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# Using the chaîne opératoire to interpret the layout of Roman workshops

Nicolas Monteix

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# Craft production systems in a cross-cultural perspective

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# Using the *chaîne opératoire* to interpret the layout of Roman workshops

Nicolas Monteix

*Since the 1970s, ethnologists and prehistorians studying ancient technology developed a heuristic tool, the chaîne opératoire, which use remained mainly limited to the French-speaking world. This article aims at presenting a clearer picture of the potentialities and limitations of this tool: it shall be used in a study of production techniques to answer to economic and social questions during the Roman Imperial time focusing on the spatial layout of workshops.*

*After a brief synthesis of the evolution of the chaîne opératoire as a concept developed and transformed through the ethnology of techniques, three examples using the chaîne opératoire as means of understanding the spatial organization of Roman urban workshops are dealt with.*

Since the 1970s, some ethnologists and prehistorians involved in the study of ancient technology have employed a heuristic tool: the *chaîne opératoire*. However, in addition to different interpretations of this tool by different disciplines, there is a linguistic barrier: the use of the *chaîne opératoire* methodology is mainly limited to the French-speaking world, with exceptions among prehistorians. This article thus aims to present a clearer picture of the potentialities and limitations of this tool for obtaining answers to economic and social questions about the Roman Imperial world through the study of production techniques. More specifically, this paper seeks to identify how a considered use of the *chaîne opératoire* can help to clarify the spatial organization of Roman urban workshops in certain situations.

The choice of this subject matter and the examples that I use here are connected to my recent research on the bakeries of Pompeii and Herculaneum. My initial use of the *chaîne opératoire* as a simple succession of operations in a manufacturing process

was misconceived, even if the concept of variants was mentioned<sup>1</sup>, and I then proposed a model for the spatialization of the bakeries using *chaîne opératoire* during a meeting in Oxford in 2011<sup>2</sup>. However, these first attempts to use this method can be criticized on two points. The first is the lack of any discussion on the theoretical development of the *chaîne opératoire*. The second concerns my failure to present the spatialization of the *chaîne opératoire* graphically while it was a key part of my objective: the figure I proposed is in fact difficult to understand and does not follow the basic rules of graphic representation<sup>3</sup>. My latest reflections on these two points constitute the backbone of this chapter. The first part is devoted to a brief synthesis of the evolution of the *chaîne opératoire* as a concept developed and transformed through the ethnology of techniques. Starting from the current definition of the *chaîne opératoire*, I propose a new methodology, adapting it to the sources available in Roman archeology. In the second part, I shall conduct three successive experiments for using the *chaîne opé-*

<sup>1</sup> Monteix 2010, 133–167.

<sup>2</sup> Monteix 2016a. As for spatialization of the *chaîne opératoire*, I

would consider here the spatial forms that each step of the *chaîne* take on and their relative positions within workshops.

<sup>3</sup> Monteix 2016a, fig. 7.2 p. 172.

*ratoire* as a means of understanding the spatial organization of three types of urban workshops, related respectively to the production of ceramic objects, bread, and the metallurgy (specifically the production of iron and bronze objects).

### Using *chaîne opératoire*, from ethnology to Classical archaeology

Although several articles have discussed the genealogy and development of the *chaîne opératoire* concept<sup>4</sup>, it is useful to summarise the main points here in order to understand its development as an analytical tool.

André Leroi-Gourhan (1911-1986), an anthropologist and prehistorian, considered to be one of the main researchers for technical processes during the second half of the 20<sup>th</sup> century, first came up with the term *chaîne opératoire*. Although he only introduced the actual term in his later research, the idea was present, at least in an underlying way, in the first of his two main books, *Evolution et techniques*, published between 1943 and 1945, in which he gives a systematic description of techniques<sup>5</sup>. In these early publications he clearly outlines two key concepts. On the one hand, he defines the *tendance* (*technique*), an evolutionary process that occurs over a very long period of time, which is “predictable” and little influenced by the environment in which it develops. Such a process leads to greater efficiency<sup>6</sup>. The *tendance* is a form of common background shared by all human groups that perform the same actions with the same means. On the other hand, he defines the *fait* (*technique*) which is in opposition to the *tendance* being unpredictable and peculiar: “an unstable compromise between *tendances* and environment”. From then on, Leroi-Gourhan’s principal aim was to collate all the *faits techniques* and analyze them, with the *tendance* in mind. In order to refine the abstract position of the *tendances* and to fully exploit this term, he believed it essential to consider the highest *degré du fait*, namely the strongest distinctive characteristics of a culture, perceived as the “ethnic style”<sup>7</sup>. Beyond the criticisms that can be made against the evolutionary basis of these theoretical

constructions and the minor role given to symbolism in the means of technical action<sup>8</sup>, the *fait technique* and its examination according to *degrés du fait* remain rarely used conceptual tools. Based on his universalist study of man’s means of action on matter, Leroi-Gourhan went on to explore techniques with a resolutely cognitive approach that led him to propose a theory on human development, published in two volumes of *Le geste et le parole*, which was later translated into English<sup>9</sup>. It is in these works that he came up with the term *chaîne opératoire*, defining it to serve his discussion: “We shall revert to the concept of operating sequences in chapters 7 and 8, but mention of it must be made here if we are to understand the link between techniques and language. Techniques involve both gestures and tools, sequentially organized by means of a ‘syntax’ that imparts both fixity and flexibility to the series of operations involved. This operating syntax is suggested by the memory and comes into being as a product of the brain and the physical environment”<sup>10</sup>. In the rest of the book, he uses this concept for understanding the origins of actions carried out in a social group, considering in particular the different types of memory that make the *fait technique* possible<sup>11</sup>. To summarize, at the middle of the 1960s the main concepts – *tendance*, *fait technique*, *degré du fait*, *chaîne opératoire* – were defined: through the observation and description of *faits techniques*, it would be possible to associate material culture with social groups and thus to better understand the latter.

This very general idea saw significant development through the work of Leroi-Gourhan’s students from the 1970s on, due to the creation of a laboratory devoted to the study of cultural technology. In the founding manifesto of this research group, Robert Cresswell explains the epistemological and methodological principles, starting from the idea that there are links between techno-economic phenomena and socio-cultural events. In the context of epistemological considerations, an operative definition of the *chaîne opératoire* was proposed: “An operational sequence is a series of operations that transform raw material into

<sup>4</sup> Desrosiers 1991; Audouze 2002. I do not consider Djindjian (2013), which is unnecessarily polemical and faulty from a linguistic point of view in its attempt to replace *chaîne opératoire* by «*processus métier*», the literal translation of a business process.

<sup>5</sup> Leroi-Gourhan 1971; Leroi-Gourhan 1973. This book has not been translated, and so has a limited audience in the Anglo-Saxon world. On this, see Audouze 2002, 277–279.

<sup>6</sup> Leroi-Gourhan 1971, 27.

<sup>7</sup> Leroi-Gourhan 1971, 27–35.

<sup>8</sup> Lemonnier 1993, 23–24.

<sup>9</sup> Leroi-Gourhan 1964; Leroi-Gourhan 1965; Leroi-Gourhan 1993.

<sup>10</sup> Leroi-Gourhan 1993, 114; Leroi-Gourhan 1964, 164.

<sup>11</sup> Leroi-Gourhan 1965, 26–32; Leroi-Gourhan 1993, 230–235.

a product, the latter being subject to consumption or being a tool. Each manufacturing process may involve one or more operational sequences, and these sequences can be integrated in various ways<sup>12</sup>. This definition is part of a conceptual corpus that seeks to understand societies through their techniques, first and foremost in an ethnological way. One of the points, a priori trivial, which should be emphasized here is the recourse, within the framework of ethnological practices, to the direct observation of the technical acts while they are being performed.

One (of the) additional step(s) in the development of these conceptual reflections was established through Pierre Lemonnier's work. By using the *chaîne opératoire* as a heuristic tool in fieldwork in Papua New Guinea, and considering it as "the raw material of the ethnology of techniques"<sup>13</sup>, he proposed a clear definition of technology: "On the one hand, the human actors, sources of energy, tools, raw materials, gestures and mental procedures involved in a given action aimed at obtaining some material result generally fit together physically, or are at least more or less mutually compatible, otherwise no tangible result would derive from their systemic interaction. On the other hand, besides their material function, in most instances some of these elements, as well as their various uses, also cohere and play a role in some symbolic aspect of social life"<sup>14</sup>. This extension of technical study to the social field of symbolism is specific to ethnology, in that it is made possible through the direct observation of technical acts.

