Water and food management in late Neolithic plateau caves and lowland substructures in the south of France (3500-2300 BCE)

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Management of water and food produces in late Neolithic plateau caves and lowland substructures of the south of France.

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Abstract

The purpose of this article is to investigate the storing behaviours in the South of France in the late Neolithic period, in plateaus and lowland structures. The plateau is a limestone formation that presents multiple natural cavities for the Neolithic people to use, but in return, has no surface water to offer. The subterranean nature of water has profoundly shaped the storing behaviours in the plateau as it is mostly turned towards water collection and storage. In the lowland area however, substructures were dug directly in the soil and potteries were used aswell as containers. This paper aims to address the similarities and differences between caves from the plateaus and cellars from the lowland

Keywords

Storage; pottery; cave; Neolithic; karstic; functional analysis; use-wear

Highlights

The wear and breakage of a pottery can help identify its content and use

Storage in caves in limestone contexts is mostly water oriented

Acidic liquids are also stored in "cistern caves"

Ceramic containers associated with the storage structures show a complex use-life

Introduction

Food temporality is defined as a series of temporal cycles, socially determined, both annual and daily (Poulain 2018 pp. 233-235). Works of Alain Testart on the matter tend to show that food related activities partly define the society (Testart *et al.* 1982), as a society depending on a single or a reduced number of staple foods, is exposed to ecological risks (Testart *et al.* 1982 p. 524). Storing is a technical answer to the matter and brings food safety by means of accumulation. Bountiful but seasonal food resources shape the activities of an entire society, it can be gathered in massive quantities during the period of availability, in order to be transformed and stored (Testart *et al.* 1982

p. 524). Four conditions have been established by Alain Testart to allow the storage of massive quantities of staples: abundance of the resource, its seasonality, efficient collecting techniques and finally, efficient transforming and storing techniques (Testart *et al.* 1982 p. 523; Tushingham and Bettinger 2013; Suttles 1968).

Storage using ceramics containers require mastery of certain techniques: the execution of a reliable pot, watertight if adequate, and techniques of food conservation. Both can be identified and studied by examining the material culture. All foods rot, no matter the conservation techniques (Wells and Singh 1998 p. 369; Singh 2000 p. 3). In fact, those techniques can only prolong time until consumption by reducing chemical, enzymatic and microbial changes. Only two solutions exist to curb microbial development: blocking access to the food (by using a sealed container) or creating an unfavourable environment for bacteria (by desiccating the food for instance, all the while trying to withhold a maximum of nutrients) (Hammond *et al.* 2015 p. 759), doing so will also exterminate parasites (Deffressigne 2012 p. 30; Garcia 1997 p. 88). Silaging in the ground is a mean for conservation, it offers a closed anaerobic atmosphere that restrains germination, thus, favouring conservation (Garcia 1987 p. 68; Sigaut 1978 pp. 145-161). Regardless, some societies have favoured the use of ceramic containers for storage or used both ceramic containers and silos.

This paper aims to offer an overview of the conservation structures during the late Neolithic of the South of France (mainly the Eastern Languedoc region). The results will address the differences and similarities of storage practices between two contrasted geological contexts. The use of potteries will be particularly addressed as part of the underlying goal to identify activities. The limited number of potteries retrieved and studied in the lowland context is to be considered as a potential comparative study. The expected results should particularly point the need to store water in the karstic plateaux contexts, as opposed to the alluvial plains where the resource is available.

This study explores the late Neolithic of the south of France, mainly around the Languedoc region. The studied time period spreads from 3500 to 2300 B.C. After a transitioning phase from the early Neolithic (also called Late Neolithic 1: 3500-3300 B.C.), two main cultures can be successively distinguished: The Ferrières (3300-2600 B.C.) and the Fontbouisse (2700-2300 B.C.) comprising around 100 years of transitioning in between cultures (Jallot and Gutherz 2014) This area offers great contrast that will provide comparative material for our study. Indeed, it can be divided into two main geographical storeys. The first consists of alluvial and littoral plains as well as lagoon areas, all composed of Quaternary and Pliocene sediments. The second storey is an ensemble of four storeys gradually increasing from 600 m to 1200 m, made of Tertiary and Perronian limestones. This area will be referred in the article as “limestone plateaus”. Erosion have sculpted many caves and crevices in the landscape. As is typical of karstic regions, there is no available water at the surface. The most reliable solution to collect water is to fetch it underground (Galant 2015). This activity was widespread as it was demonstrated that almost all of the cavities featuring a vertical drop under 20 m were explored in the Late Neolithic (Galant 2003). Caves offer a high hygrometry as well as low temperatures (around 12°C). They can provide natural pools (gours) however they are neither sustainable nor systematic, they are tributary of rainy seasons (Galant 2010). Neolithic people have managed to collect water during most of – if not all season, by using big ceramic containers (up to roughly 200 L), frequently decorated with horizontal decorative coils (Galant 2010 p. 91). They are qualified as “cistern caves” and “cistern jars” (Galant 2010; Martin *et al.* 1964). Entrances of caves are often located near or inside Neolithic houses (Coularou *et al.* 2008, 2011; Colomer and Galant 2003; Galant 2003; Galant 2010; Guilaine and Escallon 2003). Ceramics used for collecting and storing water are required to have a few technical capacities: they must be of great volume, they must resist long term use and they must be water tight to some extent.

The geographical contrast between the lowland and the limestone plateaus is also reflected in some aspects of the material culture and the morphology of settlements as well as the funerary practices. Indeed while the lowland data can be roughly summarised as extensive earthen construction settlements, individual pit burials and characterised by the lack of copper objects as well as flint tools, the limestone plateaus are in contrast made of smaller settlements of stone constructions, the burials are collective and often in caves or dolmens, and material culture show a greater number of copper objects, flint tools and anthropomorphic stele and standing stones (Jallot 2011).

