Ceramic Manufacture: The chaîne opératoire Approach

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Abstract and Keywords

This chapter presents an overview of the chaîne opératoire approach and recalls its relevance as a social and transmission signal. It describes the main components of the ceramic chaînes opératoires and the principles for identifying them on the archaeological material through diagnostic attributes including both surface features and microfabrics. Next, it takes a forward look at the classification of ceramic assemblages according to the chaîne opératoire approach in order to unravel the sociological complexity behind their variability. Finally, this chapter highlights the heuristic character of the chaîne opératoire approach when studying, on the synchronic axis, the techno-economic systems, and on the diachronic axis, changes in technical traditions considered as the expression of culture histories and the factors affecting them.

Keywords: chaîne opératoire, social signal, transmission signal, technical tradition, diagnostic attributes, techno-economic systems

Introduction

THE term *chaîne opératoire* was coined almost fifty years ago by Leroi-Gourhan while seeking to characterize techniques: "Techniques are at the same time gestures and tools, organized in sequence by a true syntax which gives the operational series both their stability and their flexibility" (Leroi-Gourhan, 1964: 164). Rooted in French cultural ethnography which promoted the cultural dimension of material culture (Mauss, 1947; Maget, 1953; Haudricourt, 1987), the study of technical facts according to this concept gave birth to numerous studies in the domain of the anthropology of techniques under the leadership of R. Creswell, whose team was gathered around the journal *Techniques &*

Culture. The definition of the *chaîne opératoire* used to be largely debated by both anthropologists and prehistorians (Karlin et al., 1986; Balfet, 1991). Nowadays, depending on authors, it describes the whole manufacturing process—defined as a series of operations that transform raw material into finished product, either consumption object or tool (Creswell, 1976: 13)—or part of the manufacturing process, which is then decomposed into several *chaînes opératoires* (Lemonnier, 1983).

In archaeology, the worldwide success of the *chaîne opératoire* owes mainly to the results obtained in the 1980s and early 1990s by studies in the anthropology of techniques and ethnoarchaeology (e.g. Balfet, 1981; Creswell, 1983, 1996; Arnold, 1985; Longacre, 1991; Gallay, 1992; Gosselain, 1992; Dietler and Herbich, 1994; Lemonnier, 1992, 1993; Latour and Lemonnier, 1994; Sigaut, 1994). Although each of these studies focused on a different culture area, their conclusions can be distilled into a universal observation or general trend: there is a strong correlation between technological behaviors and social groups. Individuals tend to do as their group does, thus maintaining the diversity of cultural traits within their social group and making visible their social borders. Applied to archaeological assemblages, this correlation opened new avenues of research since it enabled researchers to view objects from a different perspective, as part of a social and technological process and therefore as significant of the social groups behind them.

This chapter first addresses the cogency of the social dimension of the techniques since it represents the cornerstone of the technological approach. Description of the main features (p. 102) of the ceramic *chaînes opératoires* follows, completed by the procedure for highlighting diagnostic attributes. The methodology for classifying archaeological assemblage according to the *chaîne opératoire* approach is then precised. We conclude by mentioning the different domains of interpretation rendered possible by the analysis of ancient *chaînes opératoires*.

The *chaîne opératoire* and Its Social Dimension

Clarifying the link between *chaînes opératoires* and social groups requires explaining why it is that techniques have an identity dimension. Explanation is to be found in the learning and transmission processes studied in the fields of experimental psychology and social anthropology. The results of these studies indicate that the mastery of technical practices corresponds to a process of inheritance which occurs both at the individual (the learning process) and collective (the transmission process) level according to both “bio-behavioral” and “anthropological” rules.