With this brief outline of the development of its conceptual progression in mind<sup>15</sup>, it is now possible to outline how ethnologists use *chaîne opératoire* today. The *chaîne opératoire* is principally a tool for documenting technical acts carried out in a specific social context. Such a record relies on direct observation and the transcription of sequences of actions that, through

comparison and analysis, help in explaining different social relationships<sup>16</sup>. As action is not technical by definition – ethnologists observe gestures – but becomes technical through its intentionally materialistic character, as with the transcription of the observations, a first conclusion can be reached<sup>17</sup>. Finally, it should be noted that in addition to recorded actions performed by actors, an important part of the data collection involves gathering specific vocabulary used by the actors to put their own actions into words<sup>18</sup>.

Can such a research method be adapted to fields outside of ethnology such as archaeology? Certainly, with a little remodeling. Such adjustments need not be particularly at a conceptual level but rather concerned with the very nature of the observations being made: it would be very difficult, for instance, to try to make a direct observation about a Pompeian baker. Many ethnologists have stated that the *chaîne opératoire* has been adopted and successively modified by archaeologists, but it is mainly prehistorians who appropriated this tool to adapt it to their research fields. This adaptation, now multi-decadal, has taken on a cognitive trend among prehistorians who, having exploited the technicist aspects<sup>19</sup>, are now attempting to reconstruct social processes from the material productions of prehistoric societies<sup>20</sup>. For later periods, such as the Roman period (the focus of this discussion) the use of the term and its concepts is rare. One explanation could be the relatively low interest, although on the increase over the last fifteen years<sup>21</sup>, in the technology of the Roman world, which was long perceived to be a time of "technical stagnation". Moreover, the use of the *chaîne opératoire* by Roman scholars tends to reduce the term to an undefined concept, used in the background as a synonym for productive processes. As such it can only be used to introduce a succession of technical operations that do not consider the other compositional elements and thus limit its capacity for wider reflections.

<sup>12</sup> Cresswell 2010 [1976], 26.

<sup>13</sup> Lemonnier 2004, § 1.

<sup>14</sup> Lemonnier 1993, 4.

<sup>15</sup> The phylogenetic tree of the *chaîne opératoire* presented here is reduced to its essence, as I perceived it. About this evolution, see also Lemonnier 2011. Other branches of the tree could (should?) have been presented, in particular the works of Hélène Balfet (e.g. Balfet 1991) or the recent thoughts of Ludovic Coupaye (e.g. Coupaye 2015) which allow for the extension of the domain of use of the *chaîne opératoire*.

<sup>16</sup> Lemonnier 1992. I shall only refer to two examples – in ethnology or history – where studying techniques achieved in understanding social relationships: Casanova 1975; Coupaye 2013.

<sup>17</sup> Sigaut 1994, 224–230.

<sup>18</sup> Lemonnier 2010 [1983], 56.

<sup>19</sup> E.g. Karlin et al. 1991.

<sup>20</sup> E.g. Pigeot 2011.

<sup>21</sup> Brun 2016, 77–80.

If one agrees with the premises of epistemological borrowing of the *chaîne opératoire* applied to the ethnology of techniques, it is important to closely follow the methodology developed in its original discipline. The use of this tool will therefore involve the collation and description of *chaînes opératoires* that will be compared with each other in an attempt to interpret the constants and variations in order to open up debates on the society under study. The main difficulty in this process of adaptation is obviously the nature of the sources available in Antiquity, which prohibit the direct observation of technical actions and allow only the use of – often incomplete – ancient descriptions of these actions, or the result of these actions. Thus, due to the differential conservation of texts, which has reduced the technical literature to almost nothing, we practically have no unified description of technical actions. Let us look for example at the fullery during the Roman period, which is fragmentarily described in medical, encyclopedic, theatrical and legal texts that do not allow us to understand the sequence of practices and gestures associated with this profession<sup>22</sup>. Ironically, the few texts that do describe actions on matter belong to the poetic or hagiographic traditions<sup>23</sup> and can be tricky to interpret: poetic licence can lead to discrepant vocabulary and misunderstandings. I will therefore only briefly mention these bodies of written evidence since in most cases the technical indications remain marginal and often impossible to interpret in terms of actions. The practical written texts, such as the corpus associated with the ceramic production of La Graufesenque (Mees in this volume), are exceptional. The iconographic sources also appear to have potential for interpretation, such as the funerary relief of Eurysaces erected outside Porta Maggiore in Rome, which allows us to follow the different operations carried out for transforming grain into bread in detail. However, this richness of detail can be deceptive in that these sculpted or painted works were evidently never conceived as objective descriptions of the actions of man on matter. In addition to the recurrent use of stereotypes, they are often designed by their patron to

convey a message that employs technical action only as a backdrop. In the case of the Eurysaces relief, the aim was probably to show M. Vergilius Eurysaces in his role as *pistor* and *redemptor*, and the action is more that of an entrepreneur controlling the various production stages than that of the technological processes themselves<sup>24</sup>. In other cases, such as the famous frieze of the Vettii in Pompeii, the representation is inaccurate in its attempt to describe the technical action and should not be considered as a realistic representation<sup>25</sup>. Despite the issues with the written and iconographic sources, they should not be entirely rejected, but clearly the physical remains provide much better information for reconstructing the *chaîne opératoire*. At the risk of being trivial, it should be pointed out that contrary to ethnological methods which directly observe people acting on matter, the possible angle of observation in archeology is not only very different but also much more restricted. Archaeologists tend to observe a very incomplete fraction of the material elements used by people to act on matter (motionless and mobile tools) as well as the results of these actions (waste, rough shapes and wasters, finished products). One can also observe the spatial distribution of these different elements, although the simultaneous preservation of all of them is extremely rare. Beyond their simple collation<sup>26</sup>, the insertion of such different elements into a *chaîne opératoire* remains a first interpretative step that should not be undervalued, even in ethnology<sup>27</sup>.

To continue with this conceptual borrowing from ethnology, I will use the following definition of *chaîne opératoire*, essentially using the elements outlined above:

A *chaîne opératoire* is a series of operations that transform raw material into a product, the latter being subject to consumption or being a tool. It involves the interaction of six components: raw material, energy, tools, mental procedures, gestures, actors. As a result of this interaction, three elements are generated: product(s)<sup>28</sup>, by-products, waste.

Thus, by questioning the last three elements – which can only be observed through archaeology<sup>29</sup> –

<sup>22</sup> Flohr 2013, 13–15, 98–121.

<sup>23</sup> 7.g. Clément-Tarantino 2013.

<sup>24</sup> Tran 2013, 140–143.

<sup>25</sup> Monteix 2016b.

<sup>26</sup> Ancient techniques generally leave little trace or may not be recognized or collected due to lack of time. Such considerations are true obstacles in collecting the indispensable evidence.

<sup>27</sup> Lemonnier 1986, 151.

<sup>28</sup> The rough shapes must be integrated either with the products or with the wasters according to the interpretation proposed to explain their incompleteness.

<sup>29</sup> Tools and remnants of raw materials might also be preserved and thus be questioned through archaeology.

through the filter of the former six, it should be possible to (re) construct *chaînes opératoires*, compare and interpret them.

### ***Chaînes opératoires* in the Roman world: why bother?**

In principle, the preceding paragraphs should enable the reader to understand the theoretical basis of this conceptual tool, developed through the ethnology of techniques, and how it can be adapted to the archaeology of the Roman world. However, the question remains: “why bother with the methodological – more than theoretical – substrate of the *chaîne opératoire* when the study of the succession of manufacturing processes gives results?”. Responses quoting the French “cultural exception” or claims that any text mentioning the *chaîne opératoire* somehow encompasses French Theory, should be rebutted. A better response might be: “because the ‘theoretical background’ that underlies the *chaîne opératoire* only aims to study society through techniques instead of simply the study of technology by and for itself”.

The examples that follow propose more coherent answers and test the limits of this tool when used to understand the spatial layout of workshops, which is just one of the many ways of exploiting it. The following remarks share a common mode of representation for the *chaînes opératoires*, allowing for a simple graphical comparison which disregards the archaeological “reality” as reconstituted during the creation of the excavation documentation. Each step of the *chaîne opératoire* is represented by a node, the different steps being linked together by edges. For the optional steps, variants to which I will return later, edges are represented by dashes. Crucial steps are understood as those whose importance is such that if there was a problem with their realization, the production as a whole would be compromised, possibly without even leaving the opportunity to recover the elements employed before this step<sup>30</sup>. To emphasize their importance, they are inserted in a circle.

