine without detailed studies of the soils.* Furthermore, the various local terminologies used in connection with chernozem itself are very confused, so that different kinds of chernozems are distinguished as "rich" and "poor" in certain localities, and in others as "good", "medium", "mediocre" and "poor" or "sandy" and "clayey" etc. Taking these circumstances into account one strongly doubts whether information supplied by the local inhabitants can serve as a basis for the compilation of soil maps.

Even less reliable are personal investigations mainly based on soil color, i.e., the color of soils in the field, where soil color is an extremely variable characteristic. My personal observations have repeatedly demonstrated the great differences in the color of the same soil depending on the conditions of observation, whether the soil is wet, slightly moist, or completely dry, whether it is observed a day or two or a week following the last rain, whether it is observed at midday, in the morning, or towards the evening when the sun's rays strike the ground at much more oblique angles than at midday, and therefore produce a multitude of shadows behind

[1] I use the term parent rocks to designate rocks the weathering of which gave rise to chernozem and which the latter overlies even now.

* [The reader will note that by now some of these local terms have become generally accepted. Translator.]

the soil lumps. The effect of soil lumps on the general color impression produced by the soil becomes especially noticeable when a soil is viewed at the same hour of the day with the observer facing the sun and again with his back to it; the colors perceived are quite different.

Finally, the color impression is also strongly dependent on the soil structure and on the presence of extraneous bodies of various colors. The impression produced by a fresh soil section is quite different from that following fine tilling and rolling; different color impressions will also be perceived (in the soil section) when the same kind of soil is underlain by chalk and limestone, by red-brown clays and loams, or by white or light-yellow sands. Hence it is clear that in comparing soils on the basis of their color, it is absolutely necessary that the physical states of the soils be almost identical; they must all be dried at room temperature and comminuted. None of these points were borne in mind by any of the geographers investigating Russian chernozem. However even the treatment described above is far from sufficient when soils are being compared by colors; the other essential factors which must be taken into account are as follows:

1. The investigator must determine the principal mineral constituents of the soil, in order to establish whether the soil is sandy, clayey, or calcareous.

It is possible that different soils might contain identical amounts of humus, and yet produce quite different color impressions. Obviously, the reverse is likewise possible; sandy, clayey and calcareous soils may be of the same color though containing different amounts of organic substances. The collection in my possession contains several examples of this kind. Therefore only soils of the same kind can be compared: clayey soils with other clayey soils, sandy soils with other sandy soils, etc.

Comparisons between soils of different kinds will become feasible only when researchers have succeeded in expressing numerically the significance of alumina, sand, and other soil constituents in humus accumulation and soil color. In all probability, this will come about only in the distant future.

2. Attention must also be paid to the mode of origin of the soil. It is a well-known fact that many bog-terrestrial soils are hardly distinguishable from true chernozem, nevertheless a comparison with respect to color would be pointless in this case. Similarly, it would be useless to compare vegetal-terrestrial soils (chernozem, northern sod soils) with deposited soils; in the latter, the presence of humus is incidental and genetically unrelated both to the mineral nature of soil and to its origin.

3. In comparing soils on the basis of color, it is extremely useful, and at times absolutely necessary, to take into account the color of the parent rock from which the soils originated.

In Russia, various formations contain numerous dark-colored rocks, as for instance Carboniferous shaly clays and Jurassic black marls, etc. Obviously, soil formed on such rocks is always blacker than that originating from light-colored rocks, other conditions being equal. If, moreover, the parent rock is rich in organic substances,[1] then the overlying vegetal soil must be particularly rich in humus, whether or not it occurs in the chernozem zone.

[1] Sometimes Jurassic black clays contain up to 19% volatiles. Meller [V.]. Ocherk geologicheskogo stroeniya yuzhnoi chasti Nizhegorodskoi gubernii (Essay on the Geologic Structure of the Southern part of the Nizhni Novgorod Province), p. 32. 1875. [In book: Materialy dlya geologii Rossii (Materials for Russian Geology), volume 6, as well as a separate reprint, St. Petersburg.]

When the subject of the soil colors is finally elucidated, it will become possible to compile maps which will be equally useful to the peasants and learned agronomists.

Unfortunately, none of the above conditions have been taken into account in studies of Russian soils, and in the collection of almost all the pedological material which formed the basis of the available chernozem maps. Even such investigators of chernozem as Murchison, Ruprecht and Levakovskii based their judgments solely on the color of a given soil in the field.

The following facts illustrate the magnitude of possible error in this method investigation. Many landowners whose lands were sampled by me could not and would not recognize their own soil when confronted with dried samples. Furthermore, in my reports on the excursion of 1877[1] I stated that chernozems from Soroki and Lubny, together with the Balashov and the Morshansk soils, are among the most typical and the richest. Of course, my judgment at the time was based solely on the thickness and color of the soils, or more precisely, on the colors I perceived in the chernozem fields of the Soroki and Balashov districts. At present, comparing the true colors of these soils it becomes clear that my former statements concerning the Soroki and Lubny districts were naive, based on mistakes inherited from my predecessors. When comparing chernozem samples from the Denisovka and Nepada (in the Lubny and Soroki districts) with chernozem from Zubrilovka (in the Balashov District) it is now evident that the former two samples are considerably lighter in color than that from Zubrilovka; the respective humus contents are 4.579% in the Denisovka sample and 5.718% in the Nepada sample, as against 13.703% in Zubrilovka chernozem. Obviously, without samples of these soils I was not able to determine their true colors and humus contents, and would have insisted, with clear conscience, on the reliability of the facts I observed. In that case, the Soroki and the Lubny soils would have been marked on my soil map as first-rate chernozems!

Despite this lesson, despite my extensive experience in observing the color shades of soils, and notwithstanding my habitually critical attitude to color impressions, evolved during my two-year excursion in 1877—1878, (together with University Candidate A. I. Kytmanov who accompanied me, on the excursion in the summer of 1881 in southwestern Russia); I again fell into the same error. On the basis of field observations, we classified the soils of Bakhmach, Konotop, Korsun, Smela, Belaya Tserkov and other localities as typical chernozems similar to soils of the central and northeastern parts of the Russian chernozem zone. However, when the samples were analyzed, their humus contents were found to be only 2.5 to 4.5%, and their color proved to be considerably lighter than, for instance, that of the soils from Bugul'ma, Gryazi, Krutoe, etc.

After the above lines had been printed, I happened to travel in the area lying between Knyaginin and Sergach, in the summer of 1882, at the beginning of a rainy June. My travel log recorded chernozem almost throughout the area; it has now been found that the soil of this locality is gray, with a humus content of around 3—5%. This, then, was the extent

[1] Dokuchaev. Predvaritel'nyi otchet po issledovaniyu pochv yugo-zapadnoi chasti chernozemnoi polosy Rossii (Preliminary Report on Soil Investigations in the Southwestern Russian Chernozem Zone), p. 112. 1877. [Trudy Vol'nogo ekonomicheskogo obshchestva, volume 1, No. 1. 1878. Supplement to the journal of 31 October 1877.]

of my error in judging by color impression! There is no doubt that my predecessors, too, made the same mistake innumerable times. This is illustrated by the example of Borisyak and Ruprecht, two of the most reliable investigators of Russian chernozem. Borisyak regarded soils of the Poltava Province as typical chernozems, while Ruprecht was of the same opinion concerning the soils of the central, and especially the southern parts of the Chernigov Province. Obviously, both investigators based their opinions on observations of soil colors. Today, most of these soils are known to be gray soils; all the dark soils which form rare isolated patches in this area contain less than 6% humus, and usually less than 4%.

Thus, it becomes obvious that none of the available geographic maps of the chernozem zone of European Russia are satisfactory, despite the large amount of time, energy and expense involved in their compilation. Indeed, nobody, not even the authors themselves, can state what exactly is represented by any point or by a soil symbol on the map. Moreover, there are no data whatever to substantiate any aspect of the maps under consideration.

In order to find our way through the maze of doubtful information, obvious contradictions and inaccuracies, and to be able to compile a new soil map of the Russian chernozem zone, we must make a detailed examination of at least its most important areas.

For this purpose, we shall divide the entire chernozem zone of Russia into the following six regions, on the basis of orographic, pedological and partly also geological characteristics:

1. The northern boundary of the chernozem zone of European Russia.
2. Southwestern chernozem Russia: basins of the Dnieper, southern Bug and Dniester rivers.
3. Central chernozem Russia: the basins of the Donets, the upper and the middle reaches of the Don, the right tributaries of the Oka and the Volga (approximately from Tetyushi to Kamyshin) rivers.
4. The trans-Volga chernozem area.
5. Shores of the Black and Azov seas, together with the basin of the lower Don and partly also of the Volga.
6. Southern margins of European chernozem Russia: the Crimea and the Caucasus.

Since the northern chernozem boundary is the most interesting of all these regions from the scientific point of view, it was only natural that this region received more time and attention than the others during my excursions and in the compilation of this report.

Chapter II

NORTHERN BOUNDARY OF THE CHERNOZEM ZONE

Kazan – Buinsk – Tetyushi

It was in the eastern part of the Russian chernozem zone that I first crossed the northern boundary of chernozem, from Buinsk to Kazan. As we know, this area includes two essentially different formations; Jurassic formations form small isolated "islands" in the southern third of the area, while the rest is covered by variegated marl.[1]

In view of the considerable lithological differences between these formations, and the undoubted petrographic connection between the deposits and the underlying more ancient rocks in the vast majority of cases, it is very probable that the deposits themselves, in the area lying between Buinsk and Kazan, are not entirely similar, and this dissimilarity must, in turn, be reflected in the local soils.

However, external examination of the local deposits did not reveal any such difference. The subsoil over the entire area is reddish-yellow diluvial clay which apparently becomes heavier and more marly in the direction of Kazan. We did not encounter any northern boulders.

The town of Buinsk lies in the vicinity of the mouth of the Karzha River, which is a left tributary of the Sviyaga; in this locality the alluvial valley of the latter broadens and contains typical oxbow lakes. Remarkably, no chernozem whatever was found anywhere on this lowland; along the entire Tetyushi highway which traverses this area, we observed only a whitish loam which was undoubtedly deposited by the Sviyaga itself. Chernozem appeared only at the edge of the floodplain where the terrain began to rise gradually toward Buinsk; progressively more typical and thicker chernozems (reaching 2 1/2 feet [76 cm] in thickness) were encountered as we approached the town. Buinsk itself, as well as the Kazan highway up to the Burunduki station (approximately 70 versts north of Buinsk) is situated on unforested slightly rolling terrain which is almost level in some places but in others slopes gradually toward the low left bank of the Sviyaga. The right bank of this river is considerably steeper and almost entirely covered by small groves, with infrequent exposures of marls of various colors.

An artificial soil section, at a distance of half a verst from Buinsk toward Kazan, on the municipal pasture, displayed chernozem 2 ft. 3 in. [69 cm] thick. Similar typical chernozem soils, about 2 feet [61 cm] thick

[1] Golovkinskii [N.]. O permskoi formatsii v tsentral'noi chasti Kamsko-Volzhskogo basseina (Permian Formation in the Central Part of the Kama-Volga Basin). [Materialy dlya geologii Rossii (Materials on the Geology of Russia), volume 1, St. Petersburg], 1869 (map). See also Wagner's map of the soils of the Simbirsk Province.

and underlain by the same parent rock—reddish-yellow loam—were found as far as Bikbulatov and the Indyrcha station; the only areas found to be totally devoid of chernozem (covered by a light-gray loam) were two small river lowlands, 1/2—1 verst wide, which are inundated in springtime. From Indyrcha station, in the direction of Burunduki, the chernozem apparently becomes lighter in color and more compact, and as thin as 6 inches [15 cm] on the tops of gently sloping hills; in places it disappears altogether, being replaced by bedrock outcrops. Further north of Burunduki, the Kazan highway again crosses the loamy floodplain of the Sviyaga, with its gray soils, and rapidly climbs to densely forested (oak, birch, filbert, etc.) elevated and very hilly terrain.

Leaving the highway on our right, we continued to travel over lowlands at the foot of slopes for the first 7 or 8 versts. Chernozem was still found, though infrequently, on these lowlands and in places also on the lower third of hill slopes, but the soils on the hilltops and the upper two-thirds of the slopes changed to typical northern soils, or were replaced by bedrock outcrops, commonly represented by marls of various colors. On the 8th verst from Burunduki, at the edge of a forest, on a level field recently cleared from forest, an artificial soil section displayed an 8-inch [20 cm] thickness of soil the color of which was hardly distinguishable from that of the reddish-yellow clay bedrock. Chernozem totally disappeared over the next 5—6 versts, and was no longer encountered even in depressions between the hills. Remarkably, fairly dark soils, 1—1 1/2 feet [30—45 cm] thick, reappeared at approximately the 14th verst, in the immediate vicinity of the village of Kil'deevo, on the lower halves of gentle slopes. These dark-colored soils again disappeared before the village of Ulanovo, as the terrain became more elevated and hilly (they gave way to soils intermixed with Permian marly pebbles), but reappeared as small isolated strips on the low-lying fields (amid the neighboring elevations) of the villages of Malaya Derevnaya, Makulovo and Seitovo. In the latter, I observed tufts of feathergrass (*Stipa pennata*) growing on the roofs of peasant houses; the local inhabitants reported that feathergrass grows in places on very steep slopes, at the edges of minor forests. Beyond Seitovo, on the way to Kazan, I did not encounter even traces of dark-colored soil. The terrain was very hilly, as before, becoming more level only about 5 versts from the town [Kazan]. All along the way I observed outcrops of the reddish-marly clay in gullies and ruts; the same clay formed the parent rock of the soils. The soils were very thin, 5—8 inches [13—20 cm] and very slightly brownish-gray in color, both in the many small deciduous forests and in the fields (which had evidently been cleared of forests). A soil of this kind, 7 inches [18 cm] thick, was sampled by me 15 versts south of Kazan, in the middle of a very slightly rolling field.

A brief analysis of samples collected on the way is given on the following page.[1]

It should be added that all the way from Buinsk, past the Karlanga station to Tetyushi, we encountered chernozem identical to that found at

[1] Prof. Golovkinskii recognizes the presence of typical loess in the immediate vicinity of Kazan on both banks of the Volga; the loess occurs mainly on the slopes of hills and on elevations. In the author's opinion, the local loess was produced by the weathering of banded marls. "O posletretichnykh obrazovaniyakh po Volge, v ee srednem techenii" (Post-Tertiary Formations in the Middle Reaches of the Volga) pp. 42—47. 1865.

Buinsk. An adequately representative soil sample was obtained by us 8 versts west of Tetyushi; the soil was 1 1/2 feet [45 cm] thick and contained 9.20% humus. Chernozem is absent only in the following small areas: on the rise (1/2 — 1 verst long) from the floodplain of the Sviyaga towards Karlanga, and 20 — 21 versts before Tetyushi; the latter area was covered by a small (about 1 verst) forest of oak, filbert, and linden. Remarkably, the part of the forest facing Tetyushi contains typical Buinsk chernozem reaching 1 1/2 feet [45 cm] in thickness, while in the western half of the forest, facing Karlanga, there is no trace of chernozem, and the thin forest litter lies directly on blood-red (Triassic ?) marly clay which forms the medium for the tree roots. The clay contains isolated small spots of irregular shape and bluish-gray in color, 1 — 3 inches [2.5 — 8 cm] in diameter; moreover, artificial sections of the same clay displayed roundish holes with semidecayed roots the bark of which was in a better state of preservation than the woods. It should be added that in certain places the red marly clay surrounding both decayed and live roots becomes appreciably whiter and assumes a slight bluish tint.

Locality	Composition	Mode of occurrence	Thickness	Humus, %	Hygroscopic water, %
15 versts south of Kazan	Clayey	Middle of very slightly rolling cultivated field	7" [18 cm]	4.677	—
Kil'deevo	—	Almost completely level cultivated field	1'6" [46 cm]	6.787	4.549
8 versts north of Burunduki station	—	Level cultivated field cleared of forest	8" [20 cm]	3.651	2.39
Buinsk[1]	Loamy	Level pasture	2'3" [69 cm]	9.543	—

[1] Determinations of humus and hygroscopic water in these, as in all the other soil samples mentioned later, were mostly performed (under my direction) in the laboratory of the Mineralogical Department of the St. Petersburg University by various persons, listed at the end of the book.

Chernozem is also absent in the immediate vicinity of Tetyushi (1/4 — 1 verst) along the bank of the Volga. Undoubtedly, this is due to the topography of the Volga bank in the Tetyushi area (steep bluffs and strongly undulating surface which facilitate vigorous erosion by atmospheric precipitation) as well as to the fact that the area was formerly under forest. Half a verst south of the town, one can even now see the picturesque remains (shrub-like oak, filbert, linden, etc.) of the large forest which was but recently felled. The virgin soils under these shrub-like trees, lying on an almost completely level area, were brownish-red and less than 1 foot [30 cm] in thickness; they all directly overlay marly bedrock.[1] Nevertheless, an analysis of the Tetyushi soil performed by Davidovich disclosed a humus content of about 13%. This result was totally unexpected and

[1] It seems that identical brownish and reddish soils (no thicker than 0.4 m) were observed by M. N. Bogdanov on the water divide between the Volga and the Sviyaga "in the entire (?) southwestern part of the Kazan Province". According to Prof. Bogdanov, the whole area was "covered by thick, virtually impenetrable forests" even as late as in the 16th century (Bogdanov. Ptitsy i zveri chernozemnoi polosy Povolzh'ya (Birds and Mammals of the Volga Chernozem Zone), pp. 25—27 etc. 1871). For some reason the author refers to the soils in question as clayey chernozems and is of the opinion that the only reason why this soil is not black is that it overlies Permian red marl.

incomprehensible, and for a long time confused both of us . . . However, a close examination of the soil provided a completely satisfactory explanation: the soil contained numerous small brownish red particles of decayed wood. Not only were these particles of the same color as the soil, but they were in such an advanced stage of decomposition that it was impossible to distinguish them prior to analysis of the soil. This, then, explains the inevitable existence of soils which, while rich in humus (up to 13%), are entirely brownish-red in color.

Thus, the principal outcome of my investigation of the Tetyushi Buinsk—Kazan area was the final solution of the highly controversial (pp 21—22) question regarding the distribution of chernozem in this area,[1] which lacks definite boundary, presenting a series of more gradual transitions, and this was indicated by us on our map.

The same investigation of the area between Buinsk and Kazan convinced me of the error of the opinion widely held among the agricultural population at the northern boundary of the chernozem zone that the boundary mostly coincides with rivers. Not only is there no river in this area, but sands, which interrupt the chernozem cover in many other boundary areas, are also absent.

Finally, comparison of the colors of samples 1 and 3 (see table) with the other soils mentioned in the table shows that the differences in color are considerably larger than those in humus content. On the other hand, soils from Burunduki and Kazan are of almost the same color as typical northern soils (e.g., from Smolensk and Moscow) which usually contain about 1% humus. Moreover, I recorded in my travel log that the soils of Burunduki and Kazan are even "lighter in color than the northern soils".

What, then, is the explanation?

Undoubtedly, in certain instances the bright red color of Triassic and Permian marls may and must to a certain extent affect the color of the directly overlying vegetal-terrestrial soils, but this is by no means always the case. Several examples are given below of soils of typically dark color but with the same marls for parent rock; more precisely, products of the destruction and weathering of marls. On the other hand, my soil collection contains dozens of samples of the Kazan and Burunduki soil types, the parent rocks of which were various petrographically different formations.

Prof. Bogdanov himself says that the above-mentioned "clayey chernozem" overlying Permian marls appears to be identical to the chernozem clay (clay impregnated [colored] with humus) which he had seen at the southern boundaries of the chernozem zone in the Saratov Province,[2] where Permian marls are absent.

In this case, too, Prof. Bogdanov's explanation is unacceptable because the Buinsk soils and especially the Kil'deevo soils, like those sampled by me 8 versts west of Tetyushi, overlie the same parent rocks as the soils

[1] There is no doubt that the absence of typical chernozem in the immediate vicinity of the Volga (observed by me in many other localities as well) in conjunction with the completely incomprehensible (as will be seen below) statement by Plagge regarding the absence of chernozem in the entire southern part of the Nizhni Novgorod Province, led Ruprecht into the error of tracing the northern boundary of chernozem from Tetyushi directly to Pochinki and Krasnoslobodsk. Ruprecht himself did not investigate this area. Ruprecht. Ibid., pp. 47—50. [Geobotanicheskie issledovaniya o chernozeme (Geobotanical Studies of Chernozem), St. Petersburg. 1866. Supplement to "Zapiski Akademii nauk", volume 10, No. 6.]

[2] Bogdanov. Ibid., p. 25.

represented by the remaining two soil samples. Obviously, parent rock is not the principal factor. In my opinion the main cause is probably connected with the forests which were widespread in the very hilly country north of Burunduki within the lifetime of the oldest inhabitants; below appear dozens of examples of forest soils which proved to be chestnut [and] brown even when occurring amidst deep chernozem. This phenomenon is certainly related to the color of the decomposition products of ligneous residues. These always appear as brown masses of the very well-known color of decayed wood. In the course of time, they disintegrate within the soil into minute particles which are not always distinguishable by the naked eye and which readily pass through a sieve of 3 mm mesh. The result is a brownish light-colored soil with a considerable content of humus.[1]

Southeastern part of the Nizhni Novgorod Province[2]

With the financial assistance of the Free Economic Society and also that of the local "zemstvo", I succeeded in the summers of 1878 and 1882 in conducting a relatively detailed examination of nearly the entire southeastern part of the Nizhni Novgorod Province which is the most interesting area of the northern boundary of Russian chernozem, as already mentioned.[3] Leaving aside for the time being a detailed geological description of the soils within the region under consideration, I present here its principal characteristics only.

T o p o g r a p h y. The general character of the relief will be clear from the following: a) list of elevations barometrically determined by us and b) two sections (topographic — geological) of the southeastern part of the Nizhni Novgorod Province.[4]

[1] The author of a special "Extract" (Izvlecheniya) from cadastral works regarding the Kazan Province provided the following description ("Materials for Russian Statistics..." (Materialy dlya statistiki Rossii...) [collected by the Ministry of State Properties, St. Petersburg], No. 4, pp. 2–4. 1861) of the area examined by us (between the Volga and the neighboring Nizhni Novgorod and Simbirsk provinces): in the areas (a) adjacent to the boundaries of the Simbirsk Province the predominant soil is black loamy chernozem 6–24 vershoks (27–107 cm) thick; the areas (b) adjacent to the Volga are covered mainly by brown clayey and gray loamy nonchernozem, black loamy chernozem occurring but rarely in closed depressions; the transition zone between (a) and (b) is formed by gray chernozem of the same thickness as the black chernozem; the term "gray" is applied by the local inhabitants to chernozem of medium quality and to good loamy nonchernozem, i.e., nonchernozem soil of dark gray color. However, even purely chernozem areas include patches of "paglinok" chernozem on gentle slopes; this is gray chernozem of small thickness, 3–5 vershoks [13–22 cm] thick, with lumps of yellow or red clay, while on the high right banks of the rivers, gray chernozem with large admixtures of calcareous pebbles is occasionally encountered.

[2] While reading this section, the reader will find it useful to refer to the map of the Nizhni Novgorod Province drawn to the scale 10 versts to the inch [1:420,000].

[3] During my excursion last year through the Nizhni Novgorod Province, I was accompanied by my pupils University Candidates P. A. Zemyatchenskii, N. M. Sibirtsev and A. R. Ferkhmin. It will be seen later that the work of these young geologists proved very useful, and I am very grateful to them for their assistance. Author.

[4] The Lukoyanov, Sergach and Knyaginin districts, and part of the Makar'ev District.

List of barometric elevations in the southeastern part of the Nizhni Novgorod Province[1]

I. Southern slope towards the Alatyr

A) Area between the Rudnya and the Alatyr

1.	Maresevskii Farm	94.0 sazhens	[200.5 m]
2.	Diveev Usad	67.6 "	[144.2 "]
3.	Pelyakhovanskaya	109.4 "	[233.4 "]
4.	6 versts southeast of Pochinki, on the road to Pelya	86.6 "	[184.7 "]
5.	Apex of Zapadnyi Vrag gully at Pochinki	58.9 "	[125.7 "]
6.	Stepanovka	66.7 "	[142.3 "]
7.	Kergudy	71.3 "	[152.1 "]
8.	Gorskin Farm	64.7 "	[138.0 "]

B) Area between the Rudnya and the right tributaries of the Moksha

1.	Water divide between the Urkat and the Irset	103.8 sazhens	[221.4 m]
2.	Water divide between Azrapino and Tagaevo	101.2 "	[215.9 "]
3.	Water divide [between] Azrapino and Madaevo	100.3 "	[214.0 "]
4.	12 versts south of Pechi	48.7 "	[103.9 "]
5.	Water divide between Shutilovo (on the Alatyr) and Gremyachka	48.7 "	[103.9 "]
6.	Nelei[2]	40.6 "	[86.6 "]

II. Water divide Alatyr-Tesha-P'yana

Eastern half, east of the Ezhat River

a) First row[3]

1.	The Alatyr at Baikovo	38.5 sazhens	[82.1 m]
2.	3 versts south of Mikhalkov-Maidan	114.2 "	[243.7 "]
3.	Boldino	73.2 "	[156.1 "]

b) Second row

4.	The Alatyr at Baikovo	38.5 "	[82.1 "]
5.	10 versts north of the Alatyr	73.5 "	[156.8 "]
6.	1 1/2 versts south of Yaz	120.8 "	[257.7 "]
7.	Sloboda	83.4 "	[177.9 "]
8.	2 versts south of Molchanovo	76.8 "	[163.8 "]

c) Third row

9.	The Alatyr at Baikovo	38.5 "	[82.1 "]
10.	3 versts south of Uzhovo	94.5 "	[202.6 "]
11.	Bol'shie Polyany	123.9 "	[264.3 "]
12.	2 versts southeast of Maresevo	56.1 "	[119.7 "]
13.	Devich'i Gory	53.1 "	[113.3 "]
14.	2 versts west of Mansurovka	56.7 "	[120.9 "]

Western half, west of the Ezhat River

a) First row

1.	The Alatyr at Shutilovo	35.0 sazhens	[74.7 m]
2.	Between Vasilevo and Nikolai-Dar	81.1 "	[173.0 "]

[1] In the absence of trigonometrically determined figures for elevations in the southeastern part of the Nizhni Novgorod Province, it was not possible to relate my barometric measurements to a reliable reference point. Therefore, the absolute elevations as calculated from my readings by Purin-Zvigul, under the supervision of Dubyago, should not be ascribed undue significance, although my figures are completely in agreement with the general orographic pattern of Russia. Obviously, the relative elevations given later are much more reliable.

[2] The sequence of the points along the southern slope towards the Alatyr is from south northward.

[3] The rows stretched east-west.

Western half, west of the Ezhat River (continued)

3.	Gavrilovo	89.7	sazhens	[191.4 m]
4.	1/2 verst south of Kakino	111.0	"	[236.8 "]
5.	The P'yana at Gagino[1]	45.0	"	[96.0 "]

b) Second row

6.	The Alatyr at Shutilovo	35.0	"	[74.6 "]
7.	14 versts north of Orlovka	63.1	"	[134.6 "]
8.	Ivantsevo	77.6	"	[167.5 "]
9.	Lukoyanov, at the cathedral on the mountain	113.3	"	[241.7 "]
10.	Gavrilovo	89.7	"	[191.4 "]
11.	1 verst north of Sharapovo	82.2	"	[175.4 "]
12.	1 verst south of Puzyrikha	62.6	"	[133.5 "]
13.	3 versts north of Puzyrikha, on the road to Barnukovo	45.5	"	[97.1 "]

c) Third row

14.	The Alatyr at Shutilovo	35.0	"	[74.7 "]
15.	7 versts north of Shutilovo	45.4	"	[96.9 "]
16.	1/2 verst north of Saldamanovo-Maidan	83.8	"	[178.8 "]
17.	Saldamanovo	70.0	"	[149.3 "]
18.	Silino	88.3	"	[188.4 "]
19.	Berezovka	90.9	"	[193.9 "]
20.	Alemaevka	69.8	"	[148.9 "]

III. Area between southern and northern branches of the P'yana

Eastern side

1.	The P'yana at Chernovskoe	50(?)	sazhens	[106.6 m]
2.	Approximately 1 verst north of Sarga	66.3	"	[140.7 "]
3.	3 versts north of Zaist	78.0	"	[166.4 "]
4.	Vetoshkino	68.9	"	[146.8 "]
5.	1 verst north of Mangushevo	130.6	"	[278.6 "]
6.	Approximately 1 verst south of Endovishchi	117.0	"	[249.6 "]
7.	Between Akhtukova and Chembelei	109.8	"	[234.3 "]
8.	2 versts north of Urazovka	71.6	"	[152.7 "]
9.	Shubino, near the bluff	69.0	"	[147.2 "]

Western side

1.	The P'yana at Barnukovo	40(?)	"	[85.3 "]
2.	About 1/2 verst north of the Barnukovo cave	85.2	"	[181.8 "]
3.	Pogibelka	139.1	"	[296.8 "]
4.	1 verst north of Kotrosya	89.6	"	[191.2 "]
5.	2 versts south of Perevoz	79.4	"	[169.4 "]

IV. Area between the P'yana and the Volga

Eastern half of the area

1.	Stolbishchi	71.0	sazhens	[151.5 m]
2.	1 verst south of Tolba	73.4	"	[156.6 "]
3.	Between Nutrenka and Urga	83.1	"	[177.3 "]
4.	7 versts southeast of Knyaginin towards the Ozerki	100.0	"	[213.4 "]
5.	Oselok	100.8	"	[215.1 "]
6.	Graveyard church at Knyaginin	77.4	"	[165.1 "]
7.	Jurassic outcrops at Bol'shie Kolokovitsy	96.2	"	[205.2 "]
8.	Ostrovskoe	120.0	"	[256.0 "]

[1] The level of the P'yana at Gagino, Barnukovo and Perevoz is shown in comparison with the neighboring elevations, but was not determined barometrically.

Western half of the area

1. Kamenishchi	76.7 sazhens	[163.6 m]
2. Approximately 1 verst south of Vel'demanovo	81.5 "	[173.9 "]
3. Rozhestveno	120.7 "	[257.5 "]
4. Von Brunn's farm* near Nikolaevka	97.5 "	[208.0 "]
5. 1 1/2 versts south of Vershinino	80.9 "	[172.6 "]
6. 2 versts north of Sosnovka	101.0 "	[215.5 "]
7. 4 versts south of Rabotki	116.1 "	[247.7 "]

The above barometric data are supplemented by Figures 1 — 2, showing two transverse sections of the entire southeastern part of the Nizhni Novgorod Province schematically representing a) topography and b) geologic structure of this area.[1]

On the basis of the above data, in conjunction with our travel log, I could draw the following conclusions concerning the topography of the area in question.

The entire southeastern part of the Nizhni Novgorod Province is subdivided into four fairly distinct areas which are the four water divides, the long axes of which stretch from west to east, as follows; a) the water divide between the Volga and the P'yana; b) the water divide between the northern and the southern branches of the P'yana; c) the water divide between the P'yana and the Alatyr; and d) the southern slope descending toward the Alatyr and its tributary Rudnya.

The elevations of all these water divides are approximately equal, with the exception of the southern slope towards the Alatyr which appears to be somewhat lower than the rest.

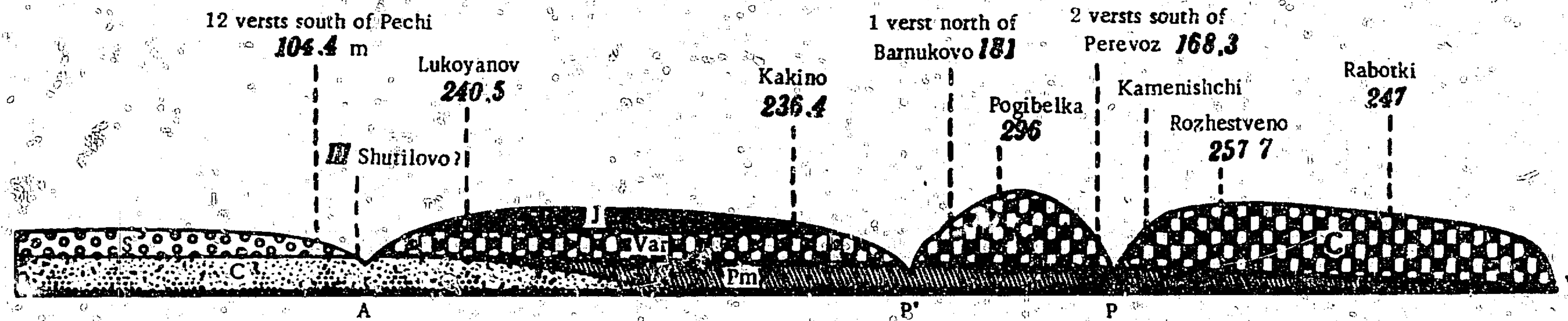
No marked differences in elevation can be noted between the western and the eastern halves of any of these divides, with the exception of the Tesha — P'yana area which is considerably lower than the Alatyr — P'yana area.

These divides are of different widths; they are all strongly asymmetric: the northern slopes are very gentle and long reaching 8—10 versts and more. The following slopes can serve as examples: Stepanovka—Kemlya (8—10 versts), Boldino—Chernovskoe (10—12 versts), Kakino—Gagino (10 versts), Pecherki—Sharapovo—Barnukovo (6—8 versts). However, in all these and other similar cases, such slopes do not reach the very edge of the neighboring river, but are separated from it by a completely horizontal floodplain which may be as much as 1—3 versts wide. It should be added that there is apparently no definite relationship between the size of a river and the width of the southern slopes descending toward it; I observed relatively very wide and gentle slopes even along the banks (right or left) of minor rivers such as, for instance, the Rudnya, the Arka, the upper reaches of the Tesha, the Sundovik, the Imza, and others.

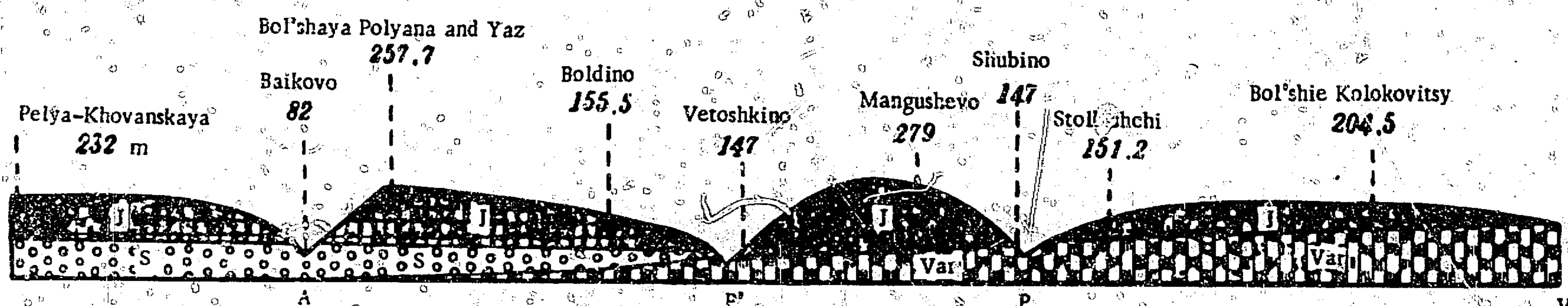
* [We used the word "farm" to translate the Russian word "khutor" which actually means a peasant's farmhouse and farmyard situated on his land, as opposed to the houses of peasants living in villages. Translator.]

[1] It will be seen that both sections were drawn in the north—south direction, section I being further east than section II. The dimensions are correlated (very generally) only with the horizontal scale. The total length of section I is about 160 versts; the distance Volga—P'yana is 55 versts; the distance between the two branches of the P'yana is 30 versts; the distance between the P'yana and the Alatyr is 45 versts; the length of the southern slope toward the Alatyr is 30 versts. In section II, the Volga—Urkat distance is 160 versts; the Volga—P'yana distance is 45 versts; the distance between the northern and the southern branches of the P'yana is 20 versts; the distance P'yana—Alatyr is 60 versts; and the length south of the Alatyr is 35 versts.

Section I. Western half of the area



Section II. Eastern half of the area



FIGURES 1—2. [Letters under the drawings]: A - Alatyr; P' - southern branch of the P'yana; P - northern branch of the P'yana; V - Volga. [Letters in the drawings]: C - Carboniferous; Pm - Permian; Var - variegated rocks; J - Jurassic; S - sands of unknown age.

On the other hand, slopes of such considerable size do not occur everywhere, not even along the P'yana and the Alatyr. For instance, between Barnukovo and Ichalki, in some places along the Alatyr (e.g., at Gulyaevo, Kergudy), and along the entire southern bank of the northern branch of the P'yana and the Volga itself, such slopes were either totally absent (in which case the neighboring (sometimes very considerable) elevations were directly adjacent to the river valley) or else the slopes were only 1—2 versts wide.

As shown in the sections, the northern slopes toward the Alatyr and especially toward the two branches of the P'yana are incomparably steeper than the southern slopes, in places rising toward the crest of the divide in the form of a series of irregular, yet distinctly marked terraces. At other places, for instance at Chernovskoe, Barnukovo, Ichalki, Vetoshkino, Sarga etc., the northern banks of the P'yana sometimes even terminate in bluffs which may rise 30 sazhens [64 m] and more above the adjacent river (the Slyudyanaya Mt.).

Little can be said about the nature of the water divides themselves. They are more or less undulating, and in some places are incised by a number of very deep gullies. Minor forests of oak, birch, filbert and linden are still fairly numerous. All these features become more pronounced as we proceed in the western direction, and good examples are provided by the ridges Ichalki—Perevoz and Buturlino—Barnukovo.

In contrast, as one proceeds towards the eastern boundaries of the province (areas adjacent to the Simbirsk Province), the slopes become gentler and wider, forests disappear (with the exception of the divide P'yana—Alatyr), and the terrain begins to resemble a steppe. Typical divides of this kind occur on the so-called Tatar lands between Chernovskoe and Sarga, as well as at Berezovka station and Pozharki; this area is still known to local population as steppe.

A common feature of both the eastern and the western halves of the water divides is the almost total absence of bogs and meadows of the northern type.

G e o l o g i c a l   s t r u c t u r e. The same sections also show the general geological structure of almost the entire southeastern part of the Nizhni Novgorod Province. It is seen that the oldest formation in the area is represented by Carboniferous limestones. These rocks were dated and their paleontological character (*Fusulina cylindrica, Productus semireticulatus, P. longispinus, Spirifer trigonalis, Streptorhynchus crenistria* etc.) was first determined by Prof. V. I. Meller.[1] In addition to outcrops enumerated by this author, I myself observed Carboniferous limestones in the following places: at the village of Malaya Puza (poor outcrop on the bottom of the Alatyr), between the latter and the village of Madaevo, 2 and 8 versts south of Pechi and at Pechi itself. All these points lie in the basin of the Alatyr in the same small area which was mapped by Prof. Meller. The apparent thickness of the limestones in question does not exceed 4—5 sazhens [8.5—10.5 m] (Shutilovo, Butskoe, Orlovka, Madaevo, 2 versts south of Pechi); in some places they are compact and strongly siliceous, in others loose and soft, always of a yellowish-gray color, often containing chert nodules. These limestones occur only in a small corner of the southeastern part of the Lukoyanov District.

[1] Meller, Ibid., pp. 76—78.

The Permian formation is somewhat more widespread in the southeastern part of the Nizhni Novgorod Province. Its presence at Ichalki, Knyazh — Pavlovo and Barnukovo (all lying along the southern branch of the P'yana) was first established by the famous Murchison[1] who had established the existence of the Permian system as such. According to his description, the lower horizon of the local Permian deposits is formed by limestones which may be compact or soft, sometimes containing such an abundance of fossils (*Productus cancrini*, *Terebratula elongata*, *Gervillia antiqua*, *Natica* (*variata*, Phill.), *Ostrea matercula* Vern. (*Hinnites speluncaria* Schlth.), *Schizodus truncatus* (*S. rossicus*), *Murchisonia subangulata* etc.), that they merited being designated as coquinas. Gypsum beds of enormous thickness, up to 80 feet [24 m], were observed by Murchison among these limestones and at Barnukovo under them. According to the author's observations the limestones are overlain by Permian marls of various colors at all the above-mentioned sites.

At the beginning of 1850s the same localities were visited by Prof. Meller who identified the following species in addition to those previously known in Ichalki limestones: *Spirifer schrenki*, *Athyris pectinifera*, *Clidophorus pallasi* and *Natica minima*. Moreover, similar formations were discovered by this author at Selishchi (on the P'yana) and at the village of Smirnovo in the so-called Prorva where specimens of *Strophalosia horrescens*[2] rarely occur.

In the summer of last year I also inspected the exposures at Ichalki (Troitskoe) together with N. M. Sibirtsev, and found the following fossils: *Strophalosia horrescens*, *Athyris pectinifera*, *Terebratula elongata*, *Murchisonia subangulata*, *Clidophorus pallasi*, *Fenestella retiformis*, *Avicula speluncaria*, *Productus cancrini* and *Spirifer rugulatus*. In the Prorva limestones in the vicinity of Smirnovo, N. M. Sibirtsev found the following fossils: *Murchisonia subangulata*, *Arca kingiana*, *Clidophorus pallasi*, *Avicula speluncaria* and *Fenestella* sp.[3]

The Barnukovo exposures and the caves in them have already been described by Pallas,[4] Murchison,[5] Meller,[6] and Dal[7]. Nevertheless, in view of certain discrepancies and inaccuracies in the data and descriptions as well as because of the specific scientific and practical significance of the Barnukovo exposures, I will presume to provide another description of the same locality.

As already mentioned, the southern slope descending toward the P'yana stretches from Pecherki and Puzyrikha on the one side to Barnukovo on the

[1] Murchison. Ibid., pp. 134–137.

[2] Meller. Ibid., pp. 189 ff.

[3] The paleontological material collected by us will be processed in due course. Meanwhile, P. N. Venyukov has identified the best specimens of Permian fossils while N. M. Sokolov has identified the best Jurassic fossil specimens.

[4] Pallas. Puteshestvie po raznym provintsiyam Rossiiskoi imperii (Journey in Various Provinces of the Russian Empire). Part 1, pp. 79–85. [St. Petersburg]. 1773.

[5] and [6] Ibid.

[7] Annual General Meeting of the Nizhni Novgorod Statistical Committee, 11 June 1869, pp. 17–18. [Nizhegorodskii sbornik (Nizhni Novgorod Collection) published by the Nizhni Novgorod Provincial Statistical Committee, Volume 6, Nizhni Novgorod, 1877. Minutes.]

other, forming a strip 6—8 versts wide, with a very small gradient and is covered by a thick layer of chernozem which appears to be excellent; the village of Barnukovo is situated at the very base of this slope on almost level terrain, at a distance of 100—200 sazhens [213—426 m] from the river. Beginning from the latitude of Pecherki and Puzyrikha, one can see the bluffy Permian heights covered with old oak forest, which bound the P'yana valley on the north at Barnukovo and form its ancient right banks. Close examination of the terrain revealed an additional lowland situated between these heights and the P'yana River. This lowland is 100—200 sazhens [213—426 m] wide and comprises two terraces. The lower terrace, which has a more regular outline, is directly adjacent to the P'yana and forms its floodplain. The upper, forested terrace is adjacent to the heights, is extremely uneven and includes a series of funnel-shaped depressions and irregular protuberances. These depressions are undoubtedly sinkholes; one situated approximately 1 1/2—2 versts downstream from Barnukovo contains a very deep lake. This second terrace is incised, approximately 1 verst west of Barnukovo (on the right bank of the P'yana) by an extremely irregular, tortuous erosion channel with pits and protuberances at its bottom; in places it is as narrow as 2 sazhens [4.3 m], and its general direction is north—south, leading to the very mouth of the famous Barnukovo Cave.[1] Approaching the cave via this channel, one sees, through the treetops, the enormous whitish-pink rocks glittering in the sun, the dark mouth of the Barnukovo cave being situated at the very base of these rocks. The quarrying of alabaster, anhydrite and limestone has created an almost vertical face of rock, reaching 12—15 sazhens [25—32 m] in height, adjacent to the cave. Reaching the top of this sheer bluff, likewise covered in places by age-old oaks, one can see that the terrain continues to rise in the northern direction from the bluff, though not sharply, nevertheless appreciably.

We shall first describe the rocks composing these heights. The lower 2/3 (about 8 sazhens [17 m]) is composed of milky-white, fine and coarse granular, translucent alabaster, which in some places contains numerous spheres, 2—3 inches [5—7.5 cm] and more in diameter of radially arranged selenite crystals; in places, the upper horizons of alabaster contain thin intercalations of fibrous gypsum and pink marl as well as isolated intercalations of crystallized transparent laminated gypsum reaching 1 1/2 inches [4 cm] in thickness. Moreover, at an approximate height of 5—6 sazhens [10.5—13 m] there is a bluish band with light-brownish veinlets 1 1/2—2 feet [45—61 cm] thick in the alabaster mass consisting of granular anhydrite; this band contrasts sharply with the milky-white alabaster background (with pinkish tinges) and penetrates the cave where it can be seen in one of the walls and in the roof.

At the base of the rock itself one can discern another anhydrite horizon reaching 3 feet [91 cm] in thickness, but its outline is diffuse, gradually merging with the alabaster; veinlets of the latter even penetrate the bed of anhydrite itself. Moreover in the alabaster mass one can discern 2 or 3 additional thin, tapering (1 1/2 inch [4 cm]) blue bands of the same anhydride as that situated between the two anhydride horizons.

At the height of approximately 8 sazhens [17 m] the alabaster gives way to a fairly compact homogeneous limestone, 2—3 feet [61—91 cm] thick

[1] This natural channel serves as a road for the transport of alabaster from the cave.

which in turn is replaced by brecciform limestone partly consisting of marl and alabaster pebbles; higher up the breccia forms a gradual transition to porous, dolomitized limestone containing many segregations of transparent, very well crystallized gypsum, iron ocher, and diffuse gypsum casts of Clidophorus pallasi, Terebratula elongata and Fenestella retiformis; in places this limestone is fairly pure and is quarried for lime. The total thickness of all the limestones is 3—4 sazhens [6.4—8.5 m].

The limestone gives way, in the upward direction, to pink marls, the lower layers of which are compact, while the upper layers are loose and sandy; the marls reach 2 sazhens [4.3 m] in thickness, and contain infrequent small alabaster spheres reaching 1 1/2 feet [15 cm] in diameter. These marls appear even in the slope from the cornice of the Barnukovo rock inland.

At the base of this artificial exposure lie enormous blocks of limestone, alabaster, and anhydrite which were separated by the workers from the upper portions of the bluff. Moreover, the workers report that the bottom of the passage leading into the cave (consequently, below the alabaster beds) contains the so-called "pechera", which is a peculiar light-gray, strongly dolomitized sandy limestone with a mass of extremely fine glittering gypsum plates; the thickness of the "pechera" reaches 4—6 vershoks [18—27 cm]; at the time when I examined the pit it was full of alabaster, and I therefore had to be content with accepting a sample of this "pechera".[1]

At the very base of the rock described above, there is an aperture leading to the Barnukovo cave which is a direct continuation of the erosion channel; the height of this aperture is about 2 sazhens and its width is about 3 sazhens [6.4 m]; in places its edges have been damaged by the quarrying of alabaster. The aperture leads into a passage which is 3—4 sazhens [6.4—8.5 m] long and tapers slightly towards the interior of the cave. To the right of the entrance the passage contains two natural props of alabaster, which are not very thick; the passage ends in a large irregular chamber; the long jagged axis of this chamber follows an approximately west—east direction (along the P'yana) over 40—45 sazhens [85—96 m]. In places the chamber is wider than 10 sazhens [21 m]; its height was visually estimated to be 4—5 sazhens [8.5—10.6 m]. On the roof of the cave there are two apertures, to the right and to the left of the entrance; the right aperture was recently formed by the quarrying of the stone, while the left aperture is a natural one, eroded by atmospheric precipitation.

Parts of inner walls of the cave have a smooth conchoidal striated appearance. The floor is extremely irregular and is moreover strewn with large alabaster and anhydrite blocks some of which had fallen in naturally, while others were detached by explosions of the walls and roof; tree

[1] On the whole, this description is in complete agreement with that by Murchison (op. cit.), but differs significantly from Prof. Meller's observations, and I deem it necessary to point out the discrepancies.

According to Prof. Meller, "Barnukovo rock is composed of interbedded layers of granular and fibrous gypsum some of which are filled with sharp angular fragments of light-gray nearly white limestone of various sizes, so that the layers assume a true breccia character". The upper horizons contain numerous selenite spheres; at the base of the rock very thin gypsum layers alternate with similar layers of light-gray limestone containing no visible fossils. Although Prof. Meller was convinced of the presence of anhydrite in the Barnukovo gypsum, he did not actually see it (ibid., pp. 12—13). Probably, at the time of his visit to Barnukovo the rock was not yet being quarried and therefore he judged its structure from the blocks which had fallen from the top of the bluff and which even now are strewn in large numbers at the foot of this exposure. - Author.

branches and roots brought by the waters of the P'yana are also scattered on the floor, and low level spots have become covered by a layer of viscous brown clay 1/2—1 arshin [36—71 cm] thick.

In the farthest corner of the chamber (the northwestern corner, to the left of the entrance), where the floor of the cave is depressed, there are two small bodies of water, 1—1 1/2 sazhens [2.1—3.2 m] in diameter; the water is crystal clear, apparently 1/2—1 sazhen [1—2.1 m] deep, and contains small fish. A semicircular aperture 2—3 feet [61—91 cm] in diameter can be seen in the gypsum rock overhanging one of these "lakes"; according to the workers (who had investigated the aperture during winter when the water in the "lake" was frozen), it leads to a low narrow passage about 2 sazhens [4.3 m] in length, terminating in a fairly large chamber which contains a third "lake". According to witnesses, this "lake" does not freeze even in winter, and during the spring floods the waters of the P'yana rush into the cave where they are lost without trace. Undoubtedly, these same waters had brought the branches and clay now found on the cave floor.

I made excursions starting along the left bank of the P'yana from Barnukovo, one in the southeastern direction to Edelevo, Vorontsovo and Gagino, the other westward to Knyazh-Pavlovo, Yakshen and Ichalki. The first road ran entirely along the lower third of the remarkably gentle slope which is also found between Puzyrikha, Pecherki and Barnukovo. Although no outcrops were encountered, the presence of numerous funnel-shaped sinkholes on this slope clearly indicated the presence of gypsum at a certain depth. The relief of the right bank appeared to be the same as at Barnukovo, probably its geological structure was also the same, at least as far as the meridian of the village of Edelevo. My companion in the excursion of 1882, N.M. Sibirtsev, provided the following description of the structure of the right bank of the P'yana at Edelevo. Along the right bank of the P'yana, opposite the village of Novo Edelevo, the floodplain is 1/2 verst wide and contains a large number of oxbow and ordinary lakes, pits and "mochevinas". This valley is bounded on the north by the old bank with fairly steep slopes rising to a height of approximately 15 sazhens [32 m]. Owing to erosion and maybe partly also to subsidence, this area is constituted by a group of hills divided by narrow hollows. The hills are forested and display several outcrops and sections on the side facing the river; some of these are natural and some are artificial, but unfortunately they are incomplete and not quite distinct. For instance, at one spot at the level of 4 sazhens [8.5 m] from the foot of a hill one could see a shaft in which alabaster was quarried in winter and which had caved in completely. Laborers reported that the alabaster bed is 1 1/4 arshin [87 cm] thick. Lumps lying near the bluff displayed fine intercalations of red clay and fibrous gypsum. Three or four vertical sections appeared somewhat higher upstream along the P'yana, at the base of the hills; the best section displayed the following layers:

1. The upper portion of the section is red clay, slightly marly, containing veinlets and spherical lumps of alabaster as well as white highly calcareous marls, all combined to form a variegated fairly loose mass ("oposhnik").* The thickness of this layer is 4 feet [122 cm].

2. The upper layer is underlain by a series of interlayers of reddish, yellowish-pink and bluish-gray marl, 2 feet [61 cm] thick.

* [The term is derived from the word "opoka". Translator.]

3. The next layer down is formed by a hard bluish-gray, glistening, strongly dolomitized limestone containing gypsum flakes of the type found in the Barnukovo cave. This rock breaks into fragments with fairly even planes and displays flaggy parting; the thickness is 1ft. 8 in. [50 cm].

4. The underlying layer is again clay mixed with pieces of alabaster and marl (as in the first layer) 12 feet [3.65 m] thick.

5. Finally, the clay is underlain by pure alabaster which is white, granular, fairly compact, and is quarried by the peasants for plaster. Its thickness is 4 feet [122 cm]. A considerable quantity of loose material lies at the base of the exposure.

Another characteristic of this section is the irregular bedding of its right or eastern part, where the beds slump. The layers themselves are crumpled, compressed, with an eastern dip, and the abovementioned gypsiferous dolomitized limestone has been fragmented into pieces 2—3 feet [61—91 cm], the interstices between the lumps being filled partly from the second layer but mainly from the fourth layer. Some of the limestone lumps were even pressed out of the section profile. In the words of the peasants, this mountain "creeps downwards". Obviously, here we deal with a sinkhole or an underground cave (formed by the leaching of gypsum) which caused the caving-in of the overlying layers forming a certain shift.

The fifth layer contained a horizontal shaft or vaulted corridor about 5 feet [1.5 m] high, 2 sazhens [4.3 m] wide, and 4 sazhens [8.5 m] long (towards the interior of the mountain). The walls of this shaft are composed of alabaster; alabaster pillars have been left in certain places as props for the roof. The roof, floor and walls are very uneven. Here, too, the alabaster contains intercalations of fibrous gypsum[1] which are 2—3 inches [5—7.5 cm] thick.

In the immediate vicinity of the village of Edelevo, both on the right and on the left banks of the P'yana, there are many sinkholes, of various sizes and shapes. Some are shallow, diffuse depressions with gentle slopes, into which plowlands directly descend. Others, in contrast, are deep pits with sheer or at least very steep walls. Some of these sinkholes are completely dry, overgrown with grass and even trees, others are filled with water and resemble lakes. Some contain pure, transparent water while the water in others is green because of floating pads of various paludine plants; still others appear simply as "mochevinas", small bogs and morasses. These pits occur in various shapes, ranging from circular to completely irregular.

In conjunction with the endlessly winding P'yana and small oak forests these lakes form part of a beautiful and very characteristic landscape. The sinkholes are of diameters varying from 1 sazhen to 1/4 verst. The depth of a few are known; according to the measurements by peasants, the depths vary from 2—15 sazhens [4.3—32 m] and more. Not infrequently the local population witnesses the formation of sinkholes. Trees still grow at the bottom of some pits which have become filled with water. About 10 years ago, a house was "swallowed up" in the village of Vorontsovo, about 3 versts east of Edelevo. The local inhabitants point out sinkholes which were formed "last summer" or "the summer before last". This phenomenon is familiar to the local peasants, who say that all their land along the entire P'yana bank is of this kind.

[1] The glistening limestone described above is also quarried by the local inhabitants and is used as flooring in corn lofts as well as for grindstones.

It can be seen from the exposures at Barnukovo and Edelevo (described above) which are only 2—3 versts apart, that beds of similar petrographic nature occur in different horizons at the various sections, are bedded in different sequences and their thicknesses also differ. In some exposures alabaster lies in the upper portions of the sections, while in others it is present in the lower portions; the glistening limestone underlies alabaster at Barnukovo but overlies it at Edelevo; the thickness of the alabaster is of the order of sazhens at Barnukovo but only of feet at Edelevo. The same situation also exists in other localities.

As already mentioned, the outcrops of Permian shelly limestone and underlying gypsum lower down the P'yana and west of the village of Barnukovo were long ago known to Murchison in the vicinity of Knyazh-Pavlovo and Ichalki, while Meller noted these formations at Selishchi and Smirnovo. The entire area contains a variety of numerous sinkholes.

During the excursion of last summer, we succeeded in establishing the presence of the same Permian formations on the water divides between the southern and the northern branches of the P'yana, at least to the meridian of Kamenishchi. For instance, my companion in the excursion, A.R. Ferkhmin, observed Permian formations in the vicinity of Annenkovo and Perevoz, while I found them between Vyzhlei and Malye Kemary and on the northern branch of the P'yana at the village of Kamenishchi. The village of Annenkovo is situated half way down the northern slope toward the Pyana at the spot where the latter takes a fairly abrupt northward turn. East and west of the village, approximately at the same level on the slope, blocks of very compact gray Permian limestone emerge to the surface, forming several irregular ledges. Reddish marls with thin intercalations of alabaster and fibrous gypsum overlie these limestones west of Annenkovo; east of the village, the following fossils, among others, could be discerned in the limestone: *Fenestella* sp., *Spirifer rugulatus*, *Strophalosia horrescens*, *Spirigera concentrica*, *Terebratula elongata* as well as imprints of crinoid stems. The presence of gypsum at a certain depth under it was again proved by the numerous sinkholes on the slope. Two versts south of Perevoz near the village of Cherga (on the northern branch of the P'yana) Ferkhmin noted Permian limestones of compact appearance. Here the limestones form exposures 2—3 feet [61—91 cm] wide at the mouth of a minor river emptying into the P'yana. Between the northern and the southern branches of the P'yana, between Vyzhlei and Malye Kemary, the highest points of the divide are composed of marls of various colors, but alabaster was quarried in many places in horizontal shafts driven into the hillsides. Unfortunately, in summer the shafts caved in, and we were thus unable to trace the conditions of ~~the mode of occurrence of~~ alabaster.

An incomparably more interesting and clearer picture is presented by the exposures of Permian formations which were successfully observed by myself in the vicinity of Kamenishchi at the latitude of Sergach, approximately 50 versts south of the Volga.

Kamenishchi lies on the left bank of the northern branch of the P'yana, from which it is separated by a narrow alluvial valley which is sandy in some places and also contains meadows. In the immediate vicinity of the house of Count Kamenskii, this valley ends sharply in a nearly vertical bluff of compact, strongly dolomitized, sometimes shelly limestone, about

3—4 sazhens [6.4—8.5 m] high; the limestone is composed of rectangular blocks 1 1/2—3 feet [45—91 cm] in length; some almost completely made up of indistinct casts and imprints of Permian shells. About 50 sazhens [107 m] to the east the same terrace contains a fresh stone quarry; the stone is used for building and for the production of lime.

The following section could be seen very distinctly:

A) (from above), 2—3 feet [61—91 cm] of undoubtedly dune sand at the very bottom of which there are traces of a very fine, 2—3 inch [5—7.5 cm] soil layer;

B) gray, probably eluvial sand, 3 feet [91 cm] thick;

C) red marl with fine plates of underlying limestone, 4 feet [122 cm] thick;

D) shelly gray limestone, the upper horizons of which are considerably denser than the lower horizons; the thickness of this rock is 20 feet [6.1 m]. I found the following fossils in both varieties of the limestone: Clidophorus pallasi, Fenestella sp., Terebratula elongata and Murchisonia subangulata. A sinkhole could be seen at the very foot of the bluff, as deep as 1/2 sazhen [1 m], filled with water. From this limestone terrace, we continued northeast toward the village of Yakovlevo, almost following the P'yana; the terrain gradually became more elevated. For the first verst we encountered sands, which gave way to marls of various colors which sometimes became exposed in the field. Approximately 1 1/2 versts from Kamenishchi, along the P'yana, on the slope of its second bank, there are two sinkholes separated from each other by an isthmus 4—5 sazhens [8.5—11 m] wide; the sinkholes are identical in appearance; their perimeters are 70—100 sazhens [149—213 m] and are completely circular; the walls are almost vertical, 5—6 sazhens [11—13 m] high, excluding the underwater part. The walls consist completely of marls, mostly pink, with some whitish plates discernible only at the very base. The sinkholes contain water at the bottom.

Thus, the northern boundary of the undoubtedly Permian limestones must be shifted at least to the northern branch of the P'yana,[1] while the northeastern boundary should pass somewhat east of Edelevo and Kamenishchi, possibly even reaching Sergach, where the deepest horizons are constituted by whitish-gray, fossil-free limestones.[2]

Almost all exposures of undoubted Permian age mentioned by me are overlain by variegated marls which conformably overlie the underlying rocks. Although these marls first appear almost immediately north of the Carboniferous formation (in the Lukoyanov District) and form a nearly continuous cover on (a) the heights between the Tesha and the P'yana as well as (b) the western half of the divide between the northern and the

[1] The well-known find of Permian limestone, alabaster and anhydrite at Balakhna at the depth of 30 sazhens [64 m], and the fact that the limestone exposures on the northern branch of the P'yana are still 3—4 sazhens [6.4—8.5 m] in thickness, leave no doubt that the base of the entire water divide P'yana—Volga is composed by Permian rocks. Author

[2] The southernmost point where I saw spongy gray Permian limestone was Ol'gin farm (the new farm belonging to O. V. Bazhenova) 3—4 versts west of Karino, of the Arzamas District. At this point, the following fossils were found in limestone slabs at the depth of 12 sazhens [25.6 m]: Terebratula elongata, Murchisonia subangulata, Arca kingiana, Clidophorus pallasi, Avicula speluncaria, Spirifer rugulatus, Spirifer schrenki, Athyris pectinifera, Natica sp., Stenopora columnaris and Fenestella sp.; the last occurs so plentifully that obviously in the distant past it formed an entire reef.

southern branches of the P'yana, they reach full development and thickness only (c) between the P'yana and the Volga. Indeed, among the many exposures of sandy marls observed by us in areas (a) and (b) we found that their thickness (in exposure) was generally less than 5 sazhens [11 m]; only in one case, in the northeastern corner of the village of Velikii Vrag (of the Arzamas District) were marl beds 7 sazhens thick [15 m] observed by N.M. Sibirtsev.

The following characteristic section was seen under a thick layer of diluvium:

1. White and pinkish hard laminated marl 4 feet [1.2 m] thick.
2. Alternating thin layers of red, greenish-gray and light pink soft marls 2 ft 6 in [76 cm] thick.
3. Palygorskite[1] intercalations 2 inches [5 cm] thick.
4. White, light yellow, or pinkish hard marl, 4 feet [1.2 m] thick.
5. A layer of palygorskite 2 inches [5 cm] thick.
6. Pink and white hard marl, 3 feet [91 cm] thick.
7. Palygorskite mixed with marl, 2 inches [5 cm] thick.
8. Pink and white marl, 4 feet [1.2 m] thick.
9. Palygorskite, 2 feet [61 cm] thick.
10. Pinkish, greenish, and white marl with 1 ft intercalation of multicolored sand, 12 feet [3.6 m] thick.
11. Greenish-gray sandy marl, 1 foot [30 cm] thick.
12. Pinkish, greenish, and white marl with spherical lumps of white alabaster, 14 feet [4.3 m] thick.

These beds are underlain by alabaster pockets which were once quarried.

The "variegated rocks" become far thicker and more fully developed between the P'yana and the Volga, where this group of rocks sometimes reaches a thickness of 10 sazhens [21 m] and more, and according to its petrographic character falls into two definite types; however, these types do not occupy specific horizons but seem to form mutual transitions and not infrequently appear mixed in the same section.

Both types of formation very often contain thin veinlets of fibrous gypsum (Shil'nikovo and Sosnovka) and spherical lumps of alabaster the long diameter of which may reach 1—2 1/2 feet [30—76 cm]. These spherical lumps are confined in certain places to fairly definite horizons (Shil'nikovo and Sosnovka), and some are even enveloped (Valgusy and Vetoshkino) in mountain leather (palygorskite). In some places palygorskite occurs independently, likewise occupying fairly definite horizons. I myself have also observed alabaster spheres and palygorskite intercalations in the vicinity of Gagino (in the estate belonging to Baron Zhomini),[2] at Tynovo, etc.

Another general feature of the variegated rocks is the apparent predominance of the marly type in the southern part of the area of their occurrence, and of the sandy type in the northern parts. Instances of the marly type are found at the villages of Oselok, Sosnovka, Lubyantsy, Inkino, Shubino, Pozharka, etc. Samples of the sandy type are found in the deposits at the villages of Konoplyanka, Kolokovitsy, Bol'shoe Murashkino,

[1] Savchenko [V.]. — Izvestiya Moskovskogo Obshchestva Estestvoznaniya, volume 33, No. 2, p. 377 [according to Shchurovskii, G. E. Asbest ili gornaya kozha v Knyagininskom uezde Nizhegorodskoi gubernii (Asbestos, or Mountain Leather in the Knyaginin District of the Nizhni Novgorod Province). — Izvestiya Obshchestva Lyubitelei Estestvoznaniya, Antropologii i Etnografii, volume 33, No. 2, Moskva, 1878.].

[2] At this site, they had been known for a long time. Author.

Tynovo, and the town of Knyaginin; this type probably also includes the thick sandy formations which are widely developed at Tolba.

The following three sections illustrate the diversity of mineral constituents of the "variegated rock" formation.

1. Right bank of the Sundovik River, one verst northwest of the village of Nelyubovo, the Knyaginin District. The following is Ferkhmin's description of this exposure:

Deposited soil layer	3' [0.9 m]
Diluvium with few crystalline boulders	2' [0.6 "]
Marly clays—various colors	4' [1.2 "]
Yellow-brown sands	7' [2.1 "]
Marls—various colors	7' [2.1 "]
Bluish-white very fine sand	6' [1.8 "]
Yellowish-gray sands in places with marked false bedding, containing 2 horizons of sandstones cemented with $CaCO_3$	40' [12.2 "]
Fairly hard conglomerate	1' [0.3 "]
Marls—various colors	7' [2.1 "]
Yellowish-gray sands with false bedding	8' [2.4 "]
Marls—various colors	30' [9.1 "]

2. Gully in the vicinity of von Brunn's farm 2 versts northeast of Nikolaevka:

Soil layer	8" [20 cm]
Yellow-brown clay with insignificant intercalation (1 1/2 feet) [45 cm] of clayey sand with rare small quartz pebbles of nut size	8' [2.4 m]
A system of loose sands displaying bands of various color (yellow, bluish, brownish) with thin intercalations of similarly multicolored clay; the lower layers of these sands and clays display intercalations of dark nearly black sand which is sometimes weakly cemented	8' [2.4 "]
Variegated (red and blue) marly clays, underlain by hard and loose likewise variegated marls with rare intercalations of multicolored sands	40' [12.2 "]
A layer of grayish-brown sandstone with calcareous cement	1' [0.3 "]
Variegated sands with false striations, completely analogous to the Knyaginin sands	25' [7.[illegible]]

The section ends in variegated marly clays.

3. Even more sandy was an exposure of "variegated rocks" which I observed 1 1/2—2 versts north of the village of Bol'shoe Murashkino. In one of the gullies in this locality, 7—8 sazhens [15—1[illegible] m] deep, the upper 2 sazhens [4.3 m] of the walls are composed by loess-like, light-yellow, boulder-free loam. This gives way in the downward direction to a nearly continuous brown quartz sand, 3—4 sazhens [6.4—8.5 m] thick, with marked false bedding. In places the quartz sand is cemented by $CaCO_3$ and even less frequently it forms a transition to conglomerates, in which the pebbles are Permian marls. The lowermost 2 sazhens [4.3 m] are occupied by sandy marls (intercalations of 1—1 1/2 feet [30—45 cm]) and plastic marly clays, but insignificant sand intercalations occur here also.

All variegated formations described above display nearly horizontal bedding, yet do not occupy definite geological horizons; very often they gradually disappear or give way one to another; neither I nor my companions succeeded in finding organic residues. For these reasons, it would be pointless to dwell on the list of variegated rocks from other sections, and we shall pass directly to the elucidation of the stratigraphic relationships between the stage of variegated rocks on the one hand and Permian limestones and Jurassic rocks on the other.

We have already pointed out that the "variegated rocks" are everywhere conformable with underlying deposits of undoubtedly Permian age; on the other hand, "variegated marls" directly overlain by Jurassic deposits can be observed in the Knyaginin District only 25—30 versts south of the Volga. At this site, 1 1/2 versts west of the village of Kolokovitsy, at the very apex of a very deep gully emptying into the minor river Kolokovitsa, we find the following section which, though not large, is very interesting.

A) Sandy-clayey deposit, 7 feet [2.1 m] thick;

B) black combustible Jurassic shale, 1 foot [0.3 m] thick;

C) bluish-black very viscous clay with pinkish spots, containing pyrite crystals and a mass of fossils, frequently very well preserved, for instance Stephanoceras elatmae Nikit., St. tschefkini d'Orb., Belemnites russiensis d'Orb., Pleuromya jurassi (?) and Cosmoceras galloviensis d'Orb.

Only 3 feet [0.9 m] of this clay was exposed. Lower down, there was a talus on which a sharp-edged fragment of dark Jurassic limestone was found with indistinct Jurassic fossils.

About 100—150 paces down the gully (which unfortunately was almost completely overgrown by shrub), we found undoubted "variegated marls and sands" of the Bol'shoe Murashkino type; at first these appeared in isolated bare patches and breaks in the shrub, later they formed a continuous cover. In the village of Kolokovitsy itself an excellent section could be seen, more then 7 sazhens [15 m] high.

The numerous belemnites and also partly some Gryphaeas found in the fields of the village of Slatina approximately 3—4 versts west of Kolokovitsy, as well as the appearance of the local marls suggest the presence of preserved Jurassic sediments in some areas of this locality also.

These two points, Kolokovitsy and Slatina, are the northernmost Jurassic "islands" in the entire Nizhni Novgorod Province.

The relationships between the "variegated marls" and Jurassic formations can be seen in far greater detail in the direct neighborhood of the northern branch of the P'yana. The following are a few examples of this kind. Krylov knew about the exposed beds of Jurassic sediments and variegated marls in the so-called Yavleika gully in the immediate vicinity of Sergach.[1]

During an investigation of this gully last summer its total depth was found to be no less than 25—30 sazhens [53—64 m]. It lies half a verst north of Sergach and its walls slope so gently that they used to be mostly overgrown by forests (now felled), covered with sod and thickly covered by debris as a result of many landslides, both old and fresh. The most typical instance of this is found in the lower part of the Yavleika gully, on

[1] Krylov [A.]. Zasedanie Nizhegorodskogo gubernskogo statisticheskogo komiteta. 16 fevralya 1877 (Meeting of the Nizhni Novgorod Provincial Statistical Committee of 16 February 1877), p. 5. [Nizhegorodskii sbornik (The Nizhni Novgorod Collection), published by the Nizhni Novgorod Provincial Statistical Committee. Volume 8, Nizhni Novgorod, 1889.]

its right-hand walls with a gradient of 35—40°. The area affected by this landslide is not less than half a dessiatine; on the surface there are rows of fairly regular ridges, the crests of which extend across the direction of the movement of the landslide; in some places, the debris includes stumps of fairly large trees, and there are cracks along the crests. The thickness of the debris is fairly uniform, not exceeding 4—6 feet [1.2—1.8 m], but generally less. On three sides (top, right and left) the debris is limited by vertical walls which serve, so to say, as the banks of the earth stream. The debris reaches the gully walls, its surface being in places higher and in others lower than the walls; on the other hand, the landslide originated at the apex of the gully, where there is a fairly smooth depression with a downward gradient and 4—6 arshins [2.8—4.3 m] in width. The bottom of the gully is composed of viscous, bluish and pinkish clay which appears to be Jurassic; the same clay also constitutes the bed of the entire landslide debris. However, the most remarkable feature is the absence of cracks in many ridges in the debris which are sodded, while the lower extremity of the area of the landslide is fairly strongly constructed, with the top, front, and partly also bottom surfaces almost completely sodded.

Thus, this landslide was almost identical to the snow avalanches which are sometimes formed in spring on gently sloping roofs and on the slopes of gentle hills.

The local inhabitants reported that landslides became much more frequent in the Yavleika gully after the felling of the forest, and this is only natural. I would add that landslide debris is characteristic of the Jurassic system almost to the same extent as sinkholes are characteristic of the Permian system.

Bedrock outcrops in the Yavleika gully are mainly masked by the debris, so that the outcrops can be observed almost exclusively at the very bottom of the gully. On the whole, their character is as follows.

The very top of the gully displays a sandy-clayey deposit with an abundance of belemnites, even in the surrounding fields. This gives way, further down the gully to a formation (about 10 sazhens [21 m]) of thick, yellowish, pinkish, bluish and black marly Jurassic clays with a high content of pyrite. The following fossils were collected, partly in the black Jurassic clays which seem to occupy the lowest horizons of the system, but mostly at the bottom of the gully: *Gryphaea dilatata*, *Aucella* sp., *Stephanoceras stenolobum* Nik., *S. coronatum* (?), *St. elatmae* Nik., *Belemnites absolutus* Fisch., *B. panderi* d'Orb., *B. subabsolutus* Nik., etc.

Typical "variegated" marls were found directly underlying the Jurassic formations approximately in the middle part of the Yavleika gully. Fairly soft gray limestones appeared below these marls at the end of the gully, on its bottom. These limestones had been artificially exposed to the extent of 1—3 feet [0.3—0.9 m] and were utilized by the local population for the production of lime.

Much less markedly expressed Jurassic formations were encountered 2 or 3 versts east of Achka (also in the vicinity of Sergach), where I found *Gryphaea dilatata*, *Aucella* sp. and other fossils in a shallow gully the walls of which were composed of reddish-yellow and bluish-dark very viscous Jurassic clays.

Fragments of belemnites and Gryphaeas were even more frequently found in the neighboring fields.

Apparently similar Jurassic formations are exposed at the village of [illegible] also, where they occupy the highest sites.

The area 1 1/2 versts east of Edelevo can probably be regarded as the [illegible] point of the occurrence of Jurassic formations north of the P'yana. Unfortunately, the local blue Jurassic clay does not contain organic residues.

Having crossed the northern branch of the P'yana and entered the so-called Tatar lands occupying the eastern half of the peninsula formed by the two branches of the P'yana, we entered the region of continuous Jurassic formations. Near the northern branch of the P'yana this system overlies thick outcrops of "variegated stony marls and clayey limestones" at the villages of Staraya Berezovka, Pozharki, Shubin [illegible], and Chufarovo; further south the exposures in gullies display Jurassic formations only.

Of the outcrops nearest to the northern branch of the P'yana, the most remarkable is the section in the gully at the village of Novaya Berezovka, where marls of various colors, with an intercalation of clayey limestone, total thickness reaching 2 sazhens [4.3 m] form, according to observations by Ferkhmin, form an anticlinal fold the top of which has been washed away. These marls are directly overlain by horizontal beds of a) reddish, probably also marly clay (directly over the marls, with an abundance of fragments which apparently belong to the underlying limestone and b) dark brown, apparently Jurassic clay. The combined thickness of the beds (a) and (b) is 2 sazhens [4.27 m]. Thus, when the determination of clay is [illegible] confirmed, we shall have an excellent example of unconformable bedding of Jurassic formations and "variegated marls".

As already mentioned, in the Tatar lands Jurassic deposits form a continuous cover and at many points are the direct subsoil of the [illegible] chernozem. In this area Jurassic outcrops occur in the vicinity of the villages of Mangushevo, Karga, Andros[illegible], Ukа, Krchanovo, [illegible] Mozharki, Kitovo, Tarkhanovo, Sarga, [illegible], and of [illegible] in the vicinity of Chernov[illegible], etc. The following fossils, among others, were collected from the bottom of gullies in these localities: [illegible] ras jason Ziet., Amaltheus sp., Belemnites panderianus, Astarte sp. and Stephanoceras [illegible] at Uka, Belemnites panderianus d'Orb. and B. absolutus Fisch. at Tarkhanovo; a mass of belemnites, Gryphaeas and Stephanoceras [illegible] at a distance of 2 versts from Sarga, on a sheer descent towards the P'yana.

In fact, we encountered a fairly complete section of local Jurassic deposits only in the last three places mentioned, whereas at all other points outcrops of only the marly dark [illegible] Jurassic clay were found. Limestone accompanied by combustible [illegible] (at Uka). Because of this, and [illegible] was described in detail by [illegible]

[illegible]

On the [illegible]

Although Jurassic [illegible]

[illegible] formations are exposed at the village of [illegible] they occupy the highest sites.

[illegible] can probably be regarded as the [illegible] of Jurassic formations north of the [illegible] Jurassic clay does not contain organic [illegible]

[illegible] branch of the P'yana and entered the so-[illegible] lands occupying the eastern half of the peninsula formed by [illegible] of the P'yana, we entered the region of continuous Jurassic formations. Near the northern branch of the P'yana this system overlies thick outcrops of "variegated stony marls and clayey limestones" at the villages of Staraya Berezovka, Pozharki, Shubino, and Chufarovo; further south the exposures in gullies display Jurassic formations only.

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As already mentioned, in the Tatar lands Jurassic deposits form a continuous cover and at many points are the direct subsoil of the local chernozem. In this area Jurassic outcrops occur in the vicinity of the villages of Mangushevo, Karga, Androsovo, Utka, Kechasovo, Salgan, Mozharki, Kitovo, Tarkhanovo, Sarga, Svirino, and at Slyudyanaya Mt., in the vicinity of Chernov[illegible]oe, etc. The following fossils, among others, were collected from the bottom of gullies in these localities: *Cosmoceras jason* Ziot., *Amalteus* sp., *Belemnites panderianus*, *Astarte* sp. and *Stephanoceras elatmae* at Utkta; *Belemnites panderianus* d'Orb. and *B. absolutus* Fisch. at Tarkhanovo; a mass of belemnites, Gryphaeas and *Stephanoceras elatmae* at a distance of 2 versts from Sarga, on a sheer descent towards the P'yana.

In fact, we encountered a fairly complete section of local Jurassic deposits only in the last three places mentioned, whereas at all other points outcrops of only the marly darkish-blue Jurassic clay were found. Limestone accompanied by combustible shale was encountered only once (at Utka). Because of this, and since the Svirino section was described in detail by Prof. Meller,[1] I will not enter into a detailed description of the Sarga and the Slyudyanaya Mt. exposure; the only feature worth mentioning is the sporadic occurrence at Slyudyanaya Mt. of fairly well-formed gypsum crystals (twins).

On the water divide under consideration, the environs of Vetoshkino, Inkino, and Kenshevo are the westernmost points where the presence of Jurassic formations can be assumed.

Although Jurassic formations do not outcrop at Vetoshkino, their presence here at a depth of 2–3 sazhens [4.[illegible]–6.4 m] has been shown by

[1] Meller, ibid., pp. [illegible]

artificial pits, where numerous concretions of pyrite and well-preserved ammonites were extracted from the viscous light-bluish clay.

In addition, 2 or 3 versts above Vetoshkino along the P'yana, in the estate belonging to Baron Zhomini, in a gully joining the P'yana, indistinct outcrops of gray sandy limestones and bluish marls are observed overlying the variegated marls, while the gully bottom contains an abundance of belemnites and Gryphaeas among which we could distinguish Belemnites volgensis d'Orb. and Gryphaea dilatata — Desh.

It appears that, dark Jurassic clays cover (according to Sibirtsev and Ferkhmin) certain hilltops in the vicinity of Inkino and Kenshevo; the exposures on slopes and in lowlands, however, are "variegated" marls throughout the area.

The southeastern corner (south of the southern branch of the P'yana) of the Sergach District and the northeastern corner (north of the Alatyr) of the Lukoyanov District are marked with the color used for the Jurassic system on Prof. Meller's map, and this is completely justified by the actual conditions. However, since this locality has not been visited by any geologists, we deem it useful to say a few words about the geology of the eastern part of the P'yana — Alatyr divide.

As seen in section I, the terrain rises gradually from Chernovskoe in the southward direction towards Bol'shie Polyany and Sloboda.

In the lower, northern third of this slope, Jurassic exposures in fairly good sections were first observed by Sibirtsev and me on the Salya River at Dmitriev Farm, 1 1/2 or 2 versts southwest of the village of Apraksino. In this locality the banks of the Salya are about 3 sazhens [6.4 m] high in places, and are composed of the following layers:

A) chernozem 1 1/2 feet [46 cm] thick;

B) yellow-brown deposits—loess with a variety of numerous calcareous concretions, veins, spots, and nodules, 10—15 feet thick [3.0—4.6 m];

C) dark bedded clay, entirely impregnated by ferrous sulfate which forms efflorescences on the clay surface; the clay has an astringent, acid taste and contains an abundance of poorly-preserved ammonite imprints; this layer is 9 feet thick [2.7 m].

In certain places near this section, the channel of the Salya contains "khlebs" ["loaves"], oval-shaped lumps which may reach 2 feet [61 cm] in diameter; they consist of bituminous-ferruginous limestone, often with veinlets of lime feldspar. Inside, they often contain well-preserved imprints of ammonites, one specimen of which measured 1 foot [30 cm] across.

Identical "khlebs" were also encountered by us in gullies emptying into the Salya in this locality. Their walls were composed of the same black Jurassic clay, nearly 2 sazhens [4.3 m] thick, which in certain places was almost entirely filled with mother-of-pearl ammonite fragments. Probably, this clay may be used as a substitute for phosphorite fertilizer.

The village of Mansurovka is situated approximately on the latitude of Apraksino but 1 verst further west. According to Sibirtsev, the bluffs descending to the Pekshat River expose gray laminated clays with fine spangles (gypsum ?) and fairly numerous residues of ammonites, belemnites and Gryphaeas. The clay contains intercalations (indistinct) of yellowish-gray limestone with the same Jurassic fossils. Near the mouth of one of the gullies the clays are abruptly replaced by light-gray sands; unfortunately, the relationship of these sands to the clays could not be distinctly seen.

At the top of the southward ascent one can see outcrops of Jurassic formations at Peresekino, Kazarinovo, Ivakovo, Ushakovo and approximately 2 versts west of Anosovo in the Bakaldy gully. The sections in the first two localities are indistinct. In the Bakaldy gully and 2 versts southwest of Ushakovo, in gullies emptying into the Ezhat River, Jurassic clays are mostly overlain by gray limestone. The fossils found in the Bakaldy clays include Gryphaea dilatata, Belemnites volgensis and fragments of ammonites. The Jurassic outcrops of 2 versts north of Ivkovo on the right bank of the Mela River (a tributary of the Pekshat) are of a somewhat different structure. According to Sibirtsev's description, here the bottom of the section exposes compact sand or loose sandstone of white or light-gray color; the sand is laminated, somewhat micaceous, with brownish ferruginous intercalations, without fossils, resembling Mansurovka sands in appearance. The thickness is no less than 3 sazhens [6.4 m]. Above the sand, the bank slope displays gray sandy finely laminated clay 15 to 20 feet [4.6—6.1 m] thick. No organic residues were found, but the clay is identical to Jurassic clay in appearance.

Of equal interest were the sections of Jurassic deposits examined by Sibirtsev and by me in the vicinity of the famous* village of Boldino which is situated still higher and further south along the slope (see section I in Figures 1—2).

The village of Boldino stands on the high right bank of the Azanka River. A light-gray, partially laminated and partially compact marly clay forms exposures in the village itself, on the slopes descending toward the river and especially in rills cut by rainwater. This clay often contains well-preserved imprints of ammonite and other Jurassic shells.

A very distinct section is found northwest of the village, immediately beyond the barns used in the manufacture of potash, on a bluff of the right bank of the Azanka; this section exposes the following series of layers:

1. Soil layer (forest soil, 1 ft 3 in [38 cm] thick.

2. Brown diluvial clay containing boulders of quartz, hornfels, diorite etc., 21 feet [6.4 m] thick.

3. Light-gray clay identical to the clay in Boldino itself; part of this layer, approximately 3 feet [0.9 m], is exposed at the Azanka River in a nearly sheer bank bluff, but is partially concealed on the slope under sod and soil;[1] the thickness of this layer is 28 feet [8.5 m].

4. Alternating layers of brownish-black and brown clay, 4—5 inches [10—13 cm] thick, quartz brownish sandstone with a blackish intercalation of brown sandstone 4—5 inches [10—13 cm] thick, with an admixture of bluish clay or without an admixture of bluish clay, 2—4 feet [0.6—1.2 m] thick.

5. Bluish-brown or greenish-brown clay with an intercalation of hard slightly ferruginous marl, 3 ft 5 in [1.04 m] thick.

This clay disappears under the channel of the Azanka. Various belemnites, ammonites and other Jurassic shells are abundant in the above-mentioned layers (3) to (5) as well as in the Azanka channel.

To the west and southwest of Boldino, on the water divide Alatyr—Tesha and P'yana, one can see poor exposures of poor Jurassic outcrops

* [Probably an allusion to the part played by this village in the life of the great Russian poet Pushkin. Translator.]

[1] It is exposed in the neighboring ditches and artificial sections.

at Pogibelka, Vasilev-Maidan, Bol'shaya Arya, Lukoyanov and Ul'yanov, the last three being the westernmost points in the region of Jurassic deposits.

The southernmost and highest point on the Alatyr — P'yana divide where the presence of Jurassic formations could still be established is Mikhalkov-Maidan. A gully, called Shirokii Vrag, is situated approximately 2 versts southwest of this village, within a forest. According to P. A. Zemyatchenskii's description, the upper reaches of this gully contain a bed of dark-gray sandstone up to 2 sazhens [4.3 m] thick, overlain by a moderately thick layer (up to 2 arshins [1.4 m]) of brownish-yellow diluvial clay. This sandstone could be broken into separate plates about 1 foot [0.3 m] across which in turn are easily cleft into thin platelets. This sandstone readily effervesces with HCl which indicates calcareous cement.

Lower down the gully this sandstone gradually disappears, uncovering the underlying thin (up to 6 inches [15 cm]) intercalations of reddish, greenish and dark sands; the sand beds become thicker at some places and contain pyrite concretions.

The sands are underlain by dark Jurassic clay, reaching 2 sazhens [4.3 m] and more in thickness, which constitute the remainder of this section; in the lower third of the gully the walls are entirely composed of this clay.

On parts of the boundary between the dark sands and the clay, and partly also in the upper portions of the latter, one can see a horizon of dark-gray heavy nodules of various shapes and sizes, almost all of which are coated with a thin envelope of red-brown ferric oxide; qualitative analysis of these nodules shows them to be lumps of sphaerosiderite. Unfortunately no fossil finds were made.

A borehole was once drilled at the top of the Shirokii Vrag gully, at a distance of approximately 100 — 200 sazhens [213 — 427 m] from the section described above. There is no information, however, either regarding the depth of the borehole or the rocks traversed by it. The only clue is a lump of dark bituminous limestone extracted from the borehole, which appeared to be identical to the "khlebs" found on Mr. Dmitriev's estate.

South of Mikhalkov-Maidan, the terrain rapidly descends towards the Alatyr sands down to the river itself.

We shall now describe the Jurassic formations of the southeastern corner of the Lukoyanov District, the so-called Zapochinkovskii* territory. The general paleontological and petrographic character of the local Jurassic formations as well as the most typical sections (at Korgudy and Pochinki) have already been described in detail by Prof. Meller; therefore, I shall only deal with the differences between his results and ours with respect to several very thick sand deposits of the Zapochinkovskii territory.

Page 37 of Prof. Meller's work features a schematic section of the so-called Zapadnyi Vrag gully lying 2 or 2 1/2 versts southwest of Pochinki; the section proceeds along one of the walls from the apex down to the mouth of the gully.

The following information is gleaned from this section and the accompanying description:

1. The country traversed by the Zapadnyi Vrag gully (as much as 3 versts in length) is assumed by the author [Prof. Meller] to be almost completely level and therefore the upper line of his section is horizontal.

* [Literally "lying beyond Pochinki". Translator.]

2. In this section, the soil layer is underlain by a layer of diluvial clay up to 7 feet [2.1 m] thick and containing northern boulders, shown to stretch perfectly horizontally along the entire length of the gully.

3. This layer is directly underlain, in the uppermost part (1/6) of the gully, by thick deposits of various undoubtedly Jurassic formations. Throughout the remaining part of the gully (5/6) the clay is underlain by beds of "loose white sand with thin ferruginous intercalations". Thus, both kinds of deposits (sands and Jurassic deposits) lie in the same horizon, as is shown in the section. Concerning these relationships, Prof. Meller remarked that the "Jurassic beds" are abruptly replaced by loose sands at approximately 1/6 of the length of the gully; these sands appearing suddenly over the entire height of the gully bluffs and continuing in them down to the very mouth of the Zapadnyi Vrag gully.[1]

According to Prof. Meller, these sands are diluvial.

Even prior to my trip to the Nizhni Novgorod Province, reading this description of the Zapadnyi Vrag gully gave rise to doubts in my mind concerning the relationship between the Jurassic formation and the alleged diluvium. These relationships seem unnatural and would be almost unprecedented in the geological literature.

In addition to the above arguments, my doubts appeared to be justified partly by the work of Prof. Meller himself, and partly by the map of this area at the scale of 10 versts to the inch [1:420,000]. The map clearly shows that all gullies joining the Rudnya—which flows due north—from the right, lie in the direction ESE to WNW, and the direction of the Zapadnyi Vrag gully is no exception. This suggested a general slope of the terrain, or at least the part directly adjacent to the gullies in the same direction. Hence it was impossible to understand the completely horizontal line depicting the surface of the section of the Zapadnyi Vrag gully.

On the other hand, Prof. Meller's description of the village of Kendya, lying 12—14 versts northeast of Pochinki, includes details of the following exposure found by him in the vicinity of this village at the very bank (right bank) of the Alatyr and an even better exposure in the large gully which stretches perpendicular to the river immediately above the village:[2]

1. Vegetal earth, 1 foot 6 inches [46 cm] thick.

2. Sandy clay of yellowish-red color with numerous boulders of red quartz sandstone and diorite reaching 2 feet [61 cm] in width; the bed is 9 feet 6 inches [289 cm] thick.

3. Black clay, 4 feet [122 cm] thick.

4. White, in places light-yellow loose sands with thin, partially very hard ferruginous intercalations up to 1 inch [2.5 cm] thick; the thickness of this formation is 140 feet [42.7 m].

Beds of the above exposure can be traced in bluffs of the right-hand bank also lower downstream the Alatyr River as well as in all the gullies emptying into this river in the locality. Meller wrote as follows, "It should be noted that the above-mentioned gully contains a small brook the channel of which is filled with small boulders and fragments of fairly compact somewhat honeycombed limestone with well preserved Jurassic fossils, such as *Gryphaea dilata* Sow. (abundant), *Ammonites biplex* Sow., *Ammonites tsheffkini* d'Orb., *Ammonites goverianus*

[1] Meller. Ibid., p. 36.
[2] Ibid., pp. 30 – 31.

Sow., Ammonites decipiens Sow., Ammonites funiterus Phill., Belemnites panderianus d'Orb."

Prof. Meller writes, "Since this limestone is totally absent from the above section, for a long time I was unable to understand the origin of these fragments and thought that the layers enumerated above (beginning with item 3) were of Jurassic origin. This opinion was also supported by the fairly frequent finds of specimens of Belemnites panderianus d'Orb., albeit somewhat worn, even on the surface of these exposures." For my part, I may add that this same conclusion is confirmed by the "excellent specimens" of the fossils found in this locality and the occurrence of black clay which is so very characteristic of Jurassic formations above and partly also amidst the sands.[1] The boulders and limestone fragments found at the bottom of the Kendya gully may well have originated from concretions and possibly also from the indistinct limestone beds — temporarily covered by a talus — from the same section; similar phenomena are frequently observed in the Nizhni Novgorod Jurassic formations. Nevertheless, Meller reached a totally different conclusion concerning the age of Kendya sands; he classified both these and the sands of the Zapadnyi Vrag gully as ancient diluvium. Prof. Meller's only argument against the Jurassic (or even older) age of the Kendya sands was his having found the following beds in an eastern wall of a large gully passing through the village of Kergudy (lying on the same bank of the Alatyr, 5 or 6 versts east of Kendya):

1. Clayey sands with boulders of red quartz sandstone reaching a foot [30 cm] in diameter, of total thickness 7 feet [2.1 m].
2. White sand, 28 feet [8.5 m] thick.
3. Black clay abounding in pyrite, 7 feet [2.1 m] thick.
4. Gray marliferous clay with subjacent layers of combustible shale of the same color, 21 feet [6.4 m] thick.
5. Light-gray somewhat calcareous clay with small calcareous crescent-shaped concretions and numerous fossils, the latter including Serpula pentagona Gldf., Gryphaea dilatata Sow., Trigonia costata Park., Ammonites jason Rein., Belemnites panderianus d'Orb. and Bel. absolutus Fisch.
6. Yellowish-gray clayey limestone, rendered oolithic by fine ferruginous grains, with the same fossils as in the preceding layer, plus Pholadomya philipsi, 2 ft. 6 in. [0.8 m] thick.
7. Black pyritaceous clay, 14 feet [4.25 m] thick.
8. The same limestone as in layer 6, 2 ft 6 in [0.8 m] thick.
9. Black clay, 7 feet [2.1 m] thick.
10. Loose yellowish-gray argillaceous sandstone,[2] 21 feet [6.4 m] thick.

Nevertheless, the foregoing argument hardly bears out Prof. Meller's views. At least, he should have firmly established the position of the Kendya sands or similar sands above the Jurassic deposits of Kergudy; however, nothing to this effect can be found in his work under consideration.

With these in mind I began the investigation of the Zapochinkovskii territory. Remarkably, my initial cursory examination of the Zapadnyi Vrag gully created the same general impression as Prof. Meller's description arouses, with the only difference that the contact between sands

[1] Ibid., p. 85.

[2] Meller. Ibid., pp. 31 – 32. Essentially the same rocks (with the exception of combustible shale) were described by the author in the abovementioned Zapadnyi Vrag gully.

and undoubtedly Jurassic deposits was masked by a talus exceeding 5 — 10 sazhens [10.7 — 21.3 m] in length. A second, more thorough examination of this gully disclosed the following new facts:

1. The entire terrain directly adjacent to the gully gradually but noticeably descends towards the Rudnya River; hence, the direction of the slope is the same as that of the Zapadnyi Vrag gully. The difference in height between the top of this gully and the site of the first distinct outcrop of sands was barometrically determined as 10 — 12 sazhens [21.3 — 25.6 m]; whereas the distance between these points did not exceed 1/2 verst.

2. Immediately below the abovementioned talus where the sands first appear, they are covered by a light-yellow marly mass reaching a sazhen [2.1 m] in thickness, filled with small marl pebbles apparently identical to the material of beds No. 3, 4 and 6 described by Meller. This blanket of sands appeared to be slump from the beds lying in the upper reaches of the gully.

3. About 100 — 150 sazhens [213 — 320 m] north of the gully mouth, in the upper third of the elevation bounding this mouth from the north and stretching towards Pochinki, there is the so-called "holy well" which yields abundant water at a temperature of 8°C; this well undoubtedly lies above the sands.

4. Finally, following my departure from Pochinki, at my request P. A. Zemyatchenskii again examined the area of the Zapadnyi Vrag gully and the adjacent countryside, investigating one of the northern branches of this gully. He found that the upper reaches of this branch were composed exclusively of Jurassic deposits (described by Prof. Meller) which stretched from top to bottom of the slope. Lower down the gully, at its very bottom, Zemyatchenskii observed sands of the Zapadnyi Vrag gully type under the Jurassic deposits; however, these sand outcrops were obscured by a talus of Jurassic "opoka". However, somewhat lower down the same branch, these sands reached the thickness of a sazhen [2.1 m], although they were still overlain by Jurassic deposits. Unfortunately, the lower third was sodded so that the structure of the mouth could not be established.

The findings described above strongly suggest that the Zapadnyi Vrag sands do not occupy the same horizon as the Jurassic formations in this locality but underlie the latter, and therefore they should be classified not as diluvial but at least as Jurassic or Triassic. This view is supported by the following additional facts.

In the first place, it should be noted that the alluvial valley of the Rudnya within the Lukoyanov District is almost entirely bounded by high right banks which in places reach a height of 80 feet [24.4 m] and more; nevertheless, the terrain continues to rise away from this bank in the eastern direction, as indicated by the local gullies also.

The village of Diveev-Usad is situated on such a bluffy right bank of the Rudnya approximately 15 versts south of Pochinki where the topography is fairly similar to that around Pochinki.

About 200 — 300 sazhens [427 — 640 m] south of the village, the right bluffy bank displays the following characteristic exposure in a completely vertical section:

a) overwashed chernozem, 1/2—1 foot [15—30 cm] thick;

b) yellowish-gray loess loam, 7—10 feet [2.1—3.0 m] thick;

c) the very bottom of this layer, in the right-hand half of the section, there is a pebble-bed of southwestern dip consisting almost entirely of the fragments of belemnites, ammonites, Gryphaea fragments, and pebbles which appear to be Jurassic marls; its thickness at places reaches 1 1/2 feet [45 cm];

d) finely laminated brownish-yellow quartz sand with a large quantity of minute flakes of silvery mica; the sand is loose in some places and weakly cemented in others. In approximately the lower third of this section, the loose sands contain a bed of light-gray sandstone up to 3 feet [91 cm] thick, which is in places broken into rectangular blocks, some a sazhen [2.1 m] long. In some areas this sandstone is very hard and consists almost exclusively of quartz grains,[1] but in others it contains a considerable admixture of flakes of the abovementioned mica, in which case the sandstone becomes laminated and readily breaks into fairly thin plates. The base of the bluff is covered by a sand talus with enormous plates of the sandstone. In the same place several fairly well preserved belemnites, Gryphaeas and two pyrite concretions of fist size were found. These fossils, together with the pyrite fragments, probably originated in layer (c). The total thickness of the sand formations is about 70 feet [21.3 m].

From the top of the bluff we saw that the terrain continued to rise appreciably eastward from the Rudnya, possibly as far as Pelya-Khovanskaya, where typical Jurassic opokas containing large amounts of belemnites and Gryphaeas protruded everywhere, even in shallow ruts.

The same section can be seen in the village of Diveev-Usad; the only difference is that here the sand layer is only half the thickness and the diluvial loam reaches 1 1/2—2 sazhens [3.2—4.3 m] thick. The local inhabitants report that a few years ago a mammoth's tusk and molars were washed out of the diluvial loam. In the same locality, on the slope toward the river, one can see in places slumped chernozem reaching 1 1/2 sazhens [3.2 m] in thickness.

I also examined the steep right bank of the Rudnya approximately 5 versts south of Diveev-Usad, on a road from the village of Maresevo (on the left bank of the Rudnya) to the Maresevskii farm belonging to Protopopov (2—2 1/2 versts east of the Rudnya). Although the river bank is completely sodded, there was landslide debris in many places which are so characteristic of the area of occurrence of Jurassic clays. On the way to the farm, which is situated considerably above the Rudnya bank, there are exposures of darkish-gray Jurassic "opoka", in certain spots in ditches, with numerous belemnite fragments and whole belemnites. The following section could be seen at the farm itself in one of the most elevated areas, in clay pits and in a cellar:

a) chernozem, 1—2 feet [30—61 cm] thick;

b) typical loess with belemnite fragments, pebbles and granite and gneiss boulders up to 1 1/2 feet [45 cm] in size; the thickness of loess 7—14 feet [2.1—4.2 m];

c) clays of various colors, mostly pink and dark plastic clays which are probably Jurassic clays according to their appearance, frequently

[1] Probably this was the stone used in the building of the church at the village of Nikitino. Meller. Ibid., p. 37.

containing pyrite concretions and small (fist-sized) lumps of sphaerosiderite which have become converted to brown iron ore at the surface. According to Protopopov, sphaerosiderite occurs only at the very bottom of the pits. The total thickness of layer (c) is 7 — 10 feet [2.1 — 3.0 m].

Consequently, it may be assumed that the Diveev-Usad sands also underlie Jurassic clays.

In concluding our discussion of the Zapochinkovskii territory between the Alatyr and the Rudnya, we shall briefly mention the village of Kendya which was investigated by Zemyatchenskii. According to his description, this village lies between two gullies which join the Alatyr, one situated west, the other east of the village. Since the first gully had already been described by Prof. Meller and has since become extensively overgrown, Zemyatchenskii was concerned only with the eastern gully. According to him, this gully is still fresh, 8 sazhens [17 m] in depth, with sheer walls in places. Nearer the mouth of the gully its walls are composed of pure quartz sand with red-brown, thin (up to 2 feet*) intercalations of ferruginous sands; this sand is directly overlain (near the gully mouth) by light-yellow diluvial clay up to a sazhen [2.1 m] thick; at one spot an enormous boulder (?) could be seen under this layer of clay embedded in the upper horizon of the sand; the boulder was composed of red-brown ferruginous sandstone and 1 1/2 — 2 sazhens [3.2 — 4.3 m][1] in height and width.

Higher along the gully the sands are directly overlain by bluish clays which are in turn covered by completely dark clays, the thickness of which reaches 1 1/2 sazhens [3.2 m]. All these layers are covered by a yellow diluvial clay which is analogous to that already mentioned but with a profusion of limestone and with poorly preserved fossils of ammonites, belemnites and Gryphaeas.

The environs of the equally interesting village of Kergudy (also mentioned by Meller) were investigated by me personally. In the first place, this was found to be one of the most elevated localities on the right bank of the Alatyr, with a charming view of the winding valley and the still extensive tracts of forest growing beyond this river.

Unfortunately, the "large gully traversing the village of Kergudy", Prof. Meller's description of which was given above, is masked by taluses and landslide debris and therefore I was concerned with the gully which joins the Alatyr about half a verst east of Kergudy. Though the sections were also indistinct, I succeeded in establishing the presence of layers 1, 3, 5, 6 and 10, as described by Meller. According to my observations, the specific features of this exposure, as compared to the structure of the gully "traversing the village of Kergudy" were as follows:

1. At the top of the gully, only yellowish loess with infrequent northern pebbles, up to 2 — 3 sazhens [4.3 — 6.4 m] thick is found.

2. Directly underlying layer of bluish-gray Jurassic marly clay, up to 7 feet [2.1 m] thick.

The lower clay horizon contains plates of combustible shale of total thickness around one foot [30 cm] thick.

3. Clayey limestone described by Prof. Meller (No. 6), forming a waterfall in the lower portion of the gully, where the thickness of the beds reaches 5 feet [1.5 m].

* [An obvious misprint; should read "2 inches" [5 cm] instead of "2 feet". Ed.]

[1] It is doubtful whether this was really a boulder, a local concretion, or an outcrop of the bedrock sandstone. Author.

Approximately 5 versts east of Kergudy, on the same right bank of the Alatyr, stands the rich village of Kemlya. On the road from Kergudy, about half or one verst from Kemlya, at one of the elevated sites near the latter, at the beginning of the descent towards the Alatyr, one could see indistinct outcrops of a dark blue Jurassic clay. At this spot a local landowner, Filosofov, collected very well preserved specimens of Belemnites extensus Tr., Stephanoceras milachevici Nik., St. coronatum Brug., Comoceras gowerianum Sow. and Pholadomya sp.

South of the Alatyr ascending towards the highest part of the water divide between this river and the Rudnya, we found outcrops of undoubtedly Jurassic clays and marls everywhere, for instance at Stepanovka, Lobaski, Simbukhovo, Andreevka,[1] Pelya-Khovanskaya, etc.

On the basis of the above facts, I classified the thick sandy and sandstone deposits of Kendya, Pochinki and Diveev-Usad not with diluvial, but at least with Lower Jurassic horizon.

Furthermore, there are strong grounds for asserting that if not all, at least a considerable part of the sandy deposits of the Lukoyanov, Krasnoslobodsk, Arzamas and Murom districts, which were classified by Prof. Meller with the ancient diluvium, are of the same age as the sands of Kendya, Diveev-Usad, etc.

I shall now dwell only on one area lying within the Lukoyanov and partly in the Arzamas districts, and the entire region will be investigated in the future.

The left bank of the Rudnya, westward toward Fedorovka, Podlomasovo (Nikitino), Naruskovo, Durakovo and Shishadeevo, is similar to the southern banks of the Alatyr and the P'yana, in places being a very gentle rise often 5—6 versts in width. This rise terminates in hills, two of which are occupied by the villages of Nikitino and Shishadeevo; Naruskovo and Durakovo lie almost on the divide between the Rudnya and the Irset which is another tributary of the Alatyr parallel to the Rudnya.

This area, even almost the entire basin of the Irset, was included by Prof. Meller among Jurassic formations; nevertheless, the author observed here only deposits of clayey sand which in places reached up to 2—3 sazhens and more [4.3—6.4 m] in thickness.

Prof. Meller's hypotheses concerning the occurrence of Jurassic formations in this area were confirmed by the results of Zemyatchenskii's investigation of last year. In the first place, Zemyatchenskii pointed out traces (albeit indistinct) of the blackish-blue Jurassic clays which in places composed the base of the banks of the Styrsha River between the villages of Shishadeevo and Durakovo. Characteristically, these clays are directly overlain by peat masses which reach 1 1/2 sazhens [3.2 m] in thickness: "Lumps of peat in places fill even the Styrsha River; all the exposures in the banks display coatings of ferrous sulfate; the accumulations of the latter are in places large enough to form sinters about 2 vershoks [9 cm] thick; the color of the sulfate is mostly yellowish or even white (pure anhydrous ferrous sulfate)." Possibly, the parent rock of these mineral new formations are the underlying clays, provided that the latter are Jurrasic.

[1] Meller. Ibid., p. 34.

Approximately 5 versts south of Shishadeevo lies the village of Nikitino (Podlomasovo), at the beginning of the abovementioned slope to the left of the Rudnya. Here, the following section is found in a small gully adjacent to the village on the north side:

a) soil layer, 1 foot [30 cm] thick;

b) loose reddish-yellow loam, 14 ft. [4.3 m] thick;

c) bluish-dark plastic clays from which the water washes out numerous fragments of gray limestone with Jurassic fossils; this layer[1] was exposed only to the extent of 2 or 3 feet [61 — 91 cm].

The sections at the village of Naruskovo lying approximately 7—8 versts west of Nikitino, observed by Zemyatchenskii, are even more interesting. This village stands on the low left bank of the insignificant minor Rubtsovka River. Opposite the village, on the right bank, there is a sheer, perfectly fresh bluff 8—10 sazhens [17—21 m] high, which is entirely composed of white quartz sand with insignificant intercalations of red-brown ferruginous sandstone. The latter sometimes appears in the form of separate elongated crescents some of which are vertical.

From the top of this bluff, one can see that the terrain continues to rise gently away from the bank in irregular terraces. At the lower portions of this slope, nearest to the bluff, black viscous clay can be seen, which is replaced higher up by yellow-brown and even milky-white probably marly-clayey deposits.[2]

Therefore, it may be assumed that the entire area between the Rudnya and the Irset within the boundaries of the Lukoyanov District has essentially the same structure as the right bank of the Rudnya at Pochinki, Diveev-Usad, etc.

It is seen from Prof. Meller's work that the entire southwestern part of the Lukoyanov District, bounded by the Alatyr and the Krasnoslobodsk District on the one side and the Veika River and the upper reaches of the Urkat on the other, is occupied solely by the Carboniferous formation. We ourselves pointed out several new exposures of the same age; nevertheless, there are grounds for assuming that Jurassic formations (clays and sands) occur even here above the Carboniferous limestones, sporadically, in the form of poorly preserved "islets".

Deposits of this kind were indicated by Prof. Meller himself directly south of this area, at the villages of Devichii Rukav and Palachino.[3]

Moreover, there are several shafts for mining ore 1 1/2—2 versts from Elkhovka lying on the Urkat. Although last summer these shafts were filled with water, Zemyatchenskii, when questioning the laborers and examining the rocks extracted from the shafts came to the conclusion that the section consisted of the following:

1. Bedded quartz sand, 10—14 feet [3—4.3 m] thick.

2. Ore nodules some of calcareous spathic iron ore, others of brown iron ore; the entire thickness is 1—2 feet [0.3—0.6 m].

3. Gray viscous clay with an abundance of Gryphaeas and some belemnites, of unknown thickness. However, horizon No. 2 is probably

[1] Many fairly abundant springs, in which the water temperature is 8°C, emerge above these blue clays.

[2] It may be added that in the area between Azrapino and the mouth of the Veika River (a tributary of the Irset), at the base of the Azrapino elevation, there is an unusually active spring, with a jet of up to 3—4 inches [7.5—10 cm] in diameter, and water temperature 7—8°C.

[3] Meller. Ibid., pp. 29—53.

nonuniform: a neighboring gully contains an outcrop of the same character but instead of the ore bed there are black micaceous sands in which only small piece of white iron ore was found.[1]

Almost all the rest of the area under consideration—at least on the road from Pechi to Rubava, from Uchuev-Maidan to Kivchi, and thence approximately over 5—10 versts west toward Nikol'skoe—is covered by loose quartz sands which are sometimes very difficult to traverse. This area is still under coniferous and decidous forests which are very dense in places. I tend to regard a majority of these quartz sands, which are sometimes distinguished by their remarkable purity (they are utilized at the glassworks belonging to Rusinov), as reworked (eluvial) sand formations of the same age as those at Pochinki.

Sands of identical appearance cover the northern slope descending toward the Alatyr, which is also very gradual over the entire extent of this river within the boundaries of the Lukoyanov District, 50—70 versts from west to east. The average width of this continuous sand belt may be taken as approximately 10 versts. However, nowhere does the sand reach the divide Alatyr —Tesha—P'yana, but always terminates approximately in the middle of the northern slope toward the Alatyr . Its northern boundary is fairly accurately defined by a line passing through the following points: 3 versts south of Chevarda, 10 versts north of Orlovka and approximately 1 verst south of Nikolai-Dar, Vasilev-Maidan, Uzhov, Yaz, and 4 versts south of Mikhalkov-Maidan. The entire belt is even now covered by large tracts of coniferous and deciduous forests.

In some places, for instance in the vicinity of Yaz, Uzhov and Mikhalkov-Maidan, the sands terminate in the north in a series of irregular ledges composed of yellow-brown loam. Wherever I happened to cross this belt (altogether four times) the following specific features were evident: the surface is pitted with small closed depressions (hollowed out by deflation ?), of circular or elongated shape, some completely dry, others filled with various bog formations; in a few places northern boulders lie on the surface; the sand is extremely fine, almost exclusively quartz; it contains many particles of coal and of brown iron oxide; only in one place (south of Yaz) did we observe a gradually increasing admixture of clay in the northern boundary of the belt under consideration, and consequently a gradual transition to formations of the neighboring water divide. Unfortunately, sections in this sandy area are nowhere deeper than 1—2 sazhens [2.1—4.3 m] (the hills opposite Obrochnoe), and only the laminated sand already mentioned can be seen.

We shall now discuss the structure of the divide between the Alatyr on the one side and the Tesha and the P'yana on the other, taking into account only the southern slope of this divide, and only those parts of it which are nearest to the northern boundary of the sandy belt within the Lukoyanov District: Mikhalkov-Maidan, Vasilev-Maidan and Saldamanov-Maidan. The structure of the country around Mikhalkov-Maidan is already known to us, whereas Vasilev-Maidan is situated at the source of the Berezovaya River on very hilly and relatively high terrain.

At the very boundary of the well-known peasants' lands of Vasilev-Maidan—which are the subject of litigation—with V.A.Gorinov's estate, 2—3 versts northeast of the village, a well 5 sazhens [11 m] deep was sunk

[1] V. I. Meller's determination of the age of Elkhovka ores (ibid., pp. 55—56) was different, but apparently he did not personally examine the local shafts. Ibid., p. 47.

a year ago at one of the highest points of this area in the forest, near the forester's cabin. On the basis of information provided by the forester, who had been present at the digging, and examination of the excavated earth, the structure of the ground was established to be as follows:

a) soil layer, 1 foot [30 cm] thick;
b) yellowish-light loess clay, 10 feet [3 m] deep;
c) bluish marly Jurassic clay 5--21 feet [1.5—6.4 m] deep.

Among the clay from layer (c), I found numerous gypsum and pyrite crystals as well as well-preserved Jurassic ammonites.

It is again emphasized that this is one of the highest points in the neighborhood of Vasilev-Maidan. The terrain descends appreciably immediately beyond the village, in the southward direction along the road to Bol'shaya and Malaya Puza, and sands appear which continue to the alluvial valley of the Alatyr. As near as 1 1/2—2 versts south of Vasilev-Maidan, in a small gully which serves as a boundary of the lands belonging to this village, one can see the light-yellow quartz sands at the surface, forming the only material of the gully walls, as much as 2 1/2 sazhens [5.3 m] thick.

The following data were obtained by Zemyatchenskii concerning the country around Saldamanov-Maidan. Approximately 2—3 versts south of Saldamanov-Maidan, at the convergence of the Progonnyi Vrag and Volodin Vrag gullies, there is a perfectly fresh section the upper third of which no less than a sazhen [2.1 m] is composed of a) grayish-brown clays and loam underlain by b) heavy, compact ferruginous sandstone 1—1 1/2 feet [30—45 cm] thick; there is a gradual downward transition to c) coarse quartz sand with fine veinlets of ferruginous sand. This layer contains sporadic calcareous concretions in the form of hollow cylinders of small size, the thickness of a goose quill. A loaf-shaped mass of calcareous sandstone was excavated from the lowest sand horizon. The total thickness of layer (c) is about 2 sazhens [4.3 m]. No fossils whatever were found in the entire section.[1]

On the basis of the foregoing there are grounds for assumption that the sandy deposits occupy a horizon lower than that of the Jurassic clays on the northern slope of the Alatyr as well.

Prof. Meller considers that the sands in the Alatyr basin are of diluvial age, because they frequently contain, in their "uppermost horizons", the same boulders which are abundant in the diluvial clay.[2] Though this is undoubtedly so and we ourselves have frequently observed boulders "on sands", this mode of occurrence in no way serves as an indication of the age of the underlying rock.

Diluvium. The oldest geological systems in the southeastern part of the Nizhni Novgorod Province, similar to almost the entire European Russia, are covered by a fairly thick layer of diluvial deposits. These probably once formed an almost continuous cover over the area in question, but at present most of the Russian deposits have undergone rather significant alterations due to the effects of various factors, such as vegetation, rainwater and the activity of rivers. In some places (on steep ridges) they

[1] The section of the Saldaman gully described by Meller to illustrate the structure of the sandy belt under consideration cannot refer to the latter. Firstly, the village of Saldamanovo lies in the basin of the Tesha, not of the Alatyr; secondly, the terrain continues to rise for part of the way between Saldamanovo in the southern direction toward Saldamanov-Maidan. Author.

[2] Meller. Ibid., p. 85.

have been eroded altogether, in some (lowlands) they have become considerably thicker, in others (gentler slopes) they have been converted to eluvium, etc.; in short, the diluvial deposits have retained their original properties only in comparatively rare cases.

There is no doubt that this circumstance, in conjunction with the almost total absence of any organic residues in the diluvium is the prime cause for the difficulty and limited success of investigations of Russian deposits; on the other hand, for the same reasons investigators are wary of drawing conclusions in this particular branch of geology.

Naturally, the diluvial formations in the part of the Nizhni Novgorod Province under consideration (as everywhere else in Russia) have been the most fully and distinctly preserved mainly on level and fairly elevated areas; in our further discussion, therefore, we shall deal mainly with such regions.

The area between the Volga and the northern branch of the P'yana is covered by almost continuous light-yellow or yellowish-brown diluvial loam, with the exception of a relatively small southeastern part and a narrow discontinuous belt along the northern slope towards the P'yana. This diluvial loam constitutes the most important local parent rock for the soil. In certain places, for instance at Bol'shie Kolokovitsy, Achka, Sergach, and partly also Stolbishchi, the diluvial loam directly overlies Jurassic deposits, clays, marls, and even combustible shale; in other places, for instance at Nelyubovo, Bol'shoe Murashkino and Knyaginin, it covers variegated sands and sandstones; still more frequently (at Oselok, Sosnovka, Lubyantsy, Mokryi-Maidan, Valgusy, etc.) the diluvial loam is underlain by variegated marls. The petrographic differences between the underlying rocks undoubtedly affect the composition of the diluvial loam itself. The dependence of diluvium on the subjacent formations is evident by the more frequent occurrence of Jurassic fossils within the area where Jurassic formations occur in diluvium (the environs of Sergach, Stolbishchi, Kolokovitsy, Bazhulino, etc.); in the region of variegated rocks one finds pebbles and boulders of sandstone, and frequently even lumps of alabaster.

The above sections, as well as many other sections we inspected, reveal that in some places the diluvium contains a relatively large number of northern boulders, whereas in others the latter could not be seen at all. The boulders were frequently formed by diorites, quartzites, and shales, less frequently by granites and gneisses. All boulders are rolled, and a majority are strongly weathered; their size varies from a few "liniyas" to 1 1/2 feet [45 cm] and more.

In this area diluvial loams are generally thin, thickness varying from 2 feet [0.6 m] to 2 1/2 sazhens [5.3 m], rarely more. Only in one place, in a gully near Achka, did we find a typical, perfectly homogeneous, clayey yellowish-brown loam, completely free of boulders, reaching a thickness of 4 or 5 sazhens [8.5—10 m]. Characteristically, only the uppermost horizon of this section, no deeper than 6 feet [1.8 m] was found to contain numerous whitish-gray segregations of calcium carbonate, and in such cases diluvium became a typical loess.

Identical cases were observed by Ferkhmin in other places also. He indicated Potapovo and Yablonka as the most typical sites, where loess reaches 3—4 feet [0.9—1.2 m] in thickness, and forms a downward transition, in the first case, "to a yellow-brown clay, and in the second, to variegated marls; in the Yablonka loess, $CaCO_3$ was apparently deposited in the multitude of small cracks permeating the diluvium."

The segregations of $CaCO_3$ occur in a variety of forms, such as very thin coatings, fine tubules, and small spheres ("zhuravchiks").

There are reasons to assume that the $CaCO_3$ contents were once approximately uniform in all diluvium horizons. Today we see its segregations — efflorescences — mainly in the horizons which are closest to the surface, and this is readily explained by the effect of atmospheric water of carbonated nature which extracts $CaCO_3$ from the soil (where its content is usually below 1%) and deposits it in the cracks and small voids of the shallower subsoil horizons. Obviously, such processes take place less readily at a depth of 1 — 2 sazhens [2.1 — 4.3 m] or more, and therefore in such deeper horizons $CaCO_3$ remains uniformly distributed throughout the entire mass of the diluvial rock.

Bones of mammoth, fossil rhinoceros, and other extinct mammals have often been found by the local inhabitants in gullies (at Sergach, Annenkovo, Kazach'ya, Sloboda and Bozhulino), but it is impossible to state whether they belong to the diluvium or to the covering alluvium.

Ferkhmin encountered "krotovinas" (diffuse) "only once or twice"; I found no krotovinas north of the P'yana.

The diluvial formations occurring between the northern and the southern branches of the P'yana are somewhat different. This is not surprising, when one considers the findings of Prof. Meller[1] as well as the fact that the eastern half of the P'yana water divide is almost continuously occupied by Jurassic formations while its western half is occupied by formations of the stage of variegated rocks. Our own investigations also confirmed this.

~~In the~~ area of a more or less continuous occurrence of Jurassic formations and particularly on elevated though fairly level sites, many parts of the P'yana divide are totally devoid of the light-yellow diluvial loam which is so widespread north of the P'yana and which differs so sharply from the underlying "variegated rocks". Here (on level elevated sites) dark-brown, unusually viscous, highly marly clay appears at the daylight surface almost everywhere in gullies and in ditches. This clay is scarcely permeable and therefore sometimes causes bogging, even on very steep slopes. Travelling through one of the highest parts of this divide, I was surprised to see at the Chernukhi village fairly extensive earth-moving and road-construction work, including an attempt at draining, if only partially, the local roads. In many places these "dark-brown clays" become part of the soil itself and such soil is known as "zaklech'" to local inhabitants.

Wherever I and my companions Ferkhmin and Sibirtsev observed exposures of this clay it merged quite imperceptibly with the underlying Jurassic bluish marls, so that its normal thickness was impossible to establish. Small northern crystalline boulders were encountered only in 2 or 3 places within the entire area. Instead of boulders, both the soil and the subsoil contain lumps of dark Jurassic limestone (of the Apraksino type) almost throughout, and calcareous-siliceous crescents of the same age are even more frequent. Very characteristically, one or two sides of many such calcareous formations are covered by laths of Ca-feldspar; segregations of the latter sometimes enter into the concretion, forming fairly sharply delimited veinlets. These residues, both in the clay itself and in

[1] Meller. Ibid., pp. 20 and 83.

the soil, are very frequently accompanied by remnants of belemnites and ammonites which are somewhat weathered on the outside.

Examples of such clay can be found in the environs of the villages of Mozharki (southward), Chernukha, Endovishchi, Kochunovo, Androsovo, Kadomka, Sarga, and Slyudyanaya Mt., in the vicinity of Chernovskoe and Vetoshkino. It is again emphasized that we found the dark-brown clay only on level and relatively very high sites at the tops of slopes.

On the basis of the above we concluded that in an overwhelming majority of cases the formations are not diluvial clay but bedrock Jurassic formations which were altered in situ[1] by various agents (including vegetation, water, CO_2, and the influences of the glacial period).

However, the black-brown clays do not occur continuously over the entire territory of Jurassic deposits in the eastern half of the P'yana divide. Even if we assume that the central, most elevated portion of the territory in question was never covered by an independent diluvial layer (there are areas of this kind in Russia) these dark brown clays (the color of which is due mainly to ferrous oxide) must have undergone oxidation, leaching of the $CaCO_3$, and translocation by water into various depressions even prior to the formation of soils and partially also during their formation. In the depressions the weathering products, in the form of red-brown and yellow-brown clays, were able to form accumulations of 2 sazhens [4.3 m] and more in thickness. It is known that even water-deposited chernozem forms layers of up to 1 1/2 sazhens [3.2 m] thick in certain parts of the Nizhni Novgorod Province; despite the fact that the soils are protected by fairly strong sod. Obviously, if the surface of dark brown Jurassic clays were strewn with northern pebbles, the latter could easily find their way into the water-deposited yellowish-red loams. It is also obvious that these loams may be laminated and even contain sand intercalations in certain places, under certain conditions of formation, while in other places they may be free of lamination. Probably, this is the origin of the reddish-yellow loams encountered in places in the center of the regions under consideration, especially on its northern and southern margins. A few instances are presented below.

The northern margin of the P'yana divide in its eastern half.

The village of Mozharki. Here, at the right bank of the P'yana (which is very bluffy) the following section is found:

a) yellowish - brown homogeneous loam, free of boulders, but with "zhuravchiks", 3 sazhens [6.4 m] thick;

b) a horizon containing a random mixture of the abovementioned loam with irregular lumps and fragments of the underlying rock, 3 feet [0.9 m] thick;

c) stony marls of various colors (variegated), 4 sazhens [8.5 m] thick.

From the cornice of this bluff one sees that the terrain continues its gradual southward rise. The village of Mozharki is located on this slope. Diffuse exposures of the same loam (a) were visible in the ditches along the streets of the village. Finally, on the road leading from Mozharki to Akuzovo, at one of the highest points in the neighborhood, indistinct outcrops of dark bluish Jurassic marls and "zaklech'" are seen.

Identical patterns are encountered at the village of Shubino and at Staraya Berezovka, on the northern branch of the P'yana.

[1] I am of the opinion that Prof. Möller's "black diluvial formations" are of the same age. Ibid.

The southern margin of the P'yana divide in its eastern half.

The sections found along the southern branch of the P'yana (variegated rocks, Jurassic formations, red-brown loam, "zaklech'" are replicas of those found on the northern margin. The following cases may be mentioned: a) Vetoshkino, b) Lush-Pomra (Baron Zhomini's farm), c) a spot 1 1/2 versts west of Zaist, d) a spot one verst east of Chernovskoe and e) Sarga.[1]

The only significant difference between all these sections is that at certain points (A and B) this loam overlies variegated marls, while at other points (C, D and E) it overlies dark-blue Jurassic marls. Its color, however, remains the same reddish-yellow, which is another indication of the mode of origin described above. Northern boulders were not observed in this loam, although they may undoubtedly occur. Throughout the neighboring fields this loam is overlain by "zaklech'", and in places also by dark-brown clay.[2]

Ten to fifteen versts north of the southern branch of the P'yana, toward the crest of the divide, Sibirtsev reported that deposits of a yellow-brown clay are exposed on hill-slopes at Zagarina, Kitovo, Mozharki, Akulinina, etc., whereas "zaklech'" occupies points higher up. Sibirtsev adds that the soil at the top of a slope may be dark, taking on a brownish tinge and even becoming completely brown lower down the slope. Only at one point on the entire territory (at the village of Aleksandrovo) was Sibirtsev successful in observing boulder-containing deposits, clayey or sandy, in pits and ditches only a few feet deep. I found boulder material (diorite, granite, Shoksha sandstone) at some spots on the fields in the form of small pebbles (not larger than a fist) in the southernmost part of the region as well. In some places the yellowish loam contained numerous "zhuravchiks".

In my opinion, all these stratigraphic features of "black-brown clay and yellowish-red or light-yellow loam" to a certain extent confirm my view regarding their age and origin. The following facts also indicate the relationship between the formations: the black-brown clay is incomparably richer in calcium carbonate than is the yellowish-red loam; the former contains a great deal of ferrous oxide while the latter contains only the ferric oxide or only traces of the ferrous oxide; as a consequence, their other properties are likewise different.

The diluvial formations in the western half of the P'yana divide (west of the Inkino meridian) everywhere overlie various "variegated rocks" and partly also Permian limestones (Barnukovo, Ichalki, etc.) and according to all their features can be classified with the type of light-yellow loam which is so widespread between the Volga and the P'yana. There is therefore no need to discuss this area in special detail. Finally, it should also be noted that in the dark-brown clay and the yellowish loam in the eastern

[1] The Vetoshkino loam and that at Zhomini's estate even contain lumps of alabaster and palygorskite about 1 1/2 foot [15 cm] in diameter.

[2] About 2 versts west of Zaist near the village of Svirina, the P'yana valley is joined by a gully from the north. Prof. Meller observed an entire suite of Jurassic rocks in the walls of this gully, overlain by clayey deposited sand, 24 feet [7.3 m] thick, light-gray, with rare boulders of red quartz sandstone reaching 1 1/2 feet [45 cm] in diameter (ibid., p. 21). When this gully was examined by Sibirtsev and I last summer, it was completely obscured by debris of landslides. Only at its very apex did I see 15–20 feet [4.5–6.1 m] of grayish-yellow sand with blocks of fairly loose light-gray sandstone reaching 1 sazhen across jutting out from the lower horizon. I also found numerous boulders of the same rock in the neighboring fields. I doubt the diluvial nature of these sands. Author.

half of the region typical krotovinas occur rather frequently (Shubino, Kadomka, Kitovo, Kochunovo, Lush-Pomra, etc.); in the western half of the region such krotovinas were encountered (by Sibirtsev) only once, in the vicinity of Ichalki.

We shall now discuss the diluvial deposits of the P'yana — Alatyr — Tesha divide. Similar to the region described above, this area can also be conveniently subdivided into two unequal parts. In the eastern part, the deposits are underlain exclusively by Jurassic formations, whereas in the western part the latter occur together with the group of variegated rocks which completely replace the Jurassic deposits in the northwestern parts of the region.

The structure of the diluvium in the eastern half of the region, as well as of the deposits of the Alatyr — Rudnya divide, has been partly discussed above. Moreover, the diluvial formations of these areas are essentially the same as the deposits of the so-called Tatar lands. The only difference is possibly the somewhat wider occurrence of light-yellow or reddish-brown loess loam and the more frequent occurrence of northern boulders.

According to the sections — down to 2 sazhens [4.3 m] and deeper — at Barnukovo, Vorontsovo, Gagino, Apraksino (along the southern branch of the P'yana), Obrochnoe, and between Stepanovka and Kemlya (on the Alatyr), the same uniform yellowish-gray loam forms, with very rare exceptions (Knyazh-Pavlovo), the very gentle southern slopes descending to the Alatyr and the P'yana; the relief of these slopes was described by us in the transverse sections.

The diluvial formations in the western half of the P'yana — Alatyr — Tesha divide, and partially also south of the Tesha, are totally different. Here, two diluvial stages are exposed in many localities, a clay upper stage and a sandy lower stage; both include small but numerous northern boulders. Diluvium of this type occurs approximately from the meridian of the upper reaches of the minor rivers Cheka and Pekshat) and becomes more distinctly developed in the westward and (especially) the southward direction.

In addition to the sections described by Prof. Meller, we would point out the sections of diluvium at the villages of Lukoyanovka, Mikhailovka, Silino, Neverovo, Arat, and Velikii Vrag.

In one of the gullies (Platonov gully) at the village of Lukoyanovka, we encountered a section of a gray-yellow sand with brown, partly laminated ferruginous intercalations, but without visible $CaCO_3$ inclusions and without boulders; the thickness of the outcrop was 2 sazhens [4.3 m].

At the southeastern end of the village of Mikhailovka stretches a narrow but deep gully with almost sheer walls. In this gully the soil layer 1 foot [30 cm] thick is underlain by a yellow-brown diluvial deposit which is at least 6 sazhens [12.8 m] deep. The upper horizon is reddish, clayey, approximately 4 feet [1.2 m] thick, while the lower, reaching to the very bottom of the gully, exposes only clayey-sandy deposits with intercalations of pure yellowish sand and numerous boulders of fine-grained granite, quartz, hornfels, pink and red sandstone, white quartzite, and diorite, reaching a foot [30 cm] and more in width. Sand intercalations are especially frequent at the bottom of the bluff; the sand is not very fine, the grains being about half a "liniya" [1.25 mm] in diameter.

At the village of Silino, in the Bol'shaya Vyazovka gully, Prof. Meller observed a section of a deposit similar to that at Mikhailovka. The deposit was underlain by marl one foot [30 cm] thick. The same was also observed in the gullies Dal'nyaya Vyazovka and Vysotinskii Vrag. At the village of Nererovo, on the bluffs on the left bank of the Psha River (opposite the church), there is an exposure of variegated marl containing a yellowish-gray highly sandy deposit 4 sazhens [8.5 m] thick. It contains rare and small boulders of hornfels and quartz, and many sandy concretions of irregular, mostly rounded shape, hollow inside and containing yellowish fine sand. The diameter of these concretions varies from 1 — 3 1/2 inches [2.5 — 8.9 cm].

Immediately west of the same village, also on a bluff on the left bank of the Psha, the following section of a deposit was observed: the soil layer, 1 foot [30 cm] thick, is underlain by a brownish-gray clay 4 1/2 feet [1.4 m] thick containing rare boulders of granite, hornfels, and sandstone, 2 — 3 inches [5 — 7.6 cm] in diameter; this is underlain by a sandy deposit 3 1/2 — 4 sazhens [7.5 — 8.5 m] thick; this sand is of brownish, yellowish, or white color, partly bedded; it contains an admixture of clay and numerous boulders of granite, quartz, hornfels and quartz sandstone; the boulders were not very big, ranging from a few "liniyas" to half a foot [15 cm] in width; in some places boulders are so numerous that they form a kind of pebble-bed.

North of these localities, nearer the P'yana, diluvium is represented by yellow-brown sandy-clayey deposits. On the Arat River, in the vicinity of the village of the same name, a section was encountered of loess-like diluvium nearly 5 sazhens [10.6 m] thick.

The structure of this section is as follows:

1. Soil layer, 1 foot [30 cm] thick.

2. Yellow-brown clay with an admixture of sand, with numerous krotovinas, 4 feet [1.2 m] thick.

3. Brownish-yellow, clayey sand, with intercalations of grayish clay and (in the lower horizons) of light-yellow, whitish and brown ferruginous sand, of total thickness 28 feet [8.5 m].

These beds contain rare small boulders of hornfels and quartz. Moreover, calcareous concretions 1 — 2 inches [1.3 — 5 cm] in diameter are often encountered. The sand and clay intercalations are slightly contorted.

By the Serdem River, near the village of Velikii Vrag, clayey grayish-yellow sand, approximately 5 sazhens [10.6 m] thick, with numerous boulders of quartz, hornfels, diorite, and sandstone, overlies variegated marl. The same phenomenon is observed in the basin of the Serdem as well as at the village of Bol'shie Pecherki. A granite boulder 3 feet [91 cm] wide and several boulders of red sandstone and diorite 1 — 2 feet [30 — 61 cm] wide were found in the village itself, and a boulder of shelly Permian limestone of Ichalki type, as much as a foot in width, was found approximately 1 1/2 versts from the village.

In the basin of the Alatyr — Tesha — P'yana, we did not succeed in finding any organic residues directly in the diluvium. Here, too, such residues were found either on the bottom of a gully or more frequently amidst alluvial deposits.

In concluding the discussion of the deposits in this area, I would add that krotovinas were encountered fairly frequently (in the loam) and mainly in the chernozem zone, as was the case in the entire southeastern part of the Nizhni Novgorod Province.

Alluvial formations of the southeastern part of the Nizhni Novgorod Province. As might be expected, the alluvium in this area, like the analogous formations in the rest of European Russia, is conditioned by the underlying rocks to a far lesser extent than is the diluvium. Alluvium is uniform almost throughout the above-mentioned regions of the Nizhni Novgorod Province, as regards both its fossils and its appearance and situation. For this reason, all these formations should be described together.

The principal feature distinguishing the alluvium in this area from similar deposits in northern and central nonchernozem Russia is its occurrence almost exclusively in river valleys. In the southeastern part of the Nizhni Novgorod Province, alluvium rarely occurs on the neighboring divides in the form of bogs and extinct lakes which are so widespread in northern Russia. During our four excursions last summer, purely lacustrine deposits were encountered by us only 2 or 3 times.

At the very boundary between the Knyaginin and Makar'ev districts, about 3 versts north of the village of Sintseva, Ferkhmin observed a fairly deep, closed depression in a forest, 10 – 15 sazhens [21 – 32 m] wide. Probably the entire depression is filled with lacustrine deposits. Its uppermost, highest part contains artificial exposures 2 arshins [1.4 m] wide and up to 7 sazhens [15 m] long. Here the vegetal layer was directly underlain by a continuous freshwater limestone, light-gray in color, of various shades. The limestone is highly porous, very lightweight, abounding in freshwater shells, and probably of a fairly pure composition; this limestone is used for the production of lime.

I encountered a similar case near Kemlya, in the Lukoyanov District, on Filosofov's estate: Here, approximately 3 versts west of Kemlya, on slightly rolling terrain, there is an insignificant but wide slope incised by the Uryupinskii gully. In the upper third of this gully one finds a nearly vertical section 20 – 30 sazhens [43 – 64 m] long; at one point this section displays the following structure:

a) slumped chernozem, 1 1/2 – 2 feet [45 – 61 cm] thick;

b) grayish-white, very loose and light shelly marl with freshwater shells of near microscopic size and so delicate that they are pulverized by the mere touch of the fingers. The marl mass contains a few isolated, very thin (1 – 2 inches [2.5 – 5 cm]) intercalations of peatlike deposits which are interrupted after a short distance; the total thickness of the layer is 6 feet [1.8 m];

c) peat, in some cases very pure and of good quality, in others earthy with admixtures of black and bluish clays; both types contain thin, irregularly shaped veinlets of the abovementioned marl; the total thickness is 6 – 7 feet [1.8 – 2.1 m];

d) blue and black extremely plastic viscous clays with an abundance of vegetal residues with a very large number of grayish-white marly spots. This layer also constitutes the bottom of the gully and its thickness is 10 feet [3 m].

The layers mentioned above form imperceptible transitions, and there are continuous variations in their composition in the horizontal direction.

Another very characteristic feature is that today the site of occurrence of these very interesting freshwater formations (which are also of practical significance) is not a closed depression but the upper portion of a slope; obviously, when this area was a lake the local topography had been quite different.

Possibly a third instance of purely freshwater-paludine deposits is on the sides of the Krasnyi Vrag gully, at a distance of half a verst from Azrapino. According to Zemyatchenskii's observations, the sides of this gully, 1 – 2 sazhens [2.1 – 4.2 m] high, contain an abundance of ligneous residues, roots, branches, bark and even whole tree trunks, the diameter of one such trunk being 8 inches [20 cm]. Most of these residues are mostly half decayed; completely black, charred trees were also found; they all occurred in the grayish silt which constitutes the sides of the Krasnyi Vrag gully.

No other purely lacustrine deposits were found, and even those mentioned above obviously occupy comparatively insignificant areas. It may be added that meadows and bogs are extremely rare on elevated sites in the south-eastern corner of the Nizhni Novgorod Province. Undoubtedly, this is one of the characteristic features of the chernozem zone of Russia.

Thus, in order to study the alluvium of this locality we must examine the river valleys, but even these cannot provide a great deal of information, since the local river valleys correspond to the general type of nearly all the Russian rivers.[1] The P'yana, the Alatyr, the Tesha, and all the other major and minor rivers of the territory under consideration flow across a fairly wide (from a few dozen sazhens to 2 – 3 versts) floodplain, usually including a large number of oxbow lakes. Most of the Alatyr valley, and the P'yana valley at Sergach, Ichalki, etc., contains almost pure sand; in other places they are boggy and rich in peat (the Imza at Knyaginin, the Rudnya at Pochinki, the Alatyr between Kendya and Kochkurovo, and especially the Styrsha River, etc.) which is always underlain by bluish, viscous clay. In a majority of cases, however, in the fluvial formations sand and clay layers alternate; this structure is very clearly exemplified by the banks of the Azanka between Sloboda and Pogibelka, where Sibirtsev described the following typical section:

a) slumped soil layer, 1 1/2 feet [45 cm] thick;

b) dark-gray clay with numerous ferruginous tubules between a "liniya" and half an inch [0.25 – 1.25 cm] in diameter; many tubules retain residues of plant roots; the thickness of this layer is 3 feet [91 cm];

c) brownish clay with similar tubules, 2 feet [61 cm] thick;

d) dark clay with similar residues, 2 1/2 feet [76 cm] thick;

e) brown clay with soft and less abundant ferruginous tubules, 3 feet [91 cm] thick;

f) yellow-brown diluvial clay with few boulders of hornfels and Shoksha sandstone.

The mode of formation of such deposits is very well illustrated around the Novozhenka River in the vicinity of the villages of Durova and Surochki. According to information supplied by the local inhabitants, this was once a true bog in which a very insignificant brook made its way in the form of a chain of half-overgrown depressions. The channel of the brook gradually became deeper; the bogs were thus naturally drained and dried, the quantity and velocity of water in the Novozhenka increased, and the brook was even divided by islands into separate channels. Sibirtsev reports that the present banks of the Novozhenka are about a sazhen high at this site, composed at the base of the bluish-gray bog "suglei" with numerous residues of paludine plants, and at top of the fluvial silty deposits which

[1] Dokuchaev. Sposoby obrazovaniya rechnykh dolin Evropeiskoi Rossii (Modes of Formation of River Valleys in European Russia). 1878.

become thicker each year during the springtime floods; a belt of brown silty formations was seen at the center of the section, the color being due to the very high content of ferric hydroxide.

As everywhere else, the slopes bounding the alluvial valleys are high and bluffy on one side, gradual and low on the other. Mostly the low banks gradually merge with the neighboring water divide; nevertheless, in some places (e.g., in the valley of the Rudnya between Azrapino and Pochinki and partially also along the southern branch of the P'yana) these low banks are also terraced. Unfortunately, as yet I have had no opportunity of observing the structure of these terraces.

Such are, on the whole, all the river valleys in the southeastern part of the Nizhni Novgorod Province[1]; it may be added that mammoth and rhinoceros bones are fairly frequently found in the local river deposits, as in the rest of Russia, yet we have never observed these residues in situ.

Formations of indeterminate age in the southeastern part of the Nizhni Novgorod Province. The formations of the sandy territory in the Sergach District, between the P'yana on the one side and the Anda River and the villages of Bereznya, Fominki and Pogorel'ski-Maidan on the other, are even more controversial than the above sands of the Alatyr basin. Over almost the entire region[2] only quartz sand occurs on the surface and in the gullies; the sand is pure, loose and drifting in the eastern part of the territory, but more compact and clayey in the western half. The sand contains neither fossils nor northern boulders, and displays no relationship to the topography. At the top, these formations form a direct transition to soil, and they are underlain by variegated rocks.

The structure of the sand is illustrated by the following two sections:

1. Gully on the Buza, along the highway leading from Sergach to Yanovo, approximately 3 versts southwest of the Sergach.

a) fine light-gray dune sand, 1 foot [30 cm] thick;

b) black dune sand mixed with coal particles, occurring only in certain places, 2 feet [61 cm] thick;

c) bedded coarser quartz sand, 12 feet [3.6 m] thick;

d) variegated stony marls, multicolored at top, 10 feet [3.0 m] thick.

2. Gully at the village of Tolba. According to Ferkhmin's description, the sandy vegetal layer is directly underlain by a) light-gray quartz sand which forms a gradual downward transition to b) red-brown ferruginous sand with a characteristic false striation of the Bol'shoe Murashkino type. The total thickness of these sandy formations reaches 3 sazhens [6.4 m]; at the base of the section there are variegated marls of various colors and sands about 1 1/2 sazhens [3.2 m] thick.