At the individual level, it has been demonstrated that learning involves a tutor and a model (Reed and Bril, 1996; Bril, 2002a, 2002b). When the individual explores the task to be learned, he does it through the observation of a model which corresponds to the tutor's way of doing it. The tutor's role is to educate the learner's attention and to orient his exploratory activities toward the model and intended outcome to be achieved. This guidance not only facilitates the learning process, it also participates directly in the reproduction of the task. This guidance is the key to cultural transmission. At the end of the learning process, the learned skills are literally "embodied" (Dobres, 2000; Gosselain, 2000; Ingold, 2001): (a) the learner has progressively acquired the perceptual-motor and cognitive skills necessary, proposed and demonstrated by the tutor, for making objects, but only these skills; (b) in the course of the apprenticeship, the learner has built up specific mental representations about the way to make objects. As a consequence, it will be difficult for the learner to perceive and manufacture objects in a different way than the one he/she learned, by virtue of the "bio-behavioral rules" which require a subject to learn not by innovating but by reproducing a model, therefore acting as true "fixing agent" of the cultural model.

At the collective level, transmission occurs within groups made up of individuals linked by social ties. These ties determine the social perimeter into which ways of doing are transmitted, and by the same token, the boundaries beyond which there are other networks with other ways of doing (e.g. Mahias, 1993; Kramer, 1997; Stark, 1998; Bowser, 2000; Livingstone-Smith, 2000; Gosselain, 2002, 2008; Degoy, 2008). The "anthropological" rules which determine the transmission network of skills are the same as those that maintain the cohesion of the group and facilitate its reproduction. The nature and structure of the groups within which a "way of doing" is transmitted are highly variable. They can correspond to a band, a clan, a faction, a caste, a subcaste, a lineage, a professional community, an ethnic group, an ethno-linguistic group, a population, or a gender (exclusive transmission of a "way of doing" among women or men). In addition, the nature and structure of a group can change over time and the social boundaries be redefined. Thus a "way of doing" can be used at a time *t* by a small social group, and at a time *t*+1 by a larger social group, the social (p. 103) boundary delimited by the transmission network having evolved in the course of time. Moreover, the same community can include several transmission networks depending on the type of objects. For example, the manufacture of culinary pots may be the responsibility of women at the household level of production, whereas storage jars may be the responsibility of a few specialized men at the regional level of production. As a result, the historical dynamics at work will vary depending on types of objects, creating phenomena of arrhythmia (Perlès, 2013).

But whatever the social boundaries, learning and transmission processes explain that technical traditions overlap with them: technology is always transmitted through tutors selected within one's social group. The immediate archaeological implications are: (a) the *chaînes opératoires* are inherited ways of doing, that is technical traditions transmitted through successive generations; (b) the distribution of technical traditions indicate the social perimeters into which they have been learned and transmitted; (c) changes within technical traditions are the expression of culture histories and the factors affecting them (Shennan, 2013); (d) technical traditions situated in space and time can be powerful chrono-cultural markers, in particular when stylistic features are not significant (Roux et al., 2011; Ard, 2013); and (e) the combined study of technical processes and objects is necessary for an anthropological understanding of archaeological assemblages.

Describing the Ceramic *chaîne opératoire*

Discussion of the ceramic *chaînes opératoires* involves two levels of description. The first describes the main actions which organize the successive transformations of the raw material into a finished product. They are: collecting and preparing the raw materials, fashioning, finishing, surface treatment, decoration, and firing. The order of these actions is universal given the properties of the material and the objective sought (making vessels). The second level describes the *chaînes opératoires* involved in each of these actions. It is at this level that technological behaviors or activities are highly variable. This diversity is determined by both cultural and functional factors.

Preparing the raw material into a ceramic paste includes: drying, pounding, sorting, hydrating, adding temper, and wedging. Each of these behaviors is dictated by the potter's natural and cultural environment, the inherent properties of the raw material, in terms of its qualities for making the desired finished products, the modifications of the raw material necessary to achieve the sought-after qualities of the finished products, and the potter's cultural tradition.

The *chaîne opératoire* related to the fashioning stage includes a series of operations which transform the clay paste into a hollow form and can be described in terms of technique, methods, gestures, and tools. Some important definitions are given below.

Method: orderly set of functional operations undertaken to obtain the desired shape, starting from the raw material. It comprises phases, stages, and operations, each of which can be achieved through different techniques. There are three main forming phases: fashioning of the body (lower part, upper part), of the orifice (neck and rim), and of the base. (p. 104) The fashioning of the body can be divided into two stages; the forming of the roughout and of the preform.