This simple graphic representation could lead one to believe that the represented *chaînes opératoires* form a graph in the sense of the graph theory. Without rejecting the interest of such a mathematical representation, the spatialized *chaînes opératoires* diagrams proposed here are not in fact graphs. Indeed, the relationships represented between different steps do not belong to a simple mathematical topology: their respective positions correspond to the projection of their real positions. In the same way, the length and the shape of the edges refer to the real distance between a step and the place of implementation of the next step<sup>31</sup>, taking into account variations in the route. The edges thus avoid possible obstacles during the transportation of the product from one point to another around the workshop.

The following three examples are case studies aimed at showing the possible use of a spatialized *chaîne opératoire*, within the framework of an economic and social interpretation. This should demonstrate the analytical benefits of confronting the theoretical *chaîne opératoire* of ceramic production with its known remains at a given site. The second, more developed example focuses on Pompeian bakeries and allows for interpretations both at a general economic level and in terms of the organization of the workshops. Finally, the study of metallurgy workshops for transforming iron and bronze helps define one of the limitations of such an analysis of spatial organization.

### **Looking for missing steps in Pompeian ceramic production**

The first example using spatialized *chaîne opératoire* follows a simple and ethereal sequence of processes. Without going into too much detail about the techniques of ceramic production in the Roman world, the various steps from the clay deposit to a ready-to-use earthenware item are as follows<sup>32</sup>: extraction of the clay and temper (generally carried out in a space separate from that of the production itself); clay preparation;

<sup>30</sup> See also Lemonnier (2010, 54), who coins the expression “strategic moments”. However subtle it may be, the difference between “strategic moments” and “crucial steps” stems from the mode of observation specific to archeology.

<sup>31</sup> Within graph theory, the ‘distance’ corresponds to the number of edges between two points and thus will not have a metrical unit.

<sup>32</sup> Each step can be subdivided into several sub-steps, not mentioned here for clarity.

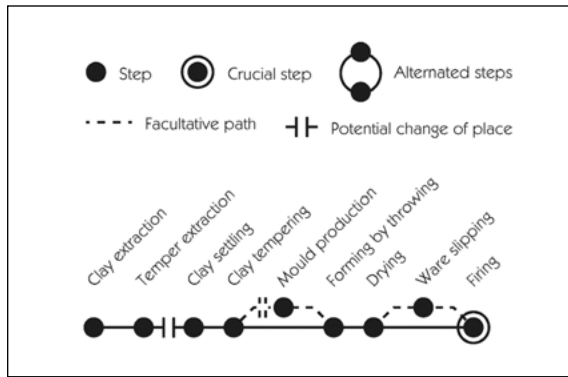


Fig. 1: Theoretical *chaîne opératoire* of ceramic production.

addition of temper; possible production of a mould (which will constitute a particular *chaîne opératoire*); forming by throwing; drying; possible addition of a slip layer; firing (fig. 1)<sup>33</sup>. To understand the missing elements from the known data of a production site, the data can simply be compared with this theoretical scheme and the reasons for the gaps examined. The example from Pompeii will help us to measure the value of this process. Two pottery production workshops are known in Pompeii and were functional at the time of the eruption. One is located outside the city (N29), beyond Porta Ercolano, in the shops built in front of the *Villa delle Colonne a Mosaico*, which were excavated in 1838. It consists of three rooms of which only one opens onto the portico that fronts a row of 13 other shops and workshops. Two kilns were discovered, one remarkably well preserved, located in room N29-2, the other in a room (N30-2) added to the end of the main building. In this workshop, 34 pots and 382 vases of unspecified form were found<sup>34</sup>.

For more than 170 years, the existence of the kiln allowed us to understand the purpose of this workshop, reducing the process of ceramic production to the single phase of firing, which is an oversimplification even if it is a crucial stage. In 2009, a new study of this workshop was published<sup>35</sup>. The various stages of production are mentioned and proposals are made for their location, but often without adequate evidence. Indeed, the entire study was carried out without on-site survey or removal of modern soil levels. In 2012, as part of a larger project exami-

ning the productive, commercial and funeral spaces in *Porta Ercolano*, cleaning and excavation campaigns were undertaken in the workshop N29 and its surroundings. The first two campaigns were carried out with the aim of identifying the different activities practised by the potter, or (tacitly) completing the missing links in the *chaîne opératoire* before the firing step. The work in room N29-1 revealed access to water and a basin, probably used to prepare the clay. Most remarkable of all, unfired vases were found southwest of room N29-3, which accommodated the oven; they were waiting to be fired at the time of the eruption in 79 CE<sup>36</sup>. In this way, it was possible to locate two of the missing links, spaces respectively for clay preparation and for drying. It also appeared that the unfired vases had traces of slip and had been formed by throwing. Understanding where these two steps occurred was the next priority to fully establish the specific spots of individual elements of the *chaîne opératoire*: thus a third campaign was undertaken<sup>37</sup>. The survey was consequently extended to the shop N28, where the remains of four potters' wheels, located along the eastern and western walls, were unearthed (fig. 2).

In this recent example, by seeking to complete the specific *chaîne opératoire* in the workshop N28-30, and by comparing it with the theoretical *chaîne*, it has been possible to further our understanding. Although the location of the space dedicated to vase slipping remains undetermined, it is possible to suggest the path of processes within the workshop. At an unknown time during the 19<sup>th</sup> century, room N28-2 was walled in to hold in the eruptive material that filled it, blocking the communication with the throwing room N28-1. Whether the shutting of the door between room N28-2 and room N29-2, where the final drying and firing occurred, is ancient or modern is debated and cannot be resolved through the simple observation of the construction techniques. I can, however, propose two hypotheses. The first, assuming the passage was closed in Antiquity, implies a form of privatization of the portico to use it as a space for drying and then slipping. The second allows a "counterclockwise" circular path between rooms N29-1, N28-1, N28-2 and N29-2, with drying and slipping taking place in N28-2.

<sup>33</sup> Desbat – Schmitt 2011.

<sup>34</sup> Cavassa et al. 2013, § 6–8.

<sup>35</sup> Peña & McCallum 2009, 72–76.

<sup>36</sup> Cavassa et al. 2013; Cavassa et al. 2014.

<sup>37</sup> Cavassa et al. 2015, § 3.

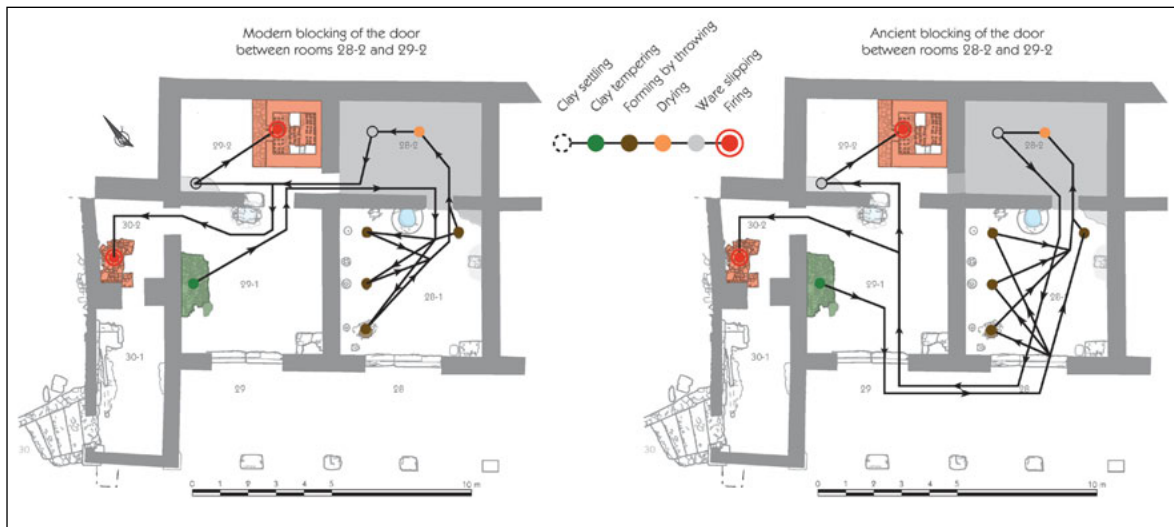


Fig. 2: Two hypothesis for the *chaîne opératoire* in workshop N28-30 (Porta Ercolano, Pompeii). The whole path changes according the ancient or modern character of the blocked door between rooms 28-2 (unexcavated) and 29-2.

Each of these two hypotheses raises many questions, notably concerning our understanding of whether the workshop and its various rooms were under the same ownership as the portico. If the use of the *chaîne opératoire* has enabled both new insights and new avenues of investigation, further research is needed to obtain more answers.