All other sections which we saw in this region are the same as the above two sections, though less instructive.

It would, therefore, be difficult to attempt to establish the age of these sands. In our opinion, the following facts might serve as a certain indication. These formations, occupying an almost continuous area up to 20 — 30 versts long and 10 versts wide, are found on water divides as well as lowlands, a rare phenomenon in the region of diluvial sands. In the region under consideration there are neither northern boulders nor diluvial light-yellow loam which is so widespread north and southwest of the northern

[1] Because of the many sinkholes in the P'yana valley, the structure and formation of this valley have certain specific features, but these need not be discussed in detail at this juncture. Author.

[2] With the only exception of the environs of Sergach (north), Kladbishche, Kuz'minka, Tombulatovo and Maloe Andosovo (east).

branch of the P'yana. The region of sand forms an "island" amid variegated rocks and Jurassic deposits, bedding completely conformable with the former. As we have seen, in the vicinity of Tolba these beds even form a transition to sand deposits of the system of variegated marls.

It would be almost equally difficult to establish the origin of the quartz sands stretching along the northern banks of the southern and northern branches of the P'yana. The transverse sections [Figures 1 — 2] show that the northern slopes descending towards the P'yana are relatively very steep and rise toward the water divide line in very irregular terraces. The sands in question at various heights cover these terraces; in some places they are continuous, but more frequently they alternate either with diluvial loams or with fairly large bare patches (on hummocks) of bedrock. Therefore it is difficult to assess the true width of this belt, which is half a verst wide in some places, but in others may reach 3 versts and more. In some instances this belt merges with the sands of floodplains, but mostly they are separated by bluffs formed by variegated rocks and Permian limestones. The sands merge with the Tolba sands between Semenovskaya and Staraya Berezovka, as well as between Yanovo and Pustyn'ka.

I crossed this belt, in the region of the northern branch of the P'yana, six times: between station Berezovka and Maloe Andosovo, between Yanovo and Sergach, between Pustyn'ka and Krutets (the width being 2 — 3 versts from Pustyn'ka), between Kamenishchi and Yakovleva (1 verst), Vaglusy and Bakaldy (approximately 3 versts from the former), between Perevoz and Velodemanovo (approximately 1 verst). In the region of the southern branch of the P'yana I saw this belt at Surochki, at Baron Zhomini's farm, west of Vetoshkino, between Barnukovo and Pogibelka (3 versts), between Ichalki and Myrmyzhi (approximately 2 versts from the former, in the form of bare patches of sand). Unfortunately, neither I nor my assistants succeeded in observing sections in this belt. I can only state that the occurrence of northern boulders is more frequent on these sands than anywhere else in the southeastern part of the Nizhni Novgorod Province.

In view of the above, it would be difficult to state the age and origin of these sands. Nevertheless, there are grounds to assume that they are eluvial and were produced by the reworking of local formations, some older and some diluvial. Our conclusion was drawn on the basis of the following circumstances:

1. Northern boulders are particularly abundant in these sands.
2. These formations occur on the high banks of the P'yana where obviously the erosion of clay, $CaCO_3$, and humus must have been the most vigorous.[1]
3. A similar phenomenon is observed throughout the southeastern corner of the Nizhni Novgorod Province wherever the topographic conditions are suitable. For instance, Sibirtsev observed that all the high banks of all the left tributaries of the southern branch of the P'yana are covered by soils, both chernozem and nonchernozem, which contain considerable amounts of coarse quartz granules. An example in the chernozem zone is the Norma River at the Akhmatovo station, where a belt of very dark, yet quartzy-granular soils stretches along the high bank, or the Ezhat River

[1] For obvious reasons, this phenomenon cannot have been as vigorous on the gentle southern slopes toward the P'yana. Moreover, the gentle slopes were simultaneously subjected to the reverse process, the deposition of clay and humus. Nevertheless, in certain places (at Gagino, opposite Surochki, Lomakino, at Yur'ev, etc.) a certain enrichment of the soils was observed on these slopes too.

at the village of Ushakovo, where the same phenomenon is even more pronounced. Within the belt of forest soils, one may indicate the high bank of the Ezhat opposite the village of Chirgushi, to the slope descending toward the Aratka, at Sychenki, etc. The same pattern is presented by the gullies. If the divides between the rivers are narrow, they may be completely covered by soils which contain more sand than does the normal vegetal soil of the same type. Sometimes the eluviation of clayey particles from soils proceeds so energetically as to leave nearly pure quartz sand in situ. This phenomenon is marked on especially steep and hummocky slopes descending toward the rivers.

Many similar instances were observed by my other companions during the excursion of 1882 over the entire southeastern part of the Nizhni Novgorod Province.

Thus, all — or at least a very considerable part — of the sands under consideration must be classified with Trautschold's eluvium.

Soils of the southeastern part of the Nizhni Novgorod Province. My pedological investigations of this area were performed mainly in the summer of 1882, whereas my schematic soil map was first submitted to the Free Economic Society in December 1881.[1]

I therefore became extremely interested in soil investigations of the Nizhni Novgorod Province because they would serve as a check and application of my scheme to a particular case ... This interest was enhanced still further by the following specific features of the area selected for our studies.

The southern half of the Nizhni Novgorod Province lies just on the northern, the most complex boundary of the chernozem zone of European Russia.

The soils of this particular territory were the subject of the largest number of controversies among our investigators and the latest investigations[2] even completely denied the presence of true chernozem in this area.

Since the time of Prof. Meller's work, this region is known to contain at least four different formations in addition to the deposits. One of these formations, the Jurassic formation, even includes combustible shales which contain up to 19% volatiles.[3]

Meller was also the first to establish the fact that the deposit itself, which commonly serves as parent rock for the soils in this area, can be divided into three significantly different types: sands, yellowish-red loams and dark-brown clays.

It is obvious, therefore, that the variety and various deviations of soils in the territory under consideration must have been affected. If one also takes account of variations in the topography and vegetation, it is easy to understand my scientific interest in investigating the soils in the southeastern part of the Nizhni Novgorod Province as well as my misgivings with regard to the applicability of my own scheme. For this reason, as well as on account of the desire for a detailed study of the effect of various geological factors on the soil, the scope of the present chapter is broadened.

In the course of this detailed investigation, I crossed the southeastern part of the Nizhni Novgorod Province without my assistants, along four routes, with the results presented in the following table.

[1] Dokuchaev. Skhematicheskaya pochvennaya karta chernozemnoi polosy Evropeiskoi Rossii (Schematic Soil Map of the Chernozem Zone of European Russia). 1882.

[2] Meller. Ibid., p. 32.

[3] Meller. Ibid., pp. 62, ff.

Soils of the Southeastern Part of the Nizhni Novgorod Province
First, easternmost route

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
1. 5 versts south of Lyskovo, in the Makar'ev District	Level field, heavily manured.	7" [18 cm]	1.140	—
2. Ratutino, in the Knyaginin District	Ditto	10" [25 cm]	—	—
3. Ostrovskoe, in the Knyaginin District	Ditto	1'1" [33 cm]	3.495	2.158
4. Dolgoe, in the Knyaginin District	Ditto	1'2" [35 cm]	—	—
5. Troitskoe, in the Vasil'evo District	Ditto	1'5" [43 cm]	4.01	2.53
6. 4 versts northwest of Leshchevka, in the Vasilevsk District	Middle of a gentle slope	1'9" [53 cm]	—	—
7. Stolbishchi, in the Sergach District	Top of a gentle hill, on "zaklech'"	7" [18 cm]	7.71	3.49
8. Stolbishchi, in the Sergach District	Bottom of a slope	1'4" [40 cm]	—	—
9. 1/2 verst north of Tombulatovo in the Sergach District	Level site	1'11" [58 cm]	7.28	3.59
10. At Bol'shoe Andosovo, in the Sergach District	Very gentle slope decending toward the Anda River	1'8" [50 cm]	—	—
11. 1/2 verst north of Starinskoe, in the Sergach District	Tilled field at lower third of the slope	1'11" [58 cm]	11.00	5.06
12. 1 1/2 versts south of the station of Berezovka, in the Sergach District	Level tilled field, typical chernozem	2'6" [76 cm]	10.08	4.50
13. The same site	Forest soil.	1' [30 cm]	4.21	1.53
14. Between Akuzovka and Berezovka	Left bank of the P'yana, sandy eluvium	1' [30 cm]	—	—
	Second route			
15. 5 versts south of Lyskovo	Left bank of the P'yana sandy eluvium	7" [18 cm]	1.140	—
16. Ratutino, in the Knyaginin District	Ditto	10" [25 cm]	—	—
17. At village of Solov'eva, in the Knyaginin District	Manured tilled field, middle of a gentle slope . .	1'4" [40 cm]	4.653	1.58
18. At village of Noven'kaya, in the Knyaginin District	Tilled field, middle of a gentle slope	1'3" [38 cm]	6.138	2.26
19. At Potapovo, in the Knyaginin District	Ditto	1'5" [43 cm]	5.52	2.95
20. 3 versts north of Krutets, in the Knyaginin District	Elevated level tilled field	1'2" [35 cm]	—	—
21. 1/2 verst northwest of Tolba, in the Sergach District	Middle of a gentle slope	1' [30 cm]	2.265	0.667
22. 3 versts north of Mokryi Maidan, in the Sergach District	Tilled field on the lower third of a slope	1'2" [35 cm]	—	—
23. 4 versts north of Pogorelovskoe, in the Knyaginin District	Old oak forest on a level site	8" [20 cm]	5.91	2.29
24. At Pogorelovka	Level tilled field	8" [20 cm]	—	—
25. Approximately 2 versts north of Sergach	Ditto	10" [25 cm]	—	—
26. The Buza at Sergach	Level pasture.	4" [10 cm]	—	—
27. 1 verst south of Yanovo, in the Sergach District	Tilled field on a slope . .	1'9" [53 cm]	7.10	3.40

Second route (continued)

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
28. At the village of Shubina, in the Sergach District	Level long fallow land near the bluff toward the P'yana	2'2" [66 cm]	10.40	—
29. 1 verst east of Tartalei, in the Sergach District	Plowland at the bottom of a gentle slope	2'6" [76 cm]	7.17	4.00
30. The same site	Top of a slope	9" [23 cm]	—	—
31. 1 verst west of Urazovka, in the Sergach District	Level tilled field	1'9" [53 cm]	—	—
32. 1 verst north of Endovishche, of the Sergach District	Level long fallow land. . .	2'10" [86 cm]	9.877	3.871
33. 11 versts north of Mangushevo, in the Sergach District	Ditto	2'7" [79 cm]	14.767	5.40
34. At the very edge of Mangushevo	Ditto	2'8" [81 cm]	13.565	4.17
35. 1 verst east of Aleksandrovo	Forest soil.	10" [25 cm]	—	—
36. 10 versts north of Cherpavskoe, between Zagarki and Kitovo, in the Sergach District	Level tilled field	2'4" [71 cm]	—	—
37. 1/2 verst north of Chernavskoe	Ditto	1'8" [50 cm]	8.095	3.041
38. Between Chernavskoe and Churkina, 3 versts from the former	Ditto	1'6" [46 cm]	11.554	3.801
39. Sarga, in the Sergach District	High level field, but near the bluff toward the P'yana	10" [25 cm]	—	—
Third route				
40. 4 versts south of Rabotki, in the Makar'ev District	Level manured plowland .	6" [15 cm]	0.91	0.86
41. Chernukha, in the Knyaginin District	Level tilled field	8" [20 cm]	3.41	2.04
42. Gorodishche, in the Knyaginin District	Ditto	1' [30 cm]	—	—
43. 1/2 verst west of Kholyazina, in the Knyaginin District	Tilled field, middle of a gentle slope	1'4" [40 cm]	7.88	—
44. Grigorovo, in the Knyaginin District	A field at the bottom of the slope descending toward the Udomka River	1'1" [33 cm]	7.54	2.448
45. 1 verst north of Murashkino	Level tilled field	1'6" [46 cm]	5.85	—
46. 5 versts south of Bol'shoe Murashkino	Middle of a gentle slope, long fallow land.	1'3" [38 cm]	—	—
47. The same site	Top of a slope	9" [23 cm]	—	—
48. 1 verst south of Rozhestveno, in the Knyaginin District	Lower third of a gentle slope	1'7" [48 cm]	—	—
49. The same site	Top of a slope	8" [20 cm]	—	—
50. Approximately 10 versts northwest of Buturlino, in the Knyaginin District	Old forest on a level site .	9" [23 cm]	3.91	2.41
51. Immediately north of Malye Valgusy	Ditto	9" [23 cm]	—	—
52. Between Malye and Srednie Valgusy (Volgly), in the Knyaginin District	Field at the middle of a gentle slope	1'6" [46 cm]	—	—
53. 2 versts south of Buturlino	Field at the middle of a gentle slope	1'6" [46 cm]	—	—

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
54. Approximately 3 versts southeast of Uvarovo	Elevated level site, forest soil	1'11" [58 cm]	5.00	2.194
55. Between Yablonka and Pogibelka, in the Knyaginin District	Level site, forests	8" [20 cm]	—	—
56. 1 verst south of Pogibelka, in the Knyaginin District	Level site amidst deciduous forest	8" [20 cm]	—	—
57. Another verst further south	Field at the bottom of a gentle slope	1'6" [46 cm]	—	—
58. Approximately 1 1/2—2 versts east of Barnukovo, in the Knyaginin District	Field on a gentle slope descending toward the P'yana	2'4" [71 cm]	6.32	2.53
59. 5 versts south of Barnukovo	Slope descending toward the P'yana	2' [61 cm]	—	—
60. 1 verst east of Vorontsovo	Ditto	2'6" [76 cm]	—	—
61. 3 versts southeast of Barnukovo	Ditto	2'6" [76 cm]	5.04	3.31
62. 2 versts north of Vetoshkino, in the Sergach District	Elevated level site on "zaklech'"	8" [20 cm]	—	—
63. 7 versts north of Vetoshkino, toward Surki	Ditto	1'4" [40 cm]	—	—
64. Vetoshkino, the Polyanskaya forest estate	Level tilled field	1'10" [55 cm]	8.42	3.58
65. Vetoshkino, approximately 3 versts southwest of this village	Deciduous forest	7" [18 cm]	—	—
66. Opposite Vetoshkino, the Tretnoe plot, on the left slope descending towards the P'yana	Old alluvial valley of the P'yana	3'6" [106 cm]	—	—
67. The same site, the Tyapkinskii farm	Ditto	2'8" [81 cm]	—	—
68. Gagino, in the Sergach District	Southern slope descending toward the P'yana	1'9" [53 cm]	—	—
69. 2 versts south of Surochki, in the Sergach District, on the left bank of the P'yana	Southern gentle slope toward the P'yana	2'6" [76 cm]	—	—
70. Molchanovo, in the Sergach District	Upper third of the same slope	2'1" [63 cm]	4.17	1.93
71. 1/2 verst south of Peresekino, in the Sergach District	Level site, forest soil . . .	8" [20 cm]	—	—
72. Klimovskii farm, south of Peresekino	Level tilled field	8" [20 cm]	—	—
73. 1 verst south of Maresevo, in the Lukoyanov District	Level tilled field cleared of forest	11" [28 cm]	2.68	1.94
74. 1 verst north of Yaz, in the Lukoyanov District	Ditto	8" [20 cm]	4.06	—
75. 3 versts south of Yaz	Forest soil on a level site .	5" [13 cm]	—	—
76. 10 versts north of Kemlya, in the Lukoyanov District	Forest soil with pieces of coal	4" [10 cm]	2.50	0.44
77. Vicinity of Obrochnaya, in the Lukoyanov District	Southern slope descending toward the Alatyr . . .	2'5" [74 cm]	—	—
78. 1 verst south of Kergudy, in the Lukoyanov District	Level tilled field	2'0" [61 cm]	7.20	3.86
79. 1 verst south of Kemlya, in the Lukoyanov District	Southern slope descending toward the Alatyr	3'2" [96 cm]	—	—
80. Stepanovka, in the Lukoyanov District	Level site, field	3" [8 cm]	7.41	5.017

Third route (continued)

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
81. Permeevo, in the Lukoyanov District	Level tilled field	2'1" [63 cm]	9.97	4.96
	Fourth, westernmost route			
82. 3 versts southwest of Slobodskoe, in the Makar'ev District	Manured level tilled field	5" [13 cm]	1.70	0.92
83. 2 versts northwest of Sosnovka, in the Knyaginin District	Ditto	6" [15 cm]	–	–
84. 1 verst north of Kurlakovo, in the Knyaginin District	Ditto	–	–	–
85. 1 1/2 versts south of Vershinino, in the Knyaginin District	Level site at the forest edge	1'3" [38 cm]	–	–
86. Approximately 1 verst south of Vel'demanovo, in the Knyaginin District	Elevated tilled field. . . .	9" [23 cm]	3.5	1.77
87. Polyana, in the Knyaginin District	Manured level field . . .	7" [18 cm]	–	–
88. Zaklyuchnaya, in the Knyaginin District	Ditto	7" [18 cm]	–	–
89. Bol'shie Kemary, in the Knyaginin District	Forest soil	1'2" [36 cm]	–	–
90. 1/2 verst north of Ketrosya	Level tilled field	1'3" [38 cm]	–	–
91. 8 versts north of Ichalki, in the Knyaginin District	Elevated tilled field . . .	5" [13 cm]	–	–
92. 2 1/2 versts north of Ichalki	Summit of a low hill . .	1'2" [35 cm]	5.784	1.835
93. 1 verst north of Sharapovo	Level tilled field	2" [5 cm]	–	–
94. 1 verst north of Kakino, in the Sergach District	Ditto	1'9" [53 cm]	–	–
95. 4 versts north of Itmanovo, in the Sergach District	Southern third of the slope	1'9" [53 cm]	–	–
96. The same site	Upper third of the slope .	8" [20 cm]	–	–
97. Chirgushi, in the Lukoyanov District	Middle of a gentle slope toward the river	1'6" [46 cm]	7.11	2.94
98. Merlinovka, in the Lukoyanov District	Level field	1'2" [35 cm]	6.9	–
99. 3 versts southeast of Tol'skii Maidan, in the Lukoyanov District	Middle of a gentle slope	1'6" [46 cm]	–	–
100. Vasilev-Maidan, in the Lukoyanov District	High level field	1'1" [33 cm]	5.49	3.49
101. 1 verst south of Berezovka, in the Lukoyanov District	Level field	6" [15 cm]	–	–
102. 1 verst south of Bol'shie Puzy, in the Lukoyanov District	Ditto	2" [61 cm]	4.90	2.97
103. Somewhat further south, 9 versts to Pochinki	Ditto	1'8" [50 cm]	6.086	–
104. Apex of the Zapadnyi Vrag gully near Pochinki, in the Lukoyanov District	Level site	2'4" [71 cm]	–	–
105. Pelya-Khovanskaya	Forest, level site	10" [25 cm]	–	–
106. 2 versts south of Pelya Khovanskaya, in the Lukoyanov District	Middle of a slope	2'8" [81 cm]	9.63	4.10

Fourth, westernmost route (continued)

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
107. Simbukhovskii Farm, belonging to Filosofov, near Pela-Khovanskaya	A gentle slope at a forest edge	3' [91 cm]	16.11	6.05
108. Diveev-Usad, in the Lukoyanov District	High field near the bluff toward the Rudnya	2'4" [71 cm]	—	—
109. Between the Maresevo village and the Maresevo Farm	Top of a slope	10" [25 cm]	—	—
110. 1/2 verst south of the village of Maresevo, in the Lukoyanov District[1]	Southern, very gentle slope; lower third	2'8" [81 cm]	—	—

[1] Samples from the southwestern part of the Lukoyanov District will be included in the next section.

The above data and those recorded in my travel logs lead to the following general conclusions concerning the soils in the southeastern part of the Nizhni Novgorod Province:

1. Soils more or less resembling chernozem (containing up to 6% and more humus) extend as far as within 15—20 versts of the Volga.

2. Traversing the northern boundary of chernozem (in the direction NW—SE) there is a general gradual increase in a) the humus content, b) the dark color, and c) the thickness of the soils.

3. An essentially similar phenomenon may be observed when crossing this boundary from west to east. In addition to the preceding table, the data in the following small table confirm statements (2) and (3):

		Mean thickness of soils
1.	Divide between the Volga and the P'yana	1'0" [30 cm]
2.	Eastern half of this region	1'1" [33 cm]
3.	Western half of this region	1'1" [33 cm]
4.	P'yana divide	1'5" [43 cm]
5.	Eastern half of this region	1'8" [51 cm]
6.	Western half of this region	1'1" [33 cm]
7.	Divide between the P'yana and the Alatyr	1'6" [45 cm]
8.	Eastern half of the region	1'5" [43 cm]
9.	Western half of the region	1'7" [48 cm]
10.	Southern slope toward the Alatyr[1]	2'3" [69 cm]

Not all the soils mentioned fit our scheme; this is not only quite natural but even inevitable, because of the reasons given on p. 72. One of the foremost factors interfering with the normal distribution of Russian chernozems is doubtless the petrographic character of the underlying (parent) rocks.

As mentioned before, all the deposits over the territory in question can be readily and naturally classified into the following three main types: a) those lying in the region of Jurassic formations, b) those in the region of the so-called variegated rocks, and c) those among the quartz sands of indeterminate age. These three types of deposits differ drastically in the

[1] I did not divide the territory lying beyond the Alatyr into two halves because of the great difference between the parent rocks east and west of the Rudnya, so that the enormous difference in the soils of these two regions is in this case insignificant. Author.

petrographic, the chemical and the physical respects, and naturally transmit their specific characteristics (composition and properties) to the soils to which they give rise.

Regarding the deposits in the southeastern part of the Nizhni Novgorod Province, types (a) and (c) differ the most sharply from each other. The former is highly clayey, rich in carbonates and partly also in ferrous oxide and organic substances; the latter is poor in all these constituents, but is rich in quartz sand. Consequently, the former is compact and viscous, absorbs and retains large amounts of water, is scarcely permeable to air, and therefore the organic substances in it are well preserved; its natural color is darkish gray. The physical properties of the latter type are diametrically opposite.

The remaining deposits of type (b) occupy an intermediate position in this respect.

Obviously, the vegetal-terrestrial soils which form on parent rocks of so widely differing properties cannot be identical even if all the other conditions of soil formation are the same. Indeed, this is confirmed by the geological and soil maps of the southeastern part of the Nizhni Novgorod Province which are at my disposal. Thus, it has been proven for the first time that not only the deposits, but the soils also are genetically related to the ancient bedrock formations. The strong influence of the bedrock is further indicated by the following two facts.

The unusually rapid increase in humus content in soil occurs on the Tatar lands and partly also in the Zapochinkovskii Territory; consequently, it occurs precisely over the territory where the Jurassic marls and clays participate most intensively in the composition of deposits and often themselves serve as the subsoils ("zaklech'").

The abnormally low humus content coincides with the region of quartz sands. The most vivid examples are the soils of the northern slopes toward the Alatyr, of the Tolba-Andosovo area, of the areas between the Rudnya and the right tributaries of the Moksha, of the steep northern slopes of both branches of the P'yana and of the other rivers and gullies.

However, deviations of the soils from normal cannot be entirely explained by the nature of the parent rock. Between the P'yana and the Volga and over most of the Alatyr—Tesha—P'yana divide the parent rocks are usually fairly similar both in composition and in structure; nevertheless, here too there are very marked variations in soils in some places. What, then, are these places? They are a) the highest portions of the divide, especially where it is narrow, and b) the gentle slopes of river valleys. On the former, the soil is thinner and poorer in humus than would be expected; on the latter, the opposite is true, though with a number of exceptions. There is no doubt that the main causes of this phenomenon are the topography and partly also the vegetation.[1]

The water divide between the Sundovik and the Imza, the region between the upper reaches of these rivers and the northern branch of the P'yana, the western half of the P'yana divide and the eastern part of the Alatyr—P'yana area (see the sections) and many other areas are poorer in humus than might be expected on account of the grounds and the geographic position. They are always elevated plateaus, usually very hilly, for the most part dry and sometimes rich in eluvial sand. These conditions inevitably lead

[1] The age and the absolute elevation of the area in question cannot have any influence in this respect because these two soil-forming factors are nearly uniform in the southeastern part of the Nizhni Novgorod Province. Author.

to the runoff of atmospheric waters in nearly all directions; sometimes this runoff is very strong. Obviously, this was not conducive to the accumulation and uniform distribution of humus over these areas. For this reason, it may be accepted as a general rule that the narrower and more hilly the water divide, the thinner and lighter the soils, and the poorer they are in organic substances (see lists). Obviously, the entire area of these water divides is not hilly, and it includes level terrain on which vegetal-terrestrial soils can form in situ. Indeed, such level areas are fairly frequent on these water divides, but remarkably they, too, are devoid of normal chernozems, and are instead covered throughout by soils of various shades of chestnut 6--12 inches [15—30 cm] thick, containing 3—6% humus; their transition horizon (hor. B) usually consists of soil of nuciform structure[1] reaching half a foot [15 cm] in thickness. Apparently, these characteristic soils have long been known to Plagge (former head gardner of the Botanical Gardens of the Kazan University). He described them as follows. In the north of Pochinki and "the Alatyr River, especially between Ardatov, Arzamas and Lukoyanov, one frequently encounters black (when moist ?) soil on elevated sites which are devoid of forest; this soil is of an insignificant thickness, only 2—3 1/2 inches [5—9 cm], and forms a gradual transition (?) to a thick infertile gray subsoil (soil of nuciform structure ?) usually underlain by several sazhens of heavy clay which, in turn, in places covers an excellent yellow gravel used to cover garden paths. The Mordovians report that such black soil was formerly covered by oak forests which were cut down by the ancestors of this tribe. Consequently, such soil may be leafmold. Plagge observed that very large oaks still grow in the neighborhood and that oak forests grow on good black leafmold which forms a downward transition to the above-mentioned gray infertile (?) soil underlain by clay."[2]

I myself found such soil and subsoil in many parts of chernozem Russia under forests. The same vegetation, the same oak, linden, filbert, birch, rowan, and other deciduous trees have also been preserved, mainly on water divides, in the southeastern part of the Nizhni Novgorod Province. Incidentally, I consider that thus this vegetation has an unfavorable effect on the development of soils on the territories under consideration. I will return to the general discussion of this subject, but meanwhile I would draw the reader's attention to the above list of forest soils, making special mention only of two or three instances selected from those observed by myself.

In the Knyaginin District, between Pogorelovka and Krutets, 4 versts north of the former, a small oak grove is preserved on an elevated but

[1] In this area, as in many other localities in Russia, the term "soil of nuciform structure" ["orekhovaya zemlya"] is applied to soil or subsoil of ashen color which readily crumbles into spheres or irregular polyhedra the size of which is usually less than that of a small nut.

[2] Ruprecht. Ibid., pp. 49—50. The following information was furnished by Plagge concerning the fertility of the three horizons: "1) the upper black layer of the soil is especially suitable for clover, vetch, mustard, woad, tarweed, and poppy; 2) if the black layer is completely removed and the gray infertile subsoil is turned with a spade or a plow, in the first year it will be unproductive; however, the following year, after large lumps of this soil have been frozen in winter, harvest will be large, even more so if farmyard manure, black soil or clay (?) is added and thoroughly plowed under. After prolonged cultivation and manuring this earth becomes darker in color and can be seen in the vicinity of villages; 3) orchards where pure light-colored clay has been brought to the surface by deep plowing, while the black earth was plowed under, yield excellent fruit already in the first year."

perfectly level site, some of the oaks reaching 9 feet [2.7 m] and more in circumference; the ground is light loam. Here, the brown layer of leafmold, 2—4 inches [5—10 cm] thick, is underlain by hor. B which is soil of nuciform structure 6—8 inches [15—20 cm] in thickness.

I found another vivid example in the environs of the village of Vetoshkino in the Sergach District, where V.A.Pashkov's estate still includes as much as 2,000 dessiatines of old deciduous forest. As we have seen, the subsoil is in places even "zaklech'". Here, too, the forest soils were of the abovementioned structure, very thin and poor in humus.

The territory from Pechi to Rubavy (Lukoyanov District), as well as the area east of Nikol'skoe, is still covered to the extent of many thousands of dessiatines by thick, often completely impassable, deciduous and coniferous forests. These are the remains of the once famous woods of timber of which was suitable for shipbuilding; even now there are many areas where the windfall is never removed and decays in situ; the ground is sandy loam or sand throughout, and the thickness of the soils is 4—6 inches [10—15 cm].

Essentially identical characteristics are found in all the forested areas of the Nizhni Novgorod Province, although in certain places the thickness of the soils (horizons A and B) reaches 1 1/2 feet [45 cm]. When soils of this kind are brought under cultivation, their leafmold is partially oxidized by the air and partially becomes mixed with the subsoil. The result is a thin grayish-chestnut soil which occurs very frequently in the southeastern parts of the Nizhni Novgorod Province.

Let us now discuss the fate of the humus which is washed off the divides and various steep hills.

Undoubtedly, a considerable portion of this humus becomes completely lost to the soils and to agriculture and finds its way into bogs (though these are very rare here) or fluvial and lacustrine deposits. Another portion of the humus lies fallow in the form of deposited chernozem at the base of steep slopes. Such chernozem, usually alternating with the deposits, sometimes reaches 1 1/2 sazhens [3.2 m] in thickness and may possibly be used as fertilizer in the course of time.

The extent of soil erosion from summits and the thickening of soils at the foot of slopes can be clearly observed in the immediate vicinity of Knyaginin. As already mentioned, the local soils cannot be classified with the typical chernozem; their thickness is about one foot [30 cm], their humus content is often below 6%, and they are gray in color. Figure 3 shows a characteristic section found in the immediate vicinity of Knyaginin in the neighborhood of the graveyard, in one of the brick pits in the lower third of the slope.

Incomparably more useful is the chernozem deposited in a more uniform layer on gentler slopes of river valleys and other inclines. I have already cited several instances of such mixed (partly normal, partly deposited, and partly rewashed) chernozems (see the lists above); the following are data obtained by my assistants.

1. Zemyatchenskii's observations in the Lukoyanov District on the thickness of soils (see the following table).

"In all the samples from Lobaski and Vasilevka determinations were made of the clay content from the swelling of soil in 1% NH_4Cl solution; the numerical results were as follows: the Lobaski soil increased in volume by 10% at the top of slope, by 14% in the middle of slope, and by 20% at the bottom of slope; the increase in the volume of soil of Vasilevka was 19% at the top of slope, 20% at the middle of slope and 30% at the bottom of slope."[1]

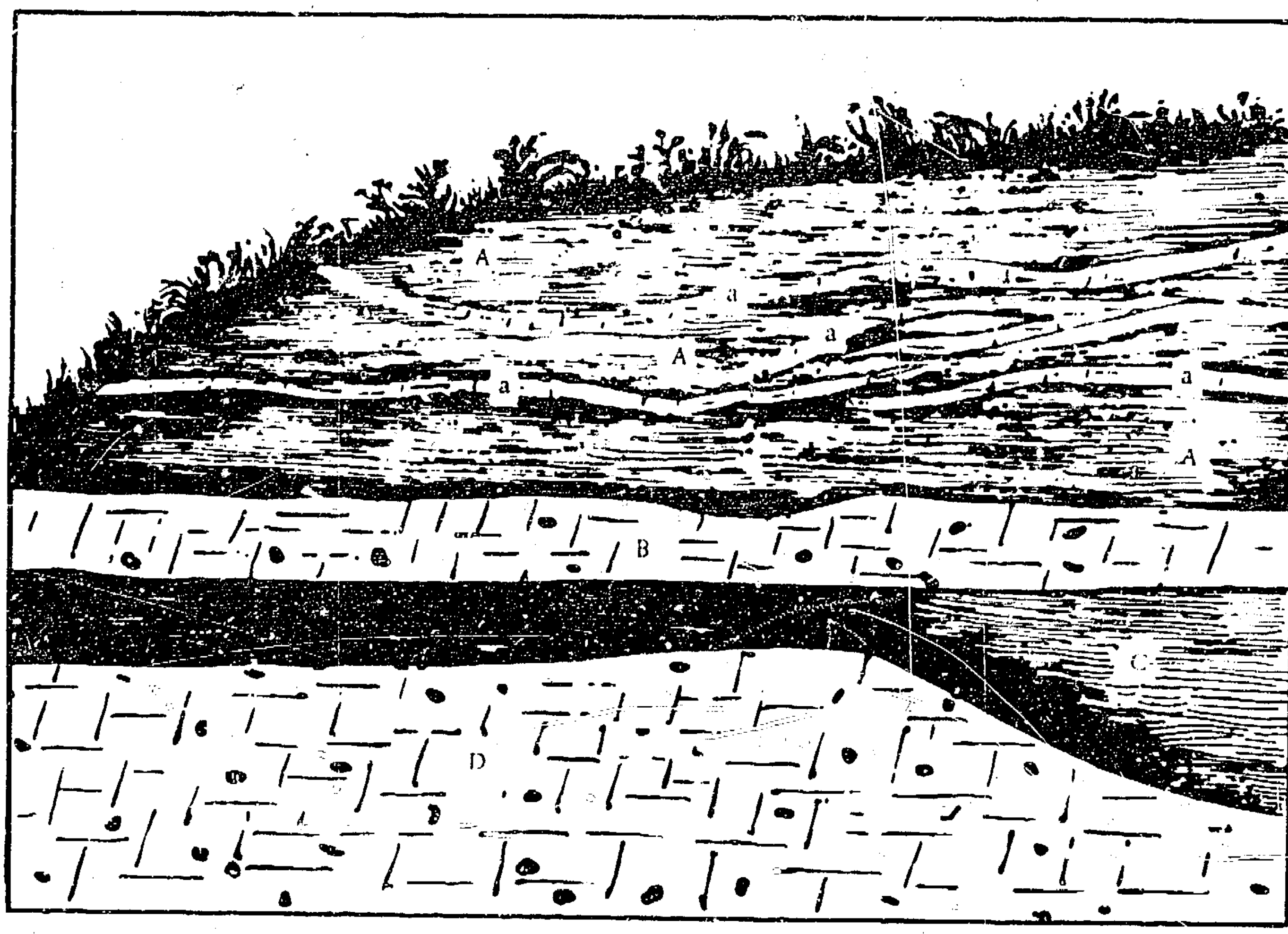

FIGURE 3. A. Darkish-gray soil (transitional to chernozem) of the Knyaginin type, but somewhat darker, the maximum thickness is 3 arshins [2.1 m]; it is seen from the figure that the entire mass of this slumped soil is permeated by a network of fine (1–3 vershoks [4.4–13.3 cm] in width) veinlets (a–a–a) of yellow-brown marly clay. B. A layer of yellow-brown clay with a mass of calcareous concretions, about 1 arshin [0.7 m] thick. C. Slumped chernozem darker than the Knyaginin soils in general; however, its right half, which is thicker (up to 2 arshins [1.4 m]) than the left part (1/2–1 arshin [0.36–0.7 m]), differs little from layer A. D. Diluvial marly yellow-brown bedrock clay, 1–2 1/2 arshins [0.7–1.8 m] thick, with infrequent calcareous veinlets and concretions.

2. Sibirtsev's observations mostly in the basin of the southern branch of the P'yana.

A. Left slope descending toward the P'yana:

a) In the vicinity of the village of Yur'evo, 1/4 verst from the P'yana, the thickness of chernozem is 2 ft 6 in [76 cm]; approximately 3 versts further south, it is 2 feet [61 cm]; 2 versts further south, it is 1 ft 7 in [48 cm]; finally, 7 versts from the P'yana, along the same meridian, it is 1 ft 4 in [41 cm].

b) In the vicinity of the village of Ichalk, the thickness of soil is 2 ft 6 in [76 cm]; 2 versts further south, it is 1 ft 10 in [56 cm]; between Suneevo and Korsakovo, 4 versts from the P'yana, it is 1 ft 5 in [43 cm].

B. Similar conditions are observed on the gentle slopes descending toward other rivers – the Aratka, Azanka, Cheka, etc. For instance, in the valley of the Ezhat, near the village of Zverevo, the thickness of the soil is 2 feet [61 cm], in the middle of the neighboring slope it is 1 ft 7 in [48 cm], and on an elevated site it is 1 ft 3 in [38 cm].

[1] In quoting these numerical results, I admit the possibility of exceptions.

Locality	Top of slope	Middle of slope	Bottom of slope
Near Pelya-Kazennaya	1'11" [58 cm]	2'2" [66 cm]	2'3" [69 cm]
6 versts southeast of Pochinki	1'1" [33 cm]	1'10" [56 cm]	3'1" [94 cm]
Lobaski	[illegible] [43 cm]	2'2" [66 cm]	2'7" [78 cm]
Vasilevka (on slope descending toward the Iset) . .	1'1" [33 cm]	1'6" [46 cm]	2'7" [78 cm]
Between Pakhotnyi Usad and Pochinki, on slope descending toward the Rudnya	1'6" [46 cm]	1'8" [50 cm]	2'1" [64 cm][1]

[1] The speed of the transfer of melkozem [fine earth] from the upper parts of a slope toward its bottom, which occurs in certain instances, is illustrated by the fact that furrows plowed across the slope are completely filled in the course of a single year.

3. Ferkhmin's observations in the basin of the northern branch of the P'yana and on the water divide between the Volga and the P'yana:

a) Near the village of Maslovka, on a gradual slope, the thickness of soil is 1 ft 3 in [38 cm] at top of the slope, 1 ft 4 in [41 cm] at the middle, and 1 ft 7 in [48 cm] at its bottom.

b) At the meridian of Kartashikha, on the slope descending toward the P'yana, 9 inches [23 cm] in the upper half of the slope, 1 foot [30 cm] half half verst down the slope, and 1 ft 8 in [50 cm] another verst downslope.

c) The southern slope descending toward the P'yana, from Dubskoe to Bol'shie Kemary, the thickness of the soil layer is 1 ft 11 in [58 cm] at Dubskoe (in the vicinity of the P'yana), but 1 ft 2 in [35 cm] 2 versts further south.

Similar conditions were observed by Ferkhmin along the Kholyazinka River, at Spirina, Krasnova, Shpilevo, Yagodnoe, Smagino, between Sergach and the village of Bogorodskoe, etc.

The inference is obvious: on gentle slopes of this kind along the northern boundary of the chernozem or among forest soils, the soils are thicker and frequently also richer in humus than those covering elevated and level areas, and this phenomenon probably obscures the regularity in the distribution of soils. An example of this are the soils covering the slope descending toward the Sundovik and the Imza in the Knyaginin District.[1]

[1] At one of the farms (Simbukhovskii) on Filosofov's estate "Pelya-Khovanskaya", near a forest, I was shown a few desiatines of land which were remarkable in that "despite the richness of the chernozem, none of the crops produce good harvests." Examination of the surface of this area did not disclose any special features; on the very gentle slope the soils merge imperceptibly with ordinary fertile chernozem. An artificial section of the infertile chernozem disclosed the following features: thickness 3 feet [91 cm] and more, as against 1 1/2—2 feet [45—61 cm] in the neighboring normal chernozem; the chernozem layer appeared homogeneous, lacking hor. B, displaying a bluish tinge only at the boundary with the subsoil; the soil mass was extremely loose and light, with an unusually high humus content, 16.11%; it was underlain by "zaklech". There is no doubt that this is a former small shallow forest bog which has become desiccated. The special features of this soil are responsible for its infertility ("it burnt up everything"). Similar instances of excessive humus contents in soils may also occur in other localities.

Nevertheless, the relationship between topography and soil is far from being as simple as may seem from the above examples.

A slope may be steep, may be stepped, or may be gradual. A thickening of the soil layer is observed only in the last case; in the preceding two cases the result is an eluvium, with the soil either washed away or thinned and impoverished in clay, $CaCO_3$, and humus. Additional cases are encountered in the neighborhood of Ichalki (in the Lukoyanov District), Gulyaevo, Aleksandrovo, Roika, Inkino, Kitovo (in the Sergach District).

An example of this type is the slope between Revezen and the P'yana River (in the Knyaginin District), where the sandy soil is 1 foot [30 cm] thick in the vicinity of Revezen, 9—10 inches [23—25 cm] thick approximately 2 versts downslope, and 4—5 inches [10—13 cm] thick at the P'yana itself, and its color becomes lighter.[1]

I would therefore stress that any evaluation of the pattern of soil distribution in the southeastern part of the Nizhni Novgorod Province must take into account the variations in topography, ground and vegetation as described above.

The following significant circumstance must be mentioned. Tracing the northern chernozem boundary through Tetyushi, Pochinki, Krasnoslobodsk, etc., Academician Ruprecht utilized, inter alia, the fact that no "plants natural to chernozem" were found north of this line.[2] In this case, as in others, he was misled by the extreme sketchiness of Russian botanical geography. Last summer I was successful in collecting large, well-developed clumps of feathergrass (S t i p a p e n n a t a) in the vicinity of Pochinki (Lukoyanov District), on the Slyudyanaya Mt. near Chernavskoe (where bushes of wild cherry were also found), at many points in the environs of Vetoshkino, Gagino (both in the Sergach District) and Vergizai (Knyaginin District), at Chufarovo and Sergach (Sergach District); finally, the local inhabitants unanimously assured Ferkhmin and me that feathergrass grows in the upper reaches of the Sundovik River in the vicinity of Bol'shoe Murashkino (Knyaginin District), while N.P. Topornin (tutor at the Nizhni Novgorod Military School) brought me a clump of this grass from "Olen'ya Mt.", at the mouth of the Sundovik very near Lyskovo on the Volga. Thus, the northern boundary of feathergrass distribution must be shifted northward by 150—200 versts, where the grass grows (e.g., on Olen'ya Mt.) amidst the most characteristic northern soils.

S t i p a p e n n a t a grows in very characteristic environments in the abovementioned localities. About 2 versts south of Pochinki, Zemyatchenskii and I found the plant exclusively on a very steep (40—50°) loamy bluff which bounds the broad floodplain of the Rudnya on the east; sparse clumps of feathergrass occur among young growths of oak, filbert, linden, birch, rowan, etc. It is unknown in the neighboring floodplain with its lush herbaceous vegetation[3]; it is also absent north and west of this locality, throughout the Alatyr basin and along the right-hand tributaries of the Moksha. This area was recently (and is still partly) occupied by an enormous continuous forest tract of deciduous and coniferous species. Last summer I saw well-developed, straight, very tall pines and spruces south of Pechi, north of Shutilovo and Orlovka (in the Lukoyanov District); the spruces were as much as 3 feet [0.9 m] in diameter.

1 It will be made clear below that in this case the character of the slope is hardly the only significant factor. Author.

2 R u p r e c h t. Ibid., p. 49.

3 East of this locality, on the Rudnya—Alatyr divide, feathergrass is reported by the local inhabitants to occur in the Umumoly gully 6 versts south of Pochinki, on the road to Pelya-Khovanskaya. Author.

At first I regarded these forests as the northwestern boundary of feathergrass in this area; about 50 versts north of Pochinki, having traversed the sandy and forested Alatyr belt described above, I was astonished to encounter feathergrass again in the vicinity of Chernavskoe, on the P'yana. Here, approximately 2—3 versts northwest of the village, a very sharply delimited Jurassic intrusion penetrates the P'yana floodplain from the north; the three slopes facing the P'yana are so steep as to inconvenience climbers, and it is somewhat more gradual and low on the northern side only, where it is separated from the neighboring Tatar plateau by a small depression. This is the so-called Slyudyanaya Mt., which is named for an abundance of glittering gypsum flakes disseminated throughout the local Jurassic marls. This "mountain" is indeed one of the highest spots in the vicinity of Chernavskoe (my visual estimation gave its height as at least 150—200 feet [46—64 m] above the P'yana floodplain). The view from the summit, encompassing the capricious winding of the P'yana valley and its remarkably gentle southern slope, is beautiful.

The lowest, more gradual section of Slyudyanaya Mt. is cultivated in some places, its middle section is covered by a forest of oak, filbert, linden, and rowan, while the summit itself, a narrow convex saddle, is overgrown by feathergrass and wild cherry.

On this basis, it was hoped to discover feathergrass north of the P'yana's southern branch as well, since the term "steppe" may be better applied to the eastern half of the P'yana divide than to any other area in the southeastern corner of the Nizhni Novgorod Province. These hopes were indeed shortly fulfilled.

The village of Vetoshkino, mentioned above, is about 25 versts northwest of Chernavskoe, on the high right bank of the P'yana. An old oak forest is located about 2—3 versts east of the village, on "Uslon Mt."; on the most elevated parts of this mountain S t i p a p e n n a t a is found among sparsely scattered large oaks. The soil in this area is chestnut colored, 1 to 1/2 feet [30—15 cm] thick. Moreover, feathergrass is also found on the Pancha farm of Pashkov's estate, likewise on an elevated area, on a steep mountain slope.

The large village of Gagino is located about 7 versts south of Vetoshkino, at the beginning of the gradual southern slope toward the P'yana. The neighborhood of the village is of a steppe nature, with no traces of forest; Sibirtsev found feathergrass on sodded walls of a gully 1 verst southwest of Gagino.

In completing the discussion of this branch of the P'yana, I should make mention of Vergizai, approximately 5 versts north of the P'yana and northeast of Edelevo. The local inhabitants reported a rich growth of feathergrass atop a high hill in the vicinity.

According to the same sources, S t i p a p e n n a t a is abundant on very steep slopes between Akhtukova and Urazovka, on Tatar land, almost at the highest point of the P'yana divide. Additional proof was supplied by finding the grass at Chufarovo (Sergach District) approximately 3 versts north of the P'yana's northern branch. At the house of the landowner, in the vicinity of Chufarovo, there is a fairly deep amphitheater-like hollow on the high right (second) bank of the Pitsa River. The floor of this hollow gradually merges with the alluvial valley of the Pitsa; its walls are vertical in some places but usually rise at 70—80°, probably reaching a height of 15 sazhens [32 m] at least. The lower two thirds of these heavily-sodded walls consist of multicolored variegated marls, and the upper third of bluish-gray Jurassic marls. From the cornice of this amphitheater, endless Tatar fields rise away from the Pitsa. These walls bore such abundant feathergrass as was unequaled throughout the southeastern part of the Nizhni Novgorod Province.

Having crossed the northern branch of the P'yana at Yanovo, I found feathergrass in the vicinity of Sergach in the so-called Buza area. The geological structure of Buza has already been described. It is very largely infertile, and thus never cultivated. Although the territory is not elevated, it still retains sparse clumps of feathergrass.

According to the information of the local inhabitants and that gained by an examination of the environs of Bol'shoe Murashkino and Olen'ya Mt. (unfortunately this was carried out after haymaking, at the end of August), feathergrass, in these localities as well, is confined to the steep bluffs among oak and filbert and occupies the most elevated sites of the territory.[1]

The following observations may be made concerning the growth conditions of *Stipa pennata* in the locality under consideration:

1. Feathergrass exists on the high (second) river banks as well as far away on water divides. Its penetration so far north cannot of course be ascribed solely to the activity of rivers. However, it does occur more frequently in the vicinity of rivers; this is due to transport of seeds by rivers and also to the dryness and unsuitability of the bluffs of high river banks for plowing, mowing and often even for grazing. They thus abound in sheltered nooks where feathergrass could best be preserved from extermination by agriculture. The present distribution of feathergrass in isolated spots enabled us to assume that it formerly spread a nearly continuous cover over the entire territory described, with the obvious exception of coniferous "bors".

2. A line drawn through all points where *Stipa pennata* has been found demarcates a very slightly undulating surface, including the highest sections of the southeastern part of the Nizhni Novgorod Province. This may point to the former steppe nature of the territory.

3. Feathergrass grows indiscriminately both in the steppe and in the forests, on chernozem and on loam (Pochinki, Gagino, Vetoshkino), on marls (Slyudyanaya Mt., Chufarovo) and on sands (Buza, Olen'ya Mt.), and outside the chernozem zone as well, provided the area is dry and sufficiently warm. Academician Ruprecht's theory that *Stipa pennata* is limited to the chernozem zone is thus placed in doubt.

Murom — Arzamas — Lukoyanov — Orlovka — Shutilovo — Rubavy

I inspected the northwestern half of this territory in 1878, and the southeastern part in 1882. On the road between Murom and Ardatov (in the

[1] Certain conditions favoring the preservation of feathergrass exist in both Bol'shoe Murashkino and Olen'ya Mt. The local population has always been engaged exclusively in processing lambskins, their lands either left under forest or rented to neighboring peasants. The locality was probably completely deserted in the recent past. "Olen'ya Mt." is enormous and towering, composed of "variegated rocks"; its nearly vertical sides are washed by the Sundovik on one side and by a Volga oxbow on the other side. The promontory is connected to the mainland at the south. The summit of Olen'ya Mt. contains the ruins of an ancient, undated fortress (a circular rampart and a moat), overgrown with large oaks, which are also found on the mountain slopes; this is the favorite walk of the Lyskovo villagers. Feathergrass has been preserved among the oaks on the slopes above the Sundovik.

Nizhni Novgorod Province) the first 10—12 versts up to Lipnya traverse a very typical floodplain of the Oka River. Level inundation meadows, partly overgrown oxbow lakes, dry sandy depressions and bogs alternate, sometimes merging. In such places the dry land is still in process of formation and therefore no vegetal-terrestrial soils can exist. Near Lipnya we climbed a small sandy elevation with a fairly steep bluff descending toward the Oka: this is the second bank, no longer inundated by the spring floods of the Oka. The once famed pine and spruce Murom forests began at this point, stretching 40—50 versts east of Murom through Savostleika, Kulebyaki and up to Teplovo. These forests are today vastly inferior to those of the Alatyr; the trees seen along the road, at any rate, did not exceed 2—3 feet [61—91 cm] in diameter. The territory is slightly rolling. Very deep, impassable quartz sands were noted along the road; their grains, while very fine, are yet considerably coarser than those of ordinary dune sands.

The diorite, granite, and sandstone boulders[1] found in these sands in the vicinity of the village of Teplovo and the Veletminskii and Vyksunskii factories mark these sands as diluvial.

In spite of the historical antiquity of the Murom forest and the virgin nature of the forest soil, the latter is only slightly colored brown-gray and is 4—6 inches [10—15 cm] thick. Characteristically, the upper 2—3 inches [5—8 cm] of this soil often consist of nearly pure mat, composed of intertwined conifer needles and roots of underbrush vegetation, with a very small earth-particle content. This cover undoubtedly accumulated over hundreds and thousands of years; upon its removal, another 2—3 inches [5—8 cm] of sand are disclosed with a slight, barely discernible bluish-gray color. The boundary between these two horizons is much more abrupt than in steppe soil. The Murom sands are occasionally interrupted by small bogs, with dark, boggy soil.

Three or four versts beyond Teplovo, toward Ardatov, the Murom forests and continuous sands disappear, the road surface becomes appreciably harder, the country becomes more rolling, and the gullies begin to display reddish-yellow diluvial clays which in some places (e.g., at the town of Ardatov) contain small boulders of Shoksha sandstone. This terrain stretches on through Ardatov, nearly to Arzamas. Approximately as far as Steksovo, halfway between Ardatov and Arzamas, the soils are thin chocolate-gray loams 6—8 inches [15—20 cm] thick; they become appreciably darker in the environs of Steksovo, and the dark shade and thickness of soils become more pronounced toward Arzamas. There is an unusual concurrent decrease in the rolling nature of the country, so that 7—8 versts before Arzamas the terrain becomes an extremely gentle slope covered by fairly typical loamy chernozem up to 2 feet [61 cm] thick and more, down to the Tesha River. Further toward Arzamas tall sagebrush on field boundaries and nettle along the road are observed. The ground seems to be as before, a fairly heavy reddish-yellow loam with increasingly common calcareous concretions. Minor forests occur only in hollows.

Crossing the floodplain of the Tesha River close to Arzamas, we climbed its right, very high, hilly bank where the town is situated. The lower horizons of this bank are composed of Permian marls of various colors and limestone up to 3—5 sazhens [6.4—10.6 m] thick[2] and its upper horizons — of diluvial yellowish-red marly clay with calcareous concretions.

[1] Meller. Ibid., pp. 71—72.

[2] Meller. Ibid.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Kovarditsy, in the immediate vicinity of Murom	Sandy loam	Flat fallow	4–5" [10–13 cm]	0.590	0.072
1–1 1/2 versts short of Ardatov	Loam	Tilled field in the middle of very gentle slope	8" [20 cm]	0.757	0.047
4–5 versts northeast of Steksovo	–	High level tilled field	1'8" [50 cm]	4.572	2.901
Arzamas	–	Tilled field on lower third of a gentle slope	8–10" [20–25 cm]	3.980	3.146
11 versts southwest of Arzamas, on the left bank of the Tesha	–	Level tilled field	1'9" [53 cm]	5.642	2.851
Mikhailovka, 2–3 versts from the Novaya Derevnya station	Sand	Waste land	4–5" [10–13 cm]	1.436	–
Near the village of Ul'yanovo, 5–6 versts northwest of Lukoyanov	Loam	Middle of scarcely noticeable tilled field	1'10" [56 cm]	8.831	–
5 versts south of Lukoyanov	–	High field	7–8" [18–20 cm]	–	–
Orlovka, on the Alatyr	Sand	Forest land	3–5" [8–13 cm]	–	–
12 versts south of Pechi	–	–	6" [15 cm]	–	–

[1] I crossed the northern sandy slope, toward the Alatyr, between Saldamanov-Maidan and Shutilovo, where the location and composition of soils are the same as between Lukoyanov and Orlovka.—Author.

The soils on the right bank of the Tesha, in the immediate vicinity of Arzamas, as well as on the Arzamas-Lukoyanov road, up to the crossing of the Tesha by a main highway, are very clayey, brownish gray, 7–9 inches [18–23 cm] thick; the soils are absent in some places on hills and may be replaced by outcrops of banded marls.

However, across the Tesha again, about 9 versts out of Arzamas, a sudden change seems to occur in the soils past the boggy floodplain; they become considerably darker and thicker, reaching 1 1/2 feet [45 cm] and more in thickness. In spite of its loamy nature, a chernozem sample taken by me at a spot 2 versts from the left bank of the Tesha "crumbled into spheres and grits." Chernozem of this kind is continuous along the entire left bank of the Tesha up to and 5 or 6 versts beyond the Ozerki station. The terrain seems increasingly more level; the parent rock is undoubtedly loess. Along nearly the entire road to Ozerki, the wide (1/2–1 verst) floodplain of the

Tesha is visible, together with the high right bank which consists of variegated marls covered with light-brown soil.

Five or six versts beyond Ozerki, these characteristics undergo a radical change, and snow-white, extremely fine quartz sand stretches up to the Novaya Derevnya station and a verst beyond the station; the terrain is completely flat, covered by coniferous forests,[1] with only small wind-accumulated sand hummocks scattered at random. Obviously, this ground is covered by very thin soil, 2 — 6 inches [5 — 15 cm] thick, a very pale gray in color, somewhat more distinct only in small closed depressions.

The old Ozerki chernozem, up to 1 1/2 feet [45 cm] thick, reappears 1 verst beyond the Novaya Derevnya station, the road crossing the very gentle slope of the Tesha's left bank. Patches of gray soil, bare of vegetation, only make their first appearance before Lukoyanov. The subsoil is reddish-yellow up to Lukoyanov; in all probability, it is marly clay. Patches of chernozem fields ("islands") characteristically appear in some places from the Novaya Derevnya station on, as well as on the fairly high and rolling right bank of the Tesha, although the parent rock of the bank continues to be the former variegated formation nearly as far as Lukoyanov. From Lukoyanov, I proceeded due south to the Alatyr and crossed it at Orlovka (Lukoyanov District); I then descended somewhat east of Pechi (in the same district) and traversed the area where a formerly continuous tract of forest existed, the wood of which was used for shipbuilding; my route led to Rubava and Nikol'skoe (within the Krasnaya Sloboda District). Along the way, first fairly dark and then chestnut-colored forest loam only occurs over the first 3 — 5 versts south of Lukoyanov; from the northern boundary of the sand tract (see above) coniferous forests and light-gray soils are encountered, commonly less than 1/2 inch [15 cm] thick; this pattern was repeated nearly to Nikol'skoe.

The samples I took in the area between Murom and Rubava are listed in the table presented on the previous page.

Moscow — Kolomna — Ryazan — Ryazhsk

The diluvial deposits in the Moscow Province are quite clearly subdivided into two horizons, according to Vosinskii's work of 1850[2]: the lower is of bedded sands with gravel and intercalations of northern pebble, while the upper is almost exclusively reddish-brown clays with a varying admixture of sand. Large northern boulders usually occur in this horizon. This pattern is clear in excavations along the Nikolaevskaya railroad* in the vicinity of Moscow. Conversely, the sand horizon is generally very slightly developed in the direction of Kolomna, except for the area east of Perovo station, so that diluvial clay with small amounts of calcareous and northern pebbles is very often directly underlain by Jurassic or Carboniferous formations, and its thickness decreases progressively toward Kolomna.

[1] These sands, as well as the coniferous — including spruce — forest, stretch far to the south, into the Krasnaya Sloboda District of the Tambov Province.

[2] Vosinsky, A. [Observations sur les terrains erratiques de gouvernement de Moscou] Bull. de la Société imp. d. naturalistes de Moscou. 1850, No. 1.

* [Now Oktyabr'skaya railroad, the trunk line joining Moscow and Leningrad. Translator.]

In the Kolomna stone quarries, both Academician Ruprecht[1] and I often encountered eroded Carboniferous limestone directly underlying soil (which was normal). However, the closer to the surface, the stronger is limestone disintegration into small lumps, ever redder and more marly. Prof. Trautschold[2] observed a similar outcrop on the surface of Jurassic clays south of Kolomna in the Protopopovskie "quarries": "The Jurassic clay very closely resembles chernozem in its dark color and structure but is easily distinguished by its content of mica flakes and fragments of belemnites".

From Kolomna to the Shchurovo station only reddish-yellow clay is visible in the railroad cuttings; beyond this station up to Lukhovitsy and for 2—3 versts in the direction of Zaraisk, only sands and sandy loams 10 feet [3 m] and more thick are seen, and I even noticed three boulders of Shoksha sandstone.

From Lukhovitsy through Ryazan and to Ryazhsk, the diluvial deposits are almost exclusively yellowish-red loam, frequently rich in calcareous pebbles of local bedrock, less frequently calcareous concretions, and rarely boulders of northern crystalline rocks. I saw one such diorite boulder, 2—3 feet [61—91 cm] in diameter, at the Nikitinskaya station. Boulders of coarse-grained granite and white quartzite were found by Barbot de Marni[3] in the vicinity of the Filatova station; Pacht observed northern pebbles in the thin deposits of the Ryazhsk District.[4] Diluvium, not very characteristic of the area, may be regarded as a transition from northern to southern diluvium. Barbot de Marni described the latter as early as 1872, 40—50 versts southwest of Ryazhsk, near Muraevnya in the Dankov District. That deposit was of very compact yellow-brown, sandy clay, taking on a reddish tinge with depth, and containing white marly intergrowths (very fine calcareous tubules), mammoth bones and a small amount of fine erratic boulders of granite, greenstone, and limestone.

The deposit was 7 sazhens [15 m] thick in some places. The clay becomes sandier with depth, with a transition to sand. In one case, the latter contained a gravel bed of granite, greenstone and quartzite over 2 arshins [141 cm] thick. Walls of pits sunk in the deposited clay are frequently dotted with round openings of tunnels filled, sausage-like, with mud, sand, pebbles, wood residues, etc., originally the underground burrows of shrews where various materials and especially chernozem particles have been deposited by rainwater. The diameter of these holes varies slightly, not exceeding 2 1/2 vershoks [11 cm].[5]

The soils under consideration at this point retained the general characteristics of the soils along the northern boundary of Russian chernozem.

[1] Ruprecht. Ibid., p. 62.

[2] Trautschold, [H.]. Yugo-Vostochnaya chast' Moskovskoi gubernii. Komentarii k spetsial'noi geologicheskoi karte etoi mestnosti (Southeastern Part of the Moscow Province. Explanatory Notes to the Special Geological Map of the Area), pp. 25—26. 1870. [In book: "Materialy dlya geologii Rossii", Vol. 2, St. Petersburg.]

[3] Barbot de Marni. Geologicheskie issiedovaniya, proizvedennye v 1870g. v Ryazanskoi i nekotorykh drugikh guberniyakh (Geological Studies Made in 1870 in the Ryazan and Certain Other Provinces), pp. 185—186. [Zapiski S.-Peterburgskogo mineralogicheskogo obshchestva, 2nd series, part 7, St. Petersburg. 1872.]

[4] Pacht, [R.]. Geognosticheskoe issledovanie, proizvedennoe v guberniyakh Voronezhskoi, Tambovskoi, Penzenskoi i Simbirskoi, ot Voronezha do Samary (Geognostic Investigation Performed in the Voronezh, Tambov, Penza, and Simbirsk Provinces, from Voronezh to Samara), p. 168. 1856. [Zapiski Russkogo geograficheskogo obshchestva, Vol. 11. 1856.]

[5] Barbot de Marni. Ibid., pp. 194—196.

The "Review of the Work of the Ryazan Provincial 'Zemstvo' on the Assessment of the Objects of the 'Zemstvo' Taxation (1877)" (Obzor rabot ryazanskogo gubernskogo zemstva po otsenke predmetov zemskogo oblozheniya (1877 god)) subdivided the entire province in two sections as regards soils, the southern beyond the Oka River and the northern part—the Meshcherskaya [Meshchera] side. According to the "Review", the most striking characteristic of soils in the southern section is the gradual deterioration in the quality of soil in a northward direction. The Dankov, Ranenburg, Sapozhok, Ryazhsk and Mikhailov districts in the south of the province are covered almost throughout by a deep layer of steppe chernozem. In a northward direction chernozem becomes poorer, decreases in thickness, and is eventually replaced by loamy soil of high quality which contains a good amount of natural humus, finally merging with soils affected by the Oka and its meadows.[1] The soil map appended to the "Review" delineates the northernmost patches of chernozem in the area between Kolomna and Ryazan.

I gained identical impressions of the soils in this area.

From Shchurovo to Lukhovitsy station there are forest (coniferous) soils throughout, sandy, 4—6 inches [10—15 cm] thick. Beyond Lukhovitsy station and up to Ryazan, they appear more clayey and darker in places, thickness apparently not exceeding 1 foot. Three versts northwest of Ryazan, I took a sample 1 ft 2 in [36 cm] thick. From Ryazan in the direction toward Ryazhsk, both the thickness and color intensity of soils increased in certain places, but this increase was extremely often interrupted by soils 1/2 foot [15 cm] thick, of light gray and brown colors. One or two such areas bear minor forests. Apparently continuous chernozem fields begin slightly north of the Pronya and stretch to Ryazhsk. Here, half a verst from the railroad station, a section made on a level fallow revealed soil 1 ft 4 in [40 cm] thick underlain by heavy "white eye" ("beloglazka"). Soil from Ryazhsk, when ground and dried, does not appear to be true chernozem.

The soils between Moscow and Kolomna are much more uniform and typically northern. Fairly dark plowlands are only observed along margins of extensive bogs and lowlands between the Faustovo, Konofeevo and Voskresenskaya stations. These plowlands are in fact meadow, silty soils, the result of drained bogs and lakes. A soil sample taken near Kolomna from a peasant's field of the village of Bachmanovo was 8 inches [20 cm] thick and was a light-gray, fairly dense clay.[2] The following table describes my samples from the Moscow—Ryazhsk area. The samples correspond to the maps I compiled.

Academician Ruprecht's hypothesis of the absence of chernozem in the entire territory between Kolomna and Ryazan in the Ryazan Province, and of true chernozem as first occurring at Ryazhsk[3], where it is 1—2 feet [30—61 cm] thick, is almost justified. At the same time, it is much more

[1] Ibid., p. 37.

[2] Academician Ruprecht reported that chernozem is claimed to form a deposit of considerable thickness on the low left bank of the Oka near Kolomna (ibid., p. 62); this is an obvious misconception. Upon inspection of the Oka floodplain and the mouth of the Moskva River I found only sands, bogs, and rather dark silty river alluvial deposits. These deposits are also present along all the rivers of northern Russia and are completely independent of chernozem, deposited chernozem included.

[3] Ruprecht. Ibid., p. 59.

difficult to agree with Academician Ruprecht as regards the presence of dark sandy chernozem on the right bank of the Oka near Kolomna. Academician Ruprecht himself reported that this chernozem, when taken in small quantities, was ashy-gray.[1] Academician Ruprecht, in my opinion, took ashy-gray soil for chernozem due to the presence of many chernozem species in the immediate neighborhood of Kolomna.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Vladimir-na-Klyaz'me[1]	Sandy loam	Level ground at the roadside	9" [23 cm]	1.035	1.751
Kolomna	Clayey	Level plowland	8" [20 cm]	2.108	2.489
Ryazan	Loam	Plowland in the middle of a gentle slope	1'2" [35 cm]	2.655	3.734
Ryazhsk	Clayey	Level plowland	1'4" [41 cm]	5.999	7.988

[1] The sample I took at Ramenskoe, between Moscow and Kolomna, was acidentally spoiled, and I took the liberty of substituting its analog in the table.

For further study of the factors influencing this pronounced southward shift of the northern chernozem boundary east of Ryazan, acknowledged unanimously by all the geographers (see general map), I traveled from Ryazan via the stations of L'gov, Panino, Kistrus and Izhevskaya to Kasimov in 1879.

This trip through the Meshchera Territory provided conclusive proof that, even were this area to occur within the most fertile territory of chernozem Russia, it would still be as barren as it is on the banks of the Oka. Indeed, nearly all along the way endless sandy or clayey Oka lowlands form the terrain — very large sand dunes, bogs on open terrain, and extensive coniferous forests with infrequent clayey-sandy, fairly level, elevations with sparsely scattered small villages. The soil is typically northern, with a slight light-gray tinge. In places on the dunes, along the Oka banks and in their immediate neighborhood, patches of dark, typically sandy soil are encountered. These patches were found[2] to be a mixture of charcoal with quartz sands, frequently abundant in traces left by men of the Stone and Bronze ages. It is therefore reasonable to assume that these patches had been cleared by fire by the prehistoric inhabitants of the Oka banks. In the vicinity of Kistrus and Murom, these carbonaceous soils sometimes reach 1 — 3 feet [30 — 91 cm] in thickness.[3]

Kolomna — Zaraisk — Venev — Tula — Chern

P. P. Semenov investigated part of this and the neighboring territory in the late 1840s, and drew the northern boundary of chernozem from the

[1] Ibid., p. 62.

[2] Dokuchaev. Kriticheskii razbor knigi grafa Uvarova: [Arkheologiya Rossii] "Kamennyi Period v Rossii" (A Critical Review of Count Uvarov's Book: [Archaelogy of Russia] (Stone Age in Russia)), p. 31ff., [St. Petersburg. 1882].

[3] Ibid.

southern part of the Venev District, past Tula, toward Krapivna on one side and north to the southern boundary of the Zaraisk District, then south to Pronsk, and eastward past Sapozhok on the other side. "The chernozem layer is very thin along the boundary of this territory; it is often washed off by spring waters from the hills, and has been mixed during plowing with the subsoil on the fields, causing considerable difficulties in determining these boundaries; to the south, in the Zemlyansk District and the southern portions of the Eletsk and Livny districts chernozem reaches depths of 1 1/2 – 2 arshins [1 – 1.4 m]."[1] However, Academician Ruprecht, having visited Kolomna, Kashira, Serpukhov and Tula in 1864, stated: "Chernozem does not begin south of Tula but stretches, with interruptions, up to the Oka where it occurs on the floodplain meadows as well as on the right-bank elevations and even on the left bank, 3 versts due north."[2] Ruprecht supported these statements, as follows. "Chernozem is frequent, and fairly distinct on the right bank of the Oka below Kashira, and up to 2 feet [61 cm] thick, its color never quite black."[3] "Sandy, smeary chernozem is also found on the Serpukhov elevations, about 3 versts from the left bank of the Oka. There are many plant species characteristic of chernozem in this area."[4]

"Opposite Tarusa, on the right side of the Oka, the sandy soil is dark and it leaves smears on the hands."[5]

"The area through which the Serpukhov-Tula highway runs in the Tula Province is a gray chernozem, blackish only in places. However, from the Oka bridge (at Serpukhov) the sides of a gully are visible, 20 – 30 sazhens [43 – 64 m] high, with the upper gray soil layer up to 3 feet [91 cm] thick, while lower down the gully side (at the brick shed) there is a layer of uniform black soil, probably deposited."[6]

Ruprecht completes his description thus: "If until now the presence of chernozem north and northeast of Tula has been denied, this is due to the nondescript light color and the thin layer of the local chernozem, as well as the rare occurrence of gullies."[7]

In spite of all these arguments, Academician Ruprecht's map depicts a continuous northern chernozem boundary south of Tula, with isolated chernozem "islands" north of the town and along the Oka, from Tarusa to Kolomna. This is understandable, since light-colored, thin soils cannot be classified as chernozem. Why, then, did Ruprecht mark these "islands" on the map? Obviously, due to the presence of chernozem flora on the banks of the Oka, as well as the considerable absolute elevation of certain of the sites.

In 1877 I travelled by rail from the Lukhovitsy station to Zaraisk, along the highway to Venev and Tul and again by rail to Chern. A description of the terrain follows.

[1] Semenov, [P.]. Pridonskaya flora [v ee otnosheniyakh s geograficheskim raspredeleniem rastenii v Evropeiskoi Rossii] (Flora Along the Don [in Relation to the Geographical Distribution of Plants in European Russia]), p. 33, St. Petersburg. 1851.

[2] Ruprecht. Ibid., p. 65.

[3] Ibid., p. 63.

[4] Ibid., p. 62.

[5] Ibid., p. 64.

[6] Ibid., p. 63.

[7] Ibid., p. 65

Close to Lukhovitsy, a red-brown clay appears; this clay is in some places exposed to a depth of 30 feet [9.1 m], and in the gullies around Zaraisk as much as 50 feet [15.2 m] and more. In some places it resembles loess and contains $CaCO_3$ concretions and chert pebbles. I encountered crystalline boulders incorporated into the pavement of the Zaraisk streets, and then rarely.

The gullies are numerous and have developed largely by nearly vertical collapses. In spite of a change in the nature of the ground, the soils remain as thin and light-gray as the Moscow soils, with extremely rare exceptions in small closed depressions. These soils are only 6 inches [15 cm] thick on tilled fields around Zaraisk. In a section I made in the Zaraisk municipal pasture, very close to the graveyard in a place which had not been plowed for at least fifty years, located at the foot of a very gentle slope, the soils are barely 9 inches [23 cm] thick.

The Zaraisk type of diluvial deposit stretches apparently uniformly through Venev to Tula and thence to Chern. This deposit is in some places in the Venev gullies underlain by white quartz sands of unknown age; at the ford over the Venevka River it was underlain by Carboniferous limestone beds, where it contains numerous limestone pebbles and blocks. Only in Venev itself did I see two crystalline boulders.

Travelling from Zaraisk to Venev via Serebryanye Prudy (on the Osetr River) the country is moderately rolling, forests are few, and the soil is extremely varied in color and thickness. At the 12th verst out of Zaraisk the soils are somewhat darker although their thickness does not exceed 10 inches [25 cm]; 8 versts further south the soils again grow lighter, and they are no more than 4 inches [10 cm] thick in places. Toward Serebryanye Prudy, especially 5 versts before the village, the plowland resumes a darker hue and at the village a nearly typical chernozem appearance is noted, with a bluish tinge. The village lies in a depression in the gentle slopes on either side of the Osetr; this depression is 3—4 versts in diameter in places. The bottom of the depression, inundated by springtime floods, as well as a considerable portion of its walls, displayed fairly dark plowland often reaching 1 1/2 feet [45 cm] and more in thickness; however, the soils were akin to deposited bog soils. In certain places on the banks of the Osetr the deposited chernozems are interbedded with ordinary river sands and clays.[1]

From the Serebryanye Prudy depression, we proceeded toward Venev over rolling, extremely clayey terrain. The soils appeared fairly dark-gray almost throughout (it should be mentioned, however, that it was raining steadily) their thickness usually not exceeding 1/2 foot [15 cm]. This pattern was observed from 3 versts beyond Serebryanye Prudy nearly up to Venev. Appreciably thicker soils were only found 2—3 versts from the town, and a section made near Venev revealed a soil thickness of 11 inches [28 cm]. The topography and ground are the same on the way from Venev to Tula, but the soils are again of the northern type. This may be due to the forests which are quite frequent along the way and certainly covered larger areas in warmer periods. I carried out several measurements of the soil layer in the environs of Tula; the best specimen was taken on the municipal pasture, halfway up a slope of 20—25°, at a soil thickness of 1 foot [30 cm]. The inhabitants report that this area has never been plowed.

[1] Local tradition holds that this area once contained vast lakes, now converted to fields and vegetable gardens. Author.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Kolomna	Clayey	Level field	8" [20 cm]	2.108	2.489
Zaraisk	—	Municipal pasture at the foot of barely perceptible slope	9" [23 cm]	2.503	1.850
12 versts from Zaraisk toward Venev	Loam	Level plowland	10" [25 cm]	3.297	2.981
Serebryanye Prudy, Venev District	—	Plowland in the lower third of the slope	1'6" [46 cm]	6.782	3.732
Venev	Loam	Level plowland	1'4" [40 cm]	6.205	4.166
Tula	Loam	Municipal pasture halfway up a 20—25° slope	[illegible] [36 cm]	2.542	4.828
Lazarevo Station	—	Plowland halfway up a very gradual slope	2' [61 cm]	8.747	8.062

I was told by Shenrok and Daniel in Tula that south of the town the northern chernozem boundary passes through the Krapivenskii District at the Yasenki railroad station—the boundary between the Carboniferous and Devonian formations. From this station, in fact, the soil becomes appreciably and fairly rapidly darker, often reaching 1—1 1/2 feet [30—45 cm] in thickness on the way to Lazarevo.[1] However, the plowlands are still gray in many places and [only] 1/2 foot [15 cm] thick on elevations, especially on the upper thirds of slopes. From Yasenki, the diluvial clay becomes markedly more marly and loess-like, and by the Lazarevo station (Krapivenskii District) it is hardly distinguishable from typical loess and its lower horizons are abundant in marly pebbles. On the gentle slopes of hills near Lazarevo station, chernozem reaches a thickness of 2 feet [61 cm] in places. At the mouth of a gully, I observed a very interesting section of deposited soils, the structure of which was described in an earlier publication.[2] I would mention once again that this clay is overlain by 5 layers visible at the foot of the gully, the walls of which are loess clay. The upper layer is a homogeneous chernozem 3 feet [91 cm] thick; the second layer is thin, 1/2 foot [15 cm], consisting of loess clay which gradually disappears

[1] A "brown-black chernozem layer often reaching 2 feet [61 cm] in thickness" was observed by Ruprecht approximately 3 versts south of Tula, close to Yasenki. Ibid., p. 66.

[2] Dokuchaev. Kartografiya russkikh pochv, tablitsa risunkov (Cartography of Russian Soils, A Table of Drawings) [St. Petersburg, 1879].

in some places. No transition exists between these two layers or between the second layer and the chernozem underlying it. The third layer reaches 2 feet [61 cm] in thickness and is of the same quality as the upper chernozem. The third layer is underlain by a distinct loess-like layer, 4—5 inches [10—13 cm] thick; its thickness, as well as that of the second layer, is variable, while the composition of the layers is apparently identical with that of clay. Finally, at the bottom of the section there is another chernozem layer 1 foot [30 cm] thick, lighter than the upper chernozem, imperceptibly passing into subsoil.

From Lazarevo, toward Chern, dark- and light-gray soils, thick (1 1/2 feet [45 cm] and thin (1/2 foot [15 cm]) soils alternate closely; it is impossible in this territory, as in the northern chernozem boundary, to indicate demarcation lines between various types of soils. The Lazarevo type plowlands stretch only 10 versts southward; while the subsoil is the same brownish-yellow clay up to 20 feet [6 m] thick, the soils change color and thickness several times on the way to Chern station, alternately taking on the appearance of the Venev and the Zaraisk soils.[1]

The brief analyses of sampled soils preliminarily subdivided into groups (presented on the previous page) provide a clearer description of the traversed territory. The soil color, generally speaking, agrees with the humus content and the color of the corresponding belts on my maps.

Chern and Novosil Districts
Kazarino — Chern — Bol'shoe Teploe — Mokhovoe — Khomutovo

I decided to examine the Chern District and part of the Novosil District in greater detail, to increase my knowledge of the central section of the Russian chernozem zone's northern boundary. The general direction of the trip was northwest — southeast.

The geological nature of the Chern District and the neighboring Efremov and Mtsensk districts was generally described as early as 1841 by Academician Gel'mersen, who first proved that the bedrock mostly consists of Devonian limestones and marls and less frequently sandstones, in places reaching 90 feet [27 m] and more in thickness. According to him, the Devonian formations underlie "calcareous-sandy reddish-yellow diluvial clay without erratics."[2] The Devonian limestones often constitute the direct subsoil of chernozem and are sometimes overlain only by sod (Mokhovoe, Chernousovo, etc.); more often, the diluvial deposits reach several dozen feet in thickness. If the deposits are thin, they usually abound in angular pebbles from the underlying rocks; if thick, they form homogeneous yellowish-brown masses with many calcareous concretions and almost totally lacking pebbles. In the village of Nikola Sindeev (Chern District), the heavy diluvial reddish-yellow clay displays very numerous dark specks, their diameter equal to that of the ordinary fine rootlets of grassy plants; these are the openings of winding tunnels, their walls coated with a black

[1] Even Academician Ruprecht called the soils of Sergievsk (57 versts south of Tula) "light-colored chernozem, of ashy-gray color". Ibid., p. 66.

[2] Gel'mersen. Geologicheskoe issledovanie devonskoi polosy srednei Rossii ot reki Z. Dviny do reki Voronezha (Geological Study of the Devonian Belt of Central Russia from the Western Dvina River to the Voronezh River), p. 41 ff.. [Zapiski Russkogo geograficheskogo obshchestva, Vol. 11, St. Petersburg, 1856].

substance, apparently carbonaceous; these phenomena are observed to a depth of 15 feet [4.5 m].

In the vicinity of Kazarino, Bol'shoe Teploe (Chern District) and Mokhovoe (Novosil District) the upper horizons of diluvium, directly adjacent to the soil layer, abound in various krotovinas.

According to Academician Gel'mersen's description, the terrain stretching between Mtsensk and Chern and then to Efremov has a steppe-like appearance: "Only in places are small oaks and birches found; meadows are extremely rare, since the area has almost completely been converted to plowland; water is so scarce that even small streams are dammed, and the water collects in hollows, forming small ponds . . . because of the lack of wood, sod fences are made."[1] The country I saw is essentially the same. The utter absence of bogs and dry lake-like depressions was especially striking to my northener's eyes. Local rivers, all small, are fed exclusively by springs; their alluvial valleys are very small although they all flow between very high and bluffy second banks, indicating their gully origin.

All these characteristics are certainly of steppe nature; at Mokhovoe I even found some feathergrass.

The only true steppe feature missing on the territory under consideration is flatness of terrain. The entire territory I observed is very hilly, especially between the Chern railroad station and the village of Bol'shoe Teploe. On the other hand, the gullies are distinguished from northern gullies by certain features. The old gullies are oval, their gently sloping walls and broad floors covered by dense sod, usually with chernozem of high quality and frequently with shrubs and oak groves; in fact, these are "balkas". The bottom of such "balkas" may contain rills totally different in nature, that of young, developing gullies; gullies of this type are found on some slopes. The walls of these gullies, mostly consisting of loess, are usually nearly vertical, their floor often a narrow crack. These gullies on the floors of "balkas" often develop to such an extent as to cover almost the entire area of the former hollows. The causes of interruption in the development of these gullies, which enabled the formation of chernozem on the bottom and the sides, as well as causes of appearance and vigorous growth of the new rill, overtaking its predecessor, are intriguing, and detailed investigations are necessary to gain full understanding of the processes.

A description of the most typical surface forms, which I saw near the village of Bol'shoe Teploe (Chern District), follows. Just past a garden owned by Mr. Domozhirov, toward the Studenets River, there is a young, still growing gully about one-third of a verst long. Its lower third shows clear signs of having occupied an old "balka" in which the chernozem soil layer was 1 — 2 feet [30 — 61 cm] thick in places; in its middle and especially upper third, the gully is wider than the old "balka" and even, characteristically, than its own lower portion. The gully apex has five ramifications, their walls consisting of reddish-yellow loess-like clay, reaching 50 feet [15 m] and even more in height; the walls are vertical and one is undermined by a welling spring. On the basis of the position of the neighboring road, and from information supplied by local inhabitants, this ramification has lengthened by 25 — 30 feet [7.6 — 9.1 m] over the last five

[1] Ibid., p. 42.

years.[1] Its bluffs display typical chernozem sections reaching 2 — 3 feet [61 — 91 cm] in thickness; a very characteristic feature is two partially decayed tree roots, 1 — 2 inches [2.5 — 5 cm] thick, which I found at a depth of 3 feet [91 cm],[2] sharply delineated against the subsoil horizon.

These geological and topographical conditions are characteristic of the entire territory of the Chern and Novosil districts which I examined (with Mokhovoe the only exception). The soils of this area, however, differed considerably among themselves.

I asked Dolinino-Ivanskii, a local landowner renowned throughout Russia for the management of his estate, and Domozhirov, a landowner who is a member of the local office for peasants' affairs and therefore certainly possesses a good knowledge of the area, to subdivide the Chern District into two — unequal — sections with regard to soils; a smaller western portion and a larger eastern portion. The boundary between these sections runs tortuously, northwest — southeast, along the Snezhed River, from Mikhailovskoe to Pokrovskaya, thence directly eastward to the village of Vypolzovaya on the Chern River, rises along this river northward to Devochkino, descends southeast to the villages of Bol'shoi Kon and Novonikol'skoe on the Rozka River, runs along the river southeast to the village of Pashutino, to the village of Studenets and toward the northern boundary of the Novosil District. This boundary demarcates chernozem, to its east, southeast, south and northeast, from clayey soils to its southwest, west and northwest. Dolinino-Ivanskii and Domozhirov stressed the decisive nature of this boundary along the rivers (the areas of Snezhed, Chern, and Rozka).

On the basis of this preliminary information, I began further investigations. My knowledge of soils in the Chern District extended from its northwestern, nonchernozem corner (on the right side of the Snezhed River) which I traversed twice from the village of Kroty: (a) toward Mikhailovskoe and Kazarino on the Snezhed; (b) from Petrovskoe (on the Snezhed) and Chern station. In the latter case, the soils are a true gray throughout, 8 to 10 inches [20 — 25 cm] thick. The soil reaches a thickness of 1 foot [30 cm] in places and it is dark gray only at the village of Kroty, on the fields of the local landowner. On the other hand, en route between Kroty and the Snezhed true chernozem soils, reaching 1 1/2 feet [45 cm] in thickness, appear 2 or 3 versts before Mikhailovskoe, on the right bank of the Snezhed. Similar chernozem is also found in the environs of Kazarino (left bank of the Snezhed) on Dolinino-Ivanskii's estate. A small stream flows close to the landowner's mansion, and its right bluffy banks consist of typical yellow-brown loess. Krotovinas, black against subsoil and yellow-brown against chernozem, abound. The chernozem reaches 3 feet [91 cm] in thickness. Krotovinas occur to a depth of 5 feet [1.5 m] and more. I made the following measurements on the slopes rising right and left of the creek.

Right slope, with a 15° gradient:

1. On the bluff mentioned above, A + B = 3 feet [91 cm].
2. About 1/2 verst up the slope, A + B = 2 ft 6 in [66 cm].

[1] The growth of gullies in the Mokhovoe is also equally rapid. Dokuchaev. Sposoby obrazovaniya rechnykh dolin Evropeiskoi Rossii (Modes of Formation of River Valleys in European Russia), p. 70, [St. Petersburg], 1878.

[2] The appearance of the new gully may be due to the felling of the forest formerly occupying the area.

Left slope, with a 10—20° gradient:

1. At the foot of the slope, where a horizontal glade begins, the soil horizon is a homogeneous clayey typical chernozem, its lower layer apparently admixed with silty soil. Total thickness was 3 ft 7 in [109 cm], but chernozem penetrated even deeper, and groundwater welling up in the pit prevented my reaching the subsoil.

2. About 50 paces up the same slope:

A. Homogeneous chernozem, 1 ft. 7 in. [48 cm].

B. Transition horizon, 1 foot [30 cm].

C. Subsoil, yellowish-brown loess.

3. 300 paces up the slope:

A. Soil horizon, 1 ft. 2 in. [35 cm].

B. Transition horizon, 1 ft. [30 cm].

C. Bedrock, same loess, possibly more sandy.

4. 600 paces up the slope, now on level terrain:

A. Soil horizon, 1 ft. 4 in. [40 cm].

B. Transition horizon, 1 foot [30 cm].

C. Typical loess.

From Kazarino I proceeded to the villages of Vypolzovo, Chernousovskie Vyselki, Brusok on the Rozka River and Bol'shoe Teploe.

The Kazarino chernozem extends approximately to Vypolzovo, where the predominant soil type becomes northern rather than chernozem, southward to Chernousovskie Vyselki. At this point, small "islands" of dark soils reaching 1 foot [30 cm] in thickness begin to appear; true chernozem appears beyond the Rozka, stretching south through Bol'shoe Teploe up to Mokhovoe and the Khomutovo station of the Orel-Elets railroad. The chernozem becomes progressively more typical to the south.

The village of Mokhovoe (Novosil District) is noteworthy, as it is Shatilov's renowned estate. The geological structure of this area, mentioned above, includes the following remarkable features: in addition to Devonian limestones and marls, outcrops of which are visible in the village of Mokhovoe, red and yellowish-brown sands outcrop on the most elevated places of the surface. These sands frequently contain sandstone blocks, similar in color, 1 sazhen and more in diameter. I encountered formations of this kind 4—5 versts south of Mokhovoe near the park on Shatilov's estate, and at the farm known as the Kamennyi Bugor. This farm owes its name* to the sandstone blocks which are occasionally visible on the surface. Unfortunately, no fossils were found, nor were the stratigraphic relationships of the formations elucidated.

Of the soil sections in the vicinity of Mokhovoe, the following three are noteworthy.

1. The following strata of deposited chernozem are visible in sandpits in the lower third of the slope, just south of Shatilov's park:

A. Chernozem, 1 ft. 4 in. [40 cm].

B. Red sand, 6 inches [15 cm].

C. Chernozem, 10 inches [25 cm].

D. Sand, 1 foot [30 cm].

E. Marly red clay, 4—6 inches [10—15 cm].

F. Chernozem, 7 inches [18 cm].

G. Underlying red sand.

* [Meaning "stone hummock." Translator.]

2. Between Mokhovoe and the village of Novolysevka, at the top of a slight incline toward the left bank of the Razovka River, with outcrops of Devonian limestones and marls:

A. Soil horizon, 1 ft 9 in [53 cm], homogeneous typical chernozem with an imperceptible transition to horizon B, 8 inches [20 cm] thick. However, even subsoil horizon C, of yellowish loess, has numerous dark spots—possibly krotovinas—where in contact with horizon B.

3. Kamennyi Bugor, one of the outlying farms in the environs of Mokhovoe.

A fairly large hummock, on which deciduous trees grow, is located in the vicinity of the farm, on the slope above an unnamed creek. The creek banks display an indistinct outcrop of limestone overlain by loess. The hummock, as noted, consists of red sand with large blocks of sandstone. A shallow sandpit was dug among old trees on the fairly level top of the hummock. The walls of this pit presented a clear soil section, as follows:

A. Perfectly homogeneous sandy chernozem, 1 ft 4 in [40 cm].

B. Transition horizon, 10 inches [25 cm], with unaltered, isolated irregularly shaped areas of subsoil C, which is represented by the sand mentioned above. Both horizons A and B are overrun with living roots. Not a trace of dead roots was discernible; they must have decomposed during the lifetime of the present trees (?).

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Kazarino	Loam	Slightly rolling pasture at the bottom of a slope	2'6" [76 cm]	8.109	9.126
Petrovskoe	—	Plowland, in the middle of a slight slope	8" [20 cm]	4.959	4.970
? versts east of Petrovskoe	—	Level plowland	11" [28 cm]	—	—
Turgenevo, approximately 4 versts west of Petrovskoe	—	—	8" [20 cm]	—	—
Bol'shoe Teploe	—	Plowland in the upper third of a gradual slope	1'6" [46 cm]	8.729	3.537
Kamennyi Bugor	Sandy loam	Elevated level site	2'2" [66 cm]	5.825	7.282
Mokhovoe	Loam	Plowland at the summit of a slight slope	2'5" [74 cm]	8.115	4.096

Descending from the Kamennyi Bugor farm to the creek, beds of deposited chernozem 6 feet [1.8 m] thick are visible in the outcrops; this chernozem is clayey rather than sandy and in places overlies Devonian marl.

To complete this description of Mokhovoe, the presence of numerous krotovinas in the subsoil, and the rare appearance of feathergrass in gullies[1] should be noted. A forest of high quality has been planted very close to the feathergrass; its principal arboreal species are spruce, pine, *Pinus strobus*, larch, oak, and birch, all displaying excellent growth, especially *Pinus strobus*, which even in western Europe is exclusive to parks. All these trees develop equally on level terrain and in gullies. Moreover, Shatilov's nurseries nurture nearly all the coniferous trees of northern Europe and America. Three-year-old saplings from the nurseries are planted in chernozem, without any admixture with sand or mineral substances, and are given no further attention. According to Shatilov, the trees grow indifferently in the first two years; the surviving trees then develop far more rapidly than in the north. The soil between Mokhovoe and Khomutovo is nearly solid typical chernozem 2 feet [61 cm] and more thick.

A list of soil samples which I took over the investigated area is given in the table on the previous page.

The information supplied by Dolinino-Ivanskii and Domozhirov proved largely reliable. The following details should, however, be corrected: a) the soils in the western and eastern portions of the Chern District do not differ on the basis of humus content and color as much as the inhabitants assume; b) the areas are not sharply delimited by any boundary, such as rivers or gullies, and gradual transitions are the rule, as in all other territories.

Different soils in the northwestern and southeastern portions of the Chern District as well as in the entire Tula Province are directly and characteristically noticeable by the very marked vegetation characteristics. The Mtsensk — Odoev — Krapivna — Venev line forms the boundary between the forest belt of the Tula Province to the northwest and the steppe belt of the province to the southeast.[2]

Milyukovo — Vyaz'ma — Kaluga — Meshchevsk — Kozel'sk — Belev — Orel

The village of Milyukovo, in the Sychevka District, Smolensk Province, lies in a country which is in all respects typical of the entire central part and partially also the northern part of Russia. This corner of Russia is typical of thousands of localities as regards topography, geological structure, and soils. I therefore decided to give a more detailed description of the area, since I know it particularly well.

It should be noted primarily that the entire northeastern corner of the Smolensk Province, which includes the Sychevka District, is a very elevated plain (900 feet [274 m] and higher) from which numerous rivers flow in almost all directions. The land adjoining the rivers, as well as their divides, are largely horizontal and therefore relatively rich in bogs on open terrain and swamp meadows, often extending over dozens of versts.

[1] According to the villagers, feathergrass was abundant 50—70 years ago.

[2] Kozhevnikov, [D.] and Tsinger, [V.]. Ocherk flory Tul'skoi gubernii (Monograph on the Flora in the Tula Province) (see map) [Trudy S.-Peterburgskogo obshchestva estestvoispytatelei, Vol. 11, No. 1, St. Petersburg, 1880]. For details see below. Author.

Areas where clearly outlined hills alternate with deep gullies and lowlands appear in the form of closed depressions are rare. More or less boggy lowlands predominate in the neighborhood of Milyukovo. [See map below.]

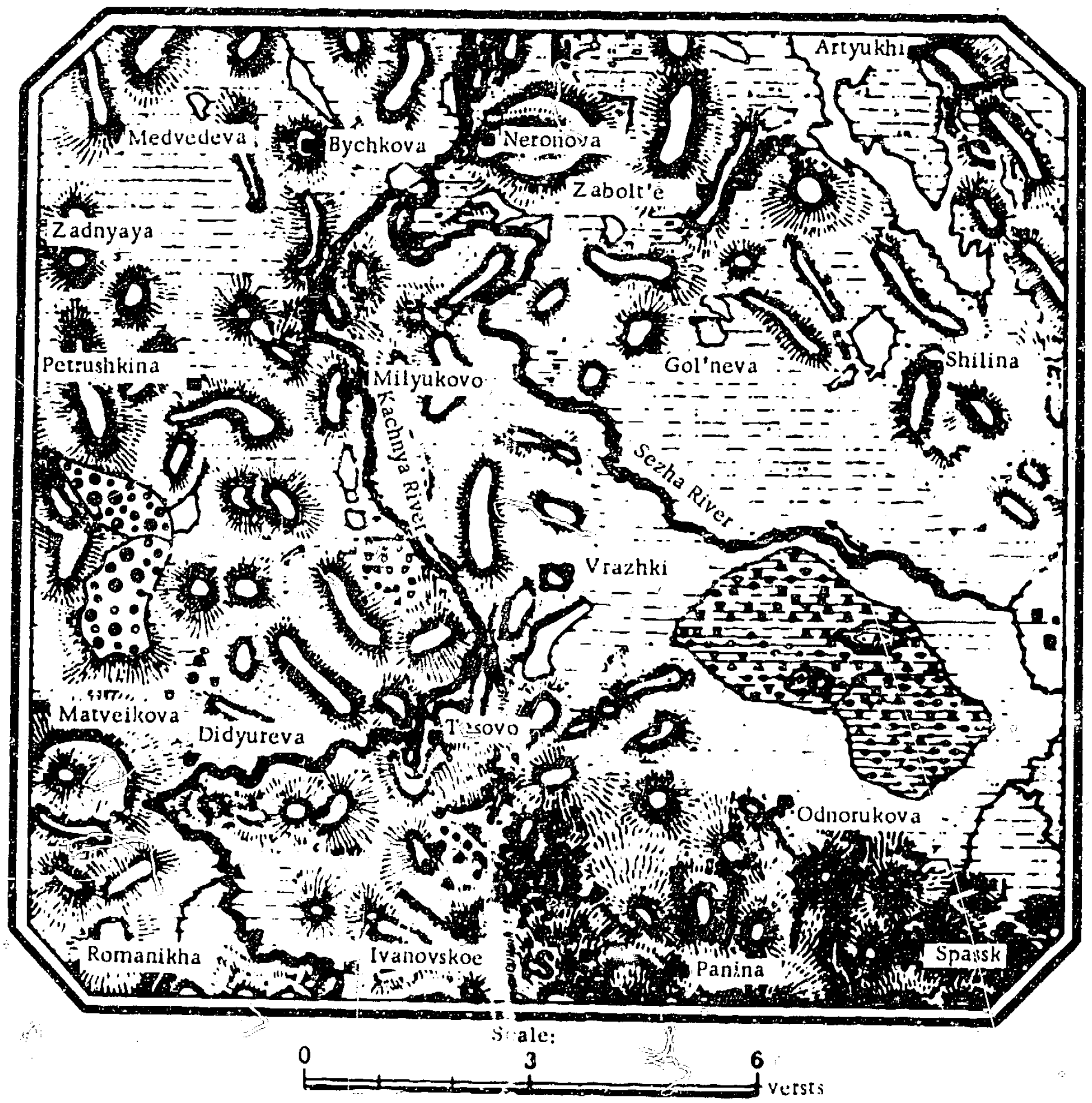

FIGURE 4. Vicinity of the village of Milyukovo.[1]

Except in the southern part of the area represented in Figure 4 (around the villages of Spassk and Ivanovskoe), less than half of the terrain is occupied by relatively elevated, completely dry places. Such places are usually vaguely outlined, almost isolated "islands" amidst meadows and bogs. These "islands" were formerly covered by forest, of which nothing now remains except very small, scattered groves (such as south of Petrushkina and northeast of Ivanovskoe).

[1] Lakes, bogs, dry and wet meadows, hills, forests, etc. are marked in the same manner used in all the general headquarters' maps (3 versts to 1 inch [1:126,000]).

The geological structure of this territory has been described elsewhere.[1] We shall therefore mention only the most typical features of the northeastern corner of the Smolensk Province. The vast majority of hills consist of typical northern diluvium; only rarely does their lower horizon consist of Carboniferous limestones. The diluvium itself may usually be sharply subdivided into two stages. In the upper stage, the predominant mineral mass is more or less sandy red clay with fairly sparse chert and Carboniferous limestone pebbles and fairly frequent northern crystalline boulders often 3 — 4 feet [0.9 — 1.2 m] in diameter. However, where diluvial clay overlies Carboniferous limestones, it is nearly displaced by the large quantity of pebbles in its lower horizons. The upper diluvial stage is generally nonstratified and in places reaches 50 feet [15 m] in thickness. Sands predominate in the lower diluvial stage, their thickness also reaching 40 — 50 feet [12 — 15 m] in places. Diluvial sand may be fine or coarse, white or yellowish-red, exclusively quartz or considerably admixed with limestone and feldspar grains; its beds may be horizontal, or strongly undulating with many horizontal interruptions.

Diluvial sand often forms a transition to gravel, and even to conglomerates. Carboniferous and northern crystalline boulders abound, and may reach 6 feet [1.8 m] in diameter. They are usually nearly spherical in both upper and lower diluvial stages, often polished by glaciers, and in several cases so disintegrated that the boundary between the boulder and the loose diluvial mass in which it was embedded is indistinguishable.

I did not find any organic remains in the diluvium of the Smolensk Province. The structure of diluvium in this territory, given above, was in fact rarely seen. One stage usually predominated, at times at the expense of the other. This was the case on hilltops from which diluvial clays have been washed off.

For instance, the highest portions of the small hills, just west of the village of Milyukovo, consist of sandy loams with virtually no diluvial clay, as is evident from wells and other pits. The slopes, however, are covered by diluvial clay, reaching 20 feet [6 m] and more in thickness, especially toward the banks of the Kachnya River.

The lowlands marked in Figure 4 may be classified as follows: a) bogs, b) alluvial river valleys (floodplain meadows), and c) meadows and plowlands which rim the diluvial elevation. They are designated by almost identical symbols in topographical maps, but differ significantly in regard to geology, pedology and agriculture.

The bogged lowlands, such as the Tatarkino lowland (between the Sezha River and the village of Odnorukova), the Medvedeva and Gol'neva lowlands (southeast of the villages of Medvedeva and Gol'neva), etc., are all undoubtedly originally lacustrine depressions, now silted up and overgrown; traces of the original lake are preserved in some places (north of Odnorukova).

Bogged lowlands of this kind may reach several dozen feet in depth here, as in other places. At the bottom, bluish, very viscous clay is found almost always overlain by masses of more or less earthy peat and sometimes by bog ores. The bog surface is extremely unstable, very tussocky and covered by typical paludine vegetation and very poor, stunted shrubs. The fairly

[1] Dokuchaev. Sposoby obrazovaniya rechnykh dolin Evropeiskoi Rossii (Modes of Formation of River Valleys in European Russia). 1878.

compact sod, similar to the subsoil, mainly consists of the mat formed by the intact roots of paludine plants. Such areas are almost worthless for agricultural purposes.

The alluvial valleys (inundated by springtime floods) of the Kachnya and Sezha rivers are entirely different in nature. A detailed description of a typical section of the Kachnya floodplain, directly south and southeast of Milyukovo, is given below, presenting the characteristic features.

Figure 4 shows that this portion of the Kachnya river valley reaches a width of 1 verst in places. Although at many points it rises appreciably toward the river, it may be generally described as horizontal. The monotony is broken only by scattered dry oxbows or by small elongated lakes. Large masses of the abundant freshwater mollusks are buried in the lake ooze together with fauna of the neighboring meadows, especially during the spring floods. The floods have silted many of these oxbows and small lakes within living memory, and have leveled them with the horizontal surface of the lowland.

The geological structure of all such valleys is uniform and simple. The 20 artificial sections I performed in the banks of the Kachnya River, between the village of Milyukovo and the latitude of the village of Vrazhki, make clear the following three horizons.

The uppermost horizon (A) consists nearly throughout of pale red or gray loose alluvial earth characteristic of floodplain valleys. Its depth here varies between 3 and 8 feet [0.9 — 2.4 m].

This layer was formed mainly by the alluvium deposited by springtime floods and partly also by suspended matter transported by rainwater from adjacent diluvial elevations. Its mineral composition, therefore, can hardly be uniform, and consists of a varied mixture of those rocks occurring in the river basin. The second banks of the Kachnya River in this area are composed exclusively of diluvial clays and sands, which in turn form the variable mixture composing the horizon. This horizon, on the other hand, is distinguished by certain constant characteristics thanks to its origin. The sandy-clayey mass is usually loose, lacking bedding,[1] and contains rare scattered pebbles and boulders, deposited by the glacier. No shells or plant residues are commonly found; the very slow deposition of this layer and its looseness and accessibility to the detrimental effects of air and atmospheric water are not conducive to preservation of organic matter. Living or dead roots of grasses of the floodplain valley are found to a depth of 2 — 3 feet [61 — 91 cm] below the surface. These roots formed the sandy, red-brown ferruginous tubules which are abundant in the clayey-sandy mass.[2]

The lower layers of this sandy loam usually form gradual transition to the second horizon (B), which consists of intercalations of blackish-clay, resembling bog-vegetal soil, alternating with intercalations of white or reddish sand. Only in two sections does this horizon consist entirely of finely-bedded, variously colored sands. The sand intercalations generally disappear or form very gradual transitions into one another every several dozen paces along the bank. In addition to rolled pebbles and gravel in

[1] Lyell. Manual of Geology, Russian translation by Golovkinskii, p. 158. [St. Petersburg. 1886].

[2] These tubules were previously described by Messrs. Golovkinskii in "O posletretichnykh obrazovaniyakh po Volge, v ee srednem techenii" (Post-Tertiary Formations Along the Middle Volga), pp. 62 — 64 [Kazan, 1865], Ruprecht (ibid., p. 31) and Ditmar.

large amounts, leaves, twigs, trunks of birch, larch, aspen, oak (usually in a horizontal position) are abundant in places. Certain points of the lowest portions contain fairly numerous remnants of fossils, including mammoth, fossil rhinoceros, urus (*Bos primigenius*), as well as elk antlers and teeth of *Equus caballus*.

The base of the Kachnya banks in the area usually consists of dark clay with a bluish tinge (horizon C). The clay is viscous in some places and fairly sandy in others. On the surface its depth does not exceed 2 feet [0.6 m], but on the other hand it occurs throughout below the river's low summer level, where it sometimes reaches 1 sazhen and more in depth. The horizon also includes pebbles, fossils, and plentiful shells of freshwater and terrestrial mollusks, as well as plant residues. The peasants use this horizon to dig out the best preserved oaks, utilized for various artifacts. I was told that the excavated oak may be denser than the living wood; in such cases the wood is probably in the initial stages of fossilization.

This floodplain valley may be classified into two pedological portions. The higher, completely dry, areas are overlain by a very thin, loose and indistinctly colored layer of sod, only slightly differing in appearance from the rest of the upper alluvial layer. Low-lying areas where springtime floods and rainwaters stagnate are covered by bog-meadow soil.

The third kind of lowland in the Milyukovo neighborhood consists of the so-called meadow-plowlands. In dry summers such areas produce excellent flax yields, while in wet summers they are better left as meadows. Lowlands of this type usually stretch in narrow strips along the foot of diluvial heights. These meadows gradually rise into elevated plowlands on one side, and on the other form a transition into adjacent bogs. These lowlands exhibit one of the following types of geological structure.

1. An artificial section made half a verst south of Milyukovo, 10 or 15 paces from the southern foot of the very gentle slope rising at the tip of the plowlands, gave the following structure, from the surface down:

A. Dark-gray layer 10 inches [25 cm] thick, with scattered residues of grass. This layer is no longer inundated by springtime waters of Gridnevskii Creek, a small stream flowing nearby, although in the past it was inundated by high floods, according to the local inhabitants. In any case, this layer originated almost exclusively in the deposition of various soil substances from the neighboring diluvial heights by atmospheric waters, and its composition is therefore extremely variable. Personal examination proved that the layer increases in thickness by the same process at present. It is completely dissociated from the underlying layer.

B. Completely black, light, loose peaty mass, rich in residues of paludine plants, 8 inches [20 cm] thick. These formations are obviously of paludine nature and are used by the farmers as fertilizer for fields low in organic residues.

C. Bluish, usually viscous layer with very thin, insignificant, intercalations of sand. Scattered alder leaves and small fragments of tree branches are found. Artificial section disclosed this layer to a depth of 1 1/2 feet [45 cm], but it certainly continues deeper. The layer was probably deposited by Gridnevskii Creek or, more precisely, by a former lake-like spreading of this creek.

2. I made another section of similar meadow soils about 2 versts northwest of Milyukovo at one of the edges of the Medvedevskie bogs. The

sod is 1/2 foot [15 cm] thick, compact, with a mass of undecayed brown, almost black (when moist) plant roots. It is underlain by the bedrock diluvial clay, only the upper 2—3 inches [5—7.6 cm] of which are of a light bluish tinge. Although the spring floods and rainwater rarely stagnate at this place, the meadow is nevertheless almost constantly rich in soil moisture, due to its low location in the immediate neighborhood of bogs.

The lowlands are of additional geological significance, since they provide an excellent example of the enormous mass of various mineral and organic substances washed off from neighboring diluvial heights and filling these lowlands. The diluvial heights were obviously much higher in the past than today, and their erosion was consequently more vigorous. The lengthy time intervals necessary for such changes in the topography are barely comprehensible!

The plowlands in the neighborhood of Milyukovo are situated almost exclusively on the diluvial heights. In Milyukovo, as in nine-tenths of central nonchernozem and northern Russia, the plowlands are classified into the following three agricultural types: a) garden soil; b) plowlands continuously cultivated according to the three-field rotation system, and finally c) lands fallow since after the emancipation of the serfs [in 1864]. Areas (a) are heavily manured almost every year, areas (b) are usually manured (farmyard manure) every three years, while areas (c) have hardly ever been manured and have always been badly cultivated. My artificial sections and samples from each of these classes of land, of Milyukovo, yielded the following results:

Site No. 1. Garden soil within the village, on a level area; only two layers are found.

A. Tilled horizon, about 1 foot thick, gray when dry and darkish-brown when wet, rich in undecayed vegetable roots and dung straw, frequently containing unaltered fragments of bedrock. Horizon A is obviously of artificial formation, at the expense of the bedrock.

No transition layer is distinguished, and horizon A is underlain by the subsoil C, consisting of diluvial yellowish-red sandy loam or light loam. No humus color is discernible, although some scattered plant roots are seen.

Site No. 2. Level area, a field belonging to the Milyukovo church, about 1/4 verst northwest of the village.

A. Tilled horizon, 6—7 inches [15—18 cm] of yellowish-gray soil, darker when moist, abounding in rootlets of cereal crops, occasionally containing fragments of bedrock.

B. Transition layer 2 inches [5 cm] thick, barely noticeable and obviously very frequently turned over by the peasant plow ["sokha"]; neither structure nor color are thus uniform.

C. Diluvial sandy loam or light loam.

Site No. 3. 1—1 1/2 versts south of Milyukovo, lying fallow since serfdom days.

A. Tilled horizon, 5—6 inches [13—15 cm] of light-gray soil containing rootlets of grassy vegetation.

B. Transition layer of 2 inches [5 cm].

C. Reddish-yellow sandy loam.

These plowlands may contain meadow depressions, whether as enclosed circular depressions or as small elongated valleys. Manure particles washed off the surrounding fields collect in these depressions and form abundant humus, combining with the decayed sod. The bottom of these hollows is usually a thick layer of very fertile soil.

Areas of this type form hayfields of high quality; in many places they have been plowed and are used for flax growing, etc. The high (5—10%) content of organic components lends this soil a dark-gray—dark-brown color which may become nearly black (this meadow soil is locally designated as chernozem) and its composition depends on the soil properties of the surrounding fields. This and the silty soil are the most fertile in the Smolensk Province; however, they occupy very small areas.[1]

Such small lowlands, extending over 1/4 to 1/2 dessiatine, also occur in the neighborhood of Milyukovo.

The following is a list of soil samples which I took in this area.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Garden soil, Site No. 1	Sandy loam or light loam	Level area	1'2" [35 cm]	3.368	2.013
Field soil, Site No. 2	—	—	6—7" [15—18 cm]	2.338	2.083
Field soil, Site No. 3	—	—	5—6" [13—15 cm]	1.150	1.123
Meadow-plowland, 1/2 verst from Milyukovo (No. 1)	Loam	—	1—1 6" [30—46 cm]	9.796	6.093

In conclusion, I would stress once again that the extremely detailed geological and pedological descriptions are given in view of the fact that the territory is typical of 9/10 of nonchernozem Russia.

No new features were in fact encountered throughout the country lying between Milyukovo, through Vyaz'ma to Kaluga. Past Kaluga, nearly to Kozel'sk, my route traversed a region of Carboniferous formations, and further on, through Belev to Orel, among Devonian formations. These formations, however, seem to be rather insignificant with respect to soils, inasmuch as they are covered by fairly uniform rocks (limestones, etc.) and are overlain throughout by deep diluvial deposits. The general character of the Sychevka deposits is retained up to the Ugra and Kaluga and even slightly south of the latter, the only difference being a marked predominance of sand, which may even emerge on the surface. The soils are of the same kinds as the Milyukovo type. South of the Ugra, approximately

[1] Solov'ev. Sel'skokhozyaistvennaya statistika Smolenskoi gubernii (Agricultural Statistics of the Smolensk Province). [Moscow, 1855.] According to my observations, peasants of the Smolensk Province and other central provinces frequently plow meadows on leveled water divides (desiccated bogs which were shallow and inundated only in the rainy season) to augment their plowlands. The soils are thus black, very rich in partially decomposed organic substances and are sometimes known as black, or chernozem soils.

7 or 8 versts before the station of Rogovichi (on the Kaluga — Meshchevsk highway) the ground becomes slightly denser and more clayey, the soils reach 10 inches [25 cm] of thickness in some places, and 1 foot [30 cm] close to the Rogovichi station, at which point they are darker. From this station up to Orel the pattern of the Zaraisk — Verev and the Tula — Chern territories recurs.

The countryside is purely agricultural, and the characteristics grow stronger toward Orel: every arable field is plowed and cornfields stretch to the horizon. The sole variety is introduced by dry gullies with forested sides and tiny, very sparsely scattered groves. The forest is deciduous (oak, aspen, linden, filbert, birch) except for the uninterrupted coniferous "bor" occupying 5 — 6 versts just beyond Kozel'sk and toward Belev; spruce in this "bor" reach 1 1/2 — 2 feet [45 — 61 cm] in diameter. Characteristically, a lack of water is marked in the Kaluga-Orel territory, and true bogs are rare. The terrain is moderately hilly throughout, with certain exceptions. For instance, an almost steppe-like character is visible in certain places between Rogovichi and Saburovshchina, Meshchevsk — Sukhinichi, Bolkhov — Raspopovo. On the other hand, between Tatarenka and Mekhovskaya, Kozel'sk and Belev and slightly north of Bolkhov the country is fairly hilly, especially in the vicinity of high river banks.

From the Rogovichi station up to Orel, the deposit is loamy throughout, becoming more marly toward the south, and turning into typical loess south of Bolkhov. I found diluvial sands under this loam in the vicinity of Sukhinichi and between Kozel'sk and the Yurinskaya station. Crystalline boulders occurred only twice: between Rogovichi and Saburovshchina, and embedded in the Bolkhov pavement. In the first case, fist-size diorite pebbles were observed, and in the second, a granite (gray) boulder reaching 1 1/2 feet [45 cm] in diameter.[1] A relationship between the soils and the topography of this region is discernible. The soils first assume a somewhat darker and thicker appearance at the Rogovichi station and between Rogovichi and Saburovshchina. The soils appeared of even better quality between Meshchevsk and Tatarenka and along the route from Bolkhov via Raspopovo nearly up to Orel, wherever the country was more level. Conversely, in the areas between Saburovshchina and Meshchevsk, Tatarenka and Bolkhov the soils seemed identical with northern soil.

The following is a list of the soil samples I took along the route:

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Just south of the Ugra, on the way from Kaluga to Meshchevsk	Sandy loam	Level plowland	10" [25 cm]	–	–

[1] Between Serebryanyi and Parmenka, in the vicinity of Meshchevsk, Prof. Romanovskii observed an entire ridge reaching 1 1/2 versts in length, in which the deposited ferruginous sand, 2—3 arshins [1.4—2.1 m] thick, was underlain by a thick layer of cherty gravel and erratics with abundant rolled limestone boulders. Romanovskii. Otchet o geognosticheskikh razvedkakh ... v Orlovskoi gub. (Report on the Geognostic Surveys ... in the Orel Province) (Gornyi Zhurnal, part [illegible], 186[illegible]), p. 3.

(Continued)

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Rogovichi station, Kaluga District	Loam	—	1' [30 cm]	—	—
4 versts north of Saburovshchina station, Meshchevsk District	—	—	1'2" [35 cm]	2.527	1.031
12—13 versts south of Meshchevsk	—	—	10" [25 cm]	1.684	1.457
Frolovo, Meshchevsk District[1]	Clayey	Plowland at the foot of a slight slope	1'4" [40 cm]	—	—
2 versts east of Mekhovskaya station, Kozel'sk District	Loam	Level plowland	9—10" [23—25 cm]	—	—
1 verst southeast of Yurinskaya station, Kozel'sk District	—	—	—	2.338	2.083
Fedenskoe, Belev District	—	—	9—10" [23—25 cm]	—	—
8 versts north of Bolkhov	—	—	10" [25 cm]	—	—
11 versts south of Bolkhov	—	—	1'5" [43 cm]	4.599	1.154
7 versts north of Raspopovskaya (Raspopovo), Bolkhov District	Clayey	Plowland in the middle of a very slight slope	1'7" [48 cm]	5.265	6.552
5 versts south of Raspopovo	—	Level plowland[2]	1'2" [35 cm]	—	—

[1] The soil in this area is considerably darker and thicker than normal, probably because of its gentle slope toward a minor river.—Author.

[2] All the noninvestigated samples are with Kytmanov at Eniseisk.

I should like to note, in addition, that the soils between the stations of Rogovichi and Saburovshchina as well as those in the vicinity of Frolovo are of bog-meadow nature to a considerable extent and, in fact, they form an imperceptible transition in some places. The soils between Bolkhov and Raspopovo as well are termed by the local population "chernogryaz'" ["black mud"], rather than chernozem. This is understandable in view of the considerable moisture content and hence boggy nature of such soils. Were these soils in northern Russia they would soon be transformed into true bogs. Throughout Russia, soils of slopes descending gently toward rivers are always darker and thicker than any neighboring soil, such as the area 5 versts west of Kozel'sk, and the soils of Frolovo.

It should be mentioned, in conclusion, that between the 6th and the 12th verst southeast of Kozel'sk the coniferous forest is replaced by deciduous forest, consisting of oak, linden, and birch. Characteristically, even under deciduous forest the soils are only 3 – 4 inches [8 – 10 cm] thick or less, let alone the soils under coniferous forest. Kytmanov and I examined the deciduous forest soils in detail, finding their composition to be almost entirely black-brown, very slightly decayed leaves, fragments of twigs and certain herbaceous elements. This combination formed a lightweight brown boggy mass which blocked access of air to the underlying rock. As in all other localities, the latter was tinged bluish-gray at its boundary with the foliage and was sharply demarcated from the forest soil.[1]

Karachev – Orel – Verkhov'e

Between Bryansk and Karachev "the country is covered by pine forests (*Pinus silvestris*), more rarely by spruce (*Pinus abies*), birch and ash; chalk fragments were found in the soil, and near Karachev sandy chalk occurred with silica nodules covered by soft white chalk... The neighborhood of Karachev is of special interest since large areas of chernozem, forming excellent plowland, occur on the way from Roslavl and Bryansk. Forest is still visible in places, although large areas are completely forestless and resemble steppe plain covered by endless cornfields extending to the horizon ... On the way from Karachev to Orel, there is a large Devonian elevation, where Orel is situated, stretching east and north."[2] At the village of Polovets, near Orel, Devonian limestones serve directly as subsoil.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Near the village of Umrikhino, in the vicinity of Khotynets station	Loam	Level tilled field	1'1" [33 cm]	3.37	1.66
At Sakhanki station, Orel District	–	–	1'2" [35 cm]	4.750	3.509
Between Orel and the village of Telegina, approximately 2 versts from Orel	–	In the middle of gently sloping plowland	1'2" [35 cm]	4.176	5.15

[1] Although cadastral investigations were twice carried out in the Kaluga Province (1852 – 18[illegible] and 1862 – 1865), extracts from these works contain very little information on soils, mentioning inundated areas, silty or podzolic sandy loams and loams, as well as ordinary sandy loams and loams. Loams appreciably admixed with humus are regarded as of highest quality. No chernozem is mentioned. Materialy dlya statistiki Rossii... (Materials for Russian Statistics...) [collected by the Ministry of Government Estates St. Petersburg. 1871], No. 5, pp. 10 – 12.

[2] Gel'mersen. Ibid., p. 31.

Kytmanov, who inspected the Orel—Khotynets stretch of the railroad at my request (Khotynets is the last station before Karachev) reported: "The country is slightly rolling, with fairly numerous minor deciduous forests, sometimes with small bogs and sand areas; the soils are gray and rarely dark gray." I observed similar soils in the near neighborhood of Orel. A brief analysis of soil samples in my collection from this locality is given on the previous page.

West of Orel, up to Verkhov'e station (Novosil District), the soils are of appreciably better quality, darker, and thicker, 1 ft 2 in — 2 ft [35 — 61 cm]; bald patches are rare, and limited to hummocks. Very characteristically, Devonian limestones, marls, and their thin (1 — 5 feet [30 — 150 cm]) weathering products are almost everywhere the direct constituents of the parent rock for local chernozem.[1] Small forests are rare, and shrubs are exclusive to meadows. The country is quite level, fairly steppe-like in character.

Identical conditions were observed in the neighborhood of the Verkhov'e station where I took a sample 1 ft 11 in [58 cm] thick, containing 8.523% humus, from perfectly level plowland.

Kromy — Ponyri — Kursk

Chaslavskii's map depicts the Kromy District of the Orel Province similarly to the Chern District, on the northwestern boundary of the Russian chernozem zone. This circumstance alone suggests that the soils of this district are nonuniform, poorer in the northwestern section. On this basis, taking into account the general trend of the chernozem zone's northwestern boundary I subdivided the entire Kromy district in two, in 1881, soils of the eastern half containing 4 — 7% humus and of the western half probably containing less than 4% humus.

A detailed geological investigation of the Kromy District was carried out by N. A. Sokolov and N. V. Kudryavtsev, in the summer of 1882. The diluvium of this territory and its soil could not be disregarded. The result was as follows:

"The best chernozem in the Kromy District occurs in its southeastern part, especially along the boundary with Fatezh District in the Kursk Province,[2] where it may reach 3 — 4 feet [0.91 — 1.2 m] in thickness; the soils along the Svon River and its tributaries as well as soils along the Tureika, Tur'ya and Belyi Nemed rivers are considered of highest quality; in the same category are those soils in the upper reaches of the Oka River, in the neighborhood of Voronets, Venderevo and Konotop.

"The soils gradually decrease in thickness from southeast to northwest, and chernozem completely disappears in the northwestern corner, at the boundary with the Karachev District. Soil prices are in complete accordance with this variation in quality, the price being 120 — 150 rubles per dessiatine in the southeastern part of the district, and 40 — 60 rubles in its western

[1] Gel'mersen. Ibid.

[2] The entire description of the Kromy District, below, was made by Sokolov and is taken from his personal communication. Author.

and northwestern parts, in the basin of the Kroma and in the belt adjoining the Karachev District.

"Nevertheless, the central and northern parts of the district also contain isolated patches of very deep, rich chernozem. Such are the village of Votovo in the central part and the village of Shakhovo and the Ivanovskii farm in the northern belt. These 'oases' are located in deep river valleys.

"The subsoil of the chernozem in the Kromy District is almost throughout clayey loess, sometimes with a transition to pure clay. This loess is not stratified, is very porous and usually contains abundant $CaCO_3$ nodules which are known as 'dutish' or 'dutik'. In the rare cases where no loess is found the subsoil consists of loose sands of the Cretaceous system; chernozem is then sandy, lighter in color and very thin. Such outcrops of Cretaceous sands may be totally bare of chernozem, and may even occur amidst the unusually rich chernozem in the southeastern part of the Kromy District."

I observed the same gradual increase in chernozem thickness between Orel and the Ponyri station of the Fatezh District. The terrain becomes more level; the subsoil is represented in places by very sandy "white eye" ("beloglazka"); arboreal vegetation occurs exclusively in gullies and "balkas". A pit dug on a level field near Ponyri station gave the following section:

A. Soil horizon 1 ft 4 in [40 cm] thick with sparsely scattered $CaCO_3$ nodules.

B. Transition horizon, with a larger content of $CaCO_3$ nodules, grayer in color, with spots of scarcely altered bedrock, 10 inches [25 cm] thick.

C. Typical "white eye".

FIGURE 5.

a- Dark-gray vegetal soil, 1/2 – 1 1/2 feet [15–45 cm] thick, slumped from the adjacent slopes; b- typical peat, 3–4 feet [91–122 cm]; c- gray clay with a bluish tinge which was disclosed to a depth of 1 foot [30 cm].

From Ponyri station, toward Maloarkhangel'sk, the same type of chernozem stretches for 7—8 versts, whereupon bare patches of very clayey thin gray soil are seen. Typical peat deposits occur, remarkably, in rather sharply demarcated lowlands crossed by small brooks. A peatery on a gentle slope displayed the section represented in Figure 5.

This territory was undoubtedly forested in the past; the traces are visible to this day. The bare patches and peat deposits mentioned above are a result of this forest.

Observations from the Ponyri station en route to Kursk were made without lengthy investigation. Railroad excavations reveal chernozem nearly throughout, although it may be somewhat sandier and lighter in color than the Ponyri soil.

Kursk—Kiev

The Kursk—Kiev railroad runs along the left bank of the Seim River, sometimes approaching the river floodplain. The terrain, gradually sloping toward the Dnieper, is composed of Cretaceous formations in the first half of the route and of early Tertiary formations in the second half, both types underlying sandy-clay deposits.

The whole section, except for a small area between Korenevo and Krasnoe, was inspected partly (Konotop—Kiev) by me and partly by Kytmanov, my companion on the 1881 excursion.

Kytmanov's description of the country between Kursk and Korenevo station on the one hand and Krasnoe station and Konotop on the other follows.

The terrain is gently rolling, to the Ivanino station, with occasional lowlands and inundation meadows containing small shallow bogs; these also occur between Gruzskoe station and Konotop. The terrain rolls more markedly over a small stretch in the vicinity of the L'govskaya [L'gov] and Korenevskaya [Korenevo] stations. Perfectly level areas are more usual between these villages as well as in some places between Ivanino and L'gov. Gullies are rare; frequent sizeable remnants of deciduous forests provide evidence that such forest was much more common on this territory in the recent past. Partly decayed remains of tree stumps are still dug out of the fields at Ivanino and Korenevo.

The soil under the trees at the edge of a forest remnant between L'gov and Korenevo is, characteristically, much lighter in color than the soil of the adjoining field.

Light-textured loams, sandy loams, and sometimes pure quartz sands appear to be the predominant parent rocks. Small sand dunes are even formed between Kursk and Ivanino as well as along the approaches to Gruzskoe.

In the neighborhood of Konotop, Bakhmach and Nezhin, as well as between these places, the country is dry and level, sometimes of a typical steppe nature. Areas of several thousands of dessiatines, entirely different in character, occur only in the vicinity of the Kruty station, the village of Pechi, and around the Nezhin station, in the form of barely discernible depressions in the steppes. They may be enclosed on all sides, and then again may ramify over the steppe, similar to river systems; they then serve as channels to carry the extremely rapid flow of snowmelt and rainwater reported by local inhabitants. In spring, as well as following the strong summer rains, water stagnates in these lowlands, often for months, forming quagmire and true steppe bogs. During a dry summer, these lowlands are dry and are distinguished from the surrounding steppe with difficulty.

Such lowland vegetation is usually a combination of steppe and bog-paludine[1] flora with one of the components predominating according to circumstances.

Purely paludine (though thin) black formations with a bluish tinge are very rare in lowlands of this kind, and occur only in the deepest closed depressions. These lowlands usually contain a pale bluish-white "suglei". "Suglei" very often gradually and imperceptibly merges with typical steppe soils along the lowland margins.

The local inhabitants designate such lowlands as bogs, clayey areas and solonetses, and domestic animals are claimed to use them as licks.[2]

On the basis of our logs and samples, a darkish sandy loam predominates in the entire territory under consideration (between Nezhin and Krasnoe and in the environs of L'gov and the Korenevo station) while gray sandy soil is rare (Ivanino). All these soils are very loose and friable and are called "pea" soils by the inhabitants of L'gov and Nezhin. According to their natures, the soils are used for potato crops and large sowings of buckwheat, especially near Korenevo.

The general character of samples taken between Kursk and Nezhin is presented in the table on the following page.

Color is no criterion, since the soils are similar in that respect. All the soils (except for the Konotop sample) are, generally, darker gray than is to be expected from their low humus content.[3] Unfortunately, this phenomenon is still obscure. The unusual thickness (in relation to humus content) of these soils is remarkable, reaching 3 ft – 4 ft 8 in [91 – 142 cm] on level heights. All these samples possess very high specific gravity (as is evident from their weight in hand), thanks to the content of quartz sand which is so considerable that many grains are visible to the naked eye. The soils are thus very loose and readily permeated by plant roots, various solutions, and even suspensions.

From Nezhin to Bobrovitsy station and 5–6 versts further on toward Kiev, the Nezhin fairly dark sandy-loamy chernozem, 1 1/2–3 feet [45–91 cm] thick, predominates, with only a few small shallow bogs. About 3–10 versts west of Nezhin, the terrain becomes appreciably lower and forms a continuous series of open bogs with dense sedges alternating with

[1] The coexisting growth of "feathergrass and rushes with enormous shoots", observed by Prof. Borisyak on the banks of the Khotomlya River in the Izyum District, must have been on such terrain. Borisyak, [N. J. O chernozeme (On Chernozem), p. 57. [Speech delivered at the Ceremonial Meeting of the Kharkov University. In book: "Otchet o sostoyanii Khar'kovskogo universiteta za 1851–1852 akademicheskii god." Khar'kov. 1852].

[2] The clayey "island" marked for this area on Chaslavskii's map was probably formed in this manner. These particular soils are reported by the local inhabitants to be very suitable for cultivation of onions, exported as far as Austria in large quantities (as many as 100 railroad cars).

[3] These soils appear especially dark when seen in a moist field; many investigators were misled concerning the nature of the Chernigov and Poltava soils.

solonetses of whitish soils, of the Nezhin type. Besides these two types, there were a few scattered small, apparently sandy light-yellow elevations usually covered by forest.[1]

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Kursk	Sandy loams	Level long fallow land	2'4" [71 cm]	4.814	4.452
L'gov station	—	Long fallow land in the middle of a very gradually sloping hill	—	3.01	—
Korenevo station	Sandy	Level, long fallow land	1'4" [40 cm]	2.069	2.554
Krasnoe	Sandy loams	Level field	2'11" [89 cm]	3.522	3.612
Bakhmach	—	Level, long fallow land	3'3" [98 cm]	2.80	1.24
Konotop	—	Level fallow field	4'8" [142 cm]	2.514	2.645
Nezhin, 1 verst east of the station	—	Level plowland	3'6" [106 cm]	2.345	2.395
Nezhin, 1 verst north of the station	—	Level plowland	3'6" [106 cm]	3.608	—

The Kiev Polesie begins 5—6 versts beyond Bobrovitsy and stretches up to Brovary, in many respects strongly resembling the Petersburg-Novgorod landscape. The terrain is almost completely level, with characteristically fairly deep bogs, lowlands containing whitish soil, and dry tussocky sandy plains covered by thin light-brown soils 3—6 inches [8—15 cm] thick, alternating. Low dune hills may occur, while forested areas are still fairly numerous.

The railroad between Brovary and Kiev almost exclusively traverses very hilly forested country with numerous gullies. Pine forests stretch as far as can be seen. The soil is very sandy, light-brown, 2—4 inches [5—10 cm] thick. A sample of this soil, taken from a fairly level site very

[1] After completing this description, the Chernigov provincial "zemstvo" office sent me "Materials for Land Valuation" (Materialy dlya otsenki zemel'nykh ugodii) of this province, volumes 5 and 6 [Chernigov, 1882]. Volume 5 contained the soil map of the Kozelets District, in which the entire district is divided into almost equal halves. "Sandy, gray-sandy, gray solonets soils" are marked in the northern half of the district, with "chernozem and chernozemic solonets" in the southern half, and sandy soils marked only in the extreme southwest of the southern half (pp. 21—29). Volume 6 contains an edifying map of crop yields in the Konotop District. The yield per dessiatine is 31—70 poods in the northern part of the district, increasing to 71—80 poods in its central part and reaching 71—90 poods in its southern part. The chernozem character of soils becomes gradually more pronounced in the same order and direction through the Konotop District (pp. 30—31).

close to Kiev, contained only 0.964% humus. The humus content can be only slightly higher in the soils of Brovary and Bobriki.

Bakhmach — Gorodnya — Starodub — Putivl

The Chernigov Polesie is known to be closely related to the Kiev Polesie. Kytmanov (who accompanied me on the 1881 excursion) travelled at my request by rail from Bakhmach to Gorodnya, and then along the highway via Starodub — Novgorod — Seversk — Glukhov — Putivl to Krasnoe, in order to examine the area at close hand and produce a more detailed pedological report, the gist of which follows.

The country between Bakhmach and Gorodnya is largely level or very slightly rolling; the undulations become stronger just before the Makoshino station and Gorodnya. All the sections observed by Kytmanov revealed either sandy loam or pure quartz sands. For some distance beyond Bakhmach the soils still appear of the Bakhmach and Konotop type, and several versts before Bondarevka thin, sandy, light-gray soils appear, frequently interrupted by sizeable forests (oak, birch, pine, etc.) and large areas of bare loose sands sometimes forming dunes.

Fields in such areas are often among forests and the humus content is so low that the soil appears white. This pattern continues up to Gorodnya, except for the area north of Makoshino station where small "islands" darker in color (probably sandy loam) are encountered.

The terrain stretching through Starodub to Novgorod-Seversk is essentially of the same nature: level, frequent coniferous forests, and sand both in the ground and in the very thin soil, 3 — 6 inches [8 — 15 cm] thick.

According to Kytmanov, "An endless sandy steppe is often observed on both sides of the Gorodnya — Starodub road; sandspouts are seen moving over the steppe due to winds of very high velocity, with obvious results. The weak rootlets are uprooted by the wind, and plowlands are drifted over by dune sands." Kytmanov reports such a case 5 — 6 versts before Khrenkova station, where a section discloses a layer of light-colored vegetal soil covered by a fairly deep dune sand drift. Only one darker "islet" was observed, about 5 versts before Novorobskaya station.

Soon after passing through Novgorod — Seversk, Kytmanov traversed several inundated meadows with deposited dark soils, and approximately 10 versts before Voronezh station he also saw "good, fairly dark vegetal-terrestrial soil"; this soil, alternating with gray soils, also stretches in the direction of Glukhov. However, about 10 versts before Glukhov, Kytmanov came across another large forest, followed by light-gray forest soils and finally again by chernozem just before Glukhov.[1]

From Glukhov to Putivl and further on to Krasnoe station the country again assumed a rolling nature and soils became appreciably darker and thicker. This change in color is gradual; loose sands stretch for a considerable distance past Glukhov, are then followed by gray soils reaching 1 foot in thickness, and 2 — 3 versts before Putivl the soils become dark and reach a thickness of nearly 3 feet [91 cm]; the latter is the case up to Krasnoe,

[1] Concerning this "chernozem", Kytmanov advises constant awareness that the local inhabitants apply the term "chernozem" to any soil somewhat darker than the gray sandy soil common to these places.

with light interruptions (inundated lowlands). All of Kytmanov's samples from the Gorodnya—Krasnoe area were of the best soils in the territory, regarded as chernozem by the local inhabitants. The high quality of these soils also seems to be indicated by their thickness; nevertheless, their humus content and, accordingly, their color to a certain extent are far inferior to those of chernozem soils; the reservation with regard to color is due to the relatively dark color of these soils, similar to that of Kursk and Nezhin soils (see the following table).

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
5 versts from Novorobskaya station, Novozybkov District	Sandy	Level plowland	1' [30 cm]	1.556	1.713
3 versts from Novgorod-Seversk	Sandy loam	—	10" [25 cm]	2.765	1.620
10 versts north of Voronezh station, Glukhov District	Sandy	—	1'4" [40 cm]	1.425	1.188
1 verst north of Glukhov	—	—	?	1.680	1.204
2 versts north of Putivl	Sandy loam	—	2'11" [89 cm]	1.862	1.237

Academician Ruprecht[1] reports that the Glukhov type of chernozem includes the "islands" in the Chernigov Polesie, also observed on the right bank of the Desna River between Novgorod-Seversk and Chernigov, at Sednev and in other places. They are also surrounded by forests, bogs, and sands; the humus content of the famous Sednev soils can thus hardly exceed 3%.

To round out the description of the Chernigov Polesie and understand its abundance in sandy soils, the following schematic structure must be borne in mind, according to latest geological studies: 1) bottom layer—chalk and chalky marl, 2) glauconite greenish-gray quartz sands, 3) ocherous-yellow quartz sands,[2] 4) gray and brown sandy clays and loose sands with boulders of granite, gneiss, diorite, quartzite, etc., sometimes reaching 10 feet [3 m] in diameter (boulders being more frequent in the northern part of the province than in the southern part), 5) yellowish calcareous clays or loess.

[1] Ruprecht. Ibid., p. 71. The data on soils of this territory presented by Kytmanov and by Academician Ruprecht differ only with respect to soil thickness. Kytmanov estimates it at 1 foot while Ruprecht observed "10 versts in Novgorod-Seversk, south of the town, at Ponornitsy and at Sednev chernozem from 2 feet to 4 1/2 inches [61—12 cm]" (ibid.). Although Academician Ruprecht's data are not improbable, especially in view of the locality's sandy nature and the proximity of the Konotop and Nezhin soils, Mr Armashevskii, who visited this territory in 1874, did mention soils only about 1 foot thick, on Monastyrskaya Mt. in Novgorod-Seversk, in the neighborhood of Chulomovo, Drobyshevo, Arapovichi, Gorbovo, Degterevka, south of Radeevo, at Chernigov, etc. (Armashevskii. Geologicheskoe issledovanie Chernigovskoi gub. v 1874 g. (Geological Investigation of Chernigov Province in 1874), pp. 1—10). [Zapiski Kievskogo obshchestva estestvoispytatelei, Kiev, 1875, vol. 4, (1), No. 1, reprinted separately].

[2] According to Armashevskii, sands No. 2 are intermediate between Cretaceous and Eocene, whereas sands No. 3 are Eocene. Author.

The latter is found only in the Mglin, Starodub, Novgorod-Seversk, Glukhov, and Krolevets districts of the province, and even then not continuously; it often disappears over considerable areas. Loess is rarest on elevated portions of river systems.[1]

Kiev — Kazatin

The Kiev — Kazatin railroad line runs entirely within the Kiev Province (the Kiev, Vasil'kov, Skvira, and Berdichev districts) west-northwest to east-southeast. The terrain rises in the same direction. Absolute elevation of the Kiev railroad station is approximately 67 sazhens [143 m]; elevation near the station of Motovilovka (47 versts from Kiev) is about 83 sazhens [177 m]; 94 sazhens [200 m] at Fastov (63 versts from Kiev), 107.32 sazhens [229 m] at Brovka (117 versts from Kiev), and 126 sazhens [269 m] 138 versts from Kiev; absolute elevations reach 142.12 sazhens [303 m] beyond Kazatin (150 1/2 versts from Kiev).[2]

The terrain is generally moderately rolling. The geological structure of this territory was incompletely studied by Hofman, Andriyevski and Rogovich long ago; more extensive work was done by Barbot de Marni and Prof. K. M. Feofilaktov. For our purpose, the only important geological features are those deposits classified into two stages in the Kiev and the Chernigov provinces: the upper, loess, and the lower, boulder, stages. The boulder stage takes the form of loose or clayey sands, or brownish sandy clays. These rocks contain large amounts of northern boulders consisting of extremely varied igneous and sedimentary rocks.[3] Prof. Feofilaktov reports that these northern erratics may be 4 — 5 feet [1.2 — 1.5 m] in diameter.

Barbot de Marni, who inspected the railroad line in 1868, during its construction, reported the presence of the two stages determined by Prof. Feofilaktov at the 7th and the 11th verst from Kiev, in excavations between the 44th and 47th verst, at the Motovilovka station and before Fastov station.

Here "on the slopes of Sorochii Brod, loess reaching 2 1/2 sazhens [5.3 m] in thickness overlies diluvial white sand which contains ferruginous intercalations with chert boulders and weathered granites."[4] Soils are not always underlain by loess between Kiev and Kazatin. For instance, near

[1] Armashevskii, [P.]. Ibid., p. 2. Idem.: O geologicheskikh issledovaniyakh chernigovskoi gub. v 1875 (Geological Studies of the Chernigov Province in 1875), pp. 6—8 [Predvaritel'noe soobshchenie o geologicheskikh nablyudeniyakh v chernigovskoi gub. v 1875 g (Preliminary Report on the Geological Observations in Chernigov Province in 1875). — Zapiski Kievskogo obshchestva estestvoispytatelei, Kiev, 1876, Vol. 4 (1), No. 3, separate reprint].

[2] Barbot de Marni, [N.]. Geologicheskie issledovaniya, proizvedennye v 1886 g. v guberniyakh Kievskoi, Podol'skoi i Volynskoi (Geological Investigations Performed in 1868 in the Kiev, Podol'sk and Volhyn Provinces), p. 41. [Zapiski S.-Peterburgskogo mineralogicheskogo obshchestva, second series, part 7, St. Petersburg. 1872.]

[3] Feofilaktov, [K.]. O mestonakhozhdenii kremnevykh orudi cheloveka vmeste s kostyami mamonta v sele Gontsakh, Lubenskogo uezda, Poltavskoi gubernii (Find of Flint Artifacts Together With Mammoth Bones at the Village of Gontsy, Lubny District, Poltava Province), p. 24. [Trudy obshchestva ispytatelei prirody pri Khar'kovskom universitete, Vol. 9, Khar'kov. 1875.]

[4] Barbot de Marni. Ibid., pp. 50—51.

Vasil'kov the soils are directly underlain by quartz sands, 30 feet [9 m] and more in thickness, often outcropping on the surface; similar sands with very thin, 2—4 inches [5—10 cm] light-gray soils extend almost continuously from here along the dirt road to Kiev. I encountered the same soils in places near the Vasil'kov railroad station and especially in the environs of Motovilovka where the sands are overgrown by a sizeable pine forest. Similar light-yellow, very sandy formations stretch nearly up to Fastov. From Fastov towards Kazatin the loess becomes slightly more clayey although sandy interruptions still occur. Besides the Motovilovka forest, fairly large minor pine groves also occur at other places[1] in the territory.

The soils are gray almost throughout, considerably lighter in color in the east than in the west, and the Kazatin soil dark-gray. Soil thickness varies in the same direction although generally greater than expected from the low humus content. I took samples at the following points.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Kiev	Sandy	Plowland in the middle of a hardly perceptible slope	1/2—1' [15—30 cm]	0.964	1.615
Boyarka station	—	Level area overgrown by oak grove	—	1.298	0.701
Town of Vasil'kov	—	Plowland in the middle of a hardly perceptible slope	2'7" [79 cm]	2.421	2.80
Fastov	Sandy loam	Level ground along the road	1'8" [50 cm]	2.883	1.830
Kazatin, Berdichev District	Loamy	Level plowland	2'6"—3' [76—91 cm]	5.167	4.562

Kazatin — Berdichev — Rovno

This territory is a plain, its character becoming more pronounced toward the north. The structure of post-Tertiary formations is essentially the same as that between Kazatin and Kiev,[2] the only significant difference being the

[1] Boulder deposits with "boulders of northern feldspar crystalline rocks, limestones, and hornfels of Silurian and Carboniferous formations" are widespread just north of the line Kiev—Kazatin—Berdichev in the Zhitomir and Radomysl districts. Feofilaktov. Otchet o geologicheskoi ekskursii v uezdakh Radomysl'skom i Zhitomirskom (Report on the Geological Excursion in the Radomysl and Zhitomir Districts), pp. 3, 7, and 8. 1877. [Zapiski Kievskogo obshchestva estestvoispytatelei 1878, Vol. V(1), No. 2, Scientific Communications, separate reprint.]