> *Roughout*: hollow form which does not present the final geometrical characteristics of the container. A roughout is obtained by thinning operations.
>
> *Preform*: container with its final geometrical characteristics but whose surface has not been (or will not be) subjected to finishing techniques. A preform is obtained by shaping a roughout.

Technique: physical modalities according to which clay is fashioned. These modalities can be described on the basis of the following parameters:

(a) the source of energy (muscular energy vs. rotative kinetic energy);
(b) the clay mass onto which the pressures are exerted (homogeneous vs. heterogeneous);
(c) the type of force (pressure vs. percussion);
(d) the type of pressure (discontinuous vs. continuous);
(e) the degree of hygrometry of the clay paste (humid vs. leather hard vs. dry)

The two main families of fashioning techniques are distinguished by the source of energy involved: techniques not using rotative kinetic energy (RKE) and those that do. There are eight roughing-out techniques that do not use RKE. They are further differentiated as techniques which act on assembled elements (the coiling technique by pinching, crushing, and drawing, and the slab technique) and those that act on a clay mass (modeling by pinching and drawing, hammering, and molding). There are seven preforming techniques which do not use RKE. They are distributed between those that act on wet clay (scraping, preforming with continuous pressures, beating) and those that act on leather hard clay (shaving, "repoussage," paddling, hammering). The roughing-out technique that uses RKE is wheel throwing. There are four preforming techniques that rely on RKE: wheel throwing, wheel coiling, wheel molding, and turning (shaving leather hard clay paste with RKE). In total, there are nine roughing-out and eleven preforming techniques which describe the ceramic fashioning process. These techniques are implemented according to methods, gestures, and tools whose description accounts for the diversity of the fashioning *chaînes opératoires* (Figure 8.1).

The finishing techniques are achieved after the preforming stage and can act on wet (smoothing) or leather hard clay (brushing, smoothing on leather hard clay). Surface treatments transform the superficial state of the vessel and involve either rubbing the vessel (softening, burnishing/polishing, shining), or coating it (slips, glazes, organic materials, graphite, silica, carbon). The three types of decorative techniques are distinguished by dimensionality: low relief or one-dimensional decoration (painting); negative relief or recessed decor (impressed—rolled, simple, pivoting, embossed; paddled; incised—simple, pivoting, scratching, carving; or excised—excised, pierced); and two-dimensional or high-relief decors (applied elements or modeling).

Firing is the final step in the manufacturing sequence. It is a major one since it is at this stage that the vessels are gaining their final physicochemical properties. The latter depend not only on the clay properties, but also on the firing parameters which include temperature, heating rate, time of exposure, and firing atmosphere. The firing techniques are distributed (p. 105) between two main families: those where the vessels are in contact with the fuel (open firings, walled firings) and those where they are not (kilns).

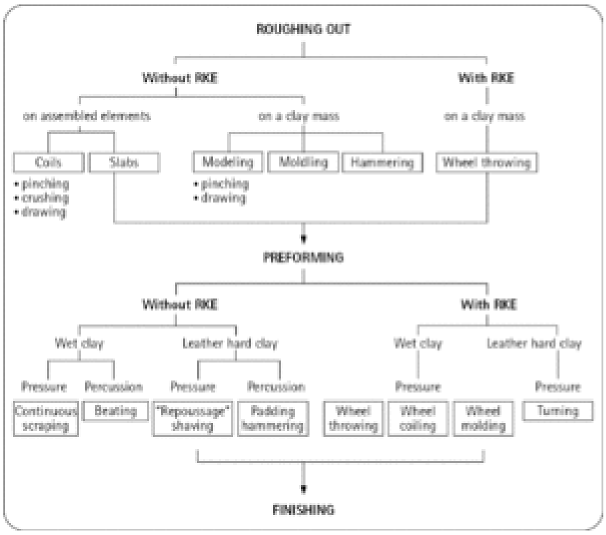

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Figure 8.1 Classification chart of roughing out and preforming techniques.

Identifying the Ceramic *chaîne opératoire*

The technological reading of the clay pastes implies a comparison between (a) the final structural state of the clay material, characterized by petrofabrics, and (b) its initial structural state (the raw material), characterized by petrofacies, in order thereafter to unravel the technical process of transformation of the raw material (pounding, hydrating, adding temper, wedging, forming, firing). The interpretation of the initial structural state calls upon general reference data of geological facies and local paleogeographic data as well as physics of materials and experimental data in order to understand the structural transformations of the clay paste (Roux in coll. with Courty, 2016).