One of the major differences between the two contexts resides in the presence of caves in the plateaus, while they are absent in the lowland. As well as the presence of dug storage substructure in the lowland. These substructures can be more or less complex and delivered a very limited number of potteries. They seem to be determined by the substratum as cellars are easily dug in plain sediments while they would have to be carved up in the limestone in the plateaus. The main hypothesis here is that the caves were used much like the lowland cellars and the other way around.

In view of this hypothesis, a functional approach has been chosen to further investigate storing practices during the late Neolithic. There exist four main types of studies gathered under the terms of "functional studies": morpho-functional studies, techno-functional studies, use-wear studies and finally, organic chemistry. They are all enriched with ethnological, archaeological and experimental data (Fanti 2015 pp. 107-127). Some functional studies have appeared as early as the 1940's (Linton 1944) but have remained rather discreet in the history of research, until the 1990s (Skibo 1992) and have been increasing since 2010 (Skibo 2013; Vieugué *et al.*2008; Vieugué 2012, 2014, 2015; Forte *et al.* 2018; Fanti 2015).

Fundamentally, while morpho and techno-functional studies can be used to identify functions, the actual use of the pottery can only be determined by use-wear and organic chemistry.

Morpho-functional and techno-functional studies explore the notion of "intended function" (Skibo 2013). « *All pots are made to be used. That is, the potter made technical choices related to performance in manufacture and use in accord with the vessel's intended function, whether techno-, socio-, ideo- or emotive function »* (Skibo 2013 p. 27). The potter is following a mental template acquired from direct experience or inherited which will give physical abilities to the pot (Abbink 1999 pp. 41-43).

Use-wear studies have mainly developed on lithic and bone tools ever since the creation of the discipline in the 1930s (Semenov 1964 translated). However, it has gradually reached to ceramic materials (Skibo 1992, 2013; Vieugué *et al.* 2015; Fanti 2015; Lis 2012). This method relies on the observation and classification of traces. Comparative collections are a central part of the interpretation process and are often based on experimental works (Forte *et al.* 2018) or organic chemistry analysis (Vieugué 2008)

By using functional studies on the ceramic containers, our goal is to attempt the identification of the type of content. By characterising the traces of the ceramic containers found in caves, we can firstly understand if the collection of water was the sole activity and secondly, compare the results with the traces found in pots from lowland cellars. This can lead to a new method for the identification of cultures, through food practices that have the same potentiality at defining them as artefacts.

Materials and Methods

A total of 20 sites offering 26 contexts is included in this study (figure 1). Among which, five cave sites that delivered a substantial number of potteries (NMI 443), six crevices, that only delivered what appears to be detrital potteries, fortuitously trapped inside from a surface site, and fifteen underground cellars. Among the underground cellars, six delivered complete ceramics or shards *in* situ (NMI 9).

The functional study has been conducted on the ceramic assemblage of five caves from the limestone plateaus and four cellars from the lowland. 443 ceramic containers from caves were studied (NMI: 63 for “Le Claux”, Hérault; 107 for “Gaude”, Ardèche; 167 for “Les Pins”, Gard; 93 for “Avencas”, Hérault and finally 13 for “La Rouvière”, Gard). It has to be signalled that the caves of “Les Pins” consists more of a crevice than a proper cave space (Galant 2005). Three underground cellars from the lowland were also studied, four delivered a single ceramic (one for “South Urban Way of Saint-André-de-Codols”, Gard; one from a substructure in “La Capoulière”, Hérault; and the last one from “Les Camartels”, Gard), and the fifth delivered two (Le Mas de Vignoles IV, Gard). In total, precisely 447 ceramic containers have been studied from a functional standpoint.

It has to be underlined that the cave of “Avencas” is dated to the beginning of the Ferrières (Late Neolithic 1). The cave of “Les Pins” is attributed to the Ferrières culture (Late Neolithic 1 and 2). The cave of “Gaude” has been determined to have had chronologically mixed assemblages of potteries: most of it is from the Ferrières (Late Neolithic 1 and 2) culture but a few elements are attributed to the Fontbouisse culture (Late Neolithic 3) (Evesque and Leprince 1959; Evesque 1989). And finally, the caves of “La Rouvière” and “Le Claux” are culturally dated to the second half of the period in focus (respectively *épiferrière* or late Fontbouisse: NF2, and Fontbouisse: NF3) and from the same geographically defined subculture. Whereas all the other caves were open for an undetermined extent of time and thus contain a superposition of ceramic assemblages, the ceramics from the cave of “La Rouvière” are all in relation with the final phase of the connected settlement. This cave was unclogged upon arrival and was clogged again after the house’s destructive fire. It is the only cave in this corpus that offers a reliable ceramic assemblage from a single occupation. There is a possibility of cultural bias in the ceramic used for collecting. Furthermore, the caves of Gaude and Avencas have delivered human remains which indicates that they served as sepulchral caves before or after the domestic and water collecting activities. Some of the potteries studied might have been deposited for accompaniment.

Figure 1 : Map of the studied area (Eastern Languedoc region and Southern Ardèche region). Studied and mentioned sites.

The representativeness of the study can be appreciated by the reader as such: The ceramic assemblages of the caves of Avencas, Gaude, Les Pins and la Rouvière were studied to an estimate of 90 %, whereas Le Claux was only studied to an estimate of 60 % (Debels 2019). The ceramics of the selected storage structures were all studied.

The sampling of the potteries included in the functional study includes all ceramics which rim diameter could be registered, and which height is preserved to at least half of the total. All of the pots were all drawn and their dimensional (rim diameter, maximum diameter, height, maximum capacity), technological (surface treatment) and use-wear traces (chemical, mechanical or physical nature) data were integrated in a specifically designed data base. The traces, whether derived from the use or from taphonomical processes, were observed macroscopically and systematically

inventoried and classified. A methodology was developed to differentiate use traces from taphonomical traces.