[2] The reader is referred, inter alia, to Barbot de Marni and Karpinskii. Geologicheskie issledovaniya v Volynskoi gubernii (Geological Investigations in the Volhyn Province) [in book:]—"Nauchno-istoricheskii sbornik. [Izd.] Gornogo Instituta. [St. Petersburg]. 1873. In this paper, Karpinskii classified the loess he investigated in the Volhyn Province into two types, one containing only terrestrial shells, the other containing only freshwater shells, and both identical in essentials of composition and structure. Karpinskii adds: "Absence of stratification should not be included among the features characterizing typical loess, in any identification. Ibid., pp. 87—88.

[illegible] there is a [illegible] point. [illegible] Pechanovka station, [illegible] terrestrial darkish- [illegible] thick, stretched only as far [illegible] appreciably thinner [illegible] toward [illegible] Kazatin type. [illegible] of the Dnieper [illegible] interferes [illegible] boggy meadows, [illegible] and Ruprecht's "chernogryaz" [illegible] ground, with diffuse banks. North of Pechanovka and Polonnoe, the forest grows more continuous, mainly consisting of oak, birches, aspen, and pine, secondarily of spruce. However, tree development is poor due to the wet soil, and the trees appeared dwarfs in comparison to forests on chernozem soils (such as the southern part of the Nizhni Novgorod Province). The monotony is interrupted only by isolated infrequent sandy hummocks, and level elevations sometimes composed of loess and sometimes of sand. In both cases (loess or sand) the vegetal-te restrial soils were almost identical in color to the light-yellow bedrock and their thickness was usually 2 – 4 inches [5 – 10 cm], rarely 6 inches [15 cm]. Terrain of this nature stretched northward almost continuously over 200 – 300 versts !

I took the last sample of definite vegetal-terrestrial soil in a tilled field at Berdichev, on a level elevation; the specimen was 2 ft 3 in [69 cm] – 3 feet [91 cm] thick; it contained 3.116% humus and 2.378% hygroscopic water and its color was similar to the Kazatin type soil.

The sample from Polonnoe (Novograd-Volhynskii District) was taken on a wet level meadow, disregarding the sod. Without the sod (2 inches [5 cm]), the soil is 6 – 7 inches [15 – 18 cm] thick, with a 2.695% humus content and 1.138% hygroscopic water. Polonnoe soil is typically northern in color, light-gray.

My third sample from along this route was taken 1 verst south of Rovno, on a typical boggy meadow. Having removed the sod, I dug 2 1/2 feet [76 cm] down to reach the bedrock. The upper 2 feet [61 cm] consist of a perfectly homogeneous, uniform, dark-bluish mass with brown ferruginous spots, with a high content of slightly decayed arboreal (leaves) and herbaceous residues. Fragments of paludine shells and very small grains of argillaceous vivianite are also visible to the eye. At about 2 feet [61 cm] down there is half a foot [15 cm] of very fine whitish clayey sand. The bedrock is a very viscous, boggy clay, blue-tinged.

An elevated tilled field in the neighborhood of the town is covered by typically northern soils. A soil sample taken from this locality is 8 – 10 inches [20 – 25 cm] thick with a 2.855% humus content and 2.050% hygroscopic water.

COMPLETE CHEMICAL ANALYSES OF SOILS FROM THE NORTHERN BOUNDARY OF THE CHERNOZEM ZONE

Published data on the chemical composition of soils of the northern boundary chernozem belt are presented on the following page. All the soils predominating sands rather than loess, from Berdichev onward; there is also a pronounced tendency toward formation of typical bogs from this point.

Before Berdichev, and especially from Berdichev to Pechanovka station, minor forests are comparatively frequent. Vegetal-terrestrial darkish-gray soils of steppe type, 2—3 feet [61—91 cm] thick, stretched only as far as Berdichev; toward Ol'shanka station they became appreciably thinner (about 1 foot) and lighter in color. From Pechanovka station toward Polonnoe, Dubno and Kovel the soils are of the typical northern type, similar in every detail to the Polesie in the upper reaches of the Dnieper and Western Dvina: the surprisingly flat terrain which strongly interferes with runoff of atmospheric waters, the abundance of wet boggy meadows, a surface of excellent green sod and numerous tussocks and Ruprecht's "chernogryaz" ["black mud"] underneath; lakes and brooks abound, with diffuse banks. North of Pechanovka and Polonnoe, the forest grows more continuous, mainly consisting of oak, birches, aspen, and pine, secondarily of spruce. However, tree development is poor due to the wet soil, and the trees appeared dwarfs in comparison to forests on chernozem soils (such as the southern part of the Nizhni Novgorod Province). The monotony is interrupted only by isolated infrequent sandy hummocks, and level elevations sometimes composed of loess and sometimes of sand. In both cases (loess or sand) the vegetal-terrestrial soils were almost identical in color to the light-yellow bedrock and their thickness was usually 2—4 inches [5—10 cm], rarely 6 inches [15 cm]. Terrain of this nature stretched northward almost continuously over 200—300 versts!

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COMPLETE CHEMICAL ANALYSES OF SOILS FROM THE NORTHERN BOUNDARY OF THE CHERNOZEM ZONE

Published data on the chemical composition of soils of the northern boundary chernozem belt are presented on the following page. All the soils may be easily and naturally classified into the following groups: a) sample Nos. 1, 23, and 25, typical northern vegetal-terrestrial soils, b) Nos. 20 and 27, meadow soils, c) Nos. 3, 4, 5, 6, 7, 8, 14, and 16, the belt of transition soils (gray soils) with a 2—4% humus content and d) Nos. 9, 11, 12, and 13, the chernozem belt with a 7—10% organic substance content, according to my map; all other samples represent subsoil. The far-reaching difference between these soil types is demonstrated by the analyses; further details are entered into later.

Analyses by Borshchov[1]

Locality	1 verst west of Suzdal	Borovskii mound, on the Moskva River	10 versts south of Novgorod-Seversk	Right bank of the Oka River, at Kolomna	Right bank of the Oka, at Serpukhovo	27 versts from Kromy	Chernozem mound at Sednev	The same mound, sod
No.	1	2	3	4	5	6	7	8
Sampling depth	1' [30 cm]	2' [61 cm]	—	from the surface	under the sod	2' [61 cm]	1' [30 cm]	—
Contents of 100 parts of soil dried at 100°C								
A. Substances unaffected by ignition: 1) Insoluble in hydrochloric acid	94.16	79.09	90.42	96.62	89.12	87.69	92.30	94.82
2) Soluble in hydrochloric acid		13.51	4.71	1.51	7.52	7.66	3.64	2.07
B. Substances volatilized on ignition	5.84	7.40	4.86	1.86	3.35	4.64	4.05	3.11
Total	100.00	100.00	99.99	99.99	99.99	99.99	99.99	100.00
C. Hygroscopic water in dry air (per 100 [illegible]s soil dried [illegible] 100°) . .	3.67	2.99	2.25	0.51	2.50	4.84	2.07	0.95

[1] Ruprecht. Ibid., pp. 117–118.

Analyses performed under Prof. Il'enkov's guidance[1]

	Components	9	10	11	12	13	14	15	Locality and investigators
Fraction dissolved by hydrochloric acid	Silicic acid	0.018	0.010	0.026	0.273	0.261	0.025	0.017	No. 9. From the village of Mokhovoe, Novosil'sk District, top layer, analyzed by Ryazantsev.
	Sulfuric acid	0.079	0.070	0.103	0.074	0.066	0.089	0.078	
	Phosphoric acid	0.065	0.120	0.075	0.080	0.080	0.085	0.083	
	Carbonic acid	0.014	0.230	0.006	0.025	0.029	0.028	0.026	No. 10. The same locality, next layer, analyzed by Levitskii.
	Chlorine	0.005	0.130	0.002	0.003	0.003	—	—	
	Iron oxide	0.991	3.130	1.915	1.787	1.737	0.708	1.875	No. 11. From the village of Gniushki, Efremov District, never manured, cultivated from 1819 according to three-field crop rotation, analyzed by Popov.
	Aluminum oxide	0.688	1.690	1.650	1.570	1.590	0.687	1.891	
	Manganese oxide	—	0.090	0.085	0.110	0.120	—	0.163	
	Lime	0.209	0.680	1.966	0.998	0.998	0.599	0.702	
	Magnesia	0.723	0.430	0.471	0.388	0.392	0.483	0.404	
	K_2O	0.046	0.120	0.100	0.095	0.094	0.043	0.066	No. 12. In the vicinity of the town of Bogoroditsk, Tula Province, analyzed by Grigor'ev.
	Na_2O	0.051	0.140	0.001	0.015	0.015	0.014	0.005	
	Organic substances and chemically bound water	1.990	2.120	1.040	2.795	3.301	0.830	1.370	
Residue insoluble in hydrochloric acid	Silicic acid soluble in sodium carbonate	2.256	9.710	4.110	4.206	4.503	4.628	—	No. 13. The same locality, analyzed by Grigor'ev.
	Insoluble silicic acid	71.615	62.940	62.014	63.993	63.838	77.629	—	
	Iron oxide	6,320	1.700	2.110	1.605	1.109	1.529		No. 14. In the neighborhood of the town of Konotop, top layer in the field, analyzed by Samolevskii.
	Aluminum oxide		8.510	10.369	8.626	8.451	7.268	—	
	Lime	1.396	0.800	0.353	0.656	0.707	0.702	—	
	Magnesia	—	0.050	0.360	0.437	0.500	0.291	—	No. 15. The same locality, from a depth of 5 1/2–9 1/2 vershoks, analyzed by Kochkonogov.
	K_2O	1.835	2.320	2.255	2.625	3.191	1.034	—	
	Na_2O	1.396	1.52						
	Organic substances (loss on ignition)	8.440	3.53	10.470	8.951	8.582	5.758	—	
	Total	98.067	99.650	90.068	99.312	99.312	102.430	—	

[1] Il'enkov. O khimicheskom sostave chernozemnykh pochv. Godichnyi akt Petrovskoi [zemledel'cheskoi i lesnoi] akademii (Chemical Composition of Chernozem Soils. Lecture delivered at the annual graduation ceremony of the Petrovskaya [Agricultural and Silvicultural] Academy). 1872.

Analyses performed by Prof. Schmidt[1]

Locality	Vasil'kov, Kiev Province, tilled field in the middle of barely perceptible slope				Rostov, Yaroslavl Province, varied locality, meadow soil		
No.	16	17	18	19	20	21	22
Depth of sampling	down to 6" [15 cm]	between 6"–1'3" [15–38 cm]	between 1'3"–2'7" [33–79 cm]	below 2'7" [79 cm]	down to 9" [23 cm]	between 9"–1'7" [23–48 cm]	below 1'7" [48 cm]
Hygroscopic water loss by 100 parts of air-dry soil at 100°C	2.31	2.26	2.98	1.96	7.93	5.79	6.17
	Total contents of 100 parts dried at 100°C (sum of components soluble in HCl and HF, + quartz sand which is insoluble in HF)						
Water loss at 100–150°C	0.260	0.203	0.348	0.290	0.348	0.850	0.708
Organic substances (and zeolite water?)	3.310	2.785	2.344	1.182	9.864	3.718	2.790
Mineral components	96.430	97.007	97.308	98.528	89.788	95.432	96.502
K_2O	1.821	1.849	1.770	1.891	2.018	2.209	2.495
Na_2O	0.725	0.656	0.724	0.650	1.008	1.016	0.928
CaO	0.755	0.674	0.673	4.706	1.228	0.972	0.768
MgO	0.625	0.605	0.643	0.781	0.682	0.732	0.724
Mn_2O_3	0.016	0.021	0.034	0.035	0.019	0.071	0.014
Fe_2O_3	1.738	1.629	1.985	1.858	1.932	2.376	4.575
Al_2O_3	7.425	6.673	8.035	8.096	12.413	14.258	14.008
CO_2	0.003	0.084	0.004	3.499	0.118	0.101	0.059
P_2O_5	0.089	0.091	0.080	0.069	0.214	0.264	0.128
SO_3	0.001	0.002	0.003	0.003	0.005	0.002	0.002
NaCl	0.006	0.005	0.004	0.004	0.004	0.004	0.004
a) silicic acid soluble in hot but weak solution of sodium hydroxide	8.322	8.989	10.112	10.169	18.076	11.212	12.798
b) silicic acid soluble in 33% HF	50.256	45.367	50.693	46.692	36.809	50.273	47.058
Quartz sand insoluble in HF	24.648	30.372	22.548	19.874	15.262	11.936	12.941
$CaCO_3$	0.007	0.191	0.009	7.952	0.268	0.230	0.134
$Ca_3P_2O_8$	0.194	0.199	0.175	0.151	0.467	0.575	0.280
CaO (residue combined with SiO_2 and with humic acid)	0.646	0.459	0.573	0.171	0.825	0.531	0.541
Nitrogen	0.130	0.121	0.097	0.012	0.409	0.103	0.046

[1] The soil samples analyzed by Prof. Schmidt were collected by myself. See "Physicochemical Studies of Soils and Subsoils in the Chernozem Zone of European Russia" (Fiziko-khimicheskie issledovaniya pochvy i podpochvy chernozemnoi polosy evropeiskoi Rossii), No. 1, 1879.

Analyses performed at the chemical laboratory of the St. Petersburg University under the direct guidance of Mendeleev[1]

Locality	Vyaz'ma District, Smolensk Province		Klin District, Moscow Province		Environs of St. Petersburg	
Depth of sampling	soil — top 4 vershoks [18 cm]	subsoil — next 4 vershoks [18 cm]	soil — top 4 vershoks [18 cm]	subsoil — next 4 vershoks [18 cm]	soil — top 4 vershoks [18 cm]	subsoil — next 4 vershoks [18 cm]
Reaction to litmus paper	weakly acid reaction	the same reaction	the same reaction	neutral reaction	acid reaction	weakly acid reaction
No.	23	24	25	26	27	28
Extracted by nitric acid from 100 g air-dry soil:						
CaO	0.167	0.154	0.140	0.160	0.109	0.083
MgO	0.336	0.378	0.186	0.159	0.070	0.079
K_2O	0.100	0.174	0.070	0.150	0.049	0.063
Na_2O	0.049	0.055	0.035	0.046	0.035	0.039
Al_2O_3	2.678	3.137	1.148	1.357	1.237	1.345
SiO_2	0.041	0.057	0.050	0.044	0.043	0.127
P_2O_5	0.005	0.0[illegible]	0.069	0.055	0.027	0.020
Iron oxides	1.555	2.320	1.106	0.944	0.456	0.551
Manganese oxide	0.048*	0.004*	0.042*	0.019*	0.011*	Traces
Total	4.978	6.285	2.846	2.934	2.037	2.307
Extracted by soda and strong sulfuric acid from residue insoluble in nitric acid:						
Al_2O_3	3.12	3.52	1.72	0.95	1.20	1.20
SiO_2	9.103*	20.216*	3.506*	5.025*	4.643*	4.170*
	12.223	23.736	5.226	5.970	5.843	5.370
Remaining insoluble (sandy) components	76.[illegible]	65.212	86.837	89.958	81.202	84.964
Substances liberated by soil ignition:						
Hygroscopic water	1.550	1.790	0.960	0.680	1.735	2.075
Carbon	0.839*	0.606*	0.461*	0.165*	2.432*	2.406*
Humus (C × 1.724)	1.450	1.040	0.790	0.280	4.190	4.140
Total nitrogen	0.113	0.040	0.131	0.041	0.158	0.115
Sulfu[illegible]ermined from separate portion of the sample	0.070*	0.030*	0.070*	0.190*	0.060*	0.050*
Total loss on ignition	5.050	4.320	4.440	1.990	9.650	6.580
Total	99.042	99.582	99.419	101.042	98.792	99.271

[1] In evaluating the analytical data, the mode of sampling must be borne in mind. Several soil and subsoil samples were taken from a given dessiatine. The soil samples were respectively mixed with the subsoil samples, and a portion of the total mass was then taken for analysis. The numerical data marked by an asterisk (*) were obtained by a single analysis, while all the other data are arithmetic means, derived from several analyses. [See] "Agricultural Experiments of the Free Economic Society. Chemical Studies of Soils and Produce of Experimental Fields in the Simbirsk, Smolensk, Moscow, and Petersburg provinces, Performed by the Chemical Laboratory of the St. Petersburg University by F. Vreden, Ya. Oliv'e, F. Titov, G. Schmidt and E. Yakobi, with Introduction by D. Mendeleev" (Sel'skokhozyaistvennye opyt. VEO. Khimicheskie issledovaniya pochv i produktov s opytnykh polei Simbirskoi, Smolenskoi, Moskovskoi i Peterburgskoi gubernii, proizvedennye v khimicheskoi laboratorii S.-Peterburgskogo Universiteta gg. F. Vredenom, Ya. Oliv'e, F. Titovym, G. Shmidtom i E. Yakobi, s predisloviem D. Mendeleeva), [Moscow]. 1870.

GENERAL CHARACTER OF THE NORTHERN BOUNDARY OF THE CHERNOZEM ZONE

No boundary, in the accepted sense of the term, may in fact be determined in the northern part of the chernozem zone. The chernozem limit is marked as a rather wide belt (sometimes reaching 100 versts and more) in which the northern low-humus sod soils form a gradual and imperceptible transition to chernozem soils which have a higher content of organic substances. This soil character is more pronounced in certain areas of this belt than in other areas; chernozem may penetrate the northern soils, forming wedges and "islands", while in other places northern soils penetrate into the chernozem.

This conclusion has been advanced repeatedly. Blasius, discussing the northern chernozem boundary in the Chernigov Province (along the Gorodnya meridian) remarked, inter alia, upon the gradual transition from the northern to the southern soils, and the barely perceptible variation in the color of the humus cover [humus horizon] (Humusdecke).[1]

The unknown author of "Studies of Chernozem" (Issledovaniya o chernozeme) also reports: "At the extreme northern and the extreme southern boundaries of the chernozem zone, there is a very gradual and continuous transition to other soils, so much so that the closest examination does not reveal any perceptible demarcation."[2] Prof. Levakovskii, who examined certain areas in the northern margin of the chernozem zone in the Orel and the Chernigov provinces also "did not see a clear, sharp boundary anywhere."[3]

However, the information cited and other, unquoted information do not lead to a suitable solution to the problem. Certain data lack any factual basis in the first place, while others (supplied by Blasius and Levakovskii) apply only to insignificant areas of the northern chernozem boundary. In addition, not one of these authors substantiates his conclusion, nor is concerned with the refutation of the numerous converse indications. Eminent scientists, such as Güldenstädt,[4] Murchison, and, to an extent, even Ruprecht, apparently recognized a sharply delineated boundary. The conclusions of the last two appear especially well-founded and convincing at first glance. Murchison recognizes the coincidence of the northern chernozem boundary with the southern boundary of "gravelly northern deposits",[5] while Academician Ruprecht is convinced that in the past the Russian "chernozem continent was definitely bounded by the Aral-Caspian basin on the south and east, while its northern boundary was formed by the shores of a shallow freshwater (diluvial) sea"; he therefore recognizes "the existence of a clear-cut northern chernozem boundary."[6]

1 Blasius. Reise im Europ. Russland [in den Jahren 1840 und 1841, Braunschweig], 1844, Part II, p. 199. According to Mr. Kryukov, "the northern chernozem boundary as well is not sharply delineated but is more or less patchy." Levakovskii. Materialy dlya izucheniya chernozema (Materials for Study of Chernozem), 1871). [Trudy obshchestva estestvoispytatelei prirody pri Khar'kovskom Universitete, Vol. 4], p. 6. However, it cannot be inferred that the author assumed the existence of transition soils at the northern boundary of chernozem.

2 Zhurnal ministerstva gosudarstvennykh imushchestv, part 52, p. 104. 1854.

3 Levakovskii. Ibid., p. 6.

4 Güldenstädt. Reise im Südl. Russl. [St. Petersburg], T. I. S. 88. 1787.

5 Murchison. Ibid., p. 541.

6 Ruprecht. Ibid., pp. 11, 20–21, 25.

This accuracy is [claimed to be] such that, according to Ruprecht, the width of rivers (Desna, Oka, Kama, etc.) suffices to form a boundary between the northern and the southern soils.[1] North of this limit "there begins a sudden rise in the number of forests, whereas within the chernozem zone the forests gradually diminish, and preclude any possibility of drawing a boundary."[2] Siberian and European spruce occur exclusively north of the boundary,[3] while to its south direct indications of chernozem are provided by such plants as "Stipa pennata, Adonis vernalis, Veronica incana, Linum flavum, Geracus fruticosa, Serratula heterophylla and coronata, Centaurea marschalliana and ruthenica, Scorzonera purpurea, Calatella punctata, Aster ammelus, Hieracium virosum, Campanula sibirica, Phlomis tuberosa, Nepeta nuda, Echium rubrum, Falcaria rivini, Trinia henningii, Euphorbia procera, Lychnis chalcedonica,"[4] and most characteristic in Ruprecht's opinion is Stipa pennata.

Thus, Ruprecht assumes a sharp change in soils and a "striking change"[5] in the flora, at the northern chernozem boundary; these facts are concurrently related by him to the geological age of the chernozem continent. Six months later, in fact, after examination of a considerable section of the northern chernozem boundary Academician Ruprecht himself regarded "the jagged northern boundary of the chernozem region as not always as sharply marked as previously assumed."[6] However, Ruprecht does not alter his former views on the subject to include the possibility of gradual transitions between the northern and southern soils. On the contrary, Academician Ruprecht admits the extreme irregularity of the boundary, as is indicated by the following facts. Firstly, Ruprecht continues as follows: "North of this (boundary) line there are many chernozem 'islands'." Secondly, his entire subsequent discussion purports to prove the close interrelationship of chernozem and steppe vegetation. Finally, the northern boundary of chernozem is marked on Academician Ruprecht's map as a definite, though very tortuous, line.

Obviously, such authorities as Murchison and Ruprecht must inevitably have influenced their contemporaries as well as later geographers of chernozem. As a result, and also due to the prevalent opinion of local farmers with regard to the distinctness of the northern boundaries of chernozem and their coincidence with rivers, all the general soil maps available today mark the northern boundary of the chernozem zone as a definite line. The map compiled by the late V.I. Chaslavskii (1879) is the first to add a "transition belt, sometimes a few versts wide, where chernozem forms a gradual and often imperceptible transition to the surrounding soils with which it merges"[7] at the northern and other boundaries. These soils of transitional color, regardless of composition, are all designated as gray soils on Chaslavskii's map.

[1] Ibid., pp. 11–13.
[2] Ibid., p. 14.
[3] Ibid., pp. 12, 14 and 17.
[4] Ibid., pp. 14–15.
[5] Ibid., pp. 11 and 12.
[6] Ibid., p. 25.
[7] Quoted from the unpublished (although printed as one sheet) paper, "Soil" (Pochva) by Chaslavskii.

The character of the boundary and thus the conclusion I drew at the beginning of this chapter were extremely controversial until very recently.[1] Only now, when the boundary has been examined in detail almost throughout, has a significant change occurred, toward a positive and final decision upon this very important question. Our conclusion is supported by virtually irrefutable arguments, as follows: a) gradual increase in humus content of soils, b) gradual darkening, and c) gradual increase in soil thickness. These phenomena are noted all along the northern boundary in a southward direction.

When I first formulated this conclusion (1877), the very close interrelationship which Academician Ruprecht strove to establish between the northern boundaries of chernozem and of steppe flora was incomprehensible to me. If, indeed, this chernozem boundary is not sharply delineated, but includes a belt, sometimes quite wide, containing a series of transitional soils, is a coincidence of the steppe vegetation limit and the northern chernozem boundary possible? All the data, on the contrary, pointed to a very gradual series of transitions from steppe to northern type of vegetation. Indeed, this theoretical conclusion was completely justified by reality.

As early as [Ruprecht's] "Geobotanical Studies of Chernozem" (Geobotanicheskie issledovaniya o chernozeme) there are numerous indications[2] that a large number of true chernozem plants penetrate far beyond the northern limits of the chernozem zone and grow on soils which may be totally dissimilar to chernozem. This fact was also lucidly stated and explained by the comprehensive "Essay on Flora of the Tula Province" (Ocherk flory Tul'skoi gubernii) by Kozhevnikov and Tsinger.[3]

According to Chaslavskii's map and to my own data[4] the Tula Province, as many other regions along the northwestern chernozem boundary, is pedologically subdivided into belts going northeast—southwest, the soils of the southeasterly belts becoming progressively higher in quality, darker, thicker and richer in humus.[5]

All the principal conclusions drawn by Kozhevnikov and Tsinger, several of which are presented below, correspond to my scheme.

1. "Since distribution of chernozem is foremost among the physical conditions influencing plant distribution in the Tula Province, the province is botanically and geographically best subdivided into two principal parts: the northwestern, nonchernozem section, and the southeastern, chernozem section. The distribution of chernozem generally coincides with the distribution of forests and wet, low-lying, boggy areas in this province, in such a way that those nonchernozem belts of the province at a lower absolute elevation will also be better forested and more abundant in stagnant waters,

[1] Dokuchaev. Predvaritel'nyi otchet po issledovaniyu yugo-zapadnoi, yugo-vostochnoi chastei chernozemnoi polosy Rossii. Soobshcheniya 31 oktyabriya 1877 i 1878 godov (Preliminary Report on the Investigations of the Southwestern, Southeastern Parts of the Chernozem Zone of Russia. Communications of 31 October 1877 and 1878). [Trudy PEO. Vol. 1, No. 1. 1878; Vol. 1, No. 1. 1879.]

[2] Ruprecht. Ibid., pp. 38—39, 48, 57—59, 63—64, 74—75, 83—89, etc.

[3] Trudy S.-Peterburgskogo obshchestva estestvoispytatelei, Vol. 11, No. 1, pp. 37—150. 1880.

[4] Skhematicheskaya pochvennaya karta chernozemnoi polosy Evropeiskoi Rossii (Schematic Soil Map of the Chernozem Zone of European Russia). 1881 [1882].

[5] In the Tula Province, I demarcated four soil belts, as follows: I—with humus contents of 0.5 to 2%; II—from 2 to 4%; III—from 4 to 7%; IV—from 7 to 10%.

while the chernozem, or steppe, higher section is bare of fore[illegible] and contains very few wet, boggy areas."[1]

2. "However, it must be noted that the boundary between these two halves, which is rather indistinct even pedologically, is even less distinct in the botanical-geographical respect, since very many plants ... which, characteristically, are frequent and abundant in the chernozem districts of the Tula Province (such as Silene noctiflora, Geranium sibiricum, Linum flavum, Genista tinctoria +, Cytisus biflorus +, Astragalus hypoglottis +, Astragalus cicer +, Lathyrus pisiformis +, Potentilla alba, Rosa canina, Eryngium planum +, Asperula tinctoria. Scabiosa ochroleuca, Aster amellus, Artemisia scoparia, Echinops sphaerocephalus, Campanula sibirica +, Echium vulgare, Verbascum lychnitis, Veronica spuria, Salvia pratensis, S. verticillata, Thymus marschallianus, Nepeta nuda, Stachys annua, Phlomis tuberosa, Euphorbia procera, Asparagus officinalis +, Anthericum ramosum) occur in its forested part as well."[2] Some of these plants are exclusive to the banks of the Oka River, while others penetrate more or less far into the nonchernozem districts, unaffected by the Oka. The majority of the latter species exist mainly on calcareous outcrops along banks of rivers and gullies, when occurring beyond the limits of chernozem; certain of these species grow exclusively on calcareous soils when occurring in the forested part of the province (Campanula sibirica, Salvia verticillata, Phlomis tuberosa), while others may also grow on other soils.[3]

3. "In addition to plants occurring in all chernozem areas in the Tula Province as well as in adjacent provinces, the Tula flora includes several forms of the southern part of the province which is of a stronger steppe nature and is covered by a thicker layer of chernozem." Among these are:

a) plants of calcareous slopes[4]:

Dianthus capitalus, Gypsophila altissima +, Silene chlorantha ++, S. viscosa ++, S. otites ++, Polygala sibirica +, Linum perenne, Amygdalus nana, Spiraea crenifolia, Asperula glauca +, Echinops ritro +, Jurinea mollis +, Scorzonera marshchalliana +, S. hispanica, Echium rubrum, Veronica incana ++, Allium albidum +, Stipa pennata, S. capillata +, Bromus patulus ++, Triticum rigidum +.

b) plants of noncalcareous soils:

Sisymbrium strictissimum, Draba repens, Vaccaria vulgaris, Scorzonera purpurea, Verbascum orientale, V. phoeniceum, Orobus albus, Trinia henningii, Peucedanum alsaticum, Centaurea ruthenica, C. biebersteinii,

[1] Kozhevnikov and Tsinger. Ibid., pp. 46 and 47.

[2] "Plants marked + also occur in nonchernozem areas in provinces adjacent to the Tula Province as well." Kozhevnikov and Tsinger. Ibid., pp. 47, 62 – 63.

[3] Ibid., p. 47, 63 – 64.

[4] Kozhevnikov and Tsinger used + for plants occurring exclusively on limestones and ++ for plants occurring beyond the boundaries of chernozem in other provinces. Ibid., p. 65.

Serratula coronata, Veronica austriaca, Atriplex rosea, Iris furcata, Bromus erectus ++, B. tectorum ++.

The northwestern boundary of these plants in the Tula Province is the "line drawn from the confluence of the Nepryadva River with the Don River (Epifan District) to the northern boundary of the Novosil District; consequently, the southern belt, which is more steppe-like, includes the southern portion of the Epifan District, part of the Bogoroditsk District and the entire Efremov and Novosil'sk districts"; in other words, that portion of the Tula Province which is composed, as depicted on my map, of chernozem with a 7 — 10% humus content. However, not all the plants mentioned are limited by the northwestern boundary on the map; some do not extend as far, while others penetrate further north. Spiraea crenifolia, Asperula glauca, Scorzonera purpurea and other plants mentioned above have been found in the southern part of the Chern District.[1]

4. Finally, examining the characteristic features of the southeastern part of the province in relation to its southwestern part, "it is noteworthy that the northern boundary of the belt of southern chernozem flora is much more northerly in the east, in the Epifan District, than in the west."[2]

The lengthy quotations from Kozhevnikov and Tsinger's work provide incomparable geobotanical proof of the validity of our conclusion with regard to the transitional character of the northern boundary of chernozem. Their work provides invaluable support for my opinions; together with my map it justifies the hypothesis that the pattern of flora distribution in the Tula Province is repeated in the provinces along the northwestern boundary of the Russian chernozem zone.

An essentially identical transition between the typical steppe flora and the northern flora was observed by Krylov in the Kazan and Perm provinces.[3] However, a detailed citation of the conclusions[4] and the most important facts he presents would only repeat the above discussion. I shall therefore dwell only on the extremely interesting circumstance noted by Krylov that some of the abundant steppe plants in the central part of the Kazan Province (north of the Kama River) "mainly inhabit more or less steep slopes, usually with a southern exposure" while others (even Stipa pennata, near Kazan) grow on sandy or heavy marly soils.[5] This fact, together with the occurrence of the same plants in the Moscow, Tula, and Perm provinces mainly on limestones led Krylov to conclude that in these data it is not soil composition which is emphasized but the physical properties and exposure to light and heat. "I believe that steppe plants are obviously distributed in the

[1] Kozhevnikov and Tsinger. Ibid., pp. 64 — 66.

[2] Ibid., pp. 65 — 66.

[3] Krylov, [P.]. Predvaritel'nyi otchet v botaniko-geograficheskikh issledovaniyakh Kazanskoi gubernii v 1881 g. (Preliminary Report on the Botanical-Geographical Investigations in the Kazan Province in 1881) [Prilozhenie k protokolam Kazanskogo obshchestva estestvoispytatelei (Supplement to Minutes of the Kazan Society of Naturalists), No. 61, Kazan. 1882], pp. 4, 5 and 8, etc. Idem. Material k flore Permskoi gubernii (Materials on the Flora of the Perm Province), No. 1, pp. 24 — 27, 91 — 94, 103, etc. — Trudy obshchestva estestvoispytatelei pri Kazanskom universitete, Kazan, Vol. 6, No. 6. 1878].

[4] and [5] Krylov. Predvaritel'nyi otchet v botaniko-geograficheskikh issledovaniyakh Kazanskoi gubernii (Preliminary Report on the Botanical-Geographical Investigations in the Kazan Province), pp. 10 — 13. Also see: Material k flore Permskoi gubernii (Materials on the Flora of the Perm Province), p. 113, etc.

Kazan Province on the basis of climate rather than according to the presence of chernozem."[1]

As seen above, this conclusion is also indicated by feathergrass distribution in the southeastern part of the Nizhni Novgorod Province, where it grows on the bank of the Volga on typical northern soil.[2]

The botanical data presented above assure us that the northern boundary of the steppe flora is also a series of gradual transitions, as proved in respect to chernozem soils.[3]

The following conclusions may be drawn:

a) Should the northern chernozem boundary be regarded as clear-cut and continuous, the endless variations and inconsistencies in its shape obvious upon comparing works by different authors are comprehensible and indeed inevitable (see general map).

b) The entire boundary should therefore be mapped as a more or less wide belt with numberless transitions of soils from typical northern to typical southern ones.

Obviously, the gradualness of transitions of soils and flora at the northern chernozem boundary is not a mathematical quantity regularly decreasing and increasing. From the detailed description of the boundary it is clear that several sizeable gaps exist, on which basis certain investigators have regarded the boundary as sharply delimited.

These interruptions, as well as the apparent sharpness of the boundary in certain places are due to the coincidence of the northern chernozem boundary in many places with a more or less wide sandy belt of European Russia, stretching almost parallel from northeast to southwest.

[1] I know of no other general geobotanical works on the northern chernozem boundary appearing after Ruprecht's work. Author.

[2] Relatively close by, in the Shatsk District, south of Elat'ma at the village of Rozhestveno, Meier found such plants (Ruprecht, Ibid., p. 59) as Stipa pennata, Serratula heterophylla, etc., which, in Ruprecht's opinion, are typical of chernozem. The Shatsk District, however, is far from a typical chernozem locality. Feathergrass was also found in the Moscow Province (ibid., p. 52), along the Moskva and Oka rivers, which have no trace of chernozem. Author.

[3] In the same way, Academician Ruprecht's following statement must be held in some doubt (ibid., p. 12): "The southern boundary of European and Siberian spruce apparently coincides with the northern chernozem boundary from Volhynia to Ufa," for the following reasons: a) Ruprecht was aware (ibid., p. 51) that "pine and spruce grow together on sandy soils near Krasnoslobodsk," fairly far south of the northern chernozem boundary of these trees; b) I have already pointed out that towering spruces grow in the once famous groves of shipbuilding timber in the Alatyr basin, Lukoyanov District, approximately 150—200 versts south of the Volga and hence of the boundary; c) the occurrence of spruce in the so-called forest-steppe section of the chernozem zone in the Perm Province was mentioned by Krylov (Materials, p. 94); d) similar examples were also observed by Pacht in the Tambov, Penza, and Simbirsk provinces on the banks of the Sura and the Tsna. Ruprecht was considerably perturbed by these facts (p. 57), although according to his hypothesis they could be explained by the former existence of very narrow bays of the glacial sea in the basins of the Moksha, the Alatyr, the Sura and the Tsna, reaching far into the chernozem continent. The occurrence of spruce in the forest-steppe section of the chernozem zone is extremely interesting in this context; close to the center of chernozem Russia "the flat left bank of the Voronezh River, consisting of deposited sand, is covered to a great extent by tall, dense forests, mostly consisting of spruce" (Pacht. Geologicheskie issledovaniya, proizvedennye v guberniyakh Voronezhskoi, Tambovskoi, Penzenskoi i Simbirskoi (Geological Investigations Performed in the Voronezh, Tambov, Penza, and Simbirsk Provinces), p. 171. 1856). This phenomenon is utterly incomprehensible from Ruprecht's standpoint and therefore he may not have mentioned it.

As early as 1851 Russian geographers noted the existence of this belt and marked it repeatedly, with certain variations, on their soil maps.[1] There is no doubt that it was marked in greatest detail and quite vividly on Chaslavskii's map (1879).

According to Chaslavskii's map, the belt commences in southwestern Russia in the form of an enormous depression, almost entirely within the Pripet River basin. The sandy belt thence descends along both banks of the Dnieper River south to Kiev, then ascends along the Desna to Chernigov. It then turns northeastward and stretches, with slight interruptions, partially through the basin of the Desna and partially somewhat to its north, to the upper reaches of the Oka, from Belev to Kaluga; in the last section the sands are especially widespread in the Trubchevsk, Karachev, Bryansk, and Zhizdra districts.

The least constancy and poorest development are noted between Kaluga, Tula, and Kolomna. On the other hand, immediately on the passing of the Oka River into Ryazan Province, to the north of the river, the well-known sandy basin begins (one section of which is known as the Meshchera [Meshcherskii] Territory), stretching almost solidly up to the Volga. This basin includes very large territories in the Moscow, Ryazan, Vladimir and other provinces. Between Spassk, Kasimov, and Murom the same region extends to the southern right bank of the Oka where it occupies a sizeable area in the Spassk District (in the Tambov Province), the Temnikov, Elat'ma, Murom, Ardatov, Krasnoslobodsk, Lukoyanov, and partly also Gorbatov districts. From the confluence of the Oka with the Volga, a broad sand belt stretches along the left bank of the Volga, roughly from Yur'evets to Kazan. Chaslavkii's map depicts clayey soils along the left bank of the Kama, from its mouth to the mouth of the Vyatka River, but loose quartz sands are also common here, at least in certain places (such as opposite Chistopol and Chelny).

The belt varies in width, as is expected and in fact made clear on Chaslavskii's map, within a very wide range, from 1—2 dozen versts to hundreds of versts, as is the case in the basins of the Pripet (Polesie) and the Oka (Meshchera Territory); this belt is generally wider in the west than in the east.

The main physical feature of the belt, as mentioned above, is the sands, which are quite compact and coherent in certain places, and are loose dune sands in other places. Under the magnifying lens, they consisted almost exclusively of quartz sands, with only sporadic grains of feldspar, hornblende, and charcoal. The sands vary in age; they may be no later than Jurassic (in the Nizhni Novgorod Province), they may belong to the Early Tertiary system (the Chernigov Province), while the prevailing case is that of diluvial sands. A considerable part of these sands are eluvial in nature, i.e., derived by erosion of sand-containing bedrock by atmospheric waters, regardless of their formation, in the region of the present-day sandy belt. The soluble and readily suspendible components were washed away, the sands remaining in situ (Nizhni Novgorod Province, etc.).

[1] See soil maps published by the Ministry of Government Estates, 1851—1869.

The eluvial origin of a considerable part of these sands is also indicated by a general characteristic, the marked coincidence of the sandy belt with the so-called central depression of European Russia.[1]

It is clear from the orographic map that elevations in the region of the sandy belt are 300—500 feet [91—152 m] high, often even lower. The Orel-Voronezh ridges ("uvals"), and spurs of the Valdai elevations lie north and south of this belt. This circumstance is the cause underlying the abundance of bogs, lakes and such rivers as the Pripet, Desna and Oka, and to a certain extent the Volga, with their numerous tributaries. These conditions obviously facilitated the wide development of eluvial formations. The final characteristic feature of the sandy belt is its vegetation, which includes abundant coniferous forests and typical paludine and arenaceous floras.

It is made sufficiently clear below that one of these features (sand or bogs) suffices to suppress chernozem development in the very heart of the chernozem region. The sandy basins of the Alatyr and the Tsna are proof that the sandy belt would undergo no change even under conditions of the Samara, Saratov and other provinces.

The northern boundary of chernozem must therefore be clear at very many points. On the other hand, it is no less clear that the rivers, which the local inhabitants identify with the chernozem boundary, demarcate the chernozem from the nonchernozem soil largely due to variation in the chemical-mineralogical character of the parent rocks in their banks. In the absence of this variation no such interruption in soil character may occur, and, in fact, is never observed. Rivers very rarely form the northern boundary of chernozem. The following hypothetical case will illustrate: A river with a broad floodplain containing many oxbow lakes, bogs and lakes, flowing east—west in those territories where chernozem begins to disappear, for instance in the belt containing 3—4—5% humus; a wide gentle slope descends toward the southern, low bank of the river, (similar to the southern slope descending to the P'yana River); on the other hand, the northern bank is bluffy and hilly. The result as regards soil will be the same as certain places on the P'yana, the Tesha, the Imza, etc.: a thick, often typical chernozem on the southern slope of the river bank, and no less typical northern soils on the northern slope. Such circumstances are obviously completely accidental and no general inferences should be made, despite the strong inclination of the local residents to do just that.

Another important role played by the sandy belt should be mentioned. We have already noted that this belt is most highly developed in its western half; the Chernigov Polesie, the Kiev Polesie, and especially the Volhynia Polesie (in the form of an enormous depression) penetrate far south into the chernozem region. The following circumstances result:

1. From Tula westward, the northern boundary of chernozem deviates markedly from the isotherms and from its previous general direction turning abruptly southwestward and in certain places even southward.

2. The "normal" width of the western half of the chernozem zone must therefore be less than is actually observed.

3. Since the distribution of steppe plants is dependent not only on soil but also on climate, their widest spread beyond the northern chernozem boundary would obviously occur in southwestern Russia.

[1] This coincidence was first expressed on Chaslavskii's map. Author.

At any rate, the sandy belt is not the cause influencing the general southwest—northeast direction of the northern chernozem boundary nor the source of its principal characteristics. Our map distinctly shows a gradual decrease in humus content of Russian chernozem, beginning far south of the sandy belt. On the other hand, such areas as the territories between Buinsk and Kazan, Starinskoe and Lyskovo, Vetoshkino and Rabotki, Burnakovo and Slobodskoe, Zaraisk and Venev, Tula and Lazarevo, etc., are nearly free of sand and bogs, the most important factors of the "unnatural depth" of chernozem at many of its northern boundaries. Yet, chernozem gradually disappears in these localities as well, obviously "dying out" for quite normal causes. Without entering into general consideration of these causes I shall try to analyze the one cause which has been heretofore ascribed the greatest importance as a most characteristic feature of the northern boundary of chernozem.

Murchison was the first to suggest that "the northern limit of the chernozem zone in European Russia is provided by the gravelly deposits of (northern) crystalline and ancient (sedimentary) rocks"[1]; he later qualifies this statement: "It is noteworthy that along the southern limit of the northern gravel deposit clastic substances brought from the north, appearing as small fragments mixed with local fragments, are replaced by chernozem, unless we assume that chernozem deposits cover the fragment; northern erratics are visible on the chernozem surface only in one place in the vicinity of Voronezh."[2]

This entire passage, however, in the work of the great geologist, is not quite clear ... The author seems to treat the distribution of northern diluvial deposits (clay, sand, gravel, boulders) and the occurrence of boulders on the surface of chernozem.

Murchison does admit that diluvial deposits may be blanketed by chernozem. I, on the other hand, observed northern boulders on chernozem only once.

Academician Ruprecht assumed that the "chernozem body of Russia is of earlier origin than the nonchernozem body" and admitted the possibility that "during the transport of Scandinavian boulders the chernozem zone was dry land while northern Russia was undersea at shallow depth"[3]; the significance of Murchison's statement for his own hypothesis was obviously understood. Ruprecht's own observations gave rise to several contradictions of Murchison's words, while not leading to their absolute refutation. Academician Ruprecht therefore treated the subject with considerable reservation, and often obscurely.

In May 1864, shortly before beginning his investigations of the northern boundaries of chernozem, Academician Ruprecht remarked that "flora of the spruce region of northern Russia is much younger than vegetation of the chernozem zone," and went on, "the period when northern Russia was under water may be even more accurately determined, and the chernozem zone proven to have already been dry land. Scandinavian boulders were transported at this time. These boulders have not been found on chernozem. Their presence [on chernozem], reported in the vicinity of Voronezh, was based on an erroneous rock identification, as noted by Academician Gel'mersen. Any erratics ever found on chernozem may occur on its

[1] and [2] Murchison. Ibid., pp. 541, 542.
[3] Ruprecht. Ibid., pp. III and IV.

northern boundary. The southern boundary of the boulders on Murchison's geognostic map clearly places them on the very shore of the former chernozem continent in certain places, and far from the shore at other places."[1]

Upon acquaintance with work done by Pacht and Gel'mersen and observation that "the northern pebbles (rather, northern diluvium) penetrate deep into the chernozem region (Voronezh and Tambov provinces),[2] although never mixed with chernozem but covered by the latter."[3] Ruprecht arrived at the logical conclusion that chernozem is younger than the northern deposits ...

Ruprecht, however, regarded this as disproving his hypothesis of the origin of chernozem, and he therefore formulated a compromise. On the basis of the fact that "on the Devonian heights of the Orel Province diluvium is thin and contains no northern boulders and pebbles" (Gel'mersen), while "in the northwestern part of the Devonian belt a thick stratum of red diluvial clay unusually abundant in cobbles stretches over several hundreds of versts," Ruprecht concluded that "the Devonian terrain near Orel was under water only at the beginning of the diluvial period, and became elevated dry land as early as the time of the transport of northern boulders."[4] Vosinskii's observations[5] show diluvium containing erratics to be divided into two stages in the Moscow Province as well, the lower stage containing only small cobbles and the upper stage containing large erratic boulders. Ruprecht therefore applied his conclusion to the entire Russian diluvium, and divided the period of its formation as well into two stages, the earlier containing pebbles and the later containing boulders.[6]

Following this generalization of an arbitrary geological conclusion,[7] Ruprecht was bound to carry it further and subdivide chernozem as well into two kinds, earlier and later; he wrote that "chernozem was formed on the diluvial stratum of European Russia prior to the transport of the large northern boulders, as proven by the boulder distribution; on the northern boundaries, chernozem was formed after the beginning of the diluvial period, on diluvial soil which had already become dry land, and contained only small (?) northern pebbles."[8]

This artificial assumption, as expected, could not aid the author in proving the impossible.

Boulders are mentioned as occurring in Putivl as early as in Murchison's work. V.I. Meller, furthermore, reports that Ruprecht already knew that, at the village of Devichii Rukav in the vicinity of Krasnoslobodsk, "the uppermost layer, formed by chernozem 3 feet [91 cm] thick" and including numerous fragments of belemnites, lies on reddish-yellow clay

[1] Ruprecht. Ibid., p. 20.
[2] The northern diluvium in the central part of chernozem Russia will be treated below. Author.
[3] Ruprecht. Ibid., p. 54.
[4] Ibid., p. 53.
[5] Vosinskii. Ibid.
[6] Ibid., p. 54.
[7] To a geologist, the groundlessness and arbitrariness of Ruprecht's inference is obvious. See, inter alia, Levakovskii. "Material for Chernozem Studies" (Materialy dlya izucheniya chernozema), pp. 41—44.
[8] Ibid., pp. 56 and 77. Unfortunately, this passage—similar to the entire treatment of the subject—is obscure and contains reservations unusual in the works of this author.

reaching 17 feet [5.1 m] in thickness with numerous erratic boulders, reaching 2 1/2 feet [76 cm] in diameter, of granite, Shoksha sandstone, etc.[1]

On the other hand, Academician Ruprecht often observed, in the vicinity of Chernigov and Sednev, large northern boulders in diluvium underlying local chernozem. For instance, "at the village of Yattsai, a boulder, over 4 1/2 feet [137 cm] long and about 3 feet [91 cm] wide, rolled off a diluvial elevation; in the lower section of Sednev there is a large granite boulder containing golden-yellow mica, over 3 feet [91 cm] long and 2 feet [61 cm] wide"; many such boulders also occur in the municipal park; "at the foot of the municipal cemetery, Ruprecht saw fairly large pebbles of granite and black shale at a depth of 3 feet [91 cm] in an excavation made in a diluvial wall of a gully."[2] Ruprecht regards these localities as within the chernozem region although in the vicinity of its northern boundary. Ruprecht himself therefore regarded these as well as certain other facts (distribution of spruce, etc.) as difficulties in the face of his hypothesis and in complete contradiction to all the other phenomena.[3]

Academician Ruprecht, however, is still reluctant to relinquish his favorite hypothesis. To lessen the significance of these facts, he assumes that in regard to the Krasnoslobodsk chernozem "we are not dealing with pure vegetal soil, gradually formed in situ," but rather with probable "foreign chernozem deposited by the waters of the Moksha." The presence of numerous belemnite fragments in the Krasnoslobodsk chernozem is cited as proof.[4] He then explains the origin of boulders in the environs of Chernigov and Sednev, on the basis of the present-day Desna and Seim rivers, by assuming a former bay of the northern sea by which the erratic pebbles could have been transported into the region.[5] Finally, these two cases (boulders of the Chernigov Province and of Krasnoslobodsk) "are isolated and therefore can hardly serve as proof of the late age of the original chernozem."[6]

For all these reasons, Academician Ruprecht hopes "that further investigations will shed new light on this apparent bedding of chernozem at two prominent corners of the chernozem continent, points which, on the basis of available data, were once the shore of a large freshwater sea and thus were subject to impacts of boulders transported from the north and to deposits of pebbles, sands, etc."[7]

However, it will be seen below that Ruprecht's views were not realistic.

It must be pointed out, in the first place, that there is no necessity or justification to separate the surface distribution of northern boulders from their general distribution.[8]

1. As far as known, the mode of transport of northern boulders and northern deposits in general was identical. Boulders, gravel and diluvial

[1] Ruprecht. Ibid., pp. 54—55 and Meller, ibid., p. 49.

[2] Ruprecht. Ibid., p. 72.

[3] Ibid., p. 57.

[4] Ibid., p. 55. The presence of fossils from parent rocks in normal soils has already been noted as a common phenomenon; it will be repeatedly observed further on.

[5] Ibid., p. 71.

[6] Ibid., p. 56.

[7] Ibid., p. 57.

[8] Borisyak.—In: Sbornik materialov, otnosyashchikhsya do geologii yuzhnoi Rossii, No. 1, p. 169, [Khar'kov. 1867].

clays were transported simultaneously by icebergs and glaciers. Consequently, wherever glaciers and icebergs began to recede, the fine and coarse materials were deposited concurrently during melting.

2. Thanks to numerous investigations by Pander, Trautschold, Kropotkin, and others the upper horizons of diluvial formations, formerly on or very near the surface, are known to have been considerably altered, with entire beds of clay and very fine sand carried away and pebbles and boulders left behind. Consequently, in certain localities boulders which occur on the surface at present did not occur there soon after deposition of the diluvium.[1]

3. On the other hand, boulders deposited on the surface and left there for thousands, perhaps tens of thousands, of years must have often undergone very strong weathering to the point of disintegration, due to fluctuations of temperature and to the effects of oxygen, carbon dioxide and water; the weathering products gradually became mixed with the underlying rock. In Finland as well as in a variety of places in Russia I have often encountered boulders which disintegrated into small grus at the touch of a light hammer.[2] Consequently, it is conceivable that boulders occurred on the surface in some localities but have disappeared in the course of time.

4. The gradual destruction of erratic surface boulders naturally became intensified during historical times, especially on cultivated territory. It is quite natural that the inhabitants of the agricultural chernozem region, where land is highly valued, collect all northern boulders — regardless of size — mainly for building purposes, since they are so rare on the surface.

The following conclusion may be drawn. In the localities covered by northern boulder-containing deposits, the latter must have been deposited equally in the lower horizons, upper horizons, and on the surface of diluvium[3]; the surface boulders were destroyed later. It is thus impossible to separate the general distribution of diluvium from the particular distribution of boulders.

The occurrence of boulders on the surface of chernozem mentioned by Murchison and Pacht should not be taken literally. Boulders are found only embedded in chernozem [4]; they usually do not lie on actual soil but on parent rock. This is understandable, since soils cannot form under large masses of stone; boulders, therefore, do not occur anywhere on northern soils. Humus may penetrate only underneath comparatively small boulders, in which case the boulders eventually lie above the humus-colored layer. Small boulders are also often plowed up from the subsoil and thus accidentally find their way into the soil.

[1] Similar examples were also cited by Borisyak. — Ibid., pp. 169 — 170.

[2] I observed more than once (especially clearly in the vicinity of Smolensk and Orsha), even at a considerable depth (3 — 4 sazhens [6.4 — 8.5 m]), enormous boulders of coarsely granular granite reaching 1 sazhen [2.1 m] in diameter amidst glacial gravel and even in sandy diluvial clay, so disintegrated that they could hardly be distinguished from the surrounding rock. Author.

[3] This, of course, is not to infer that the presence of boulders on the surface is an invariable indication of their being underlain by diluvium. Cases are known, in fact, of northern boulders occurring directly over ancient sedimentary rocks, or on Jurassic sands around the Alatyr.

[4] Before chernozem was formed the surface must have consisted of diluvial or older formations, which must have contained boulders. Humus later percolated into diluvium to a depth of 4 feet [1.2 m] in certain places, and some of the boulders were undoubtedly destroyed while others were preserved along with various fossils. The preserved boulders may now be found embedded in chernozem. Many similar facts will be cited below. Only his disbelief in the vegetal-terrestrial origin of chernozem led Prof. Levakovskii to doubt the presence of boulders in chernozem. Levakovskii. Ibid., p. 41.

In the course of investigations in the southeastern part of the Nizhni Novgorod Province I observed an additional feature of the distribution of boulders amidst chernozem. The boulders occurred predominantly as follows: a) on forest soils (between Diveev — Usad and Maresevskii Farm northeast of Buturlino etc.), b) on sands (the "shipbuilding" forest en route from Orlovka to Lukoyanov, etc.), c) on very hilly localities from which chernozem has been washed off considerably (the western half of the P'yana water divide); this is readily understood in relation to the above discussion.

Academician Ruprecht's views may now be commented upon.

My investigations of the Nizhni Novgorod Province, the presence of large boulders between Ryazan and Ryazhsk, the works mentioned above by Armashevskii, Feofilaktov and Barbot de Marni, on the Chernigov and the Kiev provinces, etc., provide indisputable proof of chernozem lying on boulder deposits almost along the entire northern boundary, northern erratics also often appearing on the surface.[1] Thus, agreeing with Prof. Levakovskii[2] I categorically deny the "coincidence, heretofore observed on the northern chernozem boundary, of erratic boulders with chernozem" assumed by Murchison and Ruprecht.[3]

I insist on another, more important aspect of the phenomenon: over the entire northern chernozem boundary (conceived as a belt, rather than a definite line, as assumed by Ruprecht) there is an undoubted variation in the general character of the Russian diluvial formations. Although it is clear from the special part of this work that the exact beginning of this change is difficult to determine (in some places such as Murom, southern half of the Makar'ev District, environs of Rovno, etc., it begins farther north than the chernozem boundary),[4] it may be characterized by fairly definite features. Proceeding from north to south of the northern chernozem boundary belt, the diluvium becomes progressively more loess-like and finally forms a gradual transition to typical loess; boulders are generally numerous both below and above the surface, becoming less abundant[5] until they are extremely rare [6]; northern diluvium is almost absent in an increasing amount of places (the eastern half of the P'yana water divide and the Orel heights); the typical glacial gravel so characteristic of Russian Finland (Kropotkin), the Baltic Provinces (Schmidt) and, generally, of a considerable part of northwestern Russia gradually disappears and even if occurring anywhere in south Russia (which is doubtful) it is extremely rare. Finally, it has been shown that these changes are accompanied by a considerable variation in the chemical composition of the diluvial deposits found in Russia.[7]

All these changes may be traced by crossing the northern boundary of chernozem at any point, though they may be more or less pronounced along certain meridians. This coincidence of the northern boundary of chernozem

[1] We shall see that the same facts are observed in the center of chernozem Russia. Author.

[2] Levakovskii. Ibid., p.43.

[3] Ruprecht. Ibid., p.54.

[4] Karpinskii, A. Ibid., p. 87, etc.

[5] For instance, see A. Karpinskii, ibid., p. 84.

[6] It was undoubtedly this circumstance which misled Murchison and Ruprecht.

[7] Cf. composition of subsoils in the analytical tables. Author.

with the general variation in the character of diluvium is indeed remarkable and highly significant as regards the origin of chernozem, as made clear below.[1] In conclusion, I would state the following fact which was not fully appreciated by Academician Ruprecht[2] but which I regard as highly important. The northern chernozem boundary as traced (see map) and understood by me very definitely coincides with the known isotherms. Almost throughout its 1500—2000 verst length this boundary lies between the June isotherms 17° and 18°C and coincides with the July isotherm 20°C.[3] A discussion of the origin of chernozem should demonstrate that this coincidence is far from accidental. It will further be made clear that this is also the most important cause of the general direction of the northern boundary of chernozem (southwest, west—southwest—northeast, east—northeast).

Thus, an elementary very close genetic relationship between all the principal features of this boundary is noted; these features are as follows: a) gradual transition from chernozem to northern soils; b) gradual weakening of the steppe nature of the flora; c) sporadic sharp delineation of the boundary and a vast depression along the boundary, abounding in sands and bogs; d) gradual variation resulting in a drastic change in the general character of diluvium; and finally e) coincidence of the northern chernozem boundary with the known character of isotherms. This genetic relationship is a major point in favor of our views on the subject.

[1] The significance of bedrock formations with regard to chernozem in general and its northern boundary in particular will be discussed below. Author.

[2] Ruprecht. Ibid., pp. 11 and 41.

[3] Wild, [H.]. O temperature vozdukha v Rossiiskoi imperii (Air Temperature in the Russian Empire), including atlas, pp. 331 and 359, [St. Petersburg]. 1882. Marked exceptions on the northwestern chernozem boundary and their causes are pointed out above. Author.

Chapter III

SOUTHWESTERN CHERNOZEM RUSSIA

The term "southwestern chernozem Russia" is used here for proper designation of the basins of the Dniester, the southern Bug, and the Dnieper. The approximate boundaries[1] of this vast region are as follows: the water divides between the upper reaches of the Oka and the Donets on the one hand, and the left tributaries of the Dnieper on the other hand in the east; the political boundary of Russia in the west; a gradual transition to the northern boundary chernozem belt in the north; and a transition to the chestnut-colored soils of the Black Sea shore in the south.[2]

The territory within these boundaries includes the following areas: the greater part of the Kursk Province, the entire Poltava Province, the southern (greater) half of the Kiev and the Kamenets-Podol'sk provinces, the western half of the Ekaterinoslav Province, the northwestern third of the Khar'kov Province, and the northern and central parts of the Bessarabia and Kherson provinces.

Although I spent the summers of 1877 and 1881 in this region, the investigated area is so vast and my pedological tasks so extensive that I could hardly hope to perform any systematic studies of the local geology. I was limited, of necessity, to studies of only those rocks and sections which could be assumed to clarify the genetic relationship between the geology and soils of the territory.

I must therefore present the geological works of my predecessors in detail, considering the works by Borisyak, Levakovskii, Feofilaktov, Barbot de Marni, Sintsov, Klemm, Domger, Gurov, Kontkevich, and others to have sufficiently elucidated the geological character of southwestern Russia.

TOPOGRAPHY

From the orographic and hydrographic map it is clear that southwestern chernozem Russia may be conveniently divided into fairly equal eastern and western halves, separated by the Dnieper valley between Kiev and Kherson, its elevation being 0—288 feet [0—88 m].[3] Both halves descend simultaneously and gradually toward the Dnieper depression and toward the Black Sea.

[1] Obviously, there can be no definite boundaries.

[2] As already mentioned (p. 27), these shores and those of the Azov Sea will be treated in detail as a separate region.

[3] This is the level of the Dnieper at Kiev. Author.

The gradualness of the descent in both directions is depicted by the following data:[1]

Eastern half[1]

No.	Locality		Elevation
1.	Kursk	up to	878' [267 m]
2.	Oboyan	up to	730' [222 m]
3.	Ryl'sk		701' [214 m]
4.	Putivl		718' [219 m]
5.	Konotop		552' [168 m]
6.	Nezhin		593' [[illegible]]
7.	Kiev	up to	656' [illegible]
8.	The Dnieper at Kiev		288' [illegible]
9.	Lokhvitsy		446' [136 m]
1.	Khar'kov	up to	663' [202 m]
2.	Gadyach		594' [181 m]
3.	Zen'kov		486' [148 m]
4.	Poltava		656' [200 m]
5.	Novomoskovsk		516' [157 m]
6.	Nikopol		251' [76 m]
7.	Genichesk		45–50' [14–15 m]

Western half[2]

No.	Locality	Elevation
1.	Zhmerinka	1065' [325 m]
2.	Kazatin	976' [297 m]
3.	Soroki	792' [241 m]
4.	Birzula	810' [247 m]
5.	Katerinovka Station, between Birzula and Elisavetgrad	511' [156 m]
6.	90 versts west of Elisavetgrad along the railroad	770' [235 m]
7.	Elisavetgrad	546' [166 m]
8.	Razdel'naya	463' [141 m]
9.	Nikolaev	160' [48 m]
10.	Odessa Station	164' [49 m]
11.	Kherson	83' [25 m]

[1] The localities run from east to west and southwest toward the Dnieper. —Author.

[2] The very gradual nature of the descent of the terrain from Kazatin toward Kiev is presented above. The numerical data below run from north to south and partly also from west to east.

It is clear from the table that the western half of the region is slightly more elevated than the eastern half, since fairly large spurs of the Galician Carpathians begin in the upper and even the middle reaches of the Dniester and Southern Bug rivers.

[1] Most of these numerical data were taken from the "Catalog of Astronomic and Trigonometric Points" (Katalog astronomicheskikh i trigonometricheskikh punktov); the rest were mainly supplied by the railroad levelings. See Barbot de Marni.

These spurs, the numerous outcrops of various crystalline rocks, which are extremely uneven in surface, in southwestern Russia[1] render the steppe here atypical and much less level[2] than such steppes of southeastern Russia, as the Samara steppes. The terrain seems to grow more hilly progressively from east to west, from the Dnieper to the Dniester and the Prut.[3]

The topography is certainly changed from east to west by the relatively heavy precipitation and relatively numerous rivers. The significance of precipitation is obvious [4]; the rivers incise the surface and greatly facilitate the generation and development of gullies and "balkas".

Remarkably, the undulations of the southwestern Russian territory are almost always very broad, and are thus distinguished from similar irregularities of terrain in nonchernozem Russia.

GEOLOGY OF SOUTHWESTERN RUSSIA

Recent investigations have stressed the fact that southwestern Russia is covered mainly by different Tertiary formations which form the immediate bedrock for the deposits and, to a certain extent, for the soils.

The relative age of these formations is irrelevant to our purpose since it has no bearing on soils, and will not be discussed here. Their petrographic features will be described.

The Tertiary formations of the territory are fairly distinctly subdivided into the northern sandy belt and the southern calcareous belt.

As early as 1787, the renowned Zuev noted the line of the rapids formed by the Bug, Ingul, and Ingulets rivers, dividing the Novorossiya Province into two parts.[5] According to him, "north of this belt the soil is, so to say, uniform, not underlain by a markedly different layer and is safe for agriculture. South of this belt, the soil is underlain at 1 sazhen [up to 2.1 m] (roughly according to locality) by a continuous layer of thick calcareous flagstone, consisting of compacted sea shells, either nearly whole, or comminuted and disintegrated."

In 1843 Dubois de Montpéreux wrote that "possibly, nowhere are lithological features as dissimilar as in the Tertiary formations north and south of the vast granite slope of Volhynia and Podolia; the general character of the northern belt is siliceous while that of the southern belt is highly calcareous." The northern belt is Eocene while the southern belt is Miocene. Murchison added, as follows: "Further southeast, where the level granite elevation ends (according to data of that time), the vast Donets coal formation may be regarded as the dividing boundary, all the Recent sediments north of it being of a sandy and clayey (?) character, while the formations of the elevated steppe south of it are extremely calcareous."[6]

1 See Domger. O kristallicheskikh porodakh yuga i yugo-zapada Evropeiskoi Rossii (Crystalline Rocks of the Southern and the Southwestern Parts of European Russia).—[Gornyi Zhurnal No. 3]. 1881.

2 Except for the entire maritime belt which stretches in certain places 100—150 versts north of the Black Sea shore.

3 Sintsov, [I.]. Geologicheskii ocherk Bessarabskoi oblasti (A Geological Description of the Bessarabia Region), p. 47, etc., [Odessa]. 1873.

4 Another contributing factor may be the longer warm season, since, in winter, erosion by water is impossible. —Author.

5 Zuev, [V.]. Puteshestvennye zapiski (Travel Notes) [from St. Petersburg to Kherson in 1781 and 1782, St. Petersburg], pp. 225—226. 1787.

6 Murchison. Ibid., pp. 1027 and 1035.

Prof. Borisyak commented on these words of Dubois de Montpéreux: "Although latest investigations have altered our opinion of the distribution of calcareous sediments north of the southeastern end of the granite belt mentioned above, they also point to considerable development of siliceous sediments to its south; however, one must recognize that, north of the Dnieper, crystalline rocks and the Tertiary formations of the Carboniferous Donets range have a character of their own." After mentioning that the southern calcareous formations have been investigated repeatedly, he continues, as follows: "Recently, Messrs. Barbot de Marni and Levakovskii, having checked the previous observations and on the basis of their own observations, presented a clear pattern of the distribution, lithological, and paleontological composition of the calcareous (southern) Tertiary strata. Their northern boundary begins at Voznesensk (on the Bug River), proceeds in a zigzag past Shesternya (on the Ingul River) and Khortitsa (on the Dnieper), Orekhovo, Ivanovo (on the Krynka River), and stretches eastward along the tributaries of Nesvitai and Grushevka to the Don, and along the latter upstream to Tsymlyanskaya Stanitsa."[1]

According to the investigations of Prof. Borisyak, the sediments lying north of the boundary consist, "in the Khar'kov and in the adjacent Poltava and Kursk provinces, of weak ferruginous sandstones, sands, dense buhrstones, argillaceous sandstones, conglomerates, and less frequently, limestones."[2] These rocks, classified by Borisyak as the so-called "supra-Cretaceous", commonly form the bedrock for the local deposits.[3]

Subsequent detailed studies of Tertiary formations in southwestern Russia follow the same general character. For instance, in his well known work "Geological Description of the Kherson Province" (Geologicheskii ocherk Khersonskoi gubernii) the late Barbot de Marni stated that "these (Tertiary) formations are sandy in the northern half of this province and calcareous in its southern part." The geological map of the Kherson Province compiled by the author shows the entire half of the province as occupied by the "Baltic stage", consisting almost entirely of yellow sands (with sandstone aggregates) and yellow or greenish sandy clays; these formations are overlain by loess.[4]

The so-called "Sarmatian stage" is depicted in the very middle of the Kherson Province, in the form of a narrow belt (approximately 20 versts wide)[5]; the general nature of this stage is "calcareous owing to the predominance of limestones and marls."[6]

Finally, the southern third, or slightly more, of this territory is occupied almost continuously by the famed Odessa limestone of the Pontian stage, which extends along the northern shores of the Black Sea in a belt up to 100 versts wide, and is overlain almost exclusively by loess, similar to the Baltic stage.[7]

[1] Borisyak.—In: Sbornik materialov, otnosyashchikhsya do geologii yuzhnoi Rossii, book I, [Khar'kov], pp. 122—123. 1867.

[2] Ibid., pp. 124—125 (scheme) and section No. 4, etc.

[3] Barbot de Marni (1870) arrived at results which are essentially the same, concerning differences in lithological character of the northern and the southern Tertiary formations in the Khar'kov and Ekaterinoslav provinces and Territory of the Don Cossacks. See "Geologicheskie issledovaniya ot Kurska cherez Khar'kov do Taganroga (Geological Studies from Kursk via Khar'kov to Taganrog).—[Gornyi Zhurnal, Vol. 4, part 11]. 1870.

[4] Barbot de Marni. Ibid., pp. 123, 124.

[5] Except for Anan'ev District where the formations of the Sarmatian stage extend nearly to the Dnieper Liman.— Author.

[6] Barbot de Marni. Ibid., p. 117.

[7] Ibid., p. 120.

The studies of Tertiary formations made by the late Barbot de Marni, the great contributor to knowledge of Russian geology, were directly continued by Myshenkov, Klemm, Gurov, Kontkevich and Domger, east of the Kherson Province (in the Ekaterinoslav and adjacent provinces) and by Prof. Sintsov west of it (in the Bessarabia Province).

Gurov's most recent work, "Contribution to the Geology of the Ekaterinoslav and the Khar'kov Provinces, Made in 1882" (K geologii Ekaterinoslavskoi i Khar'kovskoi gubernii 1882 goda), is the latest and most extensive work on the subject, including the largest expanse of Tertia y formations on the left bank of the Dnieper River. We shall therefore refer almost exclusively to this work, especially since the lithological descriptions of local formations correspond with earlier studies.

Gurov, noting that the sandy supra-Cretaceous formations described by Borisyak, especially their lower horizons (the Khar'kov stage), "are widely distributed over Russia (the Khar'kov, Kursk, Ekaterinoslav, Voronezh provinces, the northern part of the Don Region, etc.) in a wide belt from the banks of the Volga to the Dnieper and west of it," classifies them in the southern part of the Khar'kov Province and the eastern half of the Ekaterinoslav Province into Paleogene and Neogene. According to Gurov, the Paleogene group includes rocks previously classified as the Khar'kov stage proper by Barbot de Marni and Levakovskii; this is the "group of micaceous and greenish-yellow or darkish-gray sands and greenish sandstones with concentric ocherous patterns. The sandstones may be argillaceous and often contain concretions and intercalations of compact, very dense, mostly green siliceous sandstone, their color being largely due to glauconite grains."[1] Although clays may occur as minor formations among rocks of the Khar'kov stage, the predominant rock is loose argillaceous sandstone, "greenish-gray" in the fresh state and pale yellow when weathered (called tripoli-like siliceous clay by Blede and tripoli-like marl by Borisyak), distinguished by an admixture of glauconite grains and flakes of white mica, rings and patterns of iron hydroxide ... ; the sandstone is widespread in this typical form in Khar'kov itself.[2] Prof. A. P. Karpinskii performed a mechanical analysis of several rock samples from the Khar'kov stage with the following results:

No.	Locality	Sand	Clay
		percentages	
1	Bolkhovets near Belgorod	78.3	21.7
2	6 versts NNE of Bolkhovets	81.71	18.29
3	Khar'kov	49.48	50.52
4	Alekseevskaya, in the basin of the Zmiev (?) District	67.4	32.6
5	8 versts from the Nadezhdinskaya railroad station en route from Lozovaya to Slavyansk	33.34	66.66[1]

[1] Barbot de Marni. Geologicheskoe issledovaniya ot Kurska cherez Khar'kov do Taganroga (Geological Studies from Kursk via Khar'kov to Taganrog), pp. 302–309.

[1] Gurov. Ibid., p. 325. [Gurov A. K geologii Ekaterinoslavskoi i Khar'kovskoi gubernii (Geology of the Ekaterinoslav and the Khar'kov Provinces). —Trudy Khar'kovskogo obshchestva estestvoispytatelei, 1881, Vol. 16, 1883.].

[2] Ibid., p. [illegible].

Gannot's chemical analysis of the Khar'kov sandstone[1] gave the following results:

Silica	83.51
Alumina	10.22
Ferric oxide	0.11
Water	6.16

Gurov found this suite, characteristically, to "occupy high water divides and interfluvial areas."[2]

The distribution of the Khar'kov stage in the eastern part of the Ekaterinoslav Province and the southern part of the Khar'kov Province is closely related, horizontally, with the overlying "white, yellow, more rarely red sand and quartz sandstones of the same colors usually known as buhrstones."[3] Similar to sedimentary deposits of the Khar'kov stage, these formations are found in the Ekaterinoslav Province at the highest points of the elevated water divides and interfluvial areas.[4] Gurov then charts the occurrence of these sands and sandstones in the Khar'kov and Ekaterinoslav provinces, and finally arrives at the following conclusions, inter alia:

"The crystalline projections along the minor rivers Tatarka, Voronaya, Tersa, Volch'ya and Gaichul constitute the boundary between the Sarmatian (mostly calcareous) type to the south and the sandy type of the Miocene sediments to their north; the projections form a natural demarcation line between two dissimilar though contemporaneous geological basins ...

"East of this region the boundary continues in the form of outcrops of Carboniferous and crystalline rocks along the Volnovakhas, Kal'chik and Kalmius [Kalka] rivers, later becoming the Donets Carboniferous range separating the Tertiary sediments of the Donets system from similar sediments on the Azov Sea shore."[5]

In the Kiev and Podolia provinces, adjoining the Kherson Province in the north, the upper horizons of Tertiary sediments are directly overlain by loess and are usually of a more or less sandy nature although containing intercalations of "brown and greenish sandy clay". For instance, Barbot de Marni found strata of the Baltic stage, mentioned above, throughout the Dnieper-Bug divide, from Brailov to Balta (the Vinnitsa, Yampol, Bratslav, Ol'gopol, and Balta districts).[6] On the other hand Prof. Feofilaktov indicates mainly sandy formations directly under the deposits in his geological map of the Kiev Province.

[1] Borisyak, Ibid., p. 10.

[2] Gurov. Ibid., pp. 427–428.

[3] Ibid., p. 429. As in the Khar'kov stage, the buhrstone area also contains clays, but the author does not deal with them.

[4] Ibid., p. 431.

[5] Ibid., pp. 442–443. The same conclusion with regard to the boundaries between these two types, although on a smaller territory, was drawn by Mr. Klemm in his "Geological Studies Between the Saksagan and Kalmius Rivers" (Geologicheskie issledovaniya mezhdu rekami Saksagan'yu i Kal'miusom) [Trudy obshchestva ispytatelei prirody pri Khar'kovskom universitete, Vol. 9), pp. 107–109. 1875, and by Kontkevich in his "Geological Studies in the Granite Belt of Novo-Rossiya, East of the Dnieper" (Geologicheskie issledovaniya v granitnoi polose Novorossii, po vostochnuyu storonyu Dnepra) [Gornyi Zhurnal No. 1], pp. 107, etc. 1881.

[6] Barbot de Marni. Geologicheskie issledovaniya, proizvedennye v 1868 g. v guberniyakh Kievskoi, Podol'skoi i Volynskoi (Geological Investigations Performed in 1868 in the Kiev, Podolia and Volhynia Provinces), pp. 58–69. — Zapiski [S.-Peterburgskogo] Mineralogicheskogo obshchestva [No. 7], 1872.

Prof. Sintsov's studies in Bessarabia also confirmed the general rule that the "calcareous (Tertiary) rocks become progressively sandier in a northward direction,"[1] the Pliocene sands apparently even more common in the Bessarabia Province than in the Kherson Province.

The data presented above provide a more than adequate basis for the following conclusions: the upper horizons of the Tertiary formations in the southwestern part of chernozem Russia are of the following two types: a) the sandy type predominating in the larger, northern, part of the region and b) the calcareous type predominating in the smaller, southern part.

My own investigations in southwestern Russia have confirmed this statement. However, it is nearly impossible to mark a definite line dividing these regions, since such boundaries are very rare; should it exist, its delineation would require an enormous amount of chemical analyses. Therefore, certain differences of opinion between these authors in regard to this boundary are understandable. This point is not very significant, since we are dealing with the general lithological nature of the Tertiary formations, rather than with their particulars. On the other hand, it would be redundant to state that sandy regions, for instance, may contain many spots of clayey and calcareous nature, and vice versa. This is inevitable and confirmed by facts.

This rule concerning the general petrographic nature of the Tertiary formations is extremely important for our purposes, since it in turn deals with the petrographic nature of the local deposits as well. Obviously, these must be more or less sandy in the northern part of the region and calcareous in its southern part. We shall attempt to examine this relationship in greater detail.

DEPOSITS ON THE LEFT BANK OF THE DNIEPER

Eichwald first recognized Rhine-loess features in the deposits of southwestern Russia.[2] However, Prof. Levakovskii determined the formations in greater detail as late as 1861. Levakovskii regarded the local diluvial deposits as containing remains of terrestrial and freshwater mammals and mollusks; "in general, paleontologically and otherwise, these rocks are remarkably analogous to the Quaternary deposits known as loess." He found the shells of the following mollusks in the south Russian loess: *Succinea oblonga*, *Succinea amphibia*, *Helix pulchella*, *Helix crystallina*, *Pupa muscorum* and *Cyclas fontinalis*.[3]

Prof. Borisyak's work of 1867 was the first to give a systematic study of the deposits of southwestern Russia. The area examined included a vast territory on the left bank of the Dnieper and part of the upper and middle

[1] Sintsov. Geologicheskii ocherk Bessarabskoi oblasti (Geological Description of the Bessarabia Region), p. 102. 1873. Sintsov's investigations also proved that the Baltic and Pontian stages described by Barbot de Marni are not two distinct formations but, rather, different facies of the same geological basin. — Ibid., pp. 91, 103.

[2] Eichwald, [E.]. Geognoziya preimushchestvenno v otnoshenii k Rossii (Geognosy Mainly with Respect to Russia), p. 563 [St. Petersburg]. 1846.

[3] Levakovskii. Observations sur les terrains tertiaire et quaternaire dans les gouvernements de Kherson, d'Ekathérinoslaw, de la Tauride et dans le pays des Cosaques du Don. Bull. de la Soc. Imp. des natur. de Moscou, t. 34, No. 2, pp. 479-480. 1861.

reaches of the Donets and the Don rivers. Much information regarding the deposits of this territory is given. The essentials of these data are presented below.

All the sediments in Borisyak's description, given above (supra-Cretaceous, Tertiary, etc.), are "covered throughout by a thick layer of finely graded sandy loams and loams, usually light-yellow, sometimes yellow-brown, more rarely dark, consisting of fine sand and clay in variable proportions."[1] Some of these loams contain no calcareous salts while others contain up to 50% salts.[2] They may contain small gravel pockets, most frequently consisting of quartz grains (nut-sized), Lydian stone, and hornfels. Pure sands are rare.[3] In some places, such as the part of the Ekaterinoslav Province "nearest the Poltava and Khar'kov provinces" the deposited sandy loams "abound in calcareous pebbles", sometimes fist-size but usually smaller with internal cavities. Salastennikov's analysis shows that such pebbles contain "gelatinous silica 10.95%, $CaCO_3$ 83.21%, Al_2O_3 and Fe_2O_3 2.50%, sand 3.34%."[4] The author mentions "sandy deposited clay with cracks lined by calcareous incrustations and criss-crossed with fine intercalations of friable marl"[5] at Varby, Poltava Province.

Generally, "the difference in the gravelly deposits of Scandinavia and of northern Russia consists in the following features: a) uniform, fairly well graded sandy loams, b) small amounts of gravel, and c) large accumulation of clayey sands (in deposits of the Khar'kov, Poltava and Ekaterinoslav and other provinces)." Borisyak adds that the small amount of gravel and the presence of finer components caused the deposits of this territory to form fairly broad undulating elevations. However, the dissimilarity perceived at the extreme points disappears in the intermediate territories. in the Orel, Tula, and Kaluga provinces.[6]

The deposits on the territory investigated by Borisyak vary in thickness, "from a few feet to 15—20 sazhens [32—43m]." Although the deposits are found throughout, also forming level steppe areas "they lie mainly on the sloping terrain descending to the Dnieper, in the Poltava Province, where the sheer right banks of the river valleys and gullies consist of diluvial loams and sandy loams. These deposits become thinner toward the Don; wherever Cretaceous formation nears or reaches the surface, rounded chalk hills and large areas of friable sandstone are encountered, either totally exposed or else covered by a chernozem layer only."[7]

Prof. Borisyak established the significant fact that the bulk of the deposits "was formed locally by the disintegration of the underlying Cretaceous (supra-Cretaceous) and Tertiary sediments"[8]; partially decomposed fragments are still very common in the local diluvium (in the Poltava,

[1] Borisyak. Ibid., p. 151.

[2] Ibid., pp. 154—155.

[3] Ibid. p. 153.

[4] Ibid., p. 160. In my opinion, these pebbles are calcareous concretions, so characteristic of certain kinds of loess. — Author.

[5] Ibid., p. 158. The author does not seem to regard calcareous nodules ("zhuravchiks") and the general content of $CaCO_3$ in these deposits as their characteristic feature.

[6] Ibid., pp. 182—183 and 179.

[7] Ibid., p. 156.

[8] Ibid., p. 186.

Khar'kov, Kursk provinces, etc.).[1] His investigations were the first to elucidate the effect of rocks of the Dnieper crystalline range on the petrographic character of the southern deposits. The deposited soils in the Ekaterinoslav Province, for instance, contain progressively more erratics of these rocks in the direction of the granite projections, while wherever gneissous granite is exposed, as along the Vol'nen'ka and Moskovka rivers, its weathering produces a considerable mass of overlying clays."[2] In general, "a comparison of boulder composition with Dnieper and Scandinavian rocks convinced the author that they are more similar to the Dnieper variety."[3]

"The local boulders are not always found on the surface of deposits (water deposits), as seen at Konstantinov, Konotop, Stolpovskii farm, and in other localities; they usually take the form of small pebbles, in fairly deep horizons closely intermixed with loams and rarely in large masses which may reach one cubic sazhen in volume"[4]; they may be distributed throughout the deposit at random or may form definite horizons[5]; gravel intercalations result when many of them are weathered. The boulders are mostly well rounded (although not polished), rarely fairly angular; the rounded boulders are mainly greenstone, and the angular ones granites.

The author established the following facts as regards boulder distribution:

1. "Distribution is apparently independent of local relief."[6]
2. "Boulders do not decrease in size toward the south."[7]
3. "Traveling from west (the Sula) to east (the Don), I found a gradual decrease in the content of crystalline boulders on the surface of loamy rocks as well as in the rock itself. Gravel, obviously the result of weathered granite rocks along the Sula and the Khorol rivers, is not found along the Oskol and the Don."[8] In addition to the shells mentioned by Prof. Levakovskii, Borisyak noted the presence of *Bithynia troscheli* and *Planorbis marginatus*. These mollusks are often accompanied by bones of the following animals: three species of *Elephas*, *Rhinoceros tichorrhinus*, *Equus fossilis*, *Bos priscus*, *Cervus alces fossilis*, *Cervus fossilis carpeoloproximus*, *Cervus tarandus priscus s. fossilis*, *Meles taxus*, *Spalax typhlus* and *Arctomys bobac*.[9]

In 1869 Barbot de Marni and Karpinskii made a geological excursion along the route Kursk—Khar'kov—Taganrog. They too did not classify the local deposits found throughout into separate horizons or stages, but, on the basis of appearance (yellowish-gray sandy clay with calcareous tubules or aggregates, collapsing vertical walls) termed it typical loess. According

1 Ibid., pp. 161—163.
2 Ibid., p. 161.
3 Ibid., pp. 172, 179, and 183. However, Borisyak himself regards the problem as far from being solved.
4 Ibid., p. 169.
5 Ibid., p. 157, etc.
6 Ibid., p. 181.
7 Ibid., p. 180. These two items are meant to contradict Murchison.
8 Ibid., p. 170. According to him, boulders are fairly abundant along the Udai, Sula, and Khorol rivers, and are rare along the Vorskla River (found only in the vicinity of Reshetilovka and below Poltava, p. 160).
9 Ibid., pp. 165—168. It will be shown below that the remains of *Meles taxus*, *Spalax typhlus* and *Arctomys bobac* were not contemporaneous with the formations containing them. Author.

to Barbot de Marni, "the appearance of loess en route from Moscow is marked beyond Kromy, such as at Balabuevo and Kubyshkino on the highway to Sevsk. We found no diluvial red clay, and hence no erratics. Since these erratic boulders are known to occur in the Voronezh and the Ryazan provinces as well as in the Chernigov Province (in addition to the Kiev and the Poltava provinces), loess obviously forms a large wedge extending north in the direction of Orel."[1] This conclusion has great pedological significance.

The deposits mentioned by Borisyak were classified into three horizons, by Prof. Levakovskii (Khar'kov and "many similar localities") and Prof. Feofilaktov (the Lubny District and some other areas of the entire Poltava Province). The classification made by Levakovskii is based only on color (red-brown clay in the lower horizon, brownish-yellow clay in the central horizon and grayish-yellow loam in the upper horizon).[2] A description of deposits provided by Prof. Feofilaktov follows; he published several communications and a paper on diluvium of the Lubny District. The latter is the most recent and most detailed, and will be referred to later.

The lower horizon constitutes "the lower boulder stage (D_1). It is 25—30 feet [7.6—9.1 m] thick, consisting of sand-pebble aggregate, loose or clayey, intermixed. In places it consists of viscous reddish-brown calcareous loam with a considerable amount of gravel and boulders."[3]

The middle horizon constitutes the so-called loess stage (D_2) which is in turn composed of three substages, if only in color: a, b, and c. The entire loess stage displays distinct stratification. The loess itself "is a finely granular, finely porous, yellowish aggregate of low coherence, consisting of extremely fine, partially pulverulent quartz sands and yellowish ferruginous clay cementing the colorless angular quartz grains. The relative proportions of sand and clay in loess vary horizontally and vertically, the mass assuming the character of loess sandy loam in some places and of loess loam in other places ...." Typical loess usually contains calcareous concretions ("dutiks") which are "scattered at random in some places, in others concentrated, or forming vertical rows of three—four consecutive cylindrical units with adjoining end." However, "although lime is frequently admixed with loess, it is often absent when the marly 'dutiks' are absent...."

Feofilaktov found the shells of the following mollusks in the loess of the Lubny District: Pupa muscorum, Helix hispida, Succinea oblonga (and Planorbis sp.); bones of terrestrial mammals were also found, such as mammoth, rhinoceros, etc. The loess stage reaches 35 feet [10.6 m] in thickness and is free of boulders.[4]

The loess is overlain by the upper boulder stage (D^3); D^3 contains a considerable admixture of loess substance in its lower horizons, sands and

[1] Barbot de Marni. Geologicheskie issledovaniya ot Kurska cherez Khar'kov do Taganroga (Geological Studies from Kursk via Khar'kov to Taganrog), pp. 300 and 322.

[2] Levakovskii. Pochva gor. Khar'kova (Soil of the City of Khar'kov).—[O pochve i vode goroda Khar'kova. Trudy obshchestva ispytatelei prirody pri Khar'kovskom universitete, Vol. 9, Khar'kov. 1875. Separate reprint], p. 9. 1875. All layers of the Khar'kov deposit contain calcareous concretions, veinlets, and tubules. The lower horizon also contains gypsum powder; no boulders are mentioned.

[3] Geologicheskie issledovaniya v Lubenskom uezde, Poltavskoi gubernii (Geological Investigations in the Lubny District of the Poltava Province), p. 12 [Kiev.] 1879.

[4] Feofilaktov. Ibid., p. 14, 15.

gravel in its central horizons, overlain by a diluvial loam; boulders are abundant. The lithological properties of boulders and gravel in both stages (D_1 and D_3) seemed identical to the author; they are northern in origin. Boulders are rarer in the upper (D_3) than in the lower (D_1) stage and may reach 5—10 feet [1.5—3 m] in diameter; their distribution is irregular.[1]

Reference to the study made by Klemm and Kontkevich will complete our discussion of the deposits on the left bank of the Dnieper. The study pertains to the rather extensive territory roughly delimited by the Dnieper, Samara, and Kalmius rivers and the shores of the Azov Sea. Klemm mainly studied the southern half of this region while Kontkevich worked in the northern part. They obtained nearly identical results, dividing the diluvial formations into two horizons. The upper horizon (I) consists of "light-brown sandy or calcareous clays" according to Klemm and "brown-yellow calcareous clay or loess" according to Kontkevich, and the lower horizon (II) consists of red-brown sandy clay with characteristic, fist-sized, calcareous intergrowths externally amorphous and internally crystalline. Clays of the upper horizons occur almost throughout, while lower-horizon clays are quite common.[2] According to Klemm, the light-brown (I) and the red-brown (II) clays lack bedding. Both clays abound in usually rounded fragments of underlying rocks (Carboniferous, Tertiary, etc.) irregularly distributed. All the boulders are local and apparently do not occur in deposits more than 10—15 versts from their place of origin.

The local deposits also contain quartz, hornfels, feldspar, gypsum crystals, etc., according to locality, the content of all these rocks increasing closer to their place of origin, as is the case with boulders. The clays are not thick on high steppe localities and at the gully apexes, very often not exceeding 1 arshin [0.7 m]. They attain several sazhens in thickness only on the sides and at the bottom of closed depressions.

These clays effervesce with acids, although typical loess intergrowths ("zhuravchiks", "dutiks") are mentioned by Kontkevich in regard to the upper horizon[3]; both clays have a tendency to collapse, forming vertical walls. Neither of the investigators found any organic residues in the red-brown clays (II), while each made one find of fossil mammal remains (mammoth, rhinoceros) in light-brown clays (I); Klemm found many shells of *Pupa, Helix, Planorbis,* and *Succinea* in the light-brown clays.[4]

DEPOSITS ON THE RIGHT BANK OF THE DNIEPER

A description of the right bank of the Dnieper, the Kherson, the Kiev, the Podolia and the Bessarabia provinces follows. Deposits on this territory

[1] Ibid., pp. 12—13, ff.

[2] In the southern part of the territory Kontkevich found the brown-red (II) clay only within the limits of the Pontian stage. See "Geological Investigations in the Granite Belt" (Geologicheskie issledovaniya v granitnoi polose), p. 312.

[3] Kontkevich's observations showed that these marly intergrowths often occur in horizontal layers. However, he only "very rarely observed the tubular structure which Richthofen regards as so typical of loess." Ibid., p. 313.

[4] Similar remains were also found by Prof. Levakovskii in the red-brown clay (II) in the vicinity of Ekaterinoslav. Ibid., p. 474.

have recently been described by Barbot de Marni, Academician Schmidt, Prof. Sintsov, and Prof. Feofilaktov. Barbot de Marni, remarking that the Kherson loess retains its characteristic features throughout and is therefore easily identified, goes on to say that "local loess is a calcareous-sandy, grayish-yellow clay, of low plasticity, lacking visible bedding, containing marly intergrowths or concretions and collapsing in vertical walls and often including small Helix and Succinea shells. The local residents term this steppe glei or 'white eye' ('beloglazka'). Loess is visible in all exposures, but since exposures mainly occur in valleys and 'balkas', it is very likely that loess does not form a continuous cover on the territory of the province but rather fills depressions in the earlier soil," where its thickness often reaches 18 sazhens [38 m].[1]

During loess formation, the area of the Kherson Province was rich in mammoth, cave bear, cave hyena, cave tiger, urus,* rhinoceros and other animals, found as fossils at Odessa and in the Nerubaiskie farms.[2]

Identical loess (with fossil mammoth, Succinea oblonga, Helix cellaria and marl intergrowths the size of a child's head) was later observed by Barbot de Marni in the Podolia Province as well, along the line Balta—Zhmerinka—Volochisk.[3] The author did not find northern boulders anywhere in the deposits of the Kherson Province.

In 1872, Academician Schmidt gave a short report on the Dniester loess at the St. Petersburg Society of Naturalists.

According to Schmidt, "loess is very common in the valleys of the Dniester and its tributaries; it appears in thick strata on gentle slopes, while on steep slopes only rudiments are seen, providing an explanation of loess origin. Steep slopes clearly illustrate the process of washing weathered material down from loose Cretaceous and Tertiary strata; these strata overlie harder Silurian sediments. Mud streams entrain and transport shells of Pupa muscorum, Helix pomacea, Achatina lubrica, Helix caespidum inhabiting the slopes. These shells also occur in the thick loess strata covering gentle slopes."[4]

Prof. Feofilaktov, who possesses intimate knowledge of the Kiev Province, has provided a detailed description of its deposits: "The diluvian formations of the Kiev Province are binary, a lower boulder horizon and an upper loess horizon. The lower, earlier horizon appears in the form of loose or clayey sands, or as brownish sandy clays; a stratum of very variable thickness (average 9 m) is formed, abounding in rolled, polished boulders varying in size, composed of gneisses, granites, syenites, porphyries originating from Scandinavia, the Baltic Sea islands and Finland. In addition to large boulders 4—5 feet [1.2—1.5 m] in diameter, small polished pebbles occur amidst sands and clays, where they are either uniformly distributed or form nests and intercalations. However, the most important component of the boulder layer is the polished fragments of limestones, sandstones, hornfelses, and

[1] Barbot de Marni. Geologicheskii ocherk Khersonskoi gubernii (Geological Description of the Kherson Province), pp. 125—126.

* [In this context, the Russian word "tur" is taken to mean "urus". Translator.]

[2] Ibid., p. 133.

[3] Barbot de Marni. Geologicheskoe issledovanie, proizvedennoe v 1868 godu v guberniyakh Kievskoi, Podol'skoi i Volynskoi (Geological Investigation Performed in 1868 in the Kiev, the Podolia and the Volhynia Provinces), pp. 53—65.

[4] Trudy S.-Peterburgskogo obshchestva estestvoispytatelei. Vol. 4, p. CIV. [St. Petersburg. 1873.]

cherts containing fossils characteristic of the Silurian, Devonian, Carboniferous, and Cretaceous formations lying north of the Ukraine. Feofilaktov found mammoth bones in the boulder layer."

"The second upper (and in the Kiev Province, the last) member of glacial formations is the so-called loess, analogous to the Poltava loess. It contains shells of terrestrial and freshwater mollusks, and bones of mammoth, reindeer, ox, and rhinoceros, representatives of the extinct glacial fauna. The thickness of the loess stratum reaches 21 m (70 feet) in places."[1]

Prof. Sintsov's studies of the post-Pliocene deposits in Bessarabia are also extremely interesting. According to him, "the Pliocene deposits are overlain by beds (sands and gravel) of post-Tertiary formations; however, the transition is so gradual (similar to Murchison's Ancient and Recent Aral-Caspian formations) that it is utterly impossible to trace the boundary between them."

In the gravel and sands of the early post-Pliocene, Sintsov found "fossils of mammoth, rhinoceros, ox and deer; moreover, in certain places (such as between Bul'boka and Tiraspol) the same beds abound in freshwater shells belonging to contemporary species which include Unio tumida, Cyclas cornea, Pisidium priscum, Paludina achatina, Valvata piscinalis, Melanopsis sp., Neretina danubialis, N. fluviatilis, Planorbis marginatus, P. corneus, P. spirorbis, Succinea oblonga, Pupa tridens var., Helix ericitorum; the last two terrestrial mollusks still abound in the Kherson and Bessarabia provinces."[2]

Another characteristic feature is that "the composition and partially the fossil content of these strata (early post-Pliocene) are very similar to the late post-Tertiary deposits in the area of the Dniester River; they could be included in one geological class but for the high position of the early post-Tertiary deposits (up to 400 feet [122 m]) above the Dniester and their content of fossil mammals."[3]

In Bessarabia, all these deposits are covered mostly by surficial red or light-yellow clays which "thicken considerably in the western and northwestern parts of Bessarabia."[4] Sintsov describes the clays as frequently containing salt efflorescences, sometimes (Novaya Linben) snow-white throughout Bessarabia, especially in localities along the boundary with Moldavia. "Analyses of solonetses of this kind, performed by Petriev, showed that they contained considerable percentages of calcium sulfate and sometimes also of magnesium sulfate; these clays may contain large quantities of crystalline gypsum intergrowths, which in some localities (at the village of Avdorma) are such that they are quarried for preparation of plaster of Paris."[5] In many cases (Bul'boka) wells dug in this clay yield water almost worthless for household use.[6]

[1] Feofilaktov. O mestonakhozhdenii kremnevykh orudii cheloveka vmeste s kostyami mamonta v s. gontsakh, na r. Udae, Lubenskogo uezda (Find of Flint Artifacts Together with Mammoth Bones at the Village of Gontsy on the Udai River in the Lubny District), pp. 21–25. 1874.

[2] Sintsov. Ibid., pp. 106–107

[3] Ibid., p. 107.

[4] Sintsov. Otchet o geologicheskikh issledovaniyakh Bessarabii v 1873 g. (Report on Geological Investigations made in Bessarabia in 1873), p. 12.

[5] Ibid., pp. 4–5.

[6] Ibid., p. 12.

The most significant conclusion drawn from our review of the south Russian deposits is that they are largely a local formation, mainly formed by the weathering of the bedrock underlying local diluvium (or nearby bedrock). Since the bedrock is mainly arenaceous in the northern half of the region and calcareous in its southern half, the chemical composition of the south Russian post-Pliocene should generally follow the same pattern. In addition to the analyses presented of Konotop and Vasil'kov subsoils, this statement is supported by several additional results of chemical analyses for south Russian diluvium which will be given below.

SOIL IN SOUTHWESTERN CHERNOZEM RUSSIA

A. LEFT BANK OF THE DNIEPER

As is known, the area on the left bank of the Dnieper has hardly been studied pedologically. All the literature on this subject consists of the following minor information.

In 1845, the unknown author (signed by his initials N.A.) of the "Economic-Statistical View of the Poltava Province" (Khozyaistvenno-statisticheskii vzglyad na Poltavskuyu guberniyu)[1] remarked that "the soil of this locality is generally variable. Areas deep in the steppe or far from rivers are rich in chernozem; the soil of the Piryatin, Priluki, Romny, Konstantinograd, Khorol districts and partly also of the Mirgorod District, is especially rich, and wide areas are covered by chernozem 1/2 arshin—2 arshins [36—142 cm] thick..." Similarly, "steppe plains of the Lubny District (adjoining the Piryatin District) and the Zolotonosha District are covered by chernozem, in many places reaching 3/4—2 arshins [50—142 cm] in thickness." Borisyak adds that, generally speaking," chernozem in the Poltava Province is considerably blacker than that of the Orel and Ryazan provinces; the same is true of the chernozem in the Kupyansk District and partly also in the Izyum District of the Khar'kov Province."[2]

In contrast, "the Gadyach, Zen'kov, Poltava, and Lokhvitsa districts (as well as elevated areas along the Sula River in the Lubny District) have a more loamy soil." Further, "in the Poltava, and partly also in the Khorol, Kremenchug, and Konstantinograd districts, the soil contains marl in some places. Gentle slopes in the Zolotonosha District are covered by sandy loam; the same soil is also found in the Pereyaslavl District." Moreover, "certain areas on the banks of the principal rivers of the province (Dnieper, Vorskla, Psel, Sula, Orel, Berestovaya) are covered by loose sands."[3]

[1] Zhurnal Ministerstva Gosudarstvennykh imushchestv, No. 16, pp. 25—26. 1845.

[2] Borisyak. Ibid. [O chernozeme. Rech'... (On Chernozem. A Speech...).—In book: "Otchet o sostoyanii Khar'kovskogo universiteta za 1851 g.", Khar'kov. 1852.], p. 24. Borisyak also says that chernozem from virgin lands in the Lokhvitsa, Lubny, and Zolotonosha districts contained humus (volatiles) contents of 13—17% in the upper horizon, 10—12% in the middle horizon, and 7—9% in the transitional horizon. Although these percentages are certainly too high, they are quoted here because they clearly demonstrate that such an early investigator as Borisyak proved a gradual decrease in the humus content of soils from top to bottom. Author.

[3] Zhurnal Ministerstva Gosudarstvennykh imushchestv No. 16., pp. 225—226. 1845. Here the author listed all the sandy areas in detail; according to him these loose sands have a thickness of 1/2 to 9 arshins [1.1—6.4 m] and he regards them as drifted sands.

According to the same author, "many territories in the province contain small solonchak areas; the solonchak near the Vatazhok River (a tributary of the Orel' River) in the Kobelyaki District, in the Government forests near the village of Mayachki, is unusually abundant in soil particles."[1]

A similar example of solonchaks was also provided by Prof. Levakovskii, referring to the well-known Karlovka village where "brown clay is so highly impregnated with salt that it may even crystallize on the surface," and the water of the local wells is saline.[2]

According to "Description of the Kursk Commission for the Regularization of Money Taxes from Government Peasants" (Opisaniya Kurskoi Komissii uravneniya denezhnykh sborov s gosudarstevnnykh krest'yan), the terrain in the Kursk Province is fairly monotonous; "the northern part adjacent to the Orel Province, including the Shchigry, Fatezh, and partly also the Dmitriev, districts, is flat; the southern part of the Dmitriev, Putivl, Ryl'sk and L'gov districts is also mostly level and lower than the other districts, and the rivers thus flow from east to west. The remainder of the territory, mainly the eastern and the southeastern districts (including the Kursk District) consists of a horizontal and undulating terrain, similar to the flat areas mentioned above."

On the whole, the soil of the territory occupied by the Kursk Province, part of the chernozem zone of Russia, is the so-called chernozem, grayish-black in the vegetal layer, reaching a depth of 1/4—1/2 arshin [18—36 cm] (seldom more) in the western part of the province and up to 1 1/2 arshins [108 cm] deep in its southern and southeastern parts with clayey, sandy-clayey, marly, sandy and calcareous subsoils. Studies give the principal distinctive features of this chernozem as follows: 1) loamy chernozem predominates throughout over other varieties with the exception of the northwestern part of the province; its subsoil may be clayey, sandy-clayey, or marly; 2) sandy chernozem is less common, occurs mainly in low-lying areas and on river banks; its vegetal layer is variously tinged, depending on its admixture with chernozem particles, from dark-gray to pure white sand, and is viscous in a varying degree, depending on the content of clay particles; 3) calcareous chernozem is very rare, and occurs on gentle slopes in the vicinity of rivers and gullies; it is formed by lime derived from the subsoil and mixed with the top vegetal layer.

Each of these chernozem varieties may in turn be classified into three groups, in accordance with the different proportions of soil constituents, the depth of the vegetal layer, and the subsoil, and finally according to the advantages of its situation.

It must be noted, in this context, that in certain localities to the east the so-called solonetses are found on level areas; these solonetses consist of a loamy-chernozem soil, which is of a more intense black and is rendered viscous by large admixtures of humus and clay. The subsoil of solonetses is clayey, black or dark-gray. Its permeability is very low or nonexistent, and moisture is thus retained in the vegetal layer or even on the surface. These areas bear extremely scant vegetation, because the soil's viscosity in the wet season and its hardness in the dry season

[1] Ibid., p. 22 6.

[2] Levakovskii, Ibid., p. 34. Solonetses are also marked on the cadastral soil maps for the Poltava and Khar'kov provinces.

block the beneficial effect of atmospheric oxygen; solonetses therefore are mostly regarded as nonarable.

The Kursk Province also contains nonchernozem soils formed by clay and sand mixed in different ratios, admixed with chernozem particles. These soils are usually no more than 1—6 vershoks [4.4—27 cm] deep; the color of the vegetal layer varies: dark-gray, yellowish-brown, sometimes nearly white; the subsoil is usually clayey and marly. These soils occur mainly in the northwestern part of the province, which includes the L'gov and the Dmitriev districts and parts of the Ryl'sk and Putivl districts.

The nonchernozem soil may be of loamy and sandy varieties. Loamy nonchernozem yields better crops than sandy nonchernozem, usually producing less straw and more grain, and the grain itself is heavier. Rye grown on loamy nonchernozem therefore fetches a higher price, especially for distilleries.

Finally, loose sands are encountered in the eastern part of the Staryi Oskol District; these sands are barren and lower the quality of the fields into which they are transported. On some estates the sands are fixed with red willow.

Loose sands are found, to a very small extent, in other localities of the province as well.[1]

In his paper "Chernozem", 1851, Prof. Borisyak reviewed almost the entire left bank of the Dnieper. As expected, he also noted the differences in quality of chernozem: "in certain localities (for instance between Valki and Kolomak in the Khar'kov Province) it seems quite clayey, while in others (along the Lopan in the Khar'kov District) it appears to be sandy and gray, and in still other localities (in the Biryuchenskii and the Novyi Oskol districts) it is marly and darkish-whitish."[2]

Borisyak also observed wide variations in thickness of the local soils, as follows: "in the vicinity of Lokhvitsa the thickness is 2 arshins [1.4 m], in the Pavlograd District it is often as little as 6 vershoks [27 cm] and in certain localities of the Aleksandrovsk District the thickness of chernozem approached that of the Petersburg northern soil; similarly thin soils were encountered by the investigator in certain localities of the Lebedyan District and in many localities of the Ekaterinoslav Province."[3]

At present, the forested area in these provinces is very small, especially in the Poltava and the Ekaterinoslav provinces. According to the latest data of Prof. Rudzkii, the areas in the table are covered by arboreal vegetation.[4]

According to Shenrok,[5] "forest distribution in the Ekaterinoslav Province is distinguished by two characteristic features. The first is the almost perfect coincidence of forest distribution with the differences in geognostic formation: the entire belt of plutonic rocks stretching through the entire province from northwest to southeast through the Verkhnedneprovsk, the Ekaterinoslav, and the Aleksandrovsk districts is mostly forestless, forests occurring either in the Dnieper "plavni" or no more than 20 versts

1 [Vzglyad na sel'skoe khozyaistvo Kurskoi gubernii (Agriculture in the Kursk Province)]. —Zhurnal Ministerstva Gosudarstvennykh imushchestv, No. 37, pp. 102—104. 1850—1854.

2 Borisyak. Ibid., p. 17.

3 Ibid., p. 17.

4 Rudzkii. O rasprostranenii glavneishikh drevesnykh porod v Evropeiskoi Rossii (Distribution of the Most Important Arboreal Species in European Russia), pp. 184—185. 1882.

5 Shenrok. Oblesenie stepei Ekaterinoslavskoi gubernii (Afforestation of Steppes in the Ekaterinoslav Province), p. 3. 1874.

from the river; th- remainder of the forests in the province grow mainly on areas of Cretaceous formation in the Novomoskovsk and Pavlograd districts and on areas of Carboniferous formation in the Bakhmut and the Slavyanoserbsk districts."

Province	Total forested area, dessiatines [and hectares]	Ratio of the total forested area to the entire territory of the province, %	Agriculturally valuable forest soil, dessiatines [and hectares]	Agriculturally valuable area of forest soil per capita, dessiatines [and hectares]
Kursk	343,759 [375,375]	8.1	324,201 [354,027]	0.14 [0.15]
Khar'kov	518,924 [566,665]	10.4	461,495 [503,952]	0.23 [0.25]
Poltava.	222,062 [242,492]	4.9	164,743 [179,904]	0.07 [0.07]
Ekaterinoslav . . .	113,880 [124,357]	1.7	56,954 [62,194]	0.04 [0.04]

"The second characteristic of local forest distribution is that all the forests in the province, except for those in the Dnieper 'plavni' and along the Samara River, are almost exclusive to 'balkas'. Minor forests occupy either the apexes of the 'balkas' or their sides and disappear when emerging into the high steppe. Isolated trees or groups of trees occur in many places near the edges of these minor forests."

The latter is a characteristic of all steppe localities. However, we shall see below that forests may also occur outside the "balkas" in typical steppe areas, usually either on high river banks or on sandy areas. This was noted by Borisyak, who was the first to record the "absence of chernozem in forested areas in the Balki, Bogodukhov and Akhtyrka districts."[1]

Nevertheless, he is convinced that "huge forests formerly existed in the Ukraine, at least in the Poltava and the Khar'kov provinces which are richest in chernozem." This opinion is strengthened both by information gleaned from his predecessors and oldtimers, and by the "remnants of former forests still so noticeable along the Psel, Donets, Vorskla and other rivers."[2] This view is also held by Palimpsestov, Shenrok and others.

As for the relationships between Ukrainian chernozem and past and present bogs, "old men with good memories, who still remember the Ochakov campaign* showed Borisyak the 15-verst area, between the village of Bogodukhovka and the Zarozhnyi farm in the Zolotonosha District, which used to contain vast lakes overgrown with rushes, where people fished and hunted otters; this area is now a flat steppe covered by chernozem and terrestrial vegetation." The author also mentions bogs between Chuguevo and Izyum, where "there stretches a remarkably level steppe."[3] Pointing to these facts, Levakovskii wrote as follows: "My attention was drawn by the enclosed, usually circular depressions occurring on elevated sites

[1] Borisyak. Ibid., p. 34.
[2] Ibid., pp. 34, 47 and 62.
* [In 1788. Translator.]
[3] Borisyak. Ibid., p. 54.

amidst chernozem. These depressions are numerous between Krasnopol'e (Graivoron District) and Syrovatka (Sumy District), between Belovod (Sumy District), Korenevo and Aleksandrovskaya (Ryl'sk District), etc. Some are filled with water and take the form of small lakes which usually dry out in summer, while others are filled with bog humus soils directly overlying the diluvial clay."[1]

These pedological data can be supplemented by the following somewhat obsolete analyses performed by Shlippe and Schmidt.[2]

Component	No. 1, Kursk District	No. 2, Lubny District, Poltava Province	Component	No. 3	No. 4
				Parafievka, near Priluki, Poltava Province, nonfertile chernozem	
				solonets	solonets
Hygroscopic water	3.46	2,93	Water lost by heating to 180°	8,965	9.023
Organic substances (including zeolite water) .	10.50	7,10	Humus and zeolite water	7.669	6.481
Silica	73.00	78.03	Mineral constituents. . .	83,366	84.496
Lime	0.96	0.94	CaO sum	3,701	5.518
Alumina . . . . Ferric oxide	11.50	10,00	Alumina . . . . Ferric oxide	6.560 1,795	7.333 1,705
Magnesia	0,30	0,20	—	Not determined	
K_2O and Na_2O	0.96	0,90	—	"	"
—	—	—	Free gypsum	0,129	0,122
—	—	—	Nitrogen	0,290	—

Very characteristically, Petzholdt's analyses of chernozem and solonets from the Poltava Province taken a few arshins apart, of identical black color and about 1 arshin thick, revealed no significant difference in their NaCl content: "100 parts of either sample dried at 115° contained nearly the same quantity of humus (7.8 and 6.76), of insoluble minerals (87.7 and 87.6), soluble silicic acid (5.5 and 4.97), alumina (2.56), ferric oxide (1.8 and 1.7), sulfuric acid (0.07), Na_2O (0.07 and 0.06), K_2O (0.3 and 0.24), and traces of chlorine; significant differences were only noted with respect to lime (0.89 and 1.09), phosphoric acid (0.61 and 0.19), and magnesia (0.4 and 1.46).[3]

I mentioned in "Cartography of Russian Soils" (Kartografiya russkikh pochv) that the Ministry of Government Estates commissioned the compilation (mainly by the so-called cadastral groups) of soil maps for numerous provinces at different times, including the Khar'kov, Kursk, Ekaterinoslav and Poltava provinces. For the latter, the Ministry also possesses a soil map compiled by the local administrator of Government Estates.

On the basis of these data, Chaslavskii's most recent general soil map (1879) depicted the following kinds of soil in the western parts of the Kursk and the Khar'kov provinces as well as in the entire Poltava Province and

[1] Levakovskii. Ibid., p. 20.

[2] Analyses Nos. 1 and 2 were made by Shlippe (Zhurnal Ministerstva gosudarstvennykh imushchestv, 1856 [1854], No. 52, p. 121), while the other two were supplied to the Ministry by Prof. K. Schmidt of Derpt University. I am sincerely grateful. Author.

[3] Ruprecht. Ibid., p. 120.

the adjacent northeastern part of the Ekaterinoslav Province: a) rich chernozem (in the form of a peninsula penetrating from the east and bounded by the Kursk—Konotop line in the north and by the Romny—Akhtyrka—Volchansk line in the southwest; b) ordinary chernozem (the greater part of the Poltava Province, the part of the Ekaterinoslav Province mentioned above, and the remainder of the Khar'kov Province); c) loamy—sandy-loamy chernozem, principally the Zel'kov, Poltava and Gadyach districts; d) loams; e) sands; f) soil of forests growing on floodplains and g) bogs.[1] The latter four kinds of soils cover about 1/5 of this chernozem territory on Chaslavskii's map. In the Poltava Province alone, sands, loams, bogs and floodplains compose at least one-quarter of the surface, the largest ratio found in territories of this size in chernozem Russia. As expected, these four soil types (d, e, f, g) are located in the vicinity of rivers; loams occupy the right (usually steep) river banks and sands occupy the left (usually gently sloping) river banks[2]; sands of floodplain meadows and bogs are located in the alluvial river plain. The Poltava Province is traversed by as many as 150 major and minor rivers, and therefore the abundance of sands, loams, etc., in this province is readily understood.

These, then, are all the available data on soils of the left bank of the Dnieper. In order to collect more facts and, in addition, hoping to study the local soils, I made several excursions in this territory in 1877 and 1881. The area covered by these excursions may be outlined by the following principal directions: a) Kursk—Mar'ino—Belgorod—Khar'kov—Lozovaya—Sinel'nikovo—Ekaterinoslav and Aleksandrovsk; b) Prokhorovka—Zolotonosha—Lubny—Khorol—Poltava and Kremenchug; c) Belgorod—Graivoron—Bogodukhov—Akhtyrka—Zenkov—Gadyach—Romny and Bakhmach.

Kursk—Mar'ino—Belgorod—Khar'kov—Lozovaya—Sinel'nikovo—Aleksandrovsk

The neighborhood of Kursk is distinguished by a rich variety of soils on Chaslavskii's map. For instance, on the right bank of the Tuskar River ordinary chernozem is indicated, and sandy chernozem on the left bank; in the obtuse angle between the Tuskar and the Seim there is gray soil and, finally, rich chernozem is marked south of the Seim. Upon inspection of this locality, I concluded, in the first place, that the topography of the Tuskar banks is far from uniform; the right bank of this river is very steep, comparatively very high, and incised in places by deep gullies; in contrast, its left bank slopes very gently and is perfectly similar in appearance to the southern slopes of the P'yana River. The "native horizon" [bedrock] of

[1] As is known, the late V. Chaslavskii did not manage to compile the text for his map due to lack of time, and his meanings for the terms "rich chernozem" and "ordinary chernozem" are of necessity obscure; however, the terms "loam" and "sand" are clear. I should add that although it was purposed to differentiate between sandy-loamy chernozem and loamy chernozem, their symbols (colors) are so similar that they are in fact indistinguishable on the map; I am therefore using a common term, loamy—sandy-loamy, for both types of chernozem. Author.

[2] Chaslavskii depicts an extensive sandy "island" only on both banks of the Samara River, in its middle reaches. Author.

the right bank is covered by marls, chalky in the lower section, and higher up also containing the Khar'kov tripoli-like marl in places; the marls may be overlain by very sandy "white eye" ("beloglazka"), and sometimes form a direct transition to the soil. The same was observed 1 verst north of Kursk on the high right bank of the Tuskar, where the middle of a very gentle slope is covered by a layer of gray, sandy vegetal soil reaching 1 1/2 feet [45 cm] in thickness, lying directly over somewhat weathered chalky marl; the soil contained 3.30% humus.

In the angle formed by the Tuskar and the Seim, near the railroad station, I took a sample of soil 2 ft 3 in [69 cm] thick, containing 4.811% humus. To gain more detailed knowledge of the left bank of the Tuskar, I traveled from Kursk to the village of Okhochevka, approximately 35 versts east of Kursk; the terrain rises steadily. The floodplain of the Tuskar is followed by a very gentle general rise which stretches along 3—4 versts from the bank. The soils reach 2 feet in thickness in certain places [61 cm]; these are gray, very sandy soils, with a humus content not exceeding 5%. The next 1 1/2—2 versts are covered by nearly pure sands with remnants of a deciduous forest. Just past the forest we climbed a vaguely outlined terrace. The soils appeared darker, but a sample I took 8 versts east of Kursk, on a perfectly level site, was 1 ft 3 in [38 cm] thick, and consisted of sandy loam with 4.268% humus. Toward Okhochevka, the terrain becomes slightly more undulating; in some places the gullies apparently contain Kursk marl; the soils become somewhat darker and seem more clayey. An artificial section I made on a peasant's field, level, 5 versts before Okhochevka, showed A + B = 2 feet [61 cm], and humus content of 7.301%.

I also hiked from Kursk along the railroad (toward Belgorod) up to the Mladot station. My route led over almost uninterrupted sands reaching 10 feet [3 m] and more in thickness, near the railway bridge across the Seim. I noticed many boggy lowlands and small minor forests in the direction of the Seim.

The soils are sandy, light-gray, and thin. They darken considerably and reach 1—1 1/2 feet [30—45 cm] in thickness only 1 1/2—2 versts before the Mladot station.

Very characteristically, tufts of feathergrass are quite common close to Kursk on the sand mentioned above, even among groves of deciduous trees.

According to Chaslavskii's map, rich chernozem stretches almost continuously up to Belgorod and Volchansk, and I therefore decided to gain more detailed knowledge of the chernozem in the center of this area, in the vicinity of the Mar'ino railroad station in the Oboyan District. The route from Kursk to Belgorod preserves throughout the same geological character as noted on the right bank of the Tuskar, except for the pure chalk which is progressively replaced by chalky marl toward Belgorod. The terrain is slightly rolling throughout; the chernozem subsoil is usually light-yellow calcareous loam, less frequently marl; chernozem is 1 1/2—2 feet [45—61 cm] thick and more; it appears very dark in the field.[1]

The village of Mar'ino is typical of the area; I examined its environs, within a radius of approximately 5 versts, in the company of a local oldtimer.

[1] Characteristically, enroute from Kursk to Khar'kov as well as along other southern railroads, the railroad embankments seem to become sodded very much more rapidly and more densely than in nonchernozem Russia; this is obviously related to climate and vegatation. Rye, sown on newly made railroad embankments between Ponyri station and Khar'kov (as well as in many other areas in southwestern Russia), often proved as successful as on the neighboring steppes. Author.

Mar'ino lies in very gently rolling country with fairly common minor deciduous forests. Local inhabitants report that such minor forests were much more common within living memory, and there are grounds to assume that the area was once covered throughout by forest.[1] Oaks grow in Mar'ino today on typical chernozem, with a subsoil of no less typical loess abounding in $CaCO_3$ concretions ("dutiks"); these concretions may be uniformly distributed, or accumulated at random. Such concretions are usually smaller than the common filbert.

The bulk of $CaCO_3$ however is distributed throughout the loess as a very fine, intricate network of veinlets. A sample of loess which I took from such an area, from a depth of 5 feet [1.5 m] contained 22.09% carbonates as determined by Sokolov.[2] Numerous artificial (clay pits) and natural sections contained an abundance of krotovinas both in the loess and the overlying chernozem. Krotovinas are inclusions, usually oval, often quite round (in section) averaging 4—6 inches [10—15 cm], in diameter, often larger. They occur to a depth of 9 feet [2.7 m][3] and are uniform in size. The krotovinas in chernozem consist of a mixture of yellowish loess with chernozem; if the admixture of the latter is considerable the krotovinas undergo a gradual and imperceptible transition to the surrounding chernozem. Krotovinas in loess are filled by more or less pure chernozem; rare inclusions occur of almost pure loess, identical to the loess constituting the entire wall of the section; krotovinas of this type are noticeable only because they were separated from the general mass of loess in thick, sausage-like sections. Some krotovinas had a 50% content or more of segregations of finely granular $CaCO_3$, the remaining krotovinas being loess or chernozem.

I observed hundreds of krotovinas of all kinds in forest sections in the environs of Mar'ino, as well, where the soil also contains living and brown, partially decayed roots; the latter are quite rare. Such forest sections vividly demonstrate the fundamental difference between krotovinas proper and traces of former tree roots. Krotovinas, as noted, a) average 4—6 inches [10—15 cm] in diameter and are often larger, as compared with 1—3 inches [2.5—7.6 cm] in root channel diameter; b) diameter is constant in all horizons of a section while root channels narrow progressively with depth; c) krotovinas occur to a depth of 9 feet [2.7 m] at least whereas root channels occur to a maximum depth of 4—6 feet [1.2—1.8 m]; d) krotovina walls are much smoother than root channel walls. My careful inspection of hundreds of krotovinas in the vicinity of Mar'ino did not disclose any remains of animals or tree-roots. However, animal residues are undoubtedly found in krotovinas in the Kursk Province.[4]

For instance, the renowned Kipriyanov, who spent five years in geological investigations along the Orel—Khar'kov—Voronezh—Bryansk line, mentioned that "during the construction of the highway (in which he participated) in the Kursk Province, it was often necessary to dig trenches 7 to

[1] Any estimation of the former distribution of forests in southern chernozem Russia must take into account the fact that on this territory stumps are uprooted, in view of the high value placed on both fuel and land. The land is then immediately plowed up, and as little as 10—20 years later all traces of the forest have disappeared.

[2] Bricks manufactured from this mass are, naturally, poor in quality. The brickmakers improve brick quality by adding a certain proportion of chernozem to their material.

[3] This was the depth of the pits I saw; krotovinas probably also occur at greater depths. Author.

[4] Of course, tree residues may also accidentally penetrate the krotovinas. Author.

35 feet [2.1 — 10.6 m] deep. The walls of such trenches, consisting of strong clayey soil, revealed numerous vertical sections of animal burrows 12 inches [30 cm] and more in diameter, at depths of 7 — 14 feet [2.1 — 4.3 m] and more. These abandoned burrows were always filled with upper soil, i.e., chernozem or vegetal soil. I could not trace the arrangement of these burrows; it was, however, clear that they were usually at an angle to the surface. The digging of such deep and spacious burrows in fairly hard clay certainly cannot (?) be ascribed to the activities of the suslik[1] Spermophilus [Citellus] citellus Keys. and Blas. European suslik which is found in small numbers, common hamster Cricetus frumentarius Pall. and the jerboa (Dipus jaculus Gm.). These burrows were most probably dug by the bobak marmot which may have existed here in the very recent past, and skeleton residues which I sometimes found in the depressions known to local inhabitants as 'surkovinas' [marmot burrows] and 'baibakovinas' [bobak burrows]."[2] Kipriyanov also found remains of the common mole rat (Spalax typhlus Pall.) in the vicinity of Fatezh (Kursk Province), and remains of a badger (Meles storr [taxus]) at the village of Zorino (Dmitrovsk District). The mole rats' skulls lay "in vegetal soils", while the badger's bones were discovered by Kipriyanov "at a depth of down to 7 feet [2.1 m] in a mixture of yellow clay with lime."[3]

At two or three points in the environs of Mar'ino, sand deposits are visible, directly underlying loess at a depth of 9—10 feet [2.7 — 3 m]; in some places they consist of pure quartz sands, and in others they contain a considerable admixture of $CaCO_3$ (in such cases the sand effervesces with acid). The sand is underlain by bluish (chalky ?) marls. To complete the discussion of local loess, the following characteristic, long since noticed by Borisyak with regard to the "white eye" (beloglazka) in the Kursk and Khar'kov provinces[4] should be mentioned; this is its extreme density and apparently very clayey nature. Indeed, Mar'ino loess is very difficult to dig up; it seems to acquire a metallic luster along road ditches and even on fresh sections. However, a close examination of local loess shows that its principal component is $CaCO_3$ rather than clay, which is responsible for this high capacity of cementing. The Mar'ino chernozem therefore appears more clayey than it actually is.

I took soil samples at the following two points:

1. At the Mar'ino station itself, in a long freshly dug ditch in a perfectly level field, unplowed for over 10 — 15 years; chernozem 2 ft 10 in [86 cm] thick, with 6.031% humus.

2. Between Mar'ino and the village of Ploskoe, 1 1/2 — 2 versts from the former, on a barely perceptible slope, with soil thickness of 2 ft 6 in [76 cm], containing 7.319% humus. Characteristically, 150 — 200 paces from

[1] We shall see below that this opinion must be radically changed.

[2] Kipriyanov, [V.]. Neskol'ko slov o pozvonochnykh zhivotnykh, vstrechayushchikhsya v nanosnykh pochvakh, v dolinakh rek Dnepra i Volgi... (A Few Words on Vertebrate Animals Occurring in Soils Deposited in the Valleys of the Dnieper and Volga Rivers ...), p. 13, 1854. [Reprint from "Kurskie Vedomosti" No. 18.]

[3] Ibid., pp. 10, 11. This mixture may represent the content of one of the Mar'ino krotovinas described above.

[4] According to Prof. Borisyak, "'white eye' has a strong tendency to harden; during droughty periods it resembles stone, and even in the very rainy summer of 1852, the rainiest since the 1830s, the renowned Yukhnov navvies could hardly cope with 'white eye' when excavating along the line of the Kursk — Khar'kov highway." Borisyak. O chernozeme (On Chernozem), p. 33.

point (1), in a freshly dug cellar, chernozem already reaches up to 3 1/2 feet [1.6 m] in thickness and more. The subsoil apparently remains the same.

The territory lying between Mar'ino and the Prokhorovka station continues unchanged; the terrain is even more level and no minor forests are visible. Forests reappear only before Belenikhina station. The soil appears as dark as before, but its thickness (up to Kustarnoe station) rarely reaches 2 feet [61 cm] in railroad excavations. The subsoil is mostly loess, and to some extent chalky marls.

Toward Belgorod, the terrain becomes progressively more hilly and the railroad approaches the valley of the Donets River. Boggy lowlands are increasingly frequent, left of the road, while to its right chalk rocks are visible, sometimes snow-white, and thinly covered by yellowish-brown marls, probably local weathering products. The slopes of chalk bluffs and boggy lowlands are covered in some places by minor forests of deciduous trees. As seen in the railroad excavations, the Mar'ino chernozem gradually disappears just after Kustarnaya station and up to Belgorod, and is replaced by gray and even light-gray soils about 1 foot thick, rarely thicker.

The town of Belgorod is located on a lower slope of a massive chalk elevation, the vertical bluffs of which (rising about 150—200 feet [46—61 m] above the Donets) are outlined very distinctly in the blunt "cones" and are seen from the train. Belgorod stands on deep sandy ground, abundant in minute spangles of silvery mica. The terrain rises between the town and the chalk rock. Sand alternates with loess (the latter at brickyard) for about 1 verst, and after crossing a deep very narrow, freshly dug ditch the Belgorod Mts. are reached; they consist of very pure chalk with sporadic chert concretions. In some places near the surface the chalk apparently forms a transition to a very sandy yellow-brown mass, 1—5 feet [30—152 cm] thick. I say "apparently" because there is no definite proof that this is a true weathering product of chalk, rather than eluvium of the rocks which formerly covered the chalk (see below, on Glukhovets). I made the following artificial section on the virtually level summit of these rocks.

1. Soil—gray, sandy, vegetal earth, 11 inches [28 cm] thick.
2. Light-brown, also very sandy earth, 3 feet [91 cm].
3. White chalk.

I took four samples: two from the soil horizon, one from a depth of 2 feet [61 cm], and one from a depth of 12—14 feet [3.6—4.3 m]. Their analyses are given below; I shall limit myself to the following remarks. Although the local soils lie on a fairly level site, the chalk plateau terminates in nearly vertical bluffs on two sides; the washing-away of various fine particles (including soil particles) is therefore inevitable and this may be the reason for humus contents not exceeding 6%. The Donets valley, at the very foot of the chalk rocks, is a typical and fairly large alluvial valley. It grows wider in some places, narrows in other places and also contains numerous oxbow lakes, both clear and overgrown or bogged. The course of the river is as capricious as the course of the P'yana River; the soils are typical deposited bog soils.

Chaslavskii's map depicts rich chernozem as terminating halfway between Belgorod and Khar'kov, and being replaced by ordinary chernozem. In the summer of 1877 I traversed this territory twice, stopping at the

Kazachya-Lopan station; no dividing line was noticeable. This territory was identical to the Saransk—Korsun —Tagoi area, another chalky terrain which is described below; the same occasional marked undulation, the same chalky marls and thin loess as in the subsoil. The vegetal earth has no definite appearance; it is thin (about 1 foot [30 cm] thick), gray vegetal soil on hilltops and typical chernozem up to 1 1/2—2 feet [45—61 cm] thick and thicker on slopes and in lowlands.[1]

My investigations in the neighborhood of Khar'kov [2] were limited to an inspection of the area around the village of Pesochino, with the summer home of Prof. Levakovskii close by. The young forest there is composed of oak, ash, maple, etc.; about ten years ago, Prof. Levakovskii found old oaks aged up to 200—300 years. In this area, undoubtedly virgin soil, Levakovskii and I made an artificial section, which yielded the following information. The surface is covered by a fairly compact mat reaching 1 1/2 vershok [7 cm] and more in thickness. This mat is easily removed by hand, as in all forests. The horizons underlying this litter were as follows:

A. Soil horizon, dark when wet and dark-gray when dry, a loose mass 8—9 inches [20—23 cm] thick.

B. Transition horizon, earth of nuciform structure, consisting of fairly dense nodules ranging from the size of a pea to that of a small filbert; its color was gray, with an apparent bluish tinge. This horizon differed quite markedly from horizon A in both structure and color. Its thickness varied, 1—2 feet [30—61 cm].

C. Yellow-brown fairly compact loam.

Analyses of samples taken at this point are given below.[3]

Horizons A and B were permeated by live tree roots which also penetrated into horizon C.

The vegetal soils on the sandy slopes descending toward the floodplain of the Uda River were of the Belgorod type, sandy, light-gray, in some places not thicker than 1 foot [30 cm].

During the construction of the Khar'kov—Lozovaya railroad, the route was inspected throughout by Barbot de Marni. As was to be expected, the entire territory on the crest of the water divide between the Dnieper and the Donets proved to be of the same structure common throughout the left bank of the Dnieper, as follows: loess on top (although not everywhere); below, sands and loose sandstones (Miocene), further down, sandy-clayey

[1] I cannot deny the validity of this boundary, since no detailed investigations have been made. Should the line be proved to exist, it may be explained by stronger development of the Khar'kov sandy stage toward the city of Khar'kov. See Barbot de Marni. Geol[ogicheskie] issl[edovaniya] ot Kurska do Taganroga (Geological Investigations from Kursk to Taganrog), pp. 303, etc.

[2] See Levakovskii. O pochve i vode gor. Khar'kova (Soil and Water in the City of Khar'kov), 1874. The interesting observation of Prof. A. V. Sovetov is illuminating, on the distribution of soils along the banks of the Seim River in the Khar'kov Province. He found that "near the river there is pure sand, bearing mainly pine and sometimes also oak woods; farther away, sandy chernozem overlies sandy ground, and still further, chernozem on clayey ground." Sovetov. O chernozeme. Iz putevykh zametok (Chernozem. Travel Notes), p. 9, 23 September 1876. [Trudy VEO, Vol. 1, No. 1, 1877.]

[3] It should be noted that due to the rain the sample of subsoil was not taken from the pit where the soil and transition horizon samples were taken, but from a pit 20—40 paces away. This is the probable source of a certain anomaly in the Pesochino subsoil in respect to its $CaCO_3$ content. Therefore, the explanation of this phenomenon, proposed by Prof. Schmidt, is superfluous. Schmidt, Ibid. [In book: Fiziko-khimicheskie issledovaniya pochv i podpochv chernozemnoi polosy Evropeiskoi Rossii, No. 1, St. Petersburg, 1879.], pp. 7 and 21.

Khar'kov stage (Eocene); Jurassic formations appeared in places only from the Krasnopavlovka station onward (Pavlograd District), underlying these sands.[1]

My examination of the Khar'kov — Lozovaya line showed that according to the topography, surface rock composition, and nature of soils and (to a certain extent) of vegetation, the entire territory may be subdivided as follows: a) Khar'kov, 5 — 7 versts south of Merefa station, b) from Merefa station to Berki station, and c) the remainder, to Lozovaya.

The first two areas are fairly hilly; there are many gullies between Taranovka station and Berki; minor forests are fairly common, at Karachevka between Berki and Taranovka and somewhat south of Merefa; pine forests were observed at the latter point. However, from Berki station toward Alekseevka the terrain levels off considerably and from Alekseevka towards Krasnopavlovka and Lozovaya the terrain is typical steppe, devoid of forests, water, ditches, or villages; wheat and rye stretch almost to the very horizon. These characteristics become more pronounced toward Lozovaya.

Roughly speaking, in the first and the last third of area (a), sands appear on the surface almost throughout, and the soils are, accordingly, very thin, often less than 1/2 foot [15 cm] thick. In the pinewoods south of Merefa, they are often 1 — 2 inches [2.5 — 5 cm] thick and appeared no different from "bor" soils of the Murom and Alatyr forests. This is understandable, since such sandy soils are shifted by the slightest wind, with outcropping of the bedrock (Miocene) sands resulting, on the surface; these sands, in turn, are not long stationary, since they are deflated and often bury local soils. The soil section depicted in Figure 6 is a typical one, which I often observed in the vicinity of this pine forest.

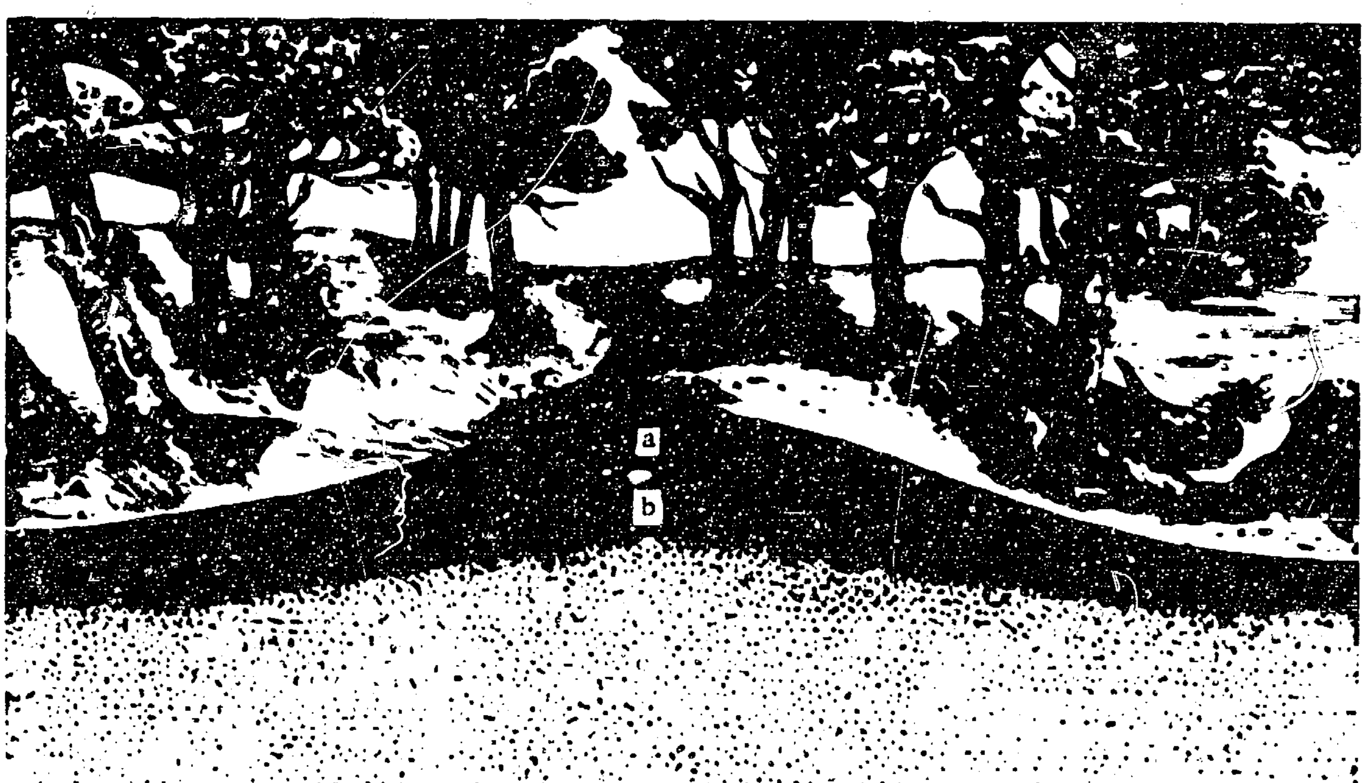

FIGURE 6. a- Dune sand up to 2 feet [61 cm] thick; b- vegetal sand layer in situ, 1—1½ feet [30—45 cm] thick; c- underlying stratified sand.

[1] Barbot de Marni. Ibid., pp. 305 — 308.

The soil near Karachevka, under oaks growing on loess is chestnut colored and does not exceed 6 inches—1 foot in thickness [15—30 cm].

Approximately 7 versts south of Merefa, "white eye" ("beloglazka") is almost the sole constituent of the soil for chernozem, of an average thickness of 2 feet [61 cm] and appearing very dark and loose in the field; this pattern continued to Lozovaya.

Barbot de Marni mentioned that near Lozovaya station "very clayey (?) loess which is therefore very compact and hard when dry reaches a thickness of up to 3 sazhens [6.4 m]"; on the basis of the earth excavated from wells, its thickness may be estimated in certain places as at least 5 sazhens [10.7 m]; it abounds in nodules ("dutiks"), apparently even more so than the Mar'ino "white eye". This, rather than its clayey nature, is undoubtedly the cause of the "great difficulties encountered by the laborers, who could hardly break [the Lozovaya loess] with crowbars."[1]

I made an artificial section in the vicinity of Lozovaya, near an almost perfectly level plowland, with the following results:

A'. Arable horizon 6 inches [15 cm] thick.

A". Remainder of the soil horizon A, 10 inches [25 cm].

B. Transition horizon with patches of little-altered bedrock, 1 ft 8 in [51 cm] thick.

C. Typical yellow-brown loess.

The Lozovaya chernozem is velvety, finely granular. This granularity is especially pronounced in horizon A", while the tilled layer A' is much more pulverulent.

Velvety black, very finely granular suspended matter is noticeable between the lumps of soil in the field following rainfall; this is even more distinct along the roads, where this matter is mixed with small areas of very finely graded floury quartz sand. The humus content in the chernozem was 8.519%.

From Lozovaya I proceeded to Kremenchug, stopping at Sinel'nikovo station. Up to this point, all the characteristic features of ground, topography and soil were apparently the same as in Lozovaya, except for large bogs between Varvarovka station and Pavlograd; these bogs are obviously part of the alluvial valley of some small tributary of the Samara River. Neither sands nor minor forests are seen; it is, however, certain that both are widespread along the lower and partly also the middle reaches of the Samara River, which we crossed at Pavlograd.

Chaslavskii's map and other sources depict a vast sand "island" along the Samara 30—40 versts wide in either direction. Apparently, the position and very occurrence of the Samara sand "island" are related to the river, and it may therefore be assumed that its mode of origin was a combination, similar to the sandy depression on the northern chernozem boundary.

A continuous pine and oak "bor", characteristically, probably occupied this sandy area as well, almost surrounded by chernozem steppes (except for the valley of the Samara, a tributary of the Dnieper).

According to "Secretary Chernyavskii's Description of Zaporozhskaya Sech"* (Opisaniya Zaporozhskoi Sechi sekretarya Chernyavskogo) (1766),

[1] Ibid., p. 308.

* [Zaporozhskaya Sech was the center of the Dnieper Cossacks (16—17th centuries). Their main permanent camp was on Khortitsa I., where Zaporozh'e stands today (formerly Aleksandrovsk), repeatedly mentioned in this section. Translator.]

"on the left side of the Dnieper (200 versts from the Kodak ferry) excellent forests of construction timber grow along the Samara where (there is) a pine 'bor', as well as a forest of oak and other deciduous species . . .; timber of these forests was used by the Zaporogian Cossacks for their houses and winter homes. In 1756, when most of the Sech was destroyed by fire, the timber from these forests was used to rebuild the Cossack 'kuren's',* merchants' and tradesmen's houses; these forests have always provided firewood for heating and other purposes."

Due to the intensive exploitation, the depredations of the neighboring Tatars, and especially since "the 'bor' suffered from several fires, all the high-quality forests were already very rare in Chernyavskii's day."[1] Pine growths still exist along the Samara.[2]

The sandy "island" described above is the southernmost point in this belt for the growth of oak and pine used for construction on steppes. Chernyavskii, as well as V. Tyapkin and the official, Zotov, who visited the Crimea in 1680, stated that south of the Samara (all the way to the Crimea), only willows and thorny bushes grow along rivers and streams (Volch'i Vody, Kalmius and their tributaries). Any minor woods occurring from time to time (Chernyavskii) "might be mostly called bushes."[3]

Sinel'nokovo station is situated on almost perfectly level terrain. Chernozem reaches 2 1/2 feet [76 cm] in thickness, its humus content is 3.892%, and the ground [subsoil] consists of typical sandy "white eye". I made a side trip toward Ekaterinoslav at this point. The first half of my route traversed country identical to that at Sinel'nikovo station, while the second half, toward the Dnieper, is considerably more hilly and numerous "balkas" appear, their walls consisting of light-yellow loess only. The gradient of their walls is usually 10—25°. The change in topography is accompanied by a change in the chernozem, which seems thinner and less intense in color. Feathergrass was abundant at many points in the immediate neighborhood of the railroad line on the right of way of the railroad, en route from Sinel'nikovo to Ekaterinoslav. This feathergrass is a remnant of the former steppe which has been totally plowed up; it is noteworthy that feathergrass also grew on the slopes of the railroad excavations, obviously on typical loess.