The identification of the manufacturing process is a difficult exercise in the sense that each gesture produces features which can obliterate the previous features and that surface features are polysemic: not only the same surface features can be obtained by different techniques, but (p. 106) (p. 107) also the same technique can produce different surface features. This explains why ceramic *chaîne opératoire* analysis has taken a longer time to develop than lithic technology, whereas its basis was elaborated as soon as the 1960s (Franken, 1970, 1978; Rye and Evans, 1976; Van der Leeuw, 1977; Rye, 1977, 1981). Since the 1990s research has been conducted, calling upon both ethnographic and experimental data and considering both surface features and microfabrics (e.g. Pierret and Moran, 1996; Livingstone-Smith et al., 2005) (Figure 8.2). The principle is the one of "controlled analogy." Attributes considered to be significant indicators of particular techniques are those whose formation has been explained and the univocal character of which has been demonstrated. For this purpose, experiments are carried out according to a protocol where only one parameter varies at a time. It is then possible to unravel the mechanisms explaining the formation of the attributes and to assess their diagnostic value. As a general rule, given the often polysemic character of the attributes, it is important to combine different scales of observation, from the naked eye down to the microscope (Roux and Courty, 1998). It is also important to combine different analytical tools (e.g. thin-section, X-ray analysis; Pierret et al., 1996; Berg, 2008).

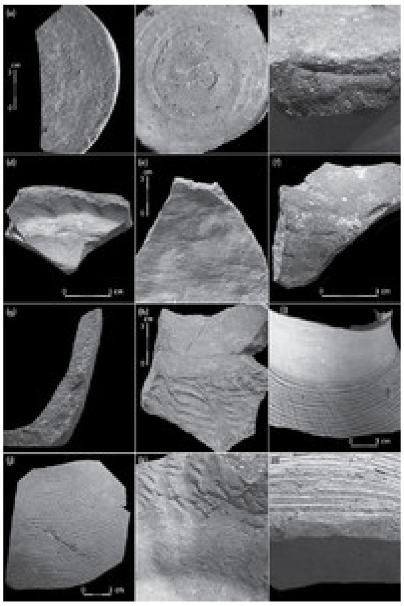

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Figure 8.2 Diagnostic features taken into account for reconstructing an Early Bronze Age *chaîne opératoire* from the site of Tell Arqa (Lebanon): (a) print on external base indicating a clay disk laid on a basalt support;(b) concentric over-thicknesses related to a coil laid on the clay disk; (c) view of the coil laid on the clay disk; (d) digital thinning prints at the junction base/body; (e, f) bumpy wall and fissures indicating discontinuous pressures on assembled elements; (g) oblique fissure indicating oblique junction of coils; (h) internal wall showing that the neck was made after the body and finished with a rotary movement; (i) external wall combed after fashioning the neck, while humid; (j) crisscross humid combing; (k) digital depressions indicating the hand support against the internal wall while combing; (l) regularizing the junction bottom/body when leather hard and while the pot was drying upside down.

Classifying Ceramic Assemblages According to the Concept of the *chaîne opératoire*

Highlighting the ancient ceramic traditions constituent of archaeological assemblages requires not only deciphering the manufacturing process involved in the making of the ceramics, but also classifying the assemblages according to the *chaîne opératoire* approach. This is an original procedure implying a hierarchical classification including three successive sortings:

(1) The first sorting is by technical groups: they are defined by the manufacturing process as expressed by both the microfabrics and the surface features present on the inner and outer walls of the vessels (sherds or full vessels).

(2) The second sorting is by technopetrographic groups; that is, by petrographic group within each technical group: it is done by reference to the classification of the petrofacies present on the site. Once the catalogue of these petrofacies is achieved, the sherds belonging to each technical groups are examined in order to identify the class of petrofacies they belong to and to characterize their petrofabrics in terms of technological transformation undergone by the raw material. It is at this stage that the modalities for preparing the clay paste are studied and the ensemble of the *chaîne opératoire* restituted, from the collection of the raw material to the firing.