### Pompeian bakeries: description and comparison of variable *chaînes opératoires*

Scholarly reviews on bread production in the Roman world, tend to represent the *chaîne opératoire* as a simple and invariant process from grinding to baking, including kneading and sometimes leavening, unchanged from the introduction of bread to Rome – ca. the end of the third century BCE – to ca. the fifth century CE (fig. 7, a, below). The following discussion presents a significantly more complex view, based on the observation of the archaeological remains of the 32 commercial bakeries known in Pompeii. By comparing the elementary *chaînes opératoires* reconstructed in four examples, it is possible to propose a new *chaîne*. In turn, the analysis of variants and paths will

raise questions about the existence of economic rationality in the organization of these workshops<sup>38</sup>. Note that the phases occurring before (obtaining raw materials) and after (marketing) the work carried out in the bakery are not included in this discussion.

The Pompeian bakeries of the third quarter of the 1st century CE tend to present a certain uniformity, sharing certain technological choices, as far as we can tell using the evidence available. The first of these is the use of the rotary treadmill. All the mills observed in the bakeries are of the “Pompeian” type, with an active surface in the form of a clepsydra which is fixed above a grinding block taking the form of a cylinder surmounted by a truncated cone, which constitutes the passive grinding surface<sup>39</sup>. These mills were rotated by equines as is indicated by the finding of animal skeletons mentioned in the excavation archives and the almost universal use of a basalt paving marking the circular course of these animals. A second technical choice is the production of leavened bread. This is not a “universal” choice in the Pompeian technical system: an inscription<sup>40</sup> and a *tabouna*-like<sup>41</sup> oven testify to the persistence of unleavened bread; however, the scarcity of evidence makes the study of such facilities

<sup>38</sup> In order not to overburden the text with constant references to the same bibliographic references, I refer the reader looking for details to Monteix 2010, 133–167, corrected and updated by Monteix 2016a. The last interim report (Monteix et al. 2015), where new facilities are described, completes previous descriptions. Each of these papers gives references to the previous bibliography.

<sup>39</sup> Peacock 2013, 77–97.

<sup>40</sup> *CIL* IV, 677.

<sup>41</sup> Observed in bakery VII 12, 7, which also includes a classic dome bread oven, this *tabouna*-like oven is built with a re-used *dolium*. For the time being, it remains the sole example amongst the Pompeian baking structures (Monteix et al. 2015, § 39).

somewhat complex. The corollary of this choice is related to the shape of the baking facilities: all the commercial bakeries are furnished with ovens designed on a single model, with, however, slight variations. The oven consists of a quadrangular block of masonry on which a raised dome was erected; its height greater than its diameter. It is usually inserted between three walls and covered with an arch, while the facade could accommodate facilities designed to evacuate smoke and help loading operations. For the baking phase, the fueling of these ovens is stopped: once the baking chamber has been heated up, the fuel is removed and then the loaves are baked.

Let us look at the bakery built in the *Casa del Labirinto* (VI 11, 8-10; fig. 3). The basalt pavement attests to the presence of four mills arranged in a square in a large room located in front of the oven. The evidence for a kneading machine suggests the next stage of the process. It is a cylindrical basalt container hollowed out on the inside. Its side is pierced by five sockets intended for wooden plugs. At the bottom of the vat, an iron pivot hole received a metal blade, itself inserted at the base of a vertical shaft held by a horizontal beam. The rotation of the vertical shaft allowed one to mix the ingredients and obtain dough. The plugs inserted in the side enabled the user to increase the homogeneity of the dough and aerate it, thus facilitating the fermentation stage. The dough is then taken to the space situated immediately in front of the oven where three earthenware receptacles are placed against the eastern wall, raised by about 80 cm by a masonry block. Their relatively shallow shape with a wide opening, suggests that these containers helped the first rising stage by increasing the dough surface in contact with the air. It was not possible to identify the area for forming the loaves with any certainty. Yet this phase is obviously mandatory, and the quadrangular shelf sockets observed on the north and east walls of the room west of the oven (in which stood the kneading machine) were probably for shelves used to store the formed loaves for a second rising before they were baked; it is not possible to determine whether the loaves were wrapped in fabric or not during this process<sup>42</sup>. Once risen, the loaves were placed in front of the mouth of the oven thanks to an opening between

the kneading and raising room and the oven facade. Then began the baking process, as described above. This description of the bakery *chaîne opératoire* observed within the *Casa del Labirinto* highlights an additional step in respect of the theoretical *chaîne*, that of the first rising.

The set up and equipment observed in bakery VII 2, 22 have similar characteristics to VI 11, 8 10, but differ in a few interesting details (fig. 4). The first of these can be seen in the modifications made to the peristyle installed in the garden which opened to the east of the main part of the bakery. In its northeast corner was built a quadrangular basin, about 2 m wide. Its height can be restored to a maximum of 80 cm. Water appears to have been evacuated into the garden through a built channel. This type of basin, which is only found in bakeries, can be linked to Pliny the Elder's text (*NH* 18, 87) in which he states: "when the grain is sprinkled with salt water it produces a whiter flour, though at the same time a greater quantity remains in the bran". During this soaking, the endosperm gains in elasticity and the bran breaks into larger elements, facilitating its removal. After this step, the grain was ground by the four mills, which are lined up to the south of the oven. The next step is more difficult to interpret: L-shaped low walls are commonly found in the mill room and may have served as supports for planks (which would not be preserved) for receiving the flour during sieving. This sieving stage was a way of removing the bran fragments, and probably also some of the basalt dust that would have collected in the flour during grinding. Sieving may have been repeated, as that gave a whiter flour. Afterwards, it was taken to a room located to the northeast of the oven to be mixed with the other ingredients in a kneading machine similar to that of the *Casa del Labirinto*, albeit wider and shallower. No forming tables were found in the bakery at VII 2, 22 – perhaps due to a lack of cleaning in the room where they may have been situated. However, since shelf sockets are preserved on the north wall, it is possible to establish that the forming of loaves and their subsequent rising took place in the room immediately north of the oven. Here too, a pass-through was made in the wall to facilitate the transport and loading of unbaked loaves.

<sup>42</sup> See Médard et al. 2011, 84–86 for an example in a domestic context.

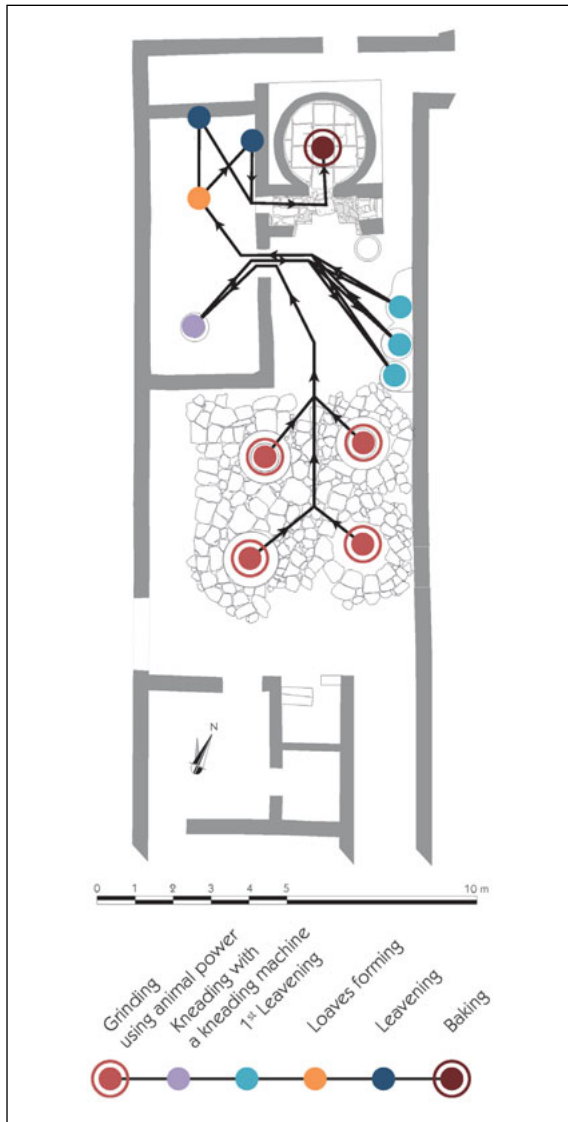


Fig. 3: Spatialized *chaîne opératoire* in the bakery embedded in the *Casa del labirinto* (Pompeii, VI 11, 8-10).