Ekaterinoslav is located partially on the right, fairly narrow half of the alluvial valley of the Dnieper and for the most part on the slopes of the second right bank of this river. In some places these slopes bulge so that their base is invisible from their top; the narrow gullies incising this bank only reveal very sandy loess with a few calcareous concretions, sometimes 20—30 feet [6.1—9.1 m] thick. Chernozem has usually been washed off these slopes or has in any case been markedly thinned and impoverished in readily washed and leached soil constituents. Prof. Levakovskii, however, reports that opposing phenomena also occur. According to his observations,

* ["Kuren'" was a unit of the Zaporogian Cossack troops; the term also applied to their buildings. Translator.]

[1] Palimpsestov, [I.]. Peremenilsya li klimat yuga Rossii? (Has the Climate of Southern Russia Changed?), pp. 19—20. —[In: Sbornik statei o sel'skom khozyaistve yuga Rossii, izvlechennykh iz Zapisok obshchestva sel'skogo khozyaistva yuzhnoi Rossii s 1830 po 1868 gg., Odessa. 1868.]

[2] Rudzkii. O rasprostranenii vazhneishikh drevesnykh porod v [Europeiskoi] Rossii (Distribution of the Most Important Arboreal Species in [European] Russia), p. 177.

[3] Palimpsestov. Ibid.

"the chernozem at the top of the slope in Ekaterinoslav is 1 — 1 1/2 arshins [71 — 107 cm] thick, downslope 2 arshins [1.4 m] thick, reaching 3 arshins [2.1 m] at the foot (of the slope)."[1]

A section made about 2 versts west of the city, on a perfectly level steppe area adjoining the top of the slope, covered by tall weeds and sagebrush, gave the soil thickness as 3 feet [91 cm], and its humus content was as low as 3.215%; the soil is dark-gray, very sandy.

After crossing to the left bank of the Dnieper, near the mouth of the Samara, at Ekaterinoslav, we encountered an alluvial valley, very wide in comparison with the right-hand bank, appearing to be composed of pure quartz sand; northwest of the Dnieper, it forms a fairly gradual transition to the neighboring heights. A characteristic feature of this sandy lowland is the small scattered sandy hills, of the following structure: the lower two-thirds of the hill consist of pure, fairly coarse, quartz sands, further uphill there is a layer (approximately 1/2 — 1 foot [15 — 30 cm] thick) of gray sandy soil, while the top cover of the hill consists of fine, light-yellow dune sands, in some places up to 2 feet [61 cm] thick.

In all my examinations of outcrops of various crystalline ("Dnieper") rocks in the environs of Ekaterinoslav and near Aleksandrovsk (see below), no direct contact with soils was observed; the outcrops appeared either as perfectly bare rocks (in the Dnieper valley), or else covered by thick deposits of sandy diluvium. Prof. Levakovskii was fortunate enough to find "granite rocks in the form of terraces bearing chernozem, on the bank of the Dnieper, opposite Potemkinskii I.; however, these deposited accumulations of loose chernozem[2] were rich in disintegrating bones of domestic animals."[3] I observed similar chernozem directly on granite in many places at the beginning of the Nenasytetskii* Rapid.[4]

Finally, at the Khortitsa "colony" [settlement] "on the very bank of the Dnieper, huge granite cliffs emerge from under the diluvium." Prof. Levakovskii was especially interested in those cliffs which protruded somewhat above the surface, their summits containing depressions of appreciable size. "Under these conditions, both deposition of chernozem from surrounding areas and erosion of any soil which might be formed are prevented. However, such areas are covered only by lichens, and in some places by a layer of humus a few 'liniyas' thick, while a normal layer of chernozem is found on the surrounding areas, over diluvial clay."[5]

Toward the Dnieper, from Sinel'nikovo to Aleksandrovsk, the same changes in topography and in soil character occur as between Sinel'nikovo

[1] Levakovskii. Materialy ... (Materials), p. 30.

[2] Similar chernozem overlying diluvium probably covered most of the steppe between Ekaterinoslav and Nikopol. Levakovskii, Ibid., p. 39. The local farmer, F. A. Levshin, comparing Tula (and partially also Tambov) chernozems with Ekaterinoslav chernozem recognizes the characteristic fact that these "two soils are completely different" and definitely preferred the former. Levshin also remarks that "the Tula chernozem is unusually plastic which is not the case in southern chernozem ... In Tula, plowing may be carried out by a team of four horses whereas plowing in the south requires four pairs of oxen. This is a measure of their varied clay content." (Trudy VEO, p. 287, March 1879). The last conclusion seems to be too hasty, since we have seen that the clayey character of a soil does not always depend solely on its actual clay content. Author.

[3] and [4] Levakovskii, Ibid., pp. 38, 39.

* [One of the once-famous Dnieper Rapids, subsequently covered by waters of the large man-made reservoir produced by the construction of the Dnieper hydroelectric station at the foot of the main rapid below Dnepropetrovsk (formerly Ekaterinoslav) and above Zaporozh'e (formerly Aleksandrovsk). Translator.]

[5] Levakovskii. Ibid., p. 39.

and Ekaterinoslav. Aleksandrovsk is on the left bank of the Dnieper, partially on the slopes of its second bank and partially in old "plavni". At the railroad station, we crossed the fairly deep and typical Moskovka "balka". A very small brook flows over its wide bottom; the "balka" sides are sodded and very gently sloping, being oval-convex in some places; their upper margins gradually merge with the adjacent steppe, slightly undulating; it was difficult to state where the steppe begins and the "balka" ends.

The Moskovka "balka" receives small, still developing gullies, the walls of which are sometimes sheer even at the apex, the bottoms usually narrow and their walls displaying loess. The Moskovka "balka" and the fresh gullies emptying into it are extreme types of water erosion in southern Russia, with many intermediate forms.[1]

The soils of Aleksandrovsk are very sandy along the entire slope of the old left bank of the Dnieper, tinged gray and 1/2 — 1 foot [15 — 30 cm] thick.[2] Local inhabitants report that the immediate environs of Aleksandrovsk are devoid of chernozem. The latter is visible after a 5-verst climb up the right-hand slope of the Dnieper to the neighboring, fairly level steppe. This is in effect indicated by Chaslavskii's map, although soils on the right bank of the Dnieper are designated as loam.

Prokhorovka — Zolotonosha — Lubny — Khorol — Poltava — Kremenchug

In the same year (1877), after going down the Dnieper by steamer from Kiev to the river station of Prokhorovka, I proceeded to Zolotonosha, first traversing the Dnieper "plavni", which is 2 — 3 versts wide. The surface is sandy throughout, incised by oxbow lakes and several irregularly-shaped (circular or elongated) depressions, which may be dry or wet. The general level of the floodplain rises toward the old Dnieper bank, in a series of vaguely outlined alluvial terraces. In an excavation of approximately 40 feet [12 m], made along the ascending road, light-yellow sandy loess is revealed, overlain by darkish-gray chernozem 4 feet [122 cm] thick, markedly sandy. The soil along the way to Zolotonosha is similar. The steppe stretches, almost perfectly level, and the only variety in the landscape is provided by the small isolated groups of trees, usually near homesteads, lone willows along the road, and man-made mounds scattered over the steppe. Toward the local minor river and the town of Zolotonosha, considerable boggy lowlands occur, sometimes of the Nezhin type and sometimes deeper.

At Zolotonosha, the gardens include Lombardy poplars [*Populus pyramidalis*], and the chernozem reaches 3 ft 7 in [109 cm] in thickness.

[1] Dokuchaev. Sposoby obrazovaniya rechnykh dolin Evropeiskoi Rossii (Modes of Formation of River Valleys in European Russia), pp. 54—78. 1878. See also Kohl, Kipriyanov, Levakovskii, and Shenrok.

[2] According to Bork [Bark] in "Stepnoe lesorazvedenie v Ekaterinoslavskoi gubernii" (Steppe Afforestation In Ekaterinoslav Province), p. 119, in the northeastern part of the Aleksandrovsk District, in the Velikii Anadol forest plot "the upper soil layer is clayey (?) heavy chernozem 6--10 vershoks [27—45 cm] deep, while the subsoil is hard clay (?), in some places admixed with lime. The soil becomes very hard when dry and develops cracks reaching 1 1/2 arshin [107 cm] in depth and 1 vershok in width . . . Small solonetses occur everywhere and are distinguished by their remarkable barrenness."

Chaslavskii's indication of a "soil of floodplain meadow" throughout the area between Prokhorovka and Zolotonosha should thus be corrected considerably. A higher, completely dry steppe, slightly rolling and lacking "balkas" and gullies, bearing similarly thick chernozem stretches nearly to Lubny; the only outstanding features are the burial mounds. Halfway along the route I stopped at the village of Denisovka, on a very gentle steppe slope descending towards the minor river Orzhitsa (beyond the confluence of the Chugmak, Guilaya and Syraya Orzhitsa streams, 2 — 3 versts north of Denisovka). The floodplains of the streams are relatively very wide at the confluence, and are impassable due to swamp and dense growth of sedges and brushes. It is impossible to delineate the boundaries of these bogs, since they gradually merge with the steppe valley; the limits of these small "mochevinas" vary considerably, and the channels and valleys of the minor steppe streams are poorly defined. Borisyak's report of the transition of former bogs to chernozem steppe thus becomes quite comprehensible.

The farmstead of the local landowner Mr. Lisevich includes three wells yielding water of poor quality. According to Lisevich, the groundwaters in this locality are either saline or lime water. The subsoil is a typical, although somewhat sandy, loess abounding in calcareous concretions. I noticed two crystalline boulders in the landowner's garden, one 6 feet [1.8 m] and the other 3 feet [0.9 m] in circumference.

The artificial sections I made in Lisevich's garden yielded the following information.

Chernozem on a level site was 3 feet [91 cm] thick and 3 ft 5 in [104 cm] 200 — 300 feet [61 — 91 m] downslope (gradient 5 — 10°).

The chernozem appeared quite typical and satisfactory; nevertheless, the first chernozem sample analyzed had a fairly high sand content and only 4.579% humus.

Between Denisovka and Lubny the steppe is broken by fairly deep gullies at the village of Cherevki and 2 — 3 versts before Lubny; the gullies displayed yellowish loess and chernozem reaching 2 — 3 feet [61 — 91 cm] in thickness. From the vicinity of Lubny onward, mixed minor woods occur, consisting mainly of oak. Such forests are especially frequent en route from Lubny, via Aleksandrovka to Gontsy (well-known to Russian pedologists) northwestward, on the Udai River. Many "balkas" occur in the latter area, some very wide and deep, usually with sodded walls.

I observed the following section in one of the fresh gullies:

1. Chernozem, 2 — 2 1/2 feet [61 — 76 cm].

2. Reddish sandy diluvial clay with scattered calcareous veinlets and small crystalline boulders (the upper boulder layer mentioned by Feofilaktov), 5 feet [1.5 m].

3. The clay forms an imperceptible transition down to light-yellow typical loess, containing numerous nodules ("dutiks") and calcareous veinlets, 2 pebbles of filbert size and a few terrestrial shells, so frail that they disintegrated on touch; this layer is 7 feet [2.1 m] thick.

The talus of this exposure bore a red granite boulder 10 feet [3 m] in circumference.

The geology of Gontsy was described in detail by Prof. Feofilaktov, and I will therefore remark only that the Udai floodplain (about 1 verst wide) in the Gontsy area is not covered by rich silt (as suggested by Chaslavskii's map), but mainly by pure white quartz sand which gradually darkens and acquires a bluish tinge in the lower horizon. The sands are underlain by viscous lacustrine-fluvial clay (glei). The soil on the floodplain is everywhere in an embryonal state. On the neighboring high steppe (bank rising above the Udai), however, chernozem is often 2 — 3 feet [61 — 91 cm] thick. The diluvium is two-membered, with typical loess on top and boulder loam below, and also contains calcareous concretions and veinlets.

In the neighborhood of Lubny, the valley of the Sula River is identical with the southern branch of the P'yana at Vetoshkino and Barnukovo, in regard to topography and other features.

Along the P'yana, the high upland bank incised by gullies is on the north, while in the case of the Sula at Lubny it is on the west; however, soils in both localities are not normal. Some of the soils are strongly eroded and depleted in humus and clay, while others have been washed away altogether, exposing patches of bedrock, sandy loess or a similar boulder layer; yet other soils are forest soils of the Vetoshkino and Ketros type. Nevertheless, practically normal soils also occur in a similar fashion in places at Lubny, as in the northern slope of the southern branch of the P'yana. A sample I took half a verst west of Lubny, on a fairly level elevation, is 2 feet [61 cm] thick and contains 3.401% humus; the soil is darkish gray. Similar soils, of a mixed type, stretch away from the town west of the Sula over about 2 — 3 versts, depending on local topography and parent rock.

Local inhabitants report that an essentially identical pattern is observed all along the right upland bank of the Sula.[1] One of the highest points on this bank, once occupied by the fortified castle of the famous Jeremia Vishnevetskii (Wiśniowiecki) affords an excellent view of the environs of Lubny.

The Sula at this point meanders, ribbonlike, and its alluvial valley contains several oxbow lakes; the floodplain lowland is almost entirely sandy. Seen from above it hardly seems higher than the river, but on traversing the valley along the road to Khorol, a gradual eastward rise is noted and the floodplain finally merges with the steppe. The rise seems to extend over 4 — 5 versts from the Sula, but is actually 7 — 8 versts wide. The soils are gray and sandy nearly all along the way to Khorol[2]; a small section of a sandy hill approximately 1 1/2 versts from the Sula revealed only a thin bed of quartz sand, of varied colors.

The territory between Lubny and Poltava can be divided topographically into two unequal parts, the smaller one up to the Mar'inskii station farm (Khorol District) and the larger part consisting of the remaining territory, up to Poltava. The former terrain is considerably more level than the latter, which abounds in "balkas" of various sizes. The subsoil en route appears the same sandy loess, with a considerable increase in the quartz admixture toward Poltava. Chernozem is accordingly darkish-gray, 2 — 2 1/2 feet [61 — 76 cm] in thickness, from the 8th verst southwest of Lubny and up to Reshetilovka (Poltava District). This chernozem appears identical with the sample previously mentioned, which I took at Lubny. After the last station [Reshetilovka] before Poltava, the soils become appreciably lighter in color and progressively more sandy, so that they barely resemble chernozem in the vicinity of Poltava. The sample I took between

[1] and [2] Chaslavskii's map should be corrected accordingly.

Kurilekhovskaya station and Poltava, 5 versts from the former, is 1 ft 10 in [55 cm] thick and contains only 2.865% humus; it is apparently very sandy.

A certain exception to the general rule occurs in the neighborhood of the Khorol and Psel rivers which I crossed on my way from Lubny. However, these cases are identical with the banks of the Sula described above. The alluvial valley of the Vorskla River at Poltava is wide and very sandy, and unremarkable in structure.

The first third of the road from Poltava to Kremenchug lies on the sandy, very hilly left bank of the Vorskla and the railroad excavations reveal sands sometimes 15—20 feet [4.6—6.1 m] deep. Sandy hummocks are fairly common along the road and the structure of those between Pereshchepino station and Beliki is especially interesting. A section (described by me elsewhere[1]) showed the lower two thirds of these hummocks to consist of fine unbedded quartz sand reaching 10 feet [3 m] and more in thickness, covered by a darkish-gray vegetal layer sometimes reaching 2 1/2 feet [76 cm] in thickness. This sandy chernozem was formed in situ, since like any other chernozem, it forms a completely imperceptible transition to the subsoil. The hilltop is covered by another layer of pure colorless sand; this surficial layer sometimes reaches 7 feet [2.1 m] in thickness.[2]

Some minor woods still exist on the left bank of the Vorskla; they were certainly more numerous in the past, as indicated, inter alia, by the following communication of the local "zemstvo" worker, Mr. Kvitka. When the springtime flood of the Vorskla undermined its banks at Kobelyaki, the undermined sections revealed "huge" oaks, almost horizontal, and distinguished by their unusual hardness and nearly black color.

The vegetal layer is indeed far from typical over the entire territory; it is gray, despite a thickness of 1 1/2—2 feet [45—61 cm] in places. At some points, the soil is literally incipient and it becomes darker only toward the Kobelyaki station.

After crossing the Vorskla near Kobelyaki, the railroad nearly traverses the Vorskla—Psel divide. This territory is quite different. The terrain is more nearly level and steppe-like. The thick layer of fairly typical chernozem is overlain by "white eye", reaching 10 feet [3 m] of depth and more; arboreal vegetation is extremely rare. I took a soil sample near Panovka, 3 feet [91 cm] thick and containing 3.73% humus. This pattern exists until re-entry into the Psel and Dnieper valley, where sands and sandy soils once again stretch all the way to Kremenchug.

Kremenchug is left of the Dnieper, at the beginning of the alluvial valley which is 2—3 versts wide at this point and normal in structure. Low dune hills occur in some places near vaguely outlined old banks.

The town has twice been inundated by springtime floods in this century (in the 1840s and in 1877). It is thus impossible to determine the boundaries of the river alluvial deposits on the basis of the area flooded in spring.

In order to study local soils in greater detail, I travelled beyond the settlement of Kryukov (opposite Kremenchug) to the adjacent steppe, where the topography is of the Aleksandrovsk type. I made an artificial section approximately 3 versts west of the Dnieper, in the upper third of a very

[1] Tchernozème de la Russie d'Europe. [St. Petersbourg. 1879], Figure 2.

[2] This phenomenon is common in the territory of dune formations in both northern and southern Russia and is explained by interruptions in the growth of dunes.

gently sloping hill. The Kryukov chernozem is 3 feet [91 cm] thick and more, and its appearance indicates its affinity with typical chernozems. Investigations disclosed a fairly large content of coarse quartz grains and 2.677% humus. The subsoil is sandy loess containing lime nodules ("zhuravchiks"). In Kremenchug and down the Dnieper to Ekaterinoslav numerous outcrops of crystalline rocks occur in the Dnieper channel and on its bank. However, these rocks cannot bear chernozem; they are either washed by springtime flood waters, project in such a manner that plant residues cannot accumulate, or else have only recently appeared.

I traversed the Orel—Khar'kov—Aleksandrovsk and Zolotonosha—Khorol—Poltava—Kremenchug routes in 1877. The principal conclusions of my trips are as follows: 1) the classification of soils over the territory into rich, sandy-loamy, and ordinary chernozem, as indicated on Chaslavskii's map, is not justified; 2) all my samples, except for the Lozovaya and Pesochino soils, contain less than 8% humus, and are thus much poorer than the chernozems of central Russia and east of the Volga. The second conclusion is surprising, since it strongly contradicts the accepted views on Ukrainian soils; it is so highly significant, both scientifically and practically speaking, that I visited the area once again, in 1881, for a more detailed examination.

Belgorod—Graivoron—Bogodukhov—Akhtyrka—Zen'kov—Gadyach—Romny—Bakhmach

As has been mentioned, I was not quite sure that the sample I took near Belgorod was completely normal soil, and suspected it to have been eroded considerably. This was one of the reasons for setting out from Belgorod. For the first 4—5 versts, the highway from Belgorod to Graivoron runs along the left bank of an insignificant tributary of the Donets. On both sides of the highway (the river being on the left), bedded sands are visible, with silvery mica spangles abounding among the fields. The soils are naturally gray, reaching as much as 2 feet [61 cm] in thickness. Rye growing on these sands in 1881 was as successful as in the neighboring true chernozem steppe. At Bolkhovets (7 versts northwest of Belgorod) the road rises rapidly to a very high, extremely hilly plateau which is the water divide between the systems of the Donets and the Vorskla (a tributary of the Dnieper). Where the width of this plateau does not exceed 10—15 versts, it is traversed by the highway to Graivoron.

Barbot de Marni gives the geological structure of this territory at the village of Bolkhovets as follows:

1.	Loess	8.00 m
2.	Light-greenish sands	1.80 m
3.	White sands	0.75 m
4.	Ocherous-yellow sands	1.70 m
5.	Greenish-gray sandstone	0.75 m
6.	The same sandstone, looser	1.00 m
7.	Chalk, down to the foot of the gully	

At Bolkhovets, sandstones Nos. 5 and 6 are somewhat argillaceous, finely granular, and in some places slightly calcareous; "minute spangles of silvery mica are scattered over the greenish-gray background[1]; yellow-brown spots and concentric patterns, often with a cylindrical hole at their center, also occur"; he also mentions that the same sandstone in the Barkhatnyi gully (approximately 6 versts NNE of Bolkhovets) is already medium-granular, and contains in addition to the above-described features, "beds of bluish-gray hornfels concretion."[2]

This sandstone (siliceous clay, tripoli-like marl according to Blede) occupies vast territories in the Ukraine, "possibly stretching from the Dnieper to the Volga."[3] Obviously, its effect on the nature of local soils is considerable.

The loess mentioned by Barbot de Marni reached such thicknesses in the lowest margins of the plateau (Bolkhovets itself is in such a margin); on the divide itself it is much thinner and sometimes disappears completely. The soils seem to lie directly over weathered bedrock, i.e., on yellowish-red light-textured loam or sandy loam.

The descent into the Vorskla valley begins approximately 2 versts before Tamarovka; soils are very glei-like where the large village is located.

I sampled the following soils between Belgorod and Tamarovka (Belgorod District):

1. Ten versts beyond Belgorod, halfway up a barely perceptible slope in one of the highest portions of the plateau; 15 — 20 years ago, this area was a feathergrass steppe; the soil thickness is 1 ft 6 in [46 cm] and it contains 6.047% humus.

2. Two versts westward, under the same conditions in a perfectly level plowland. The soil thickness is 1 ft 11 in [58 cm], and it contains 4.231% humus.

3. Two or three versts before Tamarovka, on the slope of the plateau towards the Vorskla, on a level pasture; the thickness of chernozem is 2 feet [61 cm] and it contains 5.46% humus.

All these samples appeared to be typical chernozem in the field; however, upon drying and comminution their color became analogous to the color I indicated on the schematic map.

For the 40 — 50 versts between Tamarovka and Graivoron, the highway runs along the low left bank of the Vorskla 1 — 2 versts from the river until Borisovka, and then 2 — 4 versts away. Over the entire route, the structure of the Vorskla valley and its vicinity conformed to the type which I studied in great detail near Graivoron, Borisovka, and Tamarovka.

The most distinctive part of the territory is the rising right bank of the Vorskla. It forms a transition to dry rolling steppe away from the river; the steppe is covered by typical normal chernozem in some places. However, the chernozem becomes progressively thinner toward the bluff, and chernozem patches alternate more and more frequently with outcrops of the bedrock which constitutes the entire bluff. These abnormal soils on the right bank of the Vorskla retain numerous minor forests with deciduous trees, often visible on the bluffs as well. The bluffs sometimes contain small

[1] Barbot de Marni. Geologicheskie issledovaniya ot Korska do Taganroga (Geological Investigation from Kursk to Taganrog), pp. 301 — 303. The silver spangles occurring in the Belgorod soils probably originated in this sandstone.

[2] and [3] Ibid., pp. 301 — 303.

accumulations of deposited chernozem on small terraces and depressions, the chernozem being mixed with the bedrock pebbles.

The highway from Tamarovka to Borisovka runs along the exact boundary between the Vorskla floodplain and the gentle left slope of the river, although it retreats southwest considerably between Borisovka and Graivoron.

The Vorskla floodplain is boggy in certain places, more rarely sandy and abundant in small oxbow lakes. Its gentle, broad left slope equals the height of the right bank only at 5—10 versts from the river, by visual estimation. Along nearly the entire route, ruts and excavations disclosed sandy-loamy darkish-gray chernozem 2—3 feet [61—91 cm] in thickness. A sample I took 1 verst west of Borisovka contained 3.864% humus; this is certainly the case in regard to other soils, except for an area approximately 5 versts southwest of Tamarovka, and in the vicinity of Golovkino, where the soils are extremely sandier and lighter in color than the Borisovka samples.[1]

Man-made mounds are fairly common along the route. Some of them are at the very roadside, near the river; a road may have passed this way in ancient times as well. Other mounds are visible on the left, on heights amidst cornfields; owing to their location they may have served as vantage points.[2]

One of the largest mounds was halved completely, to ease the traffic from Tamarovka to Borisovka. The section thus created made it clear that the mound consisted of excavated homogeneous chernozem; no traces of depressions around this mound are seen. It was therefore impossible to identify any normal soil on such chernozem mounds.

The steppe between Graivoron and Bogodukhov is flat, with no "balkas", water bodies, villages, or forests. The only variety is lent the landscape by low mounds occurring exclusively at summits of the steppe undulations. The mounds are distributed so that several are visible from the top of each one.

The soils appear to be most typical chernozem. Samples which I took 3 versts south of Graivoron and 20 versts further southward revealed a thickness of 2 ft 6 in — 3 ft [76 — 91 cm], and humus contents of 7.585 and 6.591%, respectively. Not even a trace of a boundary is visible between the different chernozem soils indicated for this territory by Chaslavskii.

The fallow fields appear identical to those described above. No traces of the previous year's stubble are seen on such fallow.

Approximately 3—4 versts before Bogodukhov the steppe descends toward the valley of the Merla River; Bogodukhov is situated on the northern slope of this valley. The terrain becomes progressively more hilly and traces of overgrowing by an old oak forest, now almost completely cut down, are visible.

While ascending again into the neighboring steppe, traversed by the highway to Akhtyrka, oak forest 1/2—1 verst wide was seen on the high right bank of the Merla; similar minor forests are also encountered approximately

[1] On the territory between Belgorod and Graivoron, fallow fields (local name, "potolska") were covered by a mass of thistles reaching up to 1 1/2 arshins [1.1 m]. The thistles were almost the sole vegetation with undergrowth of low grasses appearing in places between the stalks. I recall no such scene in nonchernozem Russia.

[2] The gently sloping left side of the Vorskla must have been bare of forests at that time, to make such lookout points useful. Author.

10 versts west of Bogodukhov. The soil in all these localities is gray, its thickness is 1/2 — 1 ft [15 — 30 cm]. It is underlain by atypical sandy loess. The terrain from this point up to Akhtyrka is a dry, slightly and broadly undulating steppe, similar to that on the Vorskla — Merla divide.

I took a sample at the 8th verst west of Bogodukhov, 3 ft 2 in [96 cm] thick and containing 6.425% humus. 15 — 20 versts from Bogodukhov hundreds of artificial mounds and embankments appear. Some of them undoubtedly served as fortifications, as evident from their shape: most are situated on ridges and served as vantage points. They are probably considerably more recent than the "balkas", since they are located on local water divides.

The territory between Akhtyrka and Zen'kov is relatively abundant in forests. The first 12 versts of the highway largely traverse a sandy lowland, with rare bogs. This lowland apparently forms part of the Vorskla floodplain which abounds in oxbow lakes at this point. At approximately the 13th verst the road ascends to a very hilly terrain which stretches up to Zen'kov. From the outset of the rise, the terrain on either side is completely forested. Beyond this forested territory, at the 14th verst, I took a soil sample on a level fallow field in the Lebedin District; the soil is 3 feet [91 cm] thick and contains 3.024% organic substances. Similar chernozem and a subsoil of atypical sandy, light-yellow loess continue up to Zen'kov. At the Kachenovskaya station I took a soil sample in a small oak wood; this soil is 2 ft 9 in [84 cm] thick and contains 5.709% organic substances. For the first 5 — 6 versts northwest from Zen'kov, toward Gadyach, the terrain is relatively very hilly and includes rare minor woods. This is again followed by typical dry steppe with abundant thistles. Only at approximately 2 versts from the Masyukovskaya station does the high steppe form a gradual transition to low steppe, which may form the gentle low slope toward the Veprik River. The terrain descends, step-like, approximately 7 versts beyond Masyukovskaya station, and the sand content of the soil increases visibly.

The soils en route are represented by a sample which I took 7 versts northwest of Zen'kov; its color is darkish-gray, thickness approximately 2 ft 6 in [76 cm], and humus content 3.024%. Moreover, Mr. Filip'ev supplied me with a sample of darkish-gray chernozem, 4 feet [1.2 m] thick and with 3.83% humus, taken from an estate on the Veprik. The territory lying between the last step and the Psel River consists in its first half of deep loose quartz sand overgrown by old mixed forest and in its second half contains the Psel floodplain, partly sandy and partly boggy. Of this forest, 1717 dessiatines are the property of the Veprik Company. "In the remote past the predominant species was probably Scotch pine (*Pinus silvestris*) but very little has been preserved. The predominant species today in the Veprik forest are oak (*Quercus robur* and *Q. pedunculata*), birch (*Betula alba*), aspen (*Populus tremula*) and occasionally elm (*Ulmus campestris*) and linden (*Tilia parvifolia*); the most common shrubs are blackthorn (*Prunus spinosa*), alder buckthorn (*Rhamnus frangula*) and spindletree (*Evonymus vulgaris*). At present, the low-standing oaks are being cut down and gradually, quite successfully, replaced thanks to artificial afforestation by high-standing pine. The soil under forests is usually clayey-sandy or sandy and rarely chernozem; however, the sand sometimes thickly covers a layer of chernozem which is the predominant soil on the fields along Veprik."[1]

Gadyach is on the high, bluffy right banks of the Psel and Grun rivers, which appear similar to all high right river banks in the Poltava Province; in this case, however, it is not overgrown by forest. In the course of the steep climb from the Psel valley to the town, the bank is clearly seen to consist very largely of various sandy rocks, covered by a blanket of atypical sandy loess; the thickness of chernozem reaches 3 feet [91 cm]. A sample which I took 4 versts north of Gadyach contained 3.495% organic substances. The territory from Gadyach via Romny to Bakhmach is an extremely monotonous steppe, bare, dry, level as far as Romny and abounding in minor woods along the right bank of the Romen River and also, to a certain extent, up to Bakhmach, where small groves occur north of Dmitrievka on level areas. The Khorol and Sula rivers, which I crossed, respectively, at Lipovaya Dolina and at Romny, conform in structure to the general river type of the Poltava Province; the bluffs of their banks display very sandy loess throughout. The soils en route are identical to the following two samples which I took:

1. 15 versts south of Romny, on level fallow, A + B = 2 ft 6 in [76 cm], with 5.450% humus.

2. Bakhmach, old level fallow, A + B = 3 ft 3 in [99 cm], with 2.80% humus. All the mounds encountered are situated on steppe ridges, and some are surrounded by forests. This circumstance may point to the relative youth of the arboreal vegetation.

Average humus content in all 26 samples may be taken as approximately 5%[2]; average thickness of soils (28 samples) is 2 ft 7 in [79 cm].

The following results are obtained by subdividing all the soils according to Chaslavskii's map: for rich chernozem (10 samples) average humus content 5.85%, maximum content (south of Graivoron) 7.58%, minimum content (Borisovka) 3.86%, average thickness (9 samples) 2 ft 5 in [74 cm]; for ordinary chernozem, average humus content (7 samples) is 5.56%, maximum (Pesochino) 8.78%, minimum (Ekaterinoslav) 3.21%, average thickness (10 samples) 3 ft 2 in [96 cm]; for sandy-loamy chernozem (9 samples) average humus content 4.30%, maximum (Kachenovskaya) 5.70%, minimum (Kurilekhovskaya) 2.86%, average thickness (9 samples) 2 feet [61 cm].

The previous conclusions (p. 170) as regards the general character of soils in this territory may thus be assumed valid, and the present subdivisions of local soils must be completely abandoned, temporarily.[3]

[1] Filip'ev. Iz Gadyachskogo uezda Poltavskoi gubernii (Gadyach District of the Poltava Province), pp. 58–59.

[2] This result will be modified upon additional analyses, but the variation will certainly not exceed the limits of 4–6%.

[3] I say "temporarily" since future chemical analyses will certainly establish the existence of several types in local soils as well. The local indexes which form the basis of Chaslavskii's work may be relatively correct, but any evaluation must take the following circumstances into account: 1) local inhabitants always refer to extremely limited areas and their scale of comparison is very small; an observer familiar with soils of the Oboyan and Belgorod districts on the one hand and with soils along the northern chernozem boundary (Chernigov Province) on the other hand will regard the former as rich chernozem; 2) the term "rich chernozem" may be assigned to soil on the basis of its fertility, which is well known to depend on much more than natural properties of soil alone. Author.

The predominant colors of this soil conform with the colors indicated on the schematic map.

To complete the examination of this area, analyses by Schmidt are given below of Pesochino soil (Khar'kov) and Belgorod soil; the first sample may be considered typical of loamy soils on the left bank of the Dnieper while the second may be regarded as typical of sandy loams.

B. RIGHT BANK OF THE DNIEPER AND BASINS OF THE SOUTHERN BUG AND DNIESTER RIVERS

This region includes the southern larger part of the Kiev and the Podolia provinces, the western half of the Ekaterinoslav Province and all of the Bessarabia and Kherson provinces. Chaslavskii states that the region has

Locality	Village of Pesochino, near Khar'kov			Belgorod, Kursk Province, pasture			
No.	5	6	7	8	9	10	11
Sampling depth	up to 8" [20 cm]	1–3' [30–91 cm]	below 3'2" [96 cm]	up to 5" [13 cm]	5–11" [13–28 cm]	2–4" [61–122 cm]	2 sazhens [4.3 m] (white chalk)
Hygroscopic water lost at 100°C by 100 parts of air-dry soil	6.88	6.19	7.72	3.81	2.80	4.91	0.31
	Total contents of 100 parts of soil dried at 100°C (total constituents soluble in HCl and HF + quartz sand insoluble in HF)						
Hygroscopic water lost at 100–150°C	0.800	0.635	0.522	0.575	0.263	0.632	0.080
Organic substances (humus) together with zeolite water	11.905	4.151	4.034	6.527	3.412	2.638	0.518
Mineral constituents	87.295	95.214	95.444	92.898	96.325	96.730	99.402
K_2O	2.276	2.547	2.258	1.367	1.260	1.405	0.093
Na_2O	0.782	0.663	0.863	0.349	0.275	0.230	0.043
CaO	1.206	0.931	0.910	0.676	0.599	1.334	54.525
MgO	1.172	1.450	1.181	0.488	0.597	0.818	0.158
Mn_2O_3	0.104	0.122	0.021	0.088	0.022	0.048	0.020
Fe_2O_3	3.085	3.996	4.911	1.746	1.620	3.059	0.112
Al_2O_3	10.996	12.336	14.670	5.654	4.923	5.671	0.402
CO_2	0.029	0.016	0.006	0.014	0.045	0.014	42.675
P_2O_5	0.171	0.118	0.104	0.118	0.088	0.114	0.052
SO_3	0.003	0.002	0.003	0.003	0.003	0.002	0.001
$NaCl$	0.003	0.003	0.003	0.004	0.004	0.002	0.002
a) Silicic acid = αSiO_2	9.197	14.158	19.231	5.997	8.374	13.862	0.561
b) Silicic acid = βSiO_2	43.842	46.806	35.875	38.334	45.675	65.303	0.758
Quartz sand insoluble in HF	14.429	12.066	15.408	38.060	32.840	4.868	—
$CaCO_3$	0.066	0.036	0.014	0.032	0.102	0.032	96.987
$Ca_3P_2O_8$	0.373	0.258	0.227	0.258	0.192	0.249	0.114
CaO (residue combined with SiO_2 and humic acid	0.967	0.771	0.779	0.518	0.438	1.131	0.151
Nitrogen	0.467	0.059	0.051	0.188	0.094	0.047	0.010

a remarkable variety of soils, and he used 24 out of the 32 soil symbols in the part of chernozem Russia beyond the Dnieper. Seven soils predominate:

(a) Rich chernozem occupies the center of the region, mainly Elisavetgrad, Zvenigorod, Uman, Anan'ev, Balta, Ol'gopol, Ushitsa, Kamenets-Podol'sk, Khotin, and other districts. This is an irregular belt, widening slightly from east to west, where rich chernozem is in some places replaced by (b) clayey chernozem. This is especially widespread in the Vinnitsa, Letichev, Litin, and Proskurov districts, and also forms a narrow strip along the left bank in the upper reaches of the Dniester River. Both to the north and to the south, the rich and clayey chernozems are supplanted in some places by (c) ordinary chernozem and in other places by (d) sandy-loamy—loamy chernozem. These are in turn replaced (further north and south) first by (e) gray soils and then (f) northern loams and (g) sands. This general pattern becomes intermixed in places.

Chaslavskii's scheme[1] of soils in southwestern Russia beyond the Dnieper was partly based on work done by cadastral groups and descriptions given by officers of the General Staff, partly on maps compiled by the offices of local government estates, and mainly on "information collected by the expedition for the investigation of corn production and trade in Russia." The latter data are recent and seem the most detailed, and we shall therefore dwell exclusively on them.

The Kiev Province[2] may be subdivided into the following three belts, in respect to soil character: a) northern, b) central and c) southern. Belt (a) is "sandy-boggy; it includes the Kiev Polesie and encompasses the larger part of the Radomysl District and the northern part of the Kiev District, almost reaching the Kiev—Zhitomir highway... The soil is sandy, especially in the northern part of the Polesie; after forests are cleared, the soil consists of gray sand which becomes depleted and gradually converted to yellow and white sand." This is an area purely northern in character.

The central (b) "sandy-loamy and loamy belt is sometimes admixed with chernozem (gray soil). Gray soils include all the gradations from sandy and clayey soils to pure chernozems, the soil becoming progressively richer southward. This belt occupies the south of the Radomysl District, the center of the Kiev District and the north of the Vasil'kov and Skvira districts. In the north it merges with the Polesie sands and in the south it forms a transition to pure chernozem." This constitutes the northern boundary of the chernozem zone.

The southern (c) "chernozem belt includes almost 10 southern districts of the Kiev Province. Chernozem is thickest in the Uman and Skvira districts (with the exception of the northernmost portion of the latter), in the Tarashcha District, and in parts of the Zvenigorod, Lipovets and Berdichev districts. The cereal crops are represented almost exclusively by wheat and hardly any rye is sown. The Uman, Zvenigorod, and Skvira districts are considered the most fertile sections of the province, covered by a nearly uniform thick layer of excellent rich chernozem." However, not all the southern part of the Kiev Province is covered by chernozem. For instance "along the Dnieper, from Kiev and further south a sandy belt

[1] Dokuchaev. Kartografiya russkikh pochv (Cartography of Russian Soils), pp. 1–57 [St. Petersburg. 1874].

[2] The description of soils in the Kiev and the Podolia provinces was made by Chaslavskii according to "Materials Collected by a Member of the Expedition for Investigation of Trade and Industry" (Materialy, sobrannye chlenom ekspeditsii dlya issledovaniya torgovli i promyshlennosti) by Prof. Yu. E. Yanson.

stretches nearly to the Kanev District. In the latter, the riverbank is covered by loamy-chernozem soil, followed by a lowland belt along the Dnieper and covered by sands and bogs, in the Cherkassy and the Chigirin districts. A sandy belt also stretches along the left bank of the Tyasmin, almost from the small town of Smela in the Cherkassy District, up to Chigirin, and another sandy belt along both banks of the Sob River in the Lipovets District, beginning in the Berdichev District and proceeding into the Podolia Province."

Podolia Province. The climate is favorable for field cultivation of melon and watermelon almost throughout the province, and of grapes and maize in certain places. The rich soil, hilly terrain, abundance of water, presence of forests, and finally, the dense population greatly enhance the agriculture of the Podolia Province.

The soil of the Podolia Province is almost entirely chernozem, either pure or admixed with sand or clay to a certain extent. Sands occur only in the Gaisin District on the banks of the Sob River, especially on its left bank; stretching away from the river, the sands form a transition to sandy loam, loam, loamy and clayey chernozem. Sands occur also in some places in the Balta District on the banks of the Kodyma and Savran rivers, and bogs—in some places along the Yagorlyk and Kodyma rivers. The province is clearly divided in two as regards soil character: the southern part includes the Balta and most of the Ol'gopol districts, and the northern part consists of the remaining ten districts.

The southern part is of steppe nature, a treeless plain suffering from lack of water and frequent droughts. The soil is mostly loose chernozem admixed with sand or loam. Crop yields on these soils are often poor in dry summers, while excellent in wet summers. Clayey, viscous chernozem also occurs in these districts.

The northern part of the province, on the other hand, is hilly, incised by rivers of varying sizes. Forests are common and the soil is a mixture of chernozem with variable amounts of clay. Crop yields are therefore better assured, and the main crop in this part of the province consists of wheat for marketing. Two main species of soils may be distinguished, the predominantly chernozem soil covering the left bank of the Bug, and the western and southwestern districts along the Dnieper, and the loamy chernozem soil on the right side of the Bug and in the center of the province. The latter soil is the mountainous, forested territory occupying the greater part of the Letichev and Litin districts, the western parts of the Vinnitsa and Bratslav districts, and the northern parts of the Novaya Ushitsa, Mogilev, and Yampol districts. It is found further along the heights through the Ol'gopol and the Balta districts, forming a progressive transition to fertile clayey and rich chernozem as the terrain flattens.

Loamy and sandy-loamy chernozem soils are also found along the Dniester in the Novaya Ushitsa, Mogilev, and Yampol districts. The soil in the rest of the province is chernozem, with a variable admixture of clay. The richest chernozem lies in a wide belt through the central portions of the Yampol, Mogilev, and Novaya Ushitsa districts, the entire Kamenets-Podol'sk District and the Proskurov District (?). The latter is covered almost entirely (?) by a rich chernozem soil and is the most fertile part of the province. In some places in the Podolia Province "belief in the richness and inexhaustibility of the soil is such that many landowners are vigorously opposed to manuring; many lease contracts include a condition that the lessee dump farmyard manure into gullies rather than spread it on the fields."

Manuring is practiced in the normal run of agriculture only in the central, less fertile part of the province.[1]

Chaslavskii himself regarded the above information as unsatisfactory, despite its relative detail. The description of soils in the Kiev, the Podolia, and the Bessarabia provinces, given above, is, of course, based on reports by the local population, and these personal observations are not supported by analyses, measurements of soil thicknesses, etc.

Despite similar shortcomings, besides a somewhat involved presentation, found in Grossul-Tolstoi's description of soils in the Kherson and Bessarabia provinces,[2] certain observations are so appropriate, typical and conformant with theoretical requirements that this work will be examined below in some detail.

In Grossul-Tolstoi's map, showing the "distribution of soils from the Prut to the Ingul", Novorossiya is divided into four pedological belts stretching from west to east, nearly parallel to the northern shore of the Black Sea.

The richest belt (IV), designated as "true chernozem belt" which produces equally good yields of "winter wheat and all spring crops" includes the northeastern corner (Elisavetgrad District and parts of the neighboring districts) of the northernmost Kherson Province. In the Bessarabia Province it occupies the Khotin and Bel'tsy districts and an adjacent strip in the Soroki District. The "true chernozem belt" extends considerably farther south in its western than in its eastern half. Grossul-Tolstoi's description of the Bessarabian portion of this belt follows.

"Nearly all lands, with the exception of small clay patches, consist of continuous rich very deep chernozem which yields excellent crops of both winter and spring cereals almost annually. The vegetation is luxuriant, and unusually vigorous. Spring begins later than on the shores of the Black Sea, and its progress is slower, affecting the ripening of fruit similarly. The southern (dry) winds and sea fogs do not reach this area, and it is therefore unaffected by these factors. The snow is generally deeper than in the south and covers the surface more or less uniformly; [winter] crops are thus rarely frozen and the soils saturated by large amounts of [springtime] moisture." The Khotin and Bel'tsy districts are therefore "the granary of Bessarabia".

All these characteristics of northern Bessarabia gradually decrease further east toward the Dnieper, and it is therefore clear why the "true chernozem belt" retreats somewhat north in this area.

[1] Dokuchaev. Kartografiya russkikh pochv (Cartography of Russian Soils), pp. 49–53 and 56. [St. Petersburg. 1874].

[2] Grossul-Tolstoi. Obozrenie rek, pochv i mestopolozheniya Novorossiiskogo kraya i Bessarabii v sel'skokhozyaistvennom otnoshenii (An Agricultural Review of the Rivers, Soils and Situation of the Novorossiya Territory and Bessarabia). — In: Sbornik statei o sel'skom khozyaistve na yuge Rossii, p. 48, [Odessa]. 1868.

The belt of sandy-loamy chernozem (III) stretches south of belt IV, directed ENE — WSW; it is 40 — 60 versts wide in the eastern half and 70 — 90 versts in the western half.[1]

In the eastern part (for instance, between the left bank of the Yagorlyk and the right bank of the Kuchurgan, between the upper reaches of the Yagorlyk and the Dniester) "a large part of the territory is covered by deep chernozem soils overlying silty clay; the latter is mainly responsible for [good] crop yields, because it retains considerable moisture even after intense and very prolonged heat spells. The soil is very fertile, and yields excellent crops of all winter and spring cereals with the exception of 'arnautka'.* Harmful climatic influences, especially aridity, rarely affect this belt fatally ...; the wilting of crops is almost unknown in this area. Grossul-Tolstoi's observations give for a period of ten years, five good crops, three middling crops, and two below middling poor."[2]

The belt seems even more typical in its western half, in the Kishinev and Orgeev districts and partly also in the Soroki District. The terrain is strongly rolling and "there is an abundance of water almost everywhere"; extensive and varied forests are very common, especially "along the large and small rivers and 'balkas'.[3] Soil composition is markedly affected by the large admixture of true forest chernozem ... The area does not suffer from the strong heat occurring in the southerly regions, the air is always quite humid, and the abrupt transitions from hot to cold weather, common in more southerly areas and even in the belt beyond the Dniester corresponding to this area, are absent. The forest belt of these parts of Bessarabia includes the most fertile soils which are, however, nonuniform. Forest glades on elevated areas are largely covered by deep, true, fairly loose chernozem; the areas adjoining rivers and 'balkas' generally consist of sandy-loamy, fairly compact chernozem; other areas, of more or less steppe character, are also covered by sandy-loamy soil with a high chernozem content."[4]

Nearer the sea, roughly south of Voznesensk (on the Bug) and Tiraspol (on the Dniester) there begins the "loamy belt (II) with a considerable admixture of chernozem" 40 — 60 versts wide; the characteristic cultivated crops are "arnautka" and "girka".* The local soils may be loamy, or sandy,[5] with a considerable admixture of lime; in some places they are low in humus, in which case good yields of "arnautka" are obtained only on virgin soil; in other places, such as at the apexes of "balkas" soils are fairly deep rich chernozem. This belt is generally somewhat more fertile than the seaboard belt (I), owing to its greater distance from the sea and its

[1] The boundary between belts IV and III consists of the ridge of sands stretching west—east and 80 — 100 versts away from the Black Sea. Grossul-Tolstoi's observations state that these sands form a boundary between the less fertile soil of the Kherson Province and the extremely fertile soil of the Podolia Province; he adds, "they seem to serve as the borderline of the shelly limestone strata, so common almost throughout the seaboard; limestones are also found nearer to the Podolia Province, but they are very deep and are entirely different in character." Ibid., p. 44.

* [Varieties of wheat. Translator.]

[2] Grossul-Tolstoi. Ibid., pp. 44 — 45.

[3] Remnants of forests are also preserved in the northern part of the [Anan]'ev and the Tiraspol districts.

[4] Grossul-Tostoi. Ibid., p. 48.

[5] Moreover, according to Yu. E. Yanson, soils of the valleys of the [Kogilnik?]eut, Kubal't and other minor rivers are solonetsous and stony. Author.

more level terrain; "many of those 'balkas' which become quite large in the seaboard belt . . ." begin here. In addition, "the vegetation is not so strongly affected by southern winds" in this belt and oak woods still exist in places. However, according to Grossul-Tolstoi, in the present circumstances these steppes are much more profitable for sheep and livestock breeding than for agriculture.[1]

The last belt (I), 20—60 versts wide, adjoins the sea. This is a "clayey-calcareous belt with a small admixture of chernozem", and is almost completely barren.[2]

Academician Ruprecht recognized the great significance of climate in soil formation on the basis of the regul... ...th-to-south distribution of soils in the Kherson and Bessarabia provinces. Grossul-Tolstoi's work also contained facts illustrating the close relationship between soils and topography extremely vividly.

The belts IV—I are not continuous; they are incised by numerous river valleys and "balkas", the environs of which are occupied by soils. Grossul-Tolstoi's observations find the distribution of these latter soils to be strictly regular. We shall first examine the principal rivers of the Kherson and Bessarabia provinces.

All these rivers—Bug, Tiligul, Bol'shoi Kuyal'nik, Srednii Kuyal'nik, Dniester, Kagal'nik, Yalpukh and Prut—flow almost due south with a slight southeastern deviation. Their right banks are of course higher and more hilly than the left banks. Right banks include masses of stones, minor oak woods and various shrubs, as well as springs. Left banks, on the other hand, are gently sloping and contain no "minor woods, or shrubs; if occurring, they are confined to peninsulas and 'plavni' formed by accumulated deposits."[3]

These features give rise to the following significant phenomena, first noted by Grossul-Tolstoi.

1. "The Danube, Dniester, Bug, Dnieper, and other rivers and 'balkas' emptying into the sea have the following feature in common: the left banks, gently sloping toward the river, are covered by generally fairly thin, dry, and loose soil from the first 1/6 of their course (from upper reaches down toward the mouth?); this soil is largely sandy-calcareous, gray or ashen in color, overlain by a thick clayey yellow stratum." This belt "begins to widen toward the river mouth, and 30—40 versts before the sea gradually merges with the clayey-calcareous soil on the right bank of the neighboring river. For instance, the strip along the left bank of the Dniester is 6 versts wide at Dubossary, 7 versts wide at Grigoriopol, 10 versts wide at Tiraspol, 15 versts wide at Mayaki, and 20 versts and wider at Ovidiopol and at the Dniester mouth. There is a similar gradual broadening of the clayey-calcareous (seaboard?) strip along the Kuyal'nitskii 'liman': 4 versts wide at Svinaya 'balka', 5 versts at the village of Dostanicha on the 'liman', 6 versts at Malakhovskoe, 10—15 versts at Kholodnye Khutora. These strips, belonging to two basins (the Dniester and the Kuyal'nik), merge about 30—40 versts before the coastal bluffs and form a single territory (belonging to belt I) covered by a sandy-calcareous and clayey-calcareous layer which

[1] Ibid., pp. 43—47.

[2] A detailed description of this belt will be given below. Author.

[3] Grossul-Tolstoi. Ibid., p. 39.

sharply differs from the so-called chernozem proper in its constituents and in its ashen color as well as its low fertility."[1]

The structure of the left bank of the Bug River where "poor soils stretch to a distance of 7—8 versts from the river in some places" is similar; the composition of these soils is identical with the soils along the Dniester.[2]

2. "The right upland banks of these major rivers also bear strips with soil quite different from that on the neighboring plains. The soil consists of poor clayey chernozem mixed with a considerable amount of lime and overlying a thick stratum of reddish loam." The width of the right-bank strip "may be taken as being one half of its left-bank counterpart. The right-bank strips also "begin from the first 1/6 of the river course, broadening toward the mouth and merging with the strip on the left bank of the neighboring river and forming a common territory of uniform soil; however, this clayey soil progressively disappears upstream, forming a transition to rich, fertile chernozem."

In Grossul-Tolstoi's opinion, "the (right) strip of soil on the bank of the Dniester runs as follows: 3 versts at Dubossary, 3 1/2 versts at Grigoriopol, 5 versts at Bendery, 7 versts at the village of Oloneshty, 8—10 versts at Akkerman, where it merges with the left-bank strip of the neighboring river (Khadzhider), forming a continuous cover of clayey-calcareous and sandy-calcareous chernozem."[3]

3. The same basic structure is observed in all the local minor rivers and "balkas", except for the following features: a) minor rivers and "balkas" debouching into the right side of a major river have higher and steeper right (southern) banks, while those minor rivers and "balkas" debouching into the left side of a major river have higher and steeper left (northern) banks; this feature also governs the distribution of minor forests and springs, etc., as seen in Kodyma and Yagorlyk; b) the strips of abnormal soils along the banks are not as wide as in the case of major rivers, although reaching 2 1/2—5 versts in width.[4]

River valleys in the Kherson and the Bessarabia provinces are of the same type as those in the Nizhni Novgorod, Poltava and other provinces.

The poor quality of soils in all these bank strips is manifest in their production of "one, rarely two rich crops over ten years, and then only of "arnautka", barley and maize; "the nearer a field to the river margin, the more uncertain are the crop yields." In order to ensure satisfactory crops, cereals near large rivers should be sown "at least 5—6 versts away from the river bank."[5]

Such phenomena obviously strongly affects the normal distribution of soils in the Novorossiya Territory, as is in fact indicated by Grossul-Tolstoi's map. Characteristically, even "hollowed bottoms of 'balkas', which might serve as excellent plowlands or hayfields thanks to their large area and rich deposited chernozem, are often covered by solonchaks in the southern half of Bessarabia, in certain places stretching from the sea along the hollows over distances of 100 and more versts."[6]

[1] Ibid., p. 40.
[2] Ibid., p. 42.
[3] Ibid., p. 43.
[4] Ibid., pp. 39 and 43.
[5] Ibid., p. 41.
[6] Ibid., p. 46.

The following table shows the present distribution of arboreal vegetation in the area lying right of the Dnieper, according to Rudzkii.[1]

Province	Total forested area, dessiatines [and hectares]	Ratio of total forested area to the entire territory of the province, %	Good-quality forest soil, dessiatines [and hectares]	Area of good-quality forest soil, dessiatines per capita [and hectares]
Kiev	1,078,123 [1,177,310]	25.3	1,013,168 [1,116,379]	0.41[1] [0.44]
Podolia . . .	460,771 [503,162]	12.0	424,511 [463,566]	0.19 [0.20]
Bessarabia .	475,591 [320,487]	11.2	263,514 [287,757]	0.15 [0.16]
Kherson . . .	90,000 [98,280]	1.4	61,729 [67,408]	0.04 [0.04]

[1] At least 2/3 of forested areas in the Kiev Province occur in the Kiev Polesie, its nonchernozem part. — Author.

Forested areas were undoubtedly more extensive in the past than today, but historical investigations cannot determine the exact extent and location of forests.[2] We believe that this problem may be solved by detailed soil and climatic investigations of the steppes, which will provide sufficient data.

I examined the chernozem belt on the right of the Dnieper twice. In 1877 I traveled from Odessa to Proskurov with side trips to Soroki and Kazatin, and in 1881 I made two trips, along the lines Fastov — Smela — Znamenka and Kremenchug — Elisavetgrad — Ol'viopol — Balta.[3]

Fastov — Smela — Znamenka — Nikolaev

The environs of Fastov are in the region of gray soils on the northern chernozem boundary. The railroad proceeds from Fastov due south to Belaya Tserkov, running 5—10 versts from the left bank of the Kamenka River, and then turns southeast up to Korsun, again 5—15 versts from the left bank of the Ros River. The terrain is almost typical steppe wherever these rivers have no left tributaries, as between Fastov and Belaya Tserkov on the one hand and the Ol'shanitsy and Mironovka stations on the other; there are no forests except for the Brannitskoe area, and chernozem is 2—3 feet [61—91 cm] thick. The country is quite different between Belaya Tserkov and Ol'shanitsy and between Mironovka and Korsun, where the

[1] Rudzkii. Ibid.

[2] The relatively abundant literature (by Neiman, Strukov, Skal'kovskii, Baer, Palimpsestov, Bogdanov-Shchurovskii, and others) on the subject of former forests in the steppes deals almost exclusively with particular facts which are controversial in most cases. Obviously, such information cannot answer general questions. Author.

[3] The last two trips were undertaken for the same purpose as the trip along the route Belgorod — Gadyach — Romny. Author.

tracks cross numerous minor streams and gullies. The terrain becomes very undulant before Korsun and sizeable minor woods are visible to the southwest en route in the basin of the Ros.[1] The chernozem is of course not the normal type, and its quality in the lowlands is higher than on the summits. However, chernozem clings in an amazing degree to fairly steep slopes, as is strikingly the case between Mironovka station and Togancha. Another characteristic feature is the commonness of krotovinas throughout the route.

The chernozem appeared very dark in the field. Man-made mounds are exclusive to heights up to Belaya Tserkov, and make their appearance only adjacent to forests from Belaya Tserkov to Mironovka. They are especially numerous in the environs of Korsun. Bogs and forests are still numerous in the lower reaches of the Ol'shanka, east of Korsun.

The terrain between Korsun and Bobrinskaya station is very hilly (especially before Vorontsovskaya) and unremarkable. Chernozem appeared to be typical on visual observation, 2 — 3 feet [61 — 91 cm] thick, sometimes even on slopes (in depressions it reached 4 feet [1.2 m]). Minor woods and man-made mounds are abundant, some also situated on hillsides and near forested areas. Near Vorontsovskaya station, a gully undermines a burial mound 1 1/2 sazhens [3.2 m] high, revealing perfectly uniform chernozem the entire height of the mound, underlain by typical sandy loess. Feather-grass is visible in some places en route, but thistles no longer predominate on fallow fields. According to local inhabitants, susliks occur occasionally.

Smela, in the vicinity of Bobrinskaya station, plays such an important part in the sugar industry of southwestern Russia that it merits detailed description.

Smela lies on the bank of the Tyasmin River, in relatively very hilly terrain. The 74 boreholes sunk on ridges and in depressions provide excellent information on the geological structure of the area. In the vast majority of cases, the bedding is as follows: 1 ft 2 in — 4 ft 8 in [35 — 141 cm] chernozem, followed by diluvial clay, sands, plastic clays, granite gravel, brown coal, granite. The only difference between structures of ridges and depressions is the total absence of coal deposits under the former.[2] I observed the local diluvium to be sandy loam, not clay, very often with large quantities of lime nodules ("zhuravchiks").

Of the individual sections described by Academician Gel'mersen, borehole No.4 at Nikolaevskaya estate on a minor river and borehole No.6 at Yablonovskii sugar refinery "likewise near a minor river" are especially interesting. Borehole No.4 revealed a 1 ft 9 in [53 cm] chernozem layer underlain by 4 ft 1 in [1.24 m] of peat, underlain in turn by blue clay. In contrast, borehole No.4 revealed chernozem covered by sand. Section No.4 is undoubtedly identical to the exposure found at Maloarkhangel'sk; the sand covering the Yablonovskii chernozem might be of alluvial origin.[3]

[1] Strukov, former agricultural inspector in southern Russia, remarked as follows: "From the town of Tarashcha to Belaya Tserkov, over 40 versts, the terrain was completely forested a few years ago; this territory has now been converted to steppe, serving as plowland and pasture."—Zhurnal Ministerstva gosudarstvennykh imushchestv. [O lesakh Novorossiiskogo kraya y Bessarabii], No.46, p.155. 1853.

[2] Gel'mersen. [Otchet... po issledovaniyu v 1869g. mestorozhdenii burogo uglya v Kievskoi i Khersonskoi guberniyakh] (Report... on the 1869 Investigation of Brown Coal Deposits in the Kiev and Kherson Provinces).—Gornyi Zhurnal, pp. 403—412, part II, No.6. 1880.

[3] According to the description given by Prof. A. V. Sovetov, sands stretch almost continuously over the first 20 versts (from the Dnieper) between Cherkassy and Smela; this is followed by a bog 30,000 dessiatines in area and later by "true chernozem of sandy nature which is the soil of the well-known Smela sugarbeet plantations." Sovetov. O chernozemnoi polose Rossii, iz putevykh zametok, 3 marta 1877 g. (Chernozem Zone of Russia, Traveller's Notes, 3 March 1877), p. 2.—Trudy VEO, Vol. 2, No. 3. 1877.

Chemical analyses of Smela soils are given below. These soils are commonly very sandy-loamy and deep, often 4 feet [1.2 m] in depth, even on perfectly level areas.

Count Bobrinskii, who made archeological excavations near Smela, found, among bones of horse, cow, pig and dog, remains of badger (Meles taxus Pall.), hamster (Cricetus frumentarius Pall.), mole rat (Spalax typhlus Pall.), hare (Lepus timidus) and suslik (Spermophilus guttatus).[1]

In 1876, there were still approximately 16,000 dessiatines of forest at Smela; however, the plans of this estate show[2] that the forested area was much more extensive in the past. Fine "bors" are preserved southeast of this area, on the sands of the Tyasmin River; these "bors" are now the extreme southern points of pine distribution in the Dnieper area.[3]

On the basis of the Samara "bors", described above, pine must have once occurred far south of the mouth of the Tyasmin, on the right side of the Dnieper.

From Bobrinskaya to Fundukleevka station, the country becomes somewhat more level, largely due to broadening of the undulations.

The soil is dark-gray throughout; its thickness ranges from 1 1/2 — 4 feet [45 — 122 cm], depending on topography. South of Fundukleevka and up to Tsybulevka the road runs almost exclusively along depressions between slopes of the Aleksandrovsk type, along the upper reaches of the Tyasmin River. In the first third of the route, the road passes through loose white quartz sands, nearly colorless, due to absence of humus; these sands appear in the adjacent heights and the small floodplain. Toward Tsybulevka, the sand becomes visibly more clayey, and the soils are accordingly darker, reaching 2 feet [61 cm] in thickness in certain places. From Tsybulevka through Bogdanovka and up to Znamenka the terrain becomes even more level and large areas of forest on good-quality forest soil occur, especially east of the road.[4]

Znamenka is in a forest clearing. Chernozem, reaching 2 — 3 feet [61 — 91 cm] in thickness alternates closely with forest soils 1 — 1 1/2 feet [30 — 45 cm] thick.[5] The subsoil almost everywhere is typical sandy loess.

Mr. Kytmanov, who accompanied me in the 1881 excursion, traveled by rail from Znamenka to Nikolaev. He wrote me that up to Sharovka station

[1] Identification was made by Mr. Nikol'skii. There are many man-made mounds near Smela, some overgrown by forests.

[2] Gel'mersen. Ibid., p. 419. The strong rate of deforestation in the region of sugarbeet cultivation is obvious, from the following facts reported by Palimpsestov (Ibid., p. 23): 8000 dessiatines of forest were denuded on an estate, 15 years after a sugar refinery was established!

[3] Rudzkii. Ibid., p. 177.

[4] In 1784, Güldenstädt, who visited, inter alia, the Aleksandrovsk and Bobrinets District and part of the Anan'ev District, saw construction timber forests of oak, maple, ash, elm, hornbeam, etc., along the rivers in these districts, for instance along the Tsybul'nik, Tyasmin, Ingulets, etc. The forests along the Tsybulnik extended along several versts. In Güldenstädt's time, the renowned Chut forest (in the upper reaches of the Ingulets and Chut, in the vicinity of Tsybulevka station) was 12 versts long and 8 versts wide. Palimpsestov. Ibid., p. 27.

[5] Local inhabitants report that manured fields are quite frequent from Fastov approximately up to Fundukleevka, and extremely rare further south. Even between Fastov and Fundukleevka the crops produced by sands and poorly cultivated, unmanured peasants' fields are as good as those yielded by excellent chernozem, with favorable climatic conditions. Local reports stressed that in favorable years corn crops on manured fields are poor because of lodging. These facts may indicate that the local soils are very far from depleted. Author.

(Aleksandriya District) the country is slightly rolling with occasional small minor woods; from Sharovka station to Nikolaev the terrain is a typical steppe; from Shcherbina station the soils begin to assume a strong chestnut-brown tinge.

We took the following soil samples in the territory between Fastov and Nikolaev.

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Fastov	Level field at the roadside	1'8" [50 cm]	2.683	1.830
Belaya Tserkov, Vasil'kov District	Level pasture	2'11" [89 cm]	3.514	1.901
Korsun, Kanev District	—	2'11" [89 cm]	4.372	2.209
Smela, Cherkassy District	In the middle of barely perceptible slope, old fallow	4'2" [127 cm]	2.336	1.501
Bobrinskaya station, at the railway station	Level plowland	3'11" [119 cm]	2.809	1.632
Znamenka, Aleksandriya District	Level plowland	2'9" [84 cm]	5.816	3.272
Znamenka	Oak wood, level site[1]	1'5" [43 cm]	1.870	1.523
Novyi Bug, Kherson District	Level pasture	?	5.756	4.640
Dobroe, Kherson District	—	—	6.274	4.463
Gorokhovka, Kherson District	—	—	3.222	3.320
Nikolaev	—	—	4.921	4.463

[1] Here, as everywhere, the forest soils display the following distinct horizons: forest litter on the surface, 1—2 inches [2.5—5 cm] thick, followed by fairly loose dark-brown earth 4—5 inches [10—13 cm] thick, underlain by earth of nuciform structure (10—11 inches [25—28 cm]), finally followed by very typical loess.

I could not distinguish the soil characteristics marked by Chaslavskii as occurring along this route; they seem nonexistent.

Kremenchug—Protopopovka—Znamenka—Elisavetgrad—Ol'viopol—Tomashevka—Sofievka—Balta

I stopped at all these points en route from the Dnieper to Balta; the territory is a dry, almost treeless, high steppe.

The comparatively low humus content (2.67%) in the soil of the Kryukov settlement has been mentioned. I attributed this fact to the influence of the Dnieper River, and decided to cross the water divide Dnieper—Bug and Bug—Dniester in 1881.

The country between Kryukov and Protopopovskaya is of the Aleksandrovsk type; from Aleksandrovsk toward Znamenka it becomes appreciably more level and forested. The field soils appeared fairly typical chernozem, reaching 2 ft 6 in [76 cm] in thickness and more at Protopopovskaya. I took a sample which, upon drying, proved to be gray, and very sandy, containing 3.67% humus and only 1.805% hygroscopic water. Its subsoil was yellowish sandy loam with lime nodules ("zhuravchiks").

The landscape all the way to Elisavetgrad is similar.

The entry in my travel log, regarding soils between Trepovka and Elisavetgrad states: "local chernozem resembles coal when wet."

The town is in very rolling country on the banks of the Ingul. The geology of its setting has been twice described recently, by Barbot de Marni and Gel'mersen.

Gel'mersen's schematic section of this locality indicates chernozem 3 ft 6 in [1.4 m] deep underlain by "diluvial clay" 10 ft 6 in [3.2 m] thick, underlain in turn by a series of sands probably belonging to the brown coal formation.[1] Identical geological relationships are also observed 22 versts from Elisavetgrad, on Shishkov's estate, with the difference that diluvial clay is here admixed with fine sand and flakes of white mica.[2]

Five versts from Elisavetgrad, en route to Ekaterinovka, Academician Gel'mersen observed the following characteristic exposure: a) "chernozem, b) brown sandy diluvial clay, c) and d) loose sandstone, white-yellow and greenish." The lower layers of diluvial clay contain large grains of yellow and brown quartz, rounded fragments of ferruginous sandstone reaching 6 inches [15 cm] in diameter. In the same layers, Gel'mersen collected remains of present-day mammal species, namely the following: mandible of marmot (Arctomys bobac) and mandible of a very large marmot (Cricetus vulgaris).[3] In the Elisavetgrad diluvium (as at Taganrog, Mariupol and Berdyansk) Academician Gel'mersen observed "calcareous fragments and concretions"; Rozenbladt's analysis gives their composition as follows (percentages):

Silica	5.32
Alumina	1.24
Ferric oxide	1.19
Calcium carbonate	84.77
Magnesium carbonate	6.36
K_2O	0.92
Na_2O	0.09
Organic substance and sulfuric acid	0.11[1]

[1] Gel'mersen. Ibid., p. 418.

In the Elisavetgrad diluvium, sections in clay pits "reveal tortuous underground channels with smooth sides, reaching 10 feet [3 m] and more

[1] and [2] Gel'mersen.—Gornyi Zhurnal, No. 6, pp. 413—415 and 417. 1870.
[3] Ibid., p. 417.

in depth and ramified (see Gel'mersen's diagram); their maximum diameter is about 6 inches [15 cm], and they narrow going down; some of them are circular in cross section. These channels are filled with a dark-gray substance consisting of clay and chernozem and containing plant fiber."[1] The author raises the possibility that these are burrows of steppe rodents; however, burrows do not narrow going down but rather widen, culminating in spacious breeding chambers and food stores. Exits of rodent burrows are surrounded by the familiar mounds of clay formed in the course of burrowing. No such mounds are visible in this case.

On the other hand, the outlines of the channel are very reminiscent of the appearance and dimension of tree roots, which is suggestive of past forests, their sole traces now underground. This phenomenon is significant even if proved to be fossil rodent burrows.

It is, however, impossible to agree with Academician Gel'mersen's above interpretations of the channels, for the following reasons. a) Whether root channels or rodent burrows, they appear in transverse or oblique sections, never in longitudinal sections, since neither roots nor rodents penetrate the soil vertically or on the same plane, as shown in Gel'mersen's drawing. The channels cannot be said to narrow "downward". b) The familiar mounds thrown up by burrowing susliks are found only in the vicinity of fresh, inhabited, or recently abandoned rodent burrows. In the course of time, the material composing these mounds is washed by the water back into the burrows, thus providing substances for krotovinas. c) I inspected hundreds of such channels in the vicinity of Elisavetgrad and found no "plant fibers". The "smooth sides" of these channels are obviously more natural to burrows than to root channels. The type of the Elisavetgrad krotovinas will be described below, in regard to the village of Tomashevka.

Elisavetgrad soils are sandy loams, often reaching 5 feet [1.5 m] in thickness. I took a sample 1/2 verst from the railroad station on perfectly level long-fallow land, 4 ft 8 in [1.4 m] thick and containing approximately 4% humus.[2] The subsoil is sandy-loamy loess throughout with $CaCO_3$ concretions.

The geology of the Ingul — Bug water divide between Elisavetgrad and Ol'viopol is given by Barbot de Marni; this is essentially the same structure as at Elisavetgrad. The entire territory is slightly rolling, treeless, typical steppe. In certain cases, such as railroad excavations, dark-gray chernozem reaches 2 — 3 feet [61 — 91 cm] in thickness.

I decided to make a side trip from Ol'viopol to the Uman District, in the center of the rich chernozem indicated by Chaslavskii, for investigation of this soil.

I travelled northwest from Ol'viopol to Tomashevka, Uman District. The road first rises, for 2 — 3 versts, from the right bank of the Sinyukha River (a tributary of the Bug). It later traverses a slightly rolling high treeless steppe stretching through Golovonevsk (Balta District) to Tomashevka; 2 or 3 minor forests occur along the way ... The soils throughout appear typical chernozems, except for the forests. I took the samples tabulated on the following page on this route.

The village of Tomashevka, which is the property of Baron Meiendorf, is in the Uman District, approximately 10 — 12 versts southwest of Uman.

[1] Ibid., pp. 420 — 421.

[2] A complete analysis of this sample is given below.

The terrain is nearly level in a radius of approximately 5 versts around the village. Small old woods and huge lone oaks are occasionally visible in parks. Pine and spruce artificially planted in chernozem exhibit excellent growth.

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Approximately 1 1/2 versts NW of Ol'viopol	Pasture in the lower third of the slope descending toward the Sinyukha River	3'4" [101 cm]	5.437	4.253
25 versts NW of Ol'viopol, before Pushkova, Balta District	Level long-fallow land	2'11" [89 cm]	6.102	5.285
Golovonevsk, Balta District	Level plowland	2'6" [76 cm]	3.887	3.409

I made the following soil observations very near Tomashevka:

1. On an old boundary of Baron Meiendorf's lands A + B = 4 ft 6 in [1.4 m]; parent rock is typical loess, abundant in calcareous veinlets and nodules ("zhuravchiks"); the humus content is 5.035%, its hygroscopic water content is 3.116%.

2. Approximately 2—3 versts east of Tomashevka on a perfectly level site, amidst oak forest.

The thin forest litter 1 or 2 inches [2.5—5 cm] thick is succeeded by horizon A, bluish-dark, fairly loose wet soil, 5 inches [13 cm] thick, then followed by B, whitish earth of nuciform structure (common in forests) which disintegrates into fairly angular crumbs of pea size. Subsoil C is ordinary loess.

3. A so-called solonchak occurs approximately 3 versts northeast of Tomashevka at the village of Gromy. The area is slightly tussocky, now completely dry and used as a pasture; I believe it to have been forested in the past. The soil is ash-gray, 8—12 inches [20—30 cm] thick; its humus content is about 5%. A complete analysis is given below.

4. Finally, in Tomashevka itself, a cellar 9 feet [2.8 m] deep was dug on a perfectly level site. Baron Meiendorf drew a portion of a wall (completely fresh), presented in Figure 7.

As shown in the figure, a very dense sod, 2 inches [5 cm] thick, is directly underlain by a nearly completely homogeneous dark-gray soil horizon, A, 2 1/2 feet [76 cm] thick, followed by the transition horizon, B, 1 1/2 feet [45 cm] thick. These horizons are underlain by typical light-yellow loess, C, with a carbonate content reaching 10%. The transitions between all these horizons are so gradual that the boundaries of the horizons are impossible to distinguish. This is a perfectly normal case of Russian chernozem structure.[1]

[1] The drawing of normal Russian chernozem structure presented above [see "Kartografiya..." (Cartography...)] is much more schematic than Figure 7. Moreover, it represents chernozem with no krotovinas.

FIGURE 7. A- Homogeneous dark-gray soil horizon reaching 2 1/2 feet [76 cm] in thickness; B- transition horizon 1 1/2 feet [45 cm] thick; C- light-yellow loess.

Figure 7 shows the entire section to be permeated by krotovinas varying in appearance, except for the upper horizon.

The majority of the krotovinas are rounded or oval, although very often no definite shape could be distinguished since the krotovinas make an imperceptible transition to the surrounding soil.

The dimensions of krotovinas (which I measured in situ) are far from uniform. The following large and small diameters are the most common ones: 3 and 4 inches [8 and 10 cm], 3 and 6 inches [8 and 15 cm], 3 and 6 1/2 inches [8 and 16 cm], 3 and 7 inches [8 and 18 cm], 2 1/2 and 8 inches [6 and 20 cm], 8 inches and 1 ft 5 in [20 and 43 cm], 5 inches and 1 ft 8 in. [13 and 50 cm], 5 and 10 inches [13 and 25 cm], 5 and 5 inches [13 and 13 cm], 3 and 3 inches [7.6 and 7.6 cm], etc.

Krotovinas are seen to retain their dimensions to a depth of 9 feet [2.7 m]. Taking their abundance at this depth into account, the channels may be assumed to go deeper than 9 feet [2.7 m].

The contents of krotovinas are just as varied. Some (I) are filled by the same chernozem which forms horizon A; others (II) contain the typical loess forming horizon C; yet others (III) are filled with material from horizon B, a mixture of chernozem and loess. The latter are the most common.

FIGURE 7. A- Homogeneous dark-gray soil horizon reaching 2 1/2 feet [76 cm] in thickness; B- transition horizon 1 1/2 feet [45 cm] thick; C- light-yellow loess.

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Obviously, krotovinas of type I occurring in horizon A and those of type III occurring in horizon C may be distinguished only by a very painstaking examination and then only if unusually well preserved; in the overwhelming majority of cases they are indistinguishable from the surrounding soil. Otherwise, the effect is very vivid, with rounded light-yellow patches of loess strongly marked on the background of solid chernozem (A).

At Tomashevka, as in a hundred other localities in the chernozem zone, type IV krotovina content is very common. Many sections displayed vivid $CaCO_3$ efflorescences on the sides of certain channels, usually in the form of a very fine reticulate film, sometimes in the form of a solid cover 1 or 2 "liniyas" [2.5—5 mm] thick, followed by a different filler (most frequently chernozem, sometimes mixed with loess). However, the entire krotovina is often filled mainly by $CaCO_3$, and chernozem is only an insignificant admixture.

Obviously, the krotovinas remained unfilled over the considerable period between formation of the walls and the penetration of extraneous substances. The significance of this circumstance will be discussed below.[1]

Contents of well-preserved krotovinas, especially if coated with $CaCO_3$, may be extracted quite easily, sausage-like. If the krotovina walls were already in poor condition by the time the cavity became filled with extraneous matter, the krotovina merges almost completely with the surrounding loess and may easily be mistaken for the remainder of little-altered parent rock (see horizon B), especially if the krotovina is filled with loess or a brownish mixture of loess with lightly-tinged chernozem.

No arboreal residues were noticed in the course of very careful examinations of "sausage" structure. Kipriyanov and Levakovskii, who examined thousands of such channels,[2] found no residues of this sort.

Our section shows transition horizon B, and especially the subsoil, C, to be permeated by a mass of tubular channels 1/2—3 "liniyas" [1—8 mm] in diameter.[3] The diameter sometimes remained constant over 6 inches [15 cm].[4] Some of these channels may have been created by worms, others by different larvae, yet the majority are definitely root channels of herbaceous plants. Traces of these are still discernible in certain places on the tubule walls. They are usually filled by chernozem with $CaCO_3$ segregations,

[1] The $CaCO_3$ segregations provide clear indication of the process of soil depletion and other surface formations in carbonates, still in process.

[2] As far as I know, Prof. Levakovskii was the first to remark upon the scientific significance of krotovinas (Levakovskii, ibid., p. 13, etc.). According to his description, "krotovinas are deep burrows, 2—3 vershoks [9 - 13 cm] in diameter, circular in cross section, and arching in different directions. They therefore appear as circles, ellipses, and other shapes in exposures giving sections in different planes. Krotovinas are found only (?) in subsoil, usually of brown or yellow clay, and in other localities with greenish-gray clayey sand. They are filled with chernozem, which is so dark despite its admixture with surrounding rock that the krotovinas are sharply distinguished against the lighter tone of the subsoil surface. The mass filling the krotovinas forms cauldron-shaped units the internal, i.e., concave, surface of which is often covered by friable, pulverulent $CaCO_3$. The krotovinas are randomly distributed over chernozem territory; in some places all exposures of alluvial clay contain krotovinas, while they may be very rare in others. I often observed this irregularity, which Prof. Levakovskii attributed to the irregular distribution of burrowing animals in the past as well as at present.

[3] Indistinguishable in chernozem.

[4] Longitudinal sections of these channels, obviously, are visible only at close quarters. Author.

which often completely fill the channels.[1] Obviously, loess-containing channels are indiscernible. Traces of channels commonly appear in a section in the form of black specks. I counted as much as 60 specks over 1 sq. ft [0.1 m²], but their number was usually smaller.

I proceeded northeast from Tomashevka to Yagubets, an estate belonging to Countess Golitsina. The soils are identical. Approximately 7 versts before Yagubets, I traversed a small oak wood, of sparse growth, with soils identical to those found in the wood near Tomashevka.

In Yagubets itself, on the Udicha River, there is a clear gradual upward transition of gray granite to grus, which is in turn replaced by typical loess abounding in lime nodules ("zhuravchiks").

The Odai farm, where I made the following section on virgin land in perfectly level terrain, is approximately 4—5 versts west of Yagubets, on the boundary between the Uman and Gaisin districts.

A. The soil horizon, 1 ft 8 in [50 cm] thick, 5.962% humus, 4.078% hygroscopic water.

B'. Transition horizon, 1 ft 4 in [40 cm] thick, 2.878% humus, 2.548% hygroscopic water.

B. The remainder of the transition layer, 10 inches [25 cm] thick, 1.156% humus, 2.406% hygroscopic water.

C. Typical loess with abundant krotovinas.

As is known, the railroad between Ol'viopol and Balta runs along the water divide between the Tiligul and Chichiklei rivers on the one hand and the Kodyma River on the other hand, 1—10 versts south of the Kodyma. The terrain is high, dry, slightly rolling, and treeless throughout. The subsoil is represented by very typical light-yellow loess. The chernozem appears to be of the Elisavetgrad and the Tomashevka type; I halted at Sofievka (Anan'ev District) and found chernozem 3 ft 7 in [1.09 m] thick and containing 5.98% humus. Some minor forests began to appear toward Balta.

Odessa—Razdel'naya—Birzula—Kryzhopol—Proskurov [and] Digressions toward Yampol, Soroki and Kazatin

The railway line running from Odessa nearly up to Birzula traverses the deserted, completely waterless Kuyal'nik—Kuchurgan water divide. Barbot de Marni, who inspected this line during the course of construction, reported that the "rails are nowhere deeper than the [surface] deposit," which is a brown steppe clay (or loess); sometimes it is homogeneous, when known as steppe glei, and sometimes it contains limestone intergrowths known as "beloglazka" ("white eye"); the [surface] deposit reaches a thickness of 18 sazhens [38 m] in some places.[2]

The territory between Odessa and Razdel'naya, as I observed in my 1877 excursion, is typical steppe, containing susliks and feathergrass. From

[1] Microscopic analysis of similar loess deposits in the Chernigov Province was carried out by Armashevskii. Calcium carbonate was found as small rhombohedral crystals, blunt or sharp, arranged in series along the tubules; sometimes the crystals were acicular. Armashevskii. Geologicheskii ocherk Chernigovskoi gubernii (Geological Description of the Chernigov Province), p. 127.

[2] Barbot de Marni. Geologicheskii ocherk Khersonskoi gubernii (Geological description of the Kherson Province), p. 36.

Razdel'naya toward Balta, the steppe becomes appreciably more rolling, and minor forests begin to appear in the environs of Balta and Birzulovo, first in "balkas", from which isolated trees sometimes emerge onto the edges of water divides. However, farther on, toward the Popelyukha station and Kryzhopol, the forests grow on water divides, level areas, and "balkas".[1]

The hilliness and number of "balkas" progressively increases, and the terrain is most strongly incised around the last station before Kryzhopol. The majority of "balkas" are sodded. At approximately the latitude of the Zatish'e station an abrupt change (see above) occurs in the mineral nature of the underlying Tertiary rocks; limestones are replaced by sands. This change of course affected the petrographic character of "white eye". Subsoil samples of the "steppe glei" at Kolontaevka and Razdel'naya could only be obtained with the aid of an axe. On the other hand, "white eye" at Mordarovka (Barbot de Marni), Balta, and Birzula appeared to be light-yellow or "gray-yellow sandy clay" and sometimes even sandy loam. The same sandy loess appears to form the subsoil up to Kryzhopol; at any rate, those deposits which I inspected at Popelyukha and Kryzhopol were of this type.

Thus, topography, subsoil, and vegetation all varied gradually over our route, and these changes in turn affected the character of the local soils, especially since the climate of this territory is nonuniform. Unfortunately, these effects on the soils do not agree with each other, and the local chernozem is thus distributed irregularly.

Soil appearance was as follows. At Odessa soils are 1—1 1/2 feet [30—45 cm] thick, gray-chestnut; at Kolontaevka they are appreciably darker, and at Razdel'naya and Birzula they are typical chernozem, reaching a thickness of 2—3 feet [61—91 cm].

The soils again grow lighter toward Kryzhopol, in the north, and vary considerably in thickness. Some forested areas are covered by vegetal earth, brown and thin, of the type found in nonchernozem Russia. Crop failures on this territory, however, are unknown, probably owing to the favorable climate.

The samples I took en route between Odessa and Kryzhopol are described in the table on the following page.

Grossul-Tolstoi's statement on the improvement in soil quality from the Black Sea northward is thus confirmed.[2] On the other hand, the changes in the ground, topography, and—partly—vegetation described above are sufficient cause to apply his ideas in a limited fashion. This subject will be dealt with below.

I traveled from Kryzhopol to Yampol, via Ol'shanka station to gain an impression of Bessarabia. The territory is very hilly throughout, and contains different types of "balkas", sometimes huge. The Ol'shanka "balka" is the most characteristic, and was formed in several stages. The old, widest hollow is dissected by a new, narrower one, both already sodded. A fresh gully, with nearly vertical loess walls, runs through the middle of the second hollow. All these features become evident during the descent over terraces to the third "balka". The territory between

[1] From the vicinity of the Borshcha station up to Proskurov, the forested area is so extensive as to suggest that the territory was forested throughout in the past. Author.

[2] Of course, within the Novorossiya Territory.

Kryzhopol and Ol'shanka is covered by an almost continuous oak forest, while the country between Ol'shanka and Yampol is open.

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Kolontaevka	Level plowland	2' [61 cm]	5.074	6.941
Razdel'naya	Virgin steppe	2'6" [76 cm]	7.196	7.393
Birzula	Pasture in the middle of a gentle slope	2'8" [81 cm]	12.247[1]	7.930
Kryzhopol	Pasture in the middle of a slight incline	3' [91 cm]	3.457	4.914

[1] Since this is the only sample found in southwestern Russia with such a high humus content, I gravely doubt its being a normal soil, although it was taken on a fairly level area and was analyzed by two investigators with a discrepancy of 1/2%. The area may have been occupied by a village or corn-stacks, or may have served as a dungheap; the subsoil may have been rich in organic matter, etc.

The chernozem appears typical loamy chernozem over the entire route. An admixture of sand or other unaltered particles of parent rock appears only 3 – 4 versts before Yampol, thus again justifying Grossul-Tolstoi's opinion.[1] Moreover, chernozem had been washed off certain slopes and was sometimes absent under forests. It is, however, clear that many local typical chernozem fields were covered by oak forests until recently, and stumps are visible in many places.

Yampol is situated on the left, Podolian side of the rather narrow alluvial valley of the Dniester. The bluffs of the river banks reveal the entire valley to be composed of typical "lacustrine-fluvial" deposits with abundant freshwater and partly also terrestrial shells. The valley is bounded on both the north, left bank of the Dniester and the south, right Bessarabian bank by sharply delineated heights. Their southern slopes are covered on the Podolian side by luxuriant vineyards. In the lower third of a local "balka" I observed fresh sections of typical "white eye", reaching 6 sazhens [13 m] in thickness; it consisted of 2 horizons of angular pebbles of local bedrock each about 2 feet [61 cm] thick. Between these intercalations, 2 sazhens [4.3 m] below the surface I found a fragment of a mammoth tusk. This and many other local loess sections confirmed its local origin.

I made the following two measurements on the high, nearly level steppe in the environs of Yampol.

On the left upland bank of the Dniester, 1 verst north of Yampol, A + B = = 2 ft 5 in [74 cm], soil humus content 3.729%.

On the right upland bank of the Dniester, 2 versts south of Yampol, A + B = 1 ft 10 in [55 cm]. Although I took no sample of the soil at this site, its organic-substance content is low since the soil is considerably lighter than the first sample.

[1] I observed an identical phenomenon on the left bank of the Dniester between Kamenka and Khrustova. Author.

I travelled along the right bank of the Dniester from Yampol via Soroki to the estate of N.K. Erzhiu, Nepada, in the Soroki District. The steppe, which is high, dry and hilly, is covered in some places by very tall weeds, reaching a man's height. Even the partial return of this luxuriant, vigorous wild growth would richly supply the soil with organic and mineral substances. However, the soils are of the Yampol type throughout. "White eye" is present mainly along the sides of the "balkas", with outcrops of Tertiary limestone on water divides only sometimes covered by soil.

The settlement of Nepada is on the lower slopes of the right upland bank (quite gently sloping at this point) of the Dniester, and its soils are identical to those at Yampol. Beds of deposited chernozem reaching 1 sazhen [2 m] and more in thickness are visible when descending to Nepada, in gullies and road excavations. The formation of the "vegetal-terrestrial soil"—young chernozem on alluvium deposited by the Dniester—is clear in the old alluvial valley of the river.

In order to observe soils other than along riv[illegible]n Bessarabia, I traveled to Kugureshti [Cugureşti], 10—12 versts southwest of the Dniester.

An artificial section made on a level virgin area[1] approximately 4—6 versts from Nepada, revealed the following details:

A. Soil horizon interwoven by live and dead plant roots; the soil is loose and completely black, 2 feet [61 cm] thick.

B. Transition horizon with traces of krotovinas, 1 foot [30 cm] thick.

C. Typical loess with abundant lime nodules ("zhuravchiks").

My observations of 1877 found local chernozem to be very typical and I then classified it as first-class chernozem. However, on analysis it was found to contain only 5.718% humus.

The soil appeared identical up to Kugureshti; south of it there is a sizeable wood composed of oak, maple, linden, wych elm and ash, on an elevated, dry, fairly level area.

The local forest soils are also difficult to classify.

I observed no forest litter in the Kugureshti forest. The surface is yellowish-gray earth, with scattered dry leaves and twigs. The forest soil is almost identical in color with the yellowish-brown subsoil clay very rich in marl. I regarded the organic substance content as no more than 1%, and was considerably surprised when Kul'chitskii's analyses three times revealed about 9% humus. In order to confirm this result, Ogloblin reanalyzed the sample, obtaining the same numbers. Careful visual examination revealed nothing. In 1878, I found the clue to the character of the Kugureshti sample in Tetyushi forest soil; the latter contained yellowish-brown fragments of rotten wood distinguishable by the naked eye. Under a powerful magnifying glass, the Kugureshti soil was found to contain a similar abundance of minute particles of rotten wood, indistinguishable from the entire soil mass and so minute that they could not be separated from the sample before analysis.

Feathergrass grows in some places, on steep slopes, between Nepada and Kugureshti.

I traveled from Kryzhopol to Proskurov via Zhmerinka. Large areas of deciduous forest, sometimes adjoining the road and sometimes at a distance from it occur throughout. The country is fairly rolling. The soils appear progressively less typical chernozem, and in some places chernozem is replaced by "islets" of reddish-gray soils which remained unchanged

[1] The local landowner, N. K. Erzhiu, assured me that this land had not been plowed for at least 100 years.

even after rain; these soils are progressively more frequent northwestward. From Zhmerinka, these soils, 1/2—1 foot [15—30 cm] thick, are almost continuous and fairly dark soil occurs only in depressions and on the lower third of gentle slopes. The subsoil is loess throughout. Samples which I took near Zhmerinka (Vinnitsa District) on a perfectly level area and at Proskurov, at the top of a barely perceptible slope, contained, respectively, 2.822% and 3.368% humus.

This territory, however, does not suffer from crop failures; the local inhabitants therefore call their lands "rich chernozem".

The country differs in character from Zhmerinka to Kazatin. The terrain is more level, resembling the character of the Kalinovka—Golendry steppe, forests are rarer, soils darken, often reaching 2—3 feet [61—91 cm] in thickness, and the "islands" of reddish-brown soils become comparatively rare. Kazatin chernozem, as mentioned above, contains 5.157% humus.

The chemical composition of soils in southwestern Russia should be discussed for their better knowledge. Unfortunately, only the Gromovo and Elisavetgrad samples—of my entire collection—were chemically analyzed. Therefore, I am obliged to rely upon somewhat obsolete analyses.[1]

Soils of the Kiev Province

No. 12. Uman District. Second District of military* settlements[2]
[Percentages]

Hygroscopic water	3.06
Organic substances and zeolite water	8.40
SiO_2	62.16
Al_2O_3 and Fe_2O_3	15.00
CaO	2.50
MgO	0.60
K_2O and Na_2O	1.20

No. 25. Soil from the farm belonging to the Uman School of Agriculture and Horticulture. Analysis by Mr. Zalomanov[3]
[Percentages]

Dissolved by treatment with HCl (sp. gr. 1.15)		17.85
Fraction soluble in HCl	Residue	82.15
	SiO_2	0.01
	SO_3	0.09
	P_2O_5	0.19
	CO_2	0.13
	Fe_2O_3	3.89
	Al_2O_3	6.90
	CaO	1.28
	MgO	1.20
	K_2O	0.59
	Na_2O	0.19
	Organic and other substances and chemically bound water	4.38
Organic substances (C x 1.724)		3.41
$CaCO_3$		0.30

[1] However, thanks to this circumstance we may now enjoy completely objective data, and reliable general conclusions may be drawn. Author.

* [Agricultural villages settled by military units and preserving military character. Translator.]

[2] [Issledovaniya o chernozeme (Studies of Chernozem)]. – Zhurnal Ministerstva gosudarstvennykh imushchestv, part 52, p. 121. 1854.

[3] Fiziko-khimicheskie issledovaniya pochvy i podpochvy (Physico-chemical Studies of Soil and Subsoil), No. 1, p. 37, [St. Petersburg. 1879].

No. 26. The so-called solonchak at the village of Gromy, of the Uman District. Analysis by N. M. Sibirtsev[1] [Percentages]

Loss on ignition by air-dry soil	11.312
Hygroscopic water, at 100°C	2.457
Humus (calculated for soil dried at 100°C)	4.986
Nitrogen	0.255
Residue after treatment with HNO_3	85.432
Volatiles in the residue	3.112
Composition of HNO_3 extract as follows:	
CaO	0.857
MgO	0.642
K_2O	0.101
Na_2O	0.062
Al_2O_3	2.147
P_2O_5	0.192
Fe_2O_3	1.573
Mn_3O_4	0.041
SO_3	0.275
SiO_2	0.036
Total	5.926
The residue composition which remained undecomposed by HNO_3 was as follows:	
Al_2O_3 (per 100 parts of air-dry soil)	3.204
Fe_2O_3	0.914
SiO_2 (extracted with soda)	2.583
SiO_2 (extracted with soda from residue treated with H_2SO_4)	8.309
Clay SiO_2 + (Al_2O_3, Fe_2O_3)	12.427
Quartz sand	69.586
Total	99.251[2]

Podolia Province

"Podolia". Analyses by Reichardt[3] [Percentages]

Locality	First-class soils	Second-class soils	Third-class soils
Numbers	27	28	29
Sand	56.8	58.2	39.4
Clay	43.2	41.8	60.6
Hygroscopic water at 100°C	4.70	4.40	4.86
Organic substances, zeolite water, etc.	10.72	8.68	9.78
Insoluble clay and sand	57.54	75.40	70.14
SO_3	0.19	0.15	0.05
Cl	0.08	Traces	0.18
Soluble SiO_2	10.00	0.16	0.46
Na_2O	0.46	0.38	2.39
K_2O	0.37	1.00	0.56
CaO	2.16	1.61	1.77
MgO	Traces	0.88	0.23
Al_2O_3	6.10	2.69	4.17
Fe_2O_3	5.60	4.24	4.00
P_2O_5	1.66	0.15	0.23
Total	99.58	99.74	98.82

[1] The situation of this soil has been described. Analysis performed at the Mineralogical Laboratory of St. Petersburg University.

[2] Alkalis were not determined.

[3] Reichardt. Chemische Untersuchung von Tchernosiom; Jahresbericht von Peters, XVI, S. 22, etc. The author, however, did not provide accurate information on the site and conditions of sampling. Author.

Sugar beet plantations at Smela — estate of Count Bobrinskii[1]

Locality	Balaklei farm, good beetroot field, No. 8			Yablonovka farm, poor beetroot field, No. 11					Malaya Smelyanka farm (2)		Starosel'e farm	
No.	13	14	15	16	17	18	19	20	21	22	23	24
Horizon	upper arable layer	lower arable layer	subsoil	a	a'	a"	arable layer, second sample	subsoil	arable layer	subsoil	arable layer	subsoil
Depth of sampling	7—9" [18—23 cm]	9—14" [23—35 cm]	14—23" [35—58 cm]	7—9" [18—23 cm]	9—14" [23—35 cm]	14—23" [35—58 cm]	14" [35 cm]	14—24" [35—61 cm]	14" [35 cm]	14—24" [35—61 cm]	14" [35 cm]	14—24" [35—61 cm]
	Contents per 100 parts of soil dried at 100°C											
Water at 100—150°C	0.782	0.760	0.719	1.009	1,268	0,664	0.952	0.828	0.850	1.038	0.827	0.711
Humus and zeolite water	2.989	3.645	2.789	6.100	5.538	4.516	5.234	4.807	5.404	4.818	3.103	2.879
Mineral constituents	96.229	95.595	96.292	92.891	93.194	94.820	93.814	94.370	93.746	94.144	96.070	96.410
Total CaO	0.772	0.789	0.888	1.186	1.107	1.950	1.057	1.116	0.955	1.095	0.651	0.593
$CaCO_3$	0.070	0.082	0.193	0.118	0.218	1.673	0.230	0.532	0.152	0.234	0.048	0.036
Al_2O_3	8.694	7.966	8.761	9.944	9.722	10.504	9.312	9.608	10.974	10.928	10.358	9.009
Fe_2O_3	2.057	2.061	2.102	2.837	2.713	2.190	2.538	2.556	2.425	2.573	2.050	2.299
N	0.105	0.122	0.089	0.183	0.184	0.135	0.189	0.178	0.201	0.169	0.098	0.095
Water lost by 100 parts of air-dry soil at 100°C	2.914	2.824	3.399	3.623	2.929	4.545	2.443	2.605	2.971	2.912	1.679	1.726
Water content in 100 parts moist soil	37.28	37.76	39.35	41.32	40.21	43.22	35.74	36.34	37.04	38.16	30.74	32.61

[1] Analyses supplied by Prof. Schmidt in manuscript form.

No. 30. Village of Grushki, Ol'gopol District. Analyses by Mr. Babaev[1]

[Percentages]

	Dissolved by treatment with HCl (sp. gr. 1.15)	9.3
Fraction soluble in HCl	SiO_2	0.016
	SO_3	0.099
	P_2O_5	0.055
	CO_2	0.017
	Chlorine	—
	Fe_2O_3	1.690
	Al_2O_3	2.077
	Mn_2O_3	—
	CaO	1.523
	MgO	1.533
	K_2O	0.108
	Na_2O	0.010
	Organic substances and chemically bound water	1.490
Residue insoluble in HCl	Silicic acid soluble in soda	2.813
	Insoluble silicic acid	62.975
	Fe_2O_3	2.114
	Al_2O_3	11.893
	SaO	0.226
	MgO	0.627
	K_2O	—
	Na_2O	2.792
	Organic substances (loss on ignition)	7.25
	Total	98.308

Analyses by Prof. Schmidt[2] [Percentages]

Locality	Mogil'no, 60 versts from Balta, Podolia Provinces	Kalinovka, 20 versts from Vinnitsa, at the boundary between the Kiev and the Podolia Provinces: arable layer	Kalinovka, 20 versts from Vinnitsa, at the boundary between the Kiev and the Podolia Provinces: subsoil
Numbers	31	32	33
Hygroscopic water	5.357	4.669	4.341
Water at 100−180°C		0.587	4.313
Humus + H_2O liberated above 180°C	7.963	6.207	
Mineral constituents	86.680	88.537	91.346
Total CaO	1.154	1.848	6.094
$CaCO_3$	—	2.750	10.881
Al_2O_3	13.076	9.509	9.022
Fe_2O_3	3.992	2.704	2.704
N	0.280	0.234	—

[1] Analysis performed according to Prof. Il'enkov's plan and under his direct guidance. Ibid.

[2] Schmidt. Ibid.

Bessarabia Province

No. 34. Soil taken from a tobacco plantation near Kishinev. Analysis by Babaev[1] [Percentages]

	Dissolved by treatment with HCL(1.15)	5.2
Fraction soluble in HCl	SiO_2	0.015
	SO_3	0.021
	P_2O_5	0.037
	CO_2	0.079
	Fe_2O_3	0.437
	Al_2O_3	0.838
	CaO	1.004
	MgO	0.676
	K_2O	0.050
	Na_2O	0.125
	Organic substances and chemically bound water.	1.816
Residue insoluble in HCl	Silicic acid soluble in soda	3.270
	SiO_2, insoluble	72.204
	Fe_2O_3	1.549
	Al_2O_3	4.832
	CaO	1.115
	MgO	0.967
	K_2O	2.327
	Na_2O	1.811
	Organic substances (loss on ignition)	6.286
	Total	99.549

No. 35. [Soil] from environs of Orgeev.[2] Analysis by Reichardt [Percentages]

Hygroscopic water at 100°C	3.06
Organic substances + other volatiles	18.04
Insoluble clay and sand	69.87
SO_3	0.25
Cl	Traces
Soluble SiO_2	0.24
Na_2O	0.95
K_2O	0.13
CaO	1.64
MgO	1.07
Al_2O_3	1.43
Fe_2O_3	4.09
P_2O_5	0.21
Total	100.98

No. 36. Soil from [environs of] Elisavetgrad. Analysis by Mr. Sheshukov[3] [Percentages]

Hygroscopic water lost at 100°C by 100 parts of air-dry soil	3.01
Contents of 100 parts of soil dried at 100°C:	
Hydration water liberated at 150°C	0.437
Humus	3.43

[1] Il'enkov, Ibid.

[2] Reichardt, Ibid. Unfortunately, Reichardt did not specify the place and conditions of sampling of the soil he analyzed. He only says that the soil was darkish, resembling peat, with abundant root residues visible under the microscope. This may have been a bog-meadow soil, especially since Orgeev is very near extensive forests and bogs where the Chuluk River and other minor rivers debouch. The abnormally high volatile content (18.04%) is understandable.

[3] Sheshukov's analysis was performed in the chemical section of the Mineralogical Laboratory of the St. Petersburg University; the sampling sites of this soil have been described.

Nitrogen	0.13
Zeolite water, CO_2, etc. (calculated from the difference)	0.232
Total loss on ignition	4.229
Dissolved by the treatment [of soil] with hot HNO_3:	
Organic substances	2.596
Mineral substances	4.829
Composition of soluble mineral substances:	
MgO	0.320
CaO	0.57
Al_2O_3.	2.326
Fe_2O_3.	1.103
SiO_2	0.213
K_2O, Na_2O, Cl, Mn, SO_3 calculated from the difference . .	0.291
Contents of 100 parts of HNO_3 — insoluble residue dried at 100°C:	
Organic substances	1.633
SiO_2 directly soluble in soda	8.073
Percentage of the same residue decomposed by sulfuric acid	4.772
Al_2O_3.	3.377
Fe_2O_3.	0.268
CaO, MgO, and other constituents determined from the difference	1.198
Residue left by sulfuric acid and then treated with soda:	
SiO_2	7.221

GENERAL CHARACTER OF SOUTHWESTERN CHERNOZEM RUSSIA

A summary of the principal soil features of southwestern Russia follows.

1. Average content of humus in soils of southwestern Russia does not exceed 4.5% (or rather, 4.40%). This highly significant fact may be regarded as established.[1] It is based on 67 analyses[2] of soil samples which I collected at different localities in this territory, and is also fully confirmed by at least 22 previous determinations of organic substances in soils of southwestern Russia, as already shown. This fact is especially marked in comparison to soils of central and northeastern chernozem Russia.

2. If southwestern Russia is divided in two, on either side of the Dnieper, the soils on the left side contain 4.554% humus (average of 35 samples) while those on the right side contain 4.242% humus (average of 32 samples). The causes of this difference undoubtedly underlie the fact that nearly all samples with a maximum humus content were taken on the left side of the Dnieper: the soils from Okhochevka (7.301%), Mar'ino-Ploskoe (7.319%), Pesochino (8.786%), Lozovaya (8.519%) and Graivoron (7.585%). On the right side of the Dnieper, on the other hand, chernozem with 7.196% humus was found only once, at the Razdel'naya station.

[1] I first suggested this in January 1881. See "Khod i glavneishie rezul'taty predprinyatogo Vol'no-ekonomicheskim Obshchestvom issledovaniya chernozemnoi Rossii" (Investigation of Chernozem Russia Undertaken by the Free Economic Society and its Principal Results), p.36, [St. Petersburg.] 1881.

[2] This number does not include samples from Birzulova and Kugureshti as well as soils of the territories adjoining the Black Sea, for reasons explained above. On the other hand, I thought it useful to include all soils along the line Kursk — Konotop — Fastov — Kazatin Author.

3. Since chernozem of southwestern Russia has a comparatively low content of organic substances, its color obviously cannot be as dark as soils in northeastern chernozem Russia. However, in many cases (examples of which have been given) the difference in color does not denote a difference in contents of organic substances. Prof. Borisyak's statement that "chernozem of the Poltava Province markedly exceeds Orel and Ryazan chernozem in the intensity of its black color" is, however, applicable only to the northern districts of the latter provinces.

4. The numerous artificial and natural sections which I observed, as well as the measurements presented above, indicate that the average thickness of chernozem in southwestern Russia can be estimated at 2 ft 8 in – 2 ft 9 in [81 – 84 cm], considerably exceeding thickness of any other chernozems. Soils of the left and right banks differ in this respect as well, 2 ft 7 in [79 cm] in the former compared to 2 ft 10 in – 2 ft 11 in [86 – 89 cm] in the latter. In addition to providing indication of the nature of their parent rocks, the comparatively large thickness of soils in southwestern Russia equalizes the difference between [total] humus contents of soils of southwestern and southeastern chernozem Russia. Obviously, in southwestern chernozem, the amount of humus is distributed over a larger [soil] mass than in thinner soils.

5. Conclusions (1) and (4) are directly related to another characteristic feature of soils in southwestern Russia. The difference in humus content between different horizons of the same soil should be much smaller than in the case of thinner soils which are richer in humus. This statement is substantiated by facts. In addition to the data provided by Prof. Schmidt, quoted above, analyses were performed by Sheshukov. The soil of the Odai farm (Uman District), mentioned above, was found to contain 5.962% humus at a depth of 6 in [15 cm], 2.878% humus at 21 in [53 cm], and finally 1.156% humus at 38 in [96 cm]. The difference in color of soils from different horizons must be correspondingly small.

6. The specific gravity determinations of soils (which I collected) carried out by Mr Burmachevskii at the Agronomic Laboratory of St. Petersburg University reveal the relatively very high specific gravity of chernozem gray soils in southwestern Russia, as given in the following table of specific soil gravities.

		Specific gravity
1.	2 versts from Putivl	2.67
2.	Kursk, at the railroad station .	2.65
3.	1 verst north of Nezhin . . .	2.64
4.	10 versts north of Voronezh. .	2.62
5.	Polonnoe	2.62
6.	Zhmerinka	2.62
7.	Tomashevka	2.62
8.	1 verst east of Nezhin . . .	2.61
9.	5 versts from Novorobskaya. .	2.60
10.	Kazatin	2.57

Average specific gravity of soils in southwestern Russia may be regarded as 2.62. This should be kept in mind while estimating the relatively low humus content of these soils. Determination of organic substances in soils is generally made on a sample of approximately 5 g. Since the specific gravity of sand is 2.6 and that of clay is 2.2, the samples taken for analysis of clayey soils are of larger volume than samples of sandy soil. Consequently, a given weight of clayey soil contains a comparatively large amount of humus, while the humus content of sandy soil is comparatively smaller, humus being distributed in the soils more or less uniformly within horizons.

The main features of the soils in southwestern Russia are as follows: a) relatively small content of organic substances, b) its extremely gradual variation over different soil horizons, c) considerable thickness, d) relatively weak dark color, and e) high specific gravity.

These features underlie the differences between this chernozem and similar soils in central and northeastern chernozem Russia.

These properties of soils in southwestern chernozem Russia are so unexpected, so contradictory to accepted opinion, and are of such high scientific and practical interest that they merit detailed explanation.

The basis of all these properties lies in the predominant chemical-mineralogical composition of chernozems in southwestern Russia. The geological description of this territory clarified the important role of various sandy formations as subsoil; this is clear from analyses Nos. 6, 7, 9—11, and partly also 15, 20, 22, and 24. The properties of the soils overlying these rocks must be generally similar, which is vividly demonstrated[1] [percentages]:

Locality and Nos. of samples	Al_2O_3 and Fe_2O_3	Clay	Quartz sand
Kishinev (No. 34)	7.656	10.281	72.204
Elisavetgrad (No. 36)	6.799	15.094	72.149
Gromy (No. 26)	7.838	15.750	69.580
Grushki (No. 30)	17.774	19.318	62.975
Belgorod (No. 8)	7.400	13.398	76.394
Pesochino (No. 5)	14.081	23.221	58.271

An essentially identical conclusion may be reached by calculating the clay contents (from the total of ferric oxide with alumina) for all those soils of southwestern Russia which have not yet been completely analyzed.

Property (f), the most important characteristic of these chernozems, is their very sandy composition.[2] This conclusion is substantiated by the fact that a considerable portion of the samples was not of my collection, and originated from a great variety of areas and localities in southwestern Russia; the selection of material is thus completely objective.

The following inferences may be drawn.

A. The very sandy nature of chernozems in southwestern Russia is genetically related to most of the soil properties already mentioned in regard to this region. Herbaceous vegetation does not grow readily on sandy parent rocks and is found in smaller quantities than on loams;

[1] In this case the clay content was roughly calculated "by adding the amount of alumina extracted by acid and the amount of silica extracted by alkali and by expressing the total as a hydrous compound" (15% water). Mendeleev, Ibid., p. 9. However, the clay-like substances also include ir and I therefore added the column for Al_2O_3 and Fe_2O_3.

[2] This feature of soils of southwestern Russia is especially clear in comparison to soils of central and northeastern chernozem Russia which contain nearly twice as much clay; pp. 225–226.

it decays more rapidly, in soil or underneath it. Other conditions being equal, sandy soils should be lower in humus than loamy and clayey soils. The colors of these soils therefore cannot be identical.

Sandy parent rock is certainly looser than rocks which are rich in clay, and humus will thus inevitably penetrate far more deeply in the former than in the latter case; hence the considerable thickness of chernozems in southwestern Russia and the small differences in humus content between their different horizons.

However, the low humus content in soils of southwestern Russia and their other special properties may not be due to their chemical-mineralogical nature alone. Account should also be taken of the nature of vegetation, topography, and even climate of southwestern Russia.

Thanks to the climatic conditions of southwestern chernozem Russia, forests penetrate further south than in eastern and central Russia even today. Indications have been given above that this difference was even more considerable in the past. Forests do not furnish suitable conditions for chernozem formation,[1] and it is clear that their earlier appearance in southwestern Russia in comparison to the other parts of the chernozem zone and, especially, their wider occurrence, must have retarded accumulation [of humus and formation of] rich chernozem.

The development of arboreal vegetation in southwestern Russia, as everywhere else, followed herbaceous vegetation. This is established on the basis of the nature of both arboreal and herbaceous flora, and in our opinion also by the presence of krotovinas and man-made mounds.

Krotovinas often occur, on the left bank of the Dnieper and especially throughout Gaidamatchina, in areas forested at present or in the recent past.[2] Krotovinas filled by chernozem are obviously younger than the chernozem; burrowing animals are more characteristic of steppes than of forests; finally krotovinas have not been observed existing in nonchernozem forests.[3]

It is therefore natural to conclude that forests were preceded by the steppe in all these localities. Academician Gel'mersen's opinion, regarding krotovinas as remnants of tree roots, cannot be accepted. Additional arguments to this effect are presented below.

1. Finds of tree residues in krotovinas have been made in only two or three cases,[4] in which they are certainly very recent, since a root cannot be preserved unmineralized, even for a hundred years, in soil which is accessible to water and air.

2. Investigations made by Kipriyanov, Academician Gel'mersen, and myself have demonstrated that krotovinas occur at depths of 9—10 ft [2.7—3 m] and 14 ft [4.3 m], not usually accessible to tree roots.

[1] Karta lesov Evropeiskoi Rossii (Forest Map of European Russia). See Nizhni Novgorod Province and the chapter on the origin of chernozem.

[2] Prof. Levakovskii (ibid., p. 15) also found "old krotovinas in large numbers in the northern, more forested districts of the Khar'kov Province as well as in the Kursk Province... Generally, far beyond the present-day range of susliks."

[3] Absence of krotovinas in forests of nonchernozem Russia is certainly not due to scarcity of burrowing animals, but rather to the absence of thick accumulations of chernozem which could fill the burrows. Burrows of various animals, such as moles, found in northern loam and filled with the same material of homogeneous color, become invisible. Krotovinas in chernozem (horizon A) filled with the same chernozem are extremely rare and become visible only under accidental favorable conditions.

[4] Prof. Borisyak (ibid., p. 40), in addition to Barbot de Marni and Gel'mersen, "found traces of decayed plant residues in krotovinas."

3. Many krotovinas often reach 1 — 1 1/2 ft [30 — 45 cm] and even more in diameter; krotovinas of such sizes occur in all horizons at least to a depth of 9 ft [2.7 m]. These circumstances are incompatible with Academician Gel'mersen's view.

4. Finally, decayed tree roots possess a very insignificant portion of their original weight and volume, thus casting doubt on the origin of the material filling krotovinas. Susliks and other burrowing animals throw up earth (chernozem and underlying rock) to the surface, which earth later fills their burrows. No comparable process occurs in regard to plants. Root channels and animal burrows might in the course of time be destroyed by gradual collapse of their walls or sudden collapses of the adjacent mass, in which case all traces would be obliterated and krotovinas would not exist.

Krotovinas must be regarded as burrows of animals. In forested localities, they must be regarded as proof of the former presence of steppes.

The presence of man-made mounds in forests is offered as proof of the same hypothesis; however, this lacks the decisiveness of the previous argument. Mr Skal'kovskii was the first to suggest[1] the presence of such mounds in the steppes as proof of the original absence of forests. According to him, "man-made mounds would be quite pointless amidst forests and would be unnoticeable except at very close quarters; the appearance of mounds in the steppes, these documents of the presence of numerous nomadic peoples, proves that the greater part of the Novorossiya Territory had as few forests twenty centuries ago as today." Regarding Skal'kovskii's opinion as generally justified, and in view of the mounds present amidst forests in the Poltava, Kiev, Bessarabia, and Podolia provinces, etc., these territories may be regarded as having been unforested in the past.

However, it should be stressed that this argument becomes convincing only under the following conditions: a) a precise classification of all the mounds in Russia as follows — 1) burial mounds, 2) boundary marks, 3) landmarks, 4) fortifications, 5) vantage points, 6) roadside marks, etc. — and b) the presence of types 1 and 6 in the steppe and forested areas of chernozem Russia. I should like to draw the attention of archaeologists to this subject.

I consider it very probable that forests in southwestern Russia were formerly more widespread than at present and that they were preceded by steppe. Since climatic conditions in southwestern Russia are certainly more favorable for arboreal vegetation than the climate of corresponding latitudes in central and eastern Russia, and since southwestern Russia is directly adjacent to the Carpathian Range, previously forested, it seems obvious that local steppes became forested sooner than anywhere else in corresponding latitudes of Russia. It shall be made clear below that this change was also favored by the topography of the terrain.

If all the above arguments are correct, and the territory was not a steppe for very long, a rather small amount of humus could have accumulated. Any discussion of the humus content in these chernozems should take account of the relief of southwestern Russia.

In preliminary communications and reports, I have explained the important part played by the nature of the surface in the normal distri-

[1] Skal'kovskii. Opyt statisticheskogo opisaniya Novorossiiskogo kraya (An Attempt at a Statistical Description of the Novorossiya Territory), p. 193, [Odessa]. 1850.

bution of humus in soil. One illustration is that soils of strongly rolling localities, on hilltops and on the upper third of the hillsides, as well as on upland river banks, are rarely normal, usually low in humus and clay and frequently very rich in slightly altered parent rocks.

The very rolling surface over much of the Poltava Province, the southern part of the Kiev Province, the Podolia Province and especially the northern part of the Bessarabia Province certainly facilitated accumulation and preservation of humus in soils.

Southwestern Russia may be regarded as having undergone the following processes, taking into account the secondary nature of gullies and "balkas", their facilitation of moisture redistribution and, to a certain extent, forest appearance.[1]

This vast territory was originally a level, treeless steppe, bearing rich steppe vegetation and inhabited by burrowing animals. Over the millennia, its climatic conditions and general rather steep incline toward the neighboring seas caused a formation of hilly terrain more rapid and considerable than in any other Russian steppe. At the same time water was redistributed: the ridges grew poor in water while the "balkas" grew richer in springs; the steppe flora and fauna gradually became poor. The forests growing in the neighboring territories (the Carpathians) thus expanded into southwestern Russia, initially along rivers and "balkas". The present relief of southwestern Russia is probably in a state of equilibrium. New gullies may appear, while the old gullies gradually lose their sharp outlines and their walls gradually become covered by sod and chernozem.

Mention of the climate will conclude our discussion of the causes underlying the relatively low content of organic substances in the soils of southwestern Russia.

A.I. Voeikov remarked that the climate of southwestern Russia is more favorable for vegetation than the climate of the corresponding latitudes in central and eastern Russia. In southwestern Russia "the vegetative period is longer thanks to the warmer spring and autumn, rainfall is heavier and the percentage of summer precipitation is no smaller. For instance the nonmountainous territories of Galicia and Bukovina, adjacent to the Podolia Province, have an annual precipitation of 57—24 cm, more than anywhere in the central and eastern chernozem provinces (for instance, annual precipitation at Simbirsk is only 44 cm)."[2] Voeikov concludes that a larger humus accumulation is therefore to be expected in soils of southwestern Russia.

This conclusion appears somewhat too hasty and too general.

There are thousands of territories in western Europe, as in other regions of the world, where annual and summer precipitation is heavier than in southwestern Russia and where the warm season is more prolonged, and yet they lack even traces of the poorest chernozem.

Any complex of climatic conditions cannot be equally favorable for both steppe and forest vegetation, and it is therefore impossible to

[1] Dokuchaev. Sposoby obrazovaniya rechnykh dolin (Modes of Formation of River Valleys), pp. 55-56, (St. Petersburg. 1878).

[2] Protokol zasedaniya Otdeleniya geologii i mineralogii S.-Petersburgskogo obshchestva estestvoispytatelei (Minutes of the Meeting of the Geological and Mineralogical Section of the St. Petersburg Society of Naturalists), 31 January 1880.

regard the conditions of southwestern Russia as highly favorable for vegetation in general.[1]

The Russian seaboards of the Black and the Caspian seas, especially in the southern parts of the Bessarabia, Kherson, and Astrakhan provinces, where wild flora may be totally wilted as early as the end of May, clearly demonstrate the fallacy of Mr Voeikov's technique for estimating the vegetative period on the basis of the length of the warm season. In general, it is impossible to state that the climate of a certain territory is more favorable for chernozem formation than the climatic conditions of another territory, unless the data on the total annual precipitation, the total annual amount of heat, and their distribution over the actual vegetative period in the year, the annual increment of both steppe and forest vegetation, the quantities of vegetal mass decaying and entering the soil, conditions and trend of the decay processes with regard to different plant residues in soil, etc. are taken into account. No satisfactory information on any of the above factors exists, and positive conclusions on the subject are therefore premature.

Insofar as judgements may be formed on the basis of the data currently available, the fairly abundant arboreal vegetation in southwestern Russia and, to an extent, the relief of this territory indicate climatic conditions more favorable for forests than for steppes.[2]

B. Since soils almost throughout southwestern Russia are predominantly of uniform sandy-loamy character up to the northern boundary of the calcareous Tertiary system, Chaslavskii and Yanson's subdivision of local chernozem into rich, ordinary, clayey, and sandy-loamy — loamy kinds should not be adopted, due to the lack of natural-historic substantiation.

Any difference between Chaslavskii's soil regions is due to climatic, topographic, and floral factors. It is common knowledge that favorable combination of moisture and warmth (significantly affected by forests) is one of the most significant conditions for any vegetation, especially that under cultivation. The population throughout southeastern Russia has learned by bitter experience that drought may bring about famine, even on the richest soil. On the other hand, excellent stands of corn have been

[1] Climatic conditions favorable for cultivated vegetation cannot be regarded as favorable for wild vegetation as well, especially steppe vegetation which is the principal agent in the origin of the Russian chernozem, as explained below. Author.

[2] Various historical data (Z a b e l i n [I.] Istoriya russkoi zhizni s drevneishikh vremen (History of Life in Russia Since Antiquity), part 1, pp. 2, 29, 218—281, 411, etc., [Moscow], 1876) certainly indicate that the "Scythian Rus inhabiting the territory between the Dnieper and the Danube, extending approximately 100 versts east of the former, led an agricultural existence as early as Herodotus' time, 450 years B. C." The steppes around the Sea of Azov, the Donets, the Don, and the Volga were later either uninhabited or occupied by nomads. Once the effect of cultivation on the depletion of humus in soil will have become clear, any explanation of the relatively low content of organic substances in the chernozems of southwestern Russia will have to take this circumstance into account. It is at present difficult to make any positive statement on this subject. Messrs. B o r i s y a k (ibid., p. 19) and S o v e t o v (ibid., p. 293) do tend to regard cultivation as an important agent. Borisyak recognizes the effect of cultivation on the thickness of chernozem, and Sovetov also on its color; according to Sovetov, the dark color of this soil may be completely altered by continuous plowing. I strongly object to this view. In the first place, all the samples of chernozem which I took, from virgin lands or from plowland, displayed no difference in color and humus content, provided they were taken from the same district; on the other hand, roots and lower portions of stalks of cultivated plants are capable of compensating and even overcompensating the soil for its loss of humus by mineralization, and so on.

repeatedly observed, by ourselves and by previous observers,[1] on sands and on the fresh railroad embankments nearly throughout the chernozem region, especially in southwestern Russia. Finally, under favorable weather conditions even poor northern soils often yield crops tenfold the amount of seed and more. Such is the significance of climate, and so great the distinction between richness of soil and its fertility.[2] This is the principal factor for the almost universal crop success enjoyed by the northern part of Bessarabia, southern parts of the Volhynia and Kiev provinces, and entire Podolia Province.

On the other hand, it will be made clear below that the crop yields in this territory fall short of those in the southern part of the Trans-Volga area, for instance [areas lying east of the Volga.][3]

C. The following remarkable facts are genetically related to the character of the subsoils in southwestern Russia:

1. Eastward, an increase in subsoil clay (see analyses of samples from Pesochino, Mokhovoe, etc.) occurs concurrently with an increase in the soil humus in southwestern Russia. The enormous blunt peninsula of chernozem protruding between Kromy, Novosil, Ryazhsk, and Tula, thus becomes comprehensible (see map). In Barbot de Marni's words, the typical boulder-free loamy loess advances north, forming a large promontory.

2. The regular but marked effect of climate on the soil humus content thus begins to be noticeable only at the first occurrence of the calcareous type of southwestern Tertiary formations between Zhmerinka and Odessa. This statement will be considered below in detail.

To complete our description of soils of southwestern Russia, the relationship between local chernozem and rocks of the so-called Dnieper crystalline range will be clarified, especially since this subject is sometimes regarded as being highly significant.

As is known, scientific opinion of the relationship between the Dnieper crystalline area and the south Russian deposits (and hence also soils) has varied. The principal viewpoints are given below.

The renowned investigator, Murchison, gave the following description of the area, in partial contradiction of his predecessors Sokolov and Kul'shin: "This granite steppe, in which the rocks were uplifted in antiquity...is in places[4] bare of surficial formations and thus differs markedly from the formations to its north and south. There are thus ample grounds to assume that it has not been inundated since the beginning of the

[1] Wangenheim von Qualen. Ibid., pp.4-5; Borisyak. pp.32-33; Krylov [A.]. Sovremennoe sostoyanie voprosa o chernozeme i ego proiskhozhdenii (Current State of the Subject of Chernozem and its Origin). — [In book: "Priroda , 4th year, book 1, p.50, Moskva. 1876]; Sovetov, Ibid., pp.284 and 300. Explanations of this phenomenon, however, cannot be based exclusively on climate. The northern loam is not equivalent to chernozem loam (the most normal chernozem), and, similarly, southern sands and clays are far from equivalent to the northern sands and clays, since they have been subjected to the effects of totally different weathering, climatic and vegetative conditions for millennia. Northern and southern sands cannot be of equal fertility, since they are also derived from differing rocks..

[2] Ibid., pp. 17-19.

[3] All these features of soils in southwestern Russia, in concurrence with the specific features of the local climate, lead to the following practical and very important conclusion: the choice of cultivated plants, cultivation of land and sowing times should be quite different in southwestern Russia than in the rest of the chernozem zone.

[4] For instance, Murchison observed "red porphyry" "in certain territories (basin of the River Kalmius) over considerable areas on the surface." Murchison. Ibid., part 1, p.404.

Paleozoic Era, although the surrounding territories of European Russia have been under water."[1]

Prof. Feofilaktov holds a different opinion of the western part of the Dnieper crystalline territories. "One may travel over the entire crystalline rock region without seeing a single rock; they are concealed by the thick, continuous deposits." Feofilaktov noted that "the deposits become less thick toward the central part of the crystalline area."[2]

Academician Ruprecht echoed Murchison's opinion in 1866 and even elaborated upon it. Ruprecht admitted that "The crystalline rocks are not covered by any sedimentary rock throughout the granite region (from the Pinsk bogs nearly to the Sea of Azov), and the region is even lacking in diluvium," although Murchison only mentioned the absence of marine sediments. Academician Ruprecht continues as follows: "nevertheless, by the weathering of granite, this relatively unfavorable substrate generated a layer of chernozem covered by vegetation. This example proves the terrestrial plant origin of chernozem."[3]

Neither Borisyak nor Barbot de Marni agreed with the views of Murchison and Ruprecht. Similarly, Prof. I. F. Levakovskii, who examined a considerable portion of the Dnieper crystalline rocks stated that "direct contact between chernozem and granite is very rare and accidental, found over very insignificant surfaces and due to the recent deposition of chernozem from higher adjacent areas." It may be added, on the basis of the previous discussion, that in the excursions I carried out over two years in the basins of the Dnieper, Bug and Dniester rivers I saw no layer of chernozem (although deposited) directly overlying crystalline rocks. It would however be imprudent to generalize this observation (as done previously), which is evident from the works of Klemm and Kontkevich, cited above.

Klemm, speaking of the water divides of the territory between the Dnieper and the Kalmius, the middle reaches of the Volch'ya and the Sea of Azov, remarked that there is no chernozem in the area covered by crystalline rocks; instead, there is "a thin, dark-brown sandy layer... Absence of chernozem is also noted in the middle reaches of the River Moskovka where crystalline rocks are most highly developed, and in some places on the banks of the Dnieper."[4]

Kontkevich wrote as follows: "In contrast to the western part of the south Russian granite belt, where crystalline rocks are exposed under sedimentary formations only in river valleys, on the eastern side of the Dnieper (in the entire Berdyansk and part of the Melitopol districts, half of the Aleksandrovsk District and most of the Mariupol District, about 13,000 sq. versts in all) a true granite steppe is observed, in which these rocks on interfluvial areas are covered by a very insignificant layer of the product of their decomposition or else form surface outcrops. Rocky hills, known as 'kamennye mogily' (stone graves) are fairly common"[5]; very characteristically, "chernozem is also absent on most of the area occupied by crystalline rocks"; according to Kontkevich, "the brownish-

[1] Murchison. Ibid., part 2, pp. 358-359.

[2] Feofilaktov. O kristallicheskikh porodakh gubernii Kievskoi, Volynskoi i Podol'skoi (Crystalline Rocks in the Kiev, the Volhynia, and the Podolia Provinces), p. 3. 1851.

[3] Ruprecht. Ibid., p. 22; on pp. 20 and 46 Ruprecht speaks of the "transition of chernozem to granite."

[4] Klemm. Ibid., pp. 107 and 119.

[5] Kontkevich. Ibid., January, p. 102 and February, p. 304. See also Klemm. Ibid., p. 106.

black soil consisting of the products of decomposition of these rocks tinted by vegetal substances, though not as fertile as chernozem, is nevertheless usually quite suitable for agriculture."[1]

Additional facts supplied by Kontkevich may be useful at this point. For instance, throughout the territory travelled by Kontkevich (along the Kalmius) "the top soil layer consists of brown granite grus, which in some places still contains isolated granite blocks which have escaped destruction, sometimes shaped like giant mushrooms."[2] In the basin of the Berda River, at the apex of the last "balka", Bel'manka, there is a granite "protrusion, devoid of chernozem on it or around it; the dark-brown soil abounding in mica spangles, consists of products of decomposition of (lo[illegible]) granite and gneiss."[3] At the sources of the River Korsak, disintegrating gray granite has been converted in places to fine grus covered by an insignificant layer of vegetal earth with which it merges imperceptibly.[4] Finally "below the confluence of the Sisikula, on both banks of the Yushanla, especially the right bank, numerous outcrops of crystalline rocks are observed in the immediate vicinity of the river and some distance from it, where they either appear on the surface or under a very insignificant layer of chernozem. Entire territories, especially on the left of the river, are thus unsuitable for agriculture and have been left as pastures."[6]

The truth of this matter, as in most cases, lies halfway between the extreme opinions. It may be formulated as follows: in the eastern half of the region of southern crystalline rocks, rocks outcrop on the surface in some localities; in these cases, they are covered by soils far inferior to typical chernozem both in thickness and in color; on the other hand, in the Trans-Dnieper area all crystalline rocks are covered by a thick layer of deposits. Consequently, the statements by Murchison and Ruprecht, quoted above, are grossly exaggerated and do not possess the significance ascribed to them.

[1] Kontkevich. Ibid., February, pp. 315-316.
[2] Ibid., p. 302.
[3] Ibid., pp. 277—278.
[4] Ibid., p. 261.
[5] Ibid., p. 256.

Chapter IV

CENTRAL CHERNOZEM RUSSIA

BRIEF HISTORICAL DESCRIPTION OF GEOLOGY AND SOILS

I am using the term "central chernozem Russia" to designate the basin of the Donets, the upper and middle reaches of the Don, the right-bank tributaries of the Oka and of the Volga, approximately from Tetyushi to Kamyshin. This region thus includes the southeastern parts of the Ryazan, Orel, Kursk and Khar'kov provinces, the northeastern corner of the Ekaterinoslav Province, the northern half of the Don Cossack Territory, the Voronezh Province, the northern two-thirds of the Saratov Province, the southern two-thirds of the Tambov Province, and the Penza and Simbirsk provinces.

The orographic map of European Russia depicts a water divide stretching west to east along the middle of the territory, from Orel to Tambov and Penza; this water divide reaches 700 — 1000 ft [213 — 305 m] of absolute height. The Tsna and Sura rivers flow north of this divide and the Don, Voronezh, Khoper and Medveditsa rivers flow south, their basins apparently lower than those of the Tsna and Sura. At approximately the meridian of Penza these heights become much broader and veer north — south, parallel to the Volga and serving as a water divide between the Volga and the basins of the Sura and Medveditsa. The spurs of these heights occupy most of the Saratov, Penza, and Simbirsk provinces.

The works of Murchison, Yazykov, Borisyak, Pacht, Wagner, Gofman, Sintsov[1] and others show the Cretaceous system to be as widespread in central chernozem Russia as the Tertiary system in southwestern Russia. The principal members of this system are indicated to be chalk and chalky marls.[2] It should, however, be noted that the Cretaceous system does not wholly occupy the territory. Fairly extensive Lower Tertiary sandy "islands"[3] stretch along the right bank of the Don, beginning approximately

[1] Sintsov. Geologicheskii ocherk Saratovskoi gubernii (Geological Description of the Saratov Province), p. 54. –[Zapiski S. Peterburgskogo Mineralogicheskogo obshchestva, second series, part 5, St. Petersburg.] 1870.

[2] I would again specify that I mean the predominant rocks here and in similar places. Author.

[3] See Academician Gel'mersen's most recent geological map. For better characterization of the local Tertiary formations, Prof. Sintsov's list (from the surface down) of rocks in the Tertiary system of the Saratov Province follows: a) loose gray-yellow sands with "buns" – white claystone, altogether reaching 125 ft [38m], b] loose coarsely granular green sand, 8 ft [2.4m], c) dark-gray argillaceous sandstones, 25 ft [7.6m], d) greenish-gray sands, sandstones, and shales, approximately 350 ft [107m], e) grayish-white and reddish sands and buhrstones, unknown thickness." Sintsov. Dopolnitel'naya zametka... (Supplementary Note...) [to the paper "Geologicheskii ocherk Saratovskoi gubernii" (Geological Description of the Saratov Province). - Zapiski Novorossiiskogo obshchestva estestvoispytatelei, Vol. 2, Odessa, 1875], pp. 31 – 32. The sandy Tertiary formations of the Saratov Province, excluding horizon (e), reach 508 ft [155 m] in thickness!

at Voronezh and continuing to the lower reaches of this river, between Novokhopersk and Boguchar, along the lower reaches of the Medveditsa (north of its right bank), southeast from Balashov, along the left bank of the Volga from Saratov to Syzran and finally between Syzran, Gorodishche and Korsun. According to visual observation, they occupy one-sixth to one-fifth of central chernozem Russia. Moreover, Devonian, Carboniferous and Jurassic limestones, marls and clays are found on the margins of the belt on the Samara bend of the Volga, along the right bank of the lower reaches of the Donets and between Voronezh, Ranenburg and Livny.

The sandy Tertiary rocks invariably occupy high water divides and interfluvial areas in the Voronezh Province, the northern districts of the Don Cossack Territory,[1] in the northern part of the Saratov Province,[2] and in certain portions of the Simbirsk and Penza provinces[3]; "in the Saratov Province these rocks form nearly all the mountain elevations."

It will be made clear that this circumstance, combined with the basic difference in the petrographic natures of chalk and quartz sand, is highly significant for soils of central chernozem Russia.

As in southwestern chernozem Russia, the same rocks in central chernozem Russia are usually concealed under more or less thick diluvial deposits. Until quite recently (Ruprecht, probably Bogdanov, and others) local deposits were regarded as nearly free of boulders. However, this view, first formulated by Murchison, is incorrect. For instance, as early as 1853 Pacht found erratics in the diluvial loam of the Tambov Province, in many gullies along the Leshnya, Lesnoi-Voronezh and Tsna rivers, and the latter's tributaries Kalais, Inkovka and Chembar and along the bank of the River Pyasha a tributary of the Khoper, in the Serdobsk District.[4] Pacht, who concluded his description of the ancient formations in the "Voronezh, Tambov, Penza, and Simbirsk provinces from Voronezh to Samara" in 1856, remarked that "all these formations are covered by thick deposits, largely consisting of clay-sandy strata, sometimes containing crystalline erratics." Pacht's maps denote the occurrence of such erratics according to his observations by a red dotted line running from Voronezh to Usman, Tambov, Kirsanov, Chembar, and Serdobsk. However, he assumed the boulders to extend further south. The erratics on this territory are not very abundant; they are always small and do not usually lie on the surface but are, rather, buried in sand.[5] Academician Gel'mersen observed similar formations in the environs of Elets, Zadonsk, and Voronezh.[6] A characteristic example of the diluvium exposures mentioned by the author is a hill between Khlevnoe and Yaroslavets stations (en route from Zadonsk to Voronezh?). "The hill consists of finely bedded (cross-bedded) compacted

[1] Gurov. Ibid., p. 428.

[2] Sintsov. Geologicheskii ocherk Saratovskoi gubernii (Geological Description of the Saratov Province), pp. 38-39. 1870; by the same author: Dopolnitel'nye zametki k predshestvuyushchei stat'e (Supplementary Notes to the Preceding Paper) [Zapiski Novorossiiskogo obshchestva estestvoispytatelei, Vol. 2, Odessa, 1873], p. 37. 1870.

[3] Bogdanov. Ibid., p. 8, etc.

[4] Pacht. Obshchii otchet ob issledovanii devonskoi polosy Evropeiskoi Rossii... (General Report on Investigation of the Devonian Belt of European Russia...). – Vestnik Russkogo geograficheskogo obshchestva, part 8 [9], book 7 [6th section], p. 64. 1853.

[5] Pacht. – Zapiski Russkogo geograficheskogo obshchestva, book 11, p. 170 [1856].

[6] Gel'mersen. Ibid., pp. 47-49.

sand, whitish, yellow and cinnamon. At about 14 ft [4.3 m] below the surface a bed of coarse sand (grus and gravel) is found, extremely rich in erratics which are completely rounded and sometimes reach 4 in [10 cm] in diameter"; the boulders consisted of granite, quartzite, and flinty slate.[1] Academician Gel'mersen also specifies that "large granite blocks were no longer transported to this point in the period of the diluvial sea; the present southern boundary of these erratics was reached only by small fragments of the Finland and Olonets heights."[2]

Mr. Kulibin, who supplemented these data, added that the "deposits almost throughout the Tambov Province consist of sands and clays, the latter mostly grayish-yellow; vertical fissures are visible in sections. The deposits contain erratic boulders (granite, gneiss, mica schist, chlorite schist, etc.) as well as rocks lying in the vicinity of these deposits or concealed by them among these are boulders of limestone and flint (often with fossils) and chalky and ferruginous sandstones." After mentioning that boulders in the southern part of the province are "small and hardly discernible on the surface," Kulibin traces the southern boundary of the erratics through the southern part of the Usman and the northern part of the Borisoglebsk districts.[3]

The boundary of the boulders was shifted even further south by Prof. Borisyak. After pointing out their occurrence "in the middle reaches of the Donets" and at Ostrogozhsk, and remarking the general gradual decrease in crystalline boulders from west (the Sula) to east (the Don), Borisyak continues as follows: "but the erratic phenomenon reappears on a larger scale on the left side of the Don, along the Medveditsa and the Khoper. The vast triangle, its southward apex, the Don and the Khoper as its lateral sides and its base marked by a line from the Kazanskaya 'stanitsa' (on the Don) via Zotovksaya (on the Khoper) to the settlement of Sebryakova on the Medveditsa, is strewn with boulders. Crystalline rock boulders are scattered all over the territory, and are especially noticeable on river margins. At the Slashchevkaya 'stanitsa', nearly at the very bank of the Khoper, in the Kamennyi Bairak gully they reach very large dimensions. Near the Dolgii Baran farm in the vicinity of the Kumylzhanskaya 'stanitsa' granite boulders are abundant, some reaching several sazhens in circumference. Many of them are immersed, partly emerging above water; the majority of the boulders, scattered throughout the steppe, lie on chalky, belemnite-containing marl; they are fairly often enveloped by chernozem. Many fragments of sedimentary rocks, such as limestone are found among the local boulders. No large stretches of huge boulders comparable to those in the lower reaches of the Khoper and the Medveditsa were noted over the investigated territory. Areas of crystalline fragments in the Poltava Province (mentioned above) are insignificant patches in comparison with the triangular area described."[4]

Following Borisyak's discovery, Prof. Sintsov's information concerning

[1] Ibid., p. 49.

[2] Ibid., p. 47.

[3] Kulibin [N.]. Geognosticheskii ocherk Tambovskoi gubernii (Geognostic Description of the Tambov Province), pp. 21-22. – [Zapiski S.-Peterburgskogo Mineralogicheskogo obshchestva, second series, part 1, separate reprint, St. Petersburg. 1866.]

[4] Borisyak. – In: Sbornik materialov, otnosyashchikhsya geologii yuzhnoi Rossii, book 1, pp. 170-171. 1867.

the occurrence of erratics throughout the western half of the Saratov Province up to the right bank of the Medveditsa River passed unremarked.[1] Especially significant, among the numerous instances cited by the author, is the find of boulders between Chaadaevka and Bol'shaya Kolokol'tsevka in the Atkarsk District. According to Sintsov's description, "numerous fragments of boulders consisting of crimson and white sandstones appear on the gentle slope toward the settlement of Kolokol'tsevka, where reddish clays emerge under the chernozem; these boulders are intermixed with fragments of dark-green diorite. Blocks of the same diorite, in the streets of the settlement, are of considerable dimensions.[2]

"The terrain is unvaried between Kolokol'tsevka and the settlement of Aleksandrovka. Approximately 2 versts past Kolokol'tsevka, on an open steppe, I saw a boulder about 2 1/2 arshins [1.75 m] long, 2 arshins [1.4 m] wide and high. It is dark-green diorite, and is half-buried[3] in a bed of reddish nonstratified clay. The boulder is reportedly so heavy that it cannot be moved by 10 pairs of oxen. Fragments of the same diorite, together with multicolored sandstones and finely-granular limestone, are scattered in the fields around this boulder. Both the grayish sandstones and the limestones contain poorly preserved fossils. Heaps of similar fragments are repeatedly encountered in the fields further along the way to Aleksandrovka."[4]

The following facts, among others mentioned by Prof. Sintsov and referring to post-Tertiary formations in the Saratov Province, are noteworthy: 1) the fairly widespread, though not continuous, occurrence of "atmospheric" red clay in the Saratov Province; 2) a rather marked agreement between the geography of chernozem and the distribution of chalky marls.

At Tsaritsyn the "atmospheric" clays display a "very gradual and imperceptible" transition to the underlying, more ancient yellow marls and Sintsov therefore tends to regard these clays as bedrock (marls) eroded in situ and chemically altered by atmospheric water.

I have no objection to this explanation of the origin of the Tsaritsyn deposit, but I cannot adapt Sintsov's hypothesis for all the diluvial red clays in the Saratov Province, as Prof. Bogdanov does. The reason is obvious: Prof. Sintsov observed the same clays on sands and other kinds of bedrock which obviously could not produce the clays.[5]

The agreement between the geography of chernozem and the distribution of chalky marls will prove to be of great general significance. Prof. Sintsov's description follows. "Starting from Saratov along the 'Bol'shaya Petrovskaya' highway, I crossed a sandy-clay formation. The poor quality of the overlying chernozem made me doubt whether it belonged to the Cretaceous group since the latter usually consists of moisture-retaining marls and is therefore

[1] Sintsov. Otchet ob ekskursiyakh, proizvedennykh v 1874 g. v guberniyakh Saratovskoi i Samarskoi (Report on Excursions Carried Out in 1874 in the Saratov and Samara Provinces), p. 21. – [Zapiski Novorossiiskogo universiteta, Vol. 16, Odessa, separate reprint.]

[2] One of them was approximately 1½ arshins in diameter.

[3] "More precisely, it used to be half buried and at present it has been dug around."

[4] Dopolnitel'naya zametka k stat'e: Geologicheskii ocherk Saratovskoi gubernii (Supplementary Note to the Paper "Geological Description of the Saratov Province"), pp. 26-27.