(3) The third sorting is by technomorphological and stylistic groups, that is by morphological and stylistic types within each technopetrographic group. It is at this stage that the functional categories of vessels made according to each technopetrographic group are characterized.

These successive and embedded sortings are meant to characterize the different *chaînes opératoires* present in the assemblage (the technopetrographic groups) and to link them to (p. 108) the intention of the potter (the finished products). Results can be visualized with the help of technostylistic trees of a dendrogram type (Figure 8.3). They offer a synoptic view of the different *chaînes opératoires* present in the assemblage and the finished products they are implemented for. They also allow us to discuss the nature of the technostylistic variability of the assemblage, whether functional or cultural, whether simple or complex in terms of sociological composition.

The functional variability of the *chaînes opératoires* can be established when the function of the vessels determines the variability of the *chaînes opératoires*. When it does not, this is cultural by default. As an example, when a technopetrographic group is associated with a unique type of pot (e.g. cooking pot) and when this function explains the differences in the *chaînes opératoires* of these vessels and others in the assemblage, then we are in a situation where the variability can be interpreted in functional terms, as opposed to variability created by social or cultural borders.

The sociological complexity underlying the variability of an assemblage can be established depending on its technopetrographic homogeneity or heterogeneity (Roux and Courty, 2007). (p. 109) Homogeneous assemblages are characterized by homogeneous technopetrographic groups with either low or high sociocultural variability. Homogeneous assemblages with a low sociocultural variability are characterized by only one technical tradition and the use of local clay sources and describe sites occupied by a homogeneous social group, which is a single group sharing the same way of doing. At the regional scale, the juxtaposition of simple homogeneous assemblages expresses the sociological mosaic of a region. Homogeneous assemblages with a high sociocultural variability are characterized by a few technological traditions and the use of one or several clay sources located in the neighborhoods of the site. They reveal sites with multiple social components whose sociological interpretation will depend on the petrographic, quantitative, and contextual data (e.g. urban, port, colonized, economic exploitation sites).

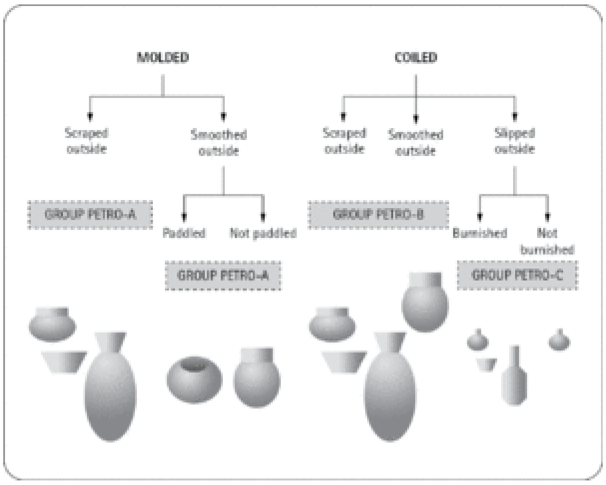

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Figure 8.3 Example of technostylistic trees. The tree on the left gathers molded ceramics made up with same clay materials. The preforming techniques vary depending on function of ceramics (functional variability). The tree on the right gathers coiled ceramics whose preforming and finishing techniques co-vary with clay sources and relate to different functional categories (functional variability). Now th e molding and the coiling techniques apply to the same functional categories, signaling therefore two technical traditions corresponding to two sociological groups.

Heterogeneous assemblages are made up of *n* technological traditions characterized by heterogeneous petrographic groups with either low or strong variability revealing a wide variety of clay sources distributed in the region (low variability) or even beyond in the macro-region (strong variability). Heterogeneous assemblages signal the presence of consumers originating from a wide regional area. The functional interpretation of the site will depend on petrographic, quantitative, and contextual data (consumer sites importing vessels from different places, marketplaces, gathering place including aggregation, pilgrimage, ceremonial sites, etc.).

Interpreting the *chaînes opératoires*

Once the functional and sociological variability of ceramic assemblages is characterized, each *chaîne opératoire* can be studied from a socioeconomic, historical, and evolutionary perspective.