A pottery is considered fit to be integrated in the use wear category if:

- The exterior surface is well preserved. Meaning the technical traces from manufacture and finishing are still visible and the temper bears no alteration.
- The internal use-wear materializes a filling limit, that can be either progressive or frank. Over this line, the pottery wall and rim should be preserved. The wear can either concern the clay wall or the temper.
- Finally, the wear can either be homogenous down to the interior bottom of the pottery, increasing in intensity or interrupted horizontally.

The horizontality of the wear is an important aspect as it is in direct link with a liquid content. Experiments have shown that even with the capillary effect, the wear remains horizontal and does not reach the rim (Debels, in press). The horizontal interruption has been demonstrated by Skibo (1992, 2013) to be a distinctive identification element of cooking in wet mode (ie: boiling, simmering, stewing etc.) (Leroi-Gourhan 1945 pp. 163-169; Graff 2015 p. 32).

From this collection of traces, an experimental protocol was elaborated in order to help the identification of content and content related activities (Debels in press).

In order to create a reliable experimental protocol on the use-wear of ceramics, the first step was to identify and recreate a common "*chaîne opératoire*" from the studied region and time period. Proper raw materials (identified source of clay and temper of karstic nature such as calcite) and the moulding and coiling techniques were used. It has to be mentioned that the pots were fired in an electric oven, this decision was made in order to have a stable parameter. They were however fired in low temperature (700°C), as consistent with the time period's techniques. The food products were chosen from the variety of available resources during the late Neolithic of southern France and for which remains were found in the Neolithic through either carpological, archaeozoological or organic chemistry studies. In total, 12 different uses of 8 produces (mutton, barley, arbutus berries, acorn, milk, water, salt and honey) were made in 45 different pots, each repeated in three to four pots in order to further secure the interpretation. The experiments can be classified into three categories: cooking in liquid mode (used for the mutton, barley, arbutus berries, milk and water), cooking in dry mode (acorns, arbutus berries) and finally, the storing and fermenting of produces (water and salt for the former, milk, honey and barley for the latter, in order to produce cheese, mead and beer).

The reference collection obtained from these experiments were compared to the archaeological wear traces. Thus, dismissing or supporting use interpretations.

Results

The caves

Most of the caves of this corpus were ancient fortuitous discoveries and underwent a systematic collection of the archaeological remains. They almost never are the subject of an excavation, except for the cave of "La Rouvière" that has been extensively excavated by Philippe Galant from 1989 to 2004 (Galant *et al.* 2000). The collection of the archaeological remains of the rest of the caves was conducted by archaeologists and are regarded in this paper as reliable. The reader must keep in mind that typically, a more or less significant portion of the materials contained in karstic caves are stuck in calcium carbonate concretions. For informative purposes: during our own exploration of the cave of Le Claux, a dozen potteries were observed partly trapped inside concretions and thus, not studied.

Regarding the potteries that were successfully collected from the caves, out of the 443, 16 could not be studied because of a covering layer of concretions (5 from the cave of Gaude, 5 from Les Pins, 3 from Le Claux, and 3 from La Rouvière). 4 more could not be studied because of overwhelming museum restoration (3 from Gaude and 1 from Les Pins).

The morphometry of the potteries from the cave sites have all been displayed on a scatter graph for comparison purposes (Figure 2). The function of cistern played by the caves is clearly visible from the sizes of the potteries that can reach up to 220 l (Galant and Halgand 2004 p. 3). These supersized potteries are the most efficient way to collect and store the water. They are often decorated with horizontal coils which can arguably be considered as a distinctive feature of water container pots, although some are regularly found in domestic household without their function clearly identified (Galant 2010). The presence of small sized potteries, defined here as potteries ranging from 0.1 l to 10 l is also consistent with the use of the caves as collection points. The smaller pots might in fact play a role in the drawing and the transporting of liquids from the larger pots. However, the presence of open, low or flat shape potteries, such as plates or low ellipsoids and ovaloids is much more difficult to justify in the "*chaîne opératoire"* of water collection.

Figure 2: Scatter graph of 443 potteries from five caves of the Late Neolithic. Visualisation of the three categories defined by the capacities.

The explograph presented below (Figure 3), is a statistical tool developed by Bruno Desachy (Desachy 2004) in order to highlight discriminative representation in a data set. This graph allows a visualisation of associations and oppositions by the means of deviation to independence. The full-size squares represent a 100 value (independence). Black squares account for an overrepresentation of the category, white squares for an underrepresentation, while the grey squares can be considered as normal proportion. The blue bars on the sides represent the amount the category has contributed to the data set.

The caves have been displayed vertically while the pottery sizes and shapes are displayed horizontally. In view of water related activities, cistern caves should have an overrepresentation of high capacity vessels (>20 l), whichever the shape, potentially associated with a representation of small capacity vessels (<10 l), either straight or closed shape. The caves of "La Rouvière" and "Le Claux" fit the most this description and can thus be interpreted as "cistern caves", in at least one of its function or at least once in its occupation (Roudil 1990; Galant 20015, 2006, 2010). It indeed has to be noted in the case of Le Claux, that there is a notable overrepresentation of medium size open and straight mouthed potteries that might hint towards alternative activities, in addition to that of a cistern cave.

Contrary to this profile, the caves of "Les Pins" and "Avencas" show not only a sever lack of big containers, they also both show an overrepresentation of small, open shapes (plates, ellipsoids and ovaloids), which is inconsistent with the function of "cistern caves", as previously stated. These observations can lead to the formulation of the hypothesis that the caves of "Les Pins" and "Avencas" can be opportunistic "cistern caves", meaning potteries from a domestic settlement have been recycled and reemployed for this usage even though they do not display the appropriate morphological attributes, or that these caves were not (only) used as "cistern caves" and were the place of other activities. An alternative hypothesis has been developed by Philippe Galant (Galant 2005), supporting that "Les Pins" has never been used as a subterranean space and the artefacts fortuitously fell down the crevice (Galant 2005). As a precaution, given that the context of Les Pins could not be secured, and that our own results show significative differences with typical cistern

caves, we consider that the hypothesis of Philippe Galant to be very likely. The cave of “Gaude” shows a normal distribution of the pottery size and shapes, without any particular overrepresentation meaning that it is not possible to interpret its precise function. The lack of big containers can however help eliminated the hypothesis of a cave specialised in water collection.