[5] Sintsov. Dopolnitel'naya zametka... (Supplementary Notes...), pp. 4, 26, etc. Clays, apparently identical with northern boulders were observed on sand by Barbot de Marni as well, en route from Saratov to Tambov. Barbot de Marni. Geologicheskie nablyudeniya v Simbirskoi, Saratovskoi i Tambovskoi guberniyakh (Geological Observations in the Simbirsk, the Saratov, and the Tambov Provinces), p. 181.

favorable to luxuriant vegetation and consequently also to chernozem formation."[1] This circumstance is discussed in greater detail below.

These are all the principal historical data on deposits in central chernozem Russia. It may be added that despite the absence of a complete analysis of local diluvium in the literature, diluvium overlies bedrocks of essentially different kinds, Cretaceous marls and Tertiary sands. There is therefore no doubt[2] that the diluvium is generally of two principal types, sandy diluvium and loamy diluvium. This circumstance is immensely significant for the local soils.

The data on soils of central chernozem Russia in the literature are considerably more extensive. As early as 1851, Petzholdt supplied several interesting items of information on chernozem of the Tambov Province. In the following year, "Mr. Astaf'ev, who investigated the chernozem soils in the Voronezh Province, writes in his manuscript of considerable differences in both physical and chemical properties and in productivity of the soil layer known as chernozem."

For this reason, Astaf'ev classified the chernozem soil of the Voronezh Province into the following five groups, with certain subdivisions, as follows:

Group I. Clayey chernozem:
- a. moderately clayey chernozem
- b. viscous " "
- c. solonetsous " "

Group II. Loamy chernozem:
- a. floury loamy chernozem
- b. soft " "
- c. sandy " "
- d. brown " "

Group III. Calcareous chernozem:
- a. chernozem with a high lime content
- b. " " " medium lime content
- c. " " " low lime content

Group IV. Sandy chernozem:
- a. slightly sandy chernozem
  1. brown
  2. gray
- b. sandy chernozem
  1. brown
  2. gray
- c. chernozemic sand
  1. brown
  2. gray
  3. chernozemic gravel

Group V. Silt:
- a. loose, rich silt
- b. clayey silt
- c. ferruginous silt

[1] Sintsov, Geologicheskii ocherk Saratovskoi gubernii (Geological Description of the Saratov Province), p. 34.

[2] In our opinion, the examples of southwestern Russia and the Nizhni Novgorod Province previously cited are so convincing and typical that further explanation and argumentation regarding the genetic relationship between bedrock and deposit are unnecessary.

Astaf'ev's terminology is based on the principal properties of soils as evident from the table presented on the following page.[1]

According to Astaf'ev, the soils poorest in humus are chernozemic sand and ferruginous silt, while those highest in humus are floury loamy chernozem (up to 15% humus) and moderately clayey chernozem (up to 14% humus). He discovered up to 4% saltpeter (?) and 8% common salt (?) in the solonetsous chernozem and up to 44% calcium carbonate in medium-calcareous chernozem; the content of $CaCO_3$ in chernozem with a low lime content is still higher.[2]

It is interesting that the very close genetic relationship between the character of soils and topography and parent rocks was discovered in the Trans-Volga Territory earlier than in any other territory.

As early as 1853 Wangenheim von Qualen[3] noted several very instructive instances of such relationships. After remarking that the Gorodishche District (Penza Province) and the Korsun District (Simbirsk Province) are composed of several high, dry plains (a) and chains of small hills (b) with depressions between them (c), and mentioning that the subsoil in all these territories belongs to the Cretaceous formation,[4] Wangenheim von Qualen describes the local soils: "Chalk and white chalky marl with sand and small grains of quartz outcrop on the hill summits and slopes; by action of annual rains and springtime waters, the sand (?) and calcareous particles are washed off the mountain tops and slopes downward to become mixed with arable land at the foot of the mountains, producing a mass predominantly whitish in color"[5] (this is one kind of soil).

"On the hills (b), mountain slopes etc., Cretaceous rocks (in rare cases calcareous loam and sand) are overlain either by chernozem or by another soil such as loam, sand or marl; the soils in this territory are generally not very thick, often not exceeding 1 ft. In the case of areas varying in size of high-quality chernozem on heights, it is usually mixed with sand and chalk particles to a small or large extent"[6] (second kind of soil).

In contrast, "depressed localities (c), slightly rolling or flat areas are covered by black-chocolate chernozem of very high quality (third kind of soil) reaching 1 – 2 arshins [71–142 cm] in thickness in low areas. This chernozem is usually underlain by a loam more or less sandy in the upper horizon and several sazhens in thickness. In such low-lying areas, chernozem soil is of highest fertility, which is readily understood since the chernozem reaching these places is loosened by cultivation and transported with other generally fertile substances from more elevated places by atmospheric waters."[7]

[1] I reproduce this table since it is the only work I know of on soils of the Voronezh Province, and it provides excellent illustration of the technique used by local inhabitants for appraisal of their lands. Author.

[2] Zhurnal Ministerstva gosudarstvennykh imushchestv, part 44 (1852-1853), bibliography, pp. 5-7.

[3] Wangenheim von Qualen. Beitrage zur Kenntniss der schwarzen Erde in Russland (Tschernosem). [Bull. de la Société des naturalistes de Moscou, 1853, t. 26, N. I.] This booklet merits closer attention than has been its lot previously, since it is one of the best works on chernozem in its precise and accurate observations and its ingenious and logical explanations.

[4] At present, Tertiary formations are also known in this territory.

[5] Ibid., p. 31.

[6] Ibid., p. 31.

[7] Ibid., p. 32.

Name of soil	Color of soil		Tactile qualities		Smell	Thickness of soil	Subsoil	Appraisal according to fertility
	wet	dry	wet	dry				
1. Moderately clayey chernozem	Black and black-brown	Dark gray	Soft	Gritty	Clayey	8–16 vershoks [35–70 cm]	Clay or marl	5
2. Viscous chernozem	Black or black-brown	Brown and dark brown	Somewhat coarse and viscous	Not gritty	As above	–	As above	9
3. Solonetsous chernozem	Dark brown	Gray brown	As above	–	As above	4–8 vershoks [17–35 cm]	Marly clay	14
4. Heavy loamy chernozem	Black	Dark gray	Neither greasy nor nongreasy	Readily crushed	Chernozemic	–	–	3
5. Soft loamy chernozem	As above	Dark brown	Delicate and slimy	Nongreasy but soft	As above	–	–	6
6. Sandy loamy chernozem	As above	As above	Soft	Nongreasy and soft	Weakly chernozemic	Up to 16 vershoks [70 cm]	–	8
7. Brown loamy chernozem	Dark brown	Brown	As above	Readily friable	Weakly chernozemic	8–12 vershoks [35–53 cm]	–	10
8. Calcareous chernozem	Dark brown or black	Grayish-brown	As above	Nongreasy	Chernozemic	4–16 vershoks [17–70 cm]	Chalk and marl	4
9. Medium calcareous chernozem	Dark brown	Brown	As above	As above	Weakly chernozemic	8–10 vershoks [35–44 cm]	–	11
10. Chernozem with a low lime content	As above	Grayish	As above	As above	–	4–6 vershoks [17–26 cm]	Chalk	15
11. Brown slightly sandy chernozem	Black	Dark brown or gray	–	Gritty	Weakly chernozemic	8–10 vershoks [35–44 cm]	–	7
12. Gray slightly sandy chernozem	Black	Dark gray	Soft	Soft	Weakly chernozemic	Deep	–	
13. Brown sandy chernozem	Dark brown	Brown and gray-brown	As above	Somewhat stiff	–	8–10 vershoks [35–44 cm]	–	12
14. Gray sandy chernozem	Black	Gray	–	–	–	Deep	–	
15. Brown chernozemic sand	Dark brown	Light brown	Nongreasy	Stiff and friable	–	6–8 vershoks [26–35 cm]	Sand	13
16. Gray chernozemic sand	Dark gray	–	Very nongreasy	Very coarse and friable	–			
17. Chernozemic gravel	Reddish-brown	Reddish-brown	Friable	Friable	–		–	16
18. Loose [illegible] silt	Gray	Light brown	Coarse	Somewhat friable	–	4–8 vershoks [17–35 cm]	Mixed with white sand	1
19. Clayey silt	Dark brown	Reddish-brown	Viscous	Fairly stiff	–	–	–	2
20. Ferruginous silt	Dark	Brown-yellow	As above	Stiff	–	Deep	–	17

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However, "this chernozem decreases in thickness and fertility higher up the slopes, with a concurrent variation in admixture of mineral constituents (fourth kind of soil); the black-chocolate color of chernozem becomes progressively lighter and the soil itself becomes less fertile until forming a transition to non-cultivated calcareous marl."[1]

Finally, this territory "also contains perfectly flat (high, dry ?) localities with broad fields, excellent and extremely fertile black earth (fifth kind of soil). However, the soils are again nonuniform as regards mineral composition and fertility. With predominant sand and fine calcareous particles the soil is dry and pulverulent; with an admixture of loamy marl, the soil becomes more viscous and compact and more difficult to cultivate; in many localities chernozem forms a transition to true loamy, sandy, and marly soils (sixth soil type), in no way similar to chernozem and not differing in color from similar (northern sod ?) soils in other countries. Nevertheless, this soil has been cultivated by peasants without any manuring for countless years, and often produces yields fourfold and sixfold the amount of seed in a good year, with propitious rains; yields eightfold the amount of seed may be obtained depending on the quality of the soil."[2]

Although the author does not suggest an explanation for the phenomenon of transition of chernozem to other soils on level areas, it will be made clear that it is certainly due mainly to a change in the subsoil. Since such transitions are largely observed on elevated plains[3] the unfavorable effect of topography and of flowing atmospheric waters[4] must be taken into account.

Detailed observation of the Volga area will convince the reader that this is the best general scheme for the distribution of soils in hilly localities under the circumstances.

Prof. M.N.Bogadanov's work "Birds and Mammals of the Chernozem Zone in the Volga Area and in the Valley of the Middle and Lower Volga" (Ptitsy i zveri chernozemnoi polosy Povolzh'ya i doliny srednei i nizhnei Volgi) is of considerable interest. One of the aims of this work was to correlate the geography of birds and mammals on this territory with the different geological ages of the chernozem and nonchernozem Russia; thus, first attention was paid to the nature and distribution of soils in the Volga area. After a personal examination almost throughout the right bank of the Volga, Prof. Bogdanov arrived at the following grouping of local soils and steppes (which is not in complete agreement with the opinion of his predecessors Wangenheim and Sintsov).

A. "Belt of former oak and linden forests with loamy chernozem on Permian sediments; this is the marginal area of the chernozem zone lying on the bank (?)[5] which is gradually separated from the rest of the chernozem...; this region has never had (?) feathergrass steppes." These are the southwestern districts of the Kazan Province.

B. "Chernozem feathergrass steppes begin at the boundary of the Kazan and Simbirsk provinces, with the appearance of Jurassic sediments. The steppes proceed into the Saratov Province through the eastern belt of the Simbirsk Province. The steppe itself (chernozem, feathergrass) is of two types:

[1] Ibid., pp. 31-32.

[2] Ibid., p. 32.

[3] Ibid., p. 33

[4] See above, on Belgorod soil.

[5] Bogdanov. Ibid., pp. 27-28.

"a. On Jurassic clays of Buinskii and on atmospheric clays between the Khoper and the Medveditsa the steppe is nearly treeless and covered by a thick layer of rich, viscous chernozem, cracking when dry;

"b. on chalk, the steppe is considerably more forested, drier, and covered by a relatively thin layer of chernozem with totally different properties."

C. Moreover, "at the center of chernozem steppes, at 53° latitude, there is an elevated region of pine 'bors' of the Tertiary basin and of the Zhiguli Mts of strong forest character. This character is retained by the upper portions (also Tertiary) of the hilly ridges in the Saratov Province."

D. "In the south, the chernozem feathergrass steppe forms a direct transition to a steppe, feathergrass although chernozem-clay, and this merges in turn with the clayey sagebrush steppe with no distinct boundaries."

The belt of loamy chernozem (A) has been discussed above, and the clayey feathergrass and sagebrush steppes (D) will be included in Chapter VI; we shall now dwell exclusively on the chernozem feathergrass steppe (B) and on the belt of pine "bors" (C).

Prof. Bogdanov divides the chernozem feathergrass steppe into two types, the first one in the northeastern part of the Simbirsk Province and in the southwestern part of the Saratov Province, which are virtually the opposite ends of the territory.

The northeastern part of the Simbirsk Province is described in the following manner: "At the latitude of Simbirsk Jurassic clays appear, causing a sharp change in the soil and topography. The (chalk) hills and hummocks disappear. The wide, level water divides are covered by a thick layer of rich viscous chernozem (up to 1.5 – 1.? m thick). Young oaks are visible in places on water divides, amidst the remnants of the feathergrass steppe. At present, nearly all steppes in the Simbirsk Province have been plowed up, although 10 – 15 years ago several large plots (government property) of the unplowed virgin steppe seen by Pallas and Lepekhin a hundred years ago still existed. The true boundaries of steppes cannot be indicated because the country has been completely altered by agriculture; generally speaking, steppe characteristics predominate in the following localities: on the ridge of the right bank of the Volga between Akhtusha and Simbirsk, in the northern part of the Sengilei District west of the Sviyaga, throughout the Simbirsk District, in the northern half of the Korsun District and in the eastern half of the Buinskii District. O.O. Baum and I found no reliable evidence of steppes west of the Sura. Large areas on ridges of chalk hills in the Ardatov District are covered by young deciduous forests, including ash, growing on a chernozem layer reaching 0.6 m in thickness. In the lower portions of slopes and on level areas chernozem reaches 0.6 – 0.9 m in thickness. It is black, viscous, and dense. In certain places, such as between Atyashevo and Paranei, it seems to overlie peat in closed depressions. Popular tradition as well as historical data (?) indicate that this area was covered in former times by continuous oak forests.

"The Buinskii chernozem steppe is bounded in the northwest by a mixed pine and spruce 'bor' growing on post-Tertiary deposits of the Sura River valley. In the north, the steppe boundary may be regarded as the Bula River and the general boundaries of the Jurassic formation."[1]

[1] Bogdanov. Ibid., p. 24.

The author thus definitely correlates this part of the chernozem steppe with the boundaries of the Jurassic formations as depicted on Wagner's map.[1]

A similar relationship between the character of chernozem and its substrate is perceived by Prof. Bogadanov in the southwestern part of the Saratov Province as well: "the area between the Medveditsa and the Khoper (within the Saratov Province) is a broad elevated plain imperceptibly sloping toward the rivers. Rills and walls of 'balkas' display brown-yellow clay (on chalky marls), in turn overlain by a layer of rich, black, viscous chernozem reaching 1.6—1.8 m in thickness. Treeless steppes with luxuriant feathergrass occupy the entire plain (northwestern part of the Kamyshin District, southwestern part of the Atkarsk District and the eastern half of the Balashov District). Small groves of deciduous trees occur only in 'balkas' and river valleys, such as the valleys of the Tersa, Talovka, and Arkadak rivers. In one deep 'balka', on the right of the Arkadak River, a very dense old grove of oak, linden, aspen, and birch with an admixture of maple, box elder, wartybark evonymus (Evonymus verrucosus), buckthorn (Rhamnus cathartica), blackthorn (Prunus spinosa), dogrose (Rosa canina), raspberry (Rubus idaeus), and even bramble (Rubus saxatilis) occurred on chernozem steppe."[2]

"During my descent from this level area, I noticed the sides of gullies or 'balkas' and river valleys to be either covered by a thick layer of chernozem down to the bottom of the valley (the floodplain) when the 'balka' was mostly overgrown by deciduous forest (in steppes of the Balashov District), or chernozem did not extend far downslope, and the soil of the lower part of the slope as well as on the valley bottom (but not of the floodplain) consisted of clay and was overgrown by different species of small aromatic steppe sagebrush (Artemisia austriaca, etc.). Further toward the south of the Saratov Province the phenomenon became more pronounced. Chernozem gradually receded toward the upper portions of hills, and ridge crests, became thinner, took on a brownish tinge, and finally lost its typical black color, forming a transition to brown clay colored by humus; sagebrush and other short steppe grasses accompanying it became predominant, replacing feathergrass, dwarf almond,* ground cherry, etc."[3]

"Northward, the steppe (feathergrass, chernozem) plain abuts on a small scarp along the right bank of the Iznair River, in some places overgrown by birch groves. Similar elevations occur further east, near Belgaza, where the terrain becomes hilly and gradually rises northward. The level steppe clay subsoil is replaced by chalky marls on which chernozem is no longer as thick and as rich as before. Birch groves appear on ridges and hilltops, alternating with steppes which occupy all the gently sloping and level areas.

The plain disappears after Petrovskoe. The terrain becomes more elevated and criss-crossed by chains of hills. The upper portions of the hills display Tertiary sands on chalk, and pine appears in the birch forests between Chunaki and Klyuchi. A purely pine 'bor' occurs near Vyrypaevskaya."[4]

[1] Wagner. Karta pochv Simbirskoi gubernii (Soil Map of the Simbirsk Province).

[2] Bogdanov. Ibid., p. 23.

* [Amygdalus nana, also known as Russian almond. Translator.]

[3] Ibid., p. 20.

[4] Ibid., p. 23.

The second type of chernozem feathergrass steppe is quite different in character. "One glance at the steppes and forests on chalky marls is sufficient in order to notice the poor nutritional conditions for plants. Weak, small, and dry steppe grasses, stunted and gnarled trees impart to the steppe vegetation and the forest an appearance of soil poverty, leading to inhibited development.

"This impression is strengthened by an examination of the soil of this steppe. The chernozem is generally thin (no thicker than 0.7 m), gray, friable, and mixed with bits of marls; it is not converted to a thick, sticky mud like chernozem of the rich steppes. The fertility of this chernozem is also low."[1]

The following two examples are cited to increase knowledge of these steppes.

"South of Syzran the feathergrass steppe attains its full typical beauty. White chalk beds which form the subsoil throughout the trans-Syzran steppe (as termed by Mr. Lipinskii) impart the steppe a special character. The level white chalk surface bears lone rounded cones reaching 50 m in height by visual estimation, known locally as 'otmal' or 'votmal'. The territory is incised in places by shallow gullies formed due to atmospheric water. The 'otmals' are mostly covered by small deciduous trees (oak, birch, aspen) on a thin layer of chernozem. On the slopes of 'otmals' from which forest has been cut down the chernozem has been washed away by the rains, the white chalk appearing on the surface. Level steppe areas and gentle slopes of the 'otmals' and gullies are covered by a layer of chernozem reaching 0.5–0.7 m in thickness and are overgrown by typical steppe vegetation. The major part of these steppes is under cultivation, although plots of virgin steppe of considerable size are found on Davydov's estates near Maza). Feathergrass steppe with a thin chernozem layer over white chalk as the surface stretches further south in the Khvalynsk and Vol'sk districts. 'Otmals' of white chalk are also found here, on the right side of the River Tereshka."[2]

The author also observed identical country at another point in the Volga chalk steppe. "Between the northern boundaries of the Tertiary region[3] and the latitude of Simbirsk, as well as on the upland bank of the Volga from Klimovka to Simbirsk there lies a belt of the Cretaceous formation. Its upper member, white chalk, appears on the surface over large areas and forms the subsoil which is identical to the subsoil we observed in the northern belt of the Saratov Province; it is overlain by a black-gray non-greasy chernozem of moderate thickness (up to 0.6 m). In many places the chalk slopes are totally devoid of chernozem. The topography throughout is the same as in the above described territory with lone rounded hills, their slopes furrowed. Here they are known as 'shishka' and 'bugor' ['bulges' and 'hummocks'] and are overgrown by birch, aspen and oak.

"On the whole, forest is more widespread on this territory than in the Saratov dry steppe. As in the latter, remnants of feathergrass steppes, with their typical plants (ground cherry and dwarf almond) occur everywhere on level areas."[4]

[1] Ibid., p. 19.
[2] Ibid., pp. 18–19.
[3] Wagner's map presents this as the approximate latitude of Sengilei.
[4] Ibid., pp. 23–24.

For understandable reasons, the region C (pine "bors") is limited to the sandy "islands" already mentioned (see p.245) dating to Tertiary and partly also post-Tertiary periods.[1]

An especially detailed description is provided by Prof. Bogdanov for the largest of these "islands" (Tertiary) extending over the southwestern part of the Simbirsk Province, the eastern part of the Penza Province and the northwestern part of the Saratov Province.[2]

According to Prof. Bogdanov, "this Tertiary basin is one of the highest places in the Volga area. Its center may be determined as that region including the sources of the Sura, Barysh, Syzran, and Sviyaga rivers and their tributaries. Generally speaking, this is an elevated plateau incised by many deep more or less parallel valleys; the terrain takes on the appearance of regular parallel series of hills. This feature conditions the soil and other local characteristics since hilltops consist mainly of quartz sand, outcroppings of which are also seen on steep slopes where it alternates with clays and hard sandstone beds.

"These sandy ridges are occupied by pure pine 'bors' with only insignificant traces of humus in the upper portions of the soil.

"Further down the gentle slope, the sand is replaced by rich yellow-brown clay, covered by a thick layer of black-gray friable chernozem. Concurrently with the replacement of the sand by clay, the pine begins to be admixed with deciduous species -- first birch, and then oak, elm, linden, filbert, etc; as a result, pine disappears, so that the valley bottoms are covered only by deciduous forests on chernozem soils; such forests used to grow in the valleys of all the rivers which originate here. The deciduous forests in the lower portions of slopes have long since been replaced by cornfields; nevertheless, remnants of these formerly continuous thick forests are noticeable in many places.

"Kettle lakes, in all phases of overgrowing and conversion to peat bogs and dry peat deposits, occur between hills and generally in all depressions on hill slopes. True deep kettle lakes usually occur in depressions between hills amidst pine 'bors'. Their number is not large, and most have already become peat bogs differing in degree of moisture."[3]

According to Prof. Bogdanov, a considerable part of such "islands" are still covered by pine "bors", and "bors" "although with a strong admixture of deciduous species, also occur amidst chernozem steppes in the Khvalynsk, Petrovsk, Vol'sk, and even the Saratov districts."[4]

On a "ridge between the village of Cheushi and Kulatka station in the Khvalynsk District" Bogdanov and Baum found a pine which grew unusually, on "black-gray chernozem"; however, closer inspection revealed that the "chernozem humus" was only 0.20—0.25 m thick, while the "pine roots were anchored in the white chalky marl."[5]

Studies of soils in central chernozem Russia must take account of the above data and of the soil maps compiled by the cadastral groups for the

[1] Ibid., p. 9.
[2] According to Wagner's map. See also p. 9.
[3] Ibid., p. 8.
[4] Ibid., p. 11.
[5] Ibid., p. 11, see also pp. 12-16.

Khar'kov, Voronezh, Tambov, Simbirsk, Penza, and Saratov provinces.[1]

Each map need not be dealt with separately, a summary of the data derived from them follows.

Chaslavskii depicts the following nine principal soils for central chernozem Russia: a) ordinary chernozem (north of 53° latitude in the Penza, Simbirsk, and Tambov provinces and partly the Khar'kov Province); b) loamy chernozem (south of 53° latitude in the southern part of the Penza Province, in the larger part of the Saratov Province, in the northern Trans-Don steppes, territory of the Don Cossacks, and the larger half of the Voronezh Province); c) rich chernozem (southwestern half of the Tambov Province, southeastern portions of the Ryazan, Tula, Orel, and Kursk provinces). The following types are much less widespread: d) clayey chernozem (an "island" in the Ekaterinoslav Province and two "islands" in the Saratov Province and in the territory of the Don Cossacks, one of them just west of the Tereshka River and the Volga at Saratov, the other between the Medveditsa (lower reaches) and the Volga; e) calcareous chernozem (a narrow long "island" along the right bank of the Don, from Ostrogozhsk to Boguchar, slightly to the south); f) sandy chernozem in "plavni" (along the left bank of the Khoper and the Don, from Uryupinskaya and Boguchar to Kalach); g) sands (in the nearest neighborhood of the Donets, Oskol, Sura, and especially Voronezh and Tsna rivers; h) northern loams (mainly in the Gorodishche District); i) floodplain meadows along the rivers.

A comparison of Chaslavskii's data, given above, with the geological map of central chernozem Russia as well as with the works cited above by Wangenheim von Qualen, Sintsov, Bogdanov and others, reveals absence of any correlation. This circumstance is sufficient to divest the 1879 map of any significance.[2] This is even more obvious on the basis of the following detailed description of certain areas in central chernozem Russia.

Verkhov'e — Livny — Shchigry — Okhochevka

I shall begin with territories lying on the boundary between southwest and central chernozem Russia, which form a natural transition between the two areas.

Leaving from the Verkhov'e station, mentioned above (p. 110), I travelled by rail to the town of Livny, and then proceeded via Evlanovo to Shchigry and Okhochevka.

The territory is almost throughout of steppe nature, except for the section Shchigry — Okhochevka; it is almost perfectly level, and the trend increases southward; hardly any flowing water, forests, and meadows are visible, and only the chernozem fields stretch to the horizon.

It was impossible to determine the southern boundary between Devonian limestones and marls, and purely Cretaceous formations, on the basis of

[1] Kartografiya russkikh pochv (Cartography of Russian Soils), pp. 6, 14, 35, 546, etc. 1879. Soils of the territory of the Don Cossacks were copied by Chaslavskii "from a map available at the Administration of irregular troops [Cossacks]." It may be added that in Saratov (1878) I saw a soil map of this province compiled by one of the officials at the local bank; it is distinguished by extreme patchiness and was based exclusively on evaluations made for mortgage purposes. Author.

[2] It will be made clear below that exceptions should be made for sands and floodplain meadows. Author.

the local soils' appearance, thickness and color[1]; the more rolling terrain west of Shchigry may indicate the appearance of more readily erosible chalky marl in the subsoil.

As in the Chern and Novosil districts, the route I took through the Livny District traversed an apparently typical chernozem, reaching 2 ft [61 cm] and more in thickness, almost everywhere directly overlying weathered Devonian limestones and marls which are of definite loess appearance at their point of contact with the soil; no boulders were encountered. I took a chernozem sample from such a site 1 1/2 versts southwest of Livny, 2 ft [61 cm] thick and with 8.06% humus.

Nevertheless, the Livny District should be assumed to contain younger bedrocks than the Devonian formation, contrary to former opinion. Messrs. Domger and Gurov also succeeded in establishing the presence of Jurassic rocks "in the banks of 'balkas' or uplands remote from rivers."[2] Domger observed one section of such a formation on the boundary between the Livny and Maloarkhangel'sk districts at the village of Evlanovo, or Timki. Here, "the uppermost portion of the exposure, directly under chernozem, consists of white and yellow loose sands with lumps of ferruginous sandstones and an intercalation of blue clay overlying Devonian limestone, the latter containing A u l o p o r a s e r p e n s."[3] A sample of chernozem which I took at one such locality in 1881 was up to 2 1/2 ft [76 cm] thick but contained only 4.607% humus; the cause is readily understandable...

En route from Evlanovo to Shchigry and further to Okhochevka the region is still undoubtedly of the Cretaceous formation and the chernozem appears unchanged; however, bedrock outcropping on the surface consists of alternating green sands[4] and chalky marl.[5] The local loess[6] and the chernozem itself are thus far from being uniform, and are alternately sandy and loamy The sandy kind is represented by a chernozem sample in my possession, taken at a point 11 versts east of Shchigry; the second is represented by the Okhochevka soil. Although approximately equal in thickness, the Shchigry chernozem contains only 3.812% humus as against 7.301% humus in the Okhochevka chernozem.

Thus, the presence of rich chernozem in the Orel and Kursk provinces (see Chaslavskii's map) again becomes highly doubtful. The information given by local inhabitants to form the basis of this map is only verified by the relatively very dark color of soils in the Livny and Shchigry districts, especially when wet.[7]

[1] According to the recent investigations of Prof. Levakovskii and Mr. Domger, this boundary almost coincides with the boundaries of the Livny and Shchigry districts. D o m g e r [V. A.]. Geologicheskie nablyudeniya, proizvedennye [v 1876 g. v Livenskom] uezde [Orlovskoi gub.] i v pogranichnoi s nim chasti Shchigrovskogo uezda, Kurskoi gub. (Geological Observations Performed [in 1876 in the Livny] District [of the Orel Province] and in the Adjacent Part of the Shchigry District of the Kursk Province), p. 3. – [Gornyi Zhurnal, St. Petersburg, Vol. 2, 1878, separate reprint.]

[2] Identified by Gurov. Ibid., p. 24J.

[3] D o m g e r. Ibid., p. 9.

[4] and [5] Ibid., pp. 6, 16, etc.

[6] In deposits of the Shchigry and Timki [Tim] districts Prof. Borisyak fairly often found fragments of limestone with excellent fossils of S p i r i f e r m o s q u e n s i s. B o r i s y a k. Ibid., p. 162.

[7] To complete this discussion of the territory, it should be noted that chernozem may overlie decayed peat or podzol here as well. D o m g e r. Ibid., p. 11.

Nikol'skoe — Staryi Oskol — Endovishche Voronezh — Grushevka

The entire territory from the Nikol'skoe railroad station (between Belgorod and Kursk) via Staryi Oskol, Nizhnedevitsk to the Turovo station (Nizhnedevitsk District) is strongly undulating, with endless rows of "balkas", partly of the Aleksandrovsk type, and with very rare small deciduous groves.

The geological structure is generally of the Belgorod type, with very frequent outcrops of chalk and chalky marls (especially at Staryi Oskol). From the vicinity of Nizhnedevitsk the chalk is covered in places by isolated sandstone "islets" of younger age. On the other hand, Tertiary sands stretch continuously south of Endovishche. The deposits are thin (1 — 3 arshins [0.7 — 2.1 m], seldom more) weathering products of the underlying bedrock; in some places the deposits are typical "white eye" with abundant calcareous concretions, while in other places the latter are absent. Large admixture of chalk pebbles is often visible in the deposits lying on hillsides but no crystalline boulders are encountered.

Just before the Turovo station and thence to Endovishche the typical loamy loess becomes appreciably thicker, often reaching 20 — 30 ft [6.1 — 9.1 m] and more in thickness; it is abundant in pebbles of local rocks and sometimes contains small (reaching 1/2 ft [15 cm] in diameter] boulders of diorite and Shoksha sandstone as well. Between Turovo and Endovishche the diluvial formations form an almost continuous blanket over the entire high, level territory; no chalk rocks are visible along the way.

The soils en route from Nikol'skoe to Endovishche are extremely varied and yet almost conformant to Wangenheim von Qualen's scheme, discussed above. Chernozem is almost totally absent from the steep as well as from the rather flat chalk ridges, covered by chalk pebbles mixed either with a gray, loose, marly mass or with thin (1/2 — 1 ft [15 — 30 cm]) yellowish red marl, the weathering product of chalk. Chalk usually appears on the surface of steep slopes (approximately 45°). Chernozem reaches a thickness of 4 ft and more [1.2 m] in some places, at the foot of gentle slopes (approximately 45°). As usual, normal chernozem occurs only on level areas; it is approximately 2 — 2 1/2 ft [61 — 76 cm] thick in the western half of the route, reaching 3 ft [91 cm] and more in the eastern part (between Turovo and Endovishche). However, I took a sample at Astanino (Timki [Tim] District, 35 versts east of Nikol'skoe) from a perfectly level area, which contained only 4.365% humus. The sample proved to be of sandy-loamy nature and is probably underlain by the same ro·'· as the Belgorod chernozem.[1]

Soils of Endovishche, Zemlyansk District[2] exhibit a different pattern.

Such geologists as Murchison, Gel'mersen, Pacht, and Barbot de Marni investigated the environs of this village, and I shall therefore only remark that the local outcrops of chalk and chalky marl are covered almost throughout by typical light-yellow loess, reaching 15 ft [4.6 m] and more in thickness.

[1] The perfectly level terrain did not permit a study of the underlying strata. Author.

[2] Academician Gel'mersen describes the highway from Elets to Zadonsk as traversing "fairly level, slightly rolling terrain covered by chernozem over vast areas"; on the other hand, the route from Zadonsk to Voronezh, consistently following the "left slope of the Don valley" is sandy, and "chernozem here occurred only in some places while the birch and oak forests became more frequent." Gel'mersen. Ibid., pp. 47-49.

I observed that the local loess in the Endovishche gullies (in a cellar dug in my presence on a perfectly level area at the mail coach station) is abundant in lime nodules ("dutiks"), small rare boulders of granite and diorite and numerous various krotovinas down to a depth of 8 ft [2.4 m]. The Endovishche loamy chernozem is black, and velvety in appearance, over 3 ft thick: it contains 11.427% humus.

Almost directly south of Endovishche, en route to Voronezh and farther, approximately to the latitude of Slavyanoserbsk[1] (along the Rostov railroad) there begins a continuous region of partly Tertiary and partly eluvial sands and sandy loams of the basins of the Don and Donets rivers. The Tertiary products are especially clear in the immediate vicinity of the town of Voronezh, on the high right bank of the Voronezh River. Here, a steep slope drops from a peak of 200 ft [61 m]; the Voronezh River is deflected and splits in two at the foot of this slope, surrounded right and left by abandoned oxbows. The entire slope (as revealed by a well 189 ft [58 m] deep) consists of cinnamon-yellow compacted fine sand, horizontally bedded and containing no organic residues... The left bank of the Voronezh, however, is flat and low; the soil (surface ?) of the valley is level, gradually rising eastward, appearing as a steppe covered by fertile fields and chernozem.[2] The soils are of course gray and very sandy in the vicinity of Voronezh as well as en route from Voronezh to Endovishche up to the Don.

In 1877, I made a side trip from Voronezh to Usman (a railway station on the way to Kozlov). P.A.Solomin, my companion on the 1878 excursion, also examined this area. According to Solomin, "it is almost continuous sand, which has displaced chernozem and given rise to a mixed forest (oak, pine, etc.)." The northwestern part of the Voronezh District, between the Usman River and Voronezh, was in fact very recently occupied almost throughout by a continuous forest.

The territory between Voronezh and Grushevka may be divided into two very unequal portions, the larger, northern portion approximately up to Kamenskaya at the Donets and the smaller, southern portion between Kamenskaya and Grushevka. The northern portion is almost entirely in the region of sandy Tertiary rocks while the southern portion occupies the region of Carboniferous limestones and bedded clays. The northern portion is slightly better forested than the southern one. Although only minor oak woods are visible along the way I took, on the basis of the local sandy ground and the small pine "bors"[3] still found in the immediate neighborhood of the Khoper River on the one hand and between Izyum and Slavyansk on the other hand, the area may be assumed to have borne coniferous forests in the past.[4]

These circumstances obviously profoundly affected the soils of these two territories. Indeed, almost throughout the area between the Voronezh and Donets rivers the soils are very sandy, gray and contain no more than 6% humus. This is shown by samples taken at Mikhailovka (Boguchar District) and Glubokaya (Don Cossack Territory, first station north of the

[1] Gurov. Ibid., pp. 328, 429, 438, etc.; also see Gel'mersen's map.
[2] Gel'mersen. Ibid., p. 50.
[3] Rudzkii. Ibid., p. 177.
[4] The reader is referred to Mr. Palimpsestov, ibid., p. 18, on the former occurrence of forests in the basin of the Don and the Donets.

Donets) where the humus contents are, respectively, 4.451% in the Mikhailovskaya sample and 5.647% in the Glubokaya sample. Such a vast territory undoubtedly contains soils which are richer in humus; this is demonstrated, inter alia, by chernozem from Rossosh, Ostrogozhsk District, containing 7.959% organic substances (made available by Mr. Shul'gin), and from the region directly south of Millerovo station; nevertheless, the predominant soils are of the Mikhailovka and Glubokaya type.

We encountered completely different soil relationships between Kamenskaya and Grushevka in the region of the Carboniferous formations. The ideal section (Figure 8) discloses a slightly rolling terrain (at least along the Rostov railroad) the undulations obviously of different origin than in the region of the Cretaceous formation. Those undulations south of the Donets River are largely an effect of the folded Carboniferous bedrock (C — bedded clays, sandstones, limestones), while in the Cretaceous region they originated due to surface erosion. In the first case the surface depressions are often almost enclosed, one side much higher than the other three; in the second case, they all form regular networks of "balkas" and gullies.

FIGURE 8. A. Soils; B. Weathering products of bedrock, often containing undecomposed fragments of the latter; C. Bedded clays, limestones, sandstones.

Figure 8 also shows that the summits of Carboniferous hills, usually consisting of "heads" (hummocks) of bedrock, are very often totally devoid of any weathering products, since these products were obviously washed off into the various hollows where they may reach a thickness of 10—20 ft [3—6.1 m] and more (B).

These atmospheric formations are usually a blood-red, extremely viscous, sometimes marly clay, abundant in rolled white, black, and even green inclusions. Any possibility of (foreign) deposit is totally excluded. This structure is especially pronounced between the Kamenskaya and Likhaya stations, and Cherevka and Sulikha. In contrast, the terrain on intervening spaces is appreciably more level although the subsoil is unchanged.

The distribution of soils naturally echoes the distribution of bedrock. The "heads (hummocks) of Carboniferous strata (see Figure 8) are devoid of soils, or soil appears as a grayish-brown mass 2—3 in [5—7.6 cm] thick and quite rich in undecomposed bedrock fragments. On the other hand, chernozem in lowlands and deppressions between hills reaches 2 ft [61 cm] and more in thickness, and on level areas it is about 1 1/2 ft [45 cm] thick. I took a sample of such chernozem (from level steppe) approximately 2 versts north of Grushevka. The local soil is 1 ft 8 in. [51 cm] thick, and its humus content is approximately 7%. The general impression gained of the soils occurring south and north of the River Donets is recorded in my travel log as follows: "The chernozem is of medium quality, with continuous variation of color and thickness, and is often completely absent." This phenomenon is certainly caused by the presence of Tertiary sands and sandy loams in the north and the presence of very heavy clayey weathering products of Carboniferous rocks in the south.

Gryazi — Borisoglebsk — Tsaritsyn

The entire section of the railroad between Gryazi and Tsaritsyn traverses a fairly level terrain which steadily and gradually descends southeast toward the Caspian Sea. With the exception of the immediate environs of Gryazi (Devonian), Tsaritsyn, and one "island" just north of the Medveditsa River (both Tertiary), the belt lies in the region of the Cretaceous formation. However, bedrock outcrops are very rare on this level terrain, while gullies and river banks display only post-Tertiary formations. My investigations in the vicinity of Gryazi, Volkonskaya, Filonovo and Arched showed that the post-Tertiary formations approximately up to the Arched River (southern tributary of the Medveditsa in the Don Cossack Territory) consist almost exclusively of typical yellowish-red loamy loess, sometimes with a fairly considerable content of crystalline boulders reaching 1 1/2 ft [45 cm] in diameter. South of this district to Tsaritsyn stretch the red-brown loams described by Sintsov, sometimes bearing salt efflorescences on their surface but lacking boulders. However, the transition between these two kinds of deposits is extremely gradual and the differences between them (except for boulders and marine salts) are very indeterminate. We encountered a sandy or sandy-loamy ground only in the Tertiary "island" mentioned above between Kachalina station and Ilovlya, north of Ternovka.

The following description of a typical exposure, seen in Krasnyi Yar gully, 7 versts southeast of Filonovo station in the Don Cossack Territory, will add to our knowledge of the predominant subsoil, boulder loess. The following section is visible on high but level steppe terrain very near the River Buzuluk (tributary of the Khoper).

A. Dark-gray loamy friable chernozem approximately 2 ft [61 cm] thick; in the section itself and in situ and on the adjacent fields as well I found a dozen granite pebbles the size of a nut and a fist.

B. A typical yellowish-brown loess loam with abundant $CaCO_3$ concretions and few krotovinas in the upper horizons, 15 – 20 ft [4.6 – 6.1 m] thick. In addition to siliceous and calcareous pebbles I found very numerous rounded crystalline gneiss, gray granite (medium grain) quartzite and diorite boulders, some reaching 1 1/2 ft [45 cm] in diameter. Local inhabitants reported that during the construction of the Tsaritsyn railroad, Krasnyi Yar provided crystalline boulders reaching 1 1/2 arshins [1.6 m] in diameter.

C. Bluish-gray plastic clay rich in variously colored specks, of indeterminate age (Eocene ?).

The soils along this route generally exhibited a strikingly gradual increase in humus content, intensity of dark color and thickness, from Tsaritsyn toward Gryazi. The diary of my companion, P. A. Solomin, has the following entry: "After the Tsaritsyn soil, which God himself seems to have parched, stretching over 100 versts northwest from Tsaritsyn, chernozem first seems to appear, indistinctly, at the bog station (110 versts from Tsaritsyn); however, the Arched station definitely lies on chernozem, although it is not very dark and does not exceed 1 1/2 ft [45 cm] in thickness." The chernozem becomes progressively more typical en route from Arched via Filonovo and Volkonskaya to Gryazi. This is clear from the following table of samples which I collected.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Gryazi, Lipetsk District[1]	Loam	Level plowland	3'7" [109 cm]	9.595	6.452
Volkonskaya, Borisoglebsk District	–	–	2'5" [74 cm]	9.148	[illegible].363
Filonovo, Don Cossack Territory	–	Level steppe	2'3" [69 cm]	6.667	3.663
Gorodishche, Tsaritsyn District	–	Level pasture	11" [28 cm]	2.536	5.127
Tsaritsyn	–	Virgin steppe	9–10" [23–25 cm]	0.908	1.081

[1] There are grounds to assume that the soils throughout the Usman District are not inferior to the Lipetsk soils. Sovetov. Soobshchenie 31 Oktyabrya 1886 (Communication of 31 October 1886), p. 3. [Sovetov, A. V. Kratkii ocherk agronomicheskogo puteshestviya po nekotorym guberniyam tsentral'noi chernozemnoi polosy Rossii v techenie leta 1876 g. (A Brief Description of an Agronomical Journey through Certain Provinces of the Central Chernozem Zone of Russia in the Summer of 1876). – Trudy VEO, Vol. 3, No. 4. St. Petersburg. 1876.]

Certainly, no more ideal regularity and continuity in variation of soil properties and their geography may be desired!

Throughout the vast territory between Gryazi and Tsaritsyn, the only exceptions are the sandy "islands" and rare forested areas already mentioned (seen while crossing the Medveditsa, the Buzuluk and the Khoper), where the soils are usually abnormally thin and colored gray. Another noteworthy feature along the route is the small depressions on dry high steppes. Near Gryazi, between Volkonskaya and Ternovskaya, between Yastrebova and Mordovaya, for instance, as in the vicinity of Nezhin, on dry, high, level, deep-chernozem steppe, in some places barely noticeable, very vaguely outlined closed depressions occur, with a light-gray vegetal layer usually 2 – 6 in [5 – 15 cm] thick. This layer was usually underlain by ash-gray podzolic very fine sand or glei. Such depressions sometimes contain insignificant tussocks. The local inhabitants and local topography provide evidence that the springtime [thaw] and rainwater are preserved in these depressions for much longer than in the surrounding steppe; this is the principal cause for the existence of such soil. However, bald patches of this sort are very small and cannot influence the general character of the surrounding, almost boundless, steppes.[1]

Kozlov – Tambov – Zubrilovka – Gurovo

In all these places, as well as on the intervening territory, the geology and climatic conditions remain largely the same as between Gryazi and Volkonskaya, thus enabling the chernozem to retain the same character. A very natural and, indeed, inevitable exception is formed only by sandy areas, where the sands lie on the surface. Sands are only located along the rivers of the area. Of this group are the sandy areas we observed on the banks of the Voronezh (in some places in the Kozlov District), on the banks of the Tsna (east of Tambov), and on the banks of the Vorona near

[1] Another interesting phenomenon occurs near Filonovo – interbedding of deposited chernozem with sands and glei transported by floods of the River Buzuluk. This phenomenon, of course, occurs exclusively within the alluvial river valley. Author.

Kirsanov; at the last point the sands even form fairly large dunes.[1] The Tambov sands are the most extensive, apparently stretching east of the Tsna over a distance of 25 – 30 versts and already overgrown in many places by pine forests. These sands are certainly partly diluvial and partly Cretaceous,[2] only slightly overwashed by the waters of the Tsna and by atmospheric waters.

The effect of these sands and of rivers on local soils was studied as early as 1877 by Prof. Sovetov in the Kozlov District, at the "Kozinki" estate of Mr Rakhmaninov.

"At this point on the right bank of the Voronezh, a large pine forest stretches... the left bank is occupied by fields with (a) sandy soils impregnated with chernozem; the sand is so deep that its bottom is reached with difficulty. However, as near the bank as 1 verst there is (b) the compact sandy chernozem, 1 arshin deep, underlain by a sandy layer which is in turn underlain by clay. The farther from the bank, the thinner the sandy layer becomes until the sand disappears altogether so that the chernozem layer rests directly on clay; at the same time, chernozem loses its sandy character, forming a gradual transition to (c) clayey chernozem."[3] These relationships, first pointed out to A.V. Sovetov by Prof. Rakhmaninov were [then] observed by Sovetov in many other localities. "For instance, on the River Motyr, one of the larger tributaries of the Voronezh, chernozem was found to lie on the sand as well, but at the 'Bychek' estate approximately 50 versts south of 'Kozinka', a very deep chernozem lay directly on a fairly plastic clay (used in this estate for brick manufacture)."[4]

Essentially the same relationships occur on the banks of the Vorona, at Kirsanov and east of the Tsna, at the latitude of Tambov. Chaslavskii's map, referring to the latitude of Morshansk, rightly depicts sands at this point, stretching just east of the Tsna, scarcely colored by humus; they are followed by gray, sandy soils; loamy chernozem gradually appears approximately east of Dubrovka. Boggy areas with strongly podzolic subsoil frequently occur amidst the sands; many of the local plowlands had a similar ashy appearance.*

Let us now deal with normal soils and ground, at the edges of the investigated territory. According to Prof. Sovetov's description, a freshly dug pit at Kozinki, Kozlov District made it very clear that the "upper chernozem layer was 1 arshin 8 vershoks [107 cm] deep. This layer is followed by a layer of sand, in some places rather strongly impregnated with chernozem, so that the laborers called it sandy loam. This sandy loam is thus the subsoil of chernozem. However, it should be noted that it is generally rather difficult to draw a definite boundary between soil and subsoil in chernozem since the bottom surface of the chernozem layer is not level but rather very irregular. In certain places chernozem may intrude to greater depths than the subsoil (?), creating rare pockets of chernozem in the

[1] Barbot de Marni. Geologicheskie issledovaniya v Simbirskoi, Saratovskoi i Tambovskoi guberniyakh (Geological Investigations in the Simbirsk, the Saratov, and the Tambov Provinces). – [Gornyi Zhurnal, Vol. 3, No. 8. St. Petersburg. 1874], p. 181.

[2] Ibid., p. 181; see also Kulibin. Ibid., p. 22.

[3] Sovetov [A. V.]. O chernozeme. Iz putevykh zametok (Chernozem. Traveller's Notes). – [Trudy VEO, Vol. 1, No. 1], p. 7. 1877. Evidently, we are dealing with eluvium. Author.

[4] Ibid., p. 8.

* [The term "podzol" is derived from the word "zola" meaning ash. Translator.]

ground [substrate] i.e., in clay, at 3 sazhens [6.4 m] and deeper. The organic substances must have been transported down by water, through krotovinas and similar holes, since chernozem could not conceivably have reached such depths. The sandy loam layer in this pit was 14 vershoks [62 cm] thick, underlain by clay which was not very plastic but rather consisted of small lumps and had low coherence, probably due to the still considerable admixture of organic substances"[1].

Even more interesting with respect to soils is the "Zubrilovka" estate, Balashov District belonging to Prince Golitsyn-Prozorovskii. This luxurious estate is situated in slightly rolling country on the picturesque banks of the Khoper, 6 – 7 versts west of the Sosnovka railroad station. From Prof. Sintsov's works[2] it is clear that near the village of Zubrilovka "on the right bank of the Khoper, the beds of variegated micaceous sand contain strata of the same sandstone (equivalent to the Saratov Upper Cretaceous clay ?) observed in the vicinity of Atkarsk and at the village of Sosnovka; in the same region, heaps of pink Shoksha sandstone occur in gullies, most probably eluted out of the reddish clay covering the rocks." The fresh section which I observed in 1877, in one of the gullies very near Prince Golitsyn's park, is informative; the constitution of this section is as follows:

A. Typical floury loamy chernozem with numerous krotovinas in the subsoil, 2 ft 6 in [76 cm].

B. Reddish-yellow "white eye" ("beloglazka") containing profuse nodules ("dutiks") and scattered crystalline boulders of diorite, red and gray medium-grain granite, pink quartzite, gneiss, and quartz. In identical loess, in a neighboring gully, the local inhabitants found fragments of mammoths tusks a few years ago; loess thickness was about 2 sazhens [4.3 m].

C. Layer B forms a gradual and quite imperceptible downward transition to gray marly clay, of unknown thickness, since the sides of the gully are concealed by talus where the clay outcrops.

D. At the very bottom of the gully, the sands and sandstones described above by Sintsov are exposed; in certain places they reach 3 sazhens [6.4 m] in thickness. The Khoper forms a most typical alluvial valley at Zubrilovka with numerous oxbow lakes and meadow soils.

I made an artificial section in Prince Golitsyn's natural old oak park on perfectly level terrain. The chernozem in this section reaches 3 ft [91 cm] in thickness and is totally devoid of forest litter. I found no decaying tree roots here either.

I travelled to Krutoe, one of the farms belonging to the owner of Zubrilovka, lying at a distance of 15 versts northwest of Zubrilovka to study the steppe soils of the area. We dug a pit in the virgin feathergrass steppe, but it was difficult to reach the subsoil since the Krutoe chernozem is about 4 ft [1.2 m] thick. All four samples which I took from different horizons of this pit have been chemically analyzed and prove the Krutoe clayey chernozem to be one of the best in Russia. The same impression is gained by visual observation because of its thickness, dark color, and granularity. It contains 11.616% humus.

The third point of interest in this region is the village of Gurovo, Morshansk District, the well-known estate belonging to Schultz. The owner

[1] Sovetov. Ibid.
[2] Sintsov. Ibid., p. 4.

of Gurovo first drew my attention to the structure of a stream bank on his estate. The figure[1] presents the structure of this alluvial valley as follows:

A. 2 ft [61 cm] of grayish sandy-loam river alluvium.

B. 2 — 3 ft [61 — 91 cm] of jet-black clayey chernozem.

C. Silty, extremely plastic lacustrine-fluvial clay of yellowish color with numerous bluish spots; it is exposed to a depth of 1 — 2 ft [30 — 61 cm] but can readily be traced under the horizon of river waters[2].

Sediment deposited by spring flood waters (A) extends over approximately 200 paces from the river banks, to be gradually replaced by nearly normal chernozem of the neighboring gentle slopes (second bank). The slopes are composed of light-yellow boulder loam with rare $CaCO_3$ concretions. Since the stream contained boulders of granite, diorite, gneiss, Shoksha red sandstone, siliceous shale, quartz, etc., the local diluvium may be assumed to contain considerable quantities of such boulders. One of these boulders was even highly polished. We made an artificial section on such subsoil, in a perfectly level tilled field on Schultz's estate which revealed local chernozem as 3 ft 4 in [1 m] thick and containing 7.625% humus.

A typical chernozem extends from Gurovo toward Vernandovka and Fitingofskaya stations (the Syzran — Ryazhsk railroad), similar to the soil occurring between Kozlov and Tambov, between Dubrovka and Kirsanov, as well as from Kirsanov to Gurov. Only from Fitingofskaya station up to the Tsna at Morshansk (about 20 — 25 versts) are there mixed forests, and the chernozem is first replaced by gray soil then by sand, as is also the case east of Tambov. On the other hand, on the left bank of the Tsna at Morshansk, "white eye" ("beloglazka") appears in the subsoil, covered by a fairly typical chernozem reaching 2 ft [61 cm] in thickness, stretching up to Ryazhsk.

Saransk — Korsun — Simbirsk

On the basis of Wagner's "Soil Map of the Simbirsk Province" (Karta pochv Simbirskoi gubernii) and my own observations (1878), the entire territory beginning almost immediately south of Lukoyanov District and extending to Simbirsk is found to be occupied by chalky marls and chalk; probably, independent alluvial deposits are totally absent. This geological structure is the principal factor determining the character of the local soils and topography.

Chalky marls, and especially chalk, fairly readily lend themselves to weathering and partly also to mechanical erosion by water. They must have therefore undergone considerable changes in appearance and composition, vanishing from whole areas and becoming covered by a dense, intricate network of gullies and rills, as was in fact found on the Saransk-Tagai territory (Simbirsk District), as well as in other, similar territories (Belgorod, Khar'kov, Nikol'skoe, Staryi Oskol, etc.). These conditions obviously left their imprint on the distribution of a) weathering products of chalk, i.e., "atmospheric" clays and b) soils.

[1] Dokuchaev. Tchernozème, p. 25. 1879.

[2] The river floods must have ceased after the deposition of layer C, when chernozem began to be washed down from the neighboring heights; this continued until the beginning of formation of deposits A.

Figure 9 presents a schematic section of the most important features of the territory.

The foundation of the entire territory is formed of chalk or chalky marls (C) which are exposed on the surface on steep hills (C') and slopes, only infrequently covered by a thin (1 – 2 arshins [0.7 – 1.4 m] thick) blanket of a mixture of chalk pebble with weak marly cement; no humus coloring is usually noticeable (first soil type).

Such chalk plateaus often still bear fairly considerable deciduous forests (oak, linden, birch, etc.). The best example of these chalk localities is provided by the areas between Timary and Gart, Saransk District (approximately 8 versts across), 4 versts beyond Gart toward Sudosevo, Korsun District, 4 versts east of Korsun (approximately 5 versts across), 14 versts east of Urensko-Karlinskaya station (Simbirsk District) etc.

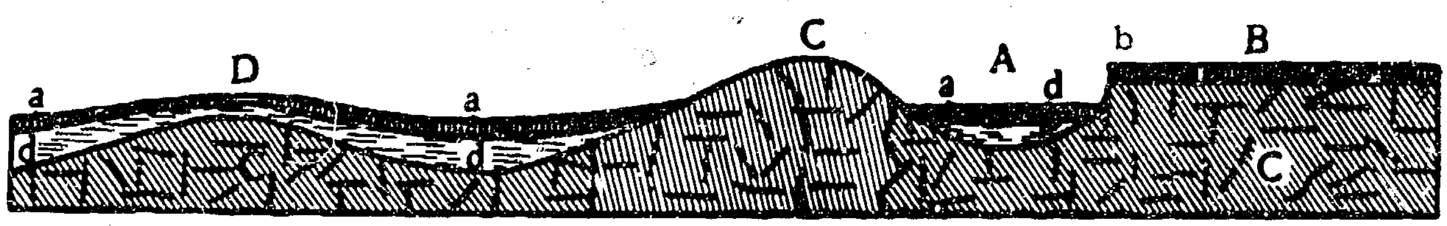

FIGURE 9.

In the last place, stony-marly soils overgrown by deciduous forests stretch approximately 4 versts, and only at the very edge of the forest (facing Togai) was there a sparse oak wood on typical chernozem.

It is reasonable to assume that it is such stony chalk plateaus that also form the Skryabinskaya, Nerneiskaya, Remizenskaya and Vorotnevskaya "volosts" where, according to data of the Saransk "zemstvo" office, the soils are "clayey and stony". Such is also the loamy "island" marked on Chaslavskii's map immediately east of Saransk, extending over approximately 20 – 25 versts.

Since this misrepresented "island" may serve to typify the hilly chalk plateaus, I will describe it at somewhat greater length.

A small silty river valley extends for a verst immediately east of Saransk; the valley forms a gradual transition (to B) to a gentle slope with fairly typical chernozem. The road then rises steeply to the elevation, the slope containing a fresh gully with walls reaching 4 – 5 sazhens [8.5 – 10.6 m] in height, composed exclusively of chalky marl; their horizons are abundant in sharply angular chalk pebbles. Pulverulent dark-gray chernozem is quite sharply distinguished at the top; chernozem reaches 1 – 1 1/2 [30 – 45 cm] in thickness and is very rich in the same small (seldom exceeding nut size) chalk pebble; its structure is generally of the Simbirsk type (see below).

Similar chernozem stretches over gently rolling terrain 12 – 15 versts beyond Saransk. Only 2 – 3 versts beyond the village of Timary, we again climbed a high chalk plateau, almost entirely overgrown by oak and birch. On this plateau the soils suddenly turn heavy-marly and are scarcely colored by humus; in some places they contain approximately 50% chalk pebbles.

These soils extend over approximately 8 versts, until the descent, approximately 4 versts[1] before Gart, to a depression containing old pulverulent chernozem, which is especially noticeable in the vicinity of snow-white chalk rocks, exposed near Gart for approximately 5 sazhens [10.6 m] and more.

We observed chalk plateaus (D) of smaller gradients, among other places, north of Saransk, en route from Sudosevo to Bereznyaki and from Sosnovka to Korsun. Weathering products of chalk and chalky marl occur even on the peaks of gradually sloping hills; these products are light-yellow or brownish yellow very marly clays (d) often very abundant in chalk and chert, usually sharply angular pebbles. However, such clays very rarely exceeded 1 – 2 arshins [0.7 – 1.4 m] in thickness. Identical chalk and chert pebbles, in smaller quantities and sizes, are also common in the pulverulent loose chernozem (second kind of soil) which (a) usually covers such hills, although seldom exceeding 1 – 1 1/2 ft [30 – 45 cm][2] in thickness; the chernozem sample I took 12 versts east of Sosnovka is of this type. This chernozem is sometimes completely devoid of pebbles, although it contains numerous nut-sized nodules which may be whitish or reddish and are always marly.

Figure 9 makes it clear that both the atmospheric clays (d) and the overlying chernozem become considerably thicker on the lower portion of the slopes of both kinds of hills (C' and D): the clays reach 2 and more sazhens [4.3 m] and the chernozem reaches 4 ft [1.2 m] and more, sometimes even containing krotovinas. As the slope descends, this chernozem becomes ever more typical and is almost totally free of chalk pebbles (third soil kind). In depressions (A) this chernozem reaches 3 – 4 ft [0.9 – 1.2 m] in thickness, and apparently becomes mixed with bog earth (fourth soil kind). Where such small closed depressions adjoin steep chalk bluffs (b) the soil becomes admixed with unweathered fragments of marl and chalk broken off the rock, and the soil assumes a whitish tinge (fifth soil kind).

In view of this diversity, it is obviously impossible to speak of normal crop yields in the Saransk – Tagai area. In certain villages the corn is insufficient even for six months, while in neighboring villages corn stacks 2 – 3 years old are found.

This is the schematic structure of the entire territory between Andreevka – Saransk – Korsun – Tagai.[3]

The description of these soils may be supplemented by the samples which I collected, listed on the following page.

Almost due west of Tagai, toward the last mail coach station before Simbirsk, the terrain becomes progressively more level, although chalk formations still outcrop in places on the surface, forming the immediate subsoil of local chernozem. Chernozem itself, probably due to the topography, becomes very typical, often reaching 2 1/2 – 3 ft [76 – 91 cm] in thickness; this chernozem continues solidly and is somewhat thinner only on less level areas. The outcrops of chalk

[1] At this point, on top of an elevated chalk plateau, the soil is very stony and only 7 – 8 in [18 – 20 cm] thick.

[2] This chernozem is very strongly reminiscent of the soils of Haapsalu (Khapsalu) and certain places on the southern shore of the Gulf of Finland, with the only difference being that these soil pebbles are Silurian limestone while the intervening mass is colored grayish-brown. Author.

[3] An exception to this scheme are the river valleys and their vicinity. For instance, 4 – 5 versts before the Sura at Bereznyaki (Korsun District) sands still covered by pine forest stretch near the river; after crossing the Sura at Bereznyaki, we traveled along 2 versts in the alluvial valley not without encountering alternate loamy and sandy sections. The valley of the Borysh is undeveloped. Author.

disappear altogether beyond this station, the terrian becomes even more level, and approximately 15 versts before Simbirsk we entered typical steppes (designated B in the figure) bearing typical Simbirsk chernozem, which will now be described.[1]

Locality	Sampling site	Thickness	Humus, %	Hygroscopic water, %
12 versts north of Saransk	Level pasture	2'1" [63 cm]	10.376	4.477
5 versts northwest of Saransk	Gently rolling plateau, old fallow land	1'6" [46 cm]	10.056	3.501
4 versts west of Gart .	Top of high chalk plateau	7–8" [18–20 cm]		
12 versts east of Sosnovka	Middle of a gentle slope	11" [28 cm]	7.576	4.156

[1] Before the beginning the description, the reader should be acquainted with the information on the soils of the Kurmysh, Ardatov, and Alatyr districts, which I obtained at the Simbirsk "zemstvo" provincial office, especially since this is the only information available on these districts.

"The Kurmysh District is divided by the Sura River into two parts, western and eastern; in the western part, the territory south of the P'yana and extending to the boundaries of the Ardatov and Alatyr districts is covered throughout by typical deep loamy chernozem." Evidently this is a continuation of the chernozem of the Tatar lands, Sergach District. "North of the P'yana River, there first stretches a sand belt 7–8 versts wide, and then, toward the northern boundary of the district, the soils become progressively more chernozemic in nature, until at Kurmysh chernozem is found with properties almost identical to those found in the soils in the southern part of the district." All these statements refer to the left side of the Sura. The right, eastern part of the Kurmysh District is covered throughout by deciduous forest and silty soils, scarcely colored by humus and "obviously forest soils, with the sole exception of Il'ina Mt.," where the chernozem soils apparently do not differ from the chernozem on the left side of the Sura.

Ardatov District. As expected, "In the northernmost part of the district the soil is identical with the high-quality chernozem in the southern part of the Kurmysh District. In the south, the chernozem belt is approximately bounded by the main Moscow highway, up to the village of Mitropol'ya, inclusive. South of this highway up to the Alatyr River, soils are first loamy, then sandy; these soils are still covered by forest in many places. The soil south of the Alatyr is chernozem nearly everywhere, except for the immediate vicinity of the river banks."

The Alatyr District, similar to the Kurmysh District, "is divided in two halves by the Sura. The right, eastern half is almost wholly forested, including deciduous forests as well as spruce with pine. The few villages are scattered in the forests, and are located on silty soil identical to the soil of the forested part of the Kurmysh District, on the right side of the Sura. The southeastern part of the Alatyr District is partly covered by sands (on the right side of the Barysh River) and partly by chernozem soils, such as near the villages of Kuvai and Astradamovka."

"The soils are considerably more varied in the western half of the district, where the following soil belts can be distinguished (from north to south):

1. The northernmost belt stretches from the boundaries of the Kurmysh District to the villages of Lyubimovka and Sutyazhnovo; the soils are chernozem, identical with soils of the southern part of the Kurmysh District.

2. From this poi to the Alatyr River the soils are sandy-clayey, and no chernozem occurs.

3. Close beyond Alatyr, thick typical chernozem begins, bounded in the south by the line Paranei-Barashevo-Gulyushevo-Kirzyat.

4. South of this line up to the Cheberchinka River the soils are stony nearly throughout, often lacking any humus coloration.

5. The remainder of the district adjacent (?) to the Ardatov District as well as the territory between the Cheberchinka and the Sura are covered by chernozem soils identical to those in the southern part of the Ardatov District."

The geological structure of the environs of Simbirsk has been described repeatedly; my observations in 1878 yielded almost the same results as those obtained near Simbirsk by N. P. Barbot de Marni. The town is on the very high right bank of the Volga, only slightly undulant; the relief is steppe-like, of the Aleksandrovsk type.

From Simbirsk toward Kazan the steppe rises over the first two versts very gradually, yet appreciably. At the outset of this ascent, 1/2 verst from the town, the following section, on the municipal pasture, is visible.

A. Strongly sodded soil layer, dark-gray, 1 ft 4 in [40 cm].

B. Transition horizon, 5 in. [13 cm].

C. Sandy clay with abundant mica flakes, identical to the Belgorod flakes, 1 sazhen [2.1 m].

Having ascended another 1/4 verst over the steppe, numerous clay pits occur, their walls revealing either loose yellowish chalky marl or red, very viscous clays with considerable lime content. Local brick is thus of poor quality, "cracking in the fire and softening in the rain."

Chernozem in these pits reaches 3 — 3 1/2 ft [0.9 — 1.6 m] in thickness.

After traveling another 0.5 — 1 verst north, we climbed one of the highest points in this area, which may be higher than the Simbirsk hummock. The place contains hundreds of shallow pits for quarrying chalk, which lies nearly at the surface, and is covered only by very typical and very loose dark chernozem.

Academician Ruprecht visited these chalk quarries as early as 1865, and provided the following description of the relationship of the local soil to chalk: "The abundance of *Artemisia austriaca*, *Ceratocarpus* and other characteristic plants points to the presence of a chernozem whose upper layers distinguish it from ordinary chernozem by predominance of phytolitharia and very fine particles with a molecular (?) movement. The quarries offer an opportunity to determine the thickness and position of chernozem. It lies directly on the chalk formation and is up to 3 1/2 ft [1.6 m] thick, as black throughout as it is on the surface, but mostly consists of small or large crumbs rather than a fine powder. Phytolitharia are visible under the microscope, but inorganic particles, colored brown externally predominate. The chalk strata are harder, thicker, and white-gray only at a depth of 10 ft [3 m]; higher, they form a transition to dirty-white, smeary belemnite chalk, silicified fragments of which also occur in the bottom layer of chernozem. On analyzing such an apparently pure chernozem sample, Borshchov found 9.99% volatiles and 18% calcium carbonate, 4 — 5 times the amount in any other sample of chernozem previously analyzed. This chernozem thus effervesces vigorously with acids, as opposed to upper layers of the same chernozem. Remarkably, 10% humus is sufficient to impart black color to 90% of the finest inorganic particles originally white or colorless, and white calcareous grains may be distinguished only under a magnifier. Moreover, the deepest layer of chernozem also contained larger fragments and even lamellar lumps, embedded in the black earth 4 — 5 vershoks [18 — 22 cm] above the rock surface."[1]

Upon my visit in the summer of 1878, I observed the following:

A. Sod, 3 in [8 cm] thick[2] interwoven with a dense network of living and dead roots, followed by a typical very dark chernozem layer with a

[1] Ruprecht. Geobotanicheskie issledovaniya chernozem (Geobotanical Studies of Chernozem), pp. 44-45.

[2] In nature, the transition of sod to horizon A is in fact much more gradual [than it appears in Figure 10].

multitude of small, always sharply angular, siliceous-chalk pebbles ranging from the size of an ordinary filbert to a walnut. These pebbles are distributed nonuniformly through the bulk of chernozem; some areas are free of these pebbles, while in other areas these pebbles may constitute 1/10 of the entire mass. Chernozem is 1 ft 6 in. [46 cm] thick.

Horizon A forms an imperceptible transition to the underlying layer B.

FIGURE 10.

B. Transition horizon; the general mass is lighter in color, denser and appreciably more clayey and heavier than layer A; the pebbles are larger and their content is considerably higher. In very many areas the pebbles constitute half of the mass, with more angular corners and edges. The transition horizon is 1 ft [30 cm] thick.

C. As seen in Figure 10, horizon B forms a gradual downward transition to the bedrock C. The latter is represented by very angular chalk cobbles, usually smaller than 1/2 ft [15 cm], mostly flat, with a slight admixture of brownish or white chalky marl. This rock is exposed to 1 – 1 1/2 sazhens [2.1 – 3.2 m].

Very characteristically, the pit which provides the above described section, and which does not exceed 1 1/2 – 2 sazhens [3.2 – 4.3 m] in diameter, contains areas where chernozem suddenly attains a thickness of 3 – 3 1/2 ft [107 cm]. The phenomenon recurs in dozens of sections. Such abrupt variation in the soil thickness is due exclusively to differences in the bedrock structure and the degree of its weathering, which affects the percolation of humus and the penetration by live roots.

Simbirsk chernozem definitely lies directly on chalk in situ. As has been seen, this area is one of the highest in the environment of Simbirsk, and was probably covered in the very recent past by feathergrass;

local inhabitants still report feathergrass on the steep slope of the steppe toward the Volga.

Analysis of this Simbirsk chernozem, performed by Kostychev, showed 19.17% humus. The composition of Simbirsk chernozem typifies those sites where chernozem directly overlies chalk (between Belgorod and Khar'kov, between Nikol'skoe and Endovishche, from Saransk to Simbirsk, etc.).

Sengilei — Syzran — Khvalynsk — Vol'sk Saratov — Atkarsk — Kamyshin

I travelled by steamer from Simbirsk to Astrakhan in 1878, in order to gain an impression of the territories adjoining the right bank of the Volga throughout the territory under consideration. I examined the Sengilei, Saratov, Atkarsk, and Kamyshin areas, while the other areas mentioned in the title above were examined by P.A. Solomin, my companion in investigations of that year.

The nearest first banks of the Volga are well known to be high, hilly on the right almost throughout the entire stretch, forming bluffs in some places and composed almost exclusively of rocks of ancient systems. The left bank on the other hand is low, level, and usually consists of post-Tertiary lacustrine-fluvial deposits. The right bank consists of a series of huge cirques formed by landslides, while the left bank contains numerous oxbow lakes. Some parts of the right bank exhibit traces of old chernozem partly eroded by atmospheric waters, lying directly over ancient (Cretaceous and Jurassic) rocks. The left bank is covered by thin gray soils, mostly of sedimentary origin; these soils often contain thin intercalations of river sand and glei.

S e n g i l e i is located in one of these cirque-like depressions in the right bank of the Volga. The town is surrounded on three sides by jagged heights. Prof. Barbot de Marni[1] was the first to present the following structure of the Sengilei vicinity: lowest are black-gray clays with selenite crystals and with A m m o n i t e s d e s h a y e s i and A . b i c u r v a t u s ; higher up — chalky marls sometimes covered by fragments of gray quartz sandstone. The clays are mainly found in the bottom of the Sengilei depression, while the adjacent height consists of the chalky marl. Soils on the height are identical to the Simbirsk chernozem, and I therefore took no samples. In contrast, the chernozem in the depressions is very viscous, and clayey, its surface is a network of cracks and it appears metallic when spaded up.

Such a pronounced dissimilarity in physical properties of soils in such proximity is readily understood, since their parent rocks belong to essentially different mineral types.

Very characteristically, the local inhabitants regard their clayey soils as solonets; this is correct in one respect, as these soils probably contain large amounts of calcium sulfate.[2] However, no positive conclusion

[1] B a r b o t d e M a r n i . Geologicheskie nablyudeniya v Simbirskoi, Saratovskoi i Tambovskoi guberniyakh (Geological Observations in the Simbirsk, Saratov, and Tambov provinces), p. 171.

[2] Workers of the local "zemstvo" divide the Sengilei District into three belts as follows: "The best soil is found in the belt adjoining the Volga, the central belt is covered by sandy-loamy chernozem, and sands and 'bor' predominate in the western belt." Upon correlation of this division with the geology of the Sengilei District, the predominant rocks in the first, second, and third belts will prove to be, respectively, Jurassic clays, chalky marl, and Eocene sands. A remarkable correlation indeed!

should be drawn until the results of the analysis now being made at Grandeau's laboratory are complete, especially since the humus content of this sample is 7.704% while its thickness is 2 ft 3 in. [69 cm].

Syzran. A similar close genetic relationship between parent rock and overlying soils is observed in the Syzran District. It must be borne in mind that this territory is divided by the Syzran River into two almost equal halves, with Tertiary sands predominating in the northern half and chalk and chalky marl predominating in the southern half. Small "islands" of Jurassic, Permian, and Carboniferous formations are occasionally observed along the Volga and on the right bank of the Syzran River as a narrow belt (not taking the Samara Bend of the Volga into account). The distribution of local soils is in complete conformity with the distribution of rocks. Local information is that "the richest chernozem coincides with Jurassic outcrops; a lighter and loose chernozem, often containing calcareous pebbles, occurs in the chalk area; finally, sandy-loamy chernozem of a lighter shade is almost exclusive to the northwestern part of the Syzran District."

Mr. Solomin took a chernozem sample 5 versts north of Syzran (on the way to Chekalinskaya station), apparently in the region of Tertiary sandy loams; its thickness is 2 ft 2 in. [66 cm] and it contains only 4.523% humus. However, it should be noted that north of the Syzran River many soils are richer in organic substances; this is confirmed, inter alia, by the analysis of soil from the village of Samoikino, given below. This is understandable, since in the northwestern part of the district the deposits may also be much more clayey in some places than the underlying Tertiary rocks.[1]

Khvalynsk, similar to Sengilei and Vol'sk, lies, according to Mr. Solomin's description, on a relatively low site, in a hollow between mountains. The terrain suggests debris of a huge landslide, reaching 20 sq. versts in area. The mountains above this depression are truncated cones, composed entirely of chalk and chalky marl; the general impression is that these cones are covered by snow, melted in some places and completely preserved in others. The chalk ranges ramify and interlock, forming series of closed depressions varying in shape, which contain the Khvalynsk fields. An artificial section made on almost perfectly level terrain in such a depression, approximately 6 versts west of Khvalynsk, revealed the following details:

A. Soil horizon, 10 – 11 in [25 – 28 cm].

B. Transition horizon, 5 – 6 in [13 – 15 cm],

C. Bedrock, almost completely consisting of chalky marl pebbles.

"Khvalynsk chernozem (A) is loose, soft, perfectly black, often containing small pebbles which usually become more numerous in horizon B." We are obviously dealing essentially with Simbirsk chernozem, the only difference being that the Khvalynsk soils are found in depressions into which various particles are washed from the neighboring heights, as confirmed by the 25.42% content of $CaCO_3$ in local chernozem. This argument is even more forceful when it is taken into account that the humus content of this chernozem is 15.079%!

Solomin describes the town of Vol'sk as "situated in a depression at the foot of steep and high chalk mountains, the upper third of which

[1] A third sample, also containing 7.40% humus, from the environs of the village of Topornino, Syzran District, was given me by Mr. Andreev. Unfortunately, I could not determine this locality on the map.

consists of bedded sands varying in color and loose gray sandstone. In the gullies between the mountains, fairly thick deposits of red-brown and yellowish (atmospheric) clay occur. Chernozem on the mountain is mostly very sandy and thin, seldom thicker than 1 ft; on the other hand, in depressions at the foot of mountains, it is darker, more clayey, and thicker. Here it very often lies directly on light-cinnamon chalky marls and sometimes directly on chalk, or more precisely on chalk pebbles and flags with only a small admixture of loose marl. A sample taken 4 – 5 versts from Vol'sk (on the way to Saratov) is 1 ft 6 in. [46 cm] thick and contains 9.647% humus; its parent rock is light-cinnamon chalky marl."[1]

Saratov. It is known, from Prof. Sintsov's works which have been cited, that the immediate environs of the town of Saratov are very hilly, with outcrops of Jurassic, Cretaceous, and Eocene rocks in different places, and, possibly, of the so-called Caspian sediments. The same dark-colored bituminous and marly clays, variegated sands and sandstones and bluish-gray marls stretch for some distance toward Atkarsk. I saw no true deposits anywhere. Obviously, uniform chernozem is not to be expected in terrain of such diverse rocks, outcropping and serving as subsoils; this was in fact confirmed. A soil sample which I took 1/2 – 1 verst west of Saratov on a pasture at the foot of a gentle slope and on marly subsoil is 2 ft [61 cm] thick and abounds in marly-chalky pebbles. This soil in its natural form, mixed with the pebbles, contains 12.040% humus, but after sifting through a 3 mm sieve its humus content is only 10.544%. Further northwest of Saratov, at the Kurdyum station, on a loamy ground, the soils appear just as dark, about 1 1/2 – 2 ft [45 – 61 cm] thick, with content of organic substances only 8.276%. The humus content of the Atkarsk soils, lying on Tertiary sandy loams, was lower, they were about 1 ft 6 in [46 cm] thick, and contained only 6.158% organic substances. In appearance and in the considerable content of mica spangles, Atkarsk chernozem strongly resembles Belgorod chernozem. They may possibly have overlain the same substrate in the past. To complete the description of local soil variety, the solonetses at the village of Dolgii Most of the Saratov District should be mentioned; the soil is light-gray and about 6 in [15 cm] thick. The terrain is perfectly level with a tendency to bog. I believe the humus content in this solonets to be far lower than in the Atkarsk soil.[2]

Kamyshin is the last point on the right bank of the Volga which I was able to investigate in the summer of 1878 in this territory. Similar to other towns, Kamyshin is located in a depression enclosed by heights on three sides. Earlier geological works as well as my examination of the vicinity of Kamyshin showed the parent rock of local soils to be formed of various loose sands throughout, especially on high sites. The Kamyshin soils are naturally gray and very low in humus (as little as 2.072%); nevertheless, their thickness on perfectly level areas often reaches 1 ft 9 in [53 cm].

[1] [Balkov, S. Popytki opredelit' obstoyatel'stva, vliyayushchie na soderzhanie peregnoya v chernozemnykh pochvakh (Attempts to Define the Circumstances Affecting Humus Content in Chernozem Soils)]. – Sel'skoe Khozyaistvo i Lesovodstvo, p. 281, St. Petersburg, November 1880.

[2] A chernozem sample supplied by Goryainov, from the village of Ataevka, 75 versts south of Atkarsk, revealed 9.561% humus according to Sibirtsev's determinations.

I should like to conclude this description of the right bank of the Volga with the general remark that the terrain is very strongly rolling nearly throughout (at least in 9 cases out of 10) along the river, for 1 – 3 versts or more, and the soils have therefore been totally washed away in some places, and very much depleted in humus and other erodible soil elements in other places. Thick layers of deposited chernozem are visible here and there in depressions on the Volga slopes. The Volga bank, in short, exhibits the same pattern seen along the Dniester, the Dnieper, the Vorskla and other rivers.

CHEMICAL COMPOSITION OF SOILS IN CENTRAL CHERNOZEM RUSSIA

A complete chemical analysis has been performed only for the Krutoe, Gurovo, and Grushevka chernozems, of the numerous soil samples I collected in Central Russia. The other samples are still being analyzed by Grandeau and Kostychev. Therefore, our tables contain some analyses (by Messrs. German, Schmidt from Jena, Petzholdt and Schlippe) which are obsolete and have greater historical than scientific value[1]; on the other hand, some data in the tables do satisfy scientific requirements.

Ryazan Province

Analyses by German[1] [percentages]

Locality		Unculti-vated soil	Top layer of arable soil	Lower layer (from a depth of 7 vershoks [31 cm])
No.		1	2	3
Sand		51.84	53.38	52.72
Clay	SiO_2	17.80	17.76	18.65
	Al_2O_3	8.90	8.40	8.85
	Fe_2O_3	5.47	5.66	5.33
	CaO	0.87	0.93	1.43
	MgO	0.10	0.47	0.67
	Water	4.08	3.75	4.04
Combined mainly with ferric oxide and aluminum	P_2O_5	0.46	0.46	0.46
	Crenic acid	2.12	1.67	2.56
	Apocrenic acid	1.77	2.34	1.87
	Humic acid	1.77	0.78	1.87
	Humic extract	3.10	2.20	0.00
Root fibers with certain traces of charred humus		1.66	1.66	1.66
		99.84	99.76	99.81

[1] Zemledel'cheskii Zhurnal Moskovskogo obshchestva sel'skogo khozyaistva, No. 1, p. 66, [Moscow], 1837. [German, R. Khimicheskie issledovaniya o chernozeme, nakhodyashchemsya v yuzhnykh guberniyakh Rossii (Chemical Studies of Chernozem from Southern Provinces of Russia)].

[1] I did not include the analyses performed by Payenne, Phillips, Knop, and others on chernozems of unknown localities. The well-known analyses made by Mr. Lachinov (of the chemical laboratory of the Agricultural Institute at St. Petersburg, 1867, pp. 59–87) were not utilized for quite another reason, since they were meant rather to check analytical methods than to determine the chemical composition of soils.

The subsoil sample from the Volga heights at Simbirsk (north of the city, in stone quarries, at a depth of 3 1/2 ft [1.6 m]) was analyzed by Borshchev (Ruprecht, ibid., p. 118). The analyses showed 61.79% substances insoluble in HCl, 28.22% substances soluble in HCl (including 18.02% $CaCO_3$) and 9.99% substances volatilized by ignition.

Analyses by Messrs. Schmidt from Jena and Petzholdt [percentages][1]

		Schmidt				Petzholdt			Locality
	No.	4	5	6	7	8	9	10	
Organic substances		12.16	8.29	5.75	8.62	18.18	9.48	8.28	Orel Province:
Water		–	–	–	–	–	–	–	4) From surface; the soil has never been cultivated
Nitrogen		0.99	0.45	0.33	0.48	0.77	0.33	0.30	
Soluble in HCl	Chlorine	–	–	–	–	0.07	0.01	0.01	
	SO_3	–	–	–	–	0.26	0.10	0.09	
	P_2O_5	0.07	–	–	0.12	0.54	0.18	0.18	5) From a depth of 4 vershoks [18 cm]
	CaO	0.78	0.49	0.24	0.88	2.34	4.45	0.88	
	MgO	0.52	0.23	0.18	0.56	0.82	1.37	0.58	6) From subsoils
	Fe_2O_3 and Mg_2O_3	2.86	2.37	2.96	3.14	9.89	10.97	9.36	7) From surface of an unmanured plowland
	Al_2O_3	1.29	2.39	1.80	1.34	1.11	1.18		Tambov Province:
	K_2O	0.21	0.27	0.31	0.25	2.32	1.33	0.63	8) From manured plowland
	Na_2O	0.08	0.11	0.12	0.10	0.87	0.98	0.43	
Insoluble in HCl	SiO_2					70.94	72.14	78.18	9) From unmanured field, at a depth not reached by plant roots
	Fe_2O_3					1.58	1.43	1.74	
	Al_2O_3	93.77	94.06	94.85	92.73	4.72	3.96	4.99	
	CaO					0.26	0.64	0.48	
	MgO					0.13	Traces		10) From surface of an unmanured soil
	K_2O					3.49	6.50	3.08	
	Na_2O					1.44	0.77	1.58	

[1] Zhurnal Ministerstva Gosudarstvennykh imushchestv, part 49, p. 3, St. Petersburg. 1852.

Analyses by Prof.

Locality	Tambov Province, Kirsanov District, Mr. Bulygin's estate									Tambov	
No.	16	17	18	19	20	21	22	23	24	25	26
Sampling depth	14" [35 cm]	28" [71 cm]	56" [142 cm]	14" [35 cm]	28" [71 cm]	14" [35 cm]	28" [71 cm]	56" [142 cm]	7" [18 cm]	-	-
Kind of soil	Arable horizon	Subsoil	Deeper subsoil	Arable horizon	Subsoil	Arable horizon	Subsoil	Deeper subsoil	Virgin soil	Arable horizon, good wheat soil	Arable horizon, exhausted and therefore poor soil for wheat
Hygroscopic water . .	6.576	6.304	6.040	6.606	6.490	7.016	6.198	4.824	6.348	5.572	5.638
Water liberated at 100–180°C	1.822	1.64[illegible]	1.600	1.983	1.550	1.322	1.533	1.234	1.580	10.018	10.006
Humus + H_2O retained above 180°C . .	11.490	7.730	3.120	12.625	7.152	12.890	6.238	3.314	13.066		
Mineral constituents . .	80.112	84.324	89.240	78.786	84.808	78.772	86.031	90.628	79.006	84.410	84.356
Total CaO .	1.102	1.078	1.157	1.099	0.989	1.560	1.074	8.402	1.004	0.923	0.998
$CaCO_3$ . .	0.114	0.145	0.191	0.091	0.154	0.300	0.136	14.255	0.061	-	-
Al_2O_3 . .	14.369	14.327	14.959	15.589	15.124	13.394	14.781	13.864	13.747	13.471	10.352
Fe_2O_3 . .	4.477	5.117	5.418	*	5.067	4.829	5.141	4.631	4.600	1.444	3.682
N . . .	0.422	-	0.113	-	-	-	-	0.117	-	-	-

1 Supplied to me in manuscript.

2 A more detailed analysis of some of these soils may be found in "Collection of Materials for the Description not know how correctly these analyses are presented. – Author.

3 In this soil, Prof. Schmidt found 0.954% calcium sulfate.

[Figure unclear in the original. Translator.]

K. Schmidt, Derpt[1]

Province, Lebedyan District, Trubetchino[2]						Saratov Province, Balashov District, Blagoveshchensk						
27	28	29	30	31	32	33	34	35	36	37	38	39
–	–	–	–	–	–	–	–	–	–	–	–	–
Arable horizon, long cultivated and left unmanured	Arable horizon of heavily manured field	Arable horizon of a good field which has not been manured for a long time	Arable horizon of virgin soil	Virgin soil	Wheat soil	Wheat soil	Bog (morast) soil	Arable horizon	Arable horizon	Solonets[3] (unfertile soil)	Good wheat soil	Hard field, left uncultivated for 15 years. Excellent wheat soil
6.226	7.272	7.298	6.378	6.395	5.137	3.090	5.810	8.893	8.638	5.288	2.807	2.540
7.726	19.258	7.536	10.542	9.205	13.318	10.540	27.635	8.631	9.084	11.994	15.176	12.592
86.048	73.470	86.166	83.080	84.400	81.545	86.370	63.555	82.476	82.278	82.718	82.017	84.868
0.862	1.824	0.866	1.052	1.042	0.971	1.598	0.950	2.133	2.370	0.988	1.608	1.407
–	–	–	–	–	0.069	1.160	0.093	1.800	2.700	0.161	–	–
12.724	8.066	12.320	9.904	11.232	13.801	14.723	9.633	13.970	13.936	13.923	13.154	12.846
3.894	2.960	3.995	3.880	3.873	3.871	3.697	4.691	3.474	3.604	3.601	5.514	6.586
0.262	–	–	–	–	–	–	–	–	–	0.467	0.446	0.363

of the Tambov Provinces" (Sbornik materialov dlya opisaniya Tambovskoi gubernii), p. 42; however, I do

Analyses by Mr. Schlippe[1] [percentages]

Locality	Dankov District, Ryazan Province	Kozlov District, Tambov Province	Khvalynsk District, Saratov Province
No.	11	12	13
Hygroscopic water	4.20	3.00	3.40
Organic substances	13.80	9.00	9.20
SiO_2	61.40	76.60	62.50
Al_2O_3 and Fe_2O_3	17.50	10.50	15.50
CaO	1.10	1.81	1.47
$CaCO_3$	–	–	–
MgO	0.40	0.26	0.51
K_2O (and Na_2O)	1.53	1.25	1.24

[1] Zhurnal Ministerstvo Gosudarstvennykh Imushchestv, p. 121. 1853–1854.

Analyses (performed under the guidance of Prof. D. I. Mendeleev), of samples from the Simbirsk District, Prince Ukhtomskii's estate[1]

Numerical results represent means from several analyses, except for results marked with an asterisk (*) [percentages]

Component	Soil. Neutral reaction	Subsoil. Neutral reaction
No.	14	15
Extracted with nitric acid from 100 g air-dry soil:		
CaO	1.340	1.226
MgO	0.920	0.972
K_2O	0.583	0.465
Na_2O	0.108	0.147
Al_2O_3	5.568	4.096
SiO_2	0.120	0.207
P_2O_5	0.074	0.097
Iron oxide	3.412	3.504
Mg_2O_3	Traces	0.008*
Total	12.125	10.722
Extracted with soda and strong sulfuric acid from residue insoluble in nitric acid:		
Al_2O_3	5.26	5.19
SiO_2	27.063* 32.323	24.825* 30.015
Insoluble residue (sandy particles)	35.920	38.582
Substances liberated by ignition of soil:		
Hygroscopic water	6.640	5.900
Carbon	2.130*	2.207*
Organic substances[2] (humus)	3.670	3.810
Total nitrogen	0.440	0.393
	18.830*[3]	17.485
Sulfur (determined in a separate fraction of a sample)	0.130	0.140*

[1] See "Sel'skokhozyaistvennye opyty Vol'no-ekonomicheskogo obshchestva. Khimicheskie issledovaniya pochv i produktov s opytnykh polei Simbirskoi, Smolenskoi, Moskovskoi i Peterburgskoi gubernii, proizvedennye v khimicheskoi laboratorii S.-Peterburgskogo universiteta gg. F. Vredenom, Ya. Oliv'e, F. Titovym, G. Shmidtom i E. Yakobi, s predisloviem D. Mendeleeva (Agricultural Experiment of the Free Economic Society. Chemical Investigations of Soils and Products from Experimental Fields in the Simbirsk, Smolensk, Moscow, and Petersburg Provinces Performed at the Chemical Laboratory of the St. Petersburg University by Messrs. F. Vreden, Ya. Oliv'e, F. Titov, H. Schmidt, and E. Jacobi, Prefaced by D. Mendeleev), Table VI. 1870.

[2] This is the result of multiplication of the amount of carbon (from the previous line) multiplied by the factor 1.724 (according to Wolff).

[3] The figures in this line were actually obtained by igniting the air-dry soil.

Analyses performed under the guidance of Prof. Il'enkov [percentages]
Syzran District, village of Somoikino

	Locality	Top layer, steppe (?)	Upper layer of cultivated soil
	No.	40	41
Fraction soluble in HCl (sp. gr. 1.15)	SiO_2	0.019	0.009
	SO_3	0.014	0.092
	P_2O_5	0.085	0.059
	CO_2	0.014	0.020
	Chlorine	0.004	0.003
	Fe_2O_3	1.432	1.059
	Al_2O_3	0.837	0.619
	Mn_2O_3	0.050	0.062
	CaO	1.158	0.294
	MgO	0.675	0.263
	K_2O	0.071	0.047
	Na_2O	0.075	0.068
	Organic substances and chemically bound water	1.813	2.130
Residue insoluble in HCl	SiO_2 soluble in soda	4.955	3.899
	Insoluble SiO_2	68.626	77.629
	Fe_2O_3, Al_2O_3	9.473	6.705
	CaO	0.505	0.504
	MgO	0.617	0.438
	K_2O, Na_2O	0.056	0.114
	Organic substances (loss on ignition)	9.286	5.821
	Total	99.765	99.835

Analyses performed by Prof. K. Schmidt[1] [percentages]

Locality	Village of Krutoe, Balashov District, Saratov Province, level feathergrass steppe					Settlement of Grushevka, level feathergrass steppe		
No.	42	43	44	45	46	47	48	49
Sampling depth . . .	Up to 1' [30 cm]	1' and 1'10" [30—55 cm]	1'10"—2'8" [55—81 cm]	2'8"—3'8" [81—111 cm]	Below 3'8" [111 cm]	Up to 11" [28 cm]	11"—1'8" [28—50 cm]	Below 1'8" [50 cm]
Hygroscopic water loss at 110°C by 100 parts air-dry soil	13.47	13.10	12.03	14.02	10.88	10.61	9.18	8.15
Total contents in 100 parts of soil dried at 100°C (total constituents soluble in HCl and HF + quartz sand insoluble in HF)								
Hygroscopic water lost at 100—150°C . .	1.354	1.388	1.035	1.474	0.903	0.188	1.130	1.123
Organic substances (humus)	14.851	11.376	8.697	6.159	3.540	9.940	7.269	3.109
Mineral constituents .	83.795	87.286	90.268	92.367	95.557	89.872	91.601	95.768
K_2O	2.269	2.373	2.338	2.272	2.032	2.192	2.158	1.809
Na_2O	0.709	0.581	0.838	0.883	0.862	0.992	1.167	0.844
CaO	1.974	2.050	1.545	5.819	9.998	1.409	2.318	9.431
MgO	1.555	1.486	1.927	1.759	1.469	1.103	1.680	1.012
Mn_2O_3	0.072	0.080	0.094	0.100	0.088	0.081	0.059	0.066
Fe_2O_3	4.522	5.163	5.197	4.831	4.640	5.265	5.516	3.838
Al_2O_3	15.797	14.845	15.751	14.614	14.648	16.404	15.798	15.945
CO_3	0.054	0.066	0.077	3.571	7.547	0.008	0.871	6.679
P_2O_5	0.228	0.187	0.167	0.160	0.151	0.147	0.127	0.118
SO_3	0.003	0.004	0.001	0.002	0.005	0.006	0.007	0.033
NaCl	0.007	0.004	0.003	0.003	0.006	0.004	0.004	0.004
a) silicic acid = a) SiO_2	17.722	16.807	16.925	14.623	12.905	21.185	23.002	18.946
b) silicic acid = b) SiO_2	26.631	39.036	40.959	39.700	35.305	20.134	27.399	16.541
Quartz sand insoluble in HF	12.254	4.554	4.446	4.030	5.801	20.942	11.495	20.502
$CaCO_3$	0.123	0.150	0.175	8.116	17.152	0.018	1.980	15.180
$Ca_3P_2O_3$	0.487	0.408	0.365	0.349	0.330	0.308	0.277	0.258
Lime (residue combined with SiO_2 and humic acid)	1.641	2.050	1.249	1.085	0.214	1.232	1.059	0.790
Nitrogen	0.607	0.417	0.272	0.180	0.076	0.305	0.204	0.116

[1] The soil samples analyzed by Prof. Schmidt are of my collection. See "Physicochemical Investigations of Soil and Subsoil in the Chernozem Zone of European Russia (Fiziko-khimicheskie issledovaniya pochvy i podpochvy chernozemnoi polosy Evropeiskoi Rossii)", No. 1. 1879.

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Analyses by Mr. Zalomanov

Village of Gurovo, Morshansk District, Tambov Province
Results for 100 parts of soil dried at 115°C and sifted through a sieve with 3 mm mesh [percentages]:

	Locality	Field soil from a very gently rolling country, sampled from depths down to 5 in. [13 cm]	The same, from depths of 5 in. and 1 ft 3 in. [13 and 38 cm]	The same, from depth 1 ft 9 in. to 3 ft 4 in. [53–101 cm]	The same, subsoil below 3 ft 4 in. [1 m]
	No.	50	51	52	53
	Dissolved by treatment with HCl (sp. gr. 1,15) (A)	18,17	20,49	15,98	21,87
	Remained undissolved in HCl (B)	81,83	79,51	84,02	78,13
Fraction dissolved by HCl (A):	SiO_2	0,02	0,02	0,02	0,01
	SO_3	0,05	0,0[illegible]	0,05	0,08
	P_2O_5	0,09	0,08	0,06	0,06
	CO_2	0,08	0,11	0,04	3,30
	Fe_2O_3	2,94	4,03	3,20	3,13
	Al_2O_3	2,02	2,03	1,97	2,29
	CaO	1,11	[illegible]	0,98	4,90
	MgO	0,12	0,05	0,14	0,10
	K_2O	0,15	0,05	0,60	0,77
	Na_2O	0,24	0,11	0,03	0,31
	Organic and other substances and chemically bound water	11,55	10,69	8,84	6,92
After fusion with soda (B):	SiO_2 soluble in water	49,28	45,02	37,51	32,50
	Water-insoluble SiO_2, oxides of aluminum, iron, calcium, organic substances (loss on ignition) etc.	32,55	34,49	46,51	45,63
	Organic substances (C × 1,724)	7,43	6,35	3,[illegible]	0,93
	$CaCO_3$	0,18	0,25	0,0[illegible]	7,50

GENERAL CHARACTER OF CENTRAL CHERNOZEM RUSSIA

The most interesting aspect of our studies of central chernozem Russia, as in our studies of southwestern chernozem Russia, is that of the relationships and the genetic connection between the local soils on the one hand and parent rocks and topography on the other. Let us once again dwell on the significance of parent rocks.[1]

The detailed description, given above, of certain areas in central chernozem Russia, as well as data found in the literature demonstrate with reasonable certainty that the soils of this territory when situated normally overlie at least the following five parent rocks. a) Jurassic marly clay, b) Tertiary and other sands, c) chalk and chalky marls, d) Devonian limestones and e) boulder loess.

The significance of parent rock (a) in regard to Russian chernozem appears to have been made quite clear in the case of the Nizhni Novgorod Province (pp. 77 – 78). Since this effect is certainly characteristic of a certain territory, it should appear in some form at any similar point. Therefore, although I did not have the opportunity to examine the subject in detail with regard to the Volga area, I have complete faith in the validity and precision of the reports by Prof. Bogdanov (p. 218) and local inhabitants (p. 237) given above, regarding the correlation of the richest chernozem in this area with Jurassic formations in the Buinsk District and in the southeastern part of the Simbirsk Province.

Even more vivid and convincing in central chernozem Russia is the effect of sandy-loamy and sandy parent rocks (b) on the nature of overlying soil. This is best demonstrated by the following table:

Astanino	4.365% humus
Mikhailovka	4.450% "
Glubokaya	5.647% "
Near Syzran	4.523% "
Atkarsk	6.158% "
Kamyshin	2.079% "
Mean humus	4.536% "

Should the reader mark these points (excluding Astanino)[2] on a geological map of European Russia, it will become obvious that they are located on Tertiary sandy loams and sands; the soils are of the same mineralogical character. This correlation is even more significant in view of the fact that these Tertiary "islands", occurring in the region of Cretaceous and Jurassic rocks, are surrounded by chernozem rich in humus, lying on level areas. I therefore decided to mark all soils resting on Tertiary "islands" in central chernozem Russia as containing 4 – 7% humus on my schematic map.[3]

[1] The general effect of topography on soils will be discussed later on.

[2] I am sure that the Astanino soil overlies sandy-loamy ground, as does Belgorod soil. However, I have no details about geology in the vicinity of this village; the geological map indicates Cretaceous formation. I shall thus make no indication of a sandy "island" in the vicinity of Astanino

[3] However, this indication on my map (as in the case of the Syzran District) does not preclude the possibility of richer chernozem occurring amidst sandy Tertiary "islands". Here, as throughout, I refer to the predominant soils.

The relationships between limestones (d) and chalky marl (c) on the one hand and the overlying chernozem on the other hand have previously seemed far more complicated.

It has been noted (p. 213) that Prof. Sintsov definitely recognizes the closest genetic relationship between distribution of Cretaceous formations and that of rich chernozem. Wangenheim von Qualen also admitted the presence of typical chernozem in the chalk region (p. 215). Prof. Bogdanov, on the other hand, just as firmly (pp. 219 – 220) denies such correlation; he regards chalk marls as providing insufficient nutrition for vegetation, and the chernozem on such marls as being thin and gray.[1]

Our chemists also hold varying views of the role played by $CaCO_3$ in chernozem formation. For instance, N. P. Zalomanov in his communication "Effect of Certain Soil Constituents on the Formation of Chernozem" (O vliyanii nekotorykh sostavnykh chastei pochvy na obrazovanie chernozema) says the following: "Calcium carbonate combines with humic substances to form compounds of humic acids and calcium insoluble in soda. These compounds are very unstable and rapidly decompose into carbonic acid and water. The destruction of humus by calcareous soils is noted by Prof. Knop and by Senft, as well as being very well known to practical farmers Finally, Petersen's investigations demonstrated that lime does strongly accelerate the mineralization of organic substances. On this premise, the obvious conclusion is drawn that chernozem cannot form on a soil (ground) containing considerable quantities of $CaCO_3$, since organic substances will decompose very rapidly and form water-insoluble compounds thus remaining fixed in the top layer and not percolating downwards." Zalomanov thus does not recognize the possibility of direct formation of chernozem from chalk and marls, and even from loess, if effervescent with acids. He regards both kinds of rocks as parent rocks only when their $CaCO_3$ contents have decreased to trace amounts.[2] Yet, Zalomanov himself knew of certain chernozems high in calcium carbonate (samples investigated by Il'enkov and Borshchev). Academician Ruprecht noted cases of chernozem directly overlying chalk marls (Simbirsk, etc.); Zalomanov therefore concluded that such "chernozem is probably deposited, but did not originate in situ."[3] He seems to find confirmation for his statement in the fact that "In chernozem containing considerable quantities of $CaCO_3$, the chernozem and the calcareous particles are separate, not forming a homogenous mass."[4] On the basis of these arguments, Zalomanov even proposes "a distinction between two kinds of chernozem: with low $CaCO_3$ content, which is rich chernozem formed in situ by percolation, and chernozem with high $CaCO_3$ content, effervescing with acids, which is deposited or formed otherwise (?) without percolation in situ."[5]

P. A. Kostychev remarked as follows in this connection: "Although $CaCO_3$ is known to accelerate decomposition of organic substances, the

[1] Trudy VEO, pp. 275 and 285, March 1879.

[2] Zalomanov. Ibid., pp. 275, 276, etc.

[3] Ibid., pp. 275, 276, etc.

[4] Ibid., p. 292, etc.

[5] Ibid., pp. 276-277. At this stage of chernozem studies, a special discussion of other arguments presented by Zalomanov in regard to his views is unnecessary. Among these arguments is the fact, mentioned by Knop, of fossil finds in Russian chernozem, and the alleged restriction of the occurrence of rich chernozem to heights.

degree of this acceleration is unknown. In varying cases this effect of lime will certainly cause dissimilar consequences. Let us imagine two soils formed by identical parent rock, with equal contents of $CaCO_3$ one of which (a) is very fertile thanks to other conditions, and may be capable of forming a larger amount of organic substances in the course of one summer than may be decomposed even in the presence of $CaCO_3$ throughout the year; the process recurs yearly, thus causing the fertile calcareous soil to accumulate a considerable reserve of humus. If the other soil (b) is not as fertile, due to its different properties, it will bear a limited amount of vegetation which may decompose during one year; soil (b) will not accumulate any humus for a long time. Humus itself is capable of dissolving different mineral substances, and once it has started to form in a calcareous soil, it will tend to diminish the $CaCO_3$ content. Mr Zalomanov also pointed out that the formation of calcium humate in soil converts the humus to an insoluble compound... This is completely erroneous. In the presence of alkalis, calcium humates form double salts, readily soluble in water without any residue; this fact was already known to Mulder... Therefore, the occurrence of humus on calcareous beds is quite easily explained by these facts."[1]

Opinions among lay observers (Messrs. Sintsov and Bogdanov) as well as among theoretical chemists (Zalomanov and Kostychev) regarding the effect of calcareous rocks on chernozem formation vary widely. The initial stage in clarifying the matter should consist of an accurate collection of established facts, leading to a theoretical solution.

In the earliest stages of studies of Russian chernozem, it became obvious that "in areas covered by Cretaceous sediments chernozem quite often lies directly on the chalk itself."[2] Such cases were repeatedly observed by Wangenheim von Qualen. Prof. Levakovskii observed chernozem lying directly on Cretaceous sediments on the banks of the Glubokaya, the Aidar, the Derkul, the Ol'khovaya and the Luganka.[3] Academician Ruprecht described the gradual transitions between chalk and chernozem in detail (p. 235); we have already seen that the occurrence of chernozem soils on chalk was considered possible even by Prof. Bogdanov.

Thus, the direct bedding of chernozem on different chalk rocks seems beyond doubt... This was not always the case. Until quite recently, the view of the local, terrestrial origin of chernozem was so uncertain that the possibility of the conversion of parent rocks to chernozem was hardly admissible. Borisyak and Levakovskii, as well as Zalomanov, regarded such chernozems as deposited, slumped chernozems; the former two authors were of this opinion since "in a majority of such cases there is a sharp difference between the chernozem and the subsoil,"[4] and Zalomanov – due to the undecomposed calcareous grains occurring in this chernozem. These opinions were held in spite of the observations made by Wangenheim von Qualen and Ruprecht, establishing the occurrence of quite normal chernozem on calcareous rocks! Obviously, in order to finally establish this phenomenon, it was necessary to prove its existence throughout localities where no deposition was possible; we have fully succeeded in doing so. Indeed,

[1] Kostychev, P. [Vystuplenie v preniyakh po dokladu Zalomanova (Statement During the Discussion of Zalomanov's Report)]. – Trudy VEO, pp. 283-289, March 1879.

[2] Borisyak. O chernozeme (Chernozem), p. 38. 1852.

[3] Levakovskii. Ibid., p. 36.

[4] Ibid., p. 40.

en route from Belgorod to Khar'kov, in the southeastern parts of the Orel and Tula provinces, on the way from Nikol'skoe to Endovishche, and finally between Saransk and Simbirsk as well as in many areas of the Saratov Provinces, we observed hundreds, even thousands of places where more or less typical chernozem lay directly on Devonian limestones or on chalky marl, and on chalk, always in the highest areas of the terrain. Similar observations were made repeatedly by Solomin in the Vol'sk, Khvalynsk, and Saratov districts.[1]

In all cases of this kind, in fact, the boundary between ground and chernozem is much more distinct than where chernozem lies on loess; indeed, the soil contains grains and even fragments (usually nut-sized but sometimes larger) of the underlying calcareous bedrock in almost all such cases. However, the explanation of these facts is much more natural and simple than appeared to Borisyak, Levakovskii and Zalomanov. Chalk, chalky marl, and Devonian limestone differ from chernozem much more markedly, especially in their physical habits (color, hardness, structure), than do such substances as loess or boulder loam. It is thus hardly surprising that where chernozem occurs directly (and quite normally) on chalk the soil differs considerably from the subsoil. This is, in fact, the only possibility. Furthermore, the section of Simbirsk soil vividly demonstrates the essential very gradual transitions between parent rock and overlying chernozem. These facts will be confirmed in every detail by chemical analysis of the Simbirsk soil.

The gradual nature of the conversion of parent rocks to soils in these cases is best demonstrated by analyses (given below) of soils, from different horizons, taken in the environs of Bugul'ma, Samara Province. Chernozem in these samples directly overlies Triassic or Permian limestone. The most characteristic numerical data follow:

Soil depth	Up to 4 in. [10 cm]	4–13 in. [10–33 cm]	13–19 in. [33–48 cm]	Below 19 in. [48 cm]
Humus with hygroscopic water, %	19.805	13.276	6.976	0.644
CaO_3, %	0.057	0.098	53.768	93.672

These analyses show that, as when chernozem overlies loess, the mineral constituents in different soil horizons are identical to those in subsoil, in quality as well as in quantity, excluding $CaCO_3$

The limestone grains and, occasionally, whole fragments, which are very common in this chernozem, especially in its lower horizons, are only slightly altered remnants of the parent rock. This is made clear by the mode of their occurrence (see section of Simbirsk soil) and by their composition (see analysis of Bugul'ma chernozem). To illustrate further, it should be added that humus and plant roots do not penetrate uniformly even such a comparatively loose rock as loess (see section of Tomashevka soil). Certain areas even of this parent rock are much more intensely colored than other areas, and horizon B may contain areas of loess nearly unaltered by vegetation humus. Small wonder, then, that the same features are encountered in chernozems lying on calcareous rocks!

Personal observations of the weathering of limestones and chalk make it obvious that the weathering process beginning at the surface and

[1] Similar facts are well known to practical farmers. – Trudy VEO, pp. 286 and 297, March 1879.

progressing into the inner, deeper layers is far from uniform, owing to differences in fissuring, stratification, hardness and composition of these rocks. Therefore, a horizon may contain some rock fragments which are completely weathered while others are almost unaltered. In certain places the weathering has proceeded to greater depths, while in others the rock has hardly been weathered at all. Finally, in certain cases, lower chalk horizons have been weathered to loose marl while upper horizons still largely preserve their original appearance. All these phenomena are clearly visible in the chalk pits in the vicinity of Simbirsk.

Thus, the direct occurrence of chernozem on calcareous rocks is quite normal and undoubted.

Another possible objection is that in all these cases chernozem formation began after the conversion of chalk and limestone into loam. This objection may be countered by the following facts. It should first be borne in mind that any parent rock being weathered on the surface undergoes this process parallel with its "colonization" by certain vegetation; consequently, the two processes should not be separated. Secondly, all the transition horizons B which I observed in soils on calcareous rocks always consisted of a mixture of chernozem with fragments of unaltered parent rock. The principal point is that chernozems with a fairly considerable $CaCO_3$ content are frequently found in soil horizon A as well; the following examples are illustrative.

Locality	Khvalynsk	Nikolaevsk, Samara Province	Simferopol	Beloglinka, Kamyshin District	Skrebnitskaya, Novouzensk District	Taigil'dino, Menzelinsk District
Investigator	Kostychev[1]	–	Balkov[2]	–	–	Schmidt[3]
Sampling depth	2–6" [5–15 cm]	2–6" [5–15 cm]	2–6" [5–15 cm]	2–6" [5–15 cm]	2–6" [5–15 cm]	2–6" [5–15 cm]
$CaCO_3$ [%]	25.42	11.14	12.63	14.63	6.75	Above 3.936
Humus [%]	15.079	6.445	4.558	5.42	4.193	13.363[4]

[1] and [2] [Balkov, S.]. – Journal "Sel'skoe Khozyaistvo i Lesovodstvo", pp. 279–282, Nov. 1880.

[3] Schmidt. Ibid., No. 2, first table. [Fiziko-khimicheskie issledovaniya pochvy i podpochvy chernozemnoi polosy Evropeiskoi Rossii] (Physicochemical Studies of Soil and Subsoil in the Chernozem Zone of European Russia), St. Petersburg. 1881.

[4] The content of lime is comparatively high in the Samara soil as well. See Voelker's analyses.

Of the six samples in the table, only those from Khvalynsk and Simferopol were taken from depressions in which extraneous substances may have been deposited; all the other samples were taken under conditions which totally excluded this possibility. Thus, the simultaneous occurrence of considerable quantities of $CaCO_3$ and humus in soils must be regarded as having been completely proved. The theoretical proposition regarding the possibility that the annual increment of vegetal materials may exceed the quantity of humus mineralized in the presence of $CaCO_3$ and the possibility that the soil may accumulate organic substances in the presence of excess $CaCO_3$ is thus automatically proved to be based on fact.

The observation by Prof. Sintsov (quoted on p. 213) and my own observations, which almost throughout touch upon the correlation between the distribution of more or less typical chernozem and the region of predominantly calcareous formations, suggests the immediate products of chalk and limestone weathering to be generally the most suitable parent rocks for the formation of rich chernozem. Additional proof of this view is provided by the following small table:

Near Vol'sk	9.467 %	humus
12 versts north of Saransk . .	10.376 %	"
Saratov	11.292 %	"
In the vicinity of Khvalynsk .	15.069 %	"
In the vicinity of Bugul'ma .	15.423 %	"
Simbirsk	19.171 %	"
Mean	13.496 %	"

All the samples in this table directly overlie calcareous rocks with a $CaCO_3$ content definitely over 90%. A content of 13.496% humus in soils is maximal among all averages obtained for more or less extensive areas. I should like to mention, as well, that of the roughly 300 samples which I collected and which have been analyzed, the Simbirsk and Bugul'ma chernozems have the highest organic substance content.[1]

The final type of parent rock important for chernozems of central Russia is (e) boulder loess loam, the subsoil predominant in this region. As has been seen, the southern and southeastern boundaries of the occurrence of this loam in European Russia are approximately represented by the zigzag line passing through the following points: northern slopes of the Galicia-Volhynia-Podolia plateau (Barbot de Marni), northern boundaries of the Kherson and Ekaterinoslav provinces (Feofilaktov) and the southern boundaries of the Voronezh and Kursk provinces (Borisyak), the River Medveditsa nearly from its mouth (Borisyak and Sintsov), Serdobsk (Pacht), Penza, Ardatov, and the western boundary of the Kazan Province (Wangenheim von Qualen). The boulders are mainly formed from granites, diorites, and especially quartzites; these, naturally, are the most durable rocks. The boulders are usually rounded and strongly weathered; polished and striated boulders were found only in the Tambov Province (Gurovo and Krutoe) and in the Chernigov Province (Armashevskii), and even then as an extreme rarity. These boulders are mostly smaller than 1 ft [30 cm]; nevertheless, some boulders in the lower reaches of the Khoper "are several sazhens in circumference" (Borisyak); the diorite boulders which Sintsov found in the Atkar District were "about 2 1/2 ft [76 cm] wide, 2 arshins [1.4 m] long and of the same height." They are usually in the subsoil where they may form rather thick accumulations (in the vicinity of Voronezh and Filonova); however, in some places they are "enveloped by chernozem" (Murchison, Borisyak, Sintsov, and according to my own observations near Filonova). It is thus quite obvious that Ruprecht's principle regarding the identity of the southern boundary of large northern boulders with the northern boundary of the Russian chernozem which he suggested is completely erroneous, since it has been found that the best Russian chernozems lie on boulder loam. All the inferences from this principle are likewise erroneous. The local boulder loam, however, should not be regarded as identical to northern loam. On comparison of analyses of the Krutoe subsoil on the one hand, and the Vyaz'ma and Klin subsoil on the other, it becomes clear that the diluvial loam is richer than the loam

[1] If our hypothesis is correct, its explanation should be mainly sought in the relatively easy weathering of calcareous rocks (a) and in the chemical composition of their immediate weathering products (b).

in the latter two areas by a factor of 4 and more, in respect to its phosphoric acid and potassium oxide contents, two principal nutrients. This is certainly one of the factors causing the dissimilarity between soils formed from the boulder deposits of northern and central Russia.

The same comparison discloses yet another characteristic of southern diluvium — its higher $CaCO_3$ content. This circumstance, together with the presence of local boulders in the deposit (Kulibin), its thinness, and predominant occurrence on slopes and in depressions demonstrates that the bulk of this loess owes its origin to the underlying calcareous rocks.

We shall see below (see the above analyses and Chapter V) that this diluvium distinctly differs from deposits of southwestern Russia, as well, being richer in clayey substances, carbonates, potassium oxide and phosphoric acid. I regard this as the cause for richer chernozem occurring in central Russia than in southwestern Russia. The average humus content in all the analyzed soils discussed above (27 samples) from central Russia is 8.430%, while average thickness is only 2 ft 2 in [66 cm]. The difference will be even more significant if samples known to be sandy are not taken into account.[1]

The post-Tertiary yellowish-red loam (atmospheric clays) east and south of the abovementioned southeastern boulder boundary differ insignificantly from the boulder loess, as far as appearance, underlying bedrock and conditions of occurrence are concerned. It is quite possible that boulders will in time be discovered in these loams as well. Thus, predominant subsoil throughout central chernozem Russia, except for areas with outcrops of Tertiary (and only partly Jurassic) rocks, is the same calcareous loam (loess) which may or may not contain boulders. In cetain localities loess directly overlies its parent rocks — chalky marls and chalk (the atmospheric clays described by Sintsov), in other places it has been redeposited over certain distances; in the basins of the Khoper and the Medveditsa, for instance, it forms a nearly continuous cover, while on other sites it occurs mainly in depressions and on the lower thirds of slopes.

In view of all these considerations, I cannot agree with M.N. Bogdanov's sharp subdivisions of the Volga chernozem feathergrass steppes (p. 217). Obviously, Chaslavskii's classification described on p. 222 is even less well-founded.

[1] Following this dicussion (especially regarding the relationship between chernozem and chalk), as well as analyses of samples from Krutoe, Gurovo, etc., no further proof (Zalomanov, ibid.) that loess can be parent rock for chernozem is needed.

Chapter V

*TRANS-VOLGA CHERNOZEM TERRITORY**

In this chapter the term "Trans-Volga territory" is used to designate the territory between the Kama, the eastern slope of the Urals and the Volga, approximately to the line Kamyshin — Ural'sk. The area thus includes the entire Samara and large (western) parts of the Orenburg and Ufa provinces as well as the Chistopol and Spassk districts of the Kazan Province. The orographic map of European Russia depicts the eastern half of the Trans-Volga territory as an elevated (sometimes higher than 1000 ft [305 m]), rolling plateau, gradually descending northward (the Kama), westward (the Volga), and southward and forming a series of terraces to the north and west. The lowest terrace (nearest to the rivers) is only slightly higher than the Aral-Caspian depression. Nevertheless, in the plateau and in the basins of the rivers incising it (Ural, Samara, Kinel, etc.) many points are relatively low — such as Orenburg, 285 ft [86 m], Buguruslan, 324 ft [98 m] and Menzelinsk, 397 ft [120 m].

F o r m e r s t u d i e s o f t h e T r a n s - V o l g a S o i l s. We believe the very close genetic relationship between the geology and soil of a terrain to have been sufficiently elucidated in the preceding chapters. Therefore, and also due the relative uniformity in structure of the Trans-Volga territory (with an apparent predominance of Triassic formations), and partly also for lack of space, the geology will not be treated, and we shall be concerned with historic descriptions of local soils. Only fairly complete systematic works will be dealt with.

First among such works is the effort of the cadastral groups on evaluation (1856 — 1859) of lands belonging to government-owned villages in the Samara Province.[1] These are the most complete and accurate of all the cadastral investigations of Russia at my disposal.[2] I shall discuss these works in detail, especially since they are typical of their kind.

The Samara Province is divided into two parts by the Bol'shoi Irgiz River, the hilly northern part, rich in streams and, to a certain extent, in forests, and the southern part which is characterized by lack of water, lack of forests, and a level surface: "The northern part is dominated by chernozem with a subsoil of clay, argillaceous limestone or various shales (?) and arenaceous rocks; in the southern, purely steppe part, the prevailing

* [The term "Trans-Volga" is used for the Russian term "Zavolzh'e," territories lying east of the Volga. Translator.]

[1] Materialy dlya statistiki Rossii, sobiraemye po vedomstvu Ministerstva gosudarstvennykh imushchestv (Materials for the Statistics of Russia, Collected by the Ministry of Government Estates). No. 3, [St. Petersburg]. 1861.

[2] D o k u c h a e v. Kartografiya russkikh pochv (Cartography of Russian Soils).

soil is loam with subsoil of the same composition or clay."[1] These two belts form fairly gradual transitions. "Chernozem of the northern belt gradually changes from black to black-brown southward; south of the Samara River it appears in all shades of black-brown up to dark brown. Beyond the Irgiz River it appears only in small patches and on elevated areas known as 'syrts'." There is a similar gradual southward decrease in the loam chernozem content.

"On level and slightly elevated areas, the upper layer of chernozem (simply chernozem ?) reaches 1/2 arshin [36 cm] and more in depth; in hilly areas, the upper (soil) layer becomes shallower, and on the hillsides it consists of a very thin layer, often exposing the subsoil formation (?!)." According to the subsoil's mineralogical character, the "soil of the Samara Province may be clayey, loamy, sandy-loamy, sandy, or gravelly." In addition, "along the banks of the Volga River, the western boundary of the Samara Province, the soil is sandy even fairly far away from the river. On the bank itself the sand is almost totally uncompacted; farther away from the Volga, the soil becomes progressively sandy-loamy and forms a gradual transition to loam, in certain places even to clay. All rivers emptying into the Volga in this area are of identical geological structure as are the tributaries of the major among the rivers. However, these sandy belts are not of uniform width; they are alternately narrower and wider and the sand becomes progressively more coherent toward the river sources."[2]

Details of soil character in the Samara Province are presented below.

A. Chernozem soils. "Good chernozem is black when dry, with an imperceptible admixture of sand," it is 1/2 — 1 arshin [36 — 71 cm] thick, and even more. "It always occurs in small patches scattered throughout the districts in the northern half of the Samara Province. It occupies larger areas in the narrow belt stretching from the western boundary of the province, in the northern half of the Stavropol District) eastward toward the boundary of the Kazan Province up to the sources of the Cheremshan, Kondurcha and Sok rivers. It then turns south in the Samara District, toward the sources of the Trostyanka and Chernovka rivers, tributaries of the Sok River. The belt then turns toward the Samara River up to the sources of the Kutuluk River, cutting through the Buzuluk and Buguruslan districts from west to east, on both sides of the Kinel and the Malyi Kinel'chik rivers, and terminates in the Matveevskaya and Bogorodskaya 'volosts'. Moreover, a branch of this belt extends toward the boundary of the Kazan Province, into the southwestern part of the Bugul'ma District. High-quality chernozem also occurs along the bank of the Ik River, which flows through the northern part of the Bugul'ma District."

Gray or brown chernozem is black-brown and black-gray when dry; it contains less humus than the variety mentioned above, and is 6 — 12 vershoks [27 — 53 cm] thick or more; it contains a small imperceptible admixture of sand. "This chernozem, at the fringe of high-quality chernozem in the above-described belt, is black-gray mainly in the southwestern part

[1] However, according to information provided by the cadaster "This general distribution of soils is somewhat modified for the Buguruslan and Bugul'ma districts, in the area stretching from the sources of the Sok and Kinel rivers to the boundary of the Orenburg Province." Here, on hilly terrain, "soil character is extremely varied; it is clayey at times, at others sandy, and in certain places even gravelly" (ibid., p. 2).

[2] Ibid., pp. 1-2.

of the Bugul'ma District, and in the northwestern part of the Buguruslan District, and a black-brown color in all the other chernozem areas in this province. The soil predominates on level elevations between the Samara and Irgiz rivers, and appears in small patches beyond the Irgiz in the Nikolaevsk and Novouzensk districts. In some localities, the brown chernozem appears to be leaner, and is dark-brown due to the appreciably lower humus content. In some places, such chernozem is known to local inhabitants as loam."

Chernozem with lumps of clay uncolored by humus ("paglinok") "contains an appreciable admixture of sand with schist (?) and quartz (?) cobbles. It is dark-brown and black-gray when dry, due to an admixture of yellow, reddish, and white clay or sand, sometimes brown and ash-gray. The upper (soil) layer is 3 — 8 vershoks [13 — 36 cm] deep and less. This chernozem occurs on all slopes descending to rivers and gullies and is always surrounded by one of the two varieties described above.

"Chernozem with an admixture of reddish and yellow clay is the prevalent soil in the area between the Samara and Irgiz rivers, in the Buzuluk, Samara, and Nikolaevsk districts. Admixed with white clay or argillaceous limestone, it appears in the Novokuvakskaya, Novopis'myanskaya and Dymskaya 'volosts' of the Bugul'ma District, in the northern part of the Adelyakovskaya 'volost' and in the Starososniskaya and Dmitrievskaya 'volosts' of the Buguruslan District. It often contains a considerable admixture of coarse sand; as such, it is the dominant soil in the Buzuluk District on the right bank of the Samara River from the confluence of the tributary, Borovka, between the Samara and Tok rivers, up to the River Uran in the Staro-Teplovskaya and Pron'kinskaya 'volosts'."

B. Nonchernozem soils. Another important soil in the Samara Province is the steppe loam (brown soil). This soil is "subdivided into fairly chernozemic dark-brown, brown, light-brown soil, and is also subdivided according to mineralogical composition into more or less clayey and sandy soils. This brown color, which is due to a considerable admixture of yellow and reddish clayey and sandy particles, distinguishes it from so-called 'gray soil'"...Steppe loam is characteristic of the southern steppe belt of the Samara Province. "It is dark-brown at the boundary between the Nikolaevsk and Novouzensk districts, on elevated plains ('syrts') which form the water divide between the tributaries of the Irgiz River and the minor steppe rivers Bol'shoi Uzen and Eruslan, and on the plains between the sources of these rivers. This soil displays a brown or light-brown color on slopes descending toward the river banks and in depressions. In this form it is the dominant soil toward the south; the poorest, light-brown, varieties of this soil, occur in the southeastern part of the Novouzensk District, along the Bol'shoi Uzen and Malyi Uzen rivers."[1]

C. Much less widespread in the Samara Province are floodplain soils, consisting of silt deposited by the springtime river floods and "sandy soils", whereas "red and white clays rarely appear on the slopes descending toward rivers and on steep declivities in mountainous areas."

D. Solonetses are much more widespread. "They resemble the surrounding soil in appearance. In composition, solonetses contain

[1] Ibid., pp. 3—4.

considerable quantities of salts; when a wet soil dries, the salts cover its surface with a thin coating of white powder. Such soil tastes of salt, and is extremely attractive to livestock, especially sheep. Vegetation on solonetses is very poor. Grasses and corn grow well in spring, but the salts appearing on the surface with the onset of dry weather cause rapid wilting. Solonetses occur mainly in loamy and clayey soils, are fairly rare and small in area in more chernozemic localities. However, they extend over larger areas southward, and are quite extensive in the poor loamy soils in the southern part of the Novouzensk District."[1]

The source quoted above also includes the highly instructive table on the following page.

An excellent addition to work done by the cadastral commissions for the Samara Province is the analyses performed by Vinogradov and Voelker,[2] presented below and on pp. 263 – 264.

Chernozem from the Bugul'ma District, long-fallow land, upper layer.[1] Analyses by V. Vinogradov [percentages]

HCl-soluble fraction (sp. gr. 1.15)	SiO_2	0.016
	SO_3	0.250
	P_2O_5	0.087
	CO_2	4.038
	Chlorine	0.088
	Fe_2O_3	3.395
	Al_2O_3	1.880
	Mn_3O_4	0.289
	CaO	3.874
	MgO	0.977
	K_2O	0.222
	Na_2O	0.018
	Organic substances and chemically bound water	3.150
HCl-insoluble residue	SiO_2 soluble in soda	13.968
	Insoluble SiO_2	34.615
	Fe_2O_3	1.548
	Al_2O_3	9.729
	CaO	1.475
	MgO	0.127
	K_2O	1.526
	Na_2O	1.498
	Loss on ignition	11.864

[1] Il'enkov. Ibid.

The work "Natural History of the Orenburg Territory" (Estestvennaya istoriya Orenburgskogo Kraya) (1840) is of even greater pedological significance. Its author, the well-known Prof. Eversmann, divided the Orenburg Territory into three major belts in accordance with the soils "closely related to the plant and animal kingdoms."

[1] Ibid., p. 5. Chaslavskii's map indicates soils in the Samara Province in accordance with these data. He deviated only once, unsuccessfully, as will be seen below, indicating a series of loamy "islands" of the type occurring in northern Russia, for the northeastern part of the Samara Province and the adjacent areas of the Ufa Province. Author.

[2] Unfortunately, all these analyses refer to soils of "chernozem type" in the Samara Province. Author.

Division of normally occurring soils, according to natural properties, accepted for classification of plowlands in the S[illegible]

Terminology: according to natural properties	Terminology: local names	Soil depth	Properties of subsoil	Characteristic features of soil	Areas of p[illegible] occurrence	[illegible]
				A. Chernozem soils		
I. Best chernozem						
1. Rich loamy chernozem	Chernozem	8 vershoks [36 cm] and more	Subsoil of the same composition with appreciably small admixture of humus, or red loam	Black when dry or wet; when the soil is dry and pulverulent, a fine sand becomes noticeable; floury, grains readily triturated	In some [illegible] Bugul'[illegible] Buguru[illegible] and Stavro[illegible] tricts	[illegible]
II. Good chernozem						
2. Best clayey chernozem	Chernozem	6 to 8 vershoks [27–36 cm]	Reddish-yellow, marly or white clay	Black-brown or black-gray when dry, black when wet; granules are angular in fracture; cracks when dry	As above, [illegible] Nikolaev[illegible] Novou[illegible]	[illegible] with [illegible]
3. Good clayey chernozem	Chernozem	6 to 8 vershoks [27–36 cm]	Reddish-yellow or white loam	Dark-brown or dark-gray when dry; fracture appears to be strewn with glittering grains of sand		[illegible] chetveriks (4.1–8.5-fold with [illegible] of sown seeds)
4. Best sandy chernozem	Chernozem	8 vershoks [36 cm] and more	Sandy (sometimes with an admixture of sand grains) or loamy, of different colors	Black-brown or black-gray to black when dry, and black when wet; very smeary when wet; considerable admixture of fine sand		[illegible] 42–60 chetveriks ([illegible]7–8.3-fold with [illegible] of sown seeds)

1 Two columns of the [original] table have been omitted here, due to lack of space: a) general remarks, b) sampling site. Only essential data from other columns has been reproduced.

* [1 chetverik of rye weighs approximately 19 kg. Ed.]

(Continued)

Terminology: according to natural properties	Terminology: local names	Soil depth	Properties of subsoil	Characteristic features of soil	Areas of predominant occurrence of soils	Classes, established according to yield of rye, minus the amount of seeds used for sowing, in "chetveriks"
10. Chernozem with whitish tinge ("belina")	Stony chernozem, clay	3–5 vershoks [13–22 cm] and less	Clay or loam of white color	Gray to ashy when dry, black-gray when wet, with an admixture of small grains of argillaceous limestones and pebbles	Bugul'ma and Buguruslan districts	Class IV 15–21 chetveriks (2.7–3.3-fold amount of sown seeds)
11. Chernozemic sand	Sand	4 vershoks [18 cm] and less	Coarse-sandy, white or yellow color	Brown or gray; coarsened by admixture of fairly large-grained sand	As above, and in the Stavropol District	
			8. Nonchernozem soils			
I. Best nonchernozem soils						
12. Chernozem loam	Brown earth	6–8 vershoks [27–36 cm] and more	The same composition, with less chernozemic particles	Dark-brown when dry, nearly black when wet, contains little, very fine sand	Buzuluk, Nikolaevsk and Novouzensk districts	II, 42–48 chetveriks ([5.7–6.3-fold amount of sown seeds)
II. Good nonchernozem soils						
13. Good loam	Brown earth	4–6 vershoks [18–27 cm] and more	The same composition	Somewhat lighter in color than the above, contains more sand	Nikolaevsk and Novouzensk districts	Class III, 33–39 chetveriks (4.7–5.3-fold amount of sown seeds)
14. Chernozemic sandy loam	Earth with sand	4–6 vershoks [18–27 cm] and more	Loam or sandy loams, loam of yellow-brown color	Dark-brown when dry, dark when wet; fine sand visible to the naked eye	Novouzensk District	—
15. Silty soil	Inundated land	3–4 vershoks [13–18 cm]	Viscous loam or sandy loam	Brown; dark when wet	In inundated depressions	—
III. Medium-quality nonchernozem soils						
16. Ordinary loam	Loam	4 vershoks [18 cm] and more	The same composition as the soil itself	Brown when dry, dark when wet. Sand coarser than in good loam	Novouzensk and Nikolaevsk districts	IV, 24–30 chetveriks (3.7–4.3-fold amount of sown seeds)

(Continued)

Terminology: according to natural properties	Terminology: local names	Soil depth	Properties of subsoil	Characteristic features of soil	Areas of predominant occurrence of soils	Classes, established according to yield of rye, minus the amount of seeds used for sowing, in "chetveriks"
17. Ordinary clayey soil	Clay	4 vershoks [18 cm] and more	The same composition or yellow clay	Brown, dark when wet, very viscous and sticky	—	—
18. Medium-quality sandy soil	Sand, "bor" soil	—	Pure coarse sand or yellow sandy loam	Brown when dry, dark when wet, with a large admixture of coarse sand	Novouzensk, Nikolaevsk, Buzuluk, and Stavropol districts	—
19. Inundated soil	Inundated	3—5 vershoks [13—22 cm]	Sandy	Light-brown when dry, dark when wet; mainly fairly coarse sands	In places along river banks	—
IV. Poor nonchernozem soils						
20. Poor loam	Loam, or yellow earth	4 vershoks [18 cm] and less	The same composition as the soil itself	Light-brown when dry, coarser than the preceding loamy soils	Novouzensk District	Class V, 15—21 chetveriks (2.7—3.3-fold amount of sown seeds)
21. Viscous loam or bad clayey soil	Clay	—	The same composition as the soil itself	Light-brown, slightly darker when wet; more viscous than ordinary clayey soil	—	—
22. Yellow and white sand	Loose sand	3 vershoks [13 cm]	Similar to the soil	Light-brown; noncompact even when wet	On high river banks	—
V. Poor nonchernozem soils						
23. Loamy and clayey solonetsous soil	Solonets	3—4 vershoks [13—18 cm]	Loam or clay of yellowish-white color	Color as in previous gradation of clayey soils	Mostly in the Novouzensk District	Class VI, from 9—12 chetveriks (1.7—2.3-fold amount of sown seeds)

Analyses by Voelker[1] [percentages], soils from the village of T[illegible]nashevo, Samara District (?)

Table I. Detailed chemical analysis of six soils (dried at [illegible]°F = 1[illegible]°C)

Thickness of soil and subsoil	31 in [80 cm] of chernozem underlain by a 10-in [25 cm] layer of clay+ chernozem mixture followed by clayey subsoil 31¾ ft [9.5 m] deep	26 in [67 cm] of chernozem, 8 in [20 cm] of mixture, underlain by the same subsoil as in No. 2	24 in [61 cm] of chernozem, 10 in [25 cm] of mixture, underlain by clayey subsoil	[illegible]	[illegible]	Taken from another estate, 24 in [6? cm] chernozem, 10 in [25 cm] mixture, underlain by clayey subsoil
Soils	No. 2	No. 3	No. 4	[illegible]	[illegible]	No. 7
Organic substances and chemically bound water	10.095	15.705	[illegible]	[illegible]	[illegible]	[illegible]
Iron oxides	[illegible]	6.407	[illegible]	[illegible]	[illegible]	[illegible]
Al_2O_3	[illegible]	4.150	[illegible]	[illegible]	[illegible]	[illegible]
CaO	[illegible]	1.984	[illegible]	[illegible]	[illegible]	[illegible]
MgO	[illegible]	0.750	[illegible]	[illegible]	[illegible]	[illegible]
K_2O	[illegible]	0.482	[illegible]	[illegible]	[illegible]	[illegible]
Na_2O	[illegible]	0.047	[illegible]	[illegible]	[illegible]	0.373
SO_3	0.071	0.089	[illegible]	[illegible]	[illegible]	0.079
Nitric acid	0.002	0.002	[illegible]	[illegible]	[illegible]	0.074
Chlorine	0.009	0.006	[illegible]	[illegible]	[illegible]	0.001
P_2O_5	0.021	0.243	[illegible]	[illegible]	[illegible]	0.006
Insoluble silicates and sand	73.201	69.550	[illegible]	[illegible]	[illegible]	0.128
CO_2 and analytical losses	1.658	0.585	[illegible]	[illegible]	[illegible]	80.165
Total	100.00	100.00	100.00	100.00	100.00	1.196
Nitrogen content in the organic substance	0.362	0.504	0.292	0.251	0.401	100.00
Ammonia, accordingly	0.437	0.612	0.354	0.365	0.487	0.272

[1] Roth's Notes on Russian Agriculture, translated by V. Kovalevskii, pp. 429–432.

Table II. Mechanical analysis of 6 samples (dried at 212° F = 100° C)

	Second soil	Second subsoil	Third soil	Third subsoil	Fourth soil	Fourth subsoil
Organic substances and chemically bound water	10.09	3.79	15.70	5.30	10.76	4.95
$CaCO_3$	6.34	18.27	3.54	20.55	3.30	13.35
Clayey particles	51.55	39.74	51.15	38.65	54.13	63.25
Sand	32.02	38.20	29.61	35.50	31.81	18.45
Total	100.00	100.00	100.00	100.00	100.00	100.00
	Fifth soil	Fifth subsoil	Sixth soil	Sixth subsoil	Seventh soil	Seventh subsoil
Organic substances and chemically bound water	10.16	6.96	11.50	3.70	9.27	7.30
$CaCO_3$	5.13	13.97	1.95	12.91	2.12	15.75
Clayey particles	58.31	54.36	53.06	48.21	48.51	52.08
Sand	26.40	24.70	33.49	35.18	40.10	24.87
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table III. Analysis of six subsoils (dried at 212° F = 100° C)

Subsoils	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Organic substance and chemically bound water	3.79	5.30	4.95	6.97	3.70	7.30
Iron oxide and alumina	4.79	7.65	9.90	12.50	9.75	9.75
$CaCO_3$	18.27	20.55	13.35	13.97	12.91	15.75
HCl - insoluble siliceous substances	73.15	66.50	71.80	66.56	73.64	67.20
	100.00	100.00	100.00	100.00	100.00	100.00

The northeastern belt (A) includes largely forested and mountainous areas; belt (B) includes northern and eastern fertile steppes covered by a chernozem layer of variable thickness; belt (C) includes the southern and southwestern steppes "completely devoid of humus" and in turn becoming clayey, solonetsous and sandy.[1]

"This subdivision is based on natural properties, but no positive and precise boundaries may be marked and the transition from one belt to another is of necessity gradual."[2]

[1] This belt should have been included in the next chapter, but Eversmann describes all the belts of the Orenburg Territory as a continuous entity and with a comparative approach, and I therefore decided to follow his example.

[2] Eversmann. Ibid., p. 18. [Estestvennaya istoriya Orenburgskogo Kraya (Natural History of the Orenburg Territory), parts 1—3, Kazan. 1840—1866.]

We shall disregard the forested belt (A) which lies almost entirely in the mountain regions of the Orenburg Urals, and includes plains only in the north of the Orenburg Province and at the boundaries of the Kazan and the Vyatka provinces, and shall present a detailed description of belts (B) and (C).

According to Prof. Eversmann, fertile steppes (B) covered by chernozem, surround the Orenburg Urals to the east, west, and south, adjacent to the forests. The extreme southern spurs of the Orenburg Urals are "bare and forestless" and form a gradual transition to rolling steppe, in turn forming a transition to a flat plain.[1] "A distinctive feature of the fertile steppes is that the (marine) silt has been covered by a more or less thick layer of chernozem produced by plant decay over the millennia."

"The boundary, or limits of these steppes cannot be established accurately, and the transition to solonetsous steppe is gradual and imperceptible."[2]

Composition of the insoluble silicates and sand in soil No. 2 (total, 73.201%, see Table I)

Fe_2O_3	2.41
Al_2O_3	6.66
CaO	0.85
MgO	0.98
K_2O	1.26
Na_2O	0.52
SiO_2	60.62
	73.20[1]

[1] An analysis of soils from the Samara District was also published by Mr. Schlippe (ibid.), but Voelker's data are more recent and were therefore reproduced. It should, however, be remarked that chernozem analyzed by Schlippe contained 11.20% humus (including hydration water). – Author.

All these areas are completely treeless, due to the extreme dryness of air, strong summer heat, and lack of water"[3]; according to Eversmann, even "annual plants scarcely occur in the steppes proper; the hot dry spring and summer, especially in the southern steppes, preclude seed maturation, since seeds dry prematurely; annual seed plants thus die out."[4] Plants characteristic of proper steppes are perennial herbs and shrubs; thanks to their thick, long, succulent roots, these "plants support life even during the severest droughts; moreover, if their seeds do not mature in a very dry year, the stalks will grow the following year and the plant does not perish."[5]

The typical flora of fertile steppes includes *Stipa pennata* and *capillata*, *Astragalus*, *Salvia*, *Veronica*, *Scabiosa*, *Linum*, *Gypsophila*, *Dianthus*, *Silene*, *Centaurea* *Echinops*, *Scorzonera*, *Aster*, etc., as well as *Spiraea*, *Cytisus*

[1] Ibid., pp. 44 and 51.
[2] Ibid., pp. 53–54.
[3] Ibid., p. 43.
[4] and [5] Ibid., p. 52.

biflorus, Caragana frutescens, Prunus chamaecerasus, and Amygdalus nana. These plants decorate the Orenburg plains successively almost throughout the spring, summer, and even autumn.[1]

"Bare (C), unfertile or 'hungry' steppes (called katkil' by the Kazakhs) are distinguished by absence of chernozem; their soil is yellowish or even whitish solonchak silt, often bearing salt efflorescences on the surface... Although the silt is not covered by chernozem, the latter often forms an admixture, since it is produced by decayed plant residues. Chernozem increases toward the north and decreases toward the south, seaward. Vegetation on silty steppes is not uniform everywhere[2]; it generally includes only a small number of species and is monotonous. The life of plants is extremely rapid; in the course of a few weeks the plant grows a stem, leaves, develops the flower, matures the seed, and the grasses again become dormant for a whole year, the only vestige being the live roots underground.[3]

Most typical of bare steppes are two species of sagebrush, Artemisia monogyna and A. nutans; however, even these grasses form a much more sparse cover than the grass cover of the northern steppes, they are scattered, do not cover the soil continuously and the visible bare silt or clay create a dismal, desolate impression of the steppe."[4]

"The southern (hungry) steppes (C) are followed by solonchaks and sands which are also partly present within these steppes."[5]

"Solonetses consist of grayish saline silt; they may be a) dry, b) wet, c) proper 'khaks' which are saline muds. Some 'khaks' are surficial, others are bottomless and impassable; all were formed by the drying of saline lakes. Small areas of mud and dry solonetses may also be formed by the thaw waters and rainwater flowing down from the heights, leaching the silt on the way and transporting it to a low-lying area. The leached salt is a mixture of different salts, one of its principal constituents magnesium sulfate. Solonetses are usually quite bare, and various saltworts only grow at their edges or shores. Most common are species of the genera Salicornia, Salsola, and Schoberia; sometimes these plants more or less cover the entire solonets."[6]

It is clear from the chapter on the properties of Russian chernozem that Prof. Eversmann attributes the distribution of soils in the Orenburg territory exclusively to different ages of the terrain and, as a result, to differences in absolute elevation. However, we hope to prove below that the soils would be distributed similarly even had the terrain been of uniform age and height. Eversmann himself points out that the flora, fauna,

[1] Ibid., pp. 54-55.