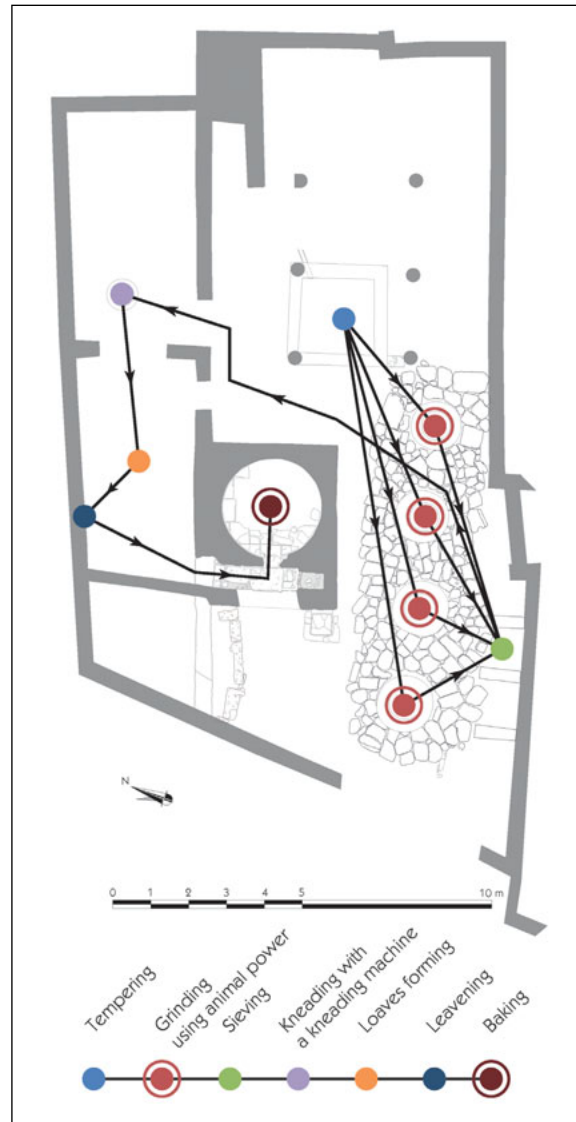


Fig. 4: Spatialized *chaîne opératoire* in bakery VII 2, 22 (Pompeii).

Turning to bakery VII 2, 3.6, it is one of the three largest in Pompeii, if we consider the number of mills as a good proxy for estimating overall size (fig. 5). However, its spatial organization is rather fragmented. It has, like VII 2, 22, a basin built into the southeast inner corner of the peristyle. The water supply came from a lead pipe, which drained into the peristyle itself. For the above mentioned reasons, this basin was probably used to improve the quality of the flour thanks to soaking prior to grinding. In the vast room that opens in front of the oven, the mills are arranged in two parallel rows, one with two mills, the second

with three. To the east of these, a low L-shaped wall housed some planks on which to sieve the flour. The following steps take place in a room located east of the oven. Unlike the previous bakeries, no kneading machine – or any trace of one – was found. On the other hand, to the north of the room, were found four post holes in the floor forming a rectangle 2.42 m long and 0.85 m wide. Thanks to the “Romolo relief”<sup>43</sup>, we can envisage a similar situation with a chest for kneading by hand rather than with a mechanized version hitherto described. Moreover, two pairs of legs from masonry tables are still preserved in this room,

<sup>43</sup> Wilson – Schörle 2009.



Fig. 5: Spatialized *chaîne opératoire* in bakery VII 2, 3.6 (Pompeii).

suggesting the presence of two tables, one oriented east-west, the other north-south, on which the loaves were formed. Two walls in this room show sockets demonstrating that there were shelves for the loaves to rise before baking. As in the previous examples, a pass-through opening in the wall facilitated their transfer to the mouth of the oven.

The last example, the bakery at VII 12, 11, is interesting because all the milling activities are in fact missing (fig. 6): neither the mill nor a space for flour sieving have been discovered, even after extensive cleaning. This absence suggests that the flour used in this bakery came from elsewhere, presumably from an urban “mill-bakery”. The lack of a kneading ma-

chine further suggests that this was done by hand, and consequently there must have been a kneading chest. Along the northern and southern walls of the room, masonry table legs were found, indicating the location for loaf-forming. Above these tables, shelf sockets once supported shelving that presumably was where the loaves were placed for raising. Finally, as before, a pass-through allowed the loaves to be moved to the mouth of the oven for loading.

In the end, even limiting our present study to one eighth of the known Pompeian commercial bakeries, the theoretical *chaîne opératoire* outlined above now appears more complete (fig. 7). This new framework would certainly benefit from further investigation

and a higher *degré du fait*, but as it stands, it has highlighted important variants that deserve attention<sup>44</sup>.

The first variant is highly significant: that the space for milling is optional in a bakery. Indeed, the example of VII 12, 11 shows a functional bakery without a mill. This means that milling and actual bakery activities may be distinct. Since no mill – even hydraulic – has yet been found in isolation, either in Pompeii or its surroundings, it seems probable that some “mill-bakeries” were generating a surplus of flour. On the theoretical diagrams, a double vertical line that breaks the edge connecting the different steps represents this possibility of multiplication of workspaces.

Four further variants have been recognized: three (grain soaking, sieving, and first rising) are optional operations; the fourth is an alternative whether to use a kneading machine for kneading the dough or not. From an economic viewpoint, but in need of further investigation, is the possibility that these variants were chosen to enhance the quality of the bread. Grain soaking before grinding resulted in a whiter flour, considered to be of better quality from Roman times. However, sieving – archaeologically invisible – would lead to a similar result, that of the elimination of bran fragments<sup>45</sup>. Should we thus change the focus from the product’s final quality to the time and effort required to obtain a similar result through sieving flour without initial soaking? Could the considerable time spent by some of the bakery staff refining the flour through sifting have been advantageously replaced by soaking? We probably cannot answer such questions yet. Moreover, isn’t seeing sieving as a “variant” somewhat problematic? Such a perspective could lead to interpreting the bakery in the *Casa del Labirinto* as a workshop offering a final unrefined “whole meal” product. Before concluding, we should consider the archaeological evidence, i.e. the quality of the notably poor manner of construction of the walls that I have interpreted as accommodating sieving facilities. Finally, according to modern bakers, the first leavening improves the taste of the dough and helps it to hold its shape better during forming and the successive stages. Kneading is obviously not an optional variant. On the other hand, the effectiveness of the two highlighted techniques for kneading, due to a lack of experimen-

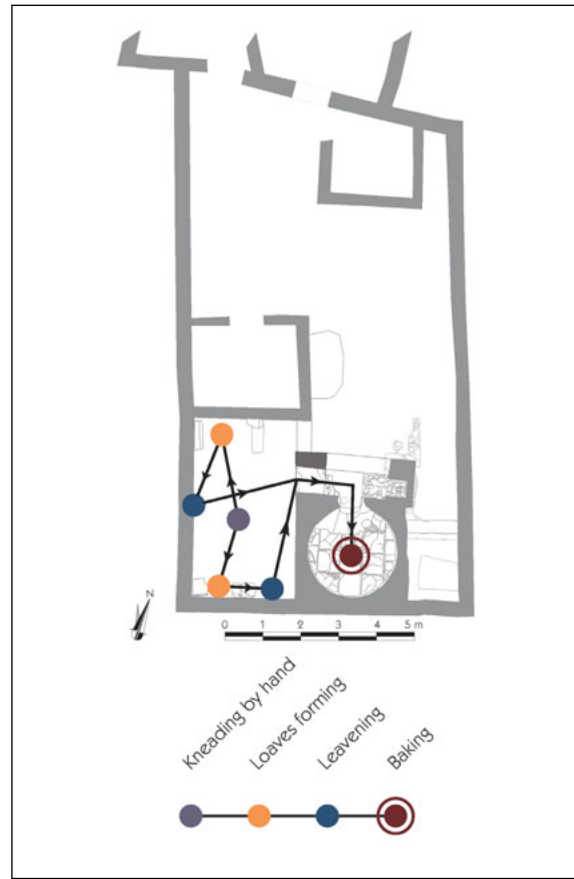


Fig. 6. Spatialized *chaîne opératoire* in bakery VII 12, 11 (Pompeii).

tation, are difficult to gauge. Mechanical kneading “in the Roman way” probably disappeared during the 5<sup>th</sup> c. CE ; kneading chests remained in use in the Western world until the end of the nineteenth century, when electricity allowed for a new form of mechanical kneading. While it would be particularly interesting to consider the adoption of “Roman” mechanical kneading as a hint at technical innovation, the contribution of this change cannot be quantified. Perhaps an explanation should be sought in the number of persons employed in the bakery and an evaluation of their efforts to knead the dough.

The diagrams of spatialized *chaînes opératoires* look for economic rationality in the layout of the workshops. The broad idea is to measure whether this organization has or has not been designed to facilitate the implementation of technical processes. Otherwise, the limits of this “rational design” would call for further explanations. In this context, I would consider as

<sup>44</sup> On the notion of variant, see Lemonnier 2010, 54–55; Delaporte 1991.