Figure 3: Explograph of the potteries from the five caves, in regard of their shape and size categories

These preliminary observations have encouraged us to further explore the hypothesis that other activities took place inside those caves interpreted as “cisterns”. The observation of the use-wear traces was the mean chosen to help identify possible content and activities of the caves. The results of this approach is exposed in the second part of the article and compared with that of the underground cellars of lowland areas.

The storage structures of the lowland

Considering that caves are open underground spaces exploited by the Neolithics to store goods, possibly of varying nature, the link with underground cellars from lowland areas is easily made. In the following part, we will further investigate how alike those structures really are and if they materialise the same storing practices?

The lowland areas of the Eastern Languedoc region have delivered a significant number of pits whose precise functions are unknown. Their distribution necessarily matches the sedimentary contexts that are adequate for digging, although the cultures that built them (Ferrières and Fontbouisse) are also well settled in the karstic plateaus. These structures appeared at the beginning of the late Neolithic and are generalised during the IVth and IIIrd millennia (Jallot 2009).

They vary from a simple pit, to poly-lobed shapes and can even be fitted with stone walls and floorings. The term “silo-cellar” was offered by Luc Jallot while excavating the open field site of “La Plaine de Chrétien”, in Montpellier (Hérault) to define the types of pits that present between one and eight smaller circular pits dug in the flooring, around 30 cm deep (Jallot 1992 a et b). Usually, the pits are dug along the walls and a space is left empty in the middle for better distribution and mobility, such case were almost systematic in the storage structures of the site of “La Plaine de Chrétien” (Montpellier, Hérault). These shallow pits have been identified as container receptacles, they can vary greatly in numbers (2, 3, 4 and 7 at “La Plaine de Chrétien”; 2 and 3 at “Le Moulin Villard”; 6 at “Zac Esplanade Sud” and “Saint-Martin-de-Colombs”, 11 at “Valagrand Mas des Chèvres”) Some structures did not deliver any pits but some clues may point towards the use of containers, the stone flooring in “Peirouse Ouest” for example, displayed circular arrangements of the stones. Although many shallow pits were empty (“La Plaine de Chrétien” pit 2, 3 and 4, Montpellier; “La Capoulière II” pit 061 and 026 ; “Zac Esplanade Sud”, Nîmes ; “Valagrand-Mas des Chèvres”, “Vers-Pont-du-Gard”, Gard) some delivered complete vessels still in place (“South Urban way of Saint-André de Codols”, Nîmes; “Les Camartels”, Le Cailar; “La Capoulière IV”, Mauguio), or portions of vessels (“Saint-Martin-de-Colombs”, Fabrègues; “Mas de Vignoles IV”, Nîmes; “La Capoulière II”, Mauguio; “Peirouse Ouest”, Marguerittes). It can be questioned whether the empty pits used to hold organic containers (bags, baskets, wooden vessels…) although it should also be specified that no carpological data has either been uncovered *in situ*.

As to why the potteries were placed inside fitted pits and receptacles shaped in the silts, some hypothesis were made regarding the conservation of the stored food: half buried storing pots indeed

offer greater freshness (Jallot 2009), it also undeniably offers greater stability for the pots. Another hypothesis was made following the techno-functional study of the large jars. It appears that storing pots often suffer from cracks and breakage as attested by the traces of repair. They often consist of the mending from either side of a crack, in order to bring the pottery parts closer, or the application of a black adhesive matter, identified as birch bark tar in some cases (Perthuison *et al.* 2019). Surprisingly, the cracks appear to be vertical along the belly of the pot, which is inconsistent with the preferential cracks of potteries built with the coiling technique. This can be interpreted as pressure from the content. Tensile strength of a pottery can be defined as the ability to withstand prolonged load and to hold content without breaking, it is a particularly valuable ability required for storing pots (Steponaitis 1984; Tite *et al.* 2001; Fanti 2015; Shepard 1956). The content of a full pottery exerts great pressure towards the exterior. Not being able to stretch, the pottery walls often develop vertical cracks (Galant 2010). Placing the potteries inside fitted pits, greatly helps relieve the pressure from the walls and prevents breakage, allowing a prolonged use of the container. It has also been theorised that the horizontal decorative coils, often found on the large potteries of the studied cultures, are in fact functional. They might indeed have played a role in binding the pottery walls, much similar to the metal hoops of a barrel (Martin *et al.* 1964 p. 168; Roudil 1972 p. 438). This seems relevant considering that horizontal decorative coils are scarce in the lowland areas in contrast with their omnipresence in the plateau. High capacity potteries in the lowland are often undecorated or only decorated with a single or double coil under the mouth (Jallot 2011 p. 92). A parallel can be made between the use of receptacles in the lowland and evidences of pottery cushioning found in caves, such is the case of “La Rouvière” (Galant, oral communication).