[2] Ibid., pp. 62 and 71. Prof. Eversmann stresses the presence of marl and gypsum on the rocks which are "a distinguishing feature of bare steppe."

[3] Ibid., pp. 62 and 71.

[4] Ibid., p. 71. In another place (p. 72), Eversmann writes as follows: "Flowering of the southern steppes becomes noticeable at the end of March and terminates as early as the first half of May; the steppe is later parched by the heat and no green strikes the eye all summer long; not a single flower can exist..."

[5] These are outside the boundaries of the Orenburg Province and are not discussed here.

[6] Ibid., p. 63. Some idea of the chemical composition in the extreme southern part of the Orenburg Province and the neighboring Kirgiz [Kazakh] steppes may be acquired from Messrs. Reichardt (ibid.), and Gebel (Reise in die Steppen des südlichen Russlands. [Dorpat]. 1837-1838. Th. I, S. 297-298 und Th. II, S. 164-168); unfortunately, all these data are obsolete. Author.

and climate of the northeastern part of the territory are central European, while these characteristics in the southwestern part of the Orenburg territory bear stronger resemblance to Turkestan steppes.[1] In the northern belt of the province, adjacent to the Perm and Ufa provinces, birch woods are very common, there is no lack of rain, and crop failures are rare; in contrast, steppe areas may be rainless in certain years, dew may not appear for weeks, the heat is unbearable, and the air excessively dry. Wild as well as cultivated plants often wilt before flowering. Eversmann goes on to add that "as soon as the snow (in the southern steppe) has thawed and the earth becomes softened, the grasses and the insects abruptly awake from their prolonged dormancy and develop with unusual rapidity, as if bearing the premonition of a brief span of existence, and the knowledge that the steppes will soon be parched of vital moisture by the summer heat."[2]

Therefore, the southern Orenburg steppes lack the organic substances which might, through percolation into the ground, facilitate the formation of rich chernozem. The existing low-humus soils probably owe their origin to the decay of deep-seated plant roots.

The works, cited above, of the cadastral commissions and Prof. Eversmann prove to be so true to nature in their main features and provide such a vivid description of the general character of soils in the Trans-Volga Territory, that all subsequent investigations of the territory could only confirm the soil scheme and enrich it in new details. I reached this conclusion on the basis of my excursions (1878) in the Samara Province and also in parts of the Kazan and Orenburg provinces.

I was able to achieve a better observation of the general character of local soils, by travelling along the following routes: a) the left bank of the Kama (Chistopol — Chelny), b) Chelny, Buzuluk, Novouzensk, c) Samara, Buzuluk, Orenburg, and finally d) along the left bank of the Volga with stops in the Spassk, Stavropol, Samara, Nikolaevsk, and Novouzensk districts.

A. LEFT BANK OF THE KAMA RIVER

Chistopol — Polyanki — Chelny

My observation and examination of the immediate neighborhood of the Kama took place only at the following three points: Chistopol, Polyanki, and Mysovye Chelny of the Menzelinsk District. These localities are all on the high left bank of the Kama, where various Permian formations are only partly covered by their weathering products, red-yellow loess loams; in other places, they formed a direct transition to soil.

The soils in the neighborhood of Chistopol are brownish-gray, strongly eroded by atmospheric waters probably due to the very hilly terrain which is common in areas along river banks. However, just east of the town, toward the villages of Malyi Tolkish and Bol'shoi Tolkish (approximately 15 versts south of the Kama) there stretches a gently rolling

[1] Ibid., p. 1.

[2] Ibid., pp. 1–11 and 56. Data reported by the cadastral commissions and by Eversmann were exactly paralleled in 1845 by the unknown author of "Description of the Trans-Volga Territory" (Opisanie Zavolzhskogo kraya) in Zhurnal Ministerstva gosudarstvennykh imushchestv, section 16, pp. 234–251, St. Petersburg. 1845.

steppe with sparse feathergrass and typical friable chernozems reaching 2 ft [61 cm] and more in thickness. The gullies and rills usually display red marly clay or, less frequently, variously colored marl underlying the soil. I made the following section on one of the highest, most level areas in this territory, two versts northwest of Bol'shoi Tolkish, on a glade in a felled oak forest.

A. Soil horizon, 1 ft 6 in [46 cm].

B. Transition horizon, 1 ft [30 cm].

C. Typical yellowish-red loess with abundant $CaCO_3$ concretions.

Analysis of Tolkish chernozem gave a 11.728% humus content. I observed essentially identical soils on the fields of the villages of Islyaikino and Romashkino. Moreover, in the village of Bol'shoi Tolkish, near the water mill, at the foot of an insignificant slope toward the neighboring minor river (the Tolkish) there are one or two dessiatines of solonchak with perfectly black, loose soil. P.A. Zemyatchenskii, who investigated this soil (complete analysis is presented below) found that "this soil has a strongly musty smell, and has an acid reaction to litmus; a piece of paper in a jar of this soil was completely decomposed in a few days; the soil effervesces vigorously with acids, and liberates abundant gas bubbles on inundation. Many small terrestrial shells and only a few plant rootlets are found. Some lumps contain pulverulent or granular white segregations, containing SO_3 and Mg (epsomite ?)."

In order to observe the effect of the Kama on the constitution of local soils, once again, I traveled from Tolkish to Polyanki (Chistopol District, approximately 25 versts northeast of Tolkish), at the beginning of the Kama floodplain. Identical chernozem stretched to Starosheshminskii, for about 10 versts; from this point up to Polyanki, for about 15 versts, there was a very rapid alternation of thin (not exceeding 1 ft [30 cm] in thickness) stony (on hilltops), gray forest and loamy floodplain soils (in the valleys of the Sheshma and Asha rivers), finally turning nearly red and very marly at Polyanki, on the general slope toward the Kama. The entire territory between Polyanki and Sokolki is a very typical floodplain with numerous oxbow lakes; the soils were either characteristic "suglei", or had a considerable admixture of deposited chernozem; the latter is often interbedded with lacustrine-fluvial sands and clays.

During my third trip, I examined the steep left bank of the Kama at the village of Mysovye Chelny, Menzelinsk District, where the bank bluffs reach 10 sazhens [21 m] in height; their "base is composed of limestone slabs, sometimes containing many well-preserved shells, overlain by pisolitic sandstone...; the entire formation is topped by a thick bed of red clay with no trace of chernozem at the surface; *Geranium sibiricum* grows only on the bank. Old vegetation and black earth are rare as far as 1—2 versts from the shore; at that point chernozem, sometimes interrupted by the forests and generally forming large continuous surfaces, becomes visible."[1]

Following Ruprecht, I found thin, gray soil at the village of Mysovye Chelny; at a casual glance, these soils are identical to the northern soils, but they obviously occur very near the Kama where the terrain is usually very hilly. Dark soils reaching 1 ft 4 in [40 cm] in thickness appear as soon as the terrain levels off, toward Orlovka, no more than 1 verst from

[1] Ruprecht. Ibid., pp. 34-35.

also sandy-loamy, of equal thickness (2 ft 4 in [71 cm]) and likewise relatively low in humus (5.293 %).

I was able to examine the left bank of the Volga en route from Pokrovskaya Sloboda (opposite Saratov) to Novouzensk, over approximately 150 versts, in much greater detail and over a much greater area. The entire territory may be divided into the following three areas: a) from the Volga to the Bol'shaya Karama River, b) between Bol'shaya Karama and the Eruslan River, and c) from the Eruslan to the Bol'shoi Irgiz River. In area (a) the terrain descends terrace-like toward the Volga (at Pokrovskaya and General'-skoe), and in area (c) toward Novouzensk, the highest point being in the water divide Eruslan — Karama. The subsoil appears identical over the entire territory, reddish-yellow, sometimes sandy, loess. Accordingly, the soils are as follows:

Territory between the Volga and the Karama	Thickness	Humus, %	Area between the Karama and the Eruslan	Thickness	Humus, %	Area between the Eruslan and the Bol'shoi Irgiz	Thickness	Humus, %
Village of General'-skoe 6 versts east of the Volga, Novouzensk District	7" [18 cm]	1.922	3 versts west of Gofental [Hofenthal], Novouzensk District	8" [20 cm]	3.375	6 versts west of Novotulka, Novouzensk District	1'2" [35 cm]	3.621
9 versts northwest of Gnadendorf, Novouzensk District	9" [23 cm]	4.218	15 versts northwest of Gofental, Novouzensk District	1'5" [43 cm]	9.105	Novouzensk	5–6" [13–15 cm]	3.030

Thus, all samples which I took from the river terraces described by Prof. Golovkinskii contain an average of 4.171 % humus, providing confirmation of the scheme evolved by the cadastral commission (see p. 255). We shall see later that this is a common phenomenon for all such formations.

Samara — Buzuluk — Orenburg

P.A. Solomin examined the entire territory between Samara and Buzuluk, along the railroad line, at my request. He divides it in two, from Buzuluk to Marychevka (Buzuluk District) and hence to Samara. In the first half, the road runs very close to the Samara River nearly throughout, except for 17 versts west of Buzuluk, over a relatively low and sandy terrain of a steppe nature. Sands and forests are especially common in the environs of the Kotlubanka station, at the center of a famous "Borovskoi" forest reaching 50 versts in length, 30 versts in width and with pines reaching 6 – 7 sazhens [13 – 15 m] in height. The pine is admixed with oak and birch

Mysovye Chelny. The vegetal layer becomes lighter again over the next 2–3 versts, not exceeding 8 in. [20 cm]. Continuous rich chernozem only begins southeast of Orlovka; 6 versts away its humus content is 11.313% and thickness 2 ft. 4 in. [71 cm]. Chernozem which appears similar and just as typical stretches further eastward, parallel to the left bank of the Kama. "Chernozem lying between Chelny and Menzelinsk was interrupted only at one point (over almost 10 versts) by a forest of aspen, filbert, and shrubs, as well as oak. The fields are black and are not manured; the country has the appearance of cultivated steppe" rich in characteristic chernozem plants.[1]

Thus, at both Chistopol and at Chelny as well as on the intervening territory, typical chernozem occurs only 5–10 versts south of the Kama, marked as the northern boundary of Russian chernozem on many existing maps! I was greatly impressed by the sands and bogs stretching over areas of 10 versts and more just north of the right bank of the Kama in many places (such as opposite Chistopol). Unfortunately, I could not visit the northeastern districts of the Kazan Province, and therefore had to rely on the literature for an explanation of this fact which appears contradictory to the general character and direction of the northern chernozem boundary.

According to Academician Ruprecht, " 40 versts northeast of Kazan, the soil forms a perfectly black layer 2 ft thick at one point; the characteristic chernozem plants include *Centaurea biebersteinii*, *Tragopogon orientalis* and *Stachys annua*; further away, on the Kazanka – Shosma water divide (a tributary of the Vyatka), at the boundary with the Vyatka Province, from 36 versts southwest of Malmyzh and up to that town, the sod soil is usually very dark and resembles chernozem. The black color of certain fields may be partly due to burnt-down forest and heavy manuring; however, in certain untouched areas the dark-brown earth, 2 ft [61 cm] thick, overlies a red clay."[2] Borshchov found 9.99% volatiles in the Malmyzh chernozem. As may be expected, in those areas

[1] Ruprecht. Ibid., p. 35. Travelling from Menzelinsk, Ruprecht visited a forested mountain, and observed the following characteristic pattern: a) "At the foot of the elevation the soil is rich in springs, with many hummocks of black earthy peat thicker than 1 arshin [71 cm], so viscous that the shape is retained when cut. Under blowpipe glows weakly and leaves much ash. Microscopic observation reveals many organic particles, such as charred tissue, as well as phytolitharia. This is a mixture of deposited chernozem and peat. b) Somewhat higher up the slope, deep true chernozem appears. c) Still higher up, on the edge of the forest, chernozem is still 1 ft [30 cm] thick. Samples from sites (b) and (c) become lighter, gray-black upon drying, while chernozem samples from the environs of Chelny and, even more so, the earthy peat mentioned above, retain their black color upon drying. d) In glades at the top, undoubtedly formerly forested, only brown sod earth 6 in [15 cm] thick is visible, overlying coarse red clay. e) In a dense deciduous forest at the top, the clay is covered by forest soil scarcely 1 in [2.5 cm] thick; microscopic examination reveals numerous large phytolitharia, large scraps of humus and a few quartz grains." Hence, the author concluded that the properties of the vegetal layer depend on the kind of [plant] cover. Chernozem is never formed by forest, nor by bogs. Ibid.

[2] Ibid., p. 91. Ruprecht observed that "On many hills and hummocks at Malmyzh, and approximately at 20 versts west of Malmyzh, this clay is covered by thin horizontal layers of soft white marl consisting of the fossil microscopic freshwater alga *Lithobrion*... This marl, covered by a layer of brown chernozem 6–9 in. [15–23 cm] thick, is obviously younger than the red diluvial clay." Ibid., p. 33. Ruprecht's observations were not confirmed by the subsequent investigations of Mr. Krotov [P.] ("Geological Investigations Between the Volga and the Vyatka along the Kazanka and the Mesha" (Geologicheskie issledovaniya mezhdu Volgoi i Vyatkoi po techeniyu Kazanki i Meshi) [Kazan]. 1881, pp. 7–9), and we shall pursue them no further.

lying in fairly northern latitudes very often "transitions from chernozems to black mud occur in depressions; this is black silt or bog soil which has been inundated over a prolonged period. It is distinguished from peat by its inability to serve as combustible material due to the predominance of inorganic substances; it is formed under sedge bog meadows at this point."[1]

If the information supplied by Messrs Bogdanov,[2] Krotov,[3] Yadrintsev,[4] and Krylov[5] is added to that supplied by Ruprecht, and if the general direction of the northern chernozem boundary is taken into account, my indications of different kinds of chernozem north of the Kama as well will become clear.

Chelny — Bugul'ma — Buguruslan — Buzuluk
Nikolaevsk — Novouzensk

The terrain rises gradually, imperceptibly, from Orlovka through Seitovo, Verkhnii Tabyn, Taigil'dino, to Chubarovo (within the Menzelinsk District) and farther nearly up to Bugul'ma. It is very gently rolling, of almost typical steppe character up to Taigil'dino (approximately 7 versts from the Kama); large areas of feathergrass may occur. From Taigil'dino, toward the water divide between the tributaries of the Kama and the Samara (where Bugul'ma is situated), the country becomes progressively more hilly especially along the right bank of the Millya River; we re-entered a perfectly level steppe area only 3—8 versts before Bugul'ma. Over the first half of the route gullies and ditches are thus shallow and infrequent, everywhere revealing either red-brown loess clay or variegated marl which often serves as the subsoil. In the southern half, on the other hand, high bluffs are often visible (especially along the right bank of the Millya), composed of argillaceous limestones and marls at the top and of red-brown sandstones and sands at the bottom (in a section 2 versts north of Chubarovo). Soil distribution was in conformity with this pattern, as follows: a) up to Taigil'dino, the soil is almost throughout perfectly uniform typical loamy chernozem about 2 ft [61 cm] thick with 10—11 % (Tabyn) humus.[6] Gray soils were found under deciduous forests only once, approximately 7—8 versts northwest of Seitovo, not deeper than 1 ft [30 cm]. A sample I took at the boundary between these forests soils and true chernozem, on the edge of a forest, contained 7.788 % humus; b) south of the village of Taigil'dino soils became altered: the same chernozem as before on level sites (7 versts north of Bugul'ma), reaching 3 ft [91 cm] in thickness at some points along the low

[1] Ruprecht, p. 32.
[2] Bogdanov. Ibid., p. 25.
[3] Krotov. Ibid., pp. 15, 19, 41, 49, 52, etc. 1881.
[4] Yadrintsev [N.]. Nashi vyseleniya i kolonizatsiya (Our Migrations and Colonization). – [Vestnik Evropy, Vol. 3] p. 454, [St. Petersburg]. 1880.
[5] Krylov. Materialy k flore Permskoi gubernii (Materials on the Flora of the Perm Province), No. 1, pp. 25, 91-93, and other works by the same author.
[6] Apparently, chernozem of even higher quality stretches eastward toward the Belaya River; samples Birsk chernozem from the Belaya River, at any rate, supplied by Mr. Bazilev, contained 12.5–14% organic substances. Author.

left slope descending toward the Millya River, while on the steep slopes and tops of hills it was either (a) totally absent (washed away) or (b) had a lower humus content in comparison to the normal content, 7.360%, and smaller thickness, 10 versts south of Chubarovo, or else (on the broad hills, such as at the village of Taigil'dino) it (c) retained its perfectly dark color and high humus content (up to 13 %), while strongly admixed with calcareous pebbles and alternating with stony areas only slightly colored by humus. The pattern is identical to the one described in detail for the region of the Cretaceous formation. Nevertheless, these very soils (a, b, c) of hilly areas are marked as northern loams on Chaslavskii's map.[1]

The section I observed 7 versts north of Bugul'ma, on gently rolling terrain of virgin soil, was the most interesting en route from the Kama to Bugul'ma. The following exposure was observed in some pits at one of the highest points, at the edge of a small oak wood.

A. Loose, perfectly uniform black soil horizon, 1 ft 11 in [58 cm] thick, with 15.423 % humus.

B. Transition horizon 4 — 5 in [10 — 13 cm] thick; this is a gravel composed of small, angular bits of limestone, partly turned brown and partly still white, intermixed with chernozem and loose marl.

C. Bedrock layer, again pebbly, larger in size and all white; at a depth of 1 — 2 ft [30 — 61 cm] it forms a gradual transition to variously colored marls, constituting the bottom of these pits.[2]

Horizons A and B are distinguishable at a glance, while horizons B and C are separated by gradual transitions.

I have observed such sections on perfectly level terrain on the way to Bugul'ma, all of which are strongly similar in constitution to the Simbirsk chalk quarries and Simbirsk chernozem.

The highway between Bugul'ma and Buguruslan runs along the water divide mentioned above. The country is very high, and in certain places (between Domoseikina and Sok-Karmala, and approximately 10 versts north of Buguruslan) it is very hilly. The terrain is completely treeless up to Sok-Karmala; further south, up to Buguruslan, small oak woods are quite common, on deep chernozem, or on typical gray forest soil.

The chernozem in all level areas (approximately 25 versts south of Bugul'ma and between Karmala and Kudrina) is as rich as at Bugul'ma (11 versts north of Kudrina it contains 12.355 % humus). Its constitution is also unchanged, the only difference being that the local soils are sometimes underlain by multicolored marls instead of limestones. Obviously, hilly localities show the same pattern as north of Bugul'ma.

The very hilly terrain and almost complete erosion of chernozem from hummocks (exposing blood-red marls on the surface) are especially noticeable approximately 7 versts north of Buguruslan, where thin chocolate-colored soils[3] predominate even in low-lying areas; these

[1] Soils of hilly localities in the Bugul'ma District were described to me at the "zemstvo" office as "loams or sandy loams." The local "zemstvo" workers explained that they did not identify these soils as the loams and sandy loams of northern Russia: they regarded it as "also chernozem but with pebbles or with a reddish tinge," obviously due to an admixture of parent rock. Author.

[2] Analyses of all these soils and rocks are given below.

[3] On the other hand, I twice observed slumped chernozem reaching 1 ½ sazhens [3.2 m] in thickness in depressions north of the Sok-Karmala station.

soils contain numerous inclusions of unaltered bedrock.[1]

En route from Buguruslan to Buzuluk, the terrain continues very elevated nearly throughout (the road runs over the upper reaches of the Bol'shaya Kinel, Malaya Kinel, and Kutuluk rivers), but it is much more level, especially south of Zimnikhi station (Buzuluk District). From the upper reaches of the Borovka River and up to Buzuluk a very typical steppe stretches. I saw a forest only once between the villages of Aleksandrovka and Berezovka in the basin of the Borovka River; the forest was unusual in being composed of pine and occupying an enormous area.

In this [forested] area the soils were naturally very sandy, light-gray, thin (not exceeding 9 in [23 cm]) and low in humus (less than 2%). Very characteristically, this very area (upper reaches of the River Borovka, near the boundary between the Buguruslan and Buzuluk districts) seems to be the borderline between typical chernozem soils stretching north, toward Buguruslan (soils lying 5 versts south of Buguruslan and 7 versts south of Nikol'skoe contain 9--13% humus), with a possible chestnut tinge, and the sandy and sandy-loamy soils stretching southward to Buzuluk, gray or dark-gray color, with a humus content not exceeding 7%. This is the case despite the topographic conditions which are far more advantageous, pedologically, in the Buzuluk District in comparison to the Buguruslan District ! I fully understood this circumstance only after studying the geological structure of the right (second) bank of the Samara River at the town of Buzuluk. The high bluffy steppe bank is mainly composed of red-brown bedded sand, replaced by a finely granular conglomerate in its upper third; the sand and the conglomerate both contained a profusion of calcareous inclusions. The entire structure is topped by weathered, loose, calcareous sandstone (reaching 1 sazhen in thickness) which form a direct transition to soil.[2] The same rocks probably continue further northward, up to the village of Aleksandrovka; beyond this point and up to Buguruslan the gullies and ditches display only variegated marls.

In order to complete my description of this territory, it should be added that the banks of the Bol'shaya Kinel and the Malaya Kinel (at Buguruslan at Nikol'skaya station) and of the Samara River (at Buzuluk) are identical in topography and pedology, to the banks of the P'yana and the Tesha in the Nizhni Novgorod Province; the similarity is such that in both cases the southern slopes are gentle and covered by chernozem.

A table of the soils which I sampled over the entire route from the Kama to the Samara follows.

[1] The following note by Mr. Löde on chernozem of the Belebei District (bordering on the Buguruslan District) may serve to supplement our description of the soils in hilly, calcareous areas: "This chernozem lies on a calcareous formation and on elevated areas. The subsoil is undoubtedly marl, slabs of which are scattered everywhere, especially on heights. These slabs are even found on the surface of chernozem, which is strewn with grains of marl, more on elevated than on low-lying areas. Calcareous subsoil thus cannot be regarded as hampering chernozem formation. I was surprised to find the same flora there as in southwestern Russia. The Belebei and Pavlograd districts are quite far apart, but in both cases the same sainfoin, the vetch and the clover varieties grow abundantly." Löde adds that the chernozem with an appreciable admixture of lime grains in the subsoil yields very rich wheat crops. See Trudy VEO, p. 297, March 1879.

[2] Some points on the slopes of this bank toward the Samara valley display layers of lumped chernozem reaching 2 sazhen in thickness, repeatedly interbedded with Triassic (?) sands. Author.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
6 versts southeast of Orlovka, Menzelinsk District	Loam	Level plowland	2' 4" [71 cm]	11.313	7.906
7–8 versts north of Seitovo, Menzelinsk District	–	Edge of deciduous forest, level field	1" [30 cm]	7.788	5.044
15 versts northeast of Verkhnii Tabyn, Menzelinsk District	–	Level virgin land	2' 2" [66 cm]	10.845	9.624
2 versts north of Bol'shoi Tolkish, Chistopol District	–	Level glade amidst felled oak forest	2' 6" [76 cm]	11.728	8.375
Taigil'dino, Menzelinsk District	Marly	Level top of a broad hill, pasture	1'–1' 6' [30–46 cm]	approx. 13	8.142
10 versts south of Chubarovo, Menzelinsk District	–	Top of a gentle slope, pasture	2' [61 cm]	7.360	–
Aibashevo (No. 2), Birsk District	–	–	–	15.502	7.011
Aibashovo (No. 3)	–	–	–	14.218	8.296
7 versts north of Bugulma	Loam	Virgin land at the edge of a deciduous forest	1' 7" [48 cm]	15.423	10.597
11 versts south of Sok-Karmala, Buguruslan District	–	Level forested area	2' [61 cm]	12.355	10.245
5 versts south of Buguruslan	–	Pasture in the middle of very gently rolling slopes	2' 4" [71 cm]	13.070	5.405
7–8 versts south of Nikol'skoe, Buguruslan District	–	Level feathergrass steppe	2' 2" [66 cm]	9.785	9.566
Between Aleksandrovka and Berezovka, Buzuluk District	Sandy	Fine forest in the middle of a very gentle slope	8–9" [20–23 cm]	1.727	1.290
5 versts north of Tverdilovka	Sandy-loam	Steppe with tall weeds	2' [61 cm]	6.662	3.234
5 versts north of Buzuluk	–	Level plowland	2' 9" [84 cm]	3.458	3.854
As above	–	Level old-fallow land	2' 6" [76 cm]	2.762	1.800[1]

[1] It is worth noting that according to information supplied by the "zemstvo" offices at Chistopol and Bugul'ma, the best chernozems are found in the southern parts of the districts; according to the same information, the best soil in the Buzuluk District lies north of the Samara River.—Author.

I noted a much greater variety in topography, geology and soils between the Samara River and the lower reaches of the Bol'shoi Irgiz River, in the southern part of the Buzuluk District and in the northern (larger) part of the Nikolaevsk District.

The northwestern part of this territory is generally elevated, almost entirely occupied by the smooth spurs of the Obshchii Syrt; outcrops of at least three formations occur – Triassic, Cretaceous and Jurassic;

minor forests still occur and running water is plentiful. The southeastern part, on the other hand, is low and mostly steppe, with a strong predominance of Aral-Caspian formations[1] and very rare forests or flowing streams. These factors have certainly influenced the character of the local soils.

My route of 1878 mainly traversed the northwestern part of the territory and the southern half of the southeastern part. From Buzuluk I headed due south on the road to Ural'sk. Almost as far as Andreevka (65 versts southward) the road ran along the left bank of a typical floodplain of the Buzuluk River; the textain is nearly steppe over the first 40 – 50 versts, covered by chernozem with a distinct chocolate tinge, reaching 2 ft [61 cm] in thickness; we travelled over the remaining 15 versts through a flat, lake-like broadening of the Buzuluk River valley, with loamy chernozem covered by a gray sandy-loamy deposit 1/2 – 1 ft [15 – 30 cm] thick. A sample which we took 3 versts northwest of Andreevka, in an insignificant depression overgrown by feathergrass contained 11.582% humus. Andreevka itself, which is situated on a slight elevation, is almost surrounded by hills with reddish-brown soils (termed solonets by the local inhabitants) which contain only up to 4% humus. From Andreevka, via Pokrovskoe (Buzuluk District), Muratchitsa (Nikolaevsk District), Morsha, and up to Bol'shaya Glushitsa, the country is mostly rolling, the rather low undulations usually covered by gray-chocolate soils up to 1 ft. [30 cm] thick, strongly admixed with particles of hardly altered bedrock (solonets). Samples from Pokrovskoe and Muratchitsa contain 6 – 7% organic substances. Nevertheless, in low-lying areas of this territory more typical chernozems are common, reaching 2 ft [61 cm] in thickness. On the basis of the structure of the Koralyk River banks (at the village of Koralyk) and of the Bol'shoi Irgiz River banks at Glushitsa, the structure of this terrain is as follows: various sandy rocks in the lower horizons, yellowish-white (Jurassic ?) marls in the upper horizon, soils lying over the weathering products of these marls. Southeast from Glushitsa (via Pestravka, Gusikha and Tavolzhanka) toward Nikolaevsk, the terrain becomes almost completely horizontal and of steppe nature. The so-called solonetses (yellowish-gray soils 1/2 ft. [15 cm] thick) are very rare. Chernozem is almost everywhere dark chocolate in color, reaching 1 1/2 – 2 ft [45 – 61 cm] in thickness and with 10.3% humus; it is especially typical between Gusikha and Tavolzhanka, underlain by loose yellowish-red loess.[2]

Just south of the last station toward Irgiz, at Nikolaevsk, the soils become progressively thinner, redder, and lighter in color; they are identical in the environs of Nikolaevsk.

[1] On the basis of the character of soils, these formations may also be assumed to occur sporadically in lowlands in the northeastern area.

[2] According to Mr. Soiomin's description, the same soil, same ground, and same topography are observed throughout the 150 versts between Tavolzhanka and Samara. He took a soil sample at Titovka (Samara District), 2 ft 6 in [76 cm] thick and with 10.48% humus. He reports only the area south of the Mocha River (approximately 10 versts across) as low, with brownish-gray, and in places with solonchak soil. The comparatively high humus content of the local soils (Pestravka, Titovka, etc.) is due to the very calcareous Jurassic marls which occur in places. Sintsov. Otchet po ekskursiyam, proizvedennym v 1874 g. v Saratovskoi i Samarskoi guberniyakh (Report on the Excursion Made in 1874 in the Saratov and Samara Provinces), pp. 16-22.

I took the following samples en route from Buzuluk to Nikolaevsk:

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
3 versts northwest of Andreevka, Buzuluk District	Loam	In a slight depression overgrown by feathergrass	2' [61 cm]	11.582	9.504
On the outskirts of Andreevka	-	In the middle of a gentle slope	8" [20 cm]	3.815	2.842
5 versts southwest of Pokrovskaya, Nikolaevsk District	-	Marly soil, plowland	1'-1' 6" [30-46 cm]	6.915	3.105
9 versts south of Muratchitsa, Nikolaevsk District	-	Level pasture	1' 2" [35 cm]	6.662	5.144
Pestravka, Nikolaevsk District	-	Virgin steppe	2' [61 cm]	10.378	5.44

As early as 1844, Mr Leopol'dov noted the principal characteristics of the Novouzensk Territory. Except for its eastern side, which includes part of the spurs of Obshchii Syrt, it is an endless plain almost throughout... with a total absence of forest. Excluding the Volga, all the water bodies are quite malodorous, saline, and unhealthy; pits or wells also do not yield pure water because of the solonetsous nature of the ground. The soil in the Novouzensk District is of three kinds: silty, clayey-chernozemic, and, in certain places, also sandy. Silty and clayey-chernozemic soils are 3—6 vershoks [13—27 cm] thick.[1] I found no true sod throughout the Novouzensk District; bald patches of red-brown soil appear among the sparse sagebrush and saltworts.

In some places, solonetses stretch for versts. In July 1878, at a temperature of 30—40°, the Novouzensk steppes appeared almost completely bare, especially in their southern sections. It seemed unbelievable then that "Beloturka" wheat could yield 25-fold and more the amount of seed in a good year, yet this is so. Such is the richness of young virgin soils.

The depressing monotony of the Novouzensk District is due to its unvaried geological structure, in addition to climatic conditions. According to the latest investigations made by Prof. Shtukenberg (Stukenberg),[2] "instead of the variegated and purely Caspian sediments indicated on the map, a freshwater formation of clay occurs between the Volga and Obshchii Syrt (at least between Pokrovskaya Sloboda and Balakovo on the Volga on the one hand, and Novouzensk on the other hand, over a distance reaching to 200 versts). This freshwater formation consists of loess-like clay and finely stratified clay and sand; these beds contain freshwater shells nearly throughout, including *Planorbis marginatus*, *P. spirorbis*, several small species of *Paludina*, a small *Cyclas*, etc. The clays

[1] Leopol'dov, [A.]. Zhurnal Ministerstva gosudarstvennykh imushchestv [Vzglyad na Novouzenskii okrug Saratovskoi gubernii (A View of the Novouzensk District, Saratov Province).] Part 13, pp. 29-36. 1844. "Rich, deep chernozem mainly occurs in hollows and on slopes toward rivers; however, it too produces good crops over two or three years, and then becomes depleted. Silty soils occur only in the Volga area while sandy soils occur near the Eruslan River."

[2] Shtukenberg, [A.]. Geologicheskie issledovaniya 1877 g. Predvaritel'nyi otchet (Geological Investigations of 1877, A Preliminary Report), pp. 7-8 [Trudy obshchestva estestvoispytatelei pri Kazanskom universitete, Vol. 6, No. 4, Kazan. 1877.]

also often contain marl aggregates, similar to those typical of loess — gypsum crystals and aggregates. The rivers and gullies in this area expose exclusively freshwater strata, which overlie saliferous clay at only one point (the Kushum River, village of Ilyuzen, approximately 40 versts from Balakovo)."

Without discussing the origin of these rocks, I am yet able to confirm their very widespread occurrence in the Novouzensk District. However, I found freshwater shells in these rocks only twice, in the banks of the Irgiz at Nikolaevsk and the banks of the Bol'shoi Uzen at Novouzensk. Moreover, the very frequent occurrence of solonetses and brackish well and river waters suggests that these rocks are saline.[1]

Hence, a detailed description of my trip from Nikolaevsk to Novouzensk would be superfluous, and only a few most striking facts are noted below.

On the right bank of the Bol'shoi Irgiz, at the outskirts of the town of Nikolaevsk, a depression gradually sloping toward the river contains a few clay pits in which the grayish-brown soil layer, 1 ft [30 cm] deep, is underlain by light-yellow nonstratified clay abounding in often hollow calcareous concretions and small, very fragile freshwater shells; it is 2 sazhens [4.3 m] thick.

Approximately 1 1/2 versts from the town, en route to Balakovo, this depression is limited [on the northwest ?] by fairly considerable heights, one known as Mayak. An excellent view of the following section is had in a local stone quarry on a level, elevated steppe.

A. Chestnut-brown loose chernozem with rare, very small, angular calcareous pebbles, 7 in [18 cm] thick, with a 6.455 % humus content and an 11.14 % $CaCO_3$ content.

B. Transition horizon, reddish-yellow marl abounding in identical pebbles, 6 in [15 cm] thick.

C. Yellow and white (Permian) marl, 5—6 in [13—15 cm] thick.

This was first followed by soft, clayey limestones and then by pure dense limestones.

The country stretches unvarying from here to Novouzensk, over more than 150 versts: an endless, very gently rolling steppe covered by sparse stunted sagebrush,[2] where the ditches reveal only red-brown loess clay. In fact, soils in this area are of two types: a) darkish-gray or chestnut on ridges and b) red or brown solonetsous in depressions.[3] The relative amount of the latter increased progressively toward the south. However, dark soils are often abruptly replaced by reddish soils even on perfectly level terrain and vice versa. For instance, one half of the peasants' soil at the Rodniki station (33 versts south of Nikolaevsk) is saline, while the other half is nonsaline; some wells in this locality are fresh, while others yield brackish water. Generally, along the entire route from Bol'shoi Irgiz to Novouzensk the water in most springs is rich in various salts, whereas in hollows rainwater usually remains fresh.

All these phenomena are natural and readily understandable if all local grounds are assumed to have been saline in the past, and been meanwhile

[1] Unfortunately, analyses of all soils from the Novouzensk District, entrusted by the Free Economic Society to Mr. Kostychev three years ago, are as yet incomplete.

[2] In the face of such poor existing vegetation, doubts arise regarding the nature of former vegetation, when the salt content in the soil was incomparably higher.

[3] In some places in the vicinity of Orlov-Gai, the chestnut soil is also covered by a gray soil 1—3 in. [2.5—7.6 cm] thick, apparently of subaerial origin.

completely leached out in certain places. At certain points, leaching has occurred in subsoil horizons as well, while at other points it occurs only on the surface.

The entire region of Novouzensk, within a radius of approximately 20 versts (toward Aleksandrov-Gai and the Uzen fortress) except for very small, rare areas, is occupied by red and reddish-brown soils, mostly saliferous, and only slightly colored [by humus]. Their thickness is 3 – 5 in [8 – 13 cm], and a transition layer is quite indistinguishable. The subsoil is, as before, Nikolaevsk loess reaching 3 sazhens [6.4 m] in thickness in the banks of the River Uzen.

The following table gives an idea of the monotonous character of soils in the Novouzensk District. I shall remark only that, except for the Orlov-Gai solonchak, the samples are of the best soils in the territory and were taken from elevated sites.

Locality	Composition	Sampling site	Thickness	Humus, %
Nikolaevsk, on Mayak	Marly	Steppe, pasture	1' 6" [46 cm]	6.445
5 versts south of Skrebnitskaya, Novouzensk District	Loam	Pasture at the summit of a very gentle slope	1' 1" [33 cm]	4.193
Osinov-Gai, Novouzensk District	–	Level elevated field	1' 11" [59 cm]	5.325
3 versts south of Orlov-Gai, Novouzensk District	–	Steppe	2' [61 cm]	4.799
5 versts south of Orlov-Gai	Solonets	As above	6" [15 cm]	2.769
Novouzensk	Solonets (?)	As above	5 – 6" [13 – 15 cm]	3.030

B. LEFT BANK OF THE VOLGA

Bolgary (Spassk District), Chasovnya and Khryashchevka (Stavropol District), Dukhovnitskoe (Nikolaevsk District) and Pokrovskaya (Novouzensk District)

Prof. N. A. Golovkinskii was first to sort out the extremely complicated and very variable geological structure of the left bank of the Middle Volga. He divided all the sediments in the area adjoining the river (5 – 10 versts and more across) into three horizons, according to the three terraces. The lower terrace is the meadow floodplain, the middle terrace largely lies above the level reached by the highest springtime floods; finally, the upper terrace rises 150 ft [46 m] and more above the Volga. The oldest geologically are those terraces which are relatively highest. The meadow and middle terraces are composed mainly of sands and sandy loams, while the upper terrace is composed at its base of sands and, higher up, of clays and loams.[1]

[1] Golovkinskii. O posletretichnykh obrazovaniyakh po Volge, v ee srednem techenii (Post-Tertiary Formations on the Middle Volga), [Kazan]. 1865.

Prof. Rozen[1] and Shtukenberg[2] subsequently differed from N. A. Golovkinskii concerning the origin of the upper terrace, but agreed with him in regard to the (a) position and (b) age of these terraces. Therefore, both (a) and (b) must be accepted as a fact: I was repeatedly convinced of this during my Volga excursion of 1878.

Obviously, this structure of the left bank of the Volga has influenced the character of the local soils, as is evident from the following examples.

B o l g a r y. It is known from Prof. Golovkinskii's work that the upper terrace within the boundaries of the Spassk District "passes east of the town of Spassk toward Bolgary; the middle (sandy) terrace on which the town stands stretches fairly far to the west, toward the Volga, where (6 versts WSW from Spassk) it forms a steep slope 15 – 20 ft. [4.6 – 6.1 m] high bordering on the meadow (lower) terrace."[3] The same essential pattern is found, though on a smaller scale, between the Volga and Bolgary. The meadow terrace soils are all deposited and their constitution is of the Kachnino type (p. 103). A sample which I took on the second terrace, 1 verst northwest from Bolgary, in a forest glade proved to be gray sandy loam, 1 ft 11 in [58 cm] thick, with a humus content of 5.432%.[4]

C h a s o v n y a. I crossed the Volga at Simbirsk to the village of Chasovnya at the edge of the middle terrace, and proceeded due east over the old Orenburg highway. The highway runs along the second terrace for six versts, and crosses three sandy dune-like elevations and three depressions with loamy soil. These depressions are reminiscent of dried oxbow lakes, one of them still flooded by especially strong spring floods. The terrain rises again at approximately the seventh verst (the third terrace?) and then the road enters the perfectly level Samara-Orenburg steppe. After travelling about 5 versts east over the steppe, I made an artificial section on the virgin steppe with chernozem reaching 3 ft 11 in [1.2 m] in thickness. Local soil appeared to be very typical chernozem in situ, but when investigated was found to contain much sand, and only 4.838 % humus.

K h r y a s h c h e v k a. Somewhat below Sengilei, the Volga receives its left tributary, the Cheremshan. Approximately 2 versts from the Cheremshan's mouth lies the village of Khryashchevka, famous for numerous finds of mammoth and rhinoceros bones. On the basis of the structure of the left bank of the Cheremshan, at this point 40 – 50 ft [12 – 15 m] high (plastic bluish or red clay at bottom, bedded sand at top), the environs of Khryashchevka may be assumed to overlie ancient lacustrine-fluvial (second terrace ?) deposits. I took a sample of darkish-gray soil in the steppe about 1 verst northeast of Khryashchevka, somewhat higher than the Cheremshan bank; the soil, 2 ft 4 in [71 cm] thick, contains 3.370% organic substances.

D u k h o v n i t s k o e is opposite Khvalynsk on the left bank of the Volga in an area not flooded by the river. P. A. Solomin, who visited this area in 1878, took a soil sample about 1 1/2 versts east of the village on a perfectly level plowland. In appearance and constitution, the Dukhovnitskoe chernozem is perfectly analogous to the Khryashchevka chernozem; it is

[1] R o z e n. O posletretichnykh obrazovaniyakh po Volge i Kame, v Kazanskoi gubernii i dr. (Post-Tertiary Formations on the Volga and the Kama in the Kazan Province, etc.). – [In book: 'Trudy chetvertogo s'ezda russkikh estestvoispytatelei v Kazani", No. 2, Kazan. 1875.]

[2] S h t u k e n b e r g. Ibid.

[3] G o l o v k i n s k i i. Ibid., p. 59.

[4] The Bolgary sample contained particles of charred wood. In spite of the painstaking separation of the charcoal, this admixture must have affected the results of humus determination.

only on the western margins of this forest "island", toward the Borskaya station and Marychevka; the soils become more sandy-loamy in nature and darker in color, especially between the two stations just mentioned. As in any other sandy and forested area, small bogs and dune sand hills sometimes covering even sandy dark-grayish soils are often visible.

West of Marychevka, the Orenburg railroad leaves the Samara valley and 5 – 6 versts past Bogatovka station it emerges onto an elevated, gently rolling steppe, stretching to Smyshlaevka station (25 versts from Samara). The shallow gullies and ditches display only red, sometimes strongly marly clay. At first, the soil is brown chernozem, no thicker than 1 – 1 1/2 ft [30 – 45 cm]; it is replaced by a more typical chernozem reaching 2 ft [61 cm] in thickness. The first kind is represented by soils of the village of Krivaya Luka (Samara District), and the second kind – by soils in the environs of Samara (see table). Chernozem does not cover this area continuously; in many places, especially in depressions, fairly large solonchaks occur, and are described by Solomin as follows: "This is hard earth, cracked by the heat, with a thin gray or brown vegetal layer overgrown by poor, sparse, and usually stiff grass, which is often totally absent. Such places are hungrily set upon by sheep and horses; they yield corn crops only in very rainy years and even then harvests are poor." Solomin observed such saline patches near the villages of Egor'evskoe, Grachevka and Marychevka, sometimes stretching over 300 dessiatines [372 hectares].

The town of Samara[1] is on the elevated left bank of the Volga which is higher than the right bank at this point[2] and is a fairly rolling terrain. My observations of ditches and gullies near the town revealed only fairly loose, light-yellow loess reaching 2 – 3 sazhens [4.3 – 6.4 m] in thickness. However, only 3 versts from Samara, at the side of the road to Buzuluk, there is a typical Triassic sandstone and conglomerate, completely analogous to the Buzuluk rock and covered by loess. I performed two soil measurements in the neighborhood of Samara, one at the St. Nicholas monastery, with chernozem 2 ft 7 in [79 cm] thick, and the other in the steppes approximately 2 versts toward Orenburg, at one of the highest points of the locality, where soil thickness is 2 ft 1 in [64 cm] and humus content 10.494%.

We shall now deal with the Buzuluk-Orenburg area.

Chaslavskii's map indicates for this area, along the left bank of the Samara River, first ordinary chernozem, then rich chernozem, then again ordinary chernozem, and finally, from the approximate region of the Sorotskaya station stony areas and northern clays and loams. The soils of this area are in fact distributed quite differently.

In the first place, it should be noted that throughout the area the railroad runs along the left, southern, gentle slope toward the Samara River; the right bank is steep and bluffy and its soils are therefore far from normal, containing a large admixture of unaltered bedrock. At the same time, the left bank of the Samara (except for the lowlands nearest Buzuluk, where apparently typical chernozem reaches 2 1/2 ft [76 cm] in thickness yet forms a gradual transition to loamy bog soils) displays the following pattern,

[1] From Smyshlyaevka to Samara the road traverses a very hilly terrain; chernozem has been washed away from the heights, and the slopes are sometimes occupied by minor deciduous forests; soils are mostly abnormal.

[2] For this reason, I did not include the Samara chernozem among soils of the river terraces. Author.

approximately to the Novosergievka station (Buzuluk District): gently rolling terrain, covered by feathergrass, with red or whitish very marly loam subsoil. In some places the soils are fairly dark (of the Soroki type, see below), with a strong chestnut shade, reaching 1 1/2 — 2 ft [45 — 61 cm] in thickness, and in some places (even on level areas) chocolate-reddish, 1/2 — 1 ft [15 — 30 cm] thick. In yet other places (especially on slight hills between Sorotskaya and Gamaleevskaya) chernozem disappears, and is replaced by soils identical in color and thickness with the Novouzensk soils. Detailed investigation is necessary to determine the boundaries of all these soil varieties and to elucidate the immediate cause of their existence.

The pattern is essentially the same in the environs of Novosergievka, although the terrain rises considerably and "islets" of very typical chernozem are visible (see below).[1] From Novosergievka to Syrt station and part-way to Kargalka the country becomes progressively more hilly and elevated, with numerous isolated, distinct domes. Chernozem is absent from hilltops, and present in depressions and on gentle slopes, dark-gray (Novosergievka type) and sometimes reaches a thickness of 2 ft [61 cm].

Table of soils which I sampled between Samara and Orenburg

Locality	Composition	Sampling site	Thickness: feet, inches [and centimeters]	Humus, %	Hygroscopic water, %
2 versts east of Samara	Loam	Steppe	2'1" [64]	10.494	5.178
At the village of Krivaya Luka, Samara District	–	Feathergrass steppe	2'4" [71]	7.616	4.23
Marychevka Buzuluk District	Sandy loam	Plowland adjacent to a solonchak	2'6" [76]	5.018	3.225
Sorotskaya, Buzuluk District	–	Level pasture	2'3" [69]	6.701	4.465
Novosergievka, Buzuluk District	Loam	–	1'6" [46]	10.033	4.557
Orenburg	Sandy loam	Steppe	1'11" [58]	2.432	2.721
Tashla,[1] Orenburg District, 100 versts northeast of Orenburg	Loam	Steppe	2'4" [71]	14.551	4.707
Aleksandrovskii Farm near Tashla	–	Plowland, in the middle of a gentle incline	2'4" [71]	15.013	5.033
Bulgakovo -Chebanka, 65 versts northeast of Orenburg	–	Long-fallow land	2' [61]	11.933	5.322
Nikol'skoe, 50 versts northeast of Orenburg	–	Plowland	1'4" [40]	6.073	3.234

[1] The sample from Tashla and the following three samples were supplied to the Free Economic Society by N. M. Mezentsev, from A. E. Timashev's estate in the Orenburg District.

En route from Kargalka toward Orenburg, the terrain becomes lower and assumes an almost pure steppe character; chernozem, however, does not reappear. Railroad excavations display a brownish-gray soil layer, reaching

[1] An employee of the well-known Vanyushin brothers reported that the Novosergievka chernozem stretches up to the right bank of the Ural River at Iletskii Gorodok and Ural'sk. This is readily understood in view of the comparatively elevated terrain.

1 ft in thickness. The sample which I took in the vicinity of Orenburg, on the right bank of the Ural, on a sandy-loamy red subsoil (Aral-Caspian formations ?) which reached 1 ft 11 in [58 cm] in thickness, had as little as 2.432% humus. Nevertheless, the table on the previous page makes it clear that typical chernozem steppes reappear northeast of Orenburg 50 — 100 versts toward the spurs of the Ural Mts.

The analyses by Voelker and Il'enkov, reproduced in the preceding pages, are substantiated by the results of chemical investigations performed by Messrs Schmidt and Zemyatchenskii, below.

Analysis by Mr Zemyatchenskii [percentages], solonchak at Bol'shoi Tolkish, No. 25

Lost by air-dry soil on ignition	30.248
Hygroscopic water determined at 100°C	5.328
Nitrogen	0.804
Humus	13.743
Contents of HNO_3 extracts:	
SO_3	2.491
Cl	0.064
CaO	6.102
MgO	0.993
Fe_2O_3	1.776
Al_2O_3	3.496
Mn_3O_4	0.095
Na_2O	0.457
K_2O	0.336
SiO_2	0.020
P_2O_5	0.177
CO_2 (liberated by HCl)	2.882
The residue which remained undecomposed by HNO_3 contained, with respect to the air-dry soil:	
SiO_2 (treatment with Na_2CO_3)	0.564
SiO_2 (preliminary treatment of residue with H_2SO_4)	1.585
$Al_2O_3 + Fe_2O_3$	4.994
MgO	0.239
Quartz sand	49.206

The following statements are worthy of note, in conclusion.

A. The entire vast Trans-Volga territory, excluding the nearest spurs of the Urals and the localities along the left banks of the Volga and the Kama[1] may be divided into the following belts: a) Kama — Samara, b) Samara — Bol'shoi Irgiz (latitude of its lower reaches), and c) basins of the Eruslan, Bol'shoi Uzen, and Malyi Uzen rivers.

The Kama — Samara belt is an elevated, broadly rolling plateau, its upper horizons composed almost exclusively of different marly rocks (Permian and Triassic formations). Running water and deciduous forests are plentiful. It is comparable to the central and southern parts of the Tambov Province and to the northwestern parts of the Saratov Province in its climatic features, character of the seasons, amount of precipitation and quality of vegetation. These areas are doubtlessly also very similar in soils.

[1] As has been seen, these areas are subject to unusual physical conditions.

Analyses by Mr K. Schmidt,[1] Ufa Province, Menzelinsk District

Locality	6 versts southeast of the village of Orlovka, level plowland	7–8 versts north of the village of Seitovo, on the edge of a deciduous forest, level plowland	15 versts northeast of the village of Verkhnii Tabyn, level plowland: a') black-brown soil with numerous rootlets	b') transition layer, somewhat lighter in color than (a')	c') subsoil, yellow to light-brown loose stones	At the village of Taigil'dino, hilltop, pasture: a) sifted chernozem, 92.94%	b) lumps of limestone remaining in the sieve, 7.06%
No.	8	9	10	11	12	13	14
Sampling depth, inches	up to 8" [20 cm]	6–7" [15–18 cm]	up to 9" [23 cm]	20–26" [51–66 cm]	below 26" [66 cm]	up to 12" [30 cm]	up to 12" [30 cm]
Hygroscopic water lost at 100°C by 100 parts of air-dry soil.	7.906	5.044	9.624	9.268	7.614	8.142	0.810
	Total constituents in 100 parts soil dried at 100°C						
Hygroscopic water evaporating at 100–150°C	0.677	0.766	1.648	0.864	0.849	0.500	0.621
Organic substances (humus)	14.194	11.693	14.080	9.086	4.433	14.084	3.883
Mineral constituents	85.129	87.541	84.272	90.050	94.718	85.416	95.496
K_2O	2.163	2.094	2.028	1.875	1.661	1.769	0.187
Na_2O	1.293	1.122	1.119	1.451	1.724	1.485	0.112
CaO	1.516	1.292	2.003	1.613	4.420	3.783	32.595
MgO	1.509	1.276	2.307	2.625	2.856	2.608	0.441
Mn_2O_3	0.014	0.015	0.016	0.021	0.034	0.026	0.034
Fe_2O_3	3.558	3.040	5.031	5.516	6.024	3.905	2.026
Al_2O_3	13.860	12.390	15.000	19.088	19.682	14.039	2.644
CO_2	0.009	0.035	0.170	0.110	2.936	1.732	25.261
P_2O_5	0.257	0.211	0.225	0.128	0.095	0.178	0.083
SO_3	0.0031	0.0027	0.0028	0.0036	0.0006	0.0012	–
NaCl	0.0071	0.0026	0.0084	0.0110	0.0012	0.0025	–
a) SiO_2[2]	13.820	11.139	18.181	19.248	19.390	14.961	32.111
b) SiO_2[3]	35.406	51.755	37.860	36.110	35.232	39.965	
Quartz sand insoluble in 33% HF	11.714	3.167	3.321	2.250	0.662	0.961	
$CaCO_3$	0.020	0.080	0.386	0.250	6.673	3.936	57.411
$Ca_3P_2O_8$	0.561	0.461	0.491	0.279	0.207	0.389	0.181
Residual CaO[4]	1.201	0.997	1.521	1.322	0.571	1.368	0.347
Nitrogen	0.504	0.416	0.519	0.235	0.102	0.459	–
Organic carbon C	6.788	4.673	6.507	3.156	0.885	5.933	–
Humic anhydride (anhydrous $= \frac{C}{0.6}$)	11.312	7.788	10.845	5.260	1.475	9.888	–
Hydration water of hydrous silicates which is not liberated at 150°C	2.881	3.905	3.235	3.826	2.958	4.196	–

(Continued)

Locality	Samara Province, Bugul'ma District					Samara Province, Buguruslan District		Samara Province, Buzuluk District		
	7 versts from Bugul'ma, gently rolling virgin land on the edge of a deciduous forest									
			c') transition layer to calcareous subsoil, divided as follows after sifting:							
	a') dark-brown soil with numerous rootlets	b') a deeper layer, with a smaller rootlet content	a) sifted chernozem	b) calcareous limestone fragments remaining in the sieve	d) subsoil: hard limestone, colored white or light-yellow	between Sok-Karmala station (Sok-Karmalinskaya) and Kudrinskaya, 11 versts south of the former, deciduous forest on level terrain; dark-brown	7—8 versts south of Nikol'skaya station, level steppe; dark-brown chernozem	between the villages of Aleksandrovka and Berezovka, coniferous forest; light-brown color with numerous rootlets	at the town of Buzuluk, level field; medium-brown color with numerous rootlets	35 versts south of the town of Buzuluk and 3 versts northwest of the village of Andreevka along the road leading to the town of Ural'sk, a slight depression overgrown with feathergrass
No.	15	16	17	18	19	20	21	22	23	24
Sampling depth, inches	up to 4" [10 cm]	4—13" [10—33 cm]	13—19" [33—48 cm]	13—19" [33—48 cm]	below 19" [48 cm]	up to 9" [23 cm]	up to 8" [20 cm]	up to 7" [18 cm]	up to 10" [25 cm]	up to 9" [23 cm]
Hygroscopic water lost at 100°C by 100 parts of air-dry soil	10.597	10.450	9.471	0.442	0.573	10.245	9.566	1.290	3.854	9.504
	Total constituents in 100 parts soil dried at 100°C:									
Hygroscopic water evaporating at 100—150°C	1.598	0.902	0.811	0.059	0.139	0.638	1.657	0.257	0.600	1.071
Organic substances (humus)	19.805	13.276	12.997	1.055	0.644	15.747	11.959	2.194	4.815	15.480
Mineral constituents	78.597	85.822	86.192	98.886	99.217	83.615	86.384	97.579	94.585	88.449
K_2O	1.958	1.907	1.716	0.063	0.110	1.887	2.023	1.126	1.505	2.003

Na_2O	1.161	1.108	1.053	0.033	0.069	1.361	1.302	0.891	1.393	1.056
CaO	1.937	1.847	8.296	53.429	52.506	1.792	1.992	0.486	1.029	2.066
MgO	1.712	2.044	1.431	0.344	0.343	1.710	1.903	0.519	0.606	1.012
Mn_2O_3	0.034	0.019	0.034	0.013	0.004	0.019	0.044	0.007	0.008	0.016
Fe_2O_3	4.110	4.393	5.230	0.555	0.112	3.945	3.965	2.004	2.722	3.693
Al_2O_3	15.203	18.519	14.322	41.834	0.614	15.614	15.666	6.664	10.551	14.986
CO_2	0.025	0.043	5.355	0.032	41.216	0.028	0.096	0.020	0.018	0.094
P_2O_5	0.202	0.159	0.210	—	0.024	0.214	0.169	0.096	0.141	0.221
SO_3	0.0096	0.0053	0.0019	—	—	0.0034	0.0014	0.0003	0.0012	0.0014
$NaCl$	0.0120	0.0041	0.0032	—	—	0.0018	0.0133	0.0009	0.0053	0.0043
a) SiO_2	20.838	22.114	13.115	0.762	0.882	15.985	18.517	14.139	12.107	15.993
b) SiO_2	29.607	32.981	29.379	1.682	3.314	40.119	37.177	51.021	49.508	31.002
Quartz sand insoluble in 33% HF	1.788	0.689	1.016	—	0.023	0.936	3.498	20.575	14.989	11.301
$CaCO_3$	0.057	0.098	12.458	95.078	33.672	0.064	0.218	0.045	0.041	0.214
$Ca_3P_2O_8$	0.441	0.347	0.232	0.070	0.052	0.467	0.369	0.210	0.308	0.482
Residual CaO	1.666	1.604	1.508	0.147	0.022	1.503	1.670	0.347	0.839	1.685
Nitrogen	0.775	0.395	0.508	0.045	0.020	0.589	0.438	0.086	0.167	0.635
Organic carbon	9.254	5.844	—	—	—	7.413	5.871	1.036	2.075	6.949
Humic anhydride (anhydrous $= \frac{C}{0.6}$)	15.423	9.740	—	—	—	12.355	9.785	1.727	3.458	11.582
Hydration water of hydrous silicates which is not liberated at 150°C	4.832	3.536	—	—	—	3.392	2.174	0.467	1.352	3.898

[1] Schmidt. Ibid. Through the fault of the worker who dispatched the sample, Schmidt's original work suffered from certain errors in designation of depth and in geographic names; these errors are corrected in our table.

[2] a) SiO_2 isolated with hot 10% HCl, soluble in 2% NaOH.

[3] b) SiO_2 not isolated with hot 10% HCl, soluble in 33% HF (including pulverulent quartz).

[4] This is residual CaO combined with humic and silicic acids.

The area between the Kama and the Samara contains the best chernozems of the entire Trans-Volga territory, their average thickness (14 samples) is 1 ft 11 in [58 cm], and average humus content (16 samples) is 9.6%. Excluding sandy soils (4 samples) from consideration, as should be done, the average humus content rises to 11.6%. The color of soils in situ is perfectly black.

The Samara—Bol'shoi Irgiz belt is far less uniform than the first belt in topography and geological structure. Its eastern half is largely composed of elevated hilly areas, and its western half is of steppe nature. The eastern section consists principally of ancient sedimentary rocks, and the western half of Aral-Caspian rocks. There is a corresponding difference in climate and vegetation. Soils of such areas cannot be uniform, which is the case in this particular territory. Generally speaking, the local chernozem forms a transition from soils of the first belt to those of the third belt. Soils average (16 samples) 1 ft 10 in [55 cm] in thickness, 8.7%[1] humus content; color is dark with a definite chestnut tinge.

The basins of the Eruslan, Bol'shoi Uzen and Malyi Uzen rivers, forming the southernmost belt of the Trans-Volga territory are far more monotonous. The area is an endless plain, with an acute lack of both running water and rain, scant vegetation with small varieties of sagebrush and saltwort predominating and unbearable summer heat which nearly destroys the vegetation as early as the beginning of July; these are the principal and most common features of the basin of the Bol'shoi Uzen and Malyi Uzen rivers and the neighboring Kirgiz* steppes. Therefore, the predominant soils are brown-chocolate or reddish-brown, with a large number of various solonetses. The thickness of these soils is, on an average of 10 samples, 1 ft 1 in [33 cm] and their humus content is 4.6%.

This territory presents a series of gradual transitions southward, regarding the complex of physical conditions and especially soil (as in the Gryazi—Tsaritsyn and Balta—Odessa territories).

Locality	$Al_2O_3 + Fe_2O_3$	Clay	Quartz sand
Krutoe (No. 42)	20.319	38.556	38.885
Grushevka (No. 47)	21.669	43.277	41.076
Seitovo (No. 9)	15.430	26.943	54.922
Orlovka (No. 8)	17.418	31.832	47.120
Andreevka (No. 24)	18.679	35.625	42.303
Kudrino (No. 20)	19.559	36.386	41.055
Verkhnii Tabyn (No. 10)	20.031	38.158	41.181
Bugul'ma (No. 15)	19.313	41.447	31.395
Taigil'dino, (No. 13)	17.944	33.350	40.926
Nikol'skoe (No. 21)	19.631	39.310	40.675

[1] Excluding the Tashla samples (4 samples), since they are obviously of the mountainous steppe type of chernozem, the humus content in soils of the second belt is as low as 7%.

* [These are actually Kazakh steppes; the Kazakhs were formerly known as Kirgiz-Kaisaks. Translator.]

B. On comparison of the average content of organic substances in chernozems of southwestern Russia (4.5%), central Russia (8.4%), and the Trans-Volga territory (9 8%),[1] an increase in humus content is noted from southwest to northeast; the difference between the extreme belts is especially marked. I have said above (p. 201), and would like to reiterate that the principal cause of this phenomenon lies in the chemical nature of parent rocks; this is indicated by the small table on the previous page.[2]

A comparison of these numerical data with those on p. 201 finds typical chernozems of central Russia and of the Trans-Volga territory to have an average sand content of about 42%, while chernozems of western Russia contain over 68% sand; the latter contain about 16% clay, as against over 36% clay in the former ! It is thus obvious that the soils richest in humus are also richest in clay. This correlation becomes more significant when it is borne in mind that those soils of central and eastern Russia which are definitely of sandy-loamy and sandy nature contain the smallest amounts of organic substances. The chernozems of Glubokaya, Mikhailovo, Samoikino, [Prince] Ukhtomskii's estate, Buzuluk (No.23), Berezovka (No.22), and all samples of the left bank of the Volga are typical, and also demonstrate the factor determining the smaller thickness of this soil than of southwestern Russian chernozem.

C. On comparison of soil thickness in the southern part of the Samara and Orenburg provinces with thickness of northern soils and soils occurring on the northern chernozem boundary, it becomes clear that the first soils (as in chernozems of southwestern Russia), are too thick to suit their humus content. I noticed this at an earlier date[3]; it occurs throughout southern Russia. It must be principally ascribed to the predominance of perennial plants with deeply-seated roots, and is unrelated to the nature of ground.

D. Samples of the richest chernozem normally occurring in southeastern Russia provide clear proof (contrary to opinions of certain scientists) that the color of the Permian and Triassic marls has no special effect on the color of the soils overlying these rocks.

E. All the "islands" with clayey and loamy northern soils indicated on Chaslavskii's map in the Penza, the Ufa, and the Orenburg provinces should be corrected to designate chernozems of hilly areas.

[1] This average was calculated for all 29 samples from the first two belts of the Trans-Volga territory. The soils of the third, southern belt are discussed in Chapter VI, following our procedure of describing southwestern and central chernozem Russia.

[2] In this table (as on p. 201), Prof. K. Schmidt presents the results of quartz sand analysis under two headings: a) sand insoluble in HF and b) SiO_2 (β). It is this procedure which makes possible an approximate comparison of Schmidt's work with other analyses where hydrochloric acid was not used.

[3] Dokuchaev. Khod i glavneishie rezul'taty predprinyatogo VEO issledovaniya russkogo chernozema (Progress and Principal Results of the Investigation of Russian Chernozem Undertaken by the Free Economic Society), p. 18. 1881.

Chapter VI

NORTHERN SEABOARDS OF THE BLACK AND AZOV SEAS AND BASINS OF THE LOWER DON AND VOLGA

It will be made obvious that this belt, stretching over nearly 1000 versts (from west to east), differs from southwestern, central, and eastern Russia in its remarkable uniformity of principal physical features; its description may thus be more concise. Nevertheless, for the sake of clarification we shall divide it, according to certain secondary distinctions, into the following regions: a) Black Sea coastal area; b) Azov Sea coastal area; c) basin of the Lower Don; d) areas along the Volga from Kamyshin to Astrakhan.

Odessa — Nikolaev — Kherson — Dnieper "plavni"

It has been pointed out on pp.140 — 144 that the predominant bedrock along this seaboard is the limestone type of Upper Tertiary formations, the Pontian stage. Barbot de Marni's map showed that the Pontian stage stretches north from the sea over 50 versts and more. It was also mentioned that the surface of the stage consists of various Recent clays and loess with a very considerable $CaCO_3$ content. Therefore, and also because of the slight flatness of this seaboard, local soils may be expected to be among the best throughout chernozem Russia. However, these generally accepted expectations are not borne out by facts. Already Grossul-Tolstoi's map (pp. 178 — 180) depicts clayey-calcareous soil, bearing unreliable crops, along the entire northern seaboard of the Black Sea (20 — 40 versts away from the coast). Grossul-Tolstoi gives the following description.

The territory is generally "covered with a hard, thin, rapidly drying clayey-calcareous soil with an extremely insignificant chernozem admixture, coloring the soil brown rather than black; the subsoil is reddish or yellowish fairly compact loam containing distinct lime nodules or specks. Sparse, stunted vegetation appears early in spring, and wilts so rapidly with the onset of hot weather (which may occur during spring) that it cannot be utilized for grazing. Some of these areas hardly develop any vegetation suitable for grazing, and plains or hilly elevations often stretch over several versts, covered only with dry, barren clay."[1] Apparently, these conditions are even more extreme in its western part, Bessarabia. "In certain years, herbaceous vegetation wilts virtually instantaneously; in a majority of cases by 15 May it is completely dead, its sole remnant an ashy-yellow or light-cinnamon brush-like cover. It is very rare that grasses retain some of

[1] Grossul-Tolstoi. Ibid., p.40. Elevated areas between rivers constitute a certain exception, "where some plots have chernozem-sandy soil and appear cultivable; however, grasses and corn wilt rapidly here as well."

their freshness up to 1 June... In some years, the inhabitants feed their livestock on hay and straw in the middle of the summer, although such fodder is stored for winter..."[1] The author remarks, with justice, "the main scourge of local vegetation" is lack of moisture, unbearable summer heat, and especially "southern and eastern winds." Such winds heat the clayey soil so that its surface develops a multitude of cracks and becomes dusty during the heat of summer, and even in springtime. "In very hot summer weather, 12 – 16 hr suffice for extreme desiccation of the top soil layer, even after the heaviest rain."[2]

These physical conditions are strikingly analogous to those of the Novouzensk District! Therefore, the following question is quite justifiable: which source of organic matter is most likely, under these conditions, for the formation of chernozem ?

I recognized the overwhelming importance of climate in the origin of Russian soils as early as 1877[3]; yet, I began checking Grossul-Tolstoi's observations with special interest in 1878. For this purpose, I traveled along the highway throughout the seaboard territory, between Odessa and Kherson. The highway runs along the very coast of the sea between Odessa and Koblevo station, and at a distance of 15 – 30 versts over its remaining length; I was thus able to examine all the principal sections of the seaboard strip described by Grossul-Tolstoi (see above).

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
2 versts west of Odessa	Loam	Steppe	1'8" [50 cm]	–	–
Gadzhibai liman, near the sea	–	Level pasture	1'9" [53 cm]	3.559	3.479
At Koblevo station, in the vicinity of the Tiligul liman.	–	Steppe	1'2" [35 cm]	–	–
Sositskaya	Marly	Steppe	6" [15 cm]		
Nikolaev.	Loam	Level long-fallow land	1'4" [40 cm]	4.921	4.463
Pokrovskaya	–	Steppe	1'6" [46 cm]	–	–
Kherson	–	Steppe	1'8" [50 cm]	2.224	3.738
Average, including Kolontaevka (p. 193).	–	–	1'5" [43 cm]	3.944	4.655

Of course, the observations of Grossul-Tolstoi, a local landowner, performed over several years, proved to be quite accurate. The entire 150-verst territory is a high steppe, incised by "balkas" and limans in its western half and almost perfectly level between Nikolaev and Kherson. Except for the terraced environs of Nikolaev, which are more or less sandy, the ground of the majority of the territory is Odessa limestone in its lower horizons, and heavy (especially between Nikolaev and Kherson), very marly brownish–yellow loam in its upper horizons; this loam is the parent rock for local soils nearly everywhere. Only at Sositskaya station (the second

[1] Ibid., p. 46.
[2] Ibid., pp. 41–43.
[3] Dokuchaev. Itogi o russkom chernozeme (Summary Concerning Russian Chernozem). – [Trudy VEO, vol. I, No. 4], pp. 14–17. [1877].

station west of Nikolaev) on a perfectly level steppe, does Odessa limestone outcrop on the surface, and form a direct transition to a vegetal layer 6 in [15 cm] thick, abundant in calcareous pebbles. The soils between Kherson and Odessa are chocolate-gray throughout, and about 1 1/2 ft [45 cm] thick; in some places they are even replaced by brownish-red solonetses with a vegetal layer thinner than 6 in [15 cm]. The vegetation is poor throughout, brownish, and stunted (June). The soil measurements on the previous page were made en route.

I made several stops in the vicinity of Kherson, as well as en route from Kherson to Nikopol and Aleksandrovsk, in order to study the famous Dnieper "plavni", where the origin of chernozem had been dated by certain authors as occurring after the time of the Zaporogian Sech.*

These "plavni" are in fact areas dotted by sands, bogs, and lakes and crisscrossed by hundreds of old and new river channels.[1] Chernozem cannot possibly exist, since the land itself is still in process of formation, and changes appearance every year and sometimes even several times a year. The geological structure of these "plavni" and their pedological relationships are essentially the same as was presented in our description of Kachnya (pp. 101 – 106).

Genichesk — Melitopol — Berdyansk — Taganrog — Rostov

The same Pontian stage found between Kherson and Odessa forms the base of the northern seaboard of the Sivash and Azov seas; its extent is restricted to 15 — 20 versts between the Molochnaya River and Rostov.[2] As is the seaboard of the Black Sea, it is covered nearly throughout (with the partial exception of the basin of the Molochnaya River) by beds of red-brown and brown-yellow marly loams, parent rocks for the local chernozem. Only in rare cases (such as the Molochnaya basin) does this chernozem with its 0.3 – 0.6 m thickness, lie directly over loose, yellowish limestone of the Pontian stage.[3]

The Azov seaboard, similar to the Black Sea area, consists of endless, completely treeless, gently rolling steppes, interrupted more frequently in the east than in the west by "balkas" and minor rivers. A more favorable climate[4] and soil, and slightly more abundant wild vegetation are the only characteristic features of the region.

Mr. Solomin's observations (along the route from Rostov to Melitopol) and my own (along the route Aleksandrovsk — Melitopol — Genichesk), regard the coast of Sivash immediately south of Novoalekseevka station as typical of the entire region. In this locality, typical feathergrass steppe extends

* [The center of the Zaporogian Cossacks, forcibly liquidated by the Russian Empress Catherine II (the great) in 1775. Translator.]

1 Krendovskii, [M]. Issledovanie Dneprovskoi del'ty (Investigation of the Dnieper Delta). 1881. [Separate reprint from "Trudy obshchestva ispytatelei prirody pri Khar'kovskom universitete, vol. 14.]

2 Kontkevich. Ibid., map.

3 Ibid., p. 248. At the village of Novotroitskoe, on the bank of the Sukhaya Volnovakha, Kontkevich also observed chernozem 1.3 m thick, overlying gray Carboniferous limestone.

4 However, local inhabitants report (Kontkevich, Ibid., p. 316) that artificial afforestation is impossible because of excessive dryness of soil, lack of rain (sometimes over entire months) and high salt content in the soil. Author.

to the sea, in the form of a vertical bluff 45 – 50 ft [14 – 15 m] high. A natural section provides the following excellent exposure:

A. Soil horizon permeated by a network of living and dead roots; the color of soil (in situ) is dark chocolate and its thickness is 1 ft 5 in [43 cm].

B. Transition horizon with krotovinas, 10 in [25 cm].

C. About 45 ft [14 m] of red-brown uniform, unstratified sandy clay, with an abundance of lime nodules ("dutiks"). I made an identical observation at Genichesk near Novoalekseevka (in a well), and in the territory between these three points. Well water is everywhere either brackish or stale. Solonetses may also occur; the surface is burrowed through by susliks in certain places. Nevertheless, the vegetation and soil color of the local steppes seem of better quality than on the steppes of the Black Sea seaboard.[1]

The following table provides a good illustration of the monotonous nature of soils over the seaboard of the Azov Sea.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Novoalekseevka, Perekop District	Loam	Steppe	2'2" [66 cm]	6.025	4.178
Sivash, at Genichesk . .	–	–	2'3" [69 cm]	4.844	8.37
Melitopol	Sandy loam	–	2'5" [74 cm]	2.368	4.130
Berdyansk, 1/4 verst from the sea	Loam	–	2'4" [71 cm]	5.180	10.845
4 versts west of Mariupol, 3 versts from the sea .	–	Level		5.760	4.69
Bezymyannoe, Mius District	–	plowland –	1'2" [35 cm]	5.375	5.283
4 versts west of Pokrovskaya, Mius District .	–	–	2'3" [69 cm]	4.947	8.803
Taganrog	–	–	2'2" [66 cm]	4.437	8.551
5 versts north of Novocherkassk	–	Pasture	2'1" [64 cm]	5.320	4.408
Average	–	–	2'1" [64 cm]	4.917	6.584

This monotonous soil pattern is interrupted only by a) spits of the Azov Sea and b) the Don "plavni" near Rostov. The spits consist exclusively of sands (often rich in shells) while the "plavni" are covered by lacustrine-fluvial and bog formations, as quite accurately marked on Chaslavskii's map.

Right bank of the Don from Konstantinovskaya to Kalach. Kalach – Tsaritsyn

From Grushevka (p. 226), I travelled toward the Don via Krymskaya station; my first sight of the river was at Konstantinovskaya "Stanitsa". The topography of the territory is similar to that at Grushevka almost throughout the 70-verst stretch, especially in its western half. The

[1] These characteristics persist up to the Dnieper "plavni", at least along the Melitopol – Aleksandrovsk route. Author.

dominant subsoil is the same heavy clays with multicolored spots as seen at Shakhtnaya. Reddish loams are visible only in the immediate vicinity of the Donets, apparently rich in magnesium salts and in sodium chloride; in any case, wells in such places contained a bitter-saline water which soon became putrid. "Islets" of this kind are readily distinguishable, since they are covered almost exclusively by small sparse sagebrush, and their soils are of the Novouzensk type.

Although the rest of the territory is covered by feathergrass, the vegetal earth is brownish-chestnut, very compact and does not usually exceed 1 — 1 1/2 ft [30 — 45 cm] in thickness. It is typified by a sample which I took on an elevated feathergrass steppe, approximately 7 versts east of Mikhailovskaya "stanitsa"; the local soil is 11 in [28 cm] thick, and its humus content 4.701%.

The road runs near the Don over the 100-verst stretch from Konstantinovskaya to Tsymlyanskaya "stanitsa", rarely descending into the floodplain and usually climbing to its second terrace, or even to the neighboring wide and high Don steppes. The landscape is extremely monotonous throughout, and dismal; thin, compact chestnut-colored soils are sparsely covered by sparse, completely desiccated (July) specimens of thorns and sagebrush, very often interrrupted by bald patches of red-brown subsoil (solonetses). Even such poor vegetation is hardly ever returned to the soil, but rather "burnt" by the heat on the spot, or blown off together with tumbleweeds into the neighboring Don "plavni" and other depressions. Local inhabitants report that this territory is sometimes subject to such hot spells and droughts that full-grown wheat with well-developed grain is completely burnt by the sun and "sukhoveis" in 1 — 2 days.

The soils on this territory, as on the Volga terraces, are progressively poorer in humus and generally inferior, since they are nearer the Don and their situation is relatively lower. However, I took a sample of vegetal earth 3 versts northwest of the Tsymla, and found the soils in this territory to be very thin (9 in [23 cm]), light-chestnut in color and very low in humus (1.969%) even on the third terrace (high steppe) away from the Don.[1] Immediately beyond the Tsymla the road continues on a high, completely dry, gently rolling steppe, over a stretch of 100 versts, away from the Don, via Zakharovka to Nizhnechirskaya "stanitsa". The soils grow darker and thicker, up to 1 1/2 ft [45 cm] thick, especially in depressions, while retaining their chocolate shade. They often alternate with reddish "islets" which are either totally devoid of vegetal layer or are brown and 4 — 6 in [10 — 15 cm] thick (solonetses). My attention was especially attracted by the following three phenomena en route:

1. Just north of the Tsymla I found fairly deep sands, the surface of which in some places is a dark, grayish color and 1 1/2 — 2 ft [45 — 61 cm] thick; in other places, they are yellowish-red, almost uncolored by humus. This became obvious only after investigations were carried out on two rounded small sand hills one of which is dissected by a neighboring minor river. This is in fact an interbedding of sandy soils with dune sands, identical to that we found south of Merefa (p. 162), except that the banks of the Tsymla are devoid of forest.

2. Moreover, banks of the Tsymla often exhibit the following structure:

A. Bluish-gray glei, deposited by springtime flood waters, 2 ft [61 cm].

[1] I am sure, together with Prof. Levakovskii (ibid., p. 4), that soils improve in quality further northwest from the Don, although they are probably far from being typical chernozems. Author.

B. Alluvial loamy chernozem, 1 1/2 ft [45 cm].

C. Red sand, 15 ft [4.6 m].

3. The level steppe between Zakharovskaya and Nizhnechirskaya "stanitsa" is covered by innumerable mounds thrown up by the susliks[1]; even sagebrush is often absent. The diameter and height of such mounds are usually 1 — 2 ft [30 — 61 cm]; they often merge, resulting in low heaps 1 — 2 ft [30 — 61 cm] high, reaching 1 1/2 sazhens [3.2 m] across. Excavation of mounds showed their lower sections to consist mostly of vegetal earth while the upper sections consist of bedrock. Some areas contain square miles of these mounds; the burrows inside the mounds can accomodate 18 "vedro" [buckets] of water. The amount of bedrock (often solonetsous) thrown up to the surface must be enormous. I agree wholeheartedly with the local inhabitants, who maintain that susliks and similar burrowing animals are quite capable of converting any fertile chernozem steppe to complete desert.

Past the Nizhnechirskaya "stanitsa", the highway re-enters the alluvial valley of the Don. Traveling toward the Kobylyanskaya "stanitsa", we crossed the first floodplain terrace, with 3 — 4 oxbow lakes, some already dry, then climbed to the second terrace which is only partially flooded by the Don at unusually high waters. Both terraces are quite typical geologically and pedologically.

North of Kobylyanskaya "stanitsa" the route again ascends into the high, dry steppe which stretches via Pyatiizbyanskaya "stanitsa" up to Kalach itself. The soils, however, are of the same nature as south of Nizhnechirskaya. They are represented by a sample of vegetal earth which I took 5 versts south of Pyatiizbyanskaya, 1 ft 3 in [38 cm] thick and with 2.932% humus content; naturally, its color is brownish-gray.

To complete this discussion of the right bank of the Don, it should be added that the area of the Pyatiizbyanskaya "stanitsa" is incised by numerous very deep gullies, some quite fresh, emptying into the Don valley. The upper third of their walls is nearly everywhere composed of fairly heavy "white eye" ("beloglazka"), while the lower two-thirds are formed of bluish-gray chalky (?) marls.[2]

Immediately outside the "stanitsa", at the foot of such a bluff, the following series from top downwards of talus and alluvium from the neighboring bank is visible: a) "white eye" 4 ft [1.2 m], b) intercalation of marly pebbles and sands 2 ft [61 cm], c) darkish-gray vegetal layer 8 ft [2.4 m], and d) "white eye" with numerous pebbles of local bedrock 20 ft [6.1 m].

The entire area between the Don and the Volga (from Kalach to Tsaritsyn) is of extremely monotonous pattern. The terrain is level, waterless, desiccated, sometimes incised by shallow "balkas" whose walls display only red-brown clay, sometimes with salt efflorescences. The thin, brownish-gray soil is hardly distinguishable from the ground; the vegetation — sparse feathergrass and stunted sagebrush — barely covers the steppe; the only variety to strike the traveller's eye is provided by the innumerable suslik mounds and artificially planted stands of poplars...

Thus, Don soils must be regarded completely similar to the Novouzensk soils and those of the Black Sea Seaboard as far as color, thickness (about 1 ft) and organic substance content (average, 3.2%) are concerned.

[1] As is known, this is a common phenomenon in the south Russian steppes. I mention it in this context only because it is especially well pronounced in the Don steppes. See, inter alia, Bogdanov. Ibid.

[2] The reader is reminded that geological maps indicate Lower Tertiary formation throughout the territory between Konstantinovskaya and, approximately, Kobylyanskaya as well as from Kalach to Tsaritsyn, and Cretaceous formation between Kobylyanskaya and Kalach.

Basin of the Lower Volga, from Kamyshin to Astrakhan

According to Prof. Bogdanov's description, "the water divide between the Ilovlya and the Volga south of Kamyshin is a low ridge with gently sloping sides, gradually becoming lower toward the south up to Tsaritsyn and then forming a transition to the Ergeni [Yergeni] Hills. The upper portions of the slopes and the crest are covered with brownish clayey soil, permeated by humus. In certain places small oak 'koloks'[1] are visible slightly south of the village of Davydovka. Gently sloping areas on the slopes are richer in chernozem (which is also brown) and occupied by feathergrass steppes. Further down, clay, overgrown by sagebrush (Artemisia austriaca), is exposed on a gently sloping area. Finally, south of Dubovka, the ridge becomes clayey (with a slight brownish tinge) and is overgrown by sagebrush, similar to the slopes. The territory between Laznaya, Davydovka and Pichuga (latitude of 49°N) may be generally regarded as the southern boundary of the chernozem zone, although it is far from distinct; in fact, faint signs of chernozem are discernible on the Ergeni Hills. Feathergrass, Salvia silvestris and other characteristic chernozem plants disappear (?) already at Davydovka. Further south, on elevated areas, light-colored clay is overgrown by sparse stunted sagebrush. The lifeless landscape and barren soil are especially noticeable following the luxuriant green vegetation of the chernozem steppe. Only a few dozen meters downslope on this moderate elevation, a new soil with different vegetation appears, the Aral-Caspian desert with its solonchaks overgrown by different saltworts, Astragalus sp. and other characteristic plants."[2]

The soils at these latitudes on the left side of the Volga are even poorer. The lands which "were used by Kirgizes* of the Bukei (Bukeevskaya) Horde and the entire Tsarevo District consist of level, waterless, and barren steppes; the soil is solonetsous throughout, and the few areas higher in quality may be classified only as lands of the lowest grade; this territory becomes more strikingly barren further south toward El'ton Lake and the boundaries of the Astrakhan Province... The only means of livelihood in this territory is livestock raising."[3]

Prof. Eversmann provided a similar, though more vivid, description of the Caspian steppes, as has been mentioned.

I inspected the entire territory along the highway between Kamyshin and Tsaritsyn. Unfortunately, since the terrain is very hilly and incised by numerous gullies and minor rivers flowing down toward the Volga, the majority of the local soils were abnormal. The country is covered almost exclusively by various sandy and sandy-loamy Lower Tertiary rocks,[4] and

[1] According to Mr Palimpsestov, there are grounds to assume the former existence of oaks up to 2 arshins in diameter here as well (on the outskirts of the settlement of Dubovka). [Stepi yuga Rossii byli li iskoni vekov stepyami i vozmozhno li oblesenie ikh (Concerning the Primordial Origin of the Russian Steppes and the Possibility of their Afforestation)]. Lesnoi Zhurnal, No. 2, pp. 134–135. 1882.

[2] Bogdanov. Ibid., pp. 22–23.

* [In fact, Kazakhs. Translator.]

[3] [Opisanie Zavolzhskogo kraya... (Description of the Trans-Volga territory)]. – Zhurnal Ministerstvo gosudarstvennykh imushchestv, part 16, p. 249. 1845.

[4] Sintsov. Ibid.

beds of clay and marls only rarely appear on the surface (for instance, at the village of Belaya Glinka) and then in the form of minor intercalations.

Locality	Composition	Sampling site	Thickness	Humus, %	Hygroscopic water, %
Belaya Glinka (Beleglinka), Kamyshin District.	Marly loam	Pasture in the middle of a barely perceptible slope	1'3" [38 cm]	5.429	6.601
5 versts north of Karavainskaya, Tsaritsyn District	Sandy loam	Pasture on gentle incline	1'2" [35 cm]	1.450	0.927
Zapadnaya, Tsaritsyn District	–	Pasture on level area	1' [30 cm]	1.422	0.933
Tsaritsyn	Loam	Virgin land	9–10" [23–25 cm]	0.908	1.081

Obviously, the Tsaritsyn sample is the only one considered normal of those in the table. The importance of this sample is enhanced by its position on the atmospheric clays[1] which Prof. Bogdanov regarded as so significant in the formation of rich chernozem.

At any rate, the unusually gradual decrease in the humus content of soils en route from Gryazi toward Tsaritsyn (p. 227) is adequate proof that the same pattern probably exists south of Kamyshin.

I took a steamer from Tsaritsyn to Astrakhan, stopping at Chernyi Yar and Enotaevsk; however, the territory supplied but little material for a pedologist. The same, exhaustingly monotonous, reddish-yellow solonchak steppes stretch throughout, loamy or sandy. In July, they were almost completely devoid of vegetation. The soils are barely distinguishable from the ground, with thickness of 4 in [10 cm] (at Chernyi Yar), and humus content of 1.081 %.

Thus, if the Zapadnaya and Karavainka samples are replaced by the Gorodishche sample (2.526% humus, p. 228), average results for soil of the Lower Volga will be 2.4% humus, 10 in [25 cm] thickness.

A list of analyses performed is presented in the table on the following page in order to provide some details of the chemical nature of these soils.

It is clear from our description of soils of the seaboards of the Black, Azov, and Caspian seas that the most stable and outstanding feature is a striking uniformity of the humus content (and thus of the chestnut-gray color). Only one (Gofental soil) of the 34 soil samples which I took on the vast territory between Odessa and Novouzensk contained about 9% organic substances. However, this too may be accidental, since all the other samples contained no more than 6.5%, usually less than 4% organic substances.

This property of these soils is indicated by the following numerical data, expressing the average humus content for particular areas of this territory [in percentages]:

[1] They stretch from north to south.

Basin of the Bol'shoi Uzen, Malyi Uzen. and Eruslan rivers	4.6
Seaboard of the Black Sea	3.9
Seaboard of the Azov Sea	4.9
Right bank of the Don	3.2
Lower Volga	2.4

Analyses by Reichardt[1] [percentages]

Locality	Odessa	Don Cossack Territory	Area of Eiton Lake, saline steppe (muds ?)	Soil of the Kalmuck steppe on the Volga
No.	1	2	3	4
Hygroscopic water at 100°C	4.44	3.20	2.52	2.52
Loss on ignition of soil dried at 100°C	5.95	7.05	20.82	7.16
Insoluble clay and sand	84.55	77.68	59.58	80.35
SO_3	0.03	Traces	0.14	0.05
Cl	Traces		1.04	Traces
Soluble SiO_2	0.08	Traces	1.90	0.03
Na_2O	0.01	0.40	1.76	1.67
K_2O	1.44	0.36	1.09	0.53
CaO	0.01	0.66	2.33	0.83
MgO	0.35	0.48	1.24	0.32
Al_2O_3	0.16	3.08	4.78	0.17
Fe_2O_3	2.08	7.12	1.58	3.36
P_2O_5	0.07	0.12	1.40	0.06
Total	99.98	100.15	100.18	99.35

Analyses by Prof. K. Schmidt[2] [percentages]

Locality	Sivash seaboard near Novoalekseevka station, level feathergrass steppe		
No.	5	6	7
Sampling depth	up to 1'5" [43 cm]	1'5" – 2'9" [43 – 84 cm]	below 2'3" [69 cm]
Hygroscopic water lost by 100 parts of air-dry soil at 100°C	8.37	9.02	8.86
Total content per 100 parts of soil dried at 100°C (total constituents soluble in HCl and HF, + quartz sand which is insoluble in HF)			
Hygroscopic water lost at 100–150°C	0.750	0.537	0.593
Organic substances (humus)	7.616	6.279	3.494

[1] Reichardt. Ibid.
[2] Schmidt. Ibid., No. 1.

(continued)

Locality	Sivash seaboard, near Novoalekseevka station, level feathergrass steppe		
No.	5	6	7
Mineral constituents	91.634	93.184	95.913
K_2O	2.608	2.970	2.098
Na_2O	1.017	0.747	1.213
CaO	1.792	1.731	9.607
MgO	0.772	1.112	1.159
Mn_2O_3	0.042	0.067	0.060
Fe_2O_3	4.538	4.430	4.420
Al_2O_3	15.422	16.697	14.682
CO_2	0.058	0.389	7.214
P_2O_5	0.245	0.201	0.143
SO_3	0.008	0.006	0.195
$NaCl$	0.004	0.020	0.197
a) SiO_2	20.890	18.051	15.802
b) SiO_2	39.294	39.953	37.561
Quartz sands insoluble in HF	4.894	6.610	1.562
$CaCO_3$	0.132	1.339	16.395
$Ca_3P_2O_8$	0.535	0.439	0.312
Lime (residue combined with SiO_2 and humic acid)	1.428	0.743	0.257
Nitrogen	0.281	0.180	0.048

It is thus obvious that soil, similar to any other natural-historic body, may retain its character over infinitely large areas, under identical conditions of origin and development (ground, climate, age of the country, vegetation, and topography).

Another distinctive feature of this belt is its abundance of solonetses. A summary of information on solonetses is presented below.

1. The most typical solonetses are known to be those which consist of more or less intact remnants of the former sea bottom. Prof. Eversmann described their origin as early as 1840, as follows. Many localities on the northeastern Caspian seaboard, with a very low shore and very shallow, gently sloping bottom, are covered by rushes which often penetrate into the sea in the form of narrow strips and small "islands". The intertwining rushes form a maze of channels, backwaters, promontories, and bogs: "The shore thus gradually expands, the promontories gradually merge, a bay is converted to a bitter lake, which is only replenished by snow and rainwater, its shores are gradually overgrown, eventually resulting in a saline puddle or a solonchak which is muddy in spring. Saltworts first appear on the shores and eventually spread over the entire surface [of the bottom of the former lake], partially decomposing the salt and forming chernozem; the latter enables the growth of other grasses, impelling the saltworts toward the center, and the solonets is gradually converted to

steppe soil. For this reason, the solonetses are less common away from the seaboard."[1] We shall see below that an essentially similar advance of land occurs along the shores of Sivash.

Distance from the sea is not the only factor controlling the existence and preservation of such solonetses. Differences in climate, or in marine salt content of the bedrock, or else in the subsoil structure, may result in different leaching rates in different parts of the steppe, despite their simultaneous emergence from under sea level. Some areas may be covered by typical steppe vegetation and fairly dark, nonsaline soil, while other areas (solonchaks) still bear sagebrush and various saltworts.

This type of solonets, distinguished by its marine origin and independence of local relief, is very widespread throughout all the Upper Tertiary formations in southern Russia.

2. The formation of new (secondary) solonetses is made possible in depressions which contain springs or collect rainwater, when certain areas of the steppe have become completely desalinized while other areas have not, when the surface rocks in a certain area have become completely leached and carry fresh running waters while their lower horizon is still rich in salts (viz, the southern parts of the Samara Province). Academician Baer demonstrated that such closed depressions may accumulate fairly large amounts of salts, although the salinity of the rocks from which the salts are derived need not exceed 1: 100,000.[2]

Such solonetses will of necessity always be strictly dependent on the topography and occur only sporadically. Of this type are a considerable portion of the saline localities in the Novouzensk (pp. 276 – 277) and Samara districts.

3. However, the local inhabitants of the same Novouzensk District, partly also en route from Nikolaevsk to Buzuluk, and in many other localities, very often report location of solonetsous soils on hilltops and hillsides. I regard these reports as reliable, since the phenomenon is easily explained by the presence of saline parent rocks. The nonsaline soils have been washed away from inclined areas, laying the bedrock bare; we have cited hundreds of such cases.

4. The fourth type of solonetses was first noted by Prof. Levakovskii. After mentioning the existence of mounds thrown up by animals burrowing in steppes (p. 293), Levakovskii continues: "In different areas I observed the heaps of solonetsous clay, thrown up by the susliks, to be leveled partly by atmospheric water, mostly by plowing, forming brown solonchak patches usually covered by sagebrush; these patches are noticeable even when the land is occupied by wheat or other crops, because of their poor growth."[3]

Such solonetses are not rare in Russia. It is known that "the susliks are extremely abundant; once they find a convenient area, their proliferation seems to be unlimited."[4] As many as 271,000 susliks were exterminated between 14 May and 1 June of 1866, in the Taganrog municipality alone. In the spring of 1851, fishermen netted several tens of thousands of susliks, washed off the steppes into the Mius liman by heavy rains.[5] In certain

[1] Eversmann. Ibid., pp. 63 – 64 and 89 – 90.
[2] Baer. Kaspische Studien. III. [St. Petersburg, 1859]. S. 26.
[3] Levakovskii. Ibid., pp. 12 – 13.
[4] Wood. [D.]. Nests, Burrows, and Lairs. p. 23. [St. Petersburg, Moscow. 1867.]
[5] Levakovskii. Ibid.

places entire square miles are filled by the mounds of steppe rodents. The activities of these animals may only be estimated when the amount of earth thrown up to the surface by every individual is taken into account. Unfortunately, no direct observations on this subject are available. Although Wood reported the tortuous burrows of susliks to extend to a depth of only 5 — 6 ft [1.5 — 1.8 m], we already know krotovinas to penetrate as deep as 10 — 15 ft [3 — 4.6 m]; the burrows of these animals broaden in various places, etc. If the mean burrow diameter is taken as 2 — 3 vershoks [9 — 13 cm], the enormous mass of subsoil thrown onto the surface by these diggers becomes imaginable.

All four types of solonetses mentioned above have one feature in common: a variable but definite content of marine salts, gypsum, magnesium sulfate, sodium chloride, etc. Types of solonetses in which the presence of these salts is highly doubtful are listed below.

5. The most interesting example of such solonetses is found in Bol'shoi Tolkish (p. 267). This soil definitely originated from bogging of the area, which is enriched in humus particles from adjoining slopes. Its barrenness is due to the moubly, acid nature of the soil. Very probably, Simbukhovo soil (p. 82) is also of this solonets type (?).

6. The nonarable lands in the environs of Gromy (p. 188), Nezhin (p. 113), etc. are even more remotely related to true solonets. Apparently, these are bogs amidst chernozem steppes. These solonetses were found to be quite normal by Sibirtsev and Petzholdt in their analyses.

7. Finally, I was able to find that in many areas of central and southwestern chernozem Russia the term solonets is also applied to simple outcroppings of parent rocks (clay, sand, etc.) on hills and hillsides, which are far less fertile than the neighboring, typically chernozem, steppes. I regard the solonetses which we mentioned (from the literature) in the Kursk and Poltava provinces, and others, to be of this category.

We thus conclude that solonets in southern Russia, similar to podzol in northern Russia,[1] is a collective term, generally applied to any local soils which are infertile, disregarding the cause.

[1] Dokuchaev. Kartografiya russkikh pochv (Cartography of Russian Soils), pp. 103—113, [St. Petersburg, 1879].

Chapter VII

SOUTHERN MARGINS OF CHERNOZEM RUSSIA, THE CRIMEA, AND THE NORTHERN SLOPE OF THE CAUCASUS

Principles of the Geography of Russian Chernozem

The Crimea and the Caucasus, a luxuriant section of Russia, are still terra incognita pedologically and in other respects. This is especially regrettable since these localities are almost completely isolated and exhibit great diversity of physical conditions (ground, age, climate, vegetation, elevation, topography, etc.) over comparatively small areas, and as such might provide excellent, and unique material for the solution of the most complicated and interesting problems of pedology. I therefore now present the observations of my brief visits to the Crimea and the Caucasus.

The Crimea

The Crimean Peninsula may be roughly divided into the following three belts, on the basis of physical properties, ENE to WSW: a) from the eastern coast to the line Bakhchisarai — Karasubazar — Staryi Krym; b) hence along the middle reaches of the Salgir River; c) the northwestern parts of the peninsula.

The first belt contains two longitudinal valleys with several ranges between them,[1] at an average height of 2000—4000 ft [610—1220 m]. This part of the Crimea is almost exclusively composed of Jurassic, Cretaceous, and Paleogene strata, and bears a fair amount of forests. The climate is comparatively mild.

Heights in the second belt range from 2000—700 ft [610—213 m], decreasing northward. The terrain is gently rolling, with an almost total absence of forests. The dominant formations are Eocene and Lower Pliocene. Climate is of steppe type.

The third, northernmost belt is identical to the nearest seaboard of the Black, and to a certain degree also of the Caspian, Sea, in respect to its topography, height, vegetation, and climate, with a possibly still more typical steppe character. Remarkably, these seaboards are composed of the same Upper Pliocene formations.

[1] Levakovskii. Issledovanie nad obrazovaniem Tavricheskikh gor (Studies of the Formation of the Crimean Mts). 1881. [Separate reprint from "Trudy obshchestva ispytatelei prirody pri Khar'kovskom universitete."]

The three belts form a series of transitions beginning with the Yaila Range and ending with the muddy lagoons of the Sivash...

Let us turn to the nature and distribution of local soils. Unfortunately, literature on the Crimea soils is controversial. Chernozem was recognized by Murchison, Huot, Radde,[1] Romanovskii, as well as by the cadastral commissions,[2] while Ruprecht and Vil'son (Wilson), denied this and regarded all Crimean soils as brown loams and sands. Essentially the same indications are given in Chaslavskii's map.

The situation was clarified considerably only after Prof. I. F. Levakovskii's visit to Crimea, in connection with the occurrence of chernozem in this region.

I. F. Levakovskii, similar to his predecessor G. D. Romanovskii, noted the sporadic and very rare occurrence of chernozem soils in closed depressions in the first, southern belt of the mountainous part of the Crimea[3]; he goes on to say that "chernozem begins to disappear at about 100 versts north of Simferopol, with a simultaneous intensification of the solonchak nature of the country toward Sivash; the solonchak consists of brown clay which is the subsoil common to chernozem...; nevertheless, chernozem also forms a fairly thick layer in certain areas in the vicinity of the Chongar bridge. North of the Chongar bridge (on the Chongar Peninsula ?) the soil is a brown clay, strongly impregnated with salt, and this soil continues up to the village of Zuya; beyond the village, the solonchak becomes weaker up to the village of Akimovka, and true chernozem begins after Tashenak.

"The same pattern occurs both to the north and south of the Perekop isthmus."[4]

Palimpsestov also observed analogous transitions from chernozem soils to solonetses in the Feodosiya District. According to this author, "Traveling from the River Karasovka along the latitude 45.3°N. toward Sivash, we first see (along the slope descending toward the river ?) a section of more or less deep chernozem, as much as 21 in [53 cm], of rather black color; on the plain, a more intense black chernozem layer occurs, reaching 1 arshin [71 cm] and more in thickness; further toward Sivash, the soil color grades gradually from black to brownish and to brown; however, the vegetal layer resembling steppe chernozem is still so rich that in favorable years one dessiatine yields 20 and more 'chetvert's' [37 centners/hectare and more] of excellent wheat; this layer thins toward Sivash, grows lighter in color, and its nutrient content becomes so low that it can only bear grazing for sheep; in the neighborhood of Sivash it finally becomes so barren that it bears only stunted sagebrush, and is eventually covered by saltworts up to the muddy waters of the Putrid Sea [Sivash]."[5]

This information enables us to draw the following conclusion in regard to the distribution of soils over the Crimean Peninsula: in the first, mountainous, belt

[1] Levakovskii. Ibid., p. 5.

[2] Dokuchaev. Kartografiya russkikh pochv. (Cartography of Russian Soils), p. 37.

[3] and [4] Levakovskii. Ibid., pp. 15 and 18.

[5] Palimpsestov. — Lesnoi Zhurnal, Book 2, p. 111. 1882. According to Kornis, "Not one fair-sized meadow occurs in the Taurida Province on the entire territory between the Dnieper banks up to the orchards of Simferopol; cereals grow in patches, covering only one-third of the surface, while the remainder is only covered by softer grasses in spring; when the grasses wilt, bare earth is left behind." Grieseb ach [A.]. Vegetation of the Globe (Russian translation by Beketov), vol. 1, p. 408, [St. Petersburg. 1874].

there is no normal chernozem, in the second belt it attains a thickness of 2 ft [61 cm] and more; in the third belt, as in all coastal areas, it is gradually replaced by solonetses. This conclusion was essentially confirmed by my investigations of 1878.

I began travels through the Crimean Peninsula from Yalta, where I visited the area of the Uchansu waterfall and other sites, and then proceeded to Sevastopol via the Baidar valley. As is known, the entire area, approximately to Balaklava, consists of extremely mountainous terrain containing thousands of declivities, depressions and hummocks, and well-forested. In 99 cases out of 100 no vegetal layer is visible on slopes nor in depressions; rather, the local stone alone or little-altered products of its weathering are common.

A sample of forest soil which I took in a thick oak forest in the vicinity of the Uchansu waterfall is 2—4 in [5—10 cm] thick and consists of equal parts of whitish-gray marly earth (with pebbles) and oak leaves and twigs turned brown.

Even in the Baidar depression which is almost enclosed, brownish-red or brownish-gray bedrock occurs throughout, with no trace of the vegetal layer in the restricted sense of this word.[1]

The terrain levels off from Balaklava toward Sevastopol and especially in the vicinity of the latter; the soils, however, remain reddish-gray and are hardly distinguishable from the bedrock. The vegetation is nearly all wilted; the unbearable heat of August seems enhanced by the white limestone rock.

The first five-sixths of the route from Sevastopol to Simferopol wind across territory of very steep inclines and gorges covered by small minor forests, and even through tunnels. The bedrock is essentially calcareous; the soil is nearly all stone or red-brown highly marly loam with a barely noticeable gray tinge in the upper 2—4 in [5—10 cm]. The dark brown vegetal layer in some areas accumulated in depressions to depths of 1 ft [30 cm].

The terrain from Alma toward Simferopol remains mountainous, but the surface forms become appreciably milder, and some small valleys are better developed and broader. Vegetal earth reaching 1—1 1/2 ft [30—45 cm] in thickness is occasionally visible in these valleys, dark-gray with a chestnut tinge. A sample of such earth which I took 2 versts north of Simferopol contained 4.588% humus, was 1 ft 2 in [35 cm] thick, and had a marl subsoil.

Chernozem of the Simferopol type may be assumed to proceed east toward Feodosiya, coinciding with the second Crimean belt mentioned above. The following facts bear out Palimpsestov's indications.

1. Mr. Kessler provided two soil samples from the environs of Suin-Adzha and Veirot in the valley of the Malyi Salgir River approximately 15 versts WSW of Simferopol. Both samples were taken on level terrain; they appear completely analogous to the Simferopol chernozem, and are only slightly lower in humus content, which is 3.768% in the Veirot soil and 4.137% in the Suin-Adzha soil.

[1] However, I agree with my predecessors, in believing some areas on the high level plateaus and in the small enclosed depressions of the Yaila Range to be covered with soils with a relatively high humus content. In any case, a sample which Kytmanov took from a "deep enclosed depression in the Yaila Range in the vicinity of Ai-Petri" has a 8.543% humus content.

2. The same soil category also includes those soils of Koshka-Chokrak, Feodosiya District, although they are more marly. The two samples which the owner of that estate. Dr. B. N. Tarnovskaya, sent me had a 4.418 — 5.211% organic substance content; soil color was gray; it contained numerous grains and specks of $CaCO_3$ and therefore some parts of it effervesced with acids.[1]

Soon past Simferopol, en route toward the Chongar bridge, the steppe levels off gradually, becoming monotonous, lower and with scantier vegetation, finally merging imperceptibly with the swampy coast of the Putrid Sea. Simferopol chernozem disappeared in a similar fashion, in full accordance with the scheme by Levakovskii and Palimpsestov mentioned above.

I stopped twice in this area, at Birman-Kemel'chi station and on the northern tip of the Tongue of Arabat. At the first point the steppe is quite level; the barely perceptible depressions are abundant in solonetses. The sample I took from a nonsaline tilled area was chocolate-gray, 1 ft thick and with 3.261% humus. The other area is incomparably more interesting. In the vicinity of Genichesk, the Tongue of Arabat is separated from the mainland by a shallow strait, very narrow, 25 — 50 sazhens [53 — 107 m] wide. The Tongue of Arabat itself is 1/4 of a verst wide at this point and rises 15 — 20 ft [4.6 — 6.1 m] above the sea. It consists entirely of a mixture of quartz grain and fragments of C a r d i u m and M i t i l u s; this mass has a strong brown tinge in some places, resembling ordinary marly loam, which it will certainly become in the course of time due to weathering. At the level of the Sivash, the Tongue is fringed by a narrow, 5 — 10 ft [1.5 — 3 m], darkish-gray line, where there is a considerable admixture of decaying algae[2]; this fringe represents the transition from dry land to the sea bottom, in this place almost perfectly horizontal and spotted with greenish spots, remnants of various marine inhabitants.

I found all the spits separating the Black Sea limans from the sea to be of identical appearance.

Regrettably, only the analyses presented on the following page are available for the entire Taurida Province. These are all the soil data[3] which I was able to collect in the Crimean Peninsula. However, they are quite sufficient for making the following inferences.

1. The Crimean soils are quite analogous to soils of the northern seaboard of the Black and the Azov seas, in both appearance and humus content (mean of 8 samples, 4.462%).

2. As in the territory Gryazi-Tsaritsyn, Chistopol — Novouzensk and Balta — Odessa, the Crimean Peninsula is composed of gradual transitions from more or less chernozemic soils to typical solonetses, the transition however proceeding in a south-north direction.

3. Even now, the sea bottom is being converted on a large scale to solonetses, and solonetses to nonsaline steppe soils, on the shores of both the Caspian Sea and Sivash.

4. The most mountainous, southeastern, part of the Crimea is devoid of typical, normally situated chernozems.

[1] As should be expected, such soils do not reach the sea coast in this area. My examination (1878) of the immediate environs of Feodosiya and Kerch found the local vegetal earth to be stony, very thin, and slightly colored by humus. Author.

[2] A complete analysis of this earth will be given somewhat further on.

[3] G e b e l ' s analysis (ibid.) is not taken into account because it is obsolete.

Analysis by Reichardt [percentages]
Sevastopol soil, No. 1

Hygroscopic water at 100°C	6.22
Loss on ignition	11.22
Insoluble clay and sand	65.50
SO_3	0.06
Cl	Traces
Soluble SiO_2	0.20
Na_2O	0.47
K_2O	1.08
CaO	6.43
MgO	1.39
Al_2O_3	2.18
Fe_2O_3	4.04
P_2O_5	0.15
Total	98.94

Analysis by Schmidt [percentages]
Coquina from the Tongue of Arabat, No. 2

Sample taken from the surface

Hygroscopic water lost at 100°C by 100 parts of air-dry soil	1.33

Total content of 100 parts of soil dried at 100°C (total components soluble in HCl and HF, + quartz sand insoluble in HF):

Hygroscopic water lost at 100–150°C	0.186
Organic substances, humus	2.809
Mineral components	97.005
K_2O	0.221
Na_2O	0.076
CaO	28.076
MgO	0.135
Mn_2O_3	0.001
Fe_2O_3	0.279
Al_2O_3	1.574
CO_2	21.741
P_2O_5	0.089
SO_3	0.007
NaCl	0.010
a) SiO_2	1.997
b) SiO_2	3.255
HF-insoluble quartz sand	39.544
$CaCO_3$	49.412
$Ca_3P_2O_8$	0.194
CaO (residue combined with SiO_2 and humic acid	0.300
Nitrogen	0.056

Northern Slope of the Caucasus

Before entering upon a proper discussion of the northern slope of the Caucasus, we shall devote some time to that part of the Caucasus in the basin of the lower reaches of the Kuma, Volga, Don, and Kuban rivers and on the territories in between.

The Sarpa heights, or Ergeni, combined with the northern Stavropol spurs, divide this part of the Caucasian isthmus into the eastern, Caspian part and the western, Black Sea part. Both are no more than 140 ft [43 m] above the neighboring seas; the elevation when viewed along the meridian, has a concave surface. Its northern section, at Sarepta, is 427 ft [130 m] above the level of the Black Sea, the middle section on the water divide between the Manyches is 60 ft [18 m] high, while the southern section in the vicinity of Stavropol rises to 2150 ft [655 m].[1]

According to Barbot de Marni, Danilevskii[2] and Meller,[3] both lowlands consist almost exclusively of the Aral-Caspian formations, which are not identical over the entire territory, but rather are Lower Caspian in the western half (Barbot de Marni's Pontian stage) and Upper Caspian in the eastern half. In the western lowland, limestones are important in their composition; in the eastern lowland, most widespread are sands and clays, still very strongly impregnated with various marine salts.[4]

All the other physical features of the steppes in question are also different. N.P. Barbot de Marni described the Astrakhan-Kalmyck lowland on the basis of his varied travels as follows. This is a juvenile, level, barely rolling steppe, completely lacking running waters and forests. In certain places it is even a true desert: "it is covered almost exclusively by sagebrush, mixed with feathergrass and timothy grass only on elevations (and sandy spots) strongly leached by springtime waters, with tumbleweeds in the vicinity of 'khuduks'*; depressed areas, on the other hand, bear saltworts only. In general, grasses develop poorly until they perish due to salinity of ground and summer drought, as well as the desiccating heat which in effect burns them. Instead of decaying in situ, residues of dead plants are virtually burned and their ashes are blown over the steppe by the wind.

"The steppe[5] therefore lacks any considerable layer of vegetal earth with sagebrush and various grasses forming isolated clumps on the reddish-

[1] Barbot de Marni. Geologichesko-orograficheskii ocherk Kalmytskoi stepi i prilezhashchikh k nei... [zemel', s geologicheskoi kartoi] (A Geological-Orographic Description of the Kalmyck Steppe and the Adjacent... [Lands, with a Geological Map]). p. 22. — [Zapiski Russkogo geograficheskogo obshchestva, Book 2, 1862].

[2] Danilevskii. [Issledovaniya v Kubanskoi del'te (Investigations in the Kuban Delta)]. — Zapiski Russkogo geograficheskogo obshchestva [General Geography], vol. 2, pp. 139-180. 1869.

[3] Meller. Paleontologicheskie dopolneniya i poyasneniya k pis'mu Danilevskogo o rezul'tatakh ego poezdki na Manych (Paleontological Supplement and Explanations to Danilevskii's Letter on the Results of his Trip to the Manych), pp. 1-12.

[4] In addition to the young age and mode of origin of this lowland, Barbot de Marni correctly regards the unfavorable orographic and climatic conditions of this territory as additional factors of its marked salinity. The strata are completely horizontal, and the precipitation is very scanty. Ibid., p. 120.

* [Steppe waterhole. Translator.]

[5] A certain exception is found in the small depressions at the foot of the Ergeni Hills, and in the northern, more elevated portion of the steppe. Ibid., p. 119.

yellow clay."[1] The Chernyi-Yar soil, described above, is typical of the soils of this territory.

Apparently, the soil and plant conditions are much more favorable in the lowland adjacent to the Black Sea. Prof. Levakovskii, who observed a considerable portion of the territory between the lower reaches of the Don, the western Manych and the eastern margins of the Ergeni heights "became convinced of the presence of chernozem in this area."[2] Furthermore, Barbot de Marni wrote that "chernozem is highly developed in certain places in the territory of the Black Sea Cossacks," and it may even be described as excellent in quality in the lower reaches of the Sal River.[3] These data were later completely confirmed by Mr. Danilevskii.[4]

It is worthy of note that Barbot de Marni found much better soils and vegetation on the Sarpa elevation, despite the Upper Caspian sediments, than in the neighboring Kalmyck steppe. He attributes this circumstance, quite correctly, to the weaker development of saline deposits, more favorable topography and relative abundance of freshwater springs.[5]

However, the soils of the Ergeni and the Black Sea area should not be regarded as typical chernozems. Investigations which Mr Solomin and I performed, as well as the complex of physical conditions on this territory, found the area to be covered by the same soil type found in the other half of the Crimean Peninsula, the northern seaboard of the Black and Azov seas, and the southern portions of the Samara and Orenburg provinces.

I traveled across most of the Territory of the Black Sea Cossacks (about 300 versts across, from west to east), from Taman and to the Kavkazskaya [Caucasian] station of the Vladikavkaz railroad. The highway traverses the highest area along the right bank of the Kuban River — the water divide between this river and numerous minor rivers flowing northwest toward the Azov Sea and very often terminating as blind limans.*

From Taman to Slavyanskaya station (112 versts) the terrain rolls gently, its surface incised by a multitude of limans** surrounding the highway. The Kuban "plavni" are a rush jungle in some places (between Emanuil'skaya and Andreevskaya and 7 versts west of Temryuk), and their bottom is abundant in greenish-dirty patches of the Sivash type (pp. 301 — 302).[6] Some of the clear areas over which we traveled are formed almost exclusively of shelly sand (west of Temryuk); others (from Andreevskaya to Temryuk) had sandy-silty ground, while still others (environs of Sennaya station and thence to Taman) consisted of yellowish-gray marl. The vegetation is poor, stunted, and sparse. The soils are thin, 2 — 4 in [5 — 10 cm], reddish-brown, barely distinguishable from the ground, and often completely absent.

[1] Ibid., pp. 67—68, 119, etc.

[2] Levakovskii. Ibid., p. 4

[3] Barbot de Marni, Ibid., pp. 91—92 and 117.

[4] Danilevskii. Ibid., pp. 100—175, etc.

[5] Ibid., p. 128, etc.

* [Submerged estuaries. Translator.]

** [Steppe depressions moistened by snowmelt and rainwater and may even contain ephemeral lakes and pools. Translator.]

[6] I believe just such soils, formed among rushes on a silty bottom, to have been mistaken for chernozem by Strangweiss and Huot on the Taman Peninsula and at the mouth of the Kuban and the Terek... Voyage... de Demidoff, II, p. 560. Murchison, ibid., part 2, p. 548.

From Kopyl'skaya (Slavyanskaya), via Ekaterinodar toward the Kavkazskaya station (200 versts) the terrain is a dry, elevated,[1] level, extremely monotonous steppe. There are no gullies, even in areas directly adjoining the Kuban River, and the only variety is introduced by the man-made mounds. Judging from the sections revealed in a few wells, 3 — 4 sazhens [6.4 — 8.5 m] deep, which we encountered en route, the territory is composed of loose (Pontian ?) yellow argillaceous limestone, apparently forming a gradual transition to ordinary loam in the upper horizon: the loam is sandy in some places, and highly calcareous in others. Waters of springs along the way do not seem bitter-saline, according to information of the local inhabitants. On lands recently plowed, the steppe is covered by enormous thickets of tall weeds; on virgin and long-fallow lands the vegetation is fairly sparse and strongly admixed with stunted sagebrush; however, in depressions, maize and hemp grow to extreme heights.

Travelling in this territory in the middle of August 1875, I was amazed at the amount of dust blown about in the steppe in the western half of my route. In this lies the explanation for the grayish-white layer, sometimes 1 — 2 in [2.5 — 5 cm], thick covering the normally situated soils in the Kuban plain.

The color of this layer as well as the light-gray of the road dust provide indications of the nature of local soils. Indeed, the latter prove to be of the following appearance everywhere[2]: gray, more rarely dark-gray, so that the distinctions between horizons A, B, and C, are not pronounced; 1/2 — 2 ft [15 — 61 cm] thick; loamy composition, with average humus content 4.95%.

The following table lists the samples which I took, from east to west.

Locality	Composition	Site	Thickness	Humus,%	Hygroscopic water, %
Slavyanskaya or Kopyl'skaya, Kuban Region.	Loam	Steppe bearing tall vegetation, in a slight depression	1'6" [46 cm]	5.086	4.049
Kopanskaya, Kuban Region	–	Steppe bearing tall vegetation, level area	2'1" [64 cm]	5.707	4.464
Ekaterinodar	–	Low-lying steppe	2'8" [81 cm]	4.934	4.443
Redutskaya, Kuban Region	–	Elevated steppe bearing tall vegetation	1'11" [58 cm]	4.912	2.322
10 versts west of Ladovskaya station, Kuban Region	–	–	2' [61 cm]	4.629	4.391
Tiflisskaya, the Kuban Region	–	–	1'6" [46 cm]	5.116	3.284
6 versts west of the Kavkazskaya station, Kuban Region	–	–	1'11" [58 cm]	4.294	1.952

[1] Except for the nearest environs of Ekaterinodar, which lie in the "Kuban depression which is drenched in greenery."

[2] Completely reddish-brown soils, of the type occurring on the Taman Peninsula, still occur between the Slavyanskaya and Karakubanskaya stations, in the form of "islets".

Mr Solomin[1] reports generally identical soils from the Kavkazskaya station to Rostov. The sample he took at Kushchevka station, Kuban Region, immediately south of the River Eya was 1 ft 6 in [46 cm] thick and contained 5.441% organic substances.

Obviously, Chaslavskii's map should also be corrected accordingly.

Let us now turn to the piedmont of the North Caucasus. This piedmont for the most part consists of the Stavropol plateau, almost traversed by the Vladikavkaz railroad, the Sunzha plateau, just southeast of the middle and part of the lower reaches of the Terek River. Both plateaus are generally at least 2000 ft [610 m] high, and are essentially composed of Eocene formations.

Works as early as those of Storch, Dubois de Montpéreux, Abich etc. established the presence of chernozem soils on the northern slope of the Caucasus, at least up to 1680 — 2460 ft [512 — 740 m]. Barbot de Marni[2] and Prof. Lyaskovskii confirmed this in their most recent observations; according to the latter, the general case is that "the higher the elevation of a Caucasian plateau, the higher the content of organic substances in its chernozem."[3] Finally, Chaslavskii's map almost exclusively indicates ordinary and rich chernozems.

Although these facts are quite natural and understandable due to the composition and age of the local rocks on the one hand and the climatic features of the Caucasian plateau, on the other hand, my personal observations (1878) did not corroborate the statements of Lyaskovskii and Chaslavskii. Generally speaking, chernozem was indeed found better in quality than in the lowland previously described, but it was far from being rich and its occurrence was only sporadic.

Over the entire 400 versts between the Kavkazskaya station and Vladikavkaz, the railroad traverses very rolling terrain, approaching the Kuban and the tributaries of the Kuma River, meandering amidst fairly high hills, or running over comparatively level terrain. South of the Kuban River, approximately to Nevinnomysk, the subsoil appears very clayey, becoming marly up to the Mineral'nye Vody; toward Vladikavkaz the ground consists of strongly rolled pebble, covered in places by a thin layer of bluish-brown clay, such as near Vladikavkaz.

The flora is quite varied, despite the predominance of tall weeds.

Obviously, in the presence of such variability in topography, subsoil, and vegetation, the soils themselves cannot be identical. In some places they are dark gray, 1 — 2 ft [30 — 61 cm] thick (Nevinnomysk, Marsuki, Mineral'nye Vody, west of Zol'skaya, northeast of Darg-Kokh and northwest of Vladikavkaz) while in other places they are gray and do not exceed 1 — 1 1/2 ft [30 — 45 cm] in thickness.

I took the samples listed in the following table over the entire route.[4]

The same general properties are also found in the soils of the Sunzha plateau, which I traversed from Vladikavkaz to Grozny, and thence to

[1] His log states that the soils between the Kuban and Eya rivers are somewhat more sandy than those north of the Eya.

[2] Barbot de Marni. Ibid., p. 94.

[3] Zalomanov. — Trudy VEO, p. 277, March 1879. This fact has been stated by Strangweiss. [Murchison, ibid., p. 548.]

[4] As in the following two tables, soil composition in a majority of cases was not determined by analysis, but rather from the nature of the bedrock with the aid of a magnifying glass and acid. Author.

Umakhan-Yurt. The terrain between Vladikavkaz and Grozny is high, gently rolling and open; en route virtual "forests" of tall weeds and sometimes also feathergrass occur. However, the Vladikavkaz chernozem does not continue over a great distance, and is soon replaced by alternating light-gray and dark-gray soils, thin (thinner than 1 ft) and thick (up to 1.5 ft [45 cm]), completely displaced by bedrock in more strongly rolling areas; this bedrock is completely untouched by humus.

Locality	Composition	Site	Thickness	Humus, %	Hygroscopic water, %
Nevinnomysk, Terek (Terskaya) Region. . .	Loam	Tall-weed steppe	1'5" [43 cm]	7.436	4.546
Mineral'nye Vody, Terek Region	–	Level pasture amidst hills	1'3" [38 cm]	7.830	4.727
Prokhladnaya, Terek Region	–	Level pasture	11' [28 cm]	5.586	2.657
Vladikavkaz	–	Steppe, 1 or 2 versts from the mountains	2'1" [64 cm]	9.226	3.543

The road en route from Grozny to Umakhan-Yurt lies nearly throughout in a broad (reaching 3 and more versts across), level valley, gradually descending southeast, fairly sharply delimited right and left by mountain chains. Deciduous forests spread over large areas of mountain slopes as well as in the valley (northeast of Ustargordoi). Nevertheless, the soils generally retain their former variability. I encountered a small chernozem "islet" of the Vladikavkaz type at one place, approximately 4–5 versts north of Ustargordoi, and took a sample. I collected the following soils on the Sunzha plateau:

Locality	Composition	Site	Thickness	Humus, %	Hygroscopic water, %
Sleptsovskaya, Terek Region.	Light-textured loam	Level pasture	1' [30 cm]	4.777	2.348
8 versts northeast of Samashkinskaya, Terek Region	Loam	–	1'8" [50 cm]	4.768	4.406
4–5 versts northeast of Ustargordoi, Terek Region.	–	–	1'9" [53 cm]	7.061	2.168

My opinion of the information supplied by Lyaskovskii and Chaslavskii, cited above, is borne out by the extreme variability of the vegetal earth in the Caucasian piedmont, their average (about 6.5%) and even maximum humus content.

The soils are even more strongly and unfavorably affected by the topography of the Caucasian mountains.

In order to solve the problem of the occurrence of chernozem on the Central Caucasus,[1] I decided in 1878 to make an excursion in Dagestan, along the line Petrovsk–Temir-Khan-Shura–Khassav-Yurt.

[1] Inter alia, see Bogdanov [O chernozeme i ego prakticheskom i nauchnom znachenii (Chernozem and its Practical and Scientific Significance)]. – Trudy VEO, 1 (2): 158–159. 1877; Ruprecht, ibid., p. 129.

Petrovsk lies at the shore of the Caspian Sea, on the slopes of the first calcareous foothills of the Andi Mts. The sandy-solonchak Astrakhan Desert begins just north of the town.

For the first 5 — 7 versts along the road Petrovsk — Temir-Khan-Shura, the road followed the foot of the Andi Mts., which drop sheerly toward the neighboring steppe; the terrain is very reminiscent of an ancient sea coast. The excellent highway then crosses this range southward, rising high and descending into elongated lowlands and enclosed circular depressions until Temir-Khan-Shura. The mountains are very strongly incised by deep gorges, slope steeply and are composed mainly of different calcareous layers showing complex plication; no horizontal strata are visible.

Sometimes tall weeds, rarely sagebrush, are visible in depressions and on gentle slopes, but vegetation is generally sparse and poor at the beginning of August, and forms no sod; the mountain slopes are occupied by forests in places.

The soils were almost identical everywhere on mountaintops, on their slopes and in lowlands, with yellowish-gray subsoil; soils are 1 — 6 in [2.5 — 15 cm] thick.

Over the entire route from Petrovsk to Temir-Khan-Shura I saw only two or three insignificant clearings with maize in the mountains.

The same strongly incised, mountainous topography and the nearly total absence of vegetal earth continues from Temir-Khan-Shura to Gumala station and Chir-Yurt. A few versts before Chir-Yurt enormous strata of strongly rolled pebbles become visible on the slopes.

At Chir-Yurt the road crosses the famous Sulak River valley with its muddy waters roaring down the rocky course and destroying everything on their way; beyond this point the road crosses the boundary of the Terek Region. We then proceeded via Gerzel-aul to the Cossack "sloboda" Umakhan-Yurt (about 100 versts); we traveled over a very gentle slope between the Nogai steppes (north of the road) and the northern Andi foothills (south of the road), incised by gorges and covered in some places by luxuriant forest. In spite of the variety of the topography, apparently favorable for soils, they are still light-gray and very thin; they darken slightly only near the Gerzel-aul and Istisu stations, reaching 1 ft and more in thickness in some places.

Soil samples which I took in a small enclosed depression near Gumala station and at Gerzel-aul on a level steppe contain, respectively, 4.041% and 4.337% humus; however, the Gumala soil was undoubtedly deposited because the adjoining areas have no trace of vegetal earth.

My Dagestan excursion was augmented by a small walking trip from Vladikavkaz to Balta station along the Military Georgian Highway. However, the terrain en route to Balta and in its nearest environs is identical to that in Dagestan and the southernmost part of the Crimea — an endless maze of mountain chains, rocks and gorges. The mountain slopes often exceed 45° and are covered by primordial forest in some places. The mountain streams have a remarkably swift current; the slopes lack soils. Dark-gray masses consisting of a mechanical mixture of stone, arboreal and herbaceous residues and fine dust or silt are visible in enclosed depressions.[1]

Thus, normally situated soils cannot occur in the mountainous parts of the Crimea or in Central Caucasus, despite the comparatively great age

[1] Only one sample was analyzed for all the Caucasian soils (Reichardt, ibid.), and its origin is unknown.

of the bedrock and the precipitation which should be quite sufficient for nourishment of vegetation.

I suggested an explanation for this phenomenon as early as 1878. In the general discussion on the effects of topography on nature of soil, I remarked as follows: "Upon seeing the chaotic arrangement of strata in the Crimea, Dagestan, and Central Caucasus, the steep mountains and the deep gorges with rivers rushing swiftly down them, I cannot help wondering about the place and conditions of origin of soils in this territory. Were the surface to remain as such for as long as it has already existed, were the amount of humus formed in central chernozem Russia increased ten and hundred-fold, neither we nor the future generation would yet witness even traces of chernozem."[1] The destruction of local soils is probably strongly augmented by the nature of local rains. Local reports are of very frequent "terrible downpours which wash entire rocks and gigantic old trees off the mountains" in the environs of Vladikavkaz and in the Temir-Khan-Shura area. Obviously, the light-textured vegetal layer never persists for long on a sloping area.

In conclusion of this brief review of Crimean and Caucasian soils, the following phenomena, which are extremely significant in these territories, are noteworthy: formation of subaerial chernozem and effect of steppe fires on local soils. Numerous Russian scientists, among them Borisyak,[2] Veselovskii,[3] Sovetov,[4] Zalomanov,[5] and Middendorf,[6] treated the influence of winds on Russian chernozem. The opinions on this subject may be summarized as follows. Dry, loose, comparatively very light-textured chernozem soils, comminuted thanks to cultivation on the fields and travelers on the roads, are raised by the wind and transported over the neighboring territories, filling up depressions in steppes (Borisyak), stripping chernozem fields of their best soils (Veselovskii), and depositing chernozem (Zalomanov). If the facts mentioned above (p. 308 ff.) are taken into account, Russian chernozem might be regarded as largely originating by subaerial processes. Such a conclusion, however, would be fallacious for the following reasons: a) even the richest chernozem is found in situ; b) roads and plowlands are comparatively very recent in the history of chernozem; c) deposited subaerial soils are exclusive to areas devoid of sod, with patches of bare bedrock visible through the sparse vegetation. Furthermore, I believe Richthofen's theory to be applicable and Chinese loess to be possible only in very hilly countries, with almost no sod and an extremely continental climate.

Steppe fires are mentioned by Prof. Eversmann in his description of the Orenburg steppes: "During the spring the dry grass and stalks left over from autumn cover the fertile steppes so densely as to prevent the growth of young grass and interfere with grazing... Therefore, nomadic tribes as well as farmers set fires in early spring or late autumn; the dry grass is highly inflammable and the flames spread with the wind as long as there is fuel; the burning strips may illuminate flat steppes up to the horizon."[7]

[1] Dokuchaev. Predvaritel'nyi otchet po poezdke 1878 g. (Preliminary Report on the 1878 Excursion), p. 10.
[2] Borisyak. Ibid., p. 36.
[3] Veselovskii. O klimate Rossii (Russian Climate). [St. Petersburg. 1857].
[4] Sovetov. — Trudy VEO, 2 (3):6. 1877.
[5] Zalomanov. Ibid., p. 286.
[6] Middendorf. Ocherki Ferganskoi doliny (Descriptions of the Fergana Valley). p. 90. [St. Petersburg]. 1882.
[7] Eversmann. Ibid., pp. 14–15.

Such steppe fires are also very common in the steppe part of the Caucasus.[1] They are obviously not limited to the subaerial parts of plants and annual increment of humus, but also affect the underground portions of plants and the accumulated humus reserve. Repeated fires of this type are detrimental to the formation of chernozem.

The essential points of the geography of Russian chernozem may be formulated as follows.[2]

1. Classifying all the vegetal-terrestrial soils with over 2% organic substances as chernozem, the chernozem zone is, northwest to southeast, of the following widths:[3]

Between Berdichev and Nikolaev . . .	350 versts
Sosnitsa and Berdyansk	550 versts
Between Tarusa and Konstantinovskaya "stanitsa" on the Don	700 versts
Vasil'sursk and Aleksandrov-Gai, Novouzensk District	600 versts
Western slopes of the Urals	700 versts

Thus, the chernozem zone gradually increases in width from west to east.[4]

2. Nevertheless, the chernozem zone adheres to its southwest-northeast direction over its entire 3000-verst extent in European Russia. This is true with respect to the entire zone (as was known long ago although not substantiated by analyses), as well as to its separate humus belts.

3. Generally speaking, the content of organic substances in Russian chernozems increases from southwest to northeast.

Upon examination of humus distribution, on the basis of samples with maximum content, NW—SE along the chernozem zone, the following is perceived.

[1] This practice must have been widespread in central Russia in the old times. Sovetov. O sistemakh zemledeliya (Agricultural Systems). pp. 12–15 etc. 1877; Bogdanov. Ibid., p. 221.

[2] I first pointed out the general character of the geographical distribution of Russian chernozem and its regularity in 1881, when I had obtained only 103 determinations of humus in my samples . . . "Khod i glavneishie rezul'taty predprinyatogo VEO issledovaniya russkogo chernozema" (Progress and Principal Results of the Investigation of Russian Chernozem Undertaken by the Free Economic Society) pp. 25–29. By the end of that year, there were 207 available analyses, and "as expected, the essential points which I set forth previously were confirmed rather than requiring change." "Skhematicheskaya pochvennaya karta chernozemnoi polosy Evropeiskoi Rossii" (Schematic Soil Map of the Chernozem Zone of European Russia), 1882. This statement may be reiterated even more strongly on the basis of 286 humus determinations. These data, listed at the end of the book, form the principal support for the present statements. Author.

[3] The relative relationships will remain basically unchanged if soils with at least 4% humus are recognized as chernozems. Author.

[4] As already referred to on p. 130, this phenomenon is mainly based on the present (only partially on the former) physiography of European Russia. The north-south extension of the Trans-Dnieper chernozem is interrupted by the vast Pinsk (Pina) bogs in the north and by the Black and Azov seas in the south. Similarly, this soil, on the left [eastern] bank of the Volga, is bounded in the south by climatic conditions as well as by solonetses and saline lakes, remnants of the Aral-Caspian Sea. On the other hand, a stretch of ancient dry land lies between Tarusa and Konstantinovskaya "stanitsa" as well as on the western slopes of the Urals, and the chernozem zone is therefore widest at this point. Author.

4. Halfway between Central and Trans-Volga Russia the maximum humus contents are 13 — 16%. This belt includes considerable portions of the Saratov, Penza, Simbirsk, Orenburg, Ufa, and especially Samara provinces.[1]

5. This central belt with its maximum humus content is surrounded in the north, south, and west by a fairly wide chernozem belt containing 10 — 13% organic substances. Such chernozem was encountered, in addition to the abovementioned province, in the northern part of the Saratov Province, the southern part of the Kazan Province, the southeastern part of the Nizhni Novgorod Province, the eastern part of the Voronezh Province, and the southern part of the Tambov Province.

6. Just beyond this semicircle stretches a wide chernozem belt with a 7 — 10% humus content. This belt completely surrounds the soils of types 4 and 5 and runs througth the southern part of the Nizhni Novgorod, Ryazan, Tula, Samara, Voronezh, Tambov, and Saratov provinces, in the eastern parts of the Orel, Kursk, and Khar'kov provinces, in the western part of the Voronezh Province and in the northern part of the Simbirsk and Penza provinces, and the Don Cossack Territory. This chernozem occurs in the form of small "islets" in southwestern Russia (in some parts of the Orgeev, Anan'ev, Balta, and possibly also Ol'gopol [districts])[2] and also on the Stavropol and Sunzha plateaus of the Caucasus.

7. This chernozem is surrounded by soils with a 4 — 7% humus content. These soils occupy 3/4 — 2/3 of the Trans-Dnieper territory — almost the entire seaboard of the Azov Sea, the southern part of the Don Cossack Territory, the Poltava Province, parts of the Chernigov, Khar'kov, Kursk, Orel, Tula, Ryazan, Niznni Novgorod, Kazan and Samara provinces as well as the Kuban Region and a small part of the Crimea. Soils with the same humus content also cover the majority of the sandy-loamy Tertiary "islands" in the Volga area.

It is clear from the table that this belt is extremely regular in characteristics.

8. Soils with 2 — 4% humus content stretch over a smaller area, around type 7 of chernozem and are also found in narrow strips along low river banks. Such soils form the most characteristic transition belt of gray soils between rather typical chernozem on the one hand and northern sod soils and southern solonchak soils on the other.

9. The northern sod soils and the southern solonchak soils contain 0.5 — 2.5% humus. This, at any rate, is the maximum content of organic substances in all my samples from the Vyatka, Nizhni Novgorod, Vladimir, Smolensk, Kaluga, Chernigov, Kursk, and Kiev provinces as well as the southern part of the Samara Province and the northern part of the Arkhangel'sk Province.

10. Obviously, all these chernozem belts are connected by an endless series of gradual transitions.

This is the distribution of the normal vegetal-terrestrial soils of chernozem Russia as is shown in our schematic map of the chernozem zone.

[1] Soils with humus contents exceeding 13% are also found in the southeastern part of the Nizhni Novgorod Province, but their existence is a result of exceptional causes, as seen above (p. 78). I do not regard the existence of a single sample of Simbirsk chernozem as sufficient to indicate a higher humus content (up to 19%) for the entire belt. Author.

[2] As stated in the detailed description, the very existence and hence the boundaries of this "island" have not been definitely established.

The different types of chernozem should not be assumed to form a continuous cover in these belts. It is in fact stated in the literature and in works of the present author that the chernozem zone is interrupted by forest areas, bogs, hilly areas, river valleys, sands and solonetses.

Sands and solonetses have already been described in great detail; the other four variations in the terrain will be discussed below. Let us now turn to the origin of chernozem, since this is the principal factor determining the present distribution of this soil.

Chapter VIII

ORIGIN OF VEGETAL-TERRESTRIAL SOILS IN GENERAL, RUSSIAN CHERNOZEM IN PARTICULAR

It has been stated repeatedly[1] that the most characteristic feature of the investigations on the origin of Russian chernozem is the lack of proportion between the relatively small amount of factual material obtained scientifically and the numerous hypotheses attempting to solve the problem of the origin of chernozem. Papers limited to the facts of the problem are in fact extremely rare in the literature dealing with chernozem. Hypotheses were advanced by, among others, Güldenstädt (1787), Pallas (1799), Hermann (1836 — 1837), Eversmann (1840), Huot (1842), Murchison (1842 and 1845), V. M. Chernyaev (1845), Eichwald (1850), Petzholdt (1851), Borisyak (1852), Petzholdt's unknown critic (taking the initials A. P., 1852 — 1853), Wangenheim von Qualen (1853), Pacht (1856), Ludwig (1862), G. Romanovskii (1863), Ruprecht (1866), M. Bogdanov (1871), and Karpinskii (1873). This "hypothetical" attitude toward the subject flourishes to the present, as evident from the work of Orth (1877), Shtukenberg (1877), Schmidt of Dorpt (1879 — 1881), and Agapitov (1881).

Although the majority of the hypotheses mentioned above are rather widely known and have been criticized repeatedly, I regard it as useful, in view of the mass of new material, the absence of a complete, systematic review of the pertinent literature, and, most important, in view of the modern formulation of the problem, to start with a critical survey of the principal views mentioned above.

The hypotheses on the origin of Russian chernozem may be divided into the following three main groups: a) aquatic origin, b) marsh origin, and c) vegetal-terrestrial origin.

The renowned scientist Pallas is regarded as having originated the theory of the marine origin of Russian chernozem. As early as 1799, in his description of the Stavropol steppes (between Stavropol, Dolga, Pregrada, Medvezhe-Kurgansk, Verkhneegorlytskaya and Peschanokolodeznaya "stanitsa"), Pallas remarked that they overlay a peculiar "silty earth; when exposed to the air, this earth liberates salt which imparts salinity to local waters everywhere. This substrate (silty, salty earth), which is apparently fertile and covered by lush grass, appears to be true marine mud. However, this plain lies above the Manych lowland and is not as bare as the Caspian steppe which was once covered by the sea; on the contrary, it bears a thick layer of rich black earth and is overgrown with grass throughout. This difference may only be explained by assuming the plain to have either been a wide reed marsh, extending at that time along the ancient sea coast, near the mouth of the Kuban River or a lowland at times

[1] Inter alia, see Mr Levakovskii, ibid.

inundated by the sea (similar to the present-day lowland lying along the shores of the Caspian Sea). Saline mud was deposited by the sea and became surficial when the sea retreated, forming a thick layer of black earth upon the decay of the vegetative mass. Indeed, this black earth more strongly resembles soil of marine mud origin than of forest humus origin; neither are there any traces indicating the existence of forests on this territory at any time."[1]

Judging from the general spirit of the quotation, and from the fact that in 1787 Pallas assumed quite a different origin for the chernozem of Ryazan and Tambov (as seen below), I believe Pallas to have limited his hypothesis to the Stavropol and similar steppes.

The next proponent of Pallas' idea was the no less renowned explorer of Russia, Murchison. He wrote, "It is very natural to assume that when the northern boulders ceased moving south, the bottom of the (glacial) sea, now freed from the influence of destructive forces, must have been covered by fine mud similar to that common in water isolated from the effects of rapid currents."[2]

Murchison continued, "If chernozem is of marine origin, it may quite probably have been formed by erosion of the black Jurassic bedded clay which is uniform in color in northern and central Russia. It is clear from a geological map that this clay was formerly much more widespread; as the top layer, it was affected by strong water currents transporting fragments from north to south. Slaked Jurassic clay may thus have been transported far beyond the southern boundary of northern boulders' transport.

"There is another reason for suggesting that the Jurassic bedded clay supplied at least part of the material for chernozem formation: the absence of chernozem south of territories where this clay cannot be assumed to have been situated. Jurassic bedded clay is not now and has never been abundant north of Moscow, but it abounds in the close vicinity of this city, and therefore this strange black substance first appears across the heights to the south of this latitude.

"Although the proffered explanation of the principal source of chernozem in European Russia is accepted, difficulties arise regarding its large accumulations in southern Siberia, where probably no northern current, transporting fragments, has ever flowed. Assuming Siberian chernozem, as well, to be of marine origin, the question arises as to whether the materials composing it may not have been transported north from the southern tip of the Ural range. Otherwise, judging from the absence of large fragments throughout the territory, the major part of the Siberian lowland may be assumed to have been covered by extensive lakes with mud at their bottom."[3]

"The absence of marine shells in this fertile Russian sediment (chernozem) is an indication which must be properly explained, otherwise our surmise will not be accepted easily. However, it must be borne in mind that after the center of the Empire emerged above the shallow waters which had

[1] Pallas [P]. Bemerkungen auf einer Reise in die sudl. Statthalterschaften des Russ. Reiches. (Leipzig) B. I, 1799, S. 442.

[2] Murchison. Ibid., part 2, p. 550.

[3] Ibid., pp. 551–552. Murchison ascribed a similar marine origin to the Indian regur, famous for its fertility. Ibid.

inundated it, the area may have remained as a transitional oozy 'mochevina' or bog with stagnant water. The residues of delicate mollusks and algae may have thus been completely destroyed by alternate effects of water and air. Thus, on the basis of uniform constitution of chernozem over such vast territories and the lack of connection between it and present-day distribution of water (as well as relief, p. 541), we deny all theories ascribing the origin of chernozem exclusively to continental, continuing causes. We attribute chernozem to subaquatic sedimentation, with a series of alterations of the surface during its transition to dry land, long before the advent of man... We do not insist that the sea covered the territories now occupied by chernozem[1] or that chernozem could not have formed but from the black Jurassic bedded clay, but we do insist, on the basis of its constitution and distribution, that chernozem must have been deposited under water... When the Russian territories now occupied by chernozem were uplifted, the stagnant waters which contained chernozem in the slaked state became putrescent. Chernozem acquired its nitrogenous substances in this process and, to a certain extent, its characteristic color, as a result of the decomposition of aquatic plants and microscopic animals whose traces may possibly be discovered."[2]

Petzholdt (1851) also regards Russian chernozem as being of marine origin,[3] and of "Recent formation; chernozem originated from sea mud left by the retreating waters of the Black and Caspian seas. The mineral substances for the formation of this mud were supplied by the sandstones of the Tertiary and the Cretaceous formations, forming the sea floor at that time, and were more or less eroded by the water. Humus was formed by the largely animal organisms inhabiting the sea waters."