<sup>45</sup> Plin., *NH*, 18, 105.

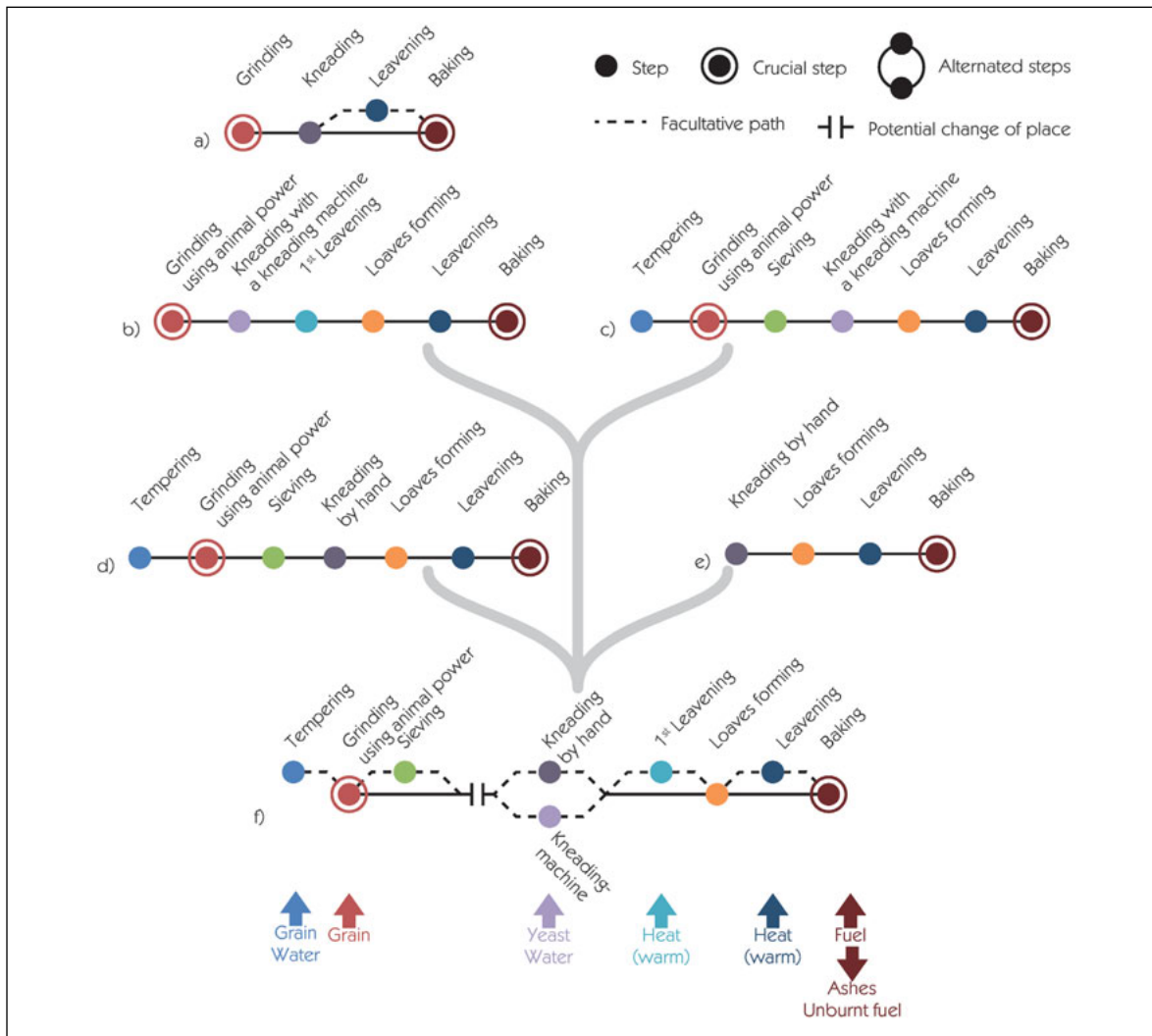


Fig. 7: From a theoretical *chaîne opératoire* of bread production in Roman times (a) to a more complete one, valid for Pompeii in the 1<sup>st</sup> c. CE (f), which reconstruction is based on the comparison of *chaînes opératoires* observed in single bakeries [VI 11, 8-10 (b); VII 2, 22 (c); VII 2, 3.6 (d); VII 12, 11 (e)].

rational a workshop (a) whose steps follow on from each other smoothly – with a low number of intersections along the route – and (b) where the duration of movement is limited thanks to shortened distances between each step<sup>46</sup>. From then on, the more the steps in a workshop are organized following a compact circuit, the more that workshop could be perceived as rational. This comparison will only relate to the first three “mill-bakeries” (fig. 3–5, above).

Generally, none of them shows a disorganized path with operations arranged in a disordered manner. With its overall linear 56 m long course, the bakery of the *Casa del labirinto* appears as the more reasoned of

the three. Although the 72 m long course in bakery VII 2, 22 presented difficult intersections, including the crossing of the line of mills from the sieving facility, it appears quite rational with its overall circular course. On the other hand, while very important work seem to have taken place shortly before the eruption, the course, which was cleaned, in the VII 2, 3.6 bakery appears rather chaotic, not so much because of its length (107 m), rather because of the smallness of the forming room that seems to prevent any fluidity in the sequence of operations. Moreover, one must take into account a factor more strictly related to the production: in this bakery, the oven is inserted under a vault

<sup>46</sup> From an evolutionary perspective – impossible to introduce here, each of the examples chosen having been observed only in its final phase – comparing the changes in path from one phase to another

would measure the investment made by the workshop owner to transform the workshop layout from an inherited organization.

that creates an air cushion between the dome and the walls around it. While this construction method allows a better insulation and therefore a better heat balance for the operating oven, at the same time it generates a significant increase in temperature for the surrounding walls, making them unsuitable for rising shelves<sup>47</sup>. So some technical factors might have taken precedence over economic factors during the rationalization of the spatial layout. The same issues may have influenced the position of the first rising bowls in the bakery of the *Casa del labirinto*. If their location suggests an illogical path in the production route, temperature issues might nevertheless explain this: as a warm atmosphere facilitates the first rising, placing the bowl in front of the oven seems fully justified. However, technical factors are not the sole explanation for “disordered” paths. The elongation and disruption of the logical path created by the installation of a grain soaking facility seems to be more a matter of economic logic: it would have seemed more sensible to change the pre-existing hydraulic implantation, and particularly that of the drainage system, rather than to create an installation from scratch that would fulfil a rational course.

This quick study of spatialized *chaînes opératoires* has facilitated a comparison between workshops by highlighting various stages of production. It has also stressed how factors strictly related to the production or to economic rationality can vary greatly. By extending this approach to all the bakeries of Pompeii and then to bakeries at other sites, it will be possible to perceive changes in the economic perception of the means of production.

### ***Chaînes opératoires* of production metallurgy in Autun and the limits of their spatialization**

This investigation of the spatial organization of the *chaîne opératoire* for bakeries has allowed us to raise questions pertaining to the economic functioning of these workshops in antiquity, so why not explore other productions in the same way in order to identify the possible limitations of this method? Metallurgical ac-

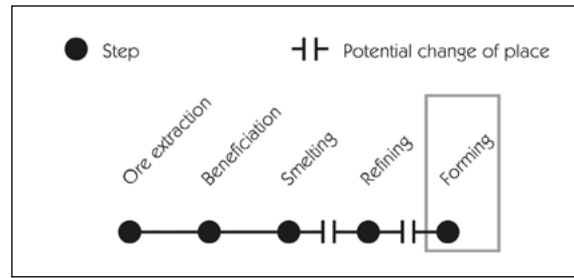


Fig. 8: Global *chaîne opératoire* of metal working, from extraction to forming.

tivities are a very good example for such an exercise as they are generally easily identified during excavations.

The *chaîne opératoire* of metallurgy has five phases, which may take place in up to three different places<sup>48</sup>. This scheme is generally valid for the entire history of metalworking: ore extraction; concentration; reduction; refining; forming. To better understand the spatial insertion of one specific *chaîne opératoire*, we shall look at production metallurgy, the forming phase, taking into consideration the work on iron and copper alloys (fig. 8) based on the evidence provided by a series of workshops discovered during rescue excavations at the *Lycée militaire* in Autun<sup>49</sup>. Given that these workshops were set in an urban context, like the bakeries, it will be possible to compare the results obtained through the study of spatialized *chaîne opératoire* in both examples. Beyond the many details that make this publication a remarkable one, our main focus is to study metallurgical workshops discovered under ‘normal’ conditions, in a single site, with a chronology between the 1<sup>st</sup> and the 3<sup>rd</sup> c. CE.