The construction choices of the cellars might sometimes remind that of the organisation of a cave. Indeed, some underground structures show signs of a stone roofing. The use of stones is far from common in lowland areas, where the housings are traditionally made of earth and other organic materials. On the contrary, structures in the plateaus thoroughly use stones for construction. This choice is both determined by environment constraints as well as possible cultural implications. In La Plaine de Chrétien (Montpelier), an underground cellar, 7 meters long, 2,5 meters wide and 1,80 meters deep was uncovered. The excavation showed that most of the filling of the structure was composed of large limestone tablets and no pot holes were found. These elements point towards a limestone corbel resting directly on the ground surface (Jallot 1992 a, Jallot 2009). The same type of roofing was also found in Peirouse Ouest (Marguerittes, Gard). Caves provide natural roofs, however crevices in the limestone are exposed. Excavations have evidences that a stone tablet roofing was sometimes added to the natural structure (La Baraquette, Gard) (Jallet *et al*. 2000 and Jallot 2009)

In addition to peculiar roofing choices, cellars have also frequently delivered arrangements to ease the descent, such as stairs or ramps, directly shaped in the silts. This layout can be observed at La Plaine de Chrétien where a ramp combined with faint stairs was uncovered, at La Capoulière IV, La Capoulière II (pit 026) and Peirouse Ouest where stairs are sculpted in the earth. Similar ramps or stairs can also be observed in cave contexts whenever a proper excavation was conducted (La Baraquette, Gard; Pouget, Gard; La Rouvière, Gard). They are however almost systematically materialised by large stone blocks and broken stalactites and stalagmites. Stairs and ramps always lead to an empty space: the receptacles are always dug along the walls of the pits and the centre is left unexploited.

The empty spaces left for better mobility as well as the use of potteries or other containers to be stored in these underground structures showcase the best the storage practices. Indeed, the same amount of energy is solicited to dig a silo capable of holding thousands of litres of grain as for a large cellar that will only be used to store containers with a capacity far inferior (never more than 100

litres). The storing behaviour in this case is very similar to the exploitation of a cave space. It can be argued whether lowland cellars are used similarly to the caves occupied by the same culture.

Use-wear study

Caves

After the similarities between cave and cellar attributes were demonstrated, this study will now focus on the observation of use-wear traces found in potteries. Evidently, the number of potteries uncovered in cave contexts is far greater than the ones found in lowland cellars. Two reasons can explain this difference. The first one is that cave sites were occupied far longer than cellars. Carbon dating as well as the study of the material culture show that cellars are usually used for a very short amount of time during the IVth millennium and the beginning of the 3rd(Jallot 2009) The second is that cave sites are mainly exploited for the collection of water and thus the potteries are multiplied and can blur the identification of potteries used for other storing activities. Consequently, a large number of potteries in cave sites are in fact not comparable to the potteries found in lowland cellars. To overcome this bias, the majority of cave assemblages were studied to help identify the use of the non-water related potteries.

Caves offer great contexts for the preservation of organic matters and surfaces. In the cave of Le Claux, traces of additive nature, such as black residues were frequently observed on large areas of the interior of potteries, and solely in the category of potteries ranging from 20 litres to 200 (category determined as “high capacity vessels”). They were interpreted as remains of water-tight coating, pointing towards a function of liquid container. The black coating as well as the pottery surface often showed traces of wear and thinning located at the bottom interior (figure 4). This can be caused by abrasion from potteries used to draw the content out of the pots but more often, we have identified that the wear was caused by dripping water. Indeed, rainwater quickly moves through the crevices of the surface, making its way to the cave and finally falling from different heights into adequately placed pots. By doing so, water droplets create a mechanical wear eroding the surface it touches. This notion called “the splash effect” causes the ceramic particles to be dislodged and the wall thinned down, sometimes leaving the mineral temper in pedestalling (Skibo 2013). Through time, the ceramic may puncture at the bottom. This can only happen if the filling of the pot is slow, exposing the pottery surface for a significant amount of time to the erosive power of water. Most of the time, the water quickly fills the pot, protecting the surface at the bottom. Once again, this wear was only encountered on potteries ranging from 20 to 200 litres, thus, still encouraging their interpretation as water containers. This type of erosion however, typical of falling drops, can be found altering the black residues or even the clay, leaving the temper pedestalling.

Figure 4 : Traces of black residues in high capacity vessels from the cave of Le Claux, possibly watertight coatings

Besides the traces of additive nature, wear of subtractive nature has been observed, such as marks of scraping, scooping and frequent handling. All these marks are linked to mechanical actions; however, another type of subtractive wear has been dominantly observed on the ceramic assemblage: the dissolving of temper, which is linked to chemical actions. This wear is only possible as the temper used in this time period in the south of France is exclusively composed of calcium carbonates, such as calcite and aragonite. They are highly soluble in an acidic environment which results in pitted surfaces caused by dissolved temper. This use-wear is easily identifiable; however, it is very similar to

the wear caused by post depositional processes, as the water (H_2O) reaching the caves is often loaded with CO_2 from decomposing matter, which transforms the water in carbonic acid (H_2CO_3). Carbonic acid is responsible for the formation of karstic caves. However, the carbonic gas is easily freed in contact with the cave's atmosphere, transforming the liquid back into H_2O. The distinction can be made by using the simple three criteria method exposed in the methodology above.

The dissolved temper wear shows distinctive filling limits, typical of liquids. Unfortunately, it is not possible to distinguish if the wear results from the containing of an acidic liquid for a short period of time or a lesser acidic liquid for an extensive duration.

The wear is found in the sites of "Le Claux", "Gaude", "Avencas" and "Les Pins". It can reach up to 41.3% of the total number of the assemblage, as it is the case in "Les Pins" (41.2% at Le Claux; 8.4% at "Gaude" and 15% at "Avencas"). As can be seen with the example of "Les Pins" (Figure 5), the wear is found regularly on all the sizes and shapes of potteries, although it is more frequent on small and restricted potteries, straight and restricted medium potteries and straight big potteries. In some cases, the wear is associated with linear pitting of the filling limits or severe peeling of the bottom of the potteries (Figure 6).

Figure 5: Explograph of the distribution of the total number of potteries and the observable cases of dissolved temper from the content, in regard of the shape and sizes of the potteries.

Use-wear study alone is not enough to determine what the acidic liquid is precisely made of. This needs to be further investigated by organic chemistry and starch analysis. However, a series of experiments were conducted in order to help identify what type of content and use could leave such traces.