In support of his view, Petzholdt first points to the "extensive uniform distribution of chernozem on the surface of the territories where the rivers now flow to the seas mentioned above." Further mineralogical investigation of chernozem reveals fragments of various sandstones and sand grains, probably results of the destruction of these rocks. Thirdly, "Some of the quartz fragments, upon examination by magnifier, revealed fossilized foraminifers; in certain places they were even filled with remains of these animals." Fourthly, "Finally, the predominant formation of humus in Russian chernozem from decomposed animal organisms is also indicated by its high nitrogen content as well as the absence of plant structure in these organic residues."

Academician Eichwald may be justly regarded as the exponent of the hypothesis of Russian chernozem formation from peat. Having examined current hypotheses and found them wanting, Academician Eichwald remarked,[4] "Consequently, the only possible alternative is the most recent origin of chernozem from bogs and tundras inhabited by microscopic diatoms or siliceous zoophytes... overgrown by low coniferous shrubs, sedges, grasses, rushes, thistles and other paludine plants. The gradual emergence of the great chernozem tract in south Russia above sea level was accompanied by gradual drying of the marshes and slow, utter decay of plant residues.

[1] Although in Murchison's opinion (ibid., p. 542) this is indicated by the northern boulders which are found on the surface of chernozem near Voronezh.

[2] Ibid., pp. 533-536.

[3] Bullet. scientif. de l'Acad. des sc. de St. Petersb., t. IX, 1851, p. 7?.

[4] Eichwald, E. Paleontologiya Rossii. Opisanie mollasovoi i namyvnoi formatsii Rossii (Russian Paleontology. Description of the Molasse and the Alluvial Formations in Russia). ?, 2?7 [St. Petersburg], 1850.

All plants lacking thick trunks left no residues, especially since the warm climate of the time must have increased the destructive effect of the atmosphere and the marsh water had no silicifying effect. The tree trunks therefore were not impregnated with silica and thus were not preserved, as opposed to the case in the earthy strata of other rock formations. The trunks probably decayed after having lain in water over a prolonged period. It is more likely, however, that the marshes were overgrown by shrubs, which would be destroyed even more rapidly by air and water."

Eichwald also added[1] that the water of these marshes percolates into the subsoil in the course of time, "leaving behind the silty layer of chernozem, which gradually thickens, containing only the siliceous zoophytic species... had any freshwater mollusks and insects inhabited these marshes, they must have gradually disappeared leaving no traces due to the swift decay; however, the mollusks and water insects gave rise to the nitrogenous constituent particles of chernozem."[2]

In Eichwald's opinion, all these processes occured during historical time

Eichwald supports his marsh hypothesis as follows:

1. As early as Herodotus' time, southern Russia was a mass of "impassable marshes, vast freshwater lakes and forests occupying the territory now covered by barren steppe, or by chernozem, which undoubtedly originated by the disappearance of these freshwater lakes and the surrounding forests."[3]

2. "In certain parts (?) of southern Russia, chernozem resembles peat, and it is obviously derived from the latter in the Grodno and Minsk provinces."[4]

3. The very occurrence of chernozem far from the sea shores provides an explanation for its true (paludine) origin: "The farther away from them the more fertile it is. Throughout the territory from Saratov and Tsaritsyn and down to Astrakhan along the northern shore of the Caspian Sea, no chernozem is visible."[5] Generally, "chernozem is the best developed, thickest and most fertile wherever it occurs between two rivers (?), in lowlands, where it is usually underlain by clayey or marly strata hardly permeable to water."[6]

4. Finally, the marsh origin of chernozem is proved by microscopic investigation. In addition to the siliceous zoophytes, so-called diatoms which are common inhabitants of all marshy areas, it contains various phytolitharia which are the minute separate plant residues, the principal durable constituents of paludine plants in general and the peat vegetation of southern Russia in particular (?).[7] Eichwald supports this by reference to the microscopic analysis made by Ehrenberg on a chernozem sample

[1] Ibid., p. 247.

[2] However, such transformation of paludine and forest formations to chernozem are admitted by the author only under the condition that "the bed of these formations consists of clay." In contrast, the forested and (formerly) marshy southern part of Russia was converted to barren steppe wherever its subsoil was sandy, since water percolated downward from the surface through the loose sands, and exerted no further influence on the fertility of the surface layers; such a steppe was described by Strabo as the Gett'an desert between the Danube and the Dniester." Ibid., p. 244.

[3] Ibid., pp. 239–241.

[4] Ibid., p. 249.

[5] Ibid., p. 238.

[6] Ibid.

[7] Ibid., p. 240.

sent to him by Eichwald.[1] The sample contained eight species of Polygastrica and 21 species of phytolitharia [?!]; as is known, this analysis led Ehrenberg to regard Russian chernozem as a forest soil.

Prof. Borisyak's view of the origin of Russian chernozem presented in his paper "On Chernozem" (O chernozeme) (1852) is essentially the same as Eichwald's theory.

On the basic premise that of all present-day formations steppe chernozem most closely resembles in appearance the black mud deposited in bogs and lakes, Prof. Borisyak concludes that Russian chernozem originated in fresh-water bogs and lakes. He writes, "This hypothesis is the more likely since in the past, when the present chernozem steppes were richer in water and vegetation, thanks to the warm, humid climate, formation and accumulation of black mud was more common than today."[2] However, Prof. Borisyak remarks that contemporary chernozem "can be likened neither to (bog) peat nor to humus" which is the product of the vegetation decay on dry land.[3] "The silty (black ?) loam formed after the complete drying of lakes and bogs was loosened and gradually altered by the climatic changes and the new terrestrial vegetation and could become true chernozem, similar to the silty soils produced by the drying of lakes which are converted spontaneously to fertile soils."[4]

In addition to Eichwald's arguments in favor of the paludine hypothesis, Prof. Borisyak added the following arguments.

"Anyone who has made careful observations of chernozem over large territories involuntarily arrives at the conclusion that the uniform mixing of chernozem particles and their separation from coarse pebbles could only be performed by water.[5] However, after observing the distribution of chernozem (its intermittent character ?), it becomes clear that it was not formed in a single water basin with distinct margins, but rather in many small basins; its variable thickness and composition also indicate that it was not formed as a purely aquatic sediment but as a silty substance left by dried lakes and bogs. Chernozem is thicker at the center of the territory where the bogs were obviously more numerous."[6]

Prof. Borisyak, substantiating his hypothesis, followed Academician Eichwald in trying to prove that the chernozem territory was formerly far more abundant in lakes, bogs, and forests than today. According to Borisyak, many of them have by now been replaced by very typical chernozem steppes.

In 1853, Wangenheim von Qualen approached the paludine hypothesis from a completely different standpoint.[7] During journeys in southeastern chernozem Russia, he found that bog and steppe humus do not form quickly or in large quantities, while forest bogs and bog soils in northern Russia are very widespread and quite thick.[8] He believed these formations being a "mixture of bog humus with sand, silt, and other earthy particles," to be

[1] Unfortunately, Eichwald did not specify the locality where this sample was taken.

[2] Borisyak. O chernozeme (On Chernozem), pp. 51-52. 1852.

[3] Ibid., pp. 53, 62-63.

[4] Ibid. p. 64.

[5] Ibid., p. 48.

[6] Ibid., p. 66.

[7] Wangenheim von Qualen. Ibid.

[8] Ibid., S. 63-64.

very similar in appearance to steppe chernozem.[1] Finally, having encountered small bog-soil areas (10 – 20 dessiatines) in the Belebei District amidst continuous typical chernozem and regarding this phenomenon, which is fairly widespread in the Urals area,[2] as incompatible with the current hypothesis, Wangenheim von Qualen arrived at his conclusion: "If an erratic flow on a global scale had entrained the enormous masses of silt, ooze, peat, and other decaying vegetal substances in the course of its flow from north to south, comminuted them as finely as possible and mixed them with the mineral particles of the flow itself and transported the entire mixture to the south, it would certainly be converted to true chernozem, deposited on the surface as the lightest component of the mixture. We should then have no need to refer to the black Jurassic clay or to the shale."[3] The views of Eichwald and Borisyak were consistently followed by Rudolf Ludwig (1862).

According to Ludwig, "If peat deposits stop developing as a result of deforestation and the ensuing desiccation of the subsoil, they become dry and loose, eventually destroyed by the atmosphere. Thus, peat yields a humus-rich soil which becomes very fertile in the course of time, thus enabling cultivation. Such soil varieties, rich in humus, are found throughout Germany, and are especially widespread near the Danube. Soon after the peat bog is dried, the soil is naturally very acid and therefore unsuitable for cultivation of corn crops. After a more or less prolonged period, when the vegetal substance of this soil is further destroyed, it becomes capable of supporting plants for a prolonged time. Such humus-rich soils occur in Russia wherever the high moors were dried by the cutting down of forest; these soils are known as chernozem."[4]

We regard the most recent defender of the hypothesis of the purely paludine-freshwater formation of Russian chernozem to be Prof. G. D. Romanovskii. He observed the following characteristic section in the chernozem zone on the banks of the Vonyavka River near the village of Kamerka, Epifan District, Tula Province.[5]

1. "Chernozem with two intercalations of sticky yellow clay (utterly different from alluvial clay).

2. "Chernozem layer about 1 arshin [71 cm] thick, containing shells of freshwater and terrestrial mollusks.

3. "Yellow and white micaceous Carboniferous sands with intercalations of separate blocks of buhrstone, with leaves and trunks of *Stigmaria ficoides*."

After washing samples from the second layer, Mr Romanovskii obtained a large amount of black residue consisting of small unslakable black particles, a few irregular siliceous and calcareous fragments, and numerous fragments of thin, small white shells resembling *Limnaeus*, *Helix*, and *Paludina* and, well-preserved shells, 1 – 2 1/2 "liniyas" [2.5 – 7 mm] in size, of freshwater mollusks of the order Pulmonata such as *Helix*

[1] Ibid., S. 64.

[2] Ibid., S. 61 – 62.

[3] Ibid., S. 64 – 65.

[4] R. Ludwig. Geogenische und geognostische Studien auf einer Reise durch Russland und den Ural. 1862. S. 109.

[5] Romanovskii. Neskol'ko slov o russkom chernozeme (A Few Remarks on Russian Chernozem). – Gornyi Zhurnal, 1 (3): 484. 1863.

marginata) and *Pupa* (*bidentata* and *striata*). Microscopic examination of the residue revealed isolated plant stalks and siliceous phytolitharia in the form of thin serrated tubules, sometimes light blue or pale pink, and also striated rhombic bodies.

According to Prof. Romanovskii, "this initial discovery of terrestrial and freshwater mollusks in central Russian chernozem is direct proof that chernozem is formed from mossy and paludine plants, since these genera are characteristically found in wet places and stagnant freshwaters. The alternation of upper chernozem with clay proves that the decayed plant residues are sometimes covered with earth deposited by springtime floods, the broad shallow streams flowing across the marshy lowlands in spring and flash floods, all mixing the delicate plant residues as well as the plants themselves with particles of clay and sand."

Mr Romanovskii concluded, "Since the humus organic substance of chernozem is very finely distributed throughout its bulk, it appears that the marshes mainly contained plants such as marsh horsetails, thistles, water-lilies, sedges, rushes, mosses, etc."[1]

V. M. Chernyaev holds an opinion intermediate between the theory of purely aquatic and paludine origin of chernozem and that of its exclusively terrestrial-vegetal formation. Chernyaev first differentiated four layers in Russian chernozem: "a) the uppermost, most recent layer, product of recent decomposition of organisms; b) the second, deeper layer, sometimes reaching 10–12 ft [3–3.6 m] of depth is more ancient, possibly contemporary with the last catastrophe (?); these layers all turn black when wet and are then difficult to distinguish from each other; c) a layer, mixed in character, consists partly of layer b and partly of the subsoil, commonly clay or sand; d) a layer consisting of innumerable holes and tunnels (called krotovinas by the peasants), filled either with the humus or with the mixed layer."[2] Chernyaev also considers it more probable that fresh water and air influenced the formation of Russian chernozem. Layers (c) and (d) obviously reflect the effect of waters, but layer (b) necessitates admission of the effect of air in addition to that of water.[3]

The principal arguments in favor of a) marine and b) paludine-lacustrine origin of Russian chernozem may be summarized as follows.

a) Arguments in favor of the marine origin of chernozem:

1. The constitution of chernozem does not vary throughout the immense expanse of European Russia (Strangweiss and Murchison).

2. Chernozem occurs in European Russia mainly within the northern boundary of the black Jurassic clays.

3. In one instance, cited by Murchison, a northern boulder was observed on the surface of chernozem, and in another instance, cited by Petzholdt, fragments of sandstone and foraminifers were found embedded in the chernozem.

b) Arguments in favor of the paludine-lacustrine origin of chernozem:

4. Of all the present-day formations, the "black mud of bogs and clays" is most similar to steppe chernozem in appearance; in the Grodno and Minsk provinces chernozem obviously derives from peat (Eichwald).

[1] Romanovskii. Ibid., p. 485.

[2] Czerniaev. Nouveaux cryptogames de l'Ukraine; p. 137–138. Bull. de la Société des Natur. de Moscou. 18[illegible], T. XVIII, No. 3.

[3] Ibid., p. 137.

5. Chernozem is completely free of any coarse components (pebbles); similar to paludine mud, it is composed of completely uniform, consistently fine particles.

6. Chernozem only occurs on grounds of low water permeability (Eichwald).

7. Chernozem samples from two localities (?) were found to contain a) several species of diatoms (Eichwald), b) various phytolitharia, and c) several species of freshewater shells and shell detritus (Romanovskii).

8. Lakes and marshes were formerly much more widespread in the steppe regions.

At the current state of factual information regarding Russian chernozem, the statements merit no further discussion. Some (1, 2, 4, and 6) are factually erroneous, others (3 and 5) are more logical if viewed according to the "vegetal-terrestrial" origin of chernozem, and the remaining statements (7 and 8) are fallacious. Indeed, Prof. Romanovskii's find of freshwater shells is obviously related to slumped chernozem rather than to normal steppe chernozem,[1] as is made clear by the interbedding of this chernozem with purely aquatic formations. The diatoms which Eichwald observed in a chernozem are well known to be distributed globally, being found at the Equator and on Polar ice, at the sea bottom and on snow peaks, on the surface and in deeper strata. Certain amounts of diatoms are included in neptunian and volcanic rocks in all formations, and in all the Recent formations, terrestrial, paludine, crenitic, fluvial, and marine, due to the dust carried by the trade winds in atmospheric precipitation.[2] Consequently, the presence of diatoms provides no clue to the origin of the rock.

Although it is quite probable that marshes and lakes were once more widespread in the south of Russia than they are today, the fact is irrelevant to the origin of chernozem, for the following reasons: a) northwestern Russia, as northern and central Russia, was always richer in marshes and lakes than southern Russia, but no chernozem was formed; b) it has not been proved that the former bogs and lakes in south Russia occupied those areas where chernozem is found today rather than on sandy soils. Such proof is even more necessary since the facts reported by Bogdanov (p.218), Gel'mersen (p.183), Domger (p.223) as well as the section which I mention on p. 94 clearly indicate that wherever chernozem overlies a bog it is sharply differentiated from peat and is of deposited origin; c) finally, although we have often found sea shoals (pp. 302 – 303, ff.) and marshy areas (Nezhin), to merge imperceptibly with the neighboring soils and in places become covered by or even converted to chernozem in the course of time (which is quite possible and natural),[3] it must be borne in mind that in chernozem formation the part played by bogs (marshes) and marine sediments is but preparatory and intermediate, and is far from being decisive. The sea

[1] Information somewhat similar to Prof. Romanovskii's data was supplied by Mr Rogovich. "In the sheer sides of a well in the vicinity of Kiev, Mr Rogovich found two beds of freshwater shells of Unio and Anodonta at 200 ft [61 cm] under chernozem 1 arshin thick and over diluvial yellow clay "(Proceedings of the Third Congress of Russian Naturalists in Kiev, 1871, p. 3). Rogovich himself, however, admitted that this place may have been covered by a river or a lake.

[2] Krylov [A.]. Podzol Mogilevskoi gubernii, proiskhozhdenie ego i rastitel'nykh biolitov (Podzol of the Mogilev Province, Its Origin and that of Plant Bioliths). pp. 91 – 92. [Zapiski S.-Peterburgskogo mineralogicheskogo obshchestva, part 8, St. Petersburg, 1873.]

[3] Dokuchaev. Po voprosu o Sibirskom chernozeme (Siberian Chernozem). – [Trudy VEO, 2(3): 17–29, St. Petersburg, separate reprint]. 1882.

bottom may remain saline and the bog acid, both unchanged, lacking favorable conditions of climate, vegetation, etc.

Thus, not a single argument of this hypothesis will withstand criticism. It will in fact be made clear below that the hypothesis is contrary to all the basic features of Russian chernozem.

The view held by the honorable Prof. K. Schmidt of Derpt is unique. Obviously, soils (German "Boden") when interpreted by Fallou, Benningsen-Förder and Meyer, are unrecognizable as independent bodies (in the natural-historic sense); Schmidt confuses them with the loose post-Tertiary formations underlying soils in the vast majority of cases in Russia and in Europe, and forming a gradual transition to actual soils. Obviously, in this case any solution of the problem of the origin of loose deposits would serve the same purpose[1] for the formation of overlying soils. Indeed, this is Prof. K. Schmidt's approach to the Russian chernozem; the essence of his hypotheses follows. Prof. Schmidt first accepts as proven fact that the Finnish granite elevation is much richer in potassium and poorer in sodium than the Irsha-Dnieper granite[2], on the basis of the following data resulting from analyses performed by Struve, Lemberg, and by himself.[3]

	Contained by 100 parts of granite		Orthoclase from granite of the Irsha River	Orthoclase from Peterlaks granite. Contents per 100 parts Al_2O_3		Amount of Na_2O per 100 parts of K_2O				
	Finland, Peterlaks	Dnieper granite on the Irsha River, 106 versts northwest of Kiev	contents per 100 parts Al_2O_3	a) from dense granite	b) from oligoclase (?) envelope	orthoclase from granite of the Irsha River	orthoclase from Peterlaks granite: a) from dense granite	orthoclase from Peterlaks granite: b) from oligoclase (?) granite	In the total mass of the Irsha granite	In the total mass of the Peterlaks granite
K_2O	6.25%	5.58	54.88	53.99	71.66	100	100	100	100	100
Na_2O	2.56%	3.86	22.94	16.34	16.18	41.8	30.3	22.6	69.2	41.1

Furthermore, Schmidt's analysis (1879) of the "clays and silty residues" (substances insoluble in hot 10% HCl) from 26 samples of soil and of subsoil of chernozem Russia convinced him that the character and ratios of the elements in the residue, presented in the above tables were far closer to the Isha than to the Peterlaks granite. Hence his conclusion that the "Products of the comminution and weathering of the upper layer of the Dnieper granite elevation form the chernozem and its subsoil in southern Russia."[4] Prof. Schmidt also supports this extremely important conclusion by the following arguments:

1. The formations which he regards as being derived from the weathering of Finnish granite (e.g., Devonian clay in the environs of Derpt and 11 samples of Lower Silurian clay from the northern coast of Estonia) are

[1] K. Schmidt.—[In book:] Fiziko-khimicheskie issledovaniya pochvy i podpochvy chernozemnoi polosy Evropeiskoi Rossii, No. 1, pp. 7, 31–32, etc. 1879.

[2] Ibid., p. 32.

[3] Ibid., pp. 31–33; ibid., No. 2, pp. 42–43. 1881.

[4] Ibid., No. 1, pp. 31–32.

much more closely related to the Peterlaks rocks than to the Irsha granite and the southern Russian chernozem.[1]

2. Prof. Schmidt's investigations of chernozem soils and subsoils in southern Russia convinced him that the closer the sample was to the site of its origin, i.e., Dnieper granite, a) the coarser grained are the feldspar weathering products and b) the less complete is the kaolinization of the feldspar (defined on the basis of the relative content of alkali per 100 parts alumina).

"Soil of Vasil'kov (of the Kiev Province, Nos. 13—16 in Schmidt's tables) which lies nearest (?) the Dnieper granite contains 49.75 parts $K_2O + Na_2O$ per 100 parts Al_2O_3 in its residue insoluble in hot 10% HCl. The soil of Pesochino (near Khar'kov) further east, away from the Dnieper granite, contained only 38.2 parts $K_2O + Na_2O$; the soil of Grushevka lying nearer (?!) the mouth of the Dnieper contained only 33.9 parts $K_2O + Na_2O$; finally, the soil of Sivash, the farthest away (?) southeast contained only 29.5 parts $K_2O + Na_2O$."[2]

Prof. Schmidt first published his views in 1879; in 1881, after completing 16 new analyses of chernozem soils and subsoils from the Samara and the Ufa provinces, he reiterated his former view and said that "the soils and subsoils (16 samples) from the Ufa and Samara provinces contain considerably more Na_2O and correspondingly less K_2O than the Baltic soils, analogous to soils of the first series." He explains this on the basis of the chernozems having been "formed by the mechanical destruction and chemical decomposition (weathering) of the south Russian granites (of the Dnieper region, etc.) which are relatively richer in Na_2O whereas the soils from the Baltic provinces were derived from the Finnish granites, richer in K_2O."[3]

Although this hypothesis is undoubtedly attractive and ingeniously argued, it cannot be regarded as proven. We regard its principal weakness to be the complete irrelevance of Schmidt's conclusions to his facts.

Crystalline rocks have to date been discovered in southern Russia on areas over 13.5° long.; they are known in the Volhynia, Podolia, Kiev, Poltava, Kherson, Ekaterinoslav, Taurida, and Voronezh provinces, and in the Don Cossack territory. The following crystalline rocks have been identified: various granites, gneiss, syenite, diorite, diabase, porphyries, porphyrite, norite, labradorite, epidosite, dolerite, anamesite, quartzites, shales, mica, chlorite, and talc schists, etc.[4] The crystalline region of Finland and of the Arkhangelsk and Olonetsk provinces is known to be just as extensive and as rich in various massive rocks.

Obviously, comparison of the weathering products of the northwestern and southern crystalline regions would require several samples at least of the commonest rocks of both regions. Yet, Prof. Schmidt limited himself to only 2 examples, one rock of each of the two vast regions.

Furthermore, it has been made clear that boulders of very many northern and sedimentary igneous rocks occur in the diluvial formations of chernozem Russia almost up to the Volga. On the other hand, there is

[1] Schmidt. pp. 33—35.
[2] Ibid., p. 32.
[3] Ibid., No. 2, p. 42. 1881.
[4] Domger. O kristallicheskikh porodakh yuga i yugo-zapada Evropeiskoi Rossii (Crystalline Rocks of Southern and Southwestern European Russia). pp. 3—4 and 7—17. 1881.

an undoubted close genetic relationship between southern diluvial and local bedrock consisting of Devonian, Carboniferous, Cretaceous, and Tertiary formations. Consequently, both kinds of rocks undoubtedly participated in the formation of the southern Russian deposits, the origin of which cannot be ascribed to the weathering of the Dnieper crystalline rocks.

There is at present no longer any doubt that soils are not rocks and chernozem cannot be compared with Devonian and Silurian clays. It may be added that Prof. Schmidt's (p. 324) arrangement of soils which he investigated, in regard to the Dnieper crystalline range, is absolutely arbitrary. It should be recalled that the samples analyzed by Prof. Schmidt, which completely satisfy his hypothesis, include three samples of northern paludine-terrestrial soils (23, 24 and 25), one (26) Recent coquina from the Tongue of Arabat, one (12) of the purest Belgorod chalk, and 16 samples from the territory east of the Volga where neither Finnish nor Dnieper boulders are found. Our opinion of his hypothesis is thus quite justified.

What, then, is the correct answer to the question of the origin of Russian chernozem?

Popular knowledge has anticipated scientific achievement, in this as in other cases. According to Prof. Borisyak, the "popular opinion of the origin of chernozem from decaying plants (in steppe lands) facilitated by atmospheric agents, followed by the mixing of the resultant humus with the loose loam of the subsoil" has long been current in the Ukraine.[1] Murchison reported the same popular view even before Borisyak did.[2] I heard the same opinion in different corners of chernozem Russia.

Possibly, this caused the opinion on the formation of chernozem from terrestrial vegetation to appear in the literature earlier than all other opinions, and to have many adherents. Nevertheless, there have been several shades of opinion, as seen below.

As far as is known, Güldenstädt was the first scientist to uphold the vegetal-terrestrial origin of chernozem.[3] Following his 1787 journey in southern Russia, he made the following comments inter alia: "Just south of Zaraisk the countryside in the upper reaches of the Don changes abruptly. An endless steppe or plain stretches, covered by a layer of perfectly black, rich soil, 2—4 ft [0.6—1.2 m] thick, extending far beyond Voronezh. It would certainly be difficult to determine the origin of this soil, rich in humus and completely analogous to the best artificially manured garden soil.[4] A probable explanation is that in these areas, where population has always been sparse, plants proliferated and decayed unchecked by grazing, thus accumulating considerable quantities of humus."[5]

In 1836, German[6] also made a definite statement supporting this view. According to him, "the loose surface of soil (taken as the ground) capable

[1] Borisyak. Ibid., p. 43.

[2] Murchison. Ibid.

[3] Güldenstädt. Reise durch Russland. Herausgegb. von Pallas [St.-Petersburg, 1787]. S. 34.

[4] In this connection, Pallas remarked that "On the basis of numerous traces (old tree stumps) these steppes were forested in antiquity. It is natural to assume that these forests were destroyed by fires during wars or by nomadic peoples, leaving behind this humic and peaty soil." Güldenstädt, ibid., p. 34.

[5] Despite the definite character of Mr Güldenstädt's statement quoted above, this opinion may be regarded as having been accidental with this author, and not characteristic of his views; somewhat later Güldenstädt confused steppe chernozem with solonetses and peat. Ibid.

[6] R. German [N]. O khimicheskom issledovanii chernozemnykh pochv, dlya opredeleniya razlichnykh svoistv ikh, v nashikh yuzhnykh guberniyakh (Chemical Investigation of Chernozem Soils for the Determination of Their Various Properties in Our Southern Provinces).— Zemledel'cheskii zhurnal, izdavaemyi Moskovskim obshchestvom sel'skogo khozyaistva, No. 5, p. 252. 1836.

of nourishing vegetation is usually covered by it. Exudations (?) from the roots and from the fallen leaves decay together with the desiccated plant residues and form the special substance known as humus or chernozem. This humus colors the soil dark-brown or even completely black. Chernozem is therefore a mixture of sand, clay, or marly soil, with a certain amount of humus, as is known by every farmer."[1]

Eversmann went on to develop the hypothesis of the terrestrial origin of chernozem. In his description of the Orenburg steppes, he wrote[2] that "The last geognostic product of the sea in this area is the solonetsous marly silt which is still the distinctive feature of these steppes. This silt constitutes the bare, upper layer of completely barren areas, while in fertile steppes it has already become covered by chernozem. As the (sea) water retreated, the silty soil became overgrown by characteristic grasses, in the first place by saltworts; with further retreat of the water an extensive silty steppe formed, in the course of centuries and possibly millennia becoming a layer of humus or chernozem produced by the vegetation and renewed annually."

Thus, the soil became capable of nourishing other plants; grasses became more luxuriant and formation of chernozem was accelerated. This is the simplest, most natural explanation for the formation of the "chernozem steppes which steadily increased in area as the water retreated."

In 1842 the well-known geologist Huot considered it "quite natural to assume that humus (in chernozem) is a product of the decay, thanks to free access of air, of the bodies of those organisms perishing in the steppes and of plants growing on the same spot over a considerable period of time." The author apparently assumed the plants to be both herbaceous and arboreal.[3]

Several new details were added to the previous views by the unknown author (A.P) who left us a small review of Mr Petzholdt's renowned work "Beiträge zur Kenntniss des Inneren von Russland".

Having reviewed all the hypotheses extant before 1852 on the origin of chernozem, A.P. regards "chernozem as only a product of the simple weathering of the soil (ground) layer, which is also confirmed by the difference in nature (with respect to the ground ?) of mineral composition; this dissimilarity must be regarded as being best confirmed by future investigators.[4]

"The difference between chernozem and other humus-rich soils consists solely in the quantity and quality of the humus . . . in our opinion the difference in quality is due to the special conditions of chernozem Russia, namely, high temperature, absence of superfluous moisture, and loose, air-permeable soil (brown) which facilitate the decay of organic residues mostly of plant origin."[5]

[1] By the same author: Khimicheskie issledovaniya o chernozeme, nakhodyashchemsya v yuzhnykh guberniyakh Rossii (Chemical Investigation on Chernozem Found in the Southern Provinces of Russia). — Zemledel'cheskii zhurnal Moskovskovo obshchestva sel'skogo khozyaistva, No. 1, pp. 47—48. 1837. Having remarked that Russian "Chernozem is nearly the same soil known in Germany as Marschboden or Dammerde," German adds here "properly speaking, chernozem consists of organic residues and products of their decay with sand, lean clay, or marl."

[2] Eversmann. Ibid. pp. 52—53.

[3] Huot. J. Voyage dans la Russie méridionale et la Crimée. (Paris), 1842. pp. 461—462 and 467.

[4] Zhurnal Ministerstva Gosudarstvennykh imushchestv, part 44, bibliography, pp. 12—14. 1852—1853.

[5] Ibid., p. 12.

Unfortunately, at a loss to understand "in what manner the water-insoluble humus particles could form such a homogeneous mixture with mineral particles even at a depth of 20 ft [6.1 m]"[1], the author resorts to an artificial explanation, and puts his own views at considerable disadvantage. He assumed that "the material for the formation of (mineral constituents of) chernozem was not supplied by graywacke rocks (clayey, of low water permeability), but by sandstones[2] and sands.

He wrote as follows: "The chernozem layer should be imagined not as it appears today but before its mixture with humus, when it constituted (?) a layer of very fine sands; the mechanical entrainment, by snow or rain-water, of the humic substances formed from residues of plants which grew on this soil must be admitted (in our opinion these were herbaceous plants which decay more readily than the arboreal ones)[3], occurring to a considerable depth, which varied with the looseness of soil."[4]

Following his acceptance of one fallacious premise (sand as almost the only parent rock of chernozem), the author was forced to accept several others: "Such accumulation of humus in the sand mentioned above introduced a change in its properties; it appears more or less hard, sometimes friable when dry, and rich (?) and slippery when wet; obviously these properties are due to humus . . ."[5]

The author then arrives at the following conclusion:

1. "Chernozem is the weathered layer of the upper rocks of the most ancient (?) sedimentary origin, mostly sandstones.

2. "It differs from other soils in the abundance of its humus, especially that insoluble (?) in alkalis and formed under special climatic and soil (ground) conditions from herbaceous plants."[6]

Academician Ruprecht is the undoubted founder of the scientific formulation and development of the theory of the origin of Russian chernozem. In his well-known work, "Geobotanical Studies of Chernozem" (Geobotanicheskie issledovaniya o chernozeme), 1866, he presented his famous hypothesis, as follows[7]:

"Northern sod soil is the true equivalent of chernozem in both external features and in chemical composition and microscopic structure, except that the color of earth under the sod is not as dark or black as the color of chernozem. Chernozem is often grayish-black, and erroneous determinations may be made if the site of sampling is unknown. The process of

[1] Ibid., p. 13. The author is obviously referring to Murchison's well-known report on the thickness of Russian chernozem.

[2] Ibid., p. 13. On the very next page (14) the author admits the possibility of the formation of chernozem also on calcareous rocks.

[3] In addition, the author remarked elsewhere (p. 14) that "In countries where a moist and humid climate is predetermined by extensive forests, organic residues generally decay very slowly; no difficulty is therefore encountered in discovering partially decayed portions of arboreal plants in the upper layer of forest soil. Because of the very density of their mass, arboreal plants do not decay as readily as do herbaceous plants; the decay of the latter, in our treeless steppe region, under completely opposed conditions, must certainly yield results differing from the preceding case, sometimes in proportion to the difference between the climatic conditions of these countries."

[4] The author offers the following illustration: "Even using the densest blotting paper, despite the insolubility of humic substances in both the free and the combined state, they will be found to partially pass through the paper pores on being mixed with water." Ibid., p. 13.

[5] Ibid., p. 13.

[6] Ibid., p. 14.

[7] Ruprecht. Ibid., pp. 7--8 and 10.

humus formation in the sod soil is obvious; the herbaceous parts of plants die, decay in the air, are partly converted to humus, percolate into the soil with rain or melting snow and color the soil to varying degrees of darkness, depending on the quantity of humus. This also happens during the formation of chernozem, when the sod crust forms a direct transition to the generally looser soil layer with no intervening layer. Despite the aridity of the chernozem zone, the soil becomes a semiliquid mud in spring, due to the melting snow. It is not, however, long until the sun's rays sear and parch the herbaceous portions of the vegetative carpet; they give rise to local steppe fires which do not destroy the entire sod but in the course of the centuries produce a general effect. It is still difficult to decide what fraction of chernozem in a given layer was formed from sod and what fraction is of the primordial inorganic soil. The humus particles and phytolitharia found in the deeper layers percolate down from the top; the silica of the uppermost layer may also be directly (?) derived from plants and its quantity may have increased thanks to sand or dust brought from other places. This silica originated from inorganic material."

Ruprecht further continued, "not a single phenomenon contradicts this hypothesis. The absence of Polythalamia and Polycystinia marine Bacillarieae, marine and freshwater mollusks; the decrease in color intensity, humus content and number of phytolitharia with increasing depth; the low content of organic substances compared to silica and other inorganic constituents; its occurrence on dome-shaped, slightly convex planes and on the summits of flat mountains and hills; its distribution, sometimes intermittent, over an enormous area; the frequent absence of chernozem along river banks when the latter are a new formation, its absence in the Black Sea-Caspian steppe and on loose sand where sod growth is slow and difficult; its presence in the foothills of the Urals and in the Caucasus on points considerably higher than where neighboring chernozem occurs, and the general differences in elevation at different points of the chernozem region; the imperceptible transition of chernozem to the sod soil, complete absence of vegetal structure, the only plant residues being cereal phytolitharia; carbon-black flakes and certain other phenomena — all are readily explained and whether taken individually or collectively prove this view of the origin of chernozem."

Yet, Academician Ruprecht does not regard this mode of chernozem formation by the percolation of humus down into the underlying rocks as the only possible one; he accepts it only in cases when the bedrock is "sandy or loamy diluvium."[1] Since this rock is not the only substrate of the soil, Academician Ruprecht also distinguished "chernozem formed without the diluvial layer and without percolation but directly over the compact or weathered rock, as for instance in the granite steppe of the southwestern parts of Russia, on limestones (Simbirsk) and on marl (Malmyzh).[2] The inorganic constituents of chernozem of the latter kind are directly derived from the plants and only indirectly from the minerals and later from vegetal-mineral subsoil."[3]

[1] Ruprecht. Ibid., p. 46.

[2] Ruprecht regards chernozem of this kind as originating "by the destruction of root filaments which, along with other agents, was detrimental to the limestone (marl, etc.), penetrated the narrow cracks and enlarged them by the strong development of roots, eroded and comminuted stone and transported its particles." Ibid., p. 46.

[3] Ibid., p. 46.

[illegible] agreed with Ruprecht's opinion that [illegible] derived from the humus of terrestrial vegetation" [illegible] the opinion that this vegetation was exclusively [illegible] are incapable of forming chernozem.

[illegible] connection, Prof. Bogdanov made the following remark[1]:

[illegible] chernozem cannot prove the presence of steppe since such [illegible] not only by feathergrass but also by other cereals growing [illegible] clearings. The presence of true chernozem in [illegible] the chernozem zone is undoubted, as may be [illegible] no signs to enable the differentiation between [illegible] and chernozem of deciduous forests, called "foliage earth" by Ruprecht, neither does Ruprecht indicate such signs. Finally, if the sparse (?) herbaceous vegetation of the dry steppe decays, forming chernozem, why does no chernozem result upon decay of the lush forest vegetation? How are the brushwood and the mass of decaying arboreal and herbaceous residues littering the soil of a thick forest transformed?

"The abundance of carbonaceous organic substances in chernozem points to only partial decay of plant residues, since complete decomposition would have left only inorganic products. The best conditions for such partial decay certainly exist in a rather shaded forest where the soil is very moist. Moreover, the humus layer must increase at a much greater rate in the forest than in the open steppe since the material for its formation is much more abundant, the forest soil is much better protected against the wind, and the rainwater flows in rills much more readily on the steppe. Since it is not absorbed, the steppe surface is eroded and loose humus reaches hollows and river valleys; in forests, on the other hand, raindrops are considerably impeded by the foliage and upon reaching the soil are gradually absorbed... There are thus no reasons to deny the possibility of humus formation in forests from residues of arboreal and herbaceous vegetation, and its eventual conversion to true chernozem of the kind Mr. Baum and I observed in all the deciduous forests of the Simbirsk and the Saratov Provinces..."[3]

He adds that "in the Syzran District there have never been (?) any steppes, the entire territory always being covered by almost continuous forest[4] which fur trappers roamed; yet, a vegetal layer of chernozem exists which could not have been formed from steppe vegetation."

In contrast to Academician Ruprecht, who recognized the predominant role of vegetation in the formation of chernozem, as we have already seen, Pacht advanced the idea (1856) that chernozem cannot be sharply differentiated from diluvium and that Russian "chernozem must be regarded

[1] Bogdanov. Ibid., p.17.

[2] M. N. Bogdanov provides the following details in this connection: "In the Syzran District I investigated the soils of 'bors' and discovered humus formation in this soil as well, although sand is most unfavorable for formation of chernozem. The topmost sand layer is cemented and becomes gray; in some places in gullies near the village of Kopevka this cemented top layer juts out, cornice-fashion, over a bluff, lower layers being eroded by water. This is clear proof of the presence of humus." Bogdanov. O chernozeme i ego prakticheskom i nauchnom znachenii (Chernozem. Its Practical and Scientific Significance). — Trudy VEO, Vol. I, pp. 161–162, 1877). "Layers of humus in pine 'bors' growing on limestones, chalky marl and clayey sandstones are considerably thicker; when overlying chalky marl they become soil which is in no way different from chernozem, and should be accepted as such." Bogdanov. Ptitsy i zveri Povolzh'ya (Birds and Mammals of the Volga Area), p. 16.

[3] Bogdanov. Ibid., pp. 209–210.

[4] Bogdanov. — Trudy VEO I(2): 161, 1877. In another place, M. N. Bogdanov agrees [illegible] with Baum's [illegible] that the entire [illegible] the Volga [illegible] between Kazan and Saratov was [illegible] covered by continuous forests." See "Ptitsy i zveri Povolzh'ya" (Birds and Mammals of the Volga Area), p. [illegible]

as the youngest member of the deposit."[1] Subsequently (1873) Prof. A. P. Karpinskii developed this view further, apparently allocating the primary role in formation of chernozem to loess in particular rather than to Russian diluvium in its entirety. Summarizing his geological investigations made between the towns of Brest and Rovno, A. P. Karpinskii presents the following series of arguments[2]: "Typical chernozem is not found in this area. Loess is overlain by dark-colored vegetal earth, its properties sometimes resembling those of loess and sometimes of chernozem; in this case it apparently differs from chernozem only by the lower vegetal-humus content. No sharp boundary is discerned between vegetal earth and underlying loess. The vegetal earth overlying all the other formations in this area differs significantly from the vegetal earth overlying loess. Somewhat south of this area loess is already overlain by typical chernozem."

Taking all these data into consideration Prof. Karpinskii ventures to advance the hypothesis that "chernozem is loess permeated by vegetal humus." He supports this hypothesis by noting that "when a rock lithologically resembling loess is directly overlain by vegetal earth (formed by the penetration of vegetal humus into the bulk of rock), the vegetal earth is either similar to chernozem or is in fact true chernozem. This phenomenon may be observed beyond the Urals, near Troitsk...." Karpinskii concludes, saying that in the formation of soil "The decay process converts $CaCO_3$ from the loess substance to the bicarbonate which is carried away by water."[3]

A. P. Karpinskii's view is very close to that held by the well-known geologist and agronomist Orth. Orth's investigations over considerable stretches of the Volga area as well as certain areas in the Don and the Azov-Black Sea steppes disclosed stone-free yellowish-cinnamon loamy marl as the surficial rocks; he considers this marl to be the principal subsoil of Russian chernozem[4], and regards chernozem also as humic loam and clay (Humoser Lehmbis Thonboden).

In Orth's opinion, the humic components in Russian chernozem "must have originated in the transitional period between the Diluvial and the Recent periods, when different conditions of moisture provided better conditions than those existing today for vegetal formations.[5] This process must be regarded as essentially terminated."[6]

In 1877 there also developed a totally new view of the subject, first propounded by Prof. A. A. Shtukenberg attributing the origin of chernozem exclusively to the absence or presence of sodium chloride in the parent bedrock.

In his discussion of the occurrence of the "freshwater" facies of young Recent Aral-Caspian deposits in the lower stretches of the Volga (especially

[1] Pacht. Ibid., p. 107. An analogous suggestion was advanced by Bischof in 1855, again in 1863. Bischof, G. Lehrbuch der chemischen und physikalischen Geologie, Band I, S. 523. [Bonn].

[2] Barbot de Marni and Karpinskii. Geologicheskie issledovaniya v Volynskoi gubernii (Geological Investigations in the Volhyni Province), p. 20. — In: Nauchno-istoricheski sbornik Gornogo instituta. 1873.

[3] Karpinskii. Ibid.

[4] Dr. Orth [A.] zu Berlin. Die Schwarzerde und ihre Bedeutung für die Kultur. Die Natur. 1877. No. 3. S. 37.

[5] The same basic view was held by Griesebach in his "Vegetation of the Globe", vol. 1, p. 363, translated by Beketov.

[6] Orth. Ibid., p. 37. Formerly (1872) Orth regarded the dark-colored soils of Silesia and Saxony (reaching 2 ft in thickness and equated by him with Russian chernozem) as aquatic-paludine, even marine. Orth. Geognostische Durchforschung des Schlesischen Schwemmlandes... 1872. S. 49–61.

on its left bank and as far inland as Orenburg), Prof. Shtukenberg remarks that "along with my studies of the freshwater facies I also observed its constant companion — chernozem, in places exceeding 1 arshin [71 cm] in thickness. The occurrence of chernozem at different elevations and its imperceptible transition to the underlying soil directly point to its local origin. The southern boundaries of chernozem coincide with those of freshwater facies, so that sediments which are purely Caspian — saline clays — are never covered by chernozem. Taking into consideration the fact that the freshwater facies are found in the feathergrass steppe, while the purely Caspian sediments occur in a sagebrush steppe, the vegetal origin of chernozem becomes more than probable. As has been mentioned, chernozem occupies various elevations within the feathergrass zone of freshwater sediments. It may now be added that chernozem, also overlies different soils (rocks). For instance, I observed chernozem, near Orenburg, overlying clay of the freshwater facies, clay outcrops belonging to the variegated rocks, and Permian limestone outcrops sometimes rising 40—50 sazhens [85—107 m] above the Caspian sediments (Grebeni, Mayak). In the latter case, chernozem lies directly on a bed of limestone gravel and fills the interstices between the individual limestone fragments."[1]

Except for Darwin,[2] the most recent authors to deal with the origin of chernozem have been Messrs Kontkevich and Agapitov. Both reiterate Prof. Karpinskii's view, the former with respect to Novo-Rossiya and the latter with respect to the Irkutsk Province. Kontkevich in no way developed[3] Karpinskii's view. Agapitov, among others, advanced the following arguments:

1. Loess is an extremely fertile soil; through its facilitation of a very rapid and abundant growth of the wild vegetation humus accumulation was increased.

2. The physical properties of chernozem and loess are very similar, both being loose, friable and porous, and distinguished only by their different colors.

3. Since their chemical properties are also closely similar, the derivation of one from the other is self-evident.

4. Loess and chernozem usually occur together in the Irkutsk Province.[4]

Thus, all the authors mentioned in this last chapter, beginning with Güldenstädt and ending with Mr. Agapitov, unanimously recognize Russian chernozem as a local terrestrial formation, originating in the alteration of the underlying parent rocks. This view may by now be regarded as axiomatic. In addition to the arguments advanced by the authors, I shall point out the following, most essential, properties of the body in question:

1. When situated normally, Russian chernozem throughout displays the closest genetic relationship with the (parent) rocks on which it lies, both in chemical composition and in physical structure.

2. The distribution of both primary (mainly mineral) and secondary (mainly volatile) chemical components in Russian chernozems always obeys

[1] Shtukenberg, A. Ibid., pp. 13—14.

[2] In his well-known work "Formation of Vegetable Mould through the Action of Worms" ([Russian] translation by Lindeman [Moscow, 1882]). Darwin does not refer to Russian chernozem as such. The reader will later be presented with those of Darwin's statements which are also applicable to Russian chernozem.

[3] Kontkevich. Ibid., February, pp. 315—316.

[4] Agapitov, [N.]. K voprosu o proiskhozhdenii chernozema (Origin of Chernozem). — Izvestiya Vostochno-Sibirskogo otdela Russkogo geograficheskogo Obshchestva, 11 (3—4): 18, 22, 25, 27—28, etc. [1880].

uniform laws: the deeper the sampled horizon, the greater its total content of primary elements, and the smaller its total content of the secondary elements, and vice versa.

3. Russian chernozem always has a definite thickness, not exceeding 5 ft [1.5 m] throughout its vast territory.

4. It retains definite physical structure everywhere.

5. It occurs equally on water divides and slopes, on elevated (absolute elevation) and on low-lying areas.

6. Its bed consists of rocks of various formations.

7. Russian chernozem is inextricably bound up with the climate and natural vegetation of the country.

8. Finally, Russian steppe chernozem is not bedded and contains residues of exclusively terrestrial organisms, as seen below. None of these most important properties may be explained by either Eichwald's, or Pallas' and Murchison's hypotheses. They are understandable only by assuming the terrestrial origin of the Russian chernozem. Unfortunately, the agreement between the exponents of the terrestrial origin of chernozem ends at this point.

Opinions vary widely in regard to a) nature of organisms (forests, grasses, animals) which participated in chernozem formation, b) mode of humus percolation, c) nature of parent rocks subsequently converted to chernozem, and d) conditions (mainly climatic) essential for the formation of chernozem.

a) Thus, Messrs Güldenstädt, Eversmann, Petzholdt's anonymous critic, Shtukenberg and especially Ruprecht are of the opinion that Russian chernozem formed with the exclusive participation of typical steppe vegetation. Ruprecht has often reiterated[1] that forests could not and in fact did not participate in the formation of this soil. On the contrary, M. N. Bogdanov, and earlier, Pallas and Ehrenberg regard the role of forests in chernozem formation as at least equal to that of the steppe vegetation. Very characteristically, Huot was the only one to regard the participation of animals in the origin of thi. soil as significant, until very recently.

b) Ruprecht regarded the dominant role in the formation of Russian chernozem as having been played by plants, while Mr. Agapitov ascribes the dominant role to rocks, namely loess.[2]

c) Furthermore, some scientists (such as German) accept two processes of humus origin: percolation from the top, and root decay; other scientists (Ruprecht) almost exclusively recognize only the former mode.

d) Finally, Eichwald, Borisyak, Orth and Petzholdt's unknown critic regard the climatic conditions suitable for the growth and decay of vegetation as highly significant for the formation of Russian chernozem.

The first three scientists assume different conditions of moisture and climate, more favorable for vegetation, to have existed during the formation of chernozems; the last author assumes higher temperatures and lack of moisture in southern Russia at that time.

Which is, then, the correct opinion? Of all the controversial points mentioned, the most difficult one to solve is the role of forests in the origin of Russian chernozem. I regard it as such since a true scientific solution

[1] Ruprecht. Ibid., pp. 3–7, etc.

[2] It should be taken into account that Mr Zalomanov denies that loess is the parent rock of chernozem; other scientists prefer to regard sands and clays in this connection. Author.

demands a mass of chemical and botanical data which are not available.[1] We shall presently see, however, that a correct approach to the solution of this problem is possible.

Let us begin, as usual, with an analysis of contemporary phenomena.

The reader already knows that neither the famous forests of Murom, nor the equally extensive ones of Alatyr, nor the even more imposing Caucasian forests have ever formed chernozem. Dozens of instances were presented above, given by myself and by my predecessors, in regard to all regions of chernozem Russia, showing the occurrence of century-old forested (deciduous and pine) areas amidst typical continuous chernozem, on soils hardly distinguishable from the northern forest soils.

It should be added that along the southern coast of the Crimea a considerable number of areas still exist, with forests in satisfactory, one may even say — in primordial, condition. This enormous quantity of arboreal vegetation apparently should have formed, in the presence of fairly high atmospheric humidity, considerable humus accumulation, whether in situ or transported by mountain streams into the subjacent valleys and hollows, depending on location and other circumstances. Yet, I have never observed any considerable accumulations of humic soils in the forests or in the valleys and hollows all along the southern coast. In forests, on areas less liable to stream erosion, the brownish soil formed by the weathering and destruction of bedrock is covered by a humus layer not over 2 vershoks [9 cm] thick and usually thinner.

The same phenomena are also observed on the northern slope of the major range of the Crimean Mts, where even small accumulations of humic soil are very rare despite the forested nature of this area.

"Thus, — concludes Prof. Levakovskii, — forests covering certain tracts in the Crimean Mts since primordial times have not formed any true chernozem, or even any considerable accumulations of humus."[2]

The following statement by the famous scientist Lyell is even stronger, more expressive, and more general: "The forests covering the land may be as dense and as tall as they are in Brazil and inhabited by myriads of mammals, birds, and insects; nevertheless, 10,000 years later a chernozem layer a few inches thick will be the only residue of all those myriads of trees, leaves, flowers, and fruits, of all the innumerable skeletons of birds, mammals, and reptiles which inhabited the fertile expanses."[3]

What significance arises from these facts?

These phenomena are largely explained partly by a) unfavorable topography (e.g., central Caucasus, most of the Crimean Mts, the territory between Saransk and Korsun, etc.) and partly b) by the unfavorable composition of ground (sandy forested areas along the Tesha, Borovka, Samara and partly the Alatyr rivers, etc.). However, this explanation cannot be applied to all cases of this kind. We have already seen that the topography and ground of forests en route from Buinsk to Simbirsk, between Orlovka and Seitovo (Menzelinsk District), in the vicinity of Vetoshkino and Pogorelovka (Sergach District), between Tomashevka and Odai (Uman District), in the vicinity

[1] I principally mean the following kinds of information: a) comparative annual increments of arboreal and herbaceous vegetation, both underground and subaerial; b) comparative annual quantity of decaying vegetation in both cases; c) nature of the decay processes in thick forests and in the open steppes, etc.

[2] Levakovskii. Ibid., pp. 18–19.

[3] Lyell, Ch. The Principles of Geology, Vol. 1, p. 218, [Russian translation, Moscow. 1886].

of Korneshti (Soroki District) between Kryzhopol and Yampol and in many other areas, seem the same as in the neighboring steppe; the latter however is covered by typical chernozem while the former are covered by no less typical forest soil.

On the basis of the numerous sections of forest vegetal earth which I observed, its most normal and common constitution may be described as follows:

A. Forest litter (mat) consisting of only slightly decayed, although very strongly browned, leaves, small twigs, slightly admixed with earthy substances, forming a lightweight brownish-dark peat-like mass which may be so compact as to be torn up by hand in one piece. Hor. A (especially in its lower portions) usually retains moisture, sometimes even after a prolonged heat spell. On stripping this horizon, actual wet spots form on the surface of hor. B. The forest litter is 1 — 4 in [2.5 — 10 cm] thick.

B. Pisiform or nuciform horizon, always sharply distinguished from hor. A. A mass ashy or near-ashy in color with an appreciable bluish tinge which seems to grow stronger toward the forest litter. The entire mass falls into small spheres or irregular polyhedra, usually smaller than a small filbert; such pea-sized units often display dark-brown imprints of small roots on their surface; coloring often becomes less intense inside the "peas". Hor. B is 1/2 — 1 ft [15 — 30 cm] thick and even more. At its bottom this horizon forms a gradual and imperceptible transition to bedrock (loam, sandy loam, etc.).[1]

When such virgin forest soils are brought under cultivation, the forest litter is partially oxidized in the air and partially mixed with the subsoil (nuciform earth), producing a thin (usually thinner than 6 in) grayish-chestnut, more rarely dark-gray arable soil horizon. Hundreds of such fields, often surrounded by typical chernozem, are especially common in the southeastern part of the Nizhni Novgorod Province. The origin of such soils, even after they have been cultivated over prolonged periods, may be easily established by making a fresh section, in which a typical nuciform horizon, only partially scratched by the Russian wooden plow, becomes evident.[2]

The ground and topography as well as the age of the country and the climate in all such forested areas are identical to those of the neighboring chernozem steppe, leading to the conclusion that chernozem formation in such localities was prevented by forests.

This statement may be objected to on the grounds that there are in fact numerous cases when forests also grow on chernozem[3] and are thus capable of forming chernozem. Indeed, this argument in favor of the "forest" hypothesis was advanced (p. 329) by Prof. M. N. Bogdanov. Nevertheless, we regard the question as being formulated incorrectly. In order to make such a statement, steppes must be proven to have been absent consistently,[4]

[1] Thus, contrary to the opinion held by many scientists and in complete accord with Ruprecht, the forest soil is always distinguishable from the steppe sod.

[2] My colleagues and I came across numerous cases of this phenomenon during detailed investigations of soils in the southeastern part of the Nizhni Novgorod Province. Author.

[3] I have repeatedly described such phenomena in preceding pages. In this connection Ruprecht and his followers in general formerly regarded the absence of arboreal residues as highly significant for Russian chernozem. However, this argument has been considerably weakened in view of the latest work of Mr Krutitskii (see below) proving that such residues could not prossibly have been preserved up to the present. Author.

[4] This statement is absolutely unfounded with regard to the Syzran District (p. 329), the 200-year-old tradition notwithstanding.

and the forest not to have spread over the existing chernozem. This argument is even more effective since both I and my assistants in our observations of forests growing on chernozem have never observed the nuciform transitional layer; on the contrary, chernozem under forest was of completely normal steppe constitution. The only exception to this rule consists of the Pesochino forest (p. 161); however, the much simpler explanation is that the chernozem has been so altered as a result of oaks growing on it for at least 200 years.[1]

This structure of forest soils is significant in yet another respect. The work of Griesebach and Rossmesler as well as the latest, most modern studies of the effects of forests on climate have made it known that summer temperatures in forested areas are always lower than in the open fields (other conditions being equal), while humidity is usually higher. The physical state of the forest litter conforms to these facts. It is common knowledge that excess water interferes with soil aeration, prevents decay of organic substances and preserves ferrous salts over prolonged periods; in short, conditions are approximately the same as in boggy areas. These circumstances facilitate the formation of acid northern meadows, rather than sweet steppe soils.[2]

The compactness of the forest litter and its relatively well-preserved constituents most likely also interfere with the mechanical percolation of various decaying substances into the subsoil. This is especially so since the massive subaerial portions of the trees, their trunks, lose most of their organic substance in the air before disintegration into particles small enough to penetrate into the ground through various pores. Anyone familiar with dense forests which are never cleared, and are littered with windfall and decaying matter knows that a fallen giant may disintegrate at the touch of a stick...

Although the exponents of the forest hypothesis claim a larger annual increment of organic substances in the forest than in the steppes, I know no facts supporting this claim. Even were this claim justified, the following circumstances should be borne in mind.

a) Very many trees live for centuries, during which period their dead predecessors decay completely. Remarkably, during the four years of my excursions I found only three or four old decaying underground arboreal portions in forest sections. On the other hand, roots of steppe plants are renewed far more rapidly. b) Tree roots never form a network as fine and dense as the underground portions of herbaceous plants, and therefore can hardly produce such a uniformly colored soil as chernozem. Moreover, the very nature of the decay of underground portions of trees counter-indicates the participation of forests in chernozem formation. Tree roots are relatively large in diameter and usually decay from the center to the periphery. It is quite possible, and is in fact often the case, for a root to occupy its old position without mingling with the surrounding earth, with its inner portions completely decayed; maintaining free connection with the atmosphere, it is eventually completely volatilized, its mineral constituents being left behind.

[1] This is the probable explanation of the peculiar color of the nuciform horizon in Pesochino soil.

[2] Thus, Prof. Bogdanov's arguments quoted above (p. 329) in favor of the "slow and incomplete 'burning' of plant residues in the forest" rather disprove the forest hypothesis than otherwise. Author.

At one time, both the exponents and the opponents of this hypothesis attributed great importance to the possibility of the Russian steppes' ever having been covered by forests. We are certain this has never been the case; however, this is hardly the proper place to discuss the point,[1] especially since its solution is actually irrelevant to our purpose. Indeed, let it even be granted, for the sake of the argument, that all the Russian chernozem southern steppes were once covered by forests... Since these trees could not have penetrated southern Russia from the south or from the southeast, they must have originated in the west, north, or northeast. Consequently, western, northern, and northeastern Russia must certainly have been covered by forests for a longer time than southern Russia. Yet chernozem is absent on these old forested territories as well as in the forested territories of western Europe and in other countries.

Finally, if we admit the former existence of continuous forests on our steppes and their significance for chernozem formation, we shall be utterly unable to explain the above regularity in the geography of the Russian soil.

Consequently, all the available facts support Ruprecht's principle that forests of themselves are incapable of chernozem production.[2]

The participation of various animals in process of origin of vegetal-terrestrial soil is somewhat more significant although much less important than assumed by Darwin.

Both the surface and the soil of the Russian steppes are known to abound in animal life, among them susliks (p. 293) hamsters, lizards, myriads of insects and worms, etc. The sheer amounts of some of these animals may be illustrated by the following few facts. "As much as 194,400 – 1,836,000 larvae of corn weevil alone (of the genus *Anisoplia*) have been counted on one dessiatine; the number of beetle larvae of the genus *Harpalus* may reach up to 216,000 per dessiatine; in 1860, 1250 'chetverts' [262 liters] of migratory locust eggs were collected over an area of 1800 dessiatines in the environs of the town of Khotin; according to Mr Keppen, larvae of *Cleonus punctiventris* may number 2,800,000 individuals per dessiatine; Keppen also informs us that on a certain estate in the Pavlograd District, 900 laborers gathered about 1,000,000 of the so-called 'winter corn worm' (caterpillars of Owlet moths, *Agrotis segetum* and *Agrotis exclamationis*) on a sugar-beet plantation on one day (23 June 1880); up to 14,000,000 individuals of 'winter corn worm' were burnt in the same year on Mr Pletitsyn's estate."[3] I may add that Genzen counted 133,000 common earthworms[4] weighing more than 974 Russian pounds (390 kg) on one hectare of garden soil.

All these animals swarm and burrow in the soil and certainly facilitate its comminution and aeration as well as the penetration of organic substances; their activities are naturally conducive to a more uniform distribution of humus and more intense weathering of bedrock. Most of the organisms

[1] As I have already observed, the forests then extended further south than they do today. Yet I believe that they never fully occupied the steppes but rather always formed a special forest-steppe zone at the southern steppe border similar to that existing in Asia and in North America. See Middendorf, Griesebach, and others.

[2] On the other hand, it is obvious that chernozem must be influenced by any trees covering it. Dokuchaev, Predvaritel'nyi otchet po ekskursii 1878. (Preliminary Report on the 1878 Excursion), p. 12.

[3] These data were kindly communicated to me by our young entomologist Mr Filip'ev.

[4] Trudy VEO, vol. 2, p. 191. 1877.

feed on both dead and live vegetation and therefore facilitate its rapid decay; their own dead bodies enrich the soil with nitrogenous substances [1]

However, Darwin did not limit himself to observations on this very important role of animals in the formation of the vegetal layer; by a series of highly ingenious observations, experiments, and calculations he wishes to prove that the entire vegetal layer covering the soil has been passed through earthworm intestines several times and will undergo the same in future. Darwin remarks that the very name "vegetal layer" is unsuitable, and prefers "animal layer".[2]

Yet, one cannot agree with such a broad generalization on the part of the famous scientist, even if earthworm activity is supplemented by the activity of other animals (which is quite necessary, as we have already seen), mainly for the following reasons:

1. For nutrition, the animals depend upon substances present in the soil and above it; thus, on dying they add no essentially new substance to the soil. When unusually abundant crops have grown on fields where large masses of different insects have perished previously, it should be borne in mind that this improvement in the soil is only temporary, since it occurred at the expense of humus from the same or the neighboring area; the net result in the total economy of soils is negative rather than positive.

2. If one agrees with Darwin that earthworms raise such masses of earth to the surface that flagstones and foundations may be buried,[3] the remarkably gradual decrease in the amount of volatiles and increase in the amount of other substances unchanged upon ignition, observed in the downward direction in all normally situated soils, is not understandable.

3. If all soils have been formed by worms, it is difficult to understand, then, why some soils are black and rich in organic substances while others are light-gray, low in humus,[4] some thin, about 1/2 — 1 ft [15 — 30 cm][5] while others are thick, reaching 2 — 4 ft and more [61 — 122 cm].

This phenomenon cannot be safely explained by the difference in the relative quantities of worms. Can the Russian chernozem steppes possibly contain an incomparable abundance of worms? In my personal diggings (hundreds and thousands of times) of the vegetal layer in northern and chernozem Russia, I observed no difference in the density of the worm population.[6]

Thus, if there is any necessity to change the term "vegetal layer", it should be changed to "vegetal-animal", and by no means to "animal".

Another question raised above is very much simpler. There is no a priori nor any factual necessity for distinguishing, as Ruprecht does, between "chernozem formed by the percolation of humus into sandy or loamy diluvium

[1] A discussion of the formation of nitric acid in soil by bacteria would lead us far afield. Author.

[2] Darwin. Formation of Vegetable Mould through the Action of Worms, Russian translation by Lindeman. 1882.

[3] In our opinion, in his explanation of this phenomenon the author underestimated the part played by the weight of stones.

[4] According to Darwin, the content of organic substances in ordinary English soil only attains 1.76%. Ibid.

[5] Darwin himself, in reference to English soils, often states that their thickness does not usually exceed 10 in [25 cm], "but frequently less, 5–6 in" [13 – 15 cm]. Ibid.

[6] In view of the well-known aridity of the Russian steppes, the worm population is probably larger in northern nonchernozem Russia than in southern Russia. As for the outstanding abundance of worms in rich garden soil, it must first be proved that the soil is rich because of the large worm population and not vice versa (Hensen).

and chernozem formed without the diluvial layer and without percolation, directly on the intact or weathered rock"; any vegetal soil and any chernozem is always formed on any bedrock by two parallel simultaneous processes, a) the penetration of humus from the surface and the upper soil horizon and b) root decay.[1]

At present, lacking suitable information, it would be extremely difficult to determine which of these processes predominates and under which conditions. In view of the nearly total decay of subaerial portions of plants on the surface of the Russian southeastern steppes, and in view of the extreme thickness of soils disproportionate to the amount of humus, it becomes clear that the predominant agent determining soil color is certainly the decay of underground plant organs and not percolation from the surface.

Further studies will call for the formulation of a scheme including several possibilities of humus penetration from the surface. Three theoretical cases are possible: 1) percolation of intact portions of plants through visible cracks and burrowings of different animals; 2) percolation of very fine, already carburized parts of plants through the soil pores; finally 3) percolation of solutions of double humates. The first mode is self-evident and requires no additional explanations, the two other variants were first factually proved by Mr Barakov's experiments, organized at my suggestion. He took two rows of fairly tall cylinders, filled them with different (known) mixtures of quartz sand and kaolin, sprinkled the mixtures in one row with mechanically elutriated chernozem particles and those in the other row with a humate extract prepared from chernozem according to Grandeau. The mixtures were appreciably colored in both cases after a certain time, differently in each row.[2]

While Academician Ruprecht mistakenly regarded chernozem as an exclusively vegetative product, the opinion held by different scientists regarding loess as practically the only rock suitable for chernozem formation is just as remote from the truth.

We have repeatedly stated, and will discuss again below, that favorable rock composition is one of the most important prerequisites for the formation of Russian chernozem, loess being one such rock. However, favorable parent rock is not the only prerequisite for chernozem formation, since chernozem results from the combined effects of climate, country age, vegetation, topography, and parent rock.

Secondly, we have already seen that the Russian chernozem indiscriminately covers Devonian (p. 224, ff.), Carboniferous (p. 290), Permian, Triassic (the Trans-Volga territory), Jurassic (p. 77), Cretaceous (central chernozem Russia), Tertiary (southwestern Russia, etc.) and post-Pliocene

[1] I cannot understand why Academician Ruprecht regards his second (essentially imaginary) mode of soil origin as proof of the strange hypothesis that "all the inorganic constituents of chernozem are derived from plants and only indirectly from the mineral and vegetal-mineral soil." The obvious objection is the source of mineral nutrition for the first plants in the area. On the other hand, a question arises regarding the origin of those sparingly soluble soil constituents which are not among the most common constituents of plant ash such as aluminum (Famintsyn [A.]). (Obmen veshchestv i prevrashchenie energii v rasteniyakh (Metabolism and Energy Transformations in Plants), pp. 111, etc. 1883). The very fact of the constant presence of quartz grains in chernozem and sometimes also of undecomposed bits of bedrock is an incontrovertible argument against Ruprecht's view.

[2] Mr Barakov's experiments will be published in full upon the completion of humus determinations in mixtures taken from different horizons.

formations (limestones, marls, loams, sandy loams, etc.). It may be added that at present cases have already become known in both Eastern and Western Siberia, where chernozem directly overlies shales, beresites, clays, sandy loams and loess.[1]

Finally, it was shown by Richthofen, Romanovskii[2] and Middendorf[3] that the Chinese and Turkestan loesses, famous for their fertility, are not covered by chernozem; chernozem is also absent from western European loess and the Nile silt. How, then, can loess be regarded as the sole and inevitable prerequisite for chernozem formation?

Let us now deal with the effect of climate on the Russian chernozem, in which I first became interested as early as 1877.[4] The subject is clear-cut, theoretically. Once accepting the mode of origin of the vegetal-terrestrial soils advanced by Ruprecht as correct, which is the case today, since herbaceous vegetation played a very important role in this process, the effect of climate on the vegetal-terrestrial origin of Russian soils is obvious.

Climate exerts an extremely varied influence, conditioning a) the nature of the vegetation (steppe flora, northern meadow flora, etc.), b) its amount (annual increment), c) the amount of vegetal mass annually decaying (on and under the surface), and finally d) the nature of the decay processes (acid and sweet humus).

Least important of the above aspects is the first one (a). Its role, for obvious reasons, is limited to its effect on the relative thickness of soils, as already seen (p. 286). Aspects (b), (c) and (d) are so important that two localities perfectly identical in physical properties will never have identical soils unless conditions (b) (c) and (d) are also identical.

All these propositions are so natural and logical that they require no special proofs. Nevertheless, for the sake of clarity I will present some general considerations on this subject.[5]

In the first place, let us stress that parent rock, however favorable it is in itself, however ancient and level of surface, once covered by glaciers or tundra, in a zone devoid of precipitation and extremely scanty or totally lacking in vegetation[6] is completely incapable of forming soils over tens, hundreds or thousands of years.

Let us imagine three localities, similar in conditions of ground, topography and age, and having become simultaneously inhabited by identical plants. One of these localities is situated in a zone of Russia with scanty precipitation and relatively excessive heat and light with prolonged summers and short winters, with a brief, vigorous vegetative period, where "sukhoveis" dry up the wells and parch the vegetation in 2—3 days,

[1] Dokuchaev. Po voprosu o Sibirskom chernozeme (Siberian Chernozem), p. 27 [No. 1]. 1882.

[2] Romanovskii G. [Geologicheskii i paleontologicheskii obzor Severo-zapadnogo Tyan' Shanya i yugo-vostochnoi chasti Turkestanskoi nizmennosti (Geological and Paleontological Review of the Northwestern Tien Shan range and the Southeastern Part of the Turkestan Lowlands). St. Petersburg]. — Material dlya geologii Turkestanskogo kraya. 1878.

[3] Middendorf. Ocherki Ferganokoi doliny (Description of the Fergana Valley). 1882.

[4] Dokuchaev. Itogi o russkom chernozeme (Results of the Studies of Russian Cher[noz]em). 1877. Present-day exponents of this opinion include Messrs Middendorf and Krylov.

[5] Detailed elaboration of this subject will only become possible in the distant future. I know of no present-day direct factual data regarding any of these conditions (b) (c) and (d).

[6] Territories with such characteristics do exist. Griesebach, vol. 1, p. 381, etc.

lacking forest, and with only a few rivers, and intense evaporation. The second locality is situated in a zone of Russia with relatively excessive moisture rich in forest and bogs, low temperatures, a winter lasting 6 — 7 months and a warm season of 3 — 4 months, very gradual evaporation, with the soil almost always fairly damp. The third locality is in a zone of Russia where climatic conditions are exactly intermediate between the two extremes. Our three hypothetical cases correspond fairly closely to a) northern Russia, b) extreme southern and southeastern Russia (see descriptions by Grossul-Tolstoi, Eversmann, Barbot de Marni) and c) the best (central) portions of the Russian chernozem zone. Obviously, there is an entire series of transitions between them.

It is certainly impossible for such essentially different conditions to give rise to identical vegetal soils, even if it is admitted, improbably, that the annual increment of vegetation will be equal everywhere. Obviously, in case (b) the amount of vegetation decaying on the surface and in the soil is incomparably larger than in case (a). It is even possible that the annual increment of wild vegetation is equal to its annual decrement, when the soil will be nearly totally devoid of humus, as in the extreme southeast of Russia. On the other hand, that humus which is somehow retained by the soil and derived from the decay of vegetation with free access of air and at relatively high temperatures will always be sweet.

On the contrary, in northern Russia the annual increment of vegetation must considerably exceed its decrement; owing to the short summer and generally low temperatures, considerable precipitation and frequent inundation of meadows even in summer, the small decrement of vegetation decays very slowly in the air and the soil. Moreover, northern humus will obviously differ in nature from southern humus; owing to the partial decay of the local vegetation and insufficient access of air into the moist soil the humus will be acid and will accumulate mainly in the form of peaty and bog-terrestrial masses.

Obviously, the climatic conditions are much more favorable for wild vegetation than in the central Russian chernozem zone, being free of both the excessive heat and the moisture deficiency which adversely affect south-eastern and part of southern Russia. This territory is also free of the excessive moisture and the warmth deficiency which cause the boggy soils of northern Russia. Thus, both the rate of vegetation decay and its nature should possess characteristics intermediate between the extreme south and the extreme north of Russia.[1]

In our opinion, the very strong influence of climate on the nature of the vegetal-terrestrial soils is based upon the following important facts:

1. The chernozem zone (as a whole) does not stretch along latitude lines, but consistently runs SW — NE, exactly paralleling the well-known isotherms, precipitation distribution and certain features of wild herbaceous and partly also arboreal vegetation.
2. The individual isohumus belts follow the same direction.

[1] This description of the climate in different zones of Russia is well known. It is also clear from the meteorological data found in the well-known works of Veselovskii, Kemets, Rykachev, Voeikov, and Wild. I summarized this information in a separate table (p. 57), and I shall neither repeat the table here nor supplement it. Meteorological data separated from their relationship to vegetative periods are not very helpful in the analysis of the subject.

3. The highest humus contents are found in soils in the exact middle of the chernozem zone. From this median line chernozem gradually and imperceptibly disappears toward the zone's northwestern and southeastern boundaries.

4. In some areas (e.g., the Tula Province), there is a remarkable correspondence between the variation in the character of the steppe flora and the gradual disappearance of chernozem.

Not one of these facts may be explained by the nature of ground, by relief, or by the country age.

Thus, the climate of European Russia may be assumed to have undergone no change throughout the entire long period of the formation of Russian chernozem to the present day.

Chapter IX

CONSTITUTION AND THICKNESS OF CHERNOZEM AND ITS RELATIONSHIP TO TOPOGRAPHY

The constitution of chernozem is directly related to its mode of origin. Indeed, once the principle that all vegetal-terrestrial soils are not peculiar independent rocks but are rather the upper horizons of the bedrock strata, more or less altered partly by vegetation processes and partly by different atmospheric agents, is accepted, it is readily understood that the constitutions of soils displays gradual transitions to the underlying rocks. Sections of the Tomashevka and Simbirsk[1] chernozem are proof of the truth of this statement. On the basis of these and a thousand other examples which I observed, the following schematic constitution was evolved: sod, 1 — 3 in [2.5 — 7.6 cm] thick, underlain by a perfectly uniform, usually finely-granular mass, dark in varying degrees. On virgin lands this mass is almost completely permeated by living and dead roots of herbaceous plants, especially in its upper portion; its average thickness is 1 — 1 1/2 ft [30 — 45 cm]. This (A) I designate as soil horizon. The soil horizon forms a gradual downward transition to the so-called transition horizon B, which often includes fairly pure, sometimes perfectly isolated portions of the upper and the lower horizons, and is intermediate between the soil horizon and the parent rock as regards a) situation, b) general structure, c) color, and d) chemical composition. Its thickness is also 1 — 1 1/2 ft [30 — 45 cm], and, similarly to the upper horizon, it forms a gradual downward transition — subsoil — to bedrock.

Obviously, the specific chemical and mineralogical character of the parent rock (which is considerably varied, as we have already seen) must and in fact does form special features in the constitution of the local chernozems. However, the detailed description of different corners of Russia, given above, clearly demonstrates that these local peculiarities do not affect the general nature of the constitution. This may also be regarded as the normal constitution of the vegetal-terrestrial soils in northern Russia, except that the individual horizons are considerably thinner. Thus, it becomes evident that our vegetal-terrestrial soils do not form any independent geological stratum.[2]

[1] See also below, section of soils at the Staraya Ladoga fortress.

[2] Prof. Borisyak's insight is praiseworthy. Contrary to the opinions held by Mr Kochetov, published in "Otchet o sostoyanii Khar'kovskogo universiteta za 1851 — 1852 gody" (Report on the Khar'kov University for 1851 — 1852), p. 15 [Khar'kov. 1852] and Mr Chernyaev (p. 290), Prof. Borisyak positively asserted, "There is no reason to assume the existence of several geological layers in chernozem" (ibid., p. 35). I should like to add that chernozem itself does not form an independent layer. Author.

For obvious reasons, this scheme is most clearly seen in soils on completely level areas.[1] On hilly areas one may always expect a certain measure of washing or deposition of soil elements and therefore the soils are not always normal in constitution.[2] The high degree of change sometimes observed in the ordinary properties of the Russian chernozem is best seen in Knyaginin (p.81), Merefa (p. 162), Maloarkhangel'sk (p.112) etc. It is thus obvious that any treatment of the normal properties of chernozem must limit itself to its normal constitution. Lack of observance of this simple truth has caused great losses of time, effort, and ingenuity.

The same origin and partly also the constitution of the vegetal-terrestrial soils enable us to assert that Russian chernozem and other vegetal-terrestrial soils may contain only those mineral remains and fossils which are also found in the parent rocks, such as diluvial boulders, Jurassic belemnites, silicified fragments of Cretaceous chalk, Triassic alabaster, etc. I say "may contain" but such remains are in fact rare. Besides the reports of Messrs Murchison, Borisyak and Sintsov cited above, I know of the following cases: I once found small boulders near Filonovo (p.227), and 2 grains of feldspar (by elutriation) in the Zaraisk and the Nezhin samples. "Peas" of smoky quartz and hornfels are much more common. Petzholdt saw a small bit of feldspar in the Tambov chernozem, as well as bits of sandstones and foraminifers; finally, "grains, apparently granites, were found in three places"[3] in Russian chernozem by Mr Kostychev. Such remains are not characteristic of Russian chernozem and their significance is far less than is usually assumed.

Organic remains of plants and terrestrial animals, which participated in the formation of chernozem, are either altogether absent or are so poorly preserved as to become unidentifiable. This last remark refers to those same famous phytolitharia so highly esteemed by Academician Ruprecht. According to Ruprecht, "Microscopic analyses of chernozem reveal no trace of plant tissues in its organic particles, while there is an abundance of phytolitharia commonly resulting from cereals; incinerated feathergrass is known to produce phytolitharia similar to those found in chernozem and carburized humus. The amount of phytolitharia and of amorphous humus usually increases a) as the soil becomes blacker and b) as the depth of sampling decreases."[4]

This fact was regarded by Ruprecht and by his followers as the main component of the theory on the origin of chernozem from steppe vegetation. At present, however, the fact is nearly worthless in this capacity. Latest microscopic analysis by P. Ya. Krutitskii[5], while confirming the presence

[1] I have therefore always tried to take soil samples a) from level areas and b) from all three horizons.

[2] In such areas I took samples either from the middle of the slope alone or also from its top and foot.

[3] Mr Kostychev remarked that the Russian "chernozems" (at least those he investigated) contain almost no unweathered anhydrous silicates. Kostychev. Dopolnitel'nye analizy... [obraztsov chernozema, issledovannykh Prof. K. Shmidtom] (Supplementary Analyses... [of Chernozem Samples Investigated by Prof. K. Schmidt]). – In the book: Fiziko-khimicheskie issledovaniya pochvy i podpochvy chernozemnoi polosy Evropeiskoi Rossii, No. 2, St. Petersburg 1881], p. 5. It should be added that there is no possible source for large quantities of such silicates in Russian chernozem; they are almost totally absent from chalk, Permian, Triassic and Jurassic limestones, and quite rare in southern loess. Author.

[4] Ruprecht. Ibid., p. 3.

[5] Krutitskii. Mikroskopicheskoe issledovanie chernozema (Microscopic Investigation of Chernozem). – [In book: Fiziko-khimicheskie issledovaniya pochvy i podpochvy chernozemnoi polosy Evropeiskoi Rossii, No. 2, St. Petersburg, 1881], pp. 30–31.

of phytolitharia in chernozem and the nature of their distribution (see (a) and (b) above), has also elicited the following two facts: 1) "Phytolitharia alone are insufficient for the identification of species and genera of extinct plants, since hardly any or indeed no distinctions are discernible... even the very relationship of phytolitharia to organisms is doubtful"; 2) phytolitharia have been found in the bog-terrestrial (meadow) soil in Rostov (Yaroslavl Province), where feathergrass steppes have never existed.[1] The thickness and color of chernozem are of similarly close genetic relationship to its mode of origin. These most characteristic properties of chernozem will be discussed below.

THICKNESS OF CHERNOZEM

The great significance of climate, vegetation, and parent rocks for the bodies being studied has been mentioned; the same soil formers will be proved to play the leading role in determining soil thickness.

It was pointed out, in Chapter VIII, that in respect to climate and wild vegetation, especially since these two factors influence the nature of chernozem soils, European Russia may be most conveniently divided into the following three regions: a) northern or chernozem, b) central chernozem, and finally c) extreme southern and especially southeastern marginal territories with chestnut and solonets soils. The same division applies to soil thickness.

The normal thickness of vegetal-terrestrial soils could not be discussed as long as they were not considered to be independent bodies, were confused with the underlying loose parent rocks or with arable land; the concept of their normal situation was not finally established, and observers recorded the soil thickness without considering its relationships to topography. The sum of these obstacles has caused attempts at establishing[2] normal thickness, even for chernozem alone, to fail. It should be added that those authors who attempted to determine the mean thickness of chernozem did not observe all the principal parts of the chernozem zone of Russia and for this reason they encountered difficulties in adopting a comprehensive approach to the subject.

At present, we possess a large body of quite accurate observations for the variety presented by the regions of Russia, and the problem of the thickness of vegetal-terrestrial soils may be finally solved.

Let us first examine data available in the literature prior to the beginning of my investigations.

Disregarding 5 or 6 reports on soil thickness which are certainly inaccurate or, more precisely, refer to abnormal soils, we may readily subdivide the remaining data according to the three above-mentioned regions, as follows: light-gray northern soils, chernozem soils of central chernozem Russia, and the chestnut or reddish soils of extreme southern and southeastern Russia.

These data, suitable grouped, will be found in the following tables.

[1] As has been seen there are even fewer chances of finding residues of arboreal plants in Russian chernozems. Animals will be discussed in the chapter "Age of Chernozem."

[2] Levakovskii. Materialy... (Materials...), pp. 24–28.

Thickness of chernozem soils at certain isolated points

Locality	Thickness, ft in [and cm]	Reference
Near Konotop	4'8" [142]	Borisyak. O chernozeme (Chernozem), p. 35. 1852.
Near Lokhvitsa	4'8" [142]	Ibid.
Zhuravka, near Smela, Cherkassy District	1'2" [35]	Gel'mersen. Gornyi Zhurnal, No. 6, p. 405. 1870.
1 verst from Zhuravka	2'4" [71]	Ibid.
"	4'8" [142]	"
"	2'11" [89]	" p. 407
3 versts south of Smela	2'4" [71]	"
Elisavetgrad, near Zlodeiskaya "balka"	3'6" [106]	" p. 413
Shishkov's estate, 22 versts from Elisavetgrad	4–5' [122–152]	" p. 415
Odessa	1'2" [35] (minimum)	Barbot de Marni. Geologicheskii ocherk Khersonskoi gub. (Geological Description of the Kherson Province), p. 2. 1869.
Zatish'e, 121 versts northwest of Odessa	2'4" [71]	Ibid. p. 34.
12 versts from Novomirgorod . . .	2'4" [71]	" p. 58
3 versts north of Elisavetgrad, at Balashovka	1'9" [53]	" p. 66
12 versts from the town of Nikolaev and 2 versts from Voskresensk . .	9" [23]	" p. 86
Efremov, at the bank of the Mecha River	2' [61]	Gel'mersen. Geognosticheskie issledovaniya devonskoi polosy srednei Rossii ot reki Z. Dviny do Voronezha (Geognostic Investigations of the Devonian Belt of Central Russia from the Western Dvina River to Voronezh), p. 43.
On the bank of Mokrye Yaly, Aleksandriya District	2' [61]	Kontkevich. Geologicheskie issledovaniya v granitnoi polose Novorossii, po vostochnuyu storonu Dnepra (Geological Investigations in the Granite Belt of Novorossia on the East Side of the Dnieper), pp. 126, 248–249, 254 and 295.
Troitskoe, on the Molochnaya River	2' [61]	
Spasskoe-Dubovoe, the same locality	1' [30]	
Furstenau colony,* in the basin of the Molochnaya River	2'4" [71]	
Novotroitskoe, on the bank of the Sukhaya Volnovakha, in the basin of the Kalmius River	4'2" [127]	
At Volochisk	4'8" [142]	Barbot de Marni. Geologicheskie issledovaniya v guberniyakh Kievskoe, Podol'skoe i Volynskoi (Geological Investigations in the Kiev, the Podolia and the Volynia Provinces), p. 68. 1872.
Muraevnya, Ryazan Province . . .	2'4" [71] 3–6' [91–183]	Barbot de Marni. Geologicheskie issledovaniya Ryazanskoi gub. (Geological Investigations in the Ryazan Province) pp. 199–200.
Ryazhsk	1–2' [30–61]	Pacht. Geognosticheskie issledovaniya v guberniyakh Voronezhskoi, Tambovskoi i dr. (Geognostic Investigations in the Voronezh, the Tambov, and in other Provinces), p. 168. 1856.

* [Obviously one of the agricultural "colonies" (settlements) founded by German immigrants. Translator.]

(Continued)

Locality	Thickness, ft in [and cm]	Reference
Near Berda	1'2"—4' [35—122]	Steven (see Levakovskii, ibid., p. 27)
Between Tsymlyanskaya "stanitsa" and Kamyshin	2'4" [71]	Levakovskii. Materialy dlya izucheniya chernozema (Materials for Studies of Chernozem), p. 28. 1871.
Between Rubezhnoe and Verkhnee Saltovo, on the right bank of the Donets	3'6" [106]	Ibid. p. 29
Between Kromy and Orel, at the village of Saltykovo	2'11" [89]	"
Ekaterinoslav	2'4"—3'6" [71—106]	" p. 30
Between Bulavino and Sadki, Bakhmut District	1'9" [53] 2' [61]	"
Right bank of the Khorol, near the villages of Gremyachaya, Popovka etc.	3'6" [106]	Borisyak. In: Sbornik materialov otnosyashchikhsya do geologii yuzhnoi Rossii, p. 134. 1867.
Village of Orlovka, on the Vorskla River	1' [30]	Ibid. p. 159
Pereshchepino, on the bank of the Orel River	2'8" [81]	Ibid. p. 208
Zavidovo, on the Byk River	1'9" [53]	Ibid. p. 195
At the village of Sergievka, on the Topila River	1'2" [35] (minimum)	Klemm. Geologicheskie issledovaniya mezhdu rr. Saksagan'yu i Kal'miusom (Geological Investigations between the Saksagan and Kalmius Rivers), p. 12.
Aleksandrovsk	2'4" [71]	Ibid. p. 19
Along the Zherebets River (tributary of the Konka River)	2'4" [71]	" p. 34
Near the village of [illegible]arovo . . .	1' [30]	Meller. Ocherk geognosticheskogo stroeniya yuzhnoi chasti Nizhegorodskoi gub. (Description of the Geognostic Structure of the Southern Part of the Nizhni Novgorod Province), p. 24. 1875.
Lukoyanov	1' [30]	Ibid. p. 26
Pochinki, Lukoyanov District . . .	1'6" [46]	" p. 29
Near Kendya, Lukoyanov District . .	1'6" [46]	" p. 30
Near Il'inskoe, Lukoyanov District	2' [61]	" p. 33
3 versts from Pochinki	1' [30]	" p. 34
At the village of Silino	1'6" [46]	" p. 42.
Near Shutilovo, Lukoyanov District	1' [30]	" p. 45
The village of Devichii Rukav . . .	3' [91]	" p. 49
Yamskaya Sloboda	1'6" [46]	" p. 52
Venyaevo	1' [30]	" p. 64
Ardatov	1'—1'6" [30—46]	" p. 65—66
Dipovka	1'—1'6"	" p. 75
40 versts northeast of Kazan	2' [61]	Ruprecht. Geobotanicheskie issledovaniya o chernozeme (Geobotanical Studies of Chernozem), p. 31.

(Continued)

Locality	Thickness, ft in [and cm]	Reference
Between Kazan and Malmyzh . . .	2' [61]	Ruprecht. Geobotanicheskie issledovaniya o chernozeme (Geobotanical Studies of Chernozem), p. 31.
Pichkasy	2' [61]	Ibid., p. 43
Simbirsk	3' 6" [106]	" p. 44
Ryazhsk	1—2' [30—61]	" p. 59
30 versts south of Tula	2' [61]	" p. 66
78 versts north of Glukhov	2—3' [61—91]	" p. 67
5—10 versts south of Novgorod-Seversk	4' 6" [137]	" p. 68
Novgorod-Seversk	4' [122]	" p. 68
At Ponornitsy	3' and more [91]	" p. 69
Sednev	2—3—5'	" pp. 69—71
Tambov	1' 7" [48]	Kulibin. Geognosticheskii ocherk Tambovskoi gub. (Geognostic Description of the Tambov Province), p. 141, 1870.
Village of Pady, on the Khoper River	1' 6" [46]	Sintsov. Geologicheskii ocherk Saratovskoi gub. (Geological Description of the Saratov Province), p. 141, 1870.
Between the villages of Khomutets, Popovka, etc., on the Khorol River	3' 6" [106]	Levakovskii. Issledovanie osadkov melovoi formatsii mezhdu Dneprom i Volgoi (Investigation of Cretaceous Sediments between the Dnieper and the Volga), p. 41.
Village of Mar'inskoe, basin of the Samara River	1' 2" [35]	Ibid., p. 62
Rostov-on-Don	2' [61]	" p. 94
Near Yablochkina "Sloboda" on the bank of the Devitsa River	1' 9" [53]	" p. 115
Lisich'ya Balka, on the Donets River	2' 4" [71]	" p. 139
Kozinki, Kozlov District	2' 4" [71]	Sovetov. O chernozeme iz putevykh zametok. Soobshchenie 23 sentyabrya 1876 (Chernozem. A Traveler's Notes. Communication of 23 September 1876), p. 6.
The same locality	3' 6" [106]	Ibid. p. 7
Vasil'evskii mine, Belebei District	1' 9" [53]	Wangenheim von Qualen. Bullet. de la la Soc. des natur de Moscou. 1845, No. 4, p. 406
2 versts from the previous observation	1' 2" [35]	Ibid.
At the Elizavetinskii mine	2' 4" [71]	"
Gordeevskii mine	2' 4" [71]	"
Bernutlinskii mine	1' 11" [58]	"
Durasovskii mine, Sterlitamak District	2' 4" [71]	"
Timashevo, Samara District (?), sample No. 1	3'5" [104]	
The same, sample No. 2	2' 10" [86]	
" No. 3	3' 4" [101]	
" No. 4	2' 10" [86]	Roth. Ibid., p. 431
" No. 5	4' [122]	
" No. 6	2' 10" [86]	
Between Perm and a point 9 versts to its east?	1' [30] (mean)	Bazilev. from a letter written to the author

(Continued)

Locality	Thickness, ft in [and cm]	Reference
1½ versts from Ufa	1' 11" [58]	Bazilev, from a letter written to the author.
At the village of Aibashevo, Birsk District, No. 1.	2'4" [71]	"
The same, No. 2	2' [61]	"
" No. 3	2' [61]	"
" No. 4	2' 6" [76]	"
Mean of all observations	2'4" [71]	"
Mean thickness of chernozem in districts or over major areas of provinces		
Southeastern, in some places also south western parts of the Nizhni Novgorod Province; black chernozem . . .	2'4" [71]	Khozyaistvenno-statisticheskie materialy, sobiraemye kommissiyami i otryadami uravneniya denezhnykh sborov s gosudarstvennykh krest'yan (Economic-statistical materials collected by Commissions and Groups for the Equalization of Money Taxes from Government-Owned Peasants), No. 2, pp. 8—9. 1877.
Black-gray and black-brown chernozem	1'4" [40]	
The Tetyushi, the Tsivil'sk, the Sviyaga and the Yadrin districts; black and gray chernozem	2'8" [81]	Materialy dlya statistiki Rossii, sobiraemye po vedomstvu Ministerstva gosudarstvennykh imushchestv (Materials for the Statistics of Russia Collected by the Ministry of Government Estates), No. 4, pp. 1—2 and 10. 1861.
The Chistopol and Spassk districts; black sandy chernozem	1'9" [53]	
Good black chernozem of the northern half of the Samara Province . . .	2'4" [71]	Ibid., No. 3, pp. 3—5
Gray or brown chernozem, mainly in the central and partly also in the southern belts of the Samara Province	1'3" [38]	
Gorodishche and Korsun districts	about 3' [91]	Wangenheim von Qualen. Beiträge zur Kenntniss der schwarzen(?) Erde in Russland. 1853, S. 5.
Khvalynsk, Vol'sk, and Syzran districts, south of the Syzran River, on level areas and very gentle slopes, on chalky and marly subsoil.	2' [61]	Bogdanov. Ptitsy i zveri chernozemnoi polosy Povolzh'ya (Birds and Mammals of the Chernozem Belt of the Volga Area), pp. 18—19. 1871.
Flat plains of the Balashov, Buinsk and the Simbirsk districts	5' 6" (maximum 6 ft) [167—183]	Ibid. p. 20—24
Elevated plain in the northwest of the Kamyshin, in the southwest of the Atkarsk and in the eastern half of the Balashov District	5' 10" (maximum 6 ft.) [176—182]	Ibid. p. 23

(Continued)

Locality	Thickness, ft in [and cm]	Reference
Water divide between the Volga and the Sviyaga, from the town of Simbirsk to the Kazan Province, as well as part of the latter between the Kama, Vyatka and Volga rivers, on Permian formation	about 1' [30]	Bogdanov. Ptitsy i zveri chernozemnoi polosy Povolzh'ya (Birds and Mammals of the Chernozem Belt of the Volga Area). pp. 24–25. 1871.
Between the upper reaches of the Ilovlya and Medveditsa rivers, in the steppe . .	2' [61]	Ibid. p. 22
West of the Tereshka River, the strip adjacent to the river, on fairly level areas	2'8" [81]	" p. 22
Granite belt of Novorossia, east of the Dnieper	about 3'3" [98]	Kontkevich. Ibid., pp. 258–260 and 315–316.
Basin of the Molochnaya River, from 53 observations [1]	2–2'6" [61–76]	
Between Balta and Ol'viopol	up to 4'8" [142]	Barbot de Marni. Geologicheskii ocherk Khersonskoi geb. (Geological Description of the Kherson Province). p. 51. 1869.
Orenburg Province, between the Sakmara and Ural rivers, in lowlands	2'3" [69]	Zapiski Russkogo geograficheskogo obshchestva, Book VI, p. 410, 1852.
Between the Sakmara and Ik rivers, on plains	3' [91]	
Melitopol District	up to 3'6" [106]	Levakovskii. Materialy dlya izucheniya chernozema (Materials for Studies of Chernozem) p. 27. 1871.
The steppe Crimea		
Stavropol Province, in the foothills of . .	2' [61]	Ibid.
the Caucasus	1'2" [35]	"
The Zemlyansk and the southern parts of the Elets and the Livny districts . .	4'1" [124]	Semenov. Pridonskaya flora (The Don Flora) p. 33. 1851.
Between Zaraisk and Voronezh	3' [91]	Güldenstädt. Reise. 1851, I. S. 33.
Between Voronezh and Tambov . . .	4' [122]	Ibidem, S. 3, 61.
From Chern to Orel and Kromy	up to 2' [61]	Ruprecht. Ibid., p. 66
Tambov Province	2'4" [71]	Bunin (see Levakovskii). Ibid.
Epifan District	about 2'6" [76]	Protopopov. —Zemledel'cheskii zhurnal Moskovskogo obshchestva sel'skikh khozyaev, No. 2, p. 188. 1837.
Many districts of the Tambov Province .	up to 3'6" [106]	Pacht. —Vestnik Russkogo geograficheskogo obshchestva, part VIII, book VII, p. 94. 1853.
Southern and southeastern parts of the Kursk Province	3'6" [106]	Zhurnal Ministerstva gosudarstvennykh imushchestv, part 37, p. 102. 1850.
The Piryatin, the Priluki, the Romny, the Konstantinograd, the Khorol, and partly the Migorod districts	3'5" [104]	Ibid., part 16, p. 225. 1845

[1] Altogether, Mr. Kontkevich reported 55 observations, but I have omitted two of them since they obviously refer to abnormal chernozem, reaching 10 ft [3 m] in thickness. Author

(Continued)

Locality	Thickness, ft in [and cm]	Reference
Slavyanoserbsk District	1'7" [48]	Zhurnal Ministerstvo gosudarstvennykh imushchestv, part 37, p. 206. 1842.
Saratov Province	2' 4" [71]	Krylov. Sovremennoe sostoyanie voprosa o chernozeme (Current State of Our Knowledge of Chernozem), p. 5.
Southern part of the Ryazan Province (southern parts of the Sapozhok and the Ryazhsk districts, nearly the entire Ranenburg District, most of the Dankov District, southern and western parts of the Skopin District and the southwestern margin of the Mikhailov and Pronsk districts)	2'4" [71] (mean)	Obzor i rezul'taty rabot Ryazanskogo gubernskogo zemstva po otsenke predmetov zemskogo oblozheniya (Review and Results of the Work Undertaken by the Ryazan Provincial "zemstvo" on the Evaluation of the Objects of "zemstvo" Taxation), pp. 57–58. 1877.
Chernozem belt immediately adjoining the previously mentioned locality on the north	1'2" [35]	Ibid. p. 59
In many localities of the Zaraisk, Pronsk, and other districts of the Ryazan Province	1' [30]	" p. 61
Southern part of the Kozelets District, Chernigov Province	3'6" [106]	Chervinskii. Materialy dlya otsenki zemel'nykh ugodii Chernigovskoi gubernii, tom V, Kozeletskii uezd (Materials for Land Valuation in the Chernigov Province, vol. V, Kozelets District), p. 22. 1882.
Mean of all observations	2'8" [81]	
Mean thickness of chernozem calculated for samples taken from more than one province		
Mean thickness of chernozem in general	1'6" [46]	Zhurnal Ministerstva gosudarstvennykh imushchestv, part 52, pp. 95 and 102. 1853–1854.
The same	2'4" [71]	Borisyak. O chernozeme (Chernozem), p. 35. 1852.
The same	2' [61]	Roth. Ibid., p. 426
Mean thickness of chernozem for the central chernozem zone (the Kiev, Poltava, Voronezh, Tambov and other provinces)	3' [91]	Sovetov. —Trudy VEO, vol. 2, pp. 284, 293. 1877.
Mean thickness of chernozem in general	2' [61]	German. —Zemledel'cheskii zhurnal Moskovskogo obshchestva sel'skikh khozyaev, No. 1, p. 48. 1837.
The same	2'7" [78]	Huot. Voyage dans la Russie mérid. II, p. 462.
The same	3'6" [106]	Kochetov. Otchet Khar'kovskogo universiteta (Report of the Kharkov University), p. 18. 1852.
The same	less than 3' [91]	Ruprecht. Ibid., p. 67
Mean thickness of chernozem along the Volga, Don Rivers, etc.	2'6" [76]	Dr. Orth. Ibid., p. 37

(Continued)

Locality	Thickness, ft in [and cm]	Reference
Mean thickness of chernozem in general	2' 6" [76]	Middendorf. Ocherki Ferganskoi doliny (Description of the Fergana Valley), p. 4. 1882.[1]
Mean of all results	2' 5" [74]	
Thickness of northern light-gray vegetal-terrestrial soils at certain points		
Kovel	3—4" [7—10]	Karpinskii. —In: Nauchno-istoricheskii sbornik Gornogo instituta, pp. 55 and 58. 1873.
Between Vladimir and Suzdal	8" [20]	Ruprecht, ibid., p. 93.
At the village of Dubovik, on the right bank of the Volkhov River	2" [5]	Ibid., p. 98
Kovrov	6" [15]	" p. 94
Near the village of Surki on the Msta River	4½" [11]	" p. 102
Arzamas, on the bank of the Tesha River	10" [25]	Meller. Ocherk geologicheskogo stroeniya yuzhnoi chasti Nizhegorodskoi gubernii (Description of the Geological Structure of the Southern Part of the Nizhni Novgorod Province), p. 6. 1875.
Mean of all results	5—6" [13—15]	
Mean thickness of the northern light-gray vegetal-terrestrial soils for entire provinces or major areas of them		
Nizhni Novgorod Province, mainly northern and western portions:		
a) "Paglinok", or poor chernozem (?), of brown or gray color	6—9" [15—23]	Khozyaistvenno-statisticheskie materialy, sobiraemye komissiyami i otryadami urovneniya denezhnykh sborov s gosudarstvennykh krest'yan (Economic-statistical Materials Collected by Commissions and Groups for the Normalization of Money Taxes from Government-Owned Peasants), No. 2, pp. 8—9. 1857.
b) Good nonchernozem of dark brown color	7—12" [18—30]	
c) Good nonchernozem of dark gray color	5—9" [13—23]	
d) Medium nonchernozem of brown or gray color	4—10" [10—25]	
e) Poor nonchernozem of light colors	3 1/2—7" [9—18]	
Kazan Province, its northern and partly also its southwestern belts:		
a) "Paglinok" - chernozem (?) . . .	5—9" [13—23]	Materialy dlya statistiki Rossii, sobiraemye po vedomstvu Ministerstva gosudarstvennykh imushchestv (Materials for Russian Statistics Collected by the Ministry of Government Estates), No. 4, pp. 2—3, and 10. 1861.
b) Sandy nonchernozem of light-gray color	3—7" [8—18]	
c) Brown clayey and gray loamy nonchernozem	5—9" [13—23]	
d) Loamy nonchernozem of dark-gray color	7—10" [18—25]	

[1] Although Mr. Middendorf's numerical result completely coincides with the result I gave as early as 1878 (Predvaritel'nyi otchet o poezdke v yugo-zapadnuyu chernozemnuyu Rossiyu (Preliminary Report on the Excursion to Southwestern Chernozem Russia)), he must have arrived at his result independently. Autho..

(Continued)

Locality	Thickness, ft in [and cm]	Reference
Whitish loamy soils of the Vetluga and the Varnavino districts and partly also of the Kologriv District of the Kostroma Province	8—10" [20—25]	Materialy dlya statistiki Rossii, sobiraemye po vedomstvu Ministerstva gosudarstvennykh imushchestv (Materials for Russian Statistics Collected by the Ministry of Government Estates), No. 4, p. 50. 1861.
Elevated, rolling, dry and clayey territories in certain parts of the Zaraisk Ryazan, Sapozhok and Pronsk districts of the Ryazan Province	8—10" [20—25]	Obzor i rezul'taty rabot Ryazanskogo gubernskogo zemstva po otsenke predmetov zemskogo oblozheniya (Review and Results of the Work Performed by the Ryazan Provincial "zemstvo" for Valuation of the Objects of the "zemstvo" Taxation), pp. 62—63. 1877.
Vegetal-terrestrial soils of the Ryazan Province on the left side of the Oka River	5—7" [13—18]	Ibid., pp. 66—71
Vladimir Province		
Sandy soils	5" [13]	
Sandy-stony	5" [13]	
Loamy and sandy-loamy	5—7" [13—18]	
Marly	5" less frequently 7" [13; 18]	Ibid., No. 5, pp. 13—11.
Clayey	5—9" [13—23]	
The Zaraisk, Pronsk, Egor'evsk, Ryazan, Kasimov, and Spassk districts . . .	7—10" [18—25]	Sokolov. Materialy dlya khozyaistvennoi statistiki Rossii (Materials for the Economic Statistics of Russia), pp. 103—105. 1853.
Frequently between Ardatov, Arzamas, and Lukoyanov, as well as west of Arzamas on elevated areas	2—5" [5—13]	Ruprecht. Ibid., p. 49
Western part of the Kursk Province, most of the L'gov and Dmitriev districts and part of the Ryl'sk and Putivl districts	7—8" [18—20]	Zhurnal Ministerstvo gosudarstvennykh imushchestv, part 37, p. 103. 1850.
Vegetal-terrestrial soils of the nonchernozem zone of Russia	4—5" [10—13]	Sovetov. Soobshchenie 14 yanvarya 1877 (Communication of 14 January 1877), p. 5.
Mean of all observations	6—7" [15—18]	

Thickness of soils in extreme southeastern Russia

Village of General'skoe, Novouzensk District, 6 versts from the Volga	10" [25]	Sagatovskii [1]
Chernyi Yar	6" [15]	Bobrov [2]
The Kalmuk steppe	thinner than 6" [15]	Barbot de Marni. Ibid.
Southern part of the Orenburg Territory	thinner than 6" [15]	Eversmann. Ibid.
Southern part of the Samara Province	8" [20]	Matrialy dlya statistiki Rossii, sobiraemye po vedomstvy Ministerstva gosudarstvennykh imushchestv (Materials for Russian Statistics Collected by the Ministry of Government Estates), No. 3, pp. 20—23. 1861.
Mean	about 7" [18]	

[1] and [2] From written communications. Author.

A comparison of all these tables actually shows that all the vegetal-terrestrial soils of Russia must be divided into three groups at least as regards their thickness. It is extremely instructive that in spite of the heterogeneous nature of the first three tables, they all indicate nearly identical chernozem thickness, 2 ft 4 in — 2 ft 8 in [71 — 81 cm]. The following two tables also give a thickness of 5 — 7 in [13 — 18 cm] for the northern sod soils, whether taken as a mean of certain isolated points or for whole districts and provinces. According to literature, approximately the same thickness of about 7 in [18 cm] must also be ascribed to soils of extreme southeastern Russia.

In order to invest these numerical data with a still more general character and therefore added significance, a summary of my observations, based on direct measurements, is given below.

The three tables on the following pages make it clear that, according to my observations, soils of southeastern and northern Russia should increase in mean thickness by as little as 1 — 2 in [2.5 — 5 cm], while the thickness of chernozem proper must be diminished by 4 — 5 in [10 — 13 cm], reaching 2 ft 2 in [66 cm]. This is the thickness recognized as normal mean of the different vegetal-terrestrial soils of Russia.

The very significant difference in the general thickness of the [different] soils is a result of a correspondingly general cause, such as vegetation and climate.

Obviously, the agents influencing the thickness of soils are not limited to vegetation and moisture. It is clear from the table on p. 354 that the difference between the thicknesses of chernozems east and west of the Oka and Donets rivers may reach 10 in [25 cm]; my own observations elicited an even greater difference between the maximum thicknesses of soils in northeastern chernozem Russia and southwestern Russia. For instance, all along the left bank of the Volga in the Kazan and the Samara provinces and partly also in the Orenburg Province I only once encountered soil 3 ft 11 in [119 cm] in thickness, once a soil of 3 ft 4 in [101 cm] and three soils 3 ft [91 cm] in thickness; on the territory between the Dnieper and Dniester rivers, thicknesses exceeding 4 ft [1.2 m] were observed four times, at Tsvetkova thicknesses reaching 4 ft 6 in [1.37 m], Tomashevka — 4 ft 6 in [1.37 m], Smela — 4 ft 2 in [1.25 m] and Elisavetgrad — 4 ft 8 in [1.4 m].[1]

Obviously, this characteristic difference in thickness of soils in northeastern and southwestern Russia can be explained neither by climate nor by vegetation, since the differences between these two soil formers are not so pronounced. The nature of parent rocks is thus undoubtedly the principal cause of the phenomenon.

As has been mentioned (pp. 201 — 203) the thickest soils of southwestern Russia lie on ground with highest sand content. The same is entirely applicable to eastern Russia, as may be seen from samples taken at Chasovnya (3 ft 11 in [119 cm]), Khryashchevka (2 ft 4 in [71 cm]), Dukhovnitskaya (2 ft 4 in [71 cm]) and Buzuluk (2 ft 9 in [84 cm]). The reader, recalling our description of the Trans-Volga territory, will note that these samples were among the thickest, while their humus contents were only 4 — 5%; all these soils are sandy-loamy. Therefore, in this case, the cause clearly lies in the ground. It may be added that Mr. Barakov's experiments, described above, directly show humus to percolate more rapidly and deeply in a looser, more sandy mixture. All this was only to be expected.

[1] 4 ft 8 in [142 cm] should be recognized as the highest thickness ever observed for vegetal-terrestrial soils of normal situation.

Chernozem

Locality	Thickness, ft and in [and cm]	Source
Left bank of the Volga, beginning with the Kama River, from 50 observations	2' [61]	Dokuchaev and Solomin
Right bank of the Volga, to the Oka and Donets rivers, from 78 observations	1' 10" [55]	The same
Between the Oka, Donets and Dnieper rivers, from 23 observations	2' 7" [79]	Dokuchaev and Kytmanov
Between the Dnieper and Dniester rivers, from 35 observations	2' 11" [89]	The same
Northern seaboards of the Black and Azov seas, and the area of the Don River, from 20 observations	1' 9" [53]	Dokuchaev and Solomin
Caucasus, Territory of the Kuban Cossacks, and the Crimea, from 18 observations	1' 7" [48]	The same
Mean	about 2' 2" [66]	

Northern light-gray vegetal-terrestrial soils

Locality	Thickness, in. [and cm]	Reference
Urzhum	7" [18]	Solomin
3 versts from Polyanki	6" [15]	Dokuchaev
15 versts south of Kazan	7" [18]	"
8 versts from Burunduki	8" [20]	"
Vladimir-on-Klyaz'ma	9" [23]	"
5 versts south of Lyskovo	7" [18]	"
1—1½ versts south of Ardatov	8" [20]	"
4 versts north of Rabotki	6" [15]	"
Chernukha	8" [20]	"
3 versts southeast of Slobodskoe . . .	5" [13]	"
Milyukovo, Sychevka District	8" [20]	"
Petrovsko-Razumovskoe	10" [25]	"
Kolomna	8" [20]	"
Zaraisk	9" [23]	"
12 versts south of Zaraisk	10" [25]	"
14—15 versts southwest of Kaluga . .	10" [25]	"
2 versts before Rogovichi	10" [25]	"
4 versts after Rogovichi	9" [23]	"
Between Saburovshchina and Meshchovsk	10" [25]	"
2 versts from Mekhovskaya	9" [23]	"
1 verst from Yurinskaya	10" [25]	"
Fedenskoe	10" [25]	"
8 versts before Bolkhovo	10" [25]	"
5 versts after Raspopovo	9" [23]	"
5 versts before Novorobskaya	1' [30]	Kytmanov
5 versts before Novgorod-Seversk . . .	10" [25]	"
Kiev	9" [23]	Dokuchaev
Between Kiev and Vasil'kov	6" [15]	"
Karacharovo, Murom District	7" [18]	"
Kovarditsy	4—5" [10—13]	"
Smolensk	6" [15]	"

(Continued)

Locality	Thickness, in [and cm]	Reference
Vyaz'ma	7" [18]	Dokuchaev
Orsha	8" [20]	"
Vitebsk	7" [18]	"
Velizh	4–6" [10–15]	"
Ulla	8" [20]	"
Sychevka	7" [18]	"
Vilnius	8" [20]	"
Dorogobuzh	5" [13]	"
Dinaburg	7" [18]	"
Volkhov River at Starya Lagoda . . .	6" [15]	"
Bab'i Gony, near Peterhof	6" [15]	"
Tret'e Pargolovo	7" [18]	"
Teriokki, Finland	6" [15]	"
Kirka-Jarvi (Yarvi), Finland	5" [13]	"
Environs of Imatra	8" [20]	"
Mean	7–8" [18–20]	"

Southern chestnut soils

Locality	Thickness, in [and cm]	Reference
Novouzensk	5–6" [13–15]	Dokuchaev
3 versts after Gofental	8" [20]	"
9 versts from Gnadendorf	9" [23]	"
Proleika, Tsaritsyn District	9" [23]	"
Zapadnovskaya, Tsaritsyn District . .	9" [23]	"
Gorodishche, Tsaritsyn District . . .	11" [28]	"
Tsaritsyn	9–10" [23–25]	"
Tsymlyanskaya "stanitsa"	9" [23]	"
Between Kalach and Tsaritsyn . . .	6–8" [15–20]	"
Mean	8–9" [20–23]	"

I am quite certain that this particular complex of conditions, relatively favorable for formation of thick soils, may also provide us with an explanation for the abnormally thick vegetal-terrestrial soils which are indicated for three or four points in northern Russia: soils of the Borovskii mound, at Kolomna, 3 versts from Kashira, and at Serpukhov, where Ruprecht found isolated plots of "gray or ashy-gray soil" ranging between 1 1/2 – 3 ft [45 – 91 cm] in thickness.[1] Indeed, Ruprecht himself designates the soil taken at Kolomna and at the Borovskii mound as "sandy chernozem".

Identical composition must also be assumed for the last two samples, unless the soils of Kashira and Serpukhov are assumed to be of purely deposited character.

Even more characteristic in this respect are the two cases observed by Wangenheim von Qualen and myself in the Ostsee Territory. Wangenheim

[1] Ruprecht. Ibid., pp. 62–63.

von Qualen wrote[1] as follows: "My estate in the Livland Province is on the seashore; its subsoil is formed by the young Recent dune (?) formation consisting of granite (pebbles and boulders) and barren (?) loose sand. However, over more than a hundred years of manuring black soil formed often reaching 2 ft [61 cm] in thickness, indistinguishable from chernozem in appearance, especially in the gardens." Wangenheim von Qualen reports the occurrence of similar soils in places, especially often in gardens, and in many other parts of the Russian Baltic Provinces.[2] In order to give a more accurate idea of such soils, those cases which I investigated, occurring in the immediate neighborhood of Hapsal, will be described.

The bedrock formation of Hapsal is composed of limestone strata of the Lickholm stage of the Silurian formation. In certain places such as at the farm and the forest belonging to Mr. Gunius, these strata emerge on the surface forming a very thin soil, 3, 6 or 8 in [8, 15, or 20 cm]. This soil consists mainly of fairly large (1, 2, or 3 in [2.5 — 7.5 cm]) completely unweathered limestone fragments, and partly of marly red-brown particles and a mass of very slightly decomposed plant residues, arboreal or herbaceous. Fields with such soils are extremely fertile and highly valued by practical farmers if they contain boulders of various feldspar rocks, usually granite. The disintegration of these rocks yields large quantities of weathering products which are agriculturally very valuable. Obviously, these soils often contain fragments and grains of such rocks as well as individual minerals such as feldspar, mica, quartz, hornblende, and even granite and crystals of lime feldspar.

The soils overlying till — glacial formations in the environs of Hapsal, sometimes covering limestone strata of the Lickholm stage, differ in character. As throughout Russia, this till consists mainly of sandy clay with large admixtures of different crystalline boulders and pebbles as well as fragments of local bedrock of varying dimensions. The latter admixture is especially abundant at Hapsal, and therefore the till itself is often marly. Soils overlying such glacial formations are extremely varied, for obvious reasons, but they always have the following common features which contrast with the properties of the former kind of soils; they contain less $CaCO_3$, are somewhat thicker, reaching 8 — 10 in [20 — 25 cm] and always more sandy.

The third type of Hapsal soils includes those overlying sandy deposits of the Baltic Sea. Such formations, sometimes reaching 2 — 3 sazhens [4.3 — 6.4 m] in thickness lie in the immediate neighborhood of Hapsal; the Hapsal cemetery lies on such soils. which also stretch inland along the road to Weissenfeld. Here, near the Jurgens summer place, these deposits are visible, directly overlying Silurian limestone.

Between the cemetery and the old windmill there are pits as much as 1 1/2 — 2 sazhens [3.2 — 4.3 m] deep. The walls of these pits consist of extremely fine sand with no noticeable packing. Nevertheless these sands are certainly of marine origin, since mollusks still inhabiting the waters of the neighboring sea were first found in them by Eichwald. I also found a whole specimen of *Cardium edule* and a fragment of *Mitilus* with hydrochloric acid magnifying lens. The bulk of these sands was found to

[1] and [2] Wangenheim von Qualen. Ibid., pp. 3-5.

consist of calcium carbonate dust and extremely fine quartz grains; feldspar grains discernible by naked eye are very rare; characteristically, they become more common toward the surface, on which several boulders of granite and other feldspar rocks are found.

On these walls I saw an excellent soil section 1 ft 8 in [50 cm] thick. The soil, upon taking the samples, appeared fairly dark, identical in color to medium-quality chernozem. When the samples dried, their color turned out to be gray, their humus brownish and apparently far from the complete carburization which is the usual case in chernozem.

I observed a similar soil, although with an appreciably larger content of feldspar grains, at the Jurgens summer place, where it reaches as much as 2 ft [61 cm] of thickness.

Comparison of the compositions and thicknesses of the three types of Hapsal soils described above reveals that both the Hapsal sandy soil and the soils described by Wangenheim von Qualen mainly owe their thickness to the peculiar structure and possibly also the chemical composition of the parent rock. This phenomenon may hardly be ascribed exclusively to prolonged cultivation and intensive manuring, as thought by Wangenheim von Qualen. The inevitable question in such a case would then be why all the rest or at least a good part of soils in the Ostsee Territory and in Western Europe do not reach such thicknesses.

Unfortunately, we do not yet know which sand (feldspathic, calcareous, quartz, etc.) admixed in what proportion is most favorable for thickening of soil, neither do we know whether a given admixture will yield identical results under all climatic and vegetative conditions.

Nevertheless, it is already known that a mixture of more than 20% quartz sand insoluble in 33% HF results in an extremely thin soil with an insignificant humus content. Suffice it to mention soils from Berezovka, Buzuluk District, with a thickness of 10 in [25 cm], containing only 1.7% humus, found in a deep-chernozem locality!

This phenomenon is obviously caused by the composition of the Berezovka soil which, while not hampering humus percolation, was responsible for its small increment and rapid decay in both the air and soil.

Most vivid is that relationship between soil thickness, and relief and, to a certain extent, also with the relative altitude of the terrain. We shall now discuss this aspect of the subject.

The general effect of altitude on the character of vegetal-terrestrial soils and on their thickness is much more complex than was previously assumed. This was the main cause for our unsatisfactory knowledge of this relationship.

A sharp distinction must first be drawn between the effects of the absolute and the relative (so to say topographic) altitudes.

As far as is known, Eversmann was the first, in 1840, to point out the significance of the absolute altitude in this respect, with reference to the Orenburg Territory. In his work, mentioned above, Eversmann wrote[1] that "the nearer to the (Urals) mountains, the higher the steppe and the thicker the layer of chernozem; the farther (from the mountains) south and west, the lower the steppe and the thinner the rich layer; chernozem finally disappears completely, whereupon the barren steppe is covered

[1] Eversmann. Ibid., pp. 53–54, etc.

only by solonetsic silt. The more fertile a steppe, the nearer it is to the foothills and the more luxuriant its vegetation, and vice versa."

Murchison expressed a diametrically opposed view in 1845, having encountered this soil at all altitudes and levels in the course of his travels in European Russia; he arrived at the conclusion that absolute altitude is irrelevant to chernozem.[1] Subsequently, mainly on the basis of Murchison's work, Academician Ruprecht again reverted to Eversmann's opinion although unfamiliar with his work. Having assumed, mainly on the basis of the distribution of northern boulders, that the chernozem part of Russia is more ancient than its nonchernozem part, and assuming the former to have already been dry land while the latter, south and north of the chernozem zone, was still above sea level, he arrived at the natural conclusion that chernozem soils lie higher than nonchernozem soils, that the thicker the soil the older it is and the higher its absolute altitude.

In this general form Ruprecht himself doubted the conclusion, since the Valdai Heights, containing typical northern soils, were then already known to lie much higher than many definite chernozem areas in Russia. Ruprecht explained this inconsistency by the relatively rapid uplift of the Valdai[2] area, and continued to apply his conclusion in the comparison of chernozem soils with soils of extreme southern and southeastern Russia. He formulated one of these ideas as follows: "Under identical conditions and circumstances,[3] the thicker the chernozem, the older the country;[4] as the area becomes uplifted, the chernozem layer becomes thicker; there is no chernozem in low-lying areas although its formation continues."[5]

Academician Ruprecht, besides referring to the absence of chernozem on alluvium and to soils of the Borovskii mound near Moscow, Novgorod-Seversk and the Desna (which is in fact irrelevant, as will be seen further on), supported these statements with the following data:

"Chernozem has not yet formed on the immediate outskirts of the Black Sea... It is absent throughout the Pontian-Caspian country" which in the distant past stretched, according to Ruprecht, along the left bank of the Volga as far as Spassk..."In general, chernozem begins in European Russia and West Siberia only at altitudes of 60 — 80 sazhens (420 — 560 ft) [128 — 171 m].[6]

This view was later upheld and regarded as especially significant by Prof. M.N. Bogdanov and Messrs Voeikov[7] and Balkov.[8] The last two authors presented no new facts, while Prof. Bogdanov did advance several. After reviewing the general distribution of soils on the right bank of the Volga (p.220), he ended his description in the following manner:

[1] Murchison. Geologiya Rossii (Geology of Russia), p. 541. Ibid. [Murchison. Issledovaniya o chernozeme vnutrennikh gubernii Rossii (Studies of Chernozem in the Inner Provinces of Russia)]. – Zhurnal Ministerstvo gosudarstvennykh imushchestv, part 7, [No. 3], p. 123. 1843.

[2] Ruprecht, p. 26.

[3] The author certainly did not imply the climate in these circumstances (p. 11) or the nature of parent rocks (p. 18), except for loose sands and solonchaks. Most probably, Ruprecht mainly implied absence of forests and bogs.

[4] Ruprecht. Ibid., p. 26.

[5] Ibid, p. 28.

[6] Ibid., pp. 10, 23 and 24.

[7] Trudy S.— Peterburgskogo obshchestva estestvoispytatelei, pp. 265 — 290, Nov. 1881.

[8] Journal "Sel'skoe Khozyaistvo i Lesovodstvo", vol. 12, pp. 83 — 86, 1880.

Beginning approximately with 52°N (slightly north of Saratov), "clayey sagebrush steppes already appear in the lower portions of the slopes", and the southern boundaries of the chernozem region occur farther south, in which direction, "chernozem retreats more and more to the higher portions of the slopes and to hill crests; the lower portions of the slopes are clayey and overgrown with sagebrush, and true solonchaks with salt efflorescences on the surface occur in places in river floodplains. Still further south, chernozem disappears, and is replaced on ridges by brown clay impregnated with humus. The last distinct traces of chernozem disappear under the latitude of 49° (slightly north of Kamyshin)". Generally speaking, "areas with less than 200 m absolute altitude are clayey, with weak chernozem development."[1]

Thus, Bogdanov raised the lowest altitude of the occurrence of chernozem in the Volga area by another 100 ft [30 m] in comparison to Ruprecht.

Finally, last year (1882) Mr Chervinskii, who divides the Kozelets District (Chernigov Province) into two parts — the low-lying, boggy, forested northern nonchernozem part, and the elevated, treeless, chernozem southern part[2] — continued as follows: "The chernozem layer is 1—2 arshins [0.7—1.4 m] thick throughout, its thickness increasing with height, corresponding with Ruprecht's observations. The thickest chernozem layer, which contains the darkest chernozem, is found in the middle of the district's chernozem belt (according to the author, this is also the most elevated part)."[3] This phenomenon is so marked and so widespread here that the farmers never confuse upland chernozem with lowland chernozem (known as chernozemic solonets or solonetsic "pripad").[4]

These are all the known factual data to substantiate this very close relationship between absolute altitude and thickness of the Russian chernozem. The argumentation is very closely linked to Messrs Ruprecht's and Bogdanov's wish to prove the relatively ancient age of the chernozem territory.

Unfortunately, I cannot agree with either one of them. It is quite obvious that any two given points emerging simultaneously from under sea level, identical in physicochemical composition and topographic situation, inhabited by identical vegetation and affected by identical climatic conditions must have identical soils. It is also obvious that the first area which becomes dry land and is inhabited by vegetation will of necessity have soil better in all respects[5] than will areas which remained under water for a longer time (assuming all the other soil formers to remain identical). Mr Ruprecht's principles that the higher areas should also have thicker soils will apply if the areas being compared are raised above sea level at the same rate.

[1] Bogdanov, pp. 21—22, 27—28.

[2] Chervinskii. — Materialy dlya otsenki zemel'nykh ugodii [sobrannye Chernigovskim statisticheskim otdeleniem pri gubernskoi zemskoi uprave] Chernigovskoi gubernii, vol. 5. Kozelets uezd, [Chernigov], p. 21. 1882.

[3] Ibid., p. 22.

[4] Ibid., pp. 27, etc.

[5] This is also true only up to a certain point.

However, not one of these objections (except for the one regarding loose sands) was disproved by the proponents of this view, who did not bother to refute but simply ignored them.

Yet we have already seen that all these conditions are at least as significant in soil formation as is the age of the country. This argument alone is sufficient to prove that the view held by Academician Ruprecht and his followers cannot withstand criticism. The factual substantiation of their view is even weaker, as noted by Prof. Levakovskii.[1]

Indeed, if one is bent on comparing the thicknesses of all chernozems without differentiation, as early as 1852 Prof. Borisyak found chernozem in the Azov and the Dnieper areas at a height of 90 – 150 ft [27 – 46 m].[2] Prof. Levakovskii wrote, "If the determination of lowest elevations of chernozem, as reported by Borisyak, needs any correction or addition, this should be toward lower rather than higher elevations, since the chernozem on the left bank of the Manych, near its confluence with the Don River, lies below 25 ft [7.6 m]." At present, I have proved the occurrence of fairly good chernozem, containing 4 – 6% humus, in the greater part of the nearest seaboards of the Azov Sea and Sivash, in the southern part of the Samara Province, and in the western half of the Caucasus isthmus on definite Aral-Caspian deposits, at absolute elevations of 50 – 100 ft [15 – 30 m].

Furthermore, even if our consideration of chernozem thickness is limited only to those facts observed by Ruprecht, Chervinskii and Bogdanov, it becomes quite clear that Ruprecht's second principle (the higher the absolute elevation, the thicker the chernozem) is not based on actual fact. The maximum thickness of chernozem at its northern boundary for instance is indicated, by Academician Ruprecht, as found near Sednev, Novgorod-Seversk, Chernigov and Starodub; all these localities are lower than many other chernozem areas where Ruprecht observed less thick chernozem. The same is obvious from the works by Prof. Bogdanov, who found the thickest chernozem in the Buinsk District, area between the Khoper and Medveditsa rivers) to coincide not with the highest elevations in the Volga territory but rather with a certain characteristic of the parent rock.

These features of the southern chernozem boundary in the Volga area and the Kozelets District may be satisfactorily explained by the relief, climate, and vegetation, without taking absolute elevations into account, as will be seen later. The following tables clearly reveal the uncertain nature of Ruprecht's argumentation meant to substantiate the significance of absolute elevation.

However, the undoubtedly most important and most vivid proof of lack of any direct relationship between the absolute altitude of an area and the nature of its soil is provided by my schematic map of chernozem distribution in European Russia; it is clear that belts with different humus contents are distributed completely independently of the absolute elevation.[3]

[1] Levakovskii. — Materialy... etc. pp. 10 – 11.

[2] Borisyak. Ibid., p. 34.

[3] I should like to stress that I do not categorically deny the effect of the age of country on soil character in general and thickness in particular, but rather I regard this effect as yet to be factually proven, especially since increase in absolute elevation is always accompanied by a change in the climate.

Table expressing the relationships between humus contents in soils, their thickness and elevation[1]

Locality	Humus, %	Altitude, ft [and m]	Thickness, ft and in [and cm]	Reference
Vladikavkaz	9.266	2,346 [715]	2' 11" [89]	Katalog trigonometricheskikh i astronomicheskikh punktov, opredelennykh v Rossii po 1860 (Catalog of Trigonometric and Astronomic Points Determined in Russia up to 1860, inclusive).
Zhmerinka	2.822	1,065 [325]	—	Barbot de Marni[2]
Kryzhopol	3.457	980 [299]	3' 0" [91]	—
Kazatin	5.167	976 [297]	2' 9" [84]	—
Mean	4.312	978 [298]	2' 10" [86]	
Ostanino	4.365	890 [271]	2' 11" [89]	Catalog
Petrovskoe	4.959	887.9 [270]	8" [20]	"
Mokhovoe	8.115	825.6 [252]	2' 5" [74]	"
Berdichev	3.146	816 [249]	2' 7" [79]	Barbot de Marni
Birzula	11.260	810 [247]	2' 6" [76]	"
Mean	6.363	846 [258]	2' 2" [66]	
Polonnoe	2.695	792 [241]	6–7" [15–18]	—
Livny	8.060	762 [232]	2' 0" [61]	Catalog
Venev	6.782	753.3 [230]	1' 4" [40]	"
Borisovka	3.864	751.8 [229]	2' 3" [69]	"
Putivl	1.862	714 [218]	2' 11" [89]	
Mean	4.652	755 [230]	1' 10" [55]	
Novgorod-Seversk . .	2.765	672 [205]	10" [25]	Catalog
Fastov	2.883	658 [200]	1' 8" [50]	Barbot de Marni
Zaraisk	2.503	648 [198]	9" [23]	Ruprecht
Kamyshin	2.072	627.3 [191]	1' 9" [53]	Catalog
Endovishche	11.427	615 [187]	3' 1" [94]	"
Pyatiizbyanskaya . . .	2.932	600.3 [183]	1' 3" [38]	"
Mean	4.014	637 [194]	1' 7" [48]	
Gadyach	3.495	594 [181]	2' 3" [69]	—
Nezhin	2.345	493.2 [150]	3' 6" [107]	—
Atkarsk	6.155	570 [174]	1' 2" [35]	—
Konotop	2.514	552 [168]	4' 8" [142]	—
Elisavetgrad	2.963	546 [166]	4' 8" [142]	Barbot de Marni
Gorodishche	2.536	504 [154]	11" [28]	Leveling for the Gryazi-Tsaritsyn railroad.
Mean	3.335	559 [170]	3' 2" [96]	

[1] A similar table with identical results could be compiled from the barometric results for the southern part of the Nizhni Novgorod Province . . . but I would again emphasize that these data are too inaccurate for the purpose. Author.

[2] In different works, based on railroad levelings

(Continued)

Locality	Humus, %	Altitude, ft [and m]	Thickness, ft and in [and cm]	Reference
Tsymlyanskaya "stanitsa"	1.969	463.6 [141]	0' 9" [23]	Catalog
Grushevka	6.864	405.6 [123]	1' 8" [50]	"
Kashka-Chokrak . . .	2.138	438.0 [134]	—	V. M. Tarnovskii, barometric determinations
Mean	3.657	435.7 [132]	1' 2" [35]	
Volkonskaya	9.148	391 [119]	2' 5" [74]	Leveling for the Gryazi-Tsaritsyn railroad
Kolontaevka	5.074	385 [17]	2' 0" [61]	Barbot de Marni
Gryazi	9.595	366 [111]	3' 6" [106]	Leveling for the Gryazi-Tsaritsyn railroad
Mean	7.939	381 [116]	2' 8" [81]	
Filonovo	6.667	292 [89]	2' 3" [69]	—
Orenburg	2.432	285 [87]	1' 11" [58]	Catalog
Ol'viopol	5.437	280 [85]	1' 11" [58]	Barbot de Marni
Mean	4.845	285 [87]	2' 1" [63]	
Taganrog	4.437	168.2 [51]	2' 2" [66]	Catalog
Khadzhibei Liman . . .	3.559	163.4 [50]	1' 10" [55]	"
Nikolaev	4.921	160.5 [49]	1' 10" [55]	"
Tsaritsyn	0.908	150 [46]	9—10" [23—25]	Leveling for the Gryazi-Tsaritsyn railroad
Mean	3.456	160 [49]	1' 7" [48]	
Kherson	2.224	82.7 [25]	1' 8" [50]	Catalog
Genichesk	4.144	45—50 [14—15]	2' 3" [69]	Dokuchaev
Novoalekseevka	6.025	50—100 [15—30]	2' 3" [69]	"
Mean	4.364	67 [20]	2' 0" [61]	

The relationship between relative elevation, or rather relief, and soil character is far clearer. However, if only those data found in the literature are taken into account, a wide variety of opinions is perceived.

In addition to the data furnished by Prof. Bogdanov cited above, and the cadastral commissions on soils of the Volga area, the following indications can and must be mentioned here.[1] In his "Description of the Troitsk-Chelyabinsk lakes" (Ocherk Troitsko-Chelyabinskikh ozer), V.D. Alenitsyn gives the following description of the relationship between soils and topography. In certain portions of these districts, "the level steppe, covered with grass seared brown by the heat, stretches in all directions... Black soil in a fairly thick layer is visible everywhere."[2]

[1] The effects of river valleys on soils will be discussed later; we are at present only concerned with the rolling terrain, the origin of which is not necessarily related to rivers. Author.

[2] Alenitsyn [V.]. Ocherk Troitsko-Chelyabinskikh ozer [Orenburgskoi gubernii] i ikh ikhtiologicheskoi fauny (Description of the Troitsk-Chelyabinsk Lakes [of the Orenburg Province] and Their Ichthyological Fauna), pp. 13—15, 47—48, 53, St. Petersburg. 1873.

However, this soil cover is far from continuous; "In one place a solonchak stretches extensively, in another it is difficult to distinguish between the dry plain, the bog mud on a lake shore and the soil on its bottom, near the shore, and in a third place a saline lake is found in the same chernozem which lies barely above water level; all these bog-aquatic formations merge with true chernozem in such a manner that demarcation is impossible. However, the 'mocharas', solonchaks, and saline lakes as well as the low position of the soil, suggest that this alleged chernozem is the 'black mud' described by Ruprecht. Nevertheless, true chernozem is very widespread, and found on all hilltops. This impression is largely gained thanks to the general character of the vegetation. However, chernozem very often literally encompasses solonchaks and saline lakes. .. It is continued only in the western parts of the region. On the other hand, the dry ' black mud ' also occupies extensive low areas, forming wedges which separate chernozem areas from each other. Chernozem is least common on the territory between the Ural foothills and the line passing from Mordvinovka via Il'men'-Kul Lake to Chesnokovskoe, although the latter is only an approximate boundary."

The observations made by Academician Ruprecht in some places along the right bank of the Desna River, especially in the vicinity of Novgorod-Seversk, essentially belong to the same category of facts. He wrote that "the right bank of the Desna 10 versts south of Novgorod-Seversk, at a ford, is fairly elevated and is highly interesting. The chernozem at the highest point is 43 in [1.3 m] thick, and grows thinner as the terrain descends up to 1 ft [30 cm]; still further down it is either totally absent or has been washed away. This phenomenon is repeated in the town of Novgorod-Seversk which is built on chernozem soil incised by many deep gullies. These gullies offer an excellent view of the chernozem profile which reaches 4 ft [1.2 m] in thickness at the highest points, gradually diminishing to 2 ft [61 cm] and less with the descent of the terrain, finally completely disappearing at a still considerable height above the level of the Desna."[1] From Novgorod-Seversk to Chernigov "the entire right bank of the Desna, inland, is covered by chernozem. . . on elevated areas which are not now or were not in the past forested."[2]

Chernozem of these areas has the following properties. On the Desna Heights, at the ford, it is as dark and pulverulent as at Glukhov; west of Novgorod-Seversk it is lighter, ashy gray; southeastward, 10 versts from Avdeevka, at Ponornitsy, the chernozem is perfectly black, over 3 ft [91 cm] thick, and is partially granular in structure ("pripad'"). At the village of Budishche chernozem reappears in the form of dust, very light in color, or is replaced by sod or forest soil.[3] The conclusion to be drawn from these facts is that the most typical chernozem (on the basis of color and thickness) may occur rather on areas higher than the neighboring lowlands than on these lowlands.

The facts pointing to totally different relationships between the thickness of soils and topography are far more numerous. Nearly all the writers on the situation of chernozem noted unanimously that in the case of uneven terrain, hilly areas, heights and steep slopes, chernozem has been washed

[1] Ruprecht. Ibid., p. 68.
[2] and [3] Ibid. p. 69. The reader is reminded that all these chernozems contained as little as 2—4% humus!

away or it is very nontypical. On the other hand, on gentle slopes chernozem always increases in thickness downslope. Chernozem usually reaches greatest thickness in low-lying areas, which is true of all vegetal-terrestrial soils. It would be superfluous to quote all the facts reported in the literature, and I will mention only the most important ones.

Petzholdt[1] and Murchison[2] already observed chernozem reaching 10 ft [3 m] in thickness, and Murchison even observed chernozem reaching 20 ft [6 m] in thickness, evidently in depressions. We have noted Wangenheim von Qualen's division of the soil of the Gorodishche and Korsun districts into at least five kinds, depending on topography. The same essential soil distribution was subsequently also observed by Prof. M.N.Bogdanov in many regions of the Volga area, especially where the parent bedrock consists of Cretaceous and Tertiary formations.[3] Furthermore, Academician Ruprecht reported an instance of a very gradual thickening of chernozem downslope in the Menzelinsk District (see above, p.267). In the vicinity of Medzhibozh, not far from the southwestern border of Russia, Barbot de Marni saw chernozem over 7 ft [2 m] thick in depressions; in the same area, on level terrain, chernozem was 3 — 4 ft [0.9 — 1.3 m] thick.[4] In the Dnieper area, Klemm observed deposited chernozem, over 10 ft [3 m] thick on bottom of "balkas".[5] In his description of the Trans-Urals chernozem, Perm Province, Sabaneev especially stresses its great thickness and solonetsic nature in depressions, its slight thickness on hummocks and on small steppe elevations, the complete disappearance of chernozem at the foot of the Urals and the Sysert Hills and its gradual southwestern thickening[6] as the terrain became lower. V.D.Alenitsyn, who visited a considerable part of the territory described by Mr Sabaneev, confirmed the fact, although he did not concur with the author in his explanations for these particular features of Trans-Urals chernozem.

The relationship between the rate of increase in chernozem thickness and slope gradient has, regrettably, hardly been discussed in the literature; data on the matter are limited almost totally to Prof. Levakovskii's observations. In view of the high value of such facts, I will quote the most important points.

"The right slope of the Berka River is incised between Verkhoberka and the Alekseevskaya fortress, by 'balkas' and gullies with exposures of underlying rocks covered by a layer of chernozem. In most of these exposures, chernozem tends to become thicker with depth. In the valley of the Berka itself the chernozem layer varies in thickness, between 0.75 — 2 arshins [53 — 142 cm].

[1] Petzholdt A. Beiträge [zur Kenntniss des Inneren von Russland. Leipzig. 1851]... S. 39.

[2] Murchison. Issled[ovaniya] o chernozeme vnutrennikh gubernii Rossii (Studies of Chernozem in the Inner Provinces of [Ru]ssia). — Zhurnal Ministerstva gosudarstvennykh imushchestv, [No. 3], p. 125. 1846.

[3] Bogdanov. Ibid., pp. 8, 19, etc.

[4] Barbot de Marni. Geologicheskie issledovaniya v guberniyakh Kievskoi, Podol'skoi i Volynskoi (Geological Investigations in the Kiev, the Podol'sk and the Volhynia Provinces), p. 67, [St. Petersburg]. 1872.

[5] Klemm, M. Geologicheskie issledovaniya mezhdu rekami Samaroi, Dneprom, Kal'miusom, i pr. (Geological Investigations Between the Samara, Dnieper, Kalmius Rivers etc.), p. 18 [Otchet o geologicheskikh issledovaniyakh na ploshchadi mezhdu Samaroi, Dneprom, Konkoi, Kal'miusom, i Tortsom (Report on the Geological Investigations in the Area Between the Rivers Samara, Dnieper, Konka, Kalmius and Torets). — Trudy Khar'kovskogo obshchestva estestvoispytatelei, vol. 8, p. XIII. 1874.]

[6] Sabaneev [L]. Zaural'skie ozera (Trans-Urals Lakes). — In: Zhurnal [Sbornik] "Priroda", book 2, p. 243. 1873.

"About 2 versts beyond the Khortitskaya (Khortitsa) colony on the road to the Neuenburg colony*, there is a 'balka' with a gully running along its bottom. The bluffy outcrops of this gully exhibit a large continuous thickening of chernozem which is 1 1/2 arshins [1.1 m] on top and about 4 1/2 arshins [3.2m] at the bottom.

"In the environs of Simferopol, near the Jewish cemetery, the chernozem is 1/4 arshin [18 cm] this at the top of a slope and exceeds 1 arshin [71 cm] at its foot.

"On the Dnieper River, at Ekaterinoslav, chernozem is 1 — 1 1/2 arshins [71 — 106 cm] thick at the top of slope, reaching 2 arshins [1.4 m] along the slope and 3 arshins [2.1 m] at the foot."

"Finally, — continues Prof. Levakovskii — I present the measurement I made of chernozem layer thickness, done to obtain results which are least dependent on the subsequent effects of water. In the Bakhmut District between the Bulavin and Sadki rivers, two pits were dug on a level steppe; chernozem proved to be 1 ft 9 in [53 cm] thick in one pit and 2 ft [61 cm] in the other. Chernozem thickness was then measured using the same method over the slopes of a sizeable 'balka', remote from the river and lacking exposures. Three pits were dug on each slope: at the top, in the middle and at its foot. The results were as follows:

	Over the southern slopes	Over the northern slopes
In the upper pit . . .	1' 7" [48 cm]	1' 7" [48 cm]
" " middle " . . .	2' 0" [61 cm]	1' 10" [55 cm]
" " lower " . . .	1' 10" [55 cm]	1' 11" [58 cm]

These data of Prof. Levakovskii may be to a certain extent supplemented by the following measurements of soil thickness communicated by Mr. Bazilev in his letter:

"Traveling east along the Siberian highway from Perm, the terrain gradually descends for 9 versts. The following features of the local soil are inevitable: at Perm itself the surface is covered by pure sand, barely colored by humus. Away from the town along the descending terrain, the sand becomes visibly gray and gradually forms a transition to thin sandy chernozem. The soil progressively becomes more chernozemic and deeper toward the foot of this slope. Along the entire stretch soil thickness increases at the following rate: 1 verst from Perm it is 1 — 2 in [2.5 — 5 cm], somewhat further 3 — 4 in [7.6 — 10 cm], a bit lower down 5 — 6 in [13 — 15 cm]; halfway down the descent, approximately 4 — 5 versts from the town soil thickness reached 6 — 7 in [15 — 18 cm], further on 8 in [20 cm], still further downslope 9 in [23 cm], then 1 ft 1 in [33 cm]; finally, at the foot of the slope it was 1 ft 9 in [53 cm]. Half a verst away from the foot of the slope, I took a chernozem sample 1 ft 7 in [48 cm] thick."

Essentially the same relationship between topography and soil thickness, though possibly not as marked, was noted by Mr Bazilev, in a "balka" with gently sloping sides near the village of Aibashevo on the Belaya River, Birsk District.

I presented completely analogous data, in previous sections, for many localities in the southeastern part of the Nizhni Novgorod Province (p. 80 ff.), the Chern District (pp. 97 — 99) and the Lubny District (p. 166)[1]

* [Obviously, these were agricultural colonies (settlements) founded by German immigrants. Translator.]