The first test was made on three iron workshops (fig. 9, a-c): (1) room 1-9 of building E in block C<sup>50</sup>; (2) room 2-1 of building C in block C (ca. 100 – 150) ; (3) room 2-1 of building C in block C (ca. 150 – 200)<sup>51</sup>. The operations associated with the *chaîne opératoire* are plastic deformation, annealing, tempering and finishing. Each of these steps can be recognized not only through the built facilities (forge furnaces, bellows, anvil, quenching basin, etc.) but also through the waste (slags, scraps, scales, coal, etc.). Although the data was gathered during a rescue excavation, different types of remains were identified and studied, allowing for closer assessment<sup>52</sup>.

<sup>47</sup> Conversely, the absence of this box in the *Casa del labirinto* would have led to a lower heat balance and thus a need for more fuel, but on the other hand allowed the installation of shelves on the wall immediately to the west of the oven.

<sup>48</sup> Minerai, scories, fer 1997; Serneels 1998.

<sup>49</sup> Chardron-Picault – Pernot 1999.

<sup>50</sup> Chardron-Picault – Pernot 1999, 128–130.

<sup>51</sup> See Chardron-Picault – Pernot 1999, 109–110.

<sup>52</sup> Chardron-Picault – Pernot 1999, 201–213.

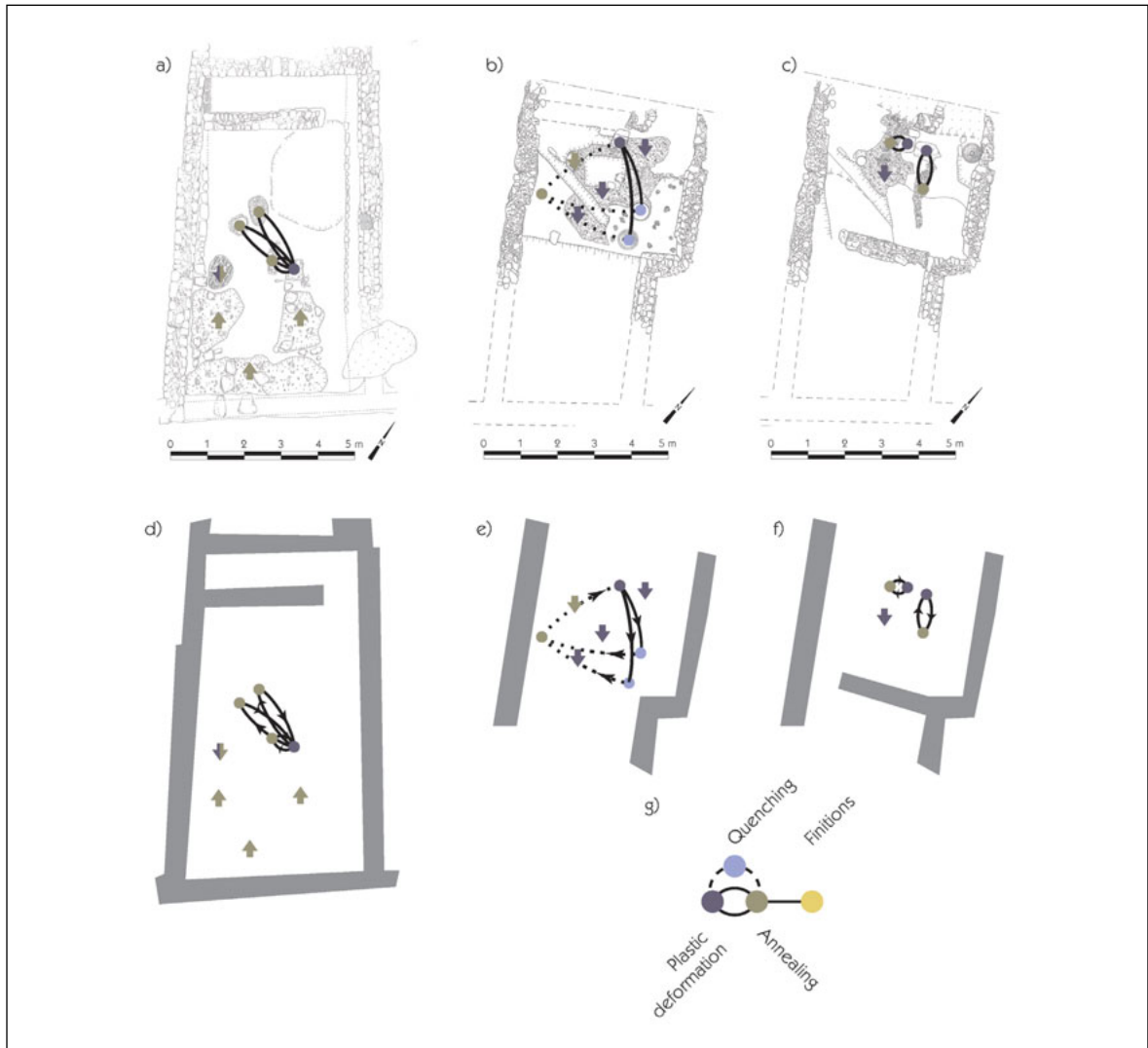


Fig. 9: Iron workshops in Autun with their own spatialized *chaîne opératoire*, reconstructed from observed archaeological remains. (a, d) room 1-9 of building E in block C; (b, e) room 2-1 of building C in block C (ca. 100 – 150); (c, f) room 2-1 of building C in block C (ca. 150 – 200); (g) theoretical *chaîne opératoire* of ironworking in Roman times.

Before we consider any spatial patterns, I will briefly outline the cyclical and variable pattern of these operations: in general, the blacksmith will alternate between annealing and plastic deformation, sometimes followed by quenching. The reality of this succession can – possibly – be reconstructed only through the study of objects produced in the workshop, and yet will vary depending on the object type. Spatial patterns (fig. 9, d-f) confirm this observation. Once the relative proximity between the annealing furnaces and anvils have been noted, as well as the possible disappearance of the quenching basin, which can be explained by their mobile nature, not much more can be said on the spatial distribution of these

facilities. At most, we can say that the furnaces seem to be arranged in the darkest part of the workshop, a specific provision that enabled the colour of the fire to be observed; this helped the blacksmith to estimate its temperature<sup>53</sup>. In cases related to iron transformation metallurgy, the analysis of the *chaîne opératoire* must necessarily go beyond the spatial distribution to look at finished objects or waste generated during their production, although this risks losing the spatial element.

A second test was conducted on one of the workshops of cuprous alloys discovered at Autun. The *chaîne opératoire* of cuprous alloys processing is different, longer and more linear than that of iron. A

<sup>53</sup> Mineraï, scories, fer 1997, 31.