Experiments have been conducted on wet cooking of mutton, whole barley, mashed barley, arbutus berries and milk (4 hours each) as well as the storing and/or fermentation of salt (6 months), milk (7 days), beer (2 months) and mead (2 months) (Debels in press). Each of the foodstuff were tested four times in four different pots in order to verify the systematicity of the wear. These preliminary results have shown that beer and mead storing and fermenting were able to recreate the same dissolving of the temper observed on the archaeological material, as their pH was low enough (pH 4) (figure 6). No other experiments showed a pH lower than 6, which can mean that the other experimented food produces might not be responsible for the wear, in the way they were processed during the experiments. However, a significant amount of available food produces in the late Neolithic could have been transformed into an acidic liquid. The results obtained by beer and mead experiments encourages us to further explore the fermentation processes of goods during this time period, whether alcoholic or not.

Figure 6 : Example of the dissolved temper wear on the archaeological record (top) and experiments on the production of fermented beverages (bottom).

For informative purposes, an acidic liquid (pH 4), was poured in four pots with different finishes: bone tool smoothing, polishing of the inside, polishing of the outside and bees wax coating. For each pot, the results were the same in just 3 hours: the temper was almost completely dissolved on the interior surface, while the exterior remained untouched. It appears that the finishing technics have no influence on the deposition of the wear, even with a water-tight coating such as beeswax.

The observations of John W. Arthur on ethnographic potteries used for fermentation purposes (ie. the producing of beer), show that pitting and peeling is often found on the inner walls and sometimes spreading to the rim (Arthur 2002, 2003, 2012). Similar observations were made on the archaeological pots although to lesser extents. However, the potteries studied by John W. Arthur do not display any dissolving of the temper. The reason is probably the nature of the temper itself.

In conclusions, the observations of the wear linked to the nature of the content of potteries found in cave contexts showcased little variability as only water erosions and the wear of an acidic liquid was observed. The rest of the marks are linked to the handling of the pots rather than the content itself.

The cave of “La Rouvière” did not deliver any wear other than cave water alterations. Deducing from observable data, it seems to solely display the function of cistern and delivered a much more limited number of potteries (MNI 13) than the other sites. The cave of “Le Claux” also fit the definition of a cistern caves, although the importance of acidic liquid wear on the assemblage may show that other liquid-related activities might have also taken place in the caves or that some potteries were reused from another settlement’s production. The cave of “Avencas” and “Les Pins” can hardly be classified as a cistern cave given the morphometry of the potteries and the significant distribution of use-wears on all shapes and sizes. This can induce that other activities took place in the caves or that the potteries were recycled from a domestic settlement although they were poorly fitted for their secondary use-life. Finally, the cave of “Gaude” displays neither a distinctive morphometrical profile of its potteries, nor significant wear types. Its function cannot be further investigated.

Lowland structures

The study of use-wear traces in potteries from lowland structures is necessarily a limited approach. In fact, the poor numbers of potteries retrieved in each context contrasts significatively with the number of potteries retrieved from cave contexts. Only four potteries from three storage structures could be examined. The difference in the number of individuals between lowland storage structures and cave contexts can be used to highlight the divergences between the use of caves sites and lowland sites. Indeed, this bias can be explained by the fact that caves endorse the primary role of collecting water. The goal is to accumulate water and the result is materialised by the abundance of potteries. Secondly, caves do not -or rarely- offer a closed context, their duration of use is probably far superior to that of lowland structures. The latter are estimated to be used in very short amount of time (Jallot 2009), while some of the caves from this study were open up to at least the Bronze age.

As such, the following study of use-wear traces in lowland storage structure contexts is not to be quantitatively compared with that of caves. The goal in fact is to characterise presence or absence of traces in order to help determine the nature of the content and the subsequent actions. Combined with the analysis of structure morphologies, this study contributes, in part, to the understanding of storing behaviours of the lowland area.

Four storage substructures were studied, the first is the site of Les Camartels (Le Cailar, Gard), dated to the late Neolithic (Borgnon 2006, excavation C. Borgnon), this structure offered a single pottery inside a narrow pit. The second substructure comes from the site of La Capoulière IV (Mauguio, Hérault) dated to the late Neolithic 2b (Jallot 2009, 2011, Gutherz and Jallot 2004; excatation V. Terminet, C. Depont, J.-P. Cros and L. Jallot). It delivered a single complete pottery repurposed as a funerary container. The third substructure comes from the site of the South urban way of Saint-André-de-Codols (Nîmes, Gard), dates to the late Neolithic 2a (Sauvage 1996, excavation L. Sauvage

and S. Barbéran). It consists of a large pit containing seven smaller pits identified as receptacles, one still contained a complete ceramic and another delivered a small shard. The last substructure comes from the site of Mas de Vignoles IV (Nîmes, Gard), dated to the late Neolithic 2a and 2b (Jallot 2009, excavation G. Escallon), the substructure presented four small circular pits identified as receptacles, and two contained remains of two potteries.

Only one pottery coming from the site of Mas de Vignoles showed traces of wear: namely, the dissolution of the calcite temper on the inside, materialising a filling limit 4 cm from the rim. This indicates that this pottery, at some point, was used to contain acidic liquids. Although the second pottery from the same site does not show wear, it was however repaired using the mending technique following a crack that spread from top to bottom, possibly leaving the pottery broken in half.

The site of the South urban way of Saint-André-de-Codols did not deliver any wear. The pottery however, was shut using a stone lid (a limestone slate), in an effort to protect the content, possibly from rodents, insects or even dusting.

The potteries coming from the sites of Les Camartels and La Capoulière IV however, showed complex wears that are detailed below:

The first case study presented here is a very large pottery found at “Les Camartels” (Gard) during a rescue excavation in 2006, in primary position inside a narrowly fitted pit. While the upper part of the pottery has been permanently damaged and lost by the mechanical excavator, it is still possible to restore a 74 cm high and 45 diameter wide cylindrical pottery (Borgnon 2006), as some shards of the upper part were found inside the filling of the pottery. The pit can hypothetically be reconstructed to reach 80 cm high, given that the pot was fully buried, and 60 cm in diameter. The pot was stabilised and cushioned by a series of mud clods. Remains from a fallen earthen superstructure were identified inside the pottery (figure 7).