[1] Nevertheless, it is hardly possible to derive any constant ratio between the slope gradient and the thickness of soil on the same slope, since thickness also depends on a multitude of other factors such as the cohesion of chernozem constituents, the nature of subsoil and vegetation, climate, underground springs, etc.

Although Prof. Levakovskii mentions several of these facts, which seem to indicate clearly that chernozem thickness is far from equal on the tops of hills and elevations, on their slopes, in depressions between them, and on fairly level terrain, he nevertheless believes that "chernozem conforms exactly with the (previous ?) form of relief and completely outlines all the numerous irregularities of the subsoil surface (existing previous to the formation of chernozem ?), and forms a continuous cover on flat elevations, over slopes and on the bottom of numerous valleys and 'balkas' wherever later action of water has not destroyed it. . ."[1] "Slopes of valleys and 'balkas' are outlined by the lower as well as by the upper surface of chernozem which forms a layer of uniform thickness when undisturbed."[2] Apparently, the author regards thickness of normally situated chernozem as quite independent of present-day topography.

It is regrettable that this highly important conclusion is substantiated by Levakovskii only by an offhand reference to "for instance,[3] hollows between Verkhoberka and Taranovka, between Krasnopol'e and Graivoron, between Bol'shie Prokhody and Lopan, between Akhtyrka and Trostenets, between Khar'kov and Bogodukhovo etc.." The author also added that "On the road leading from Verkhnii Bishkin to Srednii Bishkin large gullies incised in the slopes of a 'balka' reveal uniform thickness of the chernozem layer, about 1 arshin [71 cm] both at the top and at the bottom [of the slope]."[4]

The author provides no details, numerical data, or any information regarding the normal nature of these facts. No such facts are found in any of the works known to me. This becomes understandable once it is understood that the isolated facts taken by Prof. Levakovskii to be the general rule are purely accidental.

This discussion does not exhaust the variety of the data published on the nature of the relationship between chernozem soils and topography. For instance, some observers report chernozem to become sandier descending downslope, especially toward river valleys, and its color gradually lightens. Prof. Levakovskii may and should be named one of the proponents of this view. "On the road leading from the Derkul'skii works to the Novoaleksandrovskii works, Starobel'sk District, true chernozem is found on the steppe, on perfectly level terrain; toward the descent into the Evsug River valley there is a gradual transition to sandy-loamy chernozem (gray soil). Chernozem, however, lies everywhere in this area on diluvial clay overlying chalk or potter's clay, with no sand beds visible under the chernozem."

Levakovskii continues that "On D'yakov's estate, in the Starobel'sk District, chernozem (loamy ?) lies on level steppe, while gray soil covers the left slope of the Aidar River valley.

"In the Slavyanoserbsk District, between Uspenskoe and Ivanovka, slopes of 'balkas' and valleys are covered by gray sandy soils; higher up, the soil becomes darker, eventually becoming completely black, but only on level elevations. Sand beds however are absent here, and chernozem is underlain by deposited clay or by Carboniferous limestones, shales, etc.

[1] Levakovskii. — Materialy etc., p. 24.
[2] Ibid., pp. 31—32.
[3] Ibid., p. 24.
[4] Ibid., p. 30.

"At Golodaevka, on the Mius River, the same phenomenon occurs under similar conditions, chernozem lying on level steppe, while valley slopes are covered by sandy-loamy gray earth."

Levakovskii concludes, "many additional instances may be presented, demonstrating the consistency of the situation and relationships of the true (loamy ?) chernozem and gray soil (sandy-loamy chernozem), the first occurring on elevated plains while the second is found on slopes."[1]

A nearly identical conclusion was later independently inferred by Prof. A. V. Sovetov who was unaware of Levakovskii's conclusions (pp. 229 ff.).

Observations made by Leopol'dov,[2] Bogdanov,[3] Klemm,[4] Agapitov,[5] Zemyatchenskii (pp. 80 — 82) and certain other authors reflect quite different relationships between the topography and mineral character of chernozem. The observations are generally in accordance with Wangenheim von Qualen's scheme, showing bedrock outcrops to occur often on hilltops, where soils are thin, low in humus, rich in sand and other undecomposed coarse residues of parent rock; "Further down the gentle slope, the sand is gradually admixed with clay; finally, in the lower portions of the slope, the sand is completely replaced by rich clay covered by a thick layer of black-gray friable chernozem."[6]

Prof. Bogdanov indeed explained this fact as regards the northern part of the Middle Volga area exclusively by the effect of subsoil, certain rocks (sands and chalk) outcropping on hilltops, other rocks on hillsides, and yet other rocks at the foot of hills (clays). It is, however, impossible to concur with this exclusive explanation. In the first place, such a conformity can only be accidental. Secondly, on gently sloping hillsides (and only such hillsides are relevant) and ridges taluses and alluvium usually mask the outcrops of bedrock and become subsoil themselves. Finally, chalk and limestones,[7] as has been seen, are not incapable of forming good chernozem, but rather the opposite is true.[8]

Such is the surprising diversity found in the literature on the relationship between absolute elevation and topography on the one hand and the nature of soils, especially their thickness, on the other. Remarkably, many proponents of these views strove to develop their observations to the form of a definite scheme on the subject, ignoring facts obtained by other observers.

The question arises which of these observations and views are in fact true and are of the most general character. If certain details which are manifestly inaccurate are discarded (these observations are known to

[1] Ibid., pp. 37—38.

[2] Leopol'dov, A. Vzglyad na Novouzenskii okrug, Saratovskoi gubernii (A View of the Novouzensk District of the Saratov Province). — Zhurnal Ministerstva gosudarstvennykh imushchestv, part 13, p. 30. 1844.

[3] Bogdanov. Ptitsy i zveri... (Birds and Mammals...), pp. 8, 17 and 19.

[4] Klemm. Otchet o geologicheskikh issledovaniyakh mezhdu Samaroi, Dneprom, Konkoi i pr. (Report on the Geological Investigations between the Samara, Dnieper, Konka, and Other Rivers), pp. 17—21.

[5] Agapitov [N.]. Kratkii otchet o poezdke v Irkutskii i Balaganskii okruga [letom 1877] (Brief Report on a Trip to the Irkutsk and Balagansk Districts [in summer 1877]). — [Izvestiya vostochno-Sibirskogo otdeleniya Russkogo geograficheskogo obshchestva, vol. 9, Nos. 3—4. 1878]., pp. 85—86. Agapitov reports that even peasants in this locality distinguish between two kinds of chernozem, friable soil on hummocks, readily blown by the wind (local name, "pykhun"), and a more stable, thicker chernozem in valleys.

[6] Bogdanov. Ibid., p. 8.

[7] Ibid.

[8] Ibid., p. 19.

rarely include precise measurements of soil thickness, and the composition of soils and underlying rocks was determined only visually), and if the conclusions of these observations are limited only to the localities where they were performed and not generalized, they all will be found to be essentially correct and quite naturally fall into a common framework.

Let us imagine a territory resembling chernozem Russia which is in the process of becoming dry land, its southern and southeastern parts gradually emerging above sea level, while its northwestern half is gradually discarding its glacial cover; only very few of the present-day river valleys and gullies exist at this point.

After a certain period, the geological pattern undergoes drastic changes. The glaciers finally retreat to the Far North, and the waters of the southern seas gradually collect in their present-day basin. The territory is abundant in lakes saline in the south and in the southeast, and fresh in the north; many of these lakes undoubtedly resembled the present day Finnish water basin in their nature (lake — river systems). At the same time, the flora and fauna of the adjacent, older continents naturally eagerly spread to new colonization areas. The next stage in the development of the continent would consist of freshwater deposits in the oxbow and other lakes, formation of gullies and typical river valleys, gradual drying of lakes, considerable accumulation of peat and slow emergence of both vegetal-terrestrial and bog-terrestrial soils. At this time soils of chernozem Russia may be assumed to have borne a fairly close resemblance to the present-day [soils] of Siberia, where it is still sometimes very difficult to define the border between the vegetal-terrestrial soils, the "black mud" described by Ruprecht, and solonetses.[1]

With the passage of geological time, these processes affected central and southern Russia until their present-day appearance was completed. There is no evidence of the time elapsed during these processes of development of Russia, or whether they proceeded in the sequence just outlined, but they undoubtedly did occur.

We have discussed the formation of gullies and their gradual transformation, along with the lakes, to rivers, elsewhere;[2] other researchers have investigated the regression of southern seas and northern glaciers. We shall therefore dwell only on the processes which occurred simultaneously on the ever-widening dry land area. Of course, in all stages of its post-Tertiary development European Russia generally possessed the same variety of relief forms as it has now, including dry level areas, various hills, slopes, and depressions occupied by bogs, lakes, or rivers, with different relief forms predominating. Their mutual relationships and amounts differed from the present-day situation. At any rate, those elevated plains and hills which emerged first from under the sea were the first to become covered by vegetation and to be subjected to weathering processes. Obviously, vegetal-terrestrial soils first appeared on just such areas. Yet, the mineral-organic surficial formations could not have had uniform future development.

If vegetal-terrestrial soils appeared on dry level areas without runoff and without deposition of any extraneous elements from other areas, they

[1] Dokuchaev. Po voprosu o Sibirskom chernozeme (Siberian Chernozem).

[2] Dokuchaev. Sposoby obrazovaniya rechnykh dolin Evropeiskoi Rossii (Modes of Formation of River Valleys in European Russia) [St. Petersburg], 1878.

continued to thicken as far as climatic conditions, the various organisms and the nature of parent rocks permitted. The majority of humus and all mineral and animal residues were buried in situ. Only such areas may be expected to produce soils with natural primary properties. Therefore, I join some of my predecessors in recognizing only such soils as normal, after examination of all the principal territories of the Russian chernozem zone.

Conditions on tops of different hills and even on narrow elevated plains, were quite different. On such areas there is always the possibility of precipitation runoff and hence also that all the easily washed soil constituents. such as humus, clay, carbonates, etc. will be washed away. Obviously, hilltop soil is gradually enriched in coarse materials from the underlying rocks and can never become as thick as soil on level areas, other conditions being identical. This conclusion is based on my observations in all the hilly regions of Russia. Similar observations made by Wangenheim von Qualen were described on p. 217, as well as observations made by other workers. Soil distribution in such cases was schematically described on pp. 226 and 231. For obvious reasons, deposited soil cannot be of uniform thickness and mineral composition. This is an extremely general statement, to which there are certainly many exceptions. We have noted above that a majority of rocks which outcrop on the surface in southern Russia must have initially had a considerable marine salt content (because of their origin) such as NaCl, $CaSO_4 \cdot 2H_2O$, $MgSO_4$, etc. All these substances which are unfavorable for plants, were leached far more rapidly from comparatively elevated areas than from depressions. In fact they may even have progressively accumulated in depressions, especially if the frequent emergence of springs in such depressions is taken into account.

Quite obviously, in such cases, on ridges and "syrts" where other soil formers were identical, conditions favorable to vegetation developed earlier than in depressions between the hills where saline "mocharas" could be preserved over prolonged periods, and even reappear, as is the case up to the present. Supporting this statement, are the facts already mentioned and observed by Mr. Bogdanov (pp. 294 — 295), the compiler of the soil map for the Samara Province (p. 256), and by Alenitsyn (p. 362), as well as the observations I made in 1878 (p. 275).

It is clear that these facts depend on topography rather than on absolute elevation. Solonchaks may and in fact do occur in depressions with poor soils at any absolute altitude, often much higher than the "syrts" with their relatively good soil. This applies to Tibet, Mongolia, Siberia, etc.

Furthermore, we have already seen (p. 362) that in the Troitsk and Chelyabinsk districts areas with true chernozem barely rise above the saline lakes, and many such lakes certainly lie at higher altitudes than areas of true chernozem (Sabaneev). Finally, Mr. Agapitov, after mentioning the patchy pattern of chernozem in the Irkutsk and Balagansk districts, chernozem continually alternating with bogs, solonetses, and saline lakes, goes on to say, "chernozem always lies several feet and even several dozen feet higher than bog and solonchak soils."[1] According to the same author,[2]

[1] Agapitov. Ibid., p. 86.

[2] Agapitov, N. K voprosu o proiskhozhdenii chernozema (Origin of Chernozem). — Izvestiya Vostochno-Sibirskogo otdeleniya Russkogo geograficheskogo obshchestva, vol. 11 (3—4): 16. 1881. [1880].

it may be added that chernozem (and consequently the solonetses) occurs in this territory over an altitude range of 569 ft [173 m]; it becomes evident that the occurrence of all the above-mentioned soils is governed by topography rather than by absolute elevation.

There is no reason to assume the presence of any considerable quantity of common salt in the parent rocks outcropping on the surface in the northern parts of the Russian chernozem zone, and true solonetses are unknown in the lower portions of the slopes and in the depressions. Nevertheless, this phenomenon (occurrence of more typical soils on "syrts") may occur in certain places here. A wide, shallow depression closed on all sides may contain water for hundreds and thousands of years, during which the bordering heights which bear some vegetation are becoming increasingly weathered and are covered by soil. The lakes still exist in northern Russia whereas the neighboring dry land bears a soil cover sometimes reaching 6—8 in [15—20 cm] in thickness. Yet, the lakes are gradually desiccated due to various causes, leaving behind lacustrine silt or sands. The land area becomes progressively larger and the open water basins are eventually converted into bogs, remainders of which are still visible. Terrestrial vegetation simultaneously gradually occupies the newly formed land and together with the effects of water and air forms new vegetal-terrestrial soils. These soils are evidently relatively thinner and lower in humus than the soils on the neighboring heights. The same is true of the new river and gully valleys. Indeed, throughout the chernozem zone of Russia only embryonal vegetal-terrestrial soils were visible in the alluvial river valleys. The observations of Ruprecht and Mr Chervinskii in the Chernigov Province (pp. 358—359, ff.) fall into this category. Consequently, there is no need whatever to resort to absolute elevation.

While in the southern depressions solonetses accumulated and in the northern depressions bog soils accumulated, the rest of chernozem Russia usually underwent quite different processes — the tremendous influence exerted on the vegetal-terrestrial soils of the newly forming river and lake basins with their terraces (as well as gullies and "balkas"). The dependence of the distribution of chernozem soils on river valleys is represented schematically in Figure 11:[1]

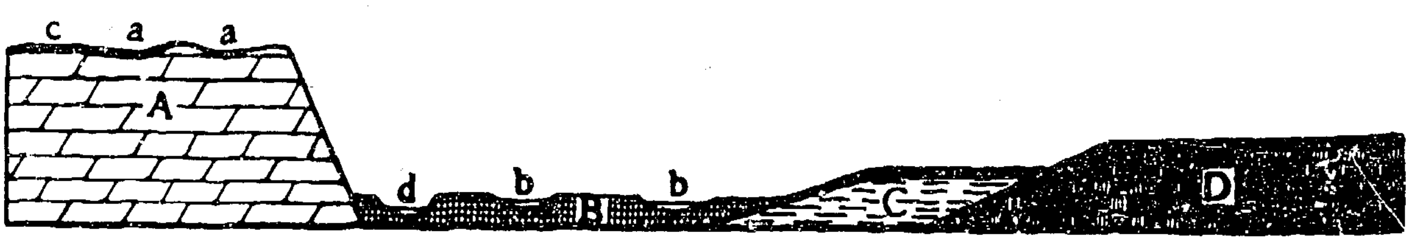


FIGURE 11.

A-right bank of a river, usually formed by ancient sedimentary rocks; B-floodplain, or the first terrace (first bottom); C-second terrace (second bottom) or alluvial plain; D-third terrace; a-small depressions containing chernozem; b-oxbow lakes; c-level elevated steppe; d-river.

It should be noted that in the majority of cases most Russian rivers, such as the Volga (p.278) and often also shores of lakes (lakes Onega,

[1] This scheme is generally a simple copy of the well-known section of the Volga river valley drawn by Prof. N. A. Golovkinskii; I have added soils and oxbow lakes.

Ladoga, etc.)[1] are terraced, most often in two or three terraces and sometimes more. The width of the terraces depends on the river and on the locality, and varies widely from a few sazhens to several and even tens of versts. These terraces, except for the floodplain, usually slope gently, sometimes imperceptibly, down to the neighboring river. They may be very distinct, while at other times almost completely merging with one another to form a general gentle slope descending toward the neighboring rivers.

Only one of these two river banks is usually terraced. The other bank, such as the right bank of the Volga, is steep, bluffy, and often drops sheerly to the river over 100—200 ft [30—61 m]. This bank is usually strongly incised by gullies which may be over 200 ft [61 m] deep and may run far inland (a dozen versts and more). The elevated steppe on the right bank of the Volga and other large rivers is usually very hilly especially where deep brooks and minor rivers flow into the river. In the case of minor rivers the terrain becomes even hillier over several dozens of versts inland, away from the river. In some places, however, such as at Simbirsk, elevated gently rolling steppes may approach the very bank of the Volga.

This structure of Russian river banks must be significant with regard to the nature of Russian soil. Let us hypothesize all the terraces to have emerged on the surface simultaneously, and to be composed of the same rock, typical loam or loess. Let us assume, further, the entire surface throughout the district became covered simultaneously by uniform vegetation; obviously the climate must be uniform throughout such small territories. Can identical vegetal-terrestrial soils be formed under such conditions on the different terraces and in the neighboring level steppe?

The answer is strongly negative, since in all these cases the chemical, and especially the mechanical, activities of atmospheric waters will be markedly different.

There is no need to enter into excessive detail to understand the activity of running water in the soils of terraces (C and D). Slowly and steadily, over centuries and millennia, readily suspensible and soluble substances such as, respectively, clay and humus and calcium carbonate, will be leached and eluviated, then transported down to the river or to its floodplain (B).[2] Obviously, the nearer a slope (terrace) to the river, the more strongly will it be affected by this process. On the other hand, it is also quite obvious that reverse processes, namely accumulation of these substances (p.83) are also possible on certain areas of terrace depending on specific topography. In any case, such reverse processes are only sporadic and temporary and the general slope down to the river will eventually have its effect. The general results must inevitably be as follows. Soils on terraces will be considerably richer in sand and poorer in humus, calcium carbonate, and clay than the neighboring level steppe. They will in fact no longer be loamy and loess-like, but rather will be converted to sandy soils with lower humus contents. Furthermore, the lower terraces are usually younger than the upper ones,[3] the latter

[1] See works by Prof. A. A. Inostrantsev.

[2] Levakovskii.—Materialy dlya izucheniya chernozema (Materials on Chernozem). 1871.

[3] Golovkinskii. Ibid.

located nearer to typical steppe chernozem; it is therefore understandable why the admixture of humus in soils generally increases progressively from the floodplain toward the neighboring level steppe.

The best proof of this pattern is supplied by Levakovskii's data, described above[1] and by the soils on the banks of the Volga (pp.277–279), the Tsna and the Voronezh (p.229), the Tuskar (p.156), the Seim (p.156), the Bug, the Dniester, the Prut (p.189) and other rivers.

The thickness of soils lying on terraces seems to be much less constant. On the basis of the data available, all the relevant cases may be divided into the following two types: a) on the banks of the rivers P'yana, Aratka, Cheka, Aranka, Kholyazinka, Sundovik (p.82), Tuskar (p.156), Tesha, the left bank of the Volga, etc, soil gradually grows thicker toward the floodplain[2]; b) the opposite pattern is found in the banks of the rivers Tsna, Voronezh, Bug, Dniester, etc. It would be difficult to determine the cause of this difference without detailed investigations. This cause may be assumed, a priori, to lie in the different sand content of the soils on the terraces, the differences in their slopes, and their greater or lesser continuity toward the river.[3]

Obviously, the soils on the other high bank of the river (A in the figure) must also be abnormal. On steep slopes toward the river they are usually completely eroded, and bedrock almost always outcrops on the surface. Further away from the bank (the distance depending on local conditions) the soils of the so-called elevated hilly areas are found; they are totally absent in some places, in others they are very stony, and in closed depressions (a — a) they are evidently of deposited nature. Only 1—10 and more versts away from the river bank is elevated level steppe (c) with normal chernozem found. As we have seen, this is a universal phenomenon; the high banks of all rivers conform to this rule almost throughout their length.

For this reason I decided to mark (schematically) soils of the immediate banks of all the principal Russian rivers on my map.

[1] Levakovskii. Ibid., pp.37—38.

[2] This is represented in the scheme [Figure 11].

[3] Floodplains are everywhere covered exclusively by deposited or bog soils.

Chapter X

AGE OF CHERNOZEM AND CAUSES OF ITS ABSENCE FROM NORTHERN AND SOUTHEASTERN RUSSIA

Attention was first drawn to the age of chernozem by Academician Ruprecht, who apparently distinguished between two essentially different aspects of the subject: the relative age (in the geological sense) and the absolute age (in th "historic" sense). Ruprecht's views regarding the relative age aspect have been discussed in this book (pp. 125, 132 – 134, 358, etc.) in detail; we shall now turn to the absolute age of Russian chernozem. Ruprecht furnished the following information. After remarking that only "terrestrial vegetation provides a criterion for determining the age of any soil" and that "the count of ages begins only after emergence of the country above sea level, so that the age of a soil has nothing in common with the age of a formation," Academician Ruprecht goes on to state that when determining the age of a country (soil) the most important point is the diluvial layer, and then virgin chernozem; other conditions being identical (?), thicker chernozem indicates older country; absence of chernozem indicates younger country, although it may be quite high."[2]

The author supplements his general statements with several details. He first points out that the vegetal layer covering the well-known (sandy) Sednev man-made mounds (as many as 800 in this locality) "is only 6 – 9 in [15 – 23 cm] thick (as measured by the author and by Blasius), while on level areas, in the vicinity untouched by man, 2 – 5 ft [0.6 – 1.5 m] of chernozem soil cover the uncolored [by humus] sandy layer (natural ground). Local tradition regards these mounds as burials of the time of Batyi[3] (the razing of Chernigov is usually dated to 1239); the chernozem layer covering them was thus formed over 600 years. If the time needed for formation of the chernozem layer is taken to be directly proportional to its thickness, the virgin chernozem in the neighborhood of the mounds was formed over 2400 – 4000 years."[4] Following his excursion, Ruprecht modified his last

[1] Before touching on this subject it would be advisable to examine the chemical composition and the physical properties of chernozem. However, the chemical analyses of chernozem soil which have been undertaken by the Free Economic Society are as yet incomplete, while the investigation of physical properties has not yet begun; thus, the study of both subjects must be postponed. Author.

[2] Ruprecht. Ibid., pp. 22 – 26.

[3] According to the newest investigations made by Mr. Samokvasov, the Chernigov mounds date to the 10th rather than to the 14th century. — Zhurnal Ministerstva narodnogo prosveshcheniya, part 174, p. 261. [Maikov, L. N. Retsenziya na rabotu N. P. Barsova. Ocherki russkoi istoricheskoi geografii . . . (Review of N. P. Barsov's work, "Essays in Russian Historical Geography. . . ")].

[4] Ruprecht. Ibid., p. 9. The author hopes thus to determine the age of such mysterious relics as the Chud graves in the Altai area, the mounds of northern Russia, etc. Ibid., p. 30.

conclusion somewhat, reasoning that since the vegetal layer of "man-made mounds contains less humus (3.11 – 4.05% volatiles) than the layer of equal thickness in the primordial soils (no percentages are given) . . . therefore the first task is analytical determination of the quantitative ratios of the organic constituents, and the conversion of volume to weight to enable determination of the relative time required for formation of chernozem on a given uniform soil (ground)." [1]

The principle suggested by Ruprecht for the determination of the age of a country and of various relics of the past seems, at first glance, to be extremely simple, natural and very promising. Regrettably, all these attractive aspects vanish rapidly when the principle is subjected to detailed analysis.

1. In the first place, both the humus content of soils and soil thickness have a definite limit which cannot be exceeded.

It has been pointed out that the maximum thickness of Russian chernozem is 4 ft 8 in [1.4 m]. On the basis of the mode of origin of vegetal-terrestrial soils, it is extremely difficult for humus to penetrate deeper than this horizon and to color such thick grounds uniformly. The rates of increase in chernozem thickness also cannot be proportional to time. The increase in thickness of this soil is not linear, but rather decreases after a certain depth has been reached. The thicker the soil, the more difficult it is for humus to percolate downward; some of it is retained by the upper horizons.

Essentially similar arguments may be applied to the increase in the total humus content. Once the content of organic substances has exceeded 20% (Simbirsk soil contains about 19% humus), its nourishing qualities will hardly improve, and consequently, yields of cultivated and wild plants will barely increase. Moreover, accumulation of humus is inevitably accompanied by its increased consumption (decay). The soil thus reaches a stage of equilibrium when the influx of humus equals its consumption.

Thus, soil thickness and content of organic substances are proportional to age of soils only up to a certain limit, [2] and Ruprecht's method is applicable only within these limits.

2. We have proved that the humus content of soil and soil thickness are not dependent solely on the age of the soil but also on climate, vegetation, and especially the chemical-mineralogical nature of the parent rock. Therefore, soil age may be estimated on the basis of thickness of the vegetal layer and content of organic substances only when the three last conditions are identical in the two soils.[3] At the present state of our knowledge, no comparison may be drawn between very sandy soils, loamy and heavy clayey soils. [4]

3. Even if these conditions were observed by Ruprecht, his choice of scale (mounds) for comparison was extremely unsuitable. We already

[1] Ibid., p. 110.

[2] This also applies to the accumulation of readily soluble mineral nutrients in Russian chernozem; the content in soil cannot exceed that originally present in the fixed state in the parent bedrock. Il'enkov. Ibid., pp. 8 etc.

[3] If this condition is observed, however, Ruprecht's method may eventually yield extremely valuable results in the study of soil formation of the Earth. Author.

[4] As we have seen, Academician Ruprecht used the sandy soils of Sednev, which are very low in humus, as his scale (pp. 89, etc.).

know (pp. 172 ff.) that very many of these mounds consist of thrown-up chernozem, and there is no guarantee that a certain fraction of such soil is not found in the vegetal layer of the Sednev and other mounds. Furthermore, the formation of chernozem on the top of a mound and on its slopes occurs under topographic conditions quite different from those for the same process in the adjacent level country. We have already seen that any difference in topographic conditions inevitably leads to basic and profound differences in the nature of the soils themselves, even if all other soil-formers are identical.

Therefore, Ruprecht's method must be used with extreme caution. The magnitude of possible errors may best be illustrated by the following examples.

a) Having remarked, correctly, that "far longer is required for chernozem development than for the development of black soil in the northern, cold and wet, zone of Russia," Ruprecht supports this statement by the following arguments among others: "Thus, no chernozem, or only an unusually small quantity, has been formed on the seaboard of the Black Sea near Ovidiopol, or near Varna, since the time of Ovid and the Greek colonies."[1] How, then, over a period of at least two thousand years was no thin vegetal layer such as Ruprecht found on the Sednev mounds formed in this place?

b) Mr. Kontkevich mentions (pp. 208—209) several localities with outcrops of crystalline massive rocks in the western half of the south Russian granite belt. Such outcrops are definite proof of the antiquity of the localities, and the chernozem may be expected to be of richest quality, especially if the well-known composition of the weathering products of granite is taken into account. Yet, in fact, "chernozem is absent on the majority of the area occupied by the crystalline rocks," and the area is covered almost entirely by an insignificant brown vegetal layer!

c) Very characteristically, in almost the same area "the lowlying plain adjoining the upper portion of the Molochnyi liman is covered by a chernozem layer 2 1/2—3 vershoks [11—13 cm] thick, strongly impregnated by salt and underlain by marine sand containing species of *Cardium* which are still found in the Sea of Azov; fragments of the same shells also occur in the lower chernozem horizon."[2]

d) Academician Ruprecht first noted the formation of vegetal-terrestrial soils on the abandoned fortifications of the Staraya Ladoga fortress during historical times. His description was obscure and contradictory,[3] but since the fact itself is very instructive I traveled there in the summer of 1880, and made the following observations.

The Staraya Ladoga fortress (built in 1116) lies at the tip of the triangle at the confluence of the Ladozhitsa and Volkhov rivers, and is in the shape of an irregular polygon. As far as discernible, its walls were mostly constructed of crystalline northern boulders with a considerable admixture of large Silurian limestone slabs, and bound with very coarse lime cement. The walls were faced, at least in places, with similar limestone slabs, smaller and more regular in shape. Such slabs faced the fortress walls

[1] Ruprecht. Ibid.

[2] Levakovskii. Ibid., p. 35.

[3] Ruprecht. Ibid., pp. 29 and 45—46.

all around the top, and were at least 2 ft [61 cm] thick. At present the fortress is in a state of ruin, and the wall, perfectly horizontal on top, has been preserved only at some stretches facing the Ladozhitsa River; the width at the top is observed to have been 7 – 8 ft [2.1 – 2.4 m].

I investigated two such stretches and made a few artificial diggings in attempts to observe the formation of soil on the level surface of the fortress wall. My results are presented in Figure 12.

FIGURE 12.

The sod, about 1 in [2.5 cm] thick, is directly underlain by brownish-gray soil (A) 4 – 5 in [10 – 13 cm] thick (mean of ten measurements). This soil contains a mass of intact roots of herbaceous plants and calcareous-argillaceous pebbles of Silurian limestone; quartz grains are also quite common. The upper soil horizon is appreciably looser and darker than the lower horizon, while the latter is richer in limestone pebbles.

Further down the soil (A) formed a gradual transition to B. The latter is a layer (about 2 in [5 cm] thick) of limestone slabs cemented with coarse mortar. These slabs have already largely been integrated into angular grus into which humus is beginning to penetrate in the thin veinlets. B is underlain by huge erratics (a) and very large Silurian limestone slabs (b) with the same cement. This is undoubtedly vegetal soil in situ, formed over 760 years from the Silurian limestone slabs, mortar, and residues of herbaceous vegetation. This is indicated, first, by the regular downward increase of substances that are stable on ignition (including lime, magnesia, etc.) and a corresponding decrease in the secondary substances (humus, etc.) as in any normal vegetal-terrestrial soil.[1] Furthermore, the local

[1] Mr. Morozov wrote me of his observations after analyzing this soil at the agronomical laboratory of the St. Petersburg University.

soil is connected with the underlying Silurian slabs with a series of transitions, as in any soil lying in situ; finally, this soil, similar to the Simbirsk soil, contains very slightly altered residues of bedrock.[1]

This is, in short, perfectly analogous to all the Russian vegetal-terrestrial soils directly underlying various calcareous formations.

Very characteristically, the soils overlying sandy-clayey diluvium in the immediate neighborhood of the Staraya Ladoga fortress were appreciably lighter in color and did not exceed 5 – 6 in [13 – 15 cm] in thickness,[2] although the age of the local diluvium is certainly on the scale of thousands of years.[3]

e) Finally, further to my discussion of the Hapsal soils (p. 401) it should be noted that between the Linden farm and the shore of the Hapsal Bay, 700 – 800 paces from the latter, at the road to Pulyane, there is a small elevation consisting of Silurian limestone. The limestone is directly overlain by a layer (8 – 10 in [22 – 25 cm] thick) of small limestone and crystalline pebbles mixed with coarsely granular sand (quartz, feldspar, $CaCO_3$). The top 4 – 6 in [10 – 15 cm] of this loose mass are markedly colored brownish-gray by humus. If the sod is carefully stripped away, one can see dozens of Cardium and Mitilus shells amidst the living grass roots; these mollusks still inhabit the neighboring bay.

We have now discussed several cases in which parent rocks are of definitely different ages whereas the thickness of overlying soils is virtually unchanged. These facts provide clear proof that the process of the formation of vegetal-terrestrial soils is still in full swing.

The age of the Russian chernozem might be best determined from the different animal residues it contains. However, it has been shown that such residues are generally very seldom found[4] (Kipriyanov). Moreover, the soil is not an independently deposited layer but rather the upper horizon of the parent rock; it can always be claimed that the residues it contains were in situ at the time of the deposition of the bedrock (mostly diluvium), or after the formation of chernozem thanks to various burrowings. Consequently, this method is also unreliable.

In 1871, Prof. Levakovskii attempted an indirect approach to the solution of this problem. Having accepted (erroneously) as proven fact that the old krotovinas only pass through diluvial clay (subsoil) but not through chernozem itself (horizons A and B), he concluded, "such burrows were dug before the formation of chernozem."[5] This conclusion is obviously fallacious; had these krotovinas appeared before the formation of the chernozem soil, they could not be filled with the chernozem found in them!

There is no doubt that in the distant past the south Russian steppes were not covered by chernozem, at one time this vegetal layer was indistinguishable in color from the northern sod soils and its maximum

[1] It differed from the Simbirsk soil in that the latter (hor. A) contains areas completely devoid of the residues of bedrock (my sample was taken from just such an area), while on the Ladoga the entire soil horizon is fairly uniformly filled with angular fragments of the parent rock. Author.

[2] Ruprecht. (Ibid., p. 98) ascribed an even smaller thickness to the local northern soils. – Author.

[3] I believe that the relatively rapid formation of the soil on the Staraya Ladoga fortress is due to the favorable weathering conditions. The water could not stagnate and the limestone wall is probably heated more rapidly and strongly than the neighboring diluvium. Author.

[4] This is understandable since the layer containing organic residues is very rich in CO , which is accessible to action of air and atmospheric moisture. It is therefore not suitable for the preservation of animal remains and shells.

[5] and [6] Levakovskii. Ibid., p. 14.

thickness was 1 in — 1 ft [2.5 — 30 cm], etc. Obviously, at the different stages of the existence of the chernozem territory the soil could be and was, in fact, inhabited by various animals who certainly burrowed in the soil. However, the older the burrows the poorer their state of preservation for obvious reasons. The soil layer was initially very similar to the ground and therefore the krotovinas were not distinct against the background; also, due to the progressive thickening and darkening of chernozem the old burrows must have become blurred to the point of obliteration.

To complete our discussion, let us now examine those arguments in favor of the relatively ancient age of the chernozem zone advanced by M.N. Bogdanov. In his communication "Chernozem and Its Practical and Scientific Significance" (O chernozeme i ego prakticheskom i nauchnom znachenii)[1] Prof. Bogdanov presented, inter alia, the following two arguments: a) "Miocene or Pliocene deposits have not been found in the chernozem region, the youngest deposits of this zone being Eocene; b) deep and richly ramified gullies are characteristic of the chernozem zone; such gullies, although not as deep and ramified, are also found in the north. I did not succeed in finding them in the Kirgiz steppes; on the Ust-Urt, which is far more ancient than the Aral-Caspian steppe while still younger than chernozem, there are gullies which are not very deep and only slightly ramified. In the chernozem zone a considerable number of gullies are so deeply incised that c) their channels serve as outlet for soil waters; the Ust-Urt gullies, on the other hand, scarcely tap any soil waters. The only possible explanation is that they are younger than the gullies of the chernozem zone."

It is not possible, however, to concur with Bogdanov in any of these arguments. The first argument is factually wrong since vast areas of southwestern chernozem Russia are Pliocene and Miocene, and Pliocene also composes the northern shores of the Black Sea nearly throughout.[2] The second argument lacks proof; even were it proved, it bears no direct relationship to the age of the chernozem territory. I regard it as unproven on the basis of my own repeated observations of gullies 150 — 200 ft [46 — 61 m] deep in the Smolensk and Tver provinces, and even deeper gullies in the Makar'ev, Gorbatov, and Nizhni Novgorod districts. Regarding the emergence of soil waters in steppe gullies (c), it is common knowledge that spring emergence is governed by rock structure rather than by depths of gullies. I did not, moreover, notice any difference between northern and southern Russia in this respect.

Even if the greater depth of steppe gullies is accepted, this phenomenon would still be very far from supporting Mr. Bogdanov's idea. Even a very ancient continent may have extremely undeveloped gullies, since the dominant role in formation of gullies is played by the composition and structure of the continent, its forestation, amount of precipitation, climatic conditions, etc. A favorable combination of all these factors may produce huge gullies even in relatively very young countries.

[1] Bogdanov. — Trudy VEO, pp. 159 and 160, February 1877.

[2] Finally, even if chernozem Russia is assumed to have no Eocene, Miocene, and Pliocene formations, what is the correct inference? We have seen repeatedly that the best Russian chernozem (Krutoe, etc.) overlies boulder loess, which is known to belong even to the post-Pliocene.

The general conclusion is obvious. There is absolutely no indication for assuming the greater age of the Russian chernozem zone, as a whole, in comparison to a similar zone in northern Russia. Similar to the northern sod soils, typical Russian chernozem overlies diluvial boulder loam in 99 out of 100 cases. Consequently, all the conclusions regarding the geography of flora and fauna, which are exclusively based on the relatively greater age of the chernozem continent must necessarily be revised. Formation of chernozem may be said to have begun when the area of its present-day occurrence emerged above the sea; this process is still continuing in many areas of southern Russia. [1]

Thus, the principal explanation (the relatively young age of northern and central nonchernozem Russia) suggested by Ruprecht and his followers for the absence of chernozem in Russia outside its present-day boundaries must be regarded as completely unfounded. [2] We must, then, search for the true explanation of this remarkable phenomenon.

As early as 1877 – 1879, in my explanation of the causes of the present-day distribution of chernozem in Russia and in other countries, I noted that "The essence of the matter and of the answer lie in the very mode of formation of the vegetal-terrestrial soil and in the natural features inevitably attending the formation of these soils in various belts of Russia and of other countries." I do not deviate from this opinion today.

Indeed, since the mode of formation of vegetal-terrestrial soils suggested by Ruprecht is undoubtedly correct, the character of this soil, and all its properties must be conditioned by a) ground, b) climate c) vegetation, d) topography, as well as e) the duration of the formation period of the soil. It is therefore clear that unless these conditions (all or even one) are not identical in the soils, they themselves of course cannot be identical, and vice versa. [3] The powerful effect of the soil-forming factors a – d in southern Russia has already been discussed; we shall now demonstrate that their role is just as important in the north.

It becomes evident that the principal error involved in Ruprecht's explanation for the absence of chernozem in northern Russia lies in the logically fallacious formulation of the problem. Instead of studying the results in relationship to all the factors, he preferred only one of them. Therefore, even had Ruprecht succeeded in establishing the principle that the chernozem territory is older than the nonchernozem continent (which is, in fact, quite possible), the problem would still be very far removed from

[1] In our opinion, precise determination of the time required for the formation of a certain quantity of chernozem calls for the following preliminary work:

a) precise determination of the total humus content in a given soil; b) determination of the annual increment and decrement (decay) of wild vegetation in all the isohumus belts of Russia; c) experimental planting of the corresponding wild vegetation in special devices (in the open air) in different zones of Russia, determining the humus in the mixtures from time to time.

Such data would enable accurate determination of the minimum and maximum time necessary for formation of different vegetal-terrestrial soils.

[2] Another explanation advanced by Academician Ruprecht for the absence of chernozem in northern Russia, the relatively young age of its flora, was already examined by Prof. Levakovskii. Ibid., pp. 47 etc.

[3] The significance of each of these factors in the formation of soil, their combined effect, and the possibility of their mutual interchangeability may each form the subject of an independent monograph.

solution. The age of the country as well as all the other factors participating in the formation of the vegetal-terrestrial soil are totally different in northern and southern Russia; why, then, should the absence of chernozem in northern Russia be assumed to stem exclusively from the young age of this zone, disregarding its topography and bogs, forests, comparatively unfavorable ground, and its unfavorable climate?

The questions are rendered even more legitimate and significant by the extremely pronounced character of all these features characteristic of nonchernozem Russia. A few details follow.

1. It was shown in the well-known works of Academician Gel'mersen, Kropotkin and Prof. A.A. Inostrantsev of Finland, the Olonetsk and Arkhangelsk provinces, that these vast territories present endless series of fairly high chains of hills ("sel'gas", eskers, hogbacks), which may be quite isolated or interconnected by many spurs. My own investigations in southern Finland have proved many of them to have such narrow crests as to be hardly traversable by horses; their slopes often exceed 30°. The territory between these "sel'gas" is usually occupied by limitless bogs and lakes, some living and others nearing death. The size of the territory occupied by these water bodies may be seen from the fact that in many localities in northern Russia the hills are the only places at all suitable for settlement and different roads. It may be added that in the past (Kropotkin) the "sel'gas" were much higher and the lakes more numerous.

Obviously, these conditions do not enable the formation of vegetal-terrestrial soils.

Further south, toward provinces of central nonchernozem Russia, the landscape changes although the general character, as far as our subject is concerned, remains the same. Here too, the "polesie" stretches endlessly, sands alternating with bogs and lakes over dozens, sometimes hundreds of versts (pp. 114, 115, etc.); more frequently, the terrain assumes the appearance of the environs of Milyukovo (p. 1[illegible]1). As we have already seen on p. 131, the "polesie" conditions do not allow the formation of soils even remotely approaching the Russian chernozem. Conditions relatively more favorable for the formation of vegetal-terrestrial soils exist in the other type of terrain found in central Russia mentioned above (pp. 100 – 103). Even here, the majority of the territory is still either occupied by open bogs or by meadow bog-terrestrial soils. The lesser part, while relatively dry, is more or less rolling; this feature was even more pronounced in the past (p. 105).[1] Obviously, such territories cannot be regarded as favorable for thick accumulations of chernozem soil in situ.

2. The general pattern of settlement in Russia, ancient agriculture,[2] especially the contemporary distribution of forests, and to a certain extent direct historical research allow us "to state, with complete assurance, that in ancient times the entire nonchernozem area in the north of Russia (with the definite exception of bogs) was covered with continuous forests."[3] Forests, especially coniferous ones, can by no means be regarded as good

[1] I am aware of areas in central nonchernozem Russia (the Valdai Heights etc.) which contain a much larger percentage of dry areas than in those areas presented above, and the reader himself is probably also familiar with such territories. On the other hand, they are often extremely hilly. Author.

[2] Sovetov [A.]. O sistemakh zemledeliya (Systems of Agriculture), pp. 12 – 15. 1867.

[3] Maikov. – Zhurnal Ministerstvo narodnogo prosveshcheniya, p. 263. 1874.

soil formers, and their presence must be taken into account in the discussion of our subject.

3. The above descriptions of soils and parent rocks on the northern nonchernozem boundary, the environs of Milyukovo and Hapsal, and my own studies in southern Finland, the Ostsee Territory and the Smolensk, Vitebsk, Moscow, Yaroslavl, Vladimir, and Nizhni Novgorod provinces, make it clear that the rocks directly underlying the soils of nonchernozem Russia essentially consist of glacial formations such as quartz and feldspar sands, gravel, and sandy or heavy clay, and sometimes contain crystalline boulders; in some places these boulders form a nearly continuous cover. An unaided, careful examination of a typical specimen from a northern till will very often reveal several undecomposed minerals; similar slightly decomposed remains of different crystalline rocks often occur in the northern soils also. On the whole, these features of parent rocks in nonchernozem Russia become more pronounced and more characteristic toward the northewest. On the contrary, the admixture of a typically glacial formation with diluvium gradually diminishes toward the northern boundary of Russian chernozem and then continues into the central portions of the chernozem zone (p. 136), until the southern deposit becomes characteristic loess with a very low anhydrous silicate content.[1]

Thus, even if the total content of different plant nutrients in parent rocks is accepted as equal in northern and southern Russia, there must be a considerable difference in the content of readily soluble nutrients which are actually available to local vegetation. This inference was completely borne out by the work mentioned above, performed by Messrs. Mendeleev, Il'enkov and Schmidt. In this respect as well the vegetation of nonchernozem Russia developed to conditions much less advantageous than those enjoyed by plants in chernozem Russia since the territory began developing in that particular direction. This circumstance, in turn, must have had a hindering effect on the accumulation of vegetal-terrestrial soils.

4. As early as 1877, just before factual studies of the chernozem zone began, I remarked [2] that even if complete identity between northern and southern vegetation is admitted, both quantitatively and qualitatively, chernozem still could not have been formed in northern Russia due to the essentially different conditions for the decay of organisms in these two zones.

Both the soil and the air in northern and central Russia are known to be incomparably richer in water than the Russian chernozem steppes. In itself, excess water in soils is very unfavorable for vegetation. Moreover, in the presence of large amounts of water in soil, which causes sluggish aeration, the end products of the decay of organic substances are mainly marsh gas and free nitrogen (as was shown, among others, by research performed by

[1] See the analysis performed by Prof. Schmidt, Kostychev, etc. Probably, this circumstance of the difference between the northern and southern deposits is not due exclusively to a) different modes of their origin and b) different ages but also, and in fact mainly, to the different climatic weathering conditions, as follows:

c) the yearly season of chemical weathering is shorter in the north than in the south; d) in nonchernozem Russia there is an excess of surface water (rivers, lakes, bogs, relatively heavy precipitation) which interferes with the free aeration of soil while rapidly washing away the products of weathering.

[2] Dokuchaev. Itogi o russkom chernozeme (Summary on Russian Chernozem), pp. 15–16. 1877.

Reise and Schloesing[1]). Decay with sufficient air, on the other hand, produces CO_2 and NH_3. Senft added that decay under water produces gein and geinic acid which are in all probability very poisonous to plants, similar to marsh gas, while carbon dioxide and ammonia are among the most favorable soil factors. The lower temperatures of northern Russia are also unfavorable as regards soil fertility during the decay processes. "Boussingault communicated very valuable observations on the effect of temperature on decay and on the varying course of this process in different climates. In his opinion, decay takes a different course in the tropics where peat, for instance, is totally unknown. However, at a height of several thousand feet, such as on an Andes plateau, peat formation is again observed; this is undoubted proof that in this case the different trend of decay processes is due solely to temperature[2]."[3] Meyer remarks that similar phenomena occur in certain regions in Russia. Excellent examples of the very close relationship between climate and the trend of decay processes in a given locality are found in Darwin's "Voyage of the Beagle." [4] It is noteworthy that the vegetal-terrestrial soils in the Vyaz'ma, Klin, and Petersburg districts, cultivated for a long time, were found to have an acid or weakly acid reaction, according to the analyses performed by D.I. Mendeleev.

In view of all these circumstances, the absence or near absence of chernozem in northern Russia is no longer remarkable; on the contrary, it would be most unusual if this territory were covered with the same fertile chernozem soil found in southern Russia.

We regard these as the real proofs, and causes still operative, regarding the absence of more or less typical chernozem in northern Russia and partly also in central Russia.

In a majority of cases the most important properties of Russian chernozem may be explained only from this and no other viewpoint, only by the complex of causes (ground, climate, topography, age, and vegetation) and by no single factor.

Therefore, I regard the numerous chernozem "islands" indicated on the general maps of the Arkhangelsk, Olonetsk, Kostroma, Yaroslavl, Vladimir, Moscow, Vitebsk, Grodno, Kovno, Suvalki, and other provinces as being extremely doubtful, especially in the northern provinces. Indeed, available physiographic information makes it very difficult to suppose a complex of ground, age and topographic conditions which could compensate for the relatively unfavorable vegetation and climate of these territories. In order to obtain a factual solution of this problem, I decided in 1877 to inspect such northern chernozem "islands" which are nearest to the northern chernozem boundary and where cadastral commissions recorded the presence of chernozem; this is the territory between Vladimir[5] and Rostov[6]

[1] Kostychev. Kratkii ocherk khimicheskikh svoistv peregnoya i ikh sel'skhokhozyaistvennogo znacheniya (Brief Description of the Chemical Properties of Humus and Their Agricultural Significance)]. —Journal "Sel'skoe khozyaistvo i lesovodstvo", pp. 25—28, 49—50, [St. Petersburg], January 1876.

[2] Probably, higher humidity also plays a certain part.

[3] Meyer, A. Zemledel'cheskaya khimiya [Uchebnik zemledel'cheskoi khimii] (Agricultural Chemistry [Textbook of Agricultural Chemistry]), p. 72, [St. Petersburg]. 1875.

[4] Darwin. Voyage of the Beagle. 1840.

[5] Materialy dlya statistiki [Rossii], sobiraemye po vedomstvu Ministerstva gosudarstvennykh imushchestv (Materials for Russian Statistics Collected by the Ministry of Government Estates), No. 1, 1859.

[6] Materialy . . . (Materials . . .), No. 2, 1871.

(Yaroslavl Province). This territory is comparatively very high, very rich in running water and almost completely treeless. [1] The southeastern half of this territory is very hilly and incised by deep gullies, while its northwestern half in the upper reaches of the Koloksha, Irmes and Nerlya rivers, on the contrary, is of the general type characteristic of the Russian northern river water divides (p. 100); almost horizontal terrain, with abundant lakes, bogs, and wet meadows. After inspecting the outskirts of Vladimir-on-Klyaz'ma where the soils proved to be typically northern (9 in [23 cm] thick, humus 1.035%), I proceeded via cart track to Suzdal. Some stretches of the road pass through the immediate neighborhood of the rivers Klyaz'ma and Nerlya, over their gentle slopes (see references to the Sundovik, Tesha rivers etc.). In other places the road is at a considerable distance from the river, in which case gullies displayed only red-yellow diluvial clay (with a certain amount of boulders) covered by light-gray, thin (4 – 6 in [10 – 15 cm] thick) soils. Stretches of the first type sometimes contain meadow plowlands (p. 101) which gradually merge, on the river side, with the alluvial boggy lowlands and upland are replaced by typical northern soils. The same pattern is seen approximately 20 versts west of Suzdal. The increase in both number and dimensions of boggy lowlands of the type found at Medvedeva, Gol'neva etc. (pp. 102 – 103) began approximately with the Gavrilovskii "posad" [settlement] and continued up to Yur'ev Pol'skii. The terrain becomes increasingly more level, enabling this development toward the water divide. In many localities, such as in the outskirts of Suzdal and of Gavrilovskii "posad" a considerable area of such meadows has already been brought under cultivation and is heavily manured. The color of such soil in the fields is light-brown or dark-brown, usually not exceeding 1 ft [30 cm] in thickness, while the humus content may rise to 5.18% (Gavrilovskii "posad"). However, as soon as one ascends to relatively higher localities which have never been covered by bogs and where stagnation of rain and spring (snowmelt) waters is impossible, one immediately encounters very characteristic soil which is hardly distinguishable from the ground.

The mode of formation of such bog-meadow soils is best observed in the environs of Rostov. [2] Rostov is situated in a closed depression at the northeastern extremity of Lake Nero (10 – 12 versts long and 3 – 5 versts wide). The lake is extremely shallow, its bottom covered by very viscous peat-like glei, and there is a multitude of shoals and islets overgrown by sedge; most of the latter are so low and boggy that sometimes the border of lake and land is indiscernible. Viewed together with reliable historic data, these facts lead to the conclusion that Lake Nero is gradually dying, and it was much larger in the past than today. Corresponding with this statement, the soil map compiled by the cadastral commission working in the Yaroslavl Province indicates a fringe of inundated floodplain land (1/2 – 1 verst wide and more) around the lake; these soils are followed by a circular strip of

[1] Very characteristically, a considerable portion of this territory "was already treeless and open in ancient times; here (and very rarely otherwise in the entire northeastern part of ancient Russia) one encounters ancient names as Belekhovo Pole ["pole" means field], Yur'evskoe Pole, Yur'ev Pol'skii ["pol'skii" is an adjective from the word "pole", field]; this territory from Yur'ev nearly to Vladimir, is still popularly known as Opol'shchina [again, a derivative of the "pole," field]." Maikov. Ibid., pp. 270 – 271.

[2] I was unable to inspect the territory between Suzdal and Rostov; even on the existing maps this territory is mostly indicated as containing different northern soils.

chernozem which forms a gradual transition to good loamy soil further away from the shore as the terrain rises; the good loamy soil is eventually replaced by ordinary loam.

The former dimensions of Lake Nero[1] and the arrangement of soils provide clear proof that the territory contains soils of typical bog origin, to a certain degree meadow soils, and partly soils slumped from neighboring heights. This nature of the soils is also indicated by the following facts:

a) Even at present, in spite of very prolonged cultivation, the Rostov soils sometimes include chernozems "from which various salts effloresce on the surface on hot days in the form of a white powder"[2] ("usol").

b) Without the aid of farmyard manure, even the best varieties of Rostov chernozem and floodplain soil yield very poor crops, similar to other local soils.[3]

c) I found Rostov chernozem to be distinctly boggy in areas nearest to Lake Nero, and containing intact paludine plants. Its dark-brown color with a strong bluish tinge does not pale downward, while horizontally it is gradually replaced by present-day lacustrine glei-like deposits.

It is far more difficult to differentiate between steppe chernozem and the former meadow lands on adjacent higher slopes which have been converted to garden soils thanks to prolonged cultivation and heavy manuring. Their usual thickness is about 1—1 1/2 ft [30—45 cm], their color is light brown and sometimes dark gray, and their humus content is 8—9% (p. 122); in other words, their constitution is identical to the constitution of similar soils in the Smolensk Province (p. 105, meadow—plowlands). In this case, the only criteria are a) the situation of such soils, b) their acid nature, c) less regularity in the distribution of their constituents, d) the bluish vivianite color of the subsoil and e) the presence of typically northern soils in the immediate neighborhoods. These criteria are applicable to a certain degree to Rostov and Milyukovo soils.

Local inhabitants en route from Vladimir to Rostov, as well as in many other points of central nonchernozem Russia, may use "chernozem" to designate vegetal soils of any kind, while others use the word to denote soils of any origin provided they are of dark color; still others use the term for any soils yielding comparatively good crops, irrespective of appearance.[4]

In view of the information presented above regarding the soils of the Vladimir—Rostov territory, we may readily understand the reason for the appearance of the chernozem "islands" on Russian maps of northern and central Russia as well as their character.[5]

[1] Springtime floods (snowmelt) in the Yaroslavl Province still rise to 10 sazhens [21 m] above the summer low. —Materialy . . . [dlya statistiki Rossii, sobiraemye po vedomstvu Ministerstva gosudarstvennykh imushchestv] No. 2, p. 25 [St. Petersburg]. 1859.

[2] Ibid., p. 3.

[3] Ibid., p. 8.

[4] Nevertheless, in this territory dark soils may also occur on elevated areas, according to Mr. [A.] Krylov Geologicheskii ocherk Vladimirskoi bug. (Geological Description of the Vladimir Province). —[In book: Materialy dlya Geologii Rossii, vol. 10, map, St. Petersburg. 1881]. Jurassic formation is designated throughout the northeastern corner of the Vladimir Province; we are acquainted (p. 78) with the significance of this factor regarding the coloring of soils.

[5] The soil sample from the Urzhum chernozem "islands", which Mr. Solomin supplied, also proved to be a typical northern soil, 7 in [18 cm] thick and with 1.703% humus. The same arguments precluding the existence of true chernozem in northern Russia also counter-indicate its presence in the northern and central parts of western Europe; I regard as a very likely exception from this rule certain steppes in Hungary, Rumania, Serbia and northern Bulgaria. Author.

Even more obvious and marked is the complex of conditions which prevented the appearance of chernozem in the southeastern steppes and the extreme southern points of Russia; the young age of the Aral-Caspian formations can no longer be regarded as the sole cause of the absence of chernozem in this area. Firstly, there is no evidence whatsoever that the Tsaritsyn, Simferopol, Odessa, and other kinds of loess are younger than the loess of Krutoe, Endovishche etc. Secondly, at present, fairly typical chernozem (containing 5 – 6% humus) is also known on the northern seaboard of the Azov Sea in the Territory of the Kuban Cossacks, and in the southern part of the Samara Province on definitely Pliocene formations. Consequently, in this case as well the phenomenon may be explained only be a complex of causes. Indeed, besides the young age of the country, the mineral composition of the bedrock is extremely important. It is known that solonetsous clays and sands are among the most important – if not the most important – members of the Aral-Caspian formations. These rocks, even in the solid chernozem zone of Russia, usually bear either nontypical chernozem or else no chernozem at all.

This is only natural; sand is always a poor substrate for vegetation, and sandy saline clays must be preliminarily leached before they may serve as tolerably good soil. In view of the well-known scarcity of precipitation in the Aral-Caspian steppes, such leaching must have taken a fairly long time.

Finally, we have seen that in the southern parts of Bessarabia and the Kherson Province (p. 288), in some places in the Taurida Province (p. 302), in the Novouzensk and Tsarevo districts (pp. 294 ff.), in the Kalmyck steppe (p. 214) etc., in summer (June-August) only stunted, poor grass grows in small isolated clumps and does not form sod. Even this scanty vegetation is usually seared by the air or is blown off by the "sukhoveis" over the parched steppe before able to penetrate into the soil.

There is thus no material available for the formation of chernozem. I am convinced that these areas, similar to the southern regions of western Europe,[1] the central mountainous regions of Asia and to all tropical countries, however long they may continue to exist, will never, under the present climatic conditions, develop the advantageous, fertile soil which is the intrinsic and unique treasure of Russia,* the result of a suprisingly fortuitous and very complicated entity of physical conditions! Outside Europe, only the steppes of Siberia, Missouri and Mississippi may possibly compete with the Russian chernozem zone.[2]

These are the principal conclusions [3] drawn from my geological and geographic studies of the Russian soils. Nevertheless, the investigation of Russian chernozem is still very far from complete. Entire regions of chernozem Russia have yet to be visited by a pedologist, and no soil sample is available. As yet, chemical studies have only been performed for a very insignificant fraction of the material I collected, and analysis

[1] Griesebach. Ibid., part 1, pp. 142, 289, 293, etc.

* [Obviously, "Russia" implies European Russia. Translator.]

[2] I have great doubts regarding the occurrence of chernozem in India. The samples of Indian chernozem supplied by Mr. Voeikov are red-yellow or brown-yellow marls with 1 – 2% humus. – Author.

[3] A classification of soils which has already been prepared for printing as well as fairly extensive information which I collected on the depletion of Russian chernozem (Item f of the program) could not be included in this work for lack of space. Nevertheless, "Principles of Soil Classification" has been published previously. – Author.

of very important physical properties of chernozem has not even been started . . . In short, if the investigations of Russian chernozem by the Free Economic Society are to yield the practical results desired, the program I proposed in the Preface of this book must be carried out in detail and to its full extent . . .

I will conclude this work, as I began it, with the words of one of the first and most respected investigators of Russian chernozem:

"Bei der Untersuchung des Tschernosem liegt ein unendlich grosses Feld der Bearbeitung vor uns, aber der Gegenstand ist auch von der höchsten Wichtigkeit für die Wissenschaft und besonders für's praktische Leben, daher denn auch wohl jeder wissenschaftliche Mann, jeder denkende praktische Landwirth, der in den Gegenden dieser berühmten schwarzen Erde wohnt oder Besitz hat, befugt ist, seinen Beitrag zu liefern . . . "*

This statement, made by Wangenheim von Qualen thirty years ago, was significant at the time, and has taken on added importance today, with the emergence of many new aspects totally unsuspected by von Qualen . . .

* ["The investigation of chernozem comprises a vast field of activity; the subject is extremely important scientifically and especially practically. Therefore, every scientific worker and every intelligent farmer in the regions of this famous 'black earth' or owning property there must make his contribution . . . " — Ed.]

APPENDIXES

List of Soils Mentioned in This Work

Explanation to the Map

Schematic Map of the Chernozem Zone of European Russia

No.	Locality	Latitude	Longitude	Thickness in ft. and in. [cm]
			Left Bank of the	
1	Urzhum, Vyatka Province	57.1	47.5	6–8 [15–20]
	6 versts southeast of Orlovka, Menzelinsk District	55.7	50.2	2' 4" [71]
	7–8 versts north of Seltovo, Menzelinsk District	55.6	50.8	1' [30]
	15 versts northwest of the village of Verkhnii Tabyn, Menzelinsk District	55.4	50.0	2' 2" [66]
5	Aibashevo, Birsk District, No. 2	55.3	53.5	–
	Aibashevo, Birsk District, No. 3	–	–	–
	2 versts north of the village of Bol'shoi Tolkish, Chistopol District	55.3	48.7	2' 6" [76]
	Taigil'dino, Menzelinsk District	55.2	50.0	1'–1' 6" [30–46]
	10 versts south of Chubarovo, Menzelinsk District	55.1	50.0	2' [61]
10	1 verst northwest of Bolgary, Spassk District	55.0	47.0	1' 11" [58]
	7 versts north of Bugul'ma	54.4	51.5	1' 7" [48]
	Opposite Simbirsk, on the left bank of the Volga, at the village of Chasovnya	54.3	46.0	3' 11" [119]
	11 versts south of Sok-Karmala, Buguruslan District	53.9	50.0	2' [61]
	Approximately 1 verst northeast of Khryashchevka, Stavropol District	53.8	46.7	2' 4" [71]
15	5 versts south of Buguruslan	53.7	50.0	2' 4' [71]
	7–8 versts south of Nikol'skoe, Buguruslan District	53.5	52.0	2' 2" [66]
	At the village of Krivaya Luka, Samara District	53.4	48.5	2' 4" [71]
	2 versts east of Samara	53.2	47.8	2' 1" [63]
	Between Aleksandrovka and Berezovka, Buzuluk District.	53.1	50.0	8–9" [20–23]

mentioned in this work

Site	Humus, %	Hygro-scopic water, %	Analyst	Observer
'olga and Kama Rivers				
Level plowland	1,703	5.724	Baikov	Solomin
The same	11.313	7.906	Schmidt	Dokuchaev
Forest margin, level plowland	7,788	5.044	"	"
Level virgin land	10.845	9.624	"	"
The same	12.502	7.011	Sibirtsev	Bazilev
The same	14.218	8.296	"	"
Level glade amidst felled oak forests	11,728	8.375	"	Dokuchaev
Pasture on the summit of a very gentle hill	app. 13	8.142	Schmidt	"
Pasture at the top of gentle slope	7.360	–	Kytmanov	"
Forest soil	5.432	3.273	Davidovich-Nashchinskii	"
Virgin land at the edge of a deciduous forest	15.423	10.597	Schmidt	"
Virgin steppe	4.838	2,268	Davidovich-Nashchinskii	"
Level forest area	12.355	10.245	Schmidt	"
Level pasture	3.370	1,831	Kul'chitskii	"
Pasture halfway down a very gentle slope	13.070	5.405	Kolotov	"
Level feathergrass steppe	9.785	9.566	Schmidt	"
Feathergrass steppe in the vicinity of a solonchak	7.616	4.23	Zemyatchenskii	"
Steppe	10.494	5.178	Davidovich-Nashchinskii	
"Bor" soil halfway down a very gentle slope	1.727	1.290	Schmidt	

No.	Locality	Latitude	Longitude	Thickness in ft. and in. [cm]
20	Marychevka, Buzuluk District	53.1	49.3	2' 6" [76]
	5 versts north of Tverdilovka, Buzuluk District	53.0	50.0	2' [61]
	8 versts south of Titovka, Samara District	53.0	47.3	up to 2' 6" [76]
	Aleksandrovskii farm, 12 versts southeast of Tashla, Orenburg District (100 versts northeast of Orenburg) . .	52.8	53.5	2' 4" [71]
	Tashla, 100 versts northeast of Orenburg, Orenburg District	52.8	53.7	2' 4" [71]
25	5 versts north of Buzuluk	52.7	49.9	2' 9" [84]
	The same locality	–	–	2' 6" [76]
	Bulgakova-Cheban'ka, 65 versts northeast of Orenburg .	52.5	53.5	2' [61]
	Left bank of the Volga, opposite Khvalynsk, at the station of Dukhovnitskaya	52.5	45.8	2' 4" [71]
	Sorotskaya, Buzuluk District	52,4	50,8	2' 3" [69]
30	Andreevka, Buzuluk District	52.4	49.7	8" [20]
	3 versts northwest of Andreevka, Buzuluk District . . .	52.4	49.7	2' [61]
	5 versts southeast of Pokrovskaya, Nikolaevsk District. .	52,4	47.6	up to 1' 6" [46]
	9 versts south of Murashitsa, Nikolaevsk District . . .	52,3	47,6	1' 2" [35]
	Village of Nikol'skoe, 50 versts northeast of Orenburg, Orenburg District	52,2	53.6	1' 4" [40]
35	Pestravka, Nikolaevsk District	52.2	47.6	2' [61]
	Novosergievka, Buzuluk District	52.1	51.2	1' 6" [46]
	Nikolaevsk	52.0	46.4	1'–1' 6" [30–46]
	Orenburg	51.8	52.8	1' 11" [58]

(Continued)

Site	Humus, %	Hygroscopic water, %	Analyst	Observer
Plowland near a solonchak	5.018	3.225	Davidovich-Nashchinskii	Dokuchaev
Tall-weed steppe	6.662	3.234	Kolotov	"
Level pasture	10.48	5.65	Zemyatchenskii	Solomin
Field soil in the middle of a gentle slope	15.013	5.053	Sheshukov	Mezentsov
Steppe	14.551	4.707	"	"
Level field near the bluff toward the Samara River	3.458	3.854	Schmidt	Solomin
Level long-fallow land	2.762	1.80	Davidovich-Nashchinskii	"
Long fallow land	11.933	5.322	Sheshukov	Mezentsov
Level field	5.293	–	Kostychev	Solomin
Level pasture	6.701	4.485	Kolotov	Dokuchaev
Field halfway down a gentle slope	3.815	2.842	Davidovich-Nashchinskii	"
Depression overgrown by feathergrass	11.582	9.504	Schmidt	"
Field at the top of a low hill	6.915	3.105	Zemyatchenskii	"
Level pasture	6.662	5.144	"	"
Level field	6.073	3.234	Sheshukov	Mezentsov
Steppe	10.378	5.44	Zemyatchenskii	Dokuchaev
Steppe	10.033	4.557	Kolotov	"
Steppe, pasture	6.445	–	Kostychev	"
Steppe	2.432	2.721	Kolotov	"

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
	5 versts south of Skrebnitskaya, Novouzensk District . .	51.5	46.6	1' 1" [33]
40	Village of General'skoe Novouzensk District, 6 versts from the left bank of the Volga	51.5	44.0	7" [18]
	9 versts northwest of Gnadendorf, Novouzensk District .	51.3	44.7	9" [23]
	Osipov-Gai, Novouzensk District	51.2	46.3	1' 11" [58]
	15 versts northwest of Gofental (Hofenthal)	51.2	44.8	1' 5" [43]
	3 versts south of Orlov-Gai, Novouzensk District . . .	50.9	46.9	2' [61]
45	5 versts south of Orlov-Gai station	-	-	6" [15]
	6 versts west of Novotulka, Samara District	50.9	45.3	1'—1' 2" [30—35]
	Novouzensk	50.5	46.8	5—6" [13—15]
		Territory between the		
	15 versts south of Kazan	55.5	46.6	7" [18]
	Kil'deevo	55.4	46.5	1' 6" [46]
50	8 versts north of Burunduki	55.3	46.5	8" [20]
	Buinsk	55.2	46.0	2' 3" [69]
	8 versts west of Tetyushi	55.0	46.3	1' 6" [46]
	Tetyushi, at the very bank of the Volga	-	-	1' 2" [35]
	Simbirsk	54.3	46.0	2' 6" [76]
55	Sengilei	53.9	46.5	2' 3" [69]
	5 versts north of Syzran	53.2	46.1	2' 2" [66]
	Topornino, Syzran District	?	?	-
	6 versts west of Khvalynsk	52.5	45.8	1' 4" [40]

(Continued)

Site	Humus, %	Hygroscopic water, %	Analyst	Observer
Pasture at the top of a gentle slope	4.193	-	Kostychev	Dokuchaev
Virgin land	1.922	2.178	Sibirtsev	Sogatovskii
Steppe	4.218	2.320	Kul'chitskii	Dokuchaev
Level field	5.325	-	Kostychev	"
Steppe	9.105	3.526	Kul'chitskii	"
Steppe	4.790	-	Kostychev	"
Steppe	2.769	?	"	"
Steppe	3.621	4.265	Zemyatchenskii	Solomin
Steppe	3.030	?	Kostychev	Dokuchaev
Volga and the Dnieper				
In the middle of a gently rolling field	4.677	?	Kostychev	Dokuchaev
Almost perfectly level plowland	6.787	4.549	Kolotov	"
Level field after forest-clearing	3.651	2.397	"	"
Level pasture	9.543	?	Kostychev	"
Field halfway down a barely perceptible slope	9.20	3.94	Zemyatchenskii	"
Level forest area	12.988	6.829	Davidovich-Nashchinskii	"
Steppe	19.171	?	Kostychev	"
Level pasture considered solonets	7.704	4.912	Davidovich-Nashchinskii	"
Steppe	4.523	?	Kostychev	"
Plowland	7.40	2.99	Zemyatchenskii	Andreev
Field in a flat hollow	15.079	?	Kostychev	Dokuchaev

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
	4–5 versts from Vol'sk, along the Saratov highway . .	52.0	45.0	1' 6" [46]
60	1 verst west of Saratov, with pebbles	51.5	44.0	2' [61]
	The same soil, without pebbles	-	-	-
	Kamyshin	50.1	43.1	1' 9" [53]
	Belogiinka, Kamyshin District	50.0	42.8	1' 3" [38]
	5 versts north of Karavainskaya, Tsaritsyn District . .	49.6	42.9	1' 2" [35]
65	Zapadnaya, Tsaritsyn District	49.3	42.6	1' [30]
	Gorodishche, Tsaritsyn District	48.8	42.1	11" [28]
	Tsaritsyn	48.7	42.2	9–10" [23–25]
	Chernyi Yar	48.1	43.7	4" [10]
	Ostrovskoe, Knyaginin District	55.9	42.6	1' 1" [33]
70	Troitskoe, Vasil'sk District	55.8	42.0	1' 5" [43]
	Stolbishche, Sergach District	55.4	42.5	7" [18]
	Starinskoe, Sergach District	55.4	42.4	1' 11" [58]
	1½ versts south of Berezovka station, Sergach District .	55.3	42.4	2' 6" [76]
	The same locality	-	-	1' [30]
75	5 versts south of Lyskovo	56.0	42.8	6–7" [15–18]
	At the village of Solov'evo, Knyaginin District . . .	55.9	42.8	1' 4" [40]
	At the village of Noven'kaya, Knyaginin District . .	55.9	42.8	1' 3" [38]
	Potapovo, Knyaginin District	55.8	42.9	1' 5" [43]
	½ verst northwest of Tolba, Sergach District	55.7	42.0	1' [30]

(Continued)

Site	Humus, %	Hygro-scopic water, %	Analyst	Observer
Pasture	9.647	5.211	Davidovich-Nash-chinskii	Dokuchaev
Pasture at the foot of a very gentle slope	10.544	4.425	Kolotov	"
The same	12.040	4.966	"	"
Level pasture	2.072	3.129	Balkov	"
Pasture halfway down a gentle slope	5.429	6.601	"	"
Pasture halfway down a gentle slope	1.450	0.927	"	"
Level pasture	1.422	0.933	"	"
The same	2.526	5.127	"	"
Virgin land, steppe	0.908	1.081	"	"
Steppe	1.081	1.135	Sibirtsev	"
Level field, heavily manured	3.405	2.158	Ferkhmin	"
The same	4.01	2.53	Levinson	"
At the top of a hill, "zaklech"	7.71	3.49	"	"
Plowland in the lower part of a slope	11.00	5.06	Amalitskii	"
Level plowland	10.08	4.50	Ferkhmin	"
Forest soil level area	4.21	1.53	Amalitskii	"
Level field, heavily manured	1.140	?	Ferkhmin	"
The same	4.653	1.58	"	"
Plowland halfway down a gentle slope	6.138	2.26	"	"
The same	5.52	2.95	"	"
Halfway down a slope	2.265	0.667	"	"

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
80	4 versts north of Pogorelovskoe, Knyaginin District . .	55.6	43.0	8" [20]
	1 verst south of Yanovo, Sergach District	55.4	42.0	1' 9" [58]
	At the village of Shubina, Sergach District	55.5	43.1	2' 2" [66]
	1 verst each of Tartaleya, Sergach District	55.4	42.8	2' 6" [76]
	1 verst north of Endovishche, Sergach District . . .	55.4	43.0	2' 10" [86]
85	11 versts north of Mangushevo, Sergach District . . .	55.3	43.1	2' 7" [79]
	Mangushevo	55.2	43.1	2' 8" [81]
	½ verst north of Chernavskoe	55.0	43.0	1' 8" [50]
	Between Chernavskoe and Churkina, 3 versts from the former	55.0	43.0	1' 6" [46]
	4 versts south of Rabotki, Makar'ev District	56.1	42.3	6" [15]
90	Chemukha, Khyaginin District	56.0	42.8	8" [20]
	Grigorovo, Knyaginin District	55.9	42.3	1' 1" [33]
	½ verst west of Kholyazina, Knyaginin District . . .	55.9	-	1' 4" [40]
	1 verst north of Bol'shoe Murashkino, Knyaginin District	55.8	42.4	1' 6" [46]
	Approximately 10 versts north of Buturlino, Knyaginin District	55.7	42.5	9" [23]
95	1½–2 versts east of Barnukovo, Knyaginin District . .	55.6	42.2	2' 4" [71]
	3 versts southeast of Barnukovo	-	-	2' 6" [76]
	Vetoshkino, Polyanskaya forest plot, Sergach District	55.6	42.5	1' 10" [55]
	Approximately 3 versts southeast of Uvarovo	55.5	42.8	1' 11" [58]
	Molchanovo, Sergach District	55.0	42.9	2' 1" [63]

(Continued)

Site	Humus, %	Hygro-scopic water, %	Analyst	Observer
Forest, level area	5.91	2.29	Levinson	Dokuchaev
Plowland halfway down a slope	7.10	3.40	Ferkhmin	"
Long-fallow land, near a bluff	10.40	?	"	"
Plowland at the foot of a gentle slope	7.17	4.00	Amalitskii	"
Level long-fallow land	9.877	3.871	Ferkhmin	"
The same	14.767	5.40	"	"
The same	13.565	4.17	"	"
Level plowland	8.095	3.041	Fokht	"
Level plowland	11.554	3.801	Sibirtsev	"
Level manured plowland	0.91	0.86	Fokht	"
The same	3,41	2,04	"	"
Field at the foot of a slope	7,54	2,448	Ferkhmin	"
Halfway down a slope	7.88	?	"	"
Level plowland	5,88	?	"	"
Oak forest, level area	3,91	2.41	"	"
On a gentle slope descending toward the P'yana River	6,32	2,53	Sibirtsev	"
The same	5.04	3.31	"	"
Level plowland	8,42	3.58	Fokht	"
Elevated level area, forest soil	5.00	2.194	Ferkhmin	"
On top of a slope	4.17	1.93	Amalitskii	"

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
100	1 verst south of Maresevo, Lukoyanov District	54.9	42.8	11" [28]
	1 verst north of Yaz, Lukoyanov District	54.8	-	8" [20]
	10 versts north of Kemlya, Lukoyanov District . . .	54.7	-	4" [10]
	1 verst south of Kergudy, Lukoyanov District	54.6	-	2' [61]
	Stepanovka, Lukoyanov District	54.5	42.9	3' [91]
105	Permeevo, Lukoyanov District	54.4	42.9	2' 1" [63]
	3 versts southwest of Slobodskoe, Makar'ev District . .	56.0	42.0	5" [13]
	1 verst north of Kurlakovo, Knyaginin District	55.9	42.3	1' [30]
	Approximately 1 verst south of Vel'demanovo . . .	55.6	42.1	9" [23]
	2½ versts north of Ichalki	55.4	42.2	1' 2" [35]
110	Chirgushi, Lukoyanov District	55.0	42.3	1' 6" [46]
	Merlinovka, Lukoyanov District	55.0	42.3	1' 2" [35]
	Vasil'ev Maidan, Lukoyanov District	54.9	42.4	1' 1" [33]
	1 verst south of Bol'shaya Puza, Lukoyanov District . .	54.8	42.4	2' [61]
	Somewhat further south, 9 versts from Pochinki . . .	-	42.5	1' 8" [50]
115	2 versts south of Pelya-Khovanskaya, Lukoyanov District	54.4	42.6	2' 8" [81]
	Simbukhovskii farm, Lukoyanov District	54.4	42.6	3' [91]
	12 versts north of Saransk	54.2	42.8	2' 1" [63]
	5 versts northwest of Saransk	54.2	43.0	-
	12 versts east of Sosnovka, Korsun District	54.3	44.3	11" [28]
120	Atkarsk	51.8	42.6	1' 6" [46]

The same	2.50	0.44	[illegible]	[illegible]
Level plowland	7.20	3.86	"	"
The same	9.41	5.017	Zemyatchenskii	"
The same	9.97	4.96	"	"
Level manured plowland	1.70	0.92	Levinson	"
The same	3.77	1.07	Ferkhmin	"
Elevated plowland	3.05	1.77	"	"
On top of a gently sloping hill	3.784	1.835	Sibirtsev	"
Halfway down a slight slope	7.11	2.94	"	"
Level field	6.9	?	"	"
Elevated level field	5.49	3.49	Zemyatchenskii	"
Level field	4.90	2.97	"	"
The same	6.086	?	"	"
Halfway down a slope	9.63	4.10	"	"
Gentle slope at the forest edge; peat-like soil	16.11	6.05	"	"
Level area at the roadside	10.376	4.477	Kul'chitskii	"
Field halfway down a barely perceptible slope	10.056	3.501	"	"
Plowland halfway down a slope	7.576	4.156	Zemyatchenskii	"
Pasture halfway down a slope	8.158	4.346	Kolotov	"

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
	At Kurdyum station, Saratov District	51.6	43.6	1' 8" [50]
	Ataevka, 75 versts south of Atkarsk	51.3	42.5	-
	Kovarditsy, Murom District	55.6	39.7	4–5" [10–13]
	Rostov, Yaroslavl Province	57.2	37.0	-
125	Gavrilovskii settlement, Suzdal District	56.5	37.5	11" [28]
	Vladimir-on-Klyaz'ma	56.1	38	9" [23]
	4–5 versts beyond Steksovo, in the direction of Arzamas	55.4	41	1' 8" [50]
	1–½ verst south of Ardatov	55.3	40.7	8" [20]
	Arzamas	55.5	41.5	8–10" [20–25]
130	11 versts southwest of Arzamas	55.4	41.6	1' 9" [53]
	Mikhailovka, Lukoyanov District	-	-	4–5" [10–13]
	Ul'yanovka, Lukoyanov District	-	-	1' 10" [55]
	Milyukovo, Sychevka District, third plot	55.8	32.0	5–6" [13–15]
	Milyukovo, Sychevka District, second plot	-	-	6–7" [15–18]
135	The same locality, first plot	-	-	1' 2" [46]
	The same locality, meadow—plowland	-	-	1'–1' 6" [30–46]
	Kolomna	55.1	36.5	8" [20]
	Zaraisk	54.7	36.6	9" [23]
	12 versts from Z[illegible]aisk to Venev	54.6	36.5	10" [25]
140	Serebryanye Prudy, Venev District	54.5	-	1' 6" [46]
	Venev	54.3	36.0	1' 4" [40]

(Continued)

Site	Humus, %	Hygroscopic water, %	Analyst	Observer
Level pasture	8.276	4.729	Kolotov	Dokuchaev
Level field	9.561	5.840	Sibirtsev	Goryainov
Level long-fallow land	0.500	0.072	Davidovich-Nashchinskii	"
Meadow land	8—9	?	"	"
Level area, field soil, heavily manured	5,166	-	Balkov	"
Level area at the roadside Rivers	1.035	1.751	Kul'chitskii	"
Elevated level field	4.572	2.901	"	"
Field halfway down of a barely perceptible slope	0.757	0.047	"	"
The same	3.080	3.146	Davidovich-Nashchinskii	"
Level field	5.642	2.851	Kul'chitskii	"
Waste land	1.436	-	Sibirtsev	"
The same	8.831	-	"	"
Level area	1.150	1.123	Zyukov	Dokuchaev
Waste land	2.338	2.083	Davidovich-Nashchinskii	
The same	3.368	2.013	"	"
The same	9.796	6.093	"	"
Level field	2.108	2.489	Balkov	"
Pasture at the foot of a barely perceptible slope	2.503	1.850	Sibirtsev	"
Level plowland	3.297	2.989	"	"
Plowland in the lower third of a slope	6.782	3.732	Davidovich-Nashchinskii	"
Level plowland	6.205	1.116	Sibirtsev	"

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
	Ryazan	54.6	37.2	1' 2" [35]
	Ryazhsk	53.7	37.4	1' 4" [40]
	Gurovo, Morshansk District	53.5	39.5	3' 4" [101]
145	Gryazi, Lipetsk District	52.5	39.3	3' 7" [109]
	Zubrilovka, Balashov District	52.3	42.0	3' 10" [116]
	Krutoe, Balashov District	52.3	42.0	3' 8" [111]
	Volkonskaya, Borisoglebsk District	51.5	39.5	2' 5" [74]
	Filonovo, Don Cossack Territory	50.5	40.4	2' 3" [69]
150	4 versts north of Saburovshchina station, Meshchevsk District	54.5	33.4	1' 2" [35]
	Between Saburovshchina and Meshchevsk, 12—13 versts from the latter	54.4	33.1	10" [25]
	1 verst southeast of Yurinskaya station, Kozel'sk District	54.0	34.0	10" [25]
	Tula	54.3	35.3	1' 2" [35]
	Lazarevo station, Krapivna District	53.7	35.0	2' [61]
155	Kazarino, Chern District	53.5	34.6	2' 6" [76]
	Petrovskoe, Chern District	53.4	34.6	8" [20]
	Bol'shoe Teploe, Chern District	53.3½	34.7	1' 6" [46]
	11 versts south of Bolkhov	53.3	37.7	1' 5" [43]
	7 versts north of Raspopovskaya, Bolkhov District . .	53.4	33.7	1' 7" [48]
160	Between Orel and the village of Telegina	53.0	33.8	1' 2" [35]
	At the village of Umrikhina, Orel District	53.0	33.2	1' 1" [33]

(Continued)

Site	Humus, %	Hygroscopic water, %	Analyst	Observer
Field halfway down a barely perceptible slope	2.655	3.734	Balkov	Dokuchaev
Level plowland	5.999	7.988	"	"
Plowland	7.625	11.093	"	"
Level plowland	9.595	6.452	"	"
Virgin land after forest clearing	13.703	7.006	Sibirtsev	"
Virgin land, steppe	11.616	13.47	Schmidt	"
Level plowland	9.148	6.363	Balkov	"
Steppe	6.667	3.663	"	"
Level plowland	2.527	1.031	Kytmanov	"
Level plowland	1.684	1.457	"	"
The same	2.338	2.080	Davidovich-Nashchinskii	"
Pasture, hilly area, on a slope	2.542	4.828	Balkov	"
Pasture halfway down a slight slope	8.747	8.062	"	"
Very gently rolling pasture at the foot of a slope	8.109	9.126	"	"
Rolling plowland halfway down a slope	4.959	4.970	"	"
Plowland on the upper third of a gentle slope	8.729	3.537	Ogloblin	"
Level plowland	4.599	2.154	Kytmanov	"
Plowland halfway down a very gentle slope	5.265	6.552	Sibirtsev	Kytmanov
Plowland halfway down a barely perceptible incline	4.176	5.153	Balkov	Dokuchaev
Level plowland	3.37	1.66	Zemyatchenskii	Zaleskii

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
	Sakhanka, Orel District	53.0	33.7	1' 2" [35]
	Kamennyi Bugor, Novosil'sk District	53.0	34.0	2' 2" [66]
	Mokhovoe, Novosil'sk District	53.0 23	34.0	2' 5" [74]
165	Verkhov'e, Novosil'sk District	52.8	35.0	1' 11" [58]
	1½ versts southwest of Livny	52.4	35.4	2' [61]
	Ponyri, Fatezh District	52.3	[illegible]4.0	2' 2" [66]
	Evlanovo or Timok	51.9	35.0	2–2½' [61–76]
	11 versts east of Shchigry	51.8	34.9	2' [61]
170	5 versts west of Okhochevka, Shchigry District . . .	51.7½	34.6	2' [61]
	8 versts before Kursk	51.6	33.8	1' 3" [38]
	Kursk, at the railroad	51.6	33.8	2' 3" [69]
	1 verst north of Kursk, on the bank of the Tuskar . .	-	-	1' 6" [46]
	Astapino, Tim District	51.5	34.7	2' 11" [89]
175	Endovishche	51.7 45	37.0	3' 1" [94]
	Between Mar'ino and Ploskoe, Oboyan District . . .	51.2	34.4	2' 6" [76]
	Mar'ino, at the railroad station, Oboyan District . .	51.2	34.4	2' 10" [86]
	At Rossosh, Ostrogozhsk District	?	?	?
	Mikhailovo, Boguchar District	50.0	37.0	2' 11" [89]
180	Glubokaya, Don Cossack Territory	48.0	37.0	2' 2" [66]
	Grushevka	47.5 33	38.0	1' 8" [50]
	Khotynets, Orel District	53.0	33.2	?
	5 versts west of Novorobskaya, Novozybkov District	52.3	29.9	1' [30]

(Continued)

Site	Humus, %	Hygroscopic water, %	Analyst	Observer
Level plowland	4.759	3.509	Kytmanov	Kytmanov
Virgin land, elevated area, amidst forest	5.825	7.282	Balkov	Dokuchaev
Plowland at summit of a barely perceptible slope	8.115	4.096	Sibirtsev	"
Level plowland	8.523	6.400	Kytmanov	"
Elevated level field	8.060	3.620	"	"
Level plowland	6.106	7.698	Balkov	"
The same	4.607	2.176	Zemyatchenskii	"
The same	3.812	5.635	Kytmanov	"
The same	7.301	4.000	"	"
The same	4.268	2.747	Sibirtsev	"
Level long-fallow land	4.811	4.452	Balkov	"
Pasture at a bluff	3.30	1.81	Focht	"
Plowland under hemp	4.365	3.168	Kolotov	"
Level pasture	11.427	13.734	Balkov	"
Plowland on a barely perceptible slope	7.319	4.809	Davidovich-Nashchinskii	"
Level plowland	6.031	4.966	Kytmanov	"
Virgin land	7.959	5.002	Sibirtsev	Tul'gin
Level grazing steppe	4.451	5.980	Balkov and Kolotov	Dokuchaev
The same	5.647	6.798	Balkov	"
Steppe	approximately 7	10.61	Schmidt	"
Level plowland	3.655	1.77	Zemyatchenskii	Kytmanov
The same	1.556	1.713	Kytmanov	"

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
	3 versts north of Novgorod-Seversk	52.0	31.0	10" [25]
185	10 versts north of Voronezh, Glukhov District	51.8	31.2	1' 4" [40]
	1 verst north of Glukhov	51.6	31.6	?
	2 versts north of Putivl	51.4	31.6	2' 11" [89]
	Krasnoe, Putivl District	51.3	31.5	2' 11" [89]
	L'gov station	51.6	33.0	-
190	Korenevskaya station	51.4½	32.6	1' 4" [40]
	Konotop	51.3 14	30.9	4' 8" [42]
	Bakhmach, Borzna District	51.2½	30.5	3' 3" [99]
	Nezhin, 1 verst north of the station	51.1	29.5	3' 6" [106]
	1 verst east of Nezhin station	51.1	29.5	-
195	15 versts south of Romny	50.7	31.3	2' 6" [76]
	Veprikskaya	50.5	31.8	4' [122]
	4 versts north of Gadyach	50.4	31.6	2–3' [61–91]
	7 versts northwest of Zen'kov	50.3	32.0	2' 6" [76]
	14 versts southwest of Akhtyrka	50.2	32.7	3' [91]
200	Denisovka, Lubny District	50.0	30.2	3' 5" [104]
	Lubny, ½ verst westward	50.0	30.7	2' [61]
	5 versts from Kurilekhovskaya station, in the direction of Poltava	49.5	32.0	1' 10" [55]
	Near Ganovka, Kobelyaki District	49.3	31.5	3' [91]
	Belgorod, near the Donets valley	50.6	34.3	-

(Continued)

Site	Humus, %	Hygro-scopic water, %	Analyst	Observer
Level plowland	2.765	1.620	Kytmanov	Kytmanov
The same	1.425	1.168	"	"
The same	1.680	1.204	"	"
The same	1.862	1.237	Zemyatchenskii	"
Level fallow field	3.522	3.612	Kytmanov	"
Old fallow land halfway down a very gentle slope	3.010	-	"	"
Level long-fallow land	2.069	2.554	Davidovich-Nash-chinskii	"
Level fallow field	2.514	2.645	Kytmanov	"
Level long-fallow land	2.80	1.24	Zemyatchenskii	Dokuchaev
Level fallow field	3.608	2.647	Davidovich-Nash-chinskii	"
The same	2.345	2.395	Kytmanov	"
Level long-fallow land	5.430	3.963	"	"
Level area	3.83	2.83	Fokht	"
Level long-fallow land	3.495	2.797	Kytmanov	"
The same	3.024	-	Sibirtsev	"
The same	3.240	3.791	Davidovich-Nash-chinskii	"
Level area after felling an orchard	4.579	5.431	Balkov	"
Elevated fairly level pasture	3.401	2.653	Zemyatchenskii	"
The same	2.865	2.404	Davidovich-Nash-chinskii	"
Long-fallow land halfway down a slight slope	3.73	2.17	"	"
Pasture near a bluff	4.141	3.81	Schmidt	"

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
205	10 versts beyond Belgorod toward Tomarovka	50.6½	34.3	1' 6" [46]
	12 versts beyond Belgorod, toward Tomarovka	50.6½	34.3	1' 11" [58]
	2—3 versts short of Tomarovka, Belgorod District . .	50.7	34.2	2' [61]
	Approximately 1 verst west of Borisovka, Graivoron District	50.5	33.7	2' 3" [69]
	3 versts south of Graivoron	50.5	33.4	2' 6" [76]
210	20 versts south of Graivoron	50.3	33.4	3' [91]
	8 versts west of Bogodukhovo	50.2	33.0	3' 2" [96]
	Kochanovskaya, Zen'kov District	50.3	32.3	2' 9" [84]
	Pesochino, near Khar'kov	50.0	33.9	3' 2" [96]
	Lozovaya	49.0	34.0	3' [91]
215	Sinel'nikovo, Pavlograd District	48.5	33.2	2' 6" [76]
		Territory between the		
	Kiev	50.4	28.2	½—1' [15—30]
	22 versts from Kiev, Boyarka station	50.4	28.0	
	Vasil'kov	50.2	27.8	2' 7" [79]
	Fastov	50.1	27.6	1' 8" [50]
220	Berdichev	49.6	26.6	2' 3" [69]
	Kazatin, Berdichev District	49.4	26.4	2' 6" [76]
	Polonnoe, Novograd-Volynsk District	50.1	25.1	6—7" [15—18]
	Rovno	50.6	23.8	9" [23]
	Proskurov	49.4	24.6	-
225	Belaya Tserkov, Vasil'kov District	49.8	27.8	2' 11" [89]
	Korsun, Kanev District	49.5	29.0	2' 11" [89]

(Continued)

Site	Humus, %	Hygro-scopic water, %	Analyst	Observer
Plowland halfway down a barely perceptible slope	6.047	4.04	Davidovich-Nashchinskii	Dokuchaev
Level plowland	4.231	5.510	Kytmanov	"
Level pasture	5.46	2.35	Zemyatchenskii	"
Level long-fallow land	3.864	2.207	"	"
Level plowland	7.585	2.550	Kytmanov	"
The same	6.591	3.809	Davidovich-Nashchinskii	"
Level pasture	6.425	4.467	"	"
Pasture after clearing oak bushes	5.709	3.280	Kytmanov	"
After felling a very old forest on a barely perceptible incline	8.786	6.88	Schmidt	"
Level plowland	8.519	10.254	Balkov	"
The same	3.892	2.059	Kul'chitskii	"
Dnieper and the Dniester				
Plowland halfway down a barely perceptible slope	0.964	1.615	Balkov	"
Level area overgrown by small oaks	1.298	0.701	Sibirtsev	Solomin
Plowland halfway down a barely perceptible slope	app. 2–3	2.80	Zyukov	Dokuchaev
Level area at the roadside	2.883	1.830	Kul'chitskii	"
Plowland on level elevation	3.116	2.378	"	"
Level plowland	5.167	4.562	"	"
Level area at the roadside	2.695	1.138	"	"
Level plowland	2.855	2.050	Davidovich-Nashchinskii	"
Top of very slightly inclined plowland	3.368	2.753	Balkov	"
Level pasture	3.514	1.901	Sibirtsev	"
The same	4.372	2.209	"	"

No.	Locality	Latitude	Longitude	Thickness in ft. and in [cm]
	Smela, Cherkassy District	49.2	29.6	4' 2" [127]
	Bobrinskaya station, near the railway station, Cherkassy District	-	-	3' 11" [119]
	Odai, Uman District	48.7	27.5	3' 10" [116]
230	Tomashevka, Uman District	48.6	27.7	4' 6" [137]
	Golovonevsk, Balta District	48.4	28.2	2' 6" [76]
	25 versts northwest of Ol'viopol, Balta District	48.3	28.3	2' 11" [89]
	Sofievka, Anan'ev District	47.8	28.0	3' 7" [109]
	Zhmerinka, Vinnitsa District	49.0	25.6	2' 0" [61]
235	Yampol	48.2½	26.0	2' 5" [74]
	4–5 versts southwest of Nepada, Soroki District	48.0	26.2	3' [91]
	Kugureshti, Soroki District	-	26.0	1' 2" [35]
	Elizavetgrad	48.5	30.0	4' 8" [142]
	Znamenka, plowland in Aleksandriya District	48.7	30.3	2' 9" [84]
240	Znamenka	-	-	-
	Protopopovka, Aleksandriya District	48.7	30.7	2' 6" [76]
	Kryukov	49.0	31.1	2' 11" [89]
	Kryzhopol	48.1	26.6	3' [91]
	Ol'viopol	48.0	28.5	3' 4" [101]
245	Novyi Bug station, Kherson District	47.7	30.3	?
	Dobroe station, Kherson District	47.4	30.2	?
	Gorokhovka station	47.2	30.0	?
	2 versts west of Ekaterinoslav	48.5	32.8½	3' [91]

(Continued)

Site	Humus, %	Hygroscopic water, %	Analyst	Observer
Long-fallow land on a barely perceptible slope	2.336	1.501	Sibirtsev	Dokuchaev
Level plowland	2.809	1.632	Kytmanov	"
Level steppe field	5.962	4.078	Kul'chitskii	"
Level plowland	5.035	3.116	Davidovich-Nashchinskii	"
The same	3.887	3.409	Kul'chitskii	"
Level long-fallow land	6.102	5.285	"	"
Level pasture	5.98	3.82	Zemyatchenskii	"
Level plowland	2.822	2.800	Kul'chitskii	"
Steppe, 1 verst north of Yampol	3.729	3.087	Sibirtsev	"
Level pasture	5.718	3.267	Ogloblin	"
Foliage muck	9.23	4.58	Kul'chitskii	"
Level pasture at the railroad station	4.912	2.457	Sheshukov	"
Level field	5.816	3.273	Kytmanov and Sibirtsev	"
Forest soil	1.870	1.533	Davidovich-Nashchinskii	"
Fairly level steppe area	3.67	1.805	Zemyatchenskii	"
Pasture in the middle of a gently rolling area	2.677	3.594	Balkov	"
Pasture halfway down a slight incline	3.457	4.914	"	"
Pasture in the lower third of a slope	5.437	4.253	Kul'chitskii	"
Level pasture	5.756	4.646	Davidovich-Nashchinskii	Kytmanov
Level field	6.274	4.463	Kul'chitskii	"
Level long-fallow land	3.222	3.300	Davidovich-Nashchinskii	"
Level steppe	3.215	5.126	Balkov	"

No.	Locality	Latitude	Longitude	Thickness in ft and in [cm]
	Birzulova	47.9	27.2	2' 8" [81]
250	Razdel'naya	46.9	27.7	2' 6" [76]
	Nikopol	47.0	32.0	1' 8" [50]
	Northern seaboard of the Black Sea, Sivash and the			
	Kolontaevka, Odessa District	46.8	27.8	2' [61]
	Gadzhibei liman	46.6	28.0	1' 9" [53]
	Nikolaev	47.0	29.7	1' 4" [40]
255	Kherson	46.6	30.3	1' 8" [50]
	Novoalekseevka, Perekop District	46.2	32.4	2' 2" [66]
	Sivash at Genichesk, Perekop District	46.2	32.5	2' 3" [68]
	Melitopol	46.8	33.0	2' 5" [74]
	Berdyansk, $\frac{1}{4}$ verst from the sea	46.7	34.5	2' 4" [71]
260	4 versts west of Mariupol, 3 versts from the sea	47.1	35.3	?
	Bezymyannyi farm, Mius District	47.3	35.5	1' 2" [35]
	4 versts west of Pokrovskoe, Mius District	47.4	36.6	2' 3" [69]
	Taganrog	47.2 12	36.4	2' 2" [66]
	5 versts north of Novocherkassk	47.5	37.8	2' 1" [63]
265	7 versts east of Mikhailovskoe	46.6	48.7	11" [28]
	3 versts northwest of Tsymlyanskaya	47.7 42	39.9	9" [23]
	Pyatiizbyanskaya	48.6 39	41.1	1' 3" [38]
	Caucasus, Territory of the			
	Gumaly	43.0	44.7	3–6" [8–15]
	Gerzel-aul, Terek Region	43.4	44.3	1' 2" [35]

(Continued)

Site	Humus, %	Hygroscopic water, %	Analyst	Observer
Pasture halfway down a slight slope	12.247	7.930	Kul'chitskii and Kytmanov	Kytmanov
Steppe	7.196	7.393	Balkov	"
Pasture halfway down a slope	1.999	3.876	"	"
Sea of Azov, as well as the Banks of the Don River				
Level plowland	5.074	6.941	Balkov	Dokuchaev
The same	3.559	3.479	"	"
Level long-fallow land	4.921	4.463	Kul'chitskii	Kytmanov
Steppe	2.224	3.738	Balkov	"
Steppe	6.025	4.178	Sibirtsev	"
Steppe	4.844	8.37	Schmidt	"
Steppe	2.368	4.130	Balkov	Solomin
Steppe	5.180	10.845	"	"
Level plowland	5.760	4.69	Zemyatchenskii	"
The same	5.375	5.283	Sibirtsev	"
The same	4.947	8.803	Balkov	"
The same	4.437	8.551	"	"
Level pasture	5.320	4.408	Kolotov	"
Steppe	4.701	5.930	Kul'chitskii	Dokuchaev
Almost perfectly level pasture	1.969	3.424	Ogloblin	"
Steppe	2.932	2.507	"	"
Kuban Cossacks and the Crimea				
A small mountain depression	4.041	3.495	Ogloblin	Dokuchaev
Level virgin land	4.337	2.962	"	"

No.	Locality	Latitude	Longitude	Thickness in ft. and in. [cm]
		Caucasus,	Territory	of the
270	4—5 versts northeast of Ustar-Gordoi, Terek Region . .	43.3	44.0	1' 9" [53]
	8 versts northeast of Samashkinskaya, Terek Region . .	43.3	43.0	1'8" [50]
	Sleptsovskaya, Terek Region	43.3	42.7	1' [30]
	Vladikavkaz	43.0	42.3	2' 1" [63]
	Prokhladnaya, Terek Region	43.7	41.7	11" [28]
275	Mineral'nye Vody, Terek Region	44.2	41.0	1' 3" [38]
	Nevinnomysskaya, Terek Region	44.7	30.5	1' 5" [43]
	6 versts west of Kavkazskaya station, Kuban Region . .	45.5	38.3	1' 11" [58]
	Kushchevka, Territory of the Kuban Cossacks	46.5	37.3	1' 6" [45]
	Tiflisskaya, Kuban Region	45.4	38.0	1' 6" [45]
280	10 versts west of Ladovskaya station, Kuban Region . .	45.3	37.6	2' [61]
	Redutskaya, Kuban Region	45.0	37.1½	1' 11" [58]
	Ekaterinodar	45.0	36.6	2' 8" [81]
	Kopanskaya, Kuban Region	45.2	36.2	2' 1" [63]
	Slavyanskaya, or Kopyl'skaya, Kuban Region	45.3	35.8	1' 6" [45]
285	Tongue of Arabat	46.0	32.5	3—4" [7—10]
	Birman Kemel'chi, Perekop District	45.5	32.0	1' [30]
	Kashka-Chokrak No. 2, Feodosiya District	45.1	33.0	?
	Kashka-Chokrak, No. 1, darker	45.1	33.0	-
	Veirot, along the Malyi Salgir, Simferopol District, 10 versts from Simferopol	44.9	31.9	?
290	Suin-Adzhi, along the Malyi Salgir, Simferopol District, 10 versts from Simferopol	44.9	31.9	?
	Yaila, near Ai-Petri	44.4	31.8	8" [20]

[Continued]

Site	Humus, %	Hygroscopic water, %	Analyst	Observer
Kuban Cossacks and the Crimea				
Virgin land	7,061	2,168	Ogloblin	Dokuchaev
Level virgin land	4,768	4.406	"	"
Level pasture	4,777	2,348	"	"
Steppe	9,266	3,543	"	"
Level pasture	5,586	2,657	"	"
Level pasture on elevated terrain	7,830	4,727	"	"
Steppe	7,436	4,546	Kolotov	Solomin
Tall-weed steppe	4,294	1,952	Ogloblin	Dokuchaev
Level pasture	5,431	4,060	Kolotov	Solomin
Steppe	5,116	3,284	Sibirtsev	Dokuchaev
Tall-weed steppe	4,629	4,391	Ogloblin	"
The same	4,912	2,322	"	"
The same	4,934	4,443	"	"
The same	5,707	4,464	"	"
Tall-weed steppe in a small depression	5,086	4,049	Sibirtsev	"
Shoal rich in shells	app. 2,00	1,33	Schmidt	"
The same	3,261	2,983	Kul'chitskii	"
A level area in the steppe	4,418	6,370	"	Tarnovskii
The same	5,211	3,82	Sibirtsev and Zemyatchenskii	"
The same	3,768	6,653	"	Kessler
The same	4,137	5,472	"	"
In a deep enclosed depression amidst mountains	8,543	4,781	"	Kytmanov

I should like to add the following remarks concerning the "List of Soils":

1. Humus determination in all soils was prepared by sifting through a 3-mm mesh sieve, the remaining lumps on the sieve were crushed by the fingers and the mass again sifted through the same sieve, discarding those constituents which are nonpulverulent and do not pass through a 3-mm mesh. Plant rootlets were painstakingly picked out of the sifted soil, and only then was a 3 – 5 g sample of air-dry melkozem (fine earth) taken (generally, larger samples were used in high-humus soils than in low-humus soils). The sample was treated with H_2SO_4 (3:2). An air current was passed through the cylinder or flask containing this mixture for a period up to 2 – 3 days, until CO_2 was completely liberated from the soil carbonates. After that, and adding potassium dichromate (subjected to a rough preliminary crushing), the mixture was oxidized first by mild heating, and then the temperature was raised to 90°C. The liberated CO_2 was passed through U-tubes containing H_2SO_4 and $CaCl_2$ (for desiccation) and absorbed in Geissler's potash bulb. Following completion of oxidation the CO_2 remaining in the tubes and in the mixture was driven off in a current of air from which atmospheric carbon dioxide had been eliminated by passing through a solution of potassium hydroxide. The potash bulb was then weighed, enabling determination of the CO_2 formed by the oxidation of the organic substances. The result was scaled to 100 g soil dried at 100°C and multiplied by the factor 0.471, proposed by Wolf.

Humus determinations were repeated twice and more for every soil until the analytical result was identical within 0.2%.

The great majority of the analyses listed above, carried out at the Mineralogical Laboratory of the St. Petersburg University, were performed according to the pattern given by Wolf, without any deviations.

Those determinations of soil humus performed by Messrs Balkov and Kostychev[1] were essentially the same as those presented above, with the only difference that CO_2 was absorbed with soda lime instead of the potassium hydroxide used by the other chemists. Furthermore, they scaled CO_2 to soil dried at 120°C instead of 100°C. Therefore, their results for humus were generally somewhat higher than when scaled to 100°C. The difference in factors (the factor used by Mr Balkov was 0.4702) caused an insignificant difference.[2] Nevertheless, as a result of all these circumstances and also certain deficiencies of the method itself (picking out the rootlets etc.), analytical error may increase to 0.5% and more. However, all these discrepancies and inaccuracies cannot have any significant effect on the precision and accuracy of our conclusions in the present stage of studies of chernozem.

2. The geographical positions of all the localities mentioned in the list were determined from the General Staff map, scale 60 versts: 1 in [1 : 2,520,000]; the degrees are subdivided into tenths rather than into minutes; at the present time, this accuracy is sufficient.

[1] Journal "Sel'skoe Khozyaistvo i Lesovodstvo", pp. 279–284, November 1880.

[2] For samples taken at Pesochino, Vasil'kovo, Grushevka, Genichesk, Belgorod, and Krutoe, Prof. Schmidt included hydration water in the same item as humus, and therefore all his numerical results are correspondingly low. — Author.

EXPLANATION TO THE MAP

I originally intended to append two maps, one general, indicating the northern and the southern boundaries of the Russian chernozem according to all the principal sources, and the other schematic, representing the distribution of chernozem according to my own data. Subsequently, it was found to be possible to combine the two without any appreciable damage to the general purpose; this map is presented at the end of this volume. It is based on the contents of organic substances in soils, the importance of which has been repeatedly discussed by myself and others. It would certainly be more natural and efficient to designate chernozem soils in such a manner as to precisely convey the nature of the vegetal-terrestrial soils. As we already know, chernozem, in actual fact, is not sharply delineated, but rather there are innumerable transitions between its varieties. The ideal map would have to express all these consecutive variations in vegetal-terrestrial soils.

Nothing would seem to be easier than to fulfil this theoretical requirement by taking ink of a certain color, preferably black, and using it in a variety of shades until it eventually becomes very pale. However, this technique at present has several fundamental shortcomings.

In the first place, we now know that the color of soils is not always solely proportional to the content of humus. If we proceed from the central strip of chernozem, with maximum humus content, toward the margins of the chernozem zone, not all the consecutive transitions of the various shades of black are observed; these transitions may be determined only generally. Furthermore, it is at present impossible to draw isohumus lines or strips connecting localities where organic-substance content in soil fluctuates within 1%. The analyses presently available enable the establishment of belts with humus fluctuations of 2 – 3%.

Finally, a map covered by a series of continuous transitions within the same color would be unclear and impractical.

Therefore, I decided to delineate separate belts, each marked on the soil map in the manner used by geologists to mark systems and stages. On a given territory, extreme points with a specific humus content are connected by straight lines, and the entire space thus enclosed is colored in one color. Obviously, the greater the number of such points, the greater the number of soils with equal humus content as determined by analyses, the better and more homogeneous is the strip and the more constant in character. The strips with higher humus content were less clear-cut. At any rate, each strip of this type does in fact exist and will not be canceled by any future research. One thing that is certain to change in future are the boundaries of these strips; however, strips with higher humus content are likely to be enlarged at the expense of strips currently marked as low in organic substances, and never the reverse. For instance, the strip with a 10 – 13% humus content will probably be extended southward, even deeper into Don Cossack territory, while the Caucasian strip with 4 – 7% organic substances will never be expanded at the expense of the strip with 7 – 10% humus.

To avoid any misunderstanding, it should be added that in the case of a fairly wide unexplored territory lying between two known soils belonging to different strips, the boundary between the latter was usually drawn half-way down the intervening territory. Obviously, in a majority of cases it is utterly impossible to predict which of the two strips may most expand on future investigations.

Another important problem of soil cartography is the notation for soil mapping. Such notation has been quite arbitrary in Russia as well as abroad for geological and geographical as well as for soil maps. Some scientists use symbols (stipples, crosses, dashes, etc.), while others use colors, varying from author to author. This approach is certainly unscientific. In the first place, accidental techniques are inconceivable in precise research, since they bear no genetic relationship to the natural objects which they designate; moreover, the method involves a mass of purely practical inconveniences. Every compiler of maps was forced to invent different symbols and colors, and any study of a map required a certain amount of time[1] devoted to a preliminary study of its symbols and colors. Finally, comparison of such maps is extremely difficult... These, "accidents" of cartographic method created a waste of much time and labor, and sometimes gave rise to misunderstandings.

This problem was raised regarding geological maps at the last geological congress at Bologna, and I believe it is high time this was done with regard to soil maps, especially since pedologists may find the solution easier than do the geologists. The standard colors for geological systems, recently adopted by the geologists, while eliminating waste of time and the possibility of misunderstanding, are at fault in that there is no genetic relationship between color and nature of the system. It is obvious that any given geological system may and actually does include strata extremely varied in color, organic residues, and structure.

Pedological work is carried out under much more advantageous conditions. The great importance of black color in chernozem soils is undoubted.[2] Moreover, the three principal soil groups of northern and central non-chernozem Russia, which are sandy, loamy and bog-terrestrial soils, also differ markedly in external appearance, and especially in color.

Therefore, I propose to adopt standard colors to designate certain soils: different shades of dark-brown for chernozem soils, dark-blue for bog-terrestrial soils, yellow for northern sandy soils, and reddish for clayey soils.

Chernozem soils, in particular, after preliminary drying at room temperature and more or less uniform comminution, are various dark shades tinged chestnut in varying degrees. Unfortunately, these shades are not sharply pronounced, and are therefore difficult to mark on the maps; the principal inconvenience[3] lies in the necessity, at times, to mix several primary colors in order to achieve shades on paper.[4]

I decided to adopt the following technique. I used the color of the most typical sample from the belt with 13 — 16% humus content (from Zubrilovka)

[1] The amount of time wasted is sometimes considerable and often does not lead to successful results. See the soil map of European Russia by Mr Chaslavskii.

[2] Among others, the reader is referred to the paper mentioned above by N. P. Zalomanov.

[3] Certainly, such difficulties should not prevent adoption of the principle. Once the question of the natural colors of soils have been thoroughly studied, and once our artists are more painstaking, the difficulties will undoubtedly be eliminated. In this matter a well developed technique will be of definite use.

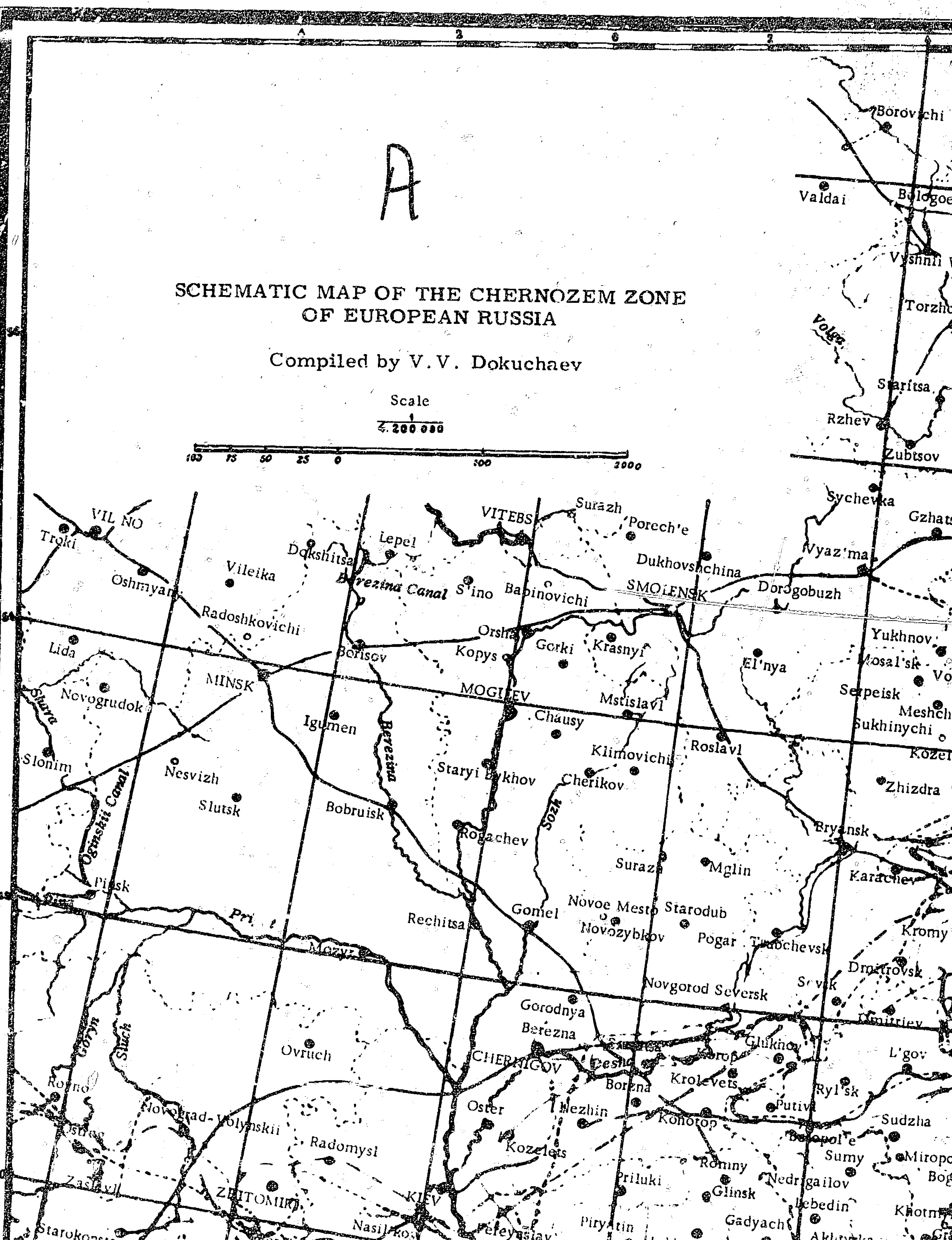
[4] These compound colors actually do provide a certain idea of the mineral composition of soils.

to designate the entire belt. I used the same technique for the belt containing 1/2 -- 2% humus, as typified by the soil sample from Vladimir-on-Klyaz'ma. The color of these two strips on the map corresponds fairly well to the natural colors of the soils.[1] The other four strips are colored intermediate shades of the same general color, color intensity increasing or diminishing as the soil resembles the extreme types from Zubrilovka or Vladimir.

Generally speaking, the colors of these strips follow and are sometimes very similar to the natural colors of soils (taken from the same districts), but are not copied from nature in detail. Once the subject of the natural colors of soils has been gone into thoroughly, when the number of available soil analyses is much greater than it is at present, the method of coloring soil maps which I propose will be still further improved. It will then be possible to use natural soil color for the mapped strips with humus fluctuations not exceeding 1%, and copying the shades of color from the majority of typical normal soils of the strip.

It may be added that even though an almost solid, uniform color is used for every isohumus belt, all soils within such a region are not completely identical in humus content and in the other elements genetically connected with humus. I should like to reiterate that my map is mainly concerned with the general nature of the distribution of normal vegetal-terrestrial soils.[2]

[1] Unfortunately, these shades were changed considerably in the course of printing.
[2] The sandy-loamy "island" with Ostrogozhsk at its center must be extended south to Starobelsk and, to a lesser degree, south of Bogucharov.


A
SCHEMATIC MAP OF THE CHERNOZEM ZONE
OF EUROPEAN RUSSIA
Compiled by V.V. Dokuchaev
Scale
100
75
50
25
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500
2000
Valdai
Rzhev
Zubtsov
Sychevka
Vyaz'ma
Volga
VITEBSK
Surazh
Porech'e
Lepel
Dukhovshchina
Vileika
Oshmyany
Troki
Radoshkovichi
Lida
Berezina Canal
S'ino
Babinovichi
SMOLENSK
Dorogobuzh
Orsha
Gorki
Krasnyi
Borisov
Kopys
Yukhnov
El'nya
MINSK
Novogrudok
Igumen
MOGILEV
Chausy
Mstislavl
Serpeisk
Sukhinychi
Slonim
Nesvizh
Slutsk
Berezina
Staryi Bykhov
Roslavl
Klimovichi
Cherikov
Zhizdra
Bobruisk
Rogachev
Sozh
Ogins'kii Canal
Bryansk
Surazh
Mglin
Karachev
Pinsk
Rechitsa
Gomel
Novoe Mesto
Novozybkov
Starodub
Pogar
Trubchevsk
Kromy
Dmitrovsk
Novgorod Seversk
Sevsk
Gorodnya
Berezna
Ovruch
Goryn
Sluch
CHERNIGOV
Desna
Glukhov
Krolevets
L'gov
Borzna
Ryl'sk
Oster
Nezhin
Konotop
Putivl
Sudzha
Novograd-Volynskii
Radomysl
Kozelets
Sumy
Romny
Priluki
Glinsk
Nedrigailov
ZHITOMIR
KIEV
Lebedin
Gadyach
Piryatin
Starokonst


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Ves'egonsk
Poshekhon
Gryazovets
Soligalich
Kologriv
Chukhloma
Bui
Lyubim
Galich
Borovichi
Krasnyi Kholm
Mologa
Rybinsk
Danilov
Unzha
Bologoe
Bezhetsk
Romanov
Makar'ev
Myshkin
Volga
KOSTROMA
Kadyi
Varna
Vyshnii Volochek
Kashin
YAROSLAVL
Kineshma
Uglich
Ples
Nerekhta
Rostov
Yur'evets
Torzhok
Ostashkovskaya
Kalyazin
Petrovsk
Tvertsa
Ivanovo
Shuya
TVER
Pereslavl-Zalesskii
Semenov
Staritsa
Korcheva
Balakhna
Aleksandrov
Yur'ev Pol'skii
Suzdal
Kovrov
Rzhev
Klin
Sergievskii Posad
Pochkinskaya
Vyazniki
Oka
NIZHNI NOVG
Dmitrov
VLADIMIR
Makar
Zubtsov
Volokolamsk
Kirghach
Gorokhovets
Gorbatov
Pokrov
Voskresensk
Sychevka
Ruza
MOSCOW
Sudogda
Knyaginin
Gzhatsk
Mozhaisk
Zvenigorod
Bogorodsk
Murom
Perevoz
Bronnitsy
Arzamas
Vereya
Melenki
Podol'sk
Egor'evsk
Medyn
Borovsk
Kolomna
Ardatov
Maloyaroslavets
Serpukhov
Flat'ma
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Temnikov
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Serpeisk
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Spassk
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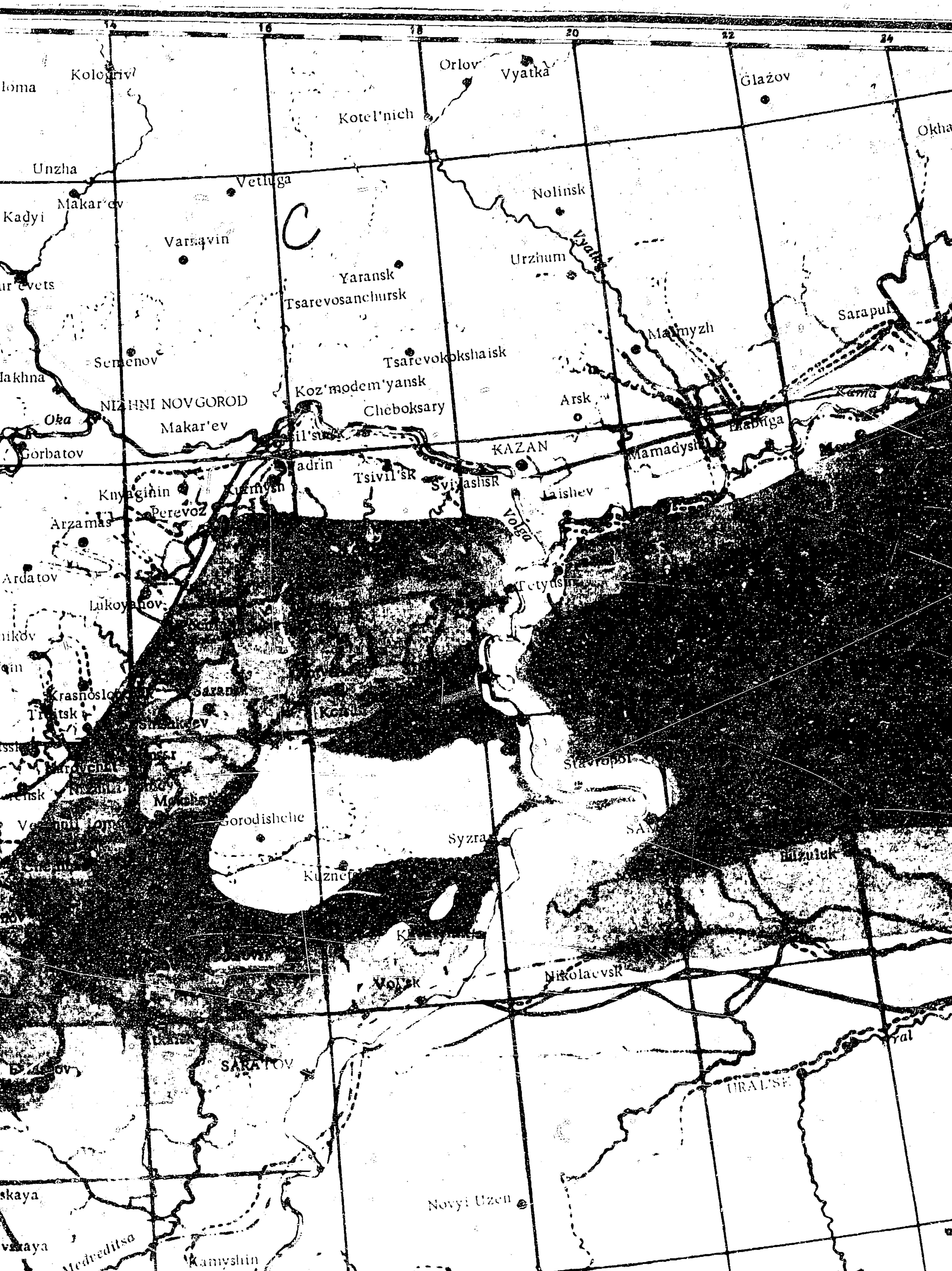

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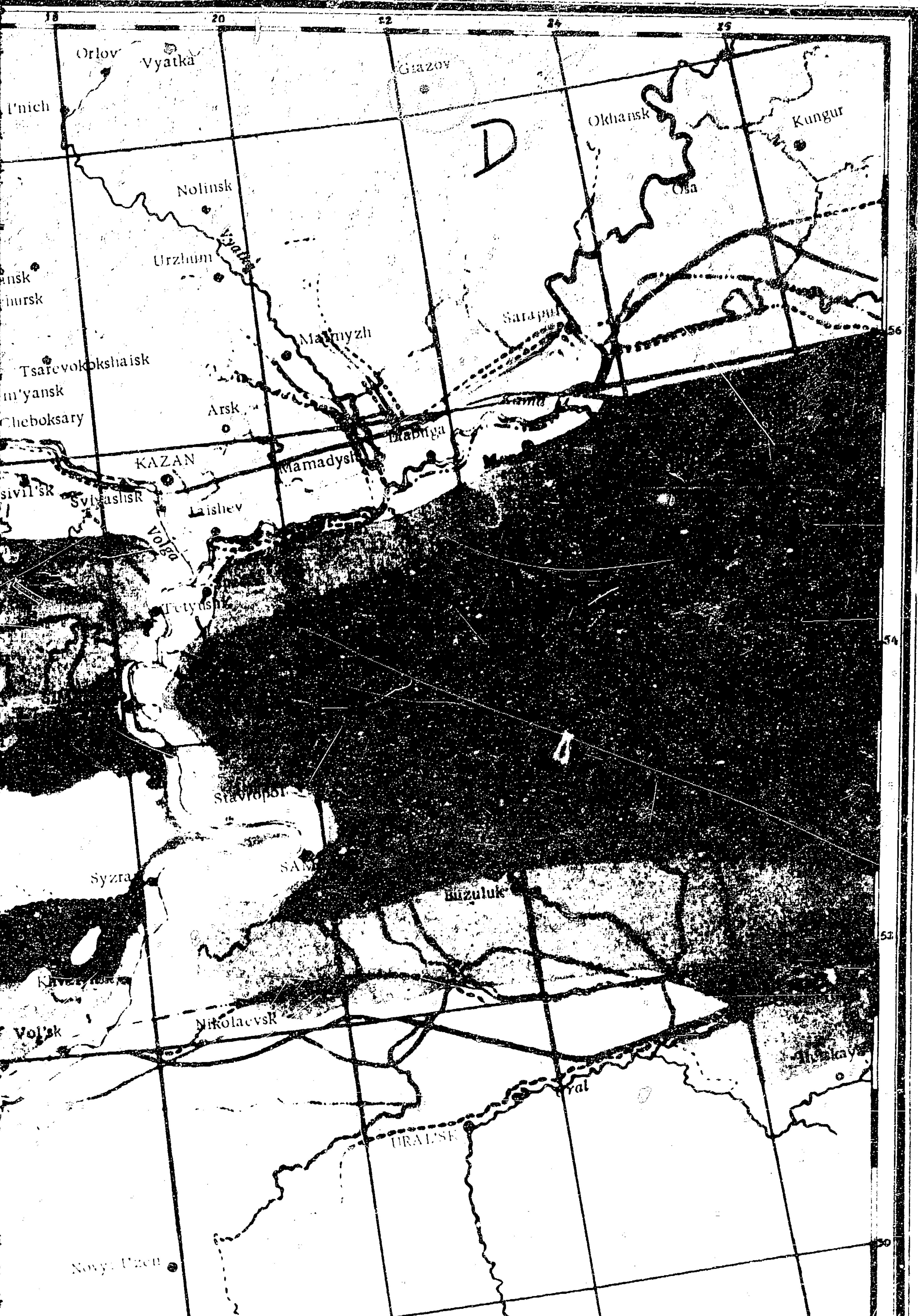

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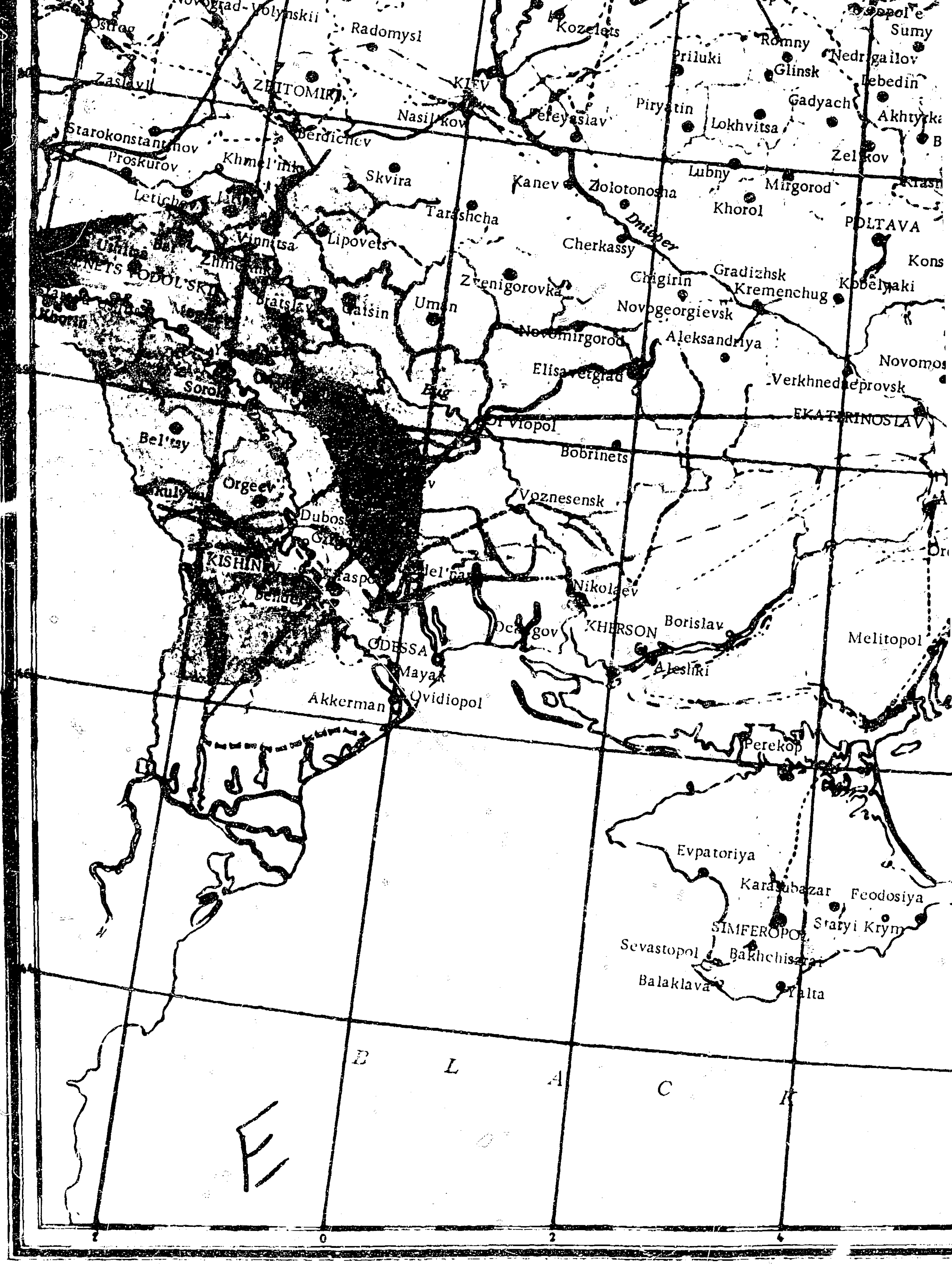

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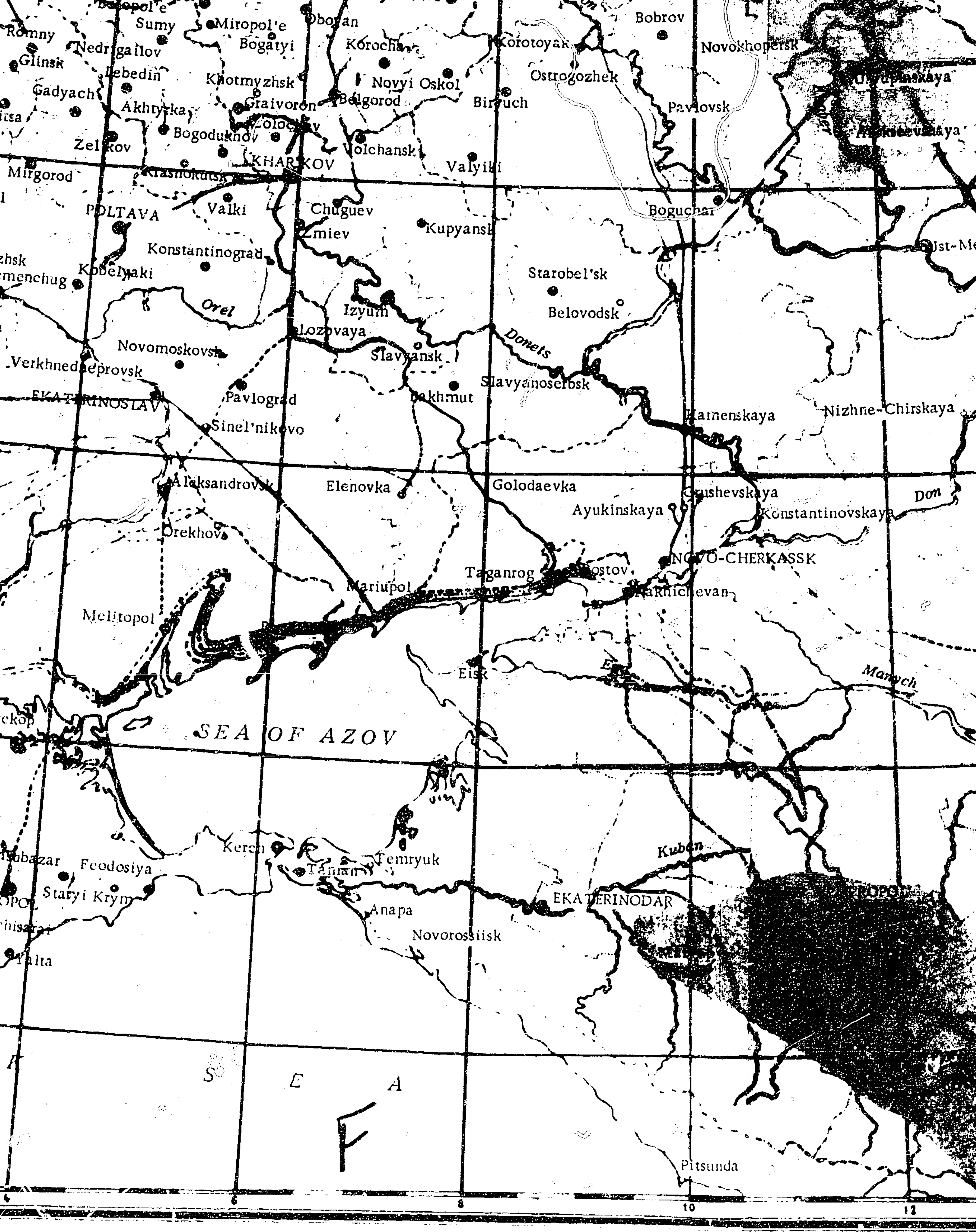
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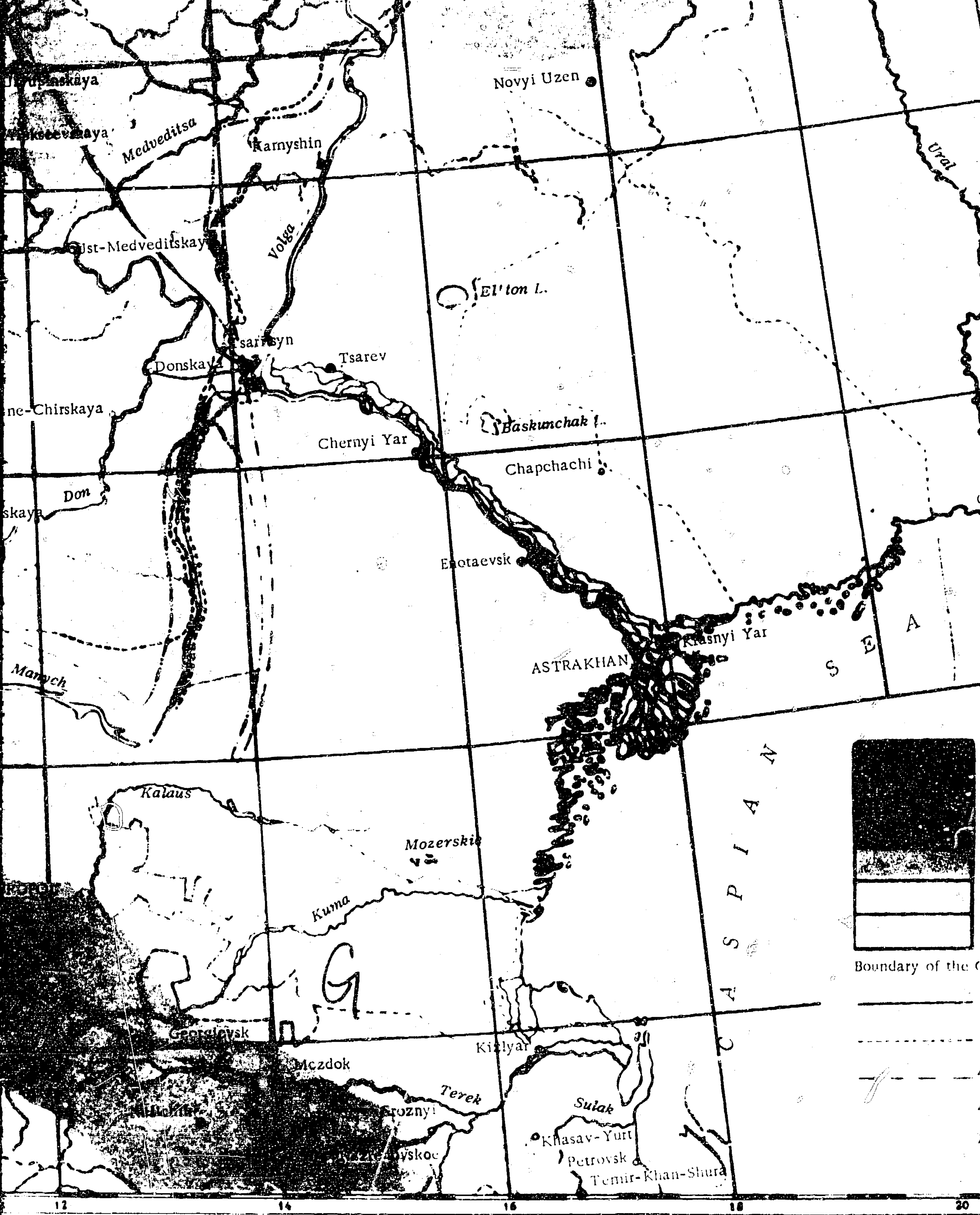

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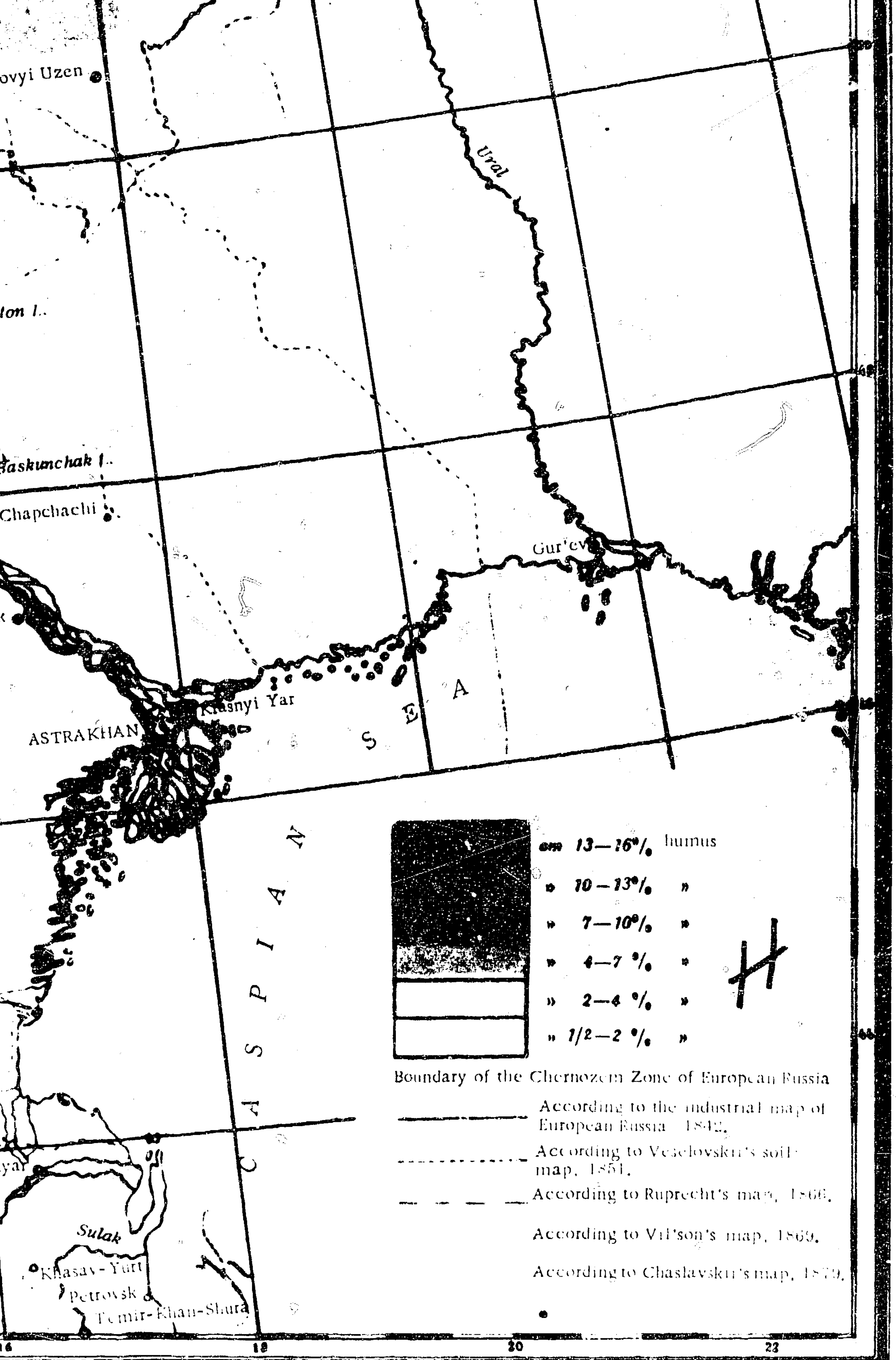
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Temir-Khan-Shura
cm 13—16% humus
» 10—13% »
» 7—10% »
» 4—7 % »
» 2—4 % »
» 1/2—2 % »
Boundary of the Chernozem Zone of European Russia
According to the industrial map of European Russia 1842.
According to Veselovskii's soil map, 1851.
According to Ruprecht's map, 1866.
According to Vil'son's map, 1869.
According to Chaslavskii's map, 1879.
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