On the synchronic axis, issues relate to the production, distribution, and circulation of ceramic vessels. They can be dealt with at the scale of the site, but it is at the macro-regional scale that an overview of the spatial distribution of technical traditions will emerge, benefiting indispensably from the comparative perspectives of multiple site analysis. Issues for modalities of production are restricted to homogeneous assemblages (those occupied by single or multiple groups of producers); issues for modalities of distribution and circulation of objects apply to both homogeneous and heterogeneous ones (those occupied by consumers exclusively). Distribution (direct or indirect) relates to the acquisition of the vessels within both social and economic frameworks. Circulation relates to the movement of the vessels in the course of their use by consumers. Modalities of distribution and circulation can be understood using two elementary mechanisms: first, that potters have an inherited way of doing, and manufacture vessels in response to a demand from all or part of their social group; and secondly, that the movement of containers combined with ways of doing, quantities, and morpho-functional types generates, at the regional scale, spatial distribution specific to the cultural components in operation (Gallay, 2007). The operation of these two mechanisms gives rise to three main zones or interaction spheres: central, peripheral, and remote. The first one designates both production and distribution zone of a particular ware or class of vessel. The latter two designate regions or social spheres into which ceramics are distributed or have circulated along with their consumers. The distinction can be made on (p. 110) the basis of the quantities of vessels, their form or type, and the recurrence of their presence through time. Non-recurrent anecdotal quantities of exogenous ceramic traditions and/or technologies indicate the circulation of containers.

On the diachronic axis, the *chaîne opératoire* approach addresses the evolution of traditions and technologies over time, and by the same token the history of the social groups, by virtue of the transmission mechanisms that allow for an anthropological link between vessels. Both the *chaînes opératoires* and the finished product are considered, given that the dynamics of historical change may affect them differently depending upon their nature and context of production. These differential dynamics are the privileged witness of endogenous or exogenous evolutionary phenomena in relationship with both the producers and consumers.

In concrete terms, the issue is first to identify patterns of cultural descent in the *chaîne opératoire* in order to establish whether there is filiation between the ceramic assemblages (Haudricourt, 1987; Creswell, 1996; Manem, 2008). When traditions are linked by inherited technical gestures, there is historical continuity. On the other hand, when traditions are not linked by inherited technical gestures, it indicates that social groups are not interconnected, and therefore there is potential for the emergence/ expansion of new groups and/or the disappearance of previous groups (Roux, 2013).

The next issue is to approach the historical dynamics behind the emergence of new technical facts. The complexity of "innovation" leads us to believe that it is not possible to order the different factors at work and, therefore, that the dynamic approach is probably most appropriate (Roux, 2003). Secondly, the issue is to examine the evolutionary forces underlying the historical dynamics. They are two categories of forces: those underlying the order of development of techniques in relationship with "the technical trend" ("*la tendance*," thus named by Leroi-Gourhan, 1964), and those specifying the conditions for change. The former explains the way techniques evolved, with a general trend toward lower energy expenditure (Simondon, 1958; Leroi-Gourhan, 1964; Boëda, 2013). The latter relate to the context in which historical scenarios occur. For example, social mutations have been shown to be determinant for technological leaps; the diffusion of a technique has been shown to depend on the sociological structure of the potters, either homogeneous or heterogeneous (Creswell, 1993, 1996; Roux, 2010, 2013). Both categories of forces represent huge areas of research within evolutionary archaeology.

Conclusion

Although the *chaîne opératoire* approach is now more than fifty years old, its operational dimensions have not finished surprising us yet. Not only does this approach enable us to identify ancient technical traditions and technosystems, it also enables us to follow the history of social groups by identifying patterns of cultural descent through the transmission of technical gestures. The huge heuristic character of the *chaîne opératoire* lies in its inherited character, which makes it both a social and a transmissional indicator. Its epistemological strength is its grounding in empirical data. Its ambition joins with evolutionary archaeology in seeking to highlight the general forces behind changes (Shennan, 2013). This (p. 111) qualitative approach, resulting in a measure of the phenomena under study, has thus a rich future ahead.

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