The bottom of the pottery bears a hole that was shut by an exogenous shard placed directly on the soil. The use-wear study of the pottery has identified two different wears (Figure 8), both of a subtractive nature. One wear is located at the base of the pottery, it consists of the attrition of the clay matrix, leaving the mineral temper pedestalling (Skibo 2013). The morphology of the wear indicates that it is of mechanical nature: the clay matrix still shows clean edges around the temper. It was most probably caused by prolonged use of the pottery and associated manipulation: the vessel was frequently tilted and rotated. Even if those operation are subtle and brief, the wear can form in the long term.

A similar wear can be found on the interior of the pottery: again, the clay matrix is affected. Macroscopical observation were not sufficient to determine whether the wear was caused by mechanical attritions or the erosion by the content. It can thus be formed by frequent scraping with the help of a utensil, probably in order to withdraw the content, or the stagnating of a humid or liquid content. Both wears on the interior and exterior bottom have participated in the thinning of the wall, resulting in the formation of the hole at the bottom, which was mentioned above to be shut using a shard from another pot. As the edges of the hole still conserved thickness, it is probable that both wears weakened the round bottom, making it brittle, and that the weight of the content is the principal agent of the breakage.

If this pottery once served as a liquid container, it is plausible that it was repurposed once the pottery was damaged by prolong use. The repurposing of the pottery might also help explain the formation of wear on the exterior bottom even though the pottery was tightly secured in the earthen

pit. In conclusion, evidences point towards the storing of solid food before its discard, however, a primary use of a liquid container cannot be dismissed.

Figure 7 : Scheme of the context of discovery (Survey Christophe Borgnon UMR 5140/ CAD Romain Séguier UMR 5140, according to Borgnon 2006)

Figure 8: Visualisation of the wear at the bottom interior and exterior of the vessel.

The second case study presented in this paper is a case of funerary repurposing uncovered in the open field site of La Capoulière (Montpellier, Hérault). Its general circular shape is 1,50 m deep and 1,50 m wide at the opening and 3 m at the base (Figure 9). A large ceramic container was found in a reclining position, and a crack can be observed extending down to the middle of the belly. The crack was repaired using the mending technique. The pottery contained the remains of a child. The pit also held the remains of an adult. Given the morphology, the archaeologists suspected a possible repurposing of a cellar-silo for funerary purposes (Gutherz et Jallot 2004).

The use-wear study of the pottery has shown that it had effectively been used before serving as a burial container. Indeed, the whole interior surface of the pottery show a dissolving of the temper (Figure 10). The clearness of the wear and the limit can plead towards an acidic liquid content. In fact, three stages of dissolved temper can be observed: it begins faintly around 5 cm below the rim, it then becomes more intense in the middle of the pottery belly and finally (Figure 10, b), the wear at the bottom becomes so acute that parts of the wall have detached in large areas (Figure 10, c). There can be several interpretations to explain the morphology of this wear, one of them is that the pottery had different recurring filling levels during its life time. This aspect coincides with the crack spreading from the rim to the middle of the belly. The possible scenario is that the pottery can have been used to hold liquid content up to 5 cm under the rim (Figure 10, n°1). Once the large crack appeared, possibly from content pressure, the pottery was mended but never filled to its maximum capacity again (Figure 10, n°2), resulting in a more severe alteration in the lower part of the pottery. The exterior bottom of the pottery shows a ring-shaped wear, resulting from abrasion, this can be interpreted as wear from the support of the pottery. It was possibly placed on a fitted ring-support or inside a poorly fitted pit (Figure 10, d).

Finally, a severe pitting of the clay matrix in a circular shape can be found in the middle of the pottery's belly (Figure 10, a). In this case, the context may help in the interpretation of the formation of the wear. The body of the child was located directly in contact with the severely pitted surface area. The decomposition and fermentation of bodily fluids may be the source of the wear formation (Figure 10, n°3).

Figure 9: Scheme of the context of discovery (survey and drawing V. Terminet, C. Depond, J.-P. Cros and L. Jallot)

Figure 10: Visualisation of the wear inside and outside the pottery and interpretative scenario of its use-life.

The observation made from the use-wear study of this funerary ceramic container led to the interpretation that not only the pit might have been repurposed, as supposed by the original

excavators, but the pottery has had a previous use life: it was used to contain an acidic liquid, cracked, was mended and still used for the same purpose but only at half its capacity. Finally, the primary function of the large pot was abandoned and it was repurposed as a funerary container. One can wonder if the storage pot used for the burial was originally used in the same cellar-silo.

In conclusion, the lowland substructures studied here offered a very limited number of potteries that does not allow direct comparisons with what was observed in the caves. However, some general tendencies show that the Neolithics were keen on repairing and repurposing their potteries inside storage pits. This consists of a great difference with the potteries coming from the caves, where repair operations are scarce (cave of La Rouvière 0%, cave of Gaude 2%, cave of Avencas 2%, cave of Claux 3%). Perhaps this could be used as and indicator of storing solid food as opposed to liquids, both in the case of lowland substructure and caves. It can be interpreted that the fact potteries coming from the lowland substructures are easily repaired and repurposed, may show that their use is of opportunistic nature. The other empty receptacles could have easily held baskets or any organic container as it seems that the water tightness was not an expected criterion. In fact, the use of organic containers could even have been the norm, given the number of empty receptacles, and the use of potteries the exception.

Discussion

Caves offer very practical contexts of storage (stable low temperature, lack of light, lack of vermin and insects etc.). It seems only natural they were used for storing large quantities of food. However, no traceological evidences could point towards this hypothesis. In fact, by studying the potteries retrieved in lowland substructures, it could be evidenced, even considering the limited amount of potteries studied, that the latter were easily repurposed, following excessive uses that led to the wearing down of the pottery, or breakage (Les Camartels, Mas de Vignoles IV, La Capoulière VI). This trait however, was not observed inside cave contexts.