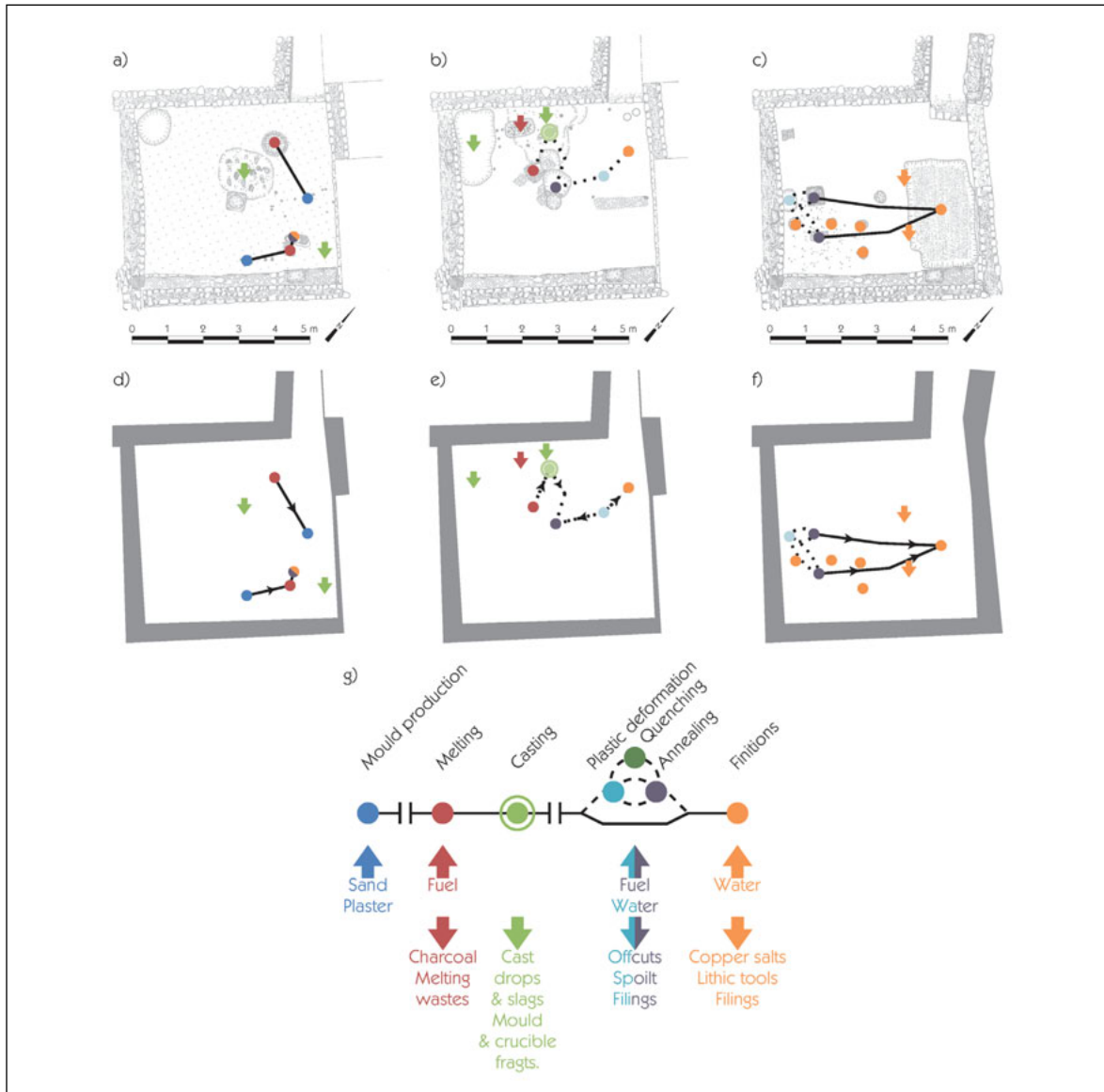


Fig. 10: Copper alloy workshop 1-11 in building E of block C in Autun with its changing spatialized *chaîne opératoire*, reconstructed from observed archaeological remains. (a, d) ca. 50 – 90 CE, 1<sup>st</sup> phase; (b, e) ca. 50 – 90 CE, 2<sup>nd</sup> phase; (c, f) ca. 150 – 200; (g) theoretical *chaîne opératoire* of bronzeworking in Roman times

clear distinction should be made between foundry operations which, in addition to the possible manufacturing of a mould inside the metallurgical workshop<sup>54</sup>, include melting and casting on one side and the post-foundry operations which may include plastic deformation, alternating with annealing and tempering, followed by proper finishing operations on the other side. The are designed to give the object its final appearance. The idea behind focusing on a single workshop is to replace the qualitative comparison

with a chronological one. Workshop 1–11 is located in building E of block C. What is particularly interesting about this workshop is that after being a ‘complete’ workshop, including foundry and post-foundry operations in the 1<sup>st</sup> c. CE, it became, during the 2<sup>nd</sup> c. CE, a smaller workshop, only for post-foundry activities<sup>55</sup> (fig. 10, a-c). This interpretation is based on the reconstruction of the *chaîne opératoire*, made possible by the combined study of built facilities and waste produced during the 150 years that this workshop was

<sup>54</sup> A mould can be manufactured in a different workshop to that in which it will be used, as demonstrated by the discoveries made in Petra in a mould /sculpture workshop dated to the 1<sup>st</sup> c. CE

(Grawehr 2010), where traces of the metal work are too small to reconstruct a bronze workshop.

<sup>55</sup> Chardon-Picault – Pernot 1999, 117–119, 124–126.

in operation: when, as is the case for each phase, part of the facility has not been preserved, the waste products allow us to fill the gaps<sup>56</sup>.

Despite this tried and tested reconstruction method for the different steps of the *chaîne opératoire* carried out in this workshop, the analysis of the spatialized patterns did not produce results (fig. 10, d-f). As for iron-working, already discussed, there is a loop in the *chaîne opératoire*. However, this does not completely explain the failure to obtain results. For the first two phases, when the workshop is “complete”, the production of fibula has been identified. Some organizational changes occur between the two phases. However, the spatialization of the operating string fails to properly describe or explain these changes.

This failure highlights the limitations of the application of this method that need further explanation. The *chaîne opératoire* is, as its name suggests, the idealistic formalisation of a sequence of actions on matter. Observed through archaeology, it is mainly followed through the tools used. Using *chaînes opératoires* whose spatial organisation can be studied, two broad groups can be distinguished. The first group includes productions for which the main tools used are immobile and so generate a real spatial mark. As the tools needed for production are immobile, the craftsman must move – or “multiply” himself by the implementation of specialized groups – which leads to the creation of “workstations” that are – partial – reflections of the *chaîne opératoire*. The second group includes productions for which the main (and/or more numerous) tools are smaller and mobile. In this case, the craftsman and the object in production will not move much, thus negating any spatial registration of the *chaîne opératoire*, or at least making it invisible for archaeology. The rare fixed points, such as furnaces for transformation metallurgy activities (and it would have been the same for, e.g., glass) will reduce the linearity of the production line, making it radial, and will conceal, from an archaeological point of view, the precise nature of the work done. The only way to study these *chaînes opératoires* would be to access to a higher *degré du fait* and take into account the complete result – both the finished product and the wastes –, which, by definition, cannot help clarify the organisation of the workshop.

## Epilogue: what to do with *chaînes opératoires*?

In sum, investigating the concept of *chaînes opératoires*, as developed by ethnologists, its use in non-prehistoric archaeology appears not only possible, with some adaptations, but really useful.

The *chaîne opératoire* remains primarily a heuristic tool, a conceptual framework for targeted questions. Thus, it might help in the resolution of technical, economic and social issues. The various components of the *chaîne opératoire* – raw materials, energy, tools, mental procedures, actions, actors – overlap in such a way as to allow the interrogation of some in order to detect others. This tool remains fundamentally pragmatic and is founded on a theoretical base with a relatively low intensity that can be reduced to “technology played a role in the functioning of ancient societies and through its analysis we can better understand social functions”.

The main advantages of the *chaîne opératoire* remain its simple implementation and its versatility: the interpretive discourse it can help generate will vary according to the observed *degré du fait*, chosen by the user or determined by available sources (tools, products, by-products and waste). In addition, it can be used at various scales, from the finished object to the city via the workshop. Thus it can be used to help explain the technical system (see Gille 1978) of a city or a region, which also allows chronological comparisons.

The attempt here to adapt this system of analysis to the conditions of Roman archaeology seems conclusive. Following the main principals of the *chaîne opératoire*, which involve descriptions, and comparisons between the reconstructed *chaînes opératoires* in order to interpret them, it has been possible to perceive gaps in the available documentation and seek to fill them. The *chaîne opératoire* served thus as a tool for defining a research strategy to address gaps in the documentation. The example provided by Pompeian bakeries allows us to reconstruct a theoretical *chaîne opératoire* with certain variants, albeit limited to 1<sup>st</sup> c. CE Pompeii. The interpretation of these variants followed economic indicators, which may lead to other social markers, made possible by an analysis of the spatialized *chaînes opératoires* within the studied bak-

<sup>56</sup> Chardon-Picault – Pernot 1999, 154–201.

eries. This attempt at a graphic representation, which forms a compromise between archaeological plans and a necessary higher abstraction, can be a powerful means to improve our socio-economic understanding of past societies, even if for now it is limited to activities using mainly stationary tools.

One can only hope that archaeologists of the Roman world and other historical and cultural areas will eventually agree with “this reassuring finding that ethnologists are not the only ones to think and speak of technical acts in the form of sequences of actions on matter[. Indeed,] focusing on the physical dimensions of the objects, understanding their production or their functioning allows us above all to update entire systems of thought or social logic *that could not otherwise be identified and understood*”<sup>57</sup>.

## Acknowledgments

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Fig. 4: N. Monteix on a plan drawn by F. Fouriaux and S. Mencarelli.

Fig. 5: N. Monteix.

Fig. 6: N. Monteix on a plan drawn by F. Fouriaux and S. Mencarelli.

Fig. 7: N. Monteix.

Fig. 8: N. Monteix.

Fig. 9: N. Monteix on plans from Chardron-Picault & Pernot 1999, fig. 109, 78-79.

Fig. 10: N. Monteix on plans from Chardron-Picault & Pernot 1999, fig. 90-91, 102.