It can be stipulated that caves could have held foodstuff in organic containers, much like the empty receptacles from the lowland substructures. And, still extrapolating observations from lowland contexts, that some potteries were exceptionally repurposed for solid foodstuff inside the caves. However, the significant amount of potteries used for water collection and other storing of liquid contents prevents a better vision of the situation.

However, the extensive amount of acidic liquid caused wear can be taken as evidenced regarding the fact that the Neolithics actually did take advantage of the many conveniences of cave contexts. Only the storing of liquids, whether water or other types, were the main objective. It has to be reminded that limestone plateaux offer extremely dry conditions.

Another type of structure from the plateaus may have endorsed the same function as the cellar-silos of the lowland: the crevices. Indeed, many were found near or even connecting to houses. Such is the case of the settlement site of Les Vautes (Saint-Gély-du-Fesc, Hérault; Colomer and Galant 2003), the settlement site of Cambous (Viols-en-Laval, Hérault; Galant and Canet 1992, Jallot *et al.* 2003), that delivered several but two of them were actually documented, the site of Vaunage (Calvisson, Gard), that delivered two (Jallot 2003), the site of Pouget (Souvignargue, Gard; Jallet *et al.* 2000) and La Baraquette (Vézénobre, Gard; Jallot 2009). Each of the cited crevices showed traces of arrangements, such as intelligently placed blocks in order to form stairs or slopes, widened entries

etc. The care showed for arranging a safe access may indicate that the crevices were used on a daily basis (Jallot 2009) and is very similar to what was observed in the lowland cellar-silos. The site of La Baraquette even delivered two potteries at the far end of the crevice. These elements could indicate that the crevices were used similarly to the lowland substructures, by storing foodstuffs, while the caves were mainly dedicated to liquids.

It has to be noted as well that some crevices were exclusively used for collecting water if the water level could allow it, this is the case of the site of Grand Coucouyon (Capelle et Masmolène, Gard; Ratz 1993). The crevice was in fact used a cistern, without needing to collect or store water inside potteries.

Conclusion

The conclusion of this study showcases the differences between natural or human-made underground spaces according to the geological context. Indeed, in the limestone caves found in the plateaus, storing activities are much more influenced by the lack of surface water. The great number of ceramics, particularly in contrast with what is found in lowland substructures, materialises the need for accumulating. Storing activities of solid and semi solid food products could not be observed clearly inside the karstic caves. The most visible activity remains the collecting of water. This can be observed through the morphometrical study of the potteries as well as the water erosion wear from falling drops and possible calcite depositions although it is inherent with the context. This aspect is most visible in the caves of “La Rouvière” and “Le Claux”.

The other caves however delivered insecure contexts: The morphology of the caves show that potteries and shards could have fallen inside from the erosion of a surface site (Galant 2005) and the study of the morphometry of the assemblage showed a great quantity of small very open potteries (such as plates and flared bowls) and very few high capacity potteries. Given this information, the actual use of the cave as storage area is regarded as uncertain. Other hypothesis could advocate in the favour of possible caches for a seasonal surface settlement. The cave of “Gaude”, does not show any discriminating features in his overall profile that would allow an interpretation nor any distinctive wear types. This cave has delivered human remains which main indicate that some potteries were in fact deposited in *viaticum* for the dead.

Most importantly, the cave of Le Claux delivered a very frequent wear: the dissolving of the temper, which is consistent with the storing of acidic liquids. The potteries showing such wear are spatialised in the back of the cave. The distribution of the wear and the fact that a filling limit can clearly be seen in each case at the approximate same level of filling, proves that it is not natural. Subterranean spaces offer specific conditions, such as high hygrometry, low temperature, total obscurity and lack of vermin. These features could be taken advantage of in order to store specific fluids. The nature of the fluids however, remains to be investigated, although our own experiments and ethnological studies (Arthur 2002, 2003, 2012) showed that the morphology and distribution can preliminarily be compared to that of fermented beverages.

Regardless, the use-wear study has shown that the cave ceramic assemblages show little variety in the wears. In fact, either no wear can be observed, mechanical wear from handling, or water related wear and the dissolved temper wear type. Many activities might not have left any traces inside the pots, given that the use was not intensive or prolonged enough. However, the cave ceramic

assemblages repeatedly show that cave activities are tightly linked with liquid contents, whether collecting or storing. Cave atmosphere show a high hygrometry (around 100% depending on the season) and a constant temperature (around 12°C yearly) that helps prevent the evaporating of contents. This feature is particularly welcomed in the karstic contexts of limestone plateaus from the south of France.

In the lowland on the other hand, different types of wear were observed inside the pots found in interpreted cellar pits. Although the study collection is quite restrained, it still offers a glimpse of the possible variety of usage of a storing pot in the late Neolithic. From solid content to liquid content, an investigation through organic chemistry and starch analysis might help narrowing the interpretations. It is possible that the underground structures of the lowland might serve as shelter to a variety of products, edibles and non-edibles. However, the most important aspect that was shown in the small corpus of potteries studied is the extent and intensity of the wear, often associated with repair operations such as mending. This may point towards prolong use. Potteries are far from systematic inside the shallow inner pit or even inside the cellars. It is possible that organic container was most commonly used. The presence of repaired and repurposed potteries encourages us to think that potteries were conveniently repurposed in replacement of broken or missing basketries. It seems the water tightness was not a necessary feature. The complex life cycle of the potteries showcases an economy of recycling in the late Neolithic.

The flagrant will to bury or semi bury the pots can be linked with the purpose of keeping the content cool, and/or relieving the pressure on the pottery walls to prolong their use life. This behaviour is fundamentally different from the potteries standing bear inside the caves.

We believe the results of this study show that the storing practices of the lowland shouldn't be searched for inside the caves of the limestone plateaus (Galant and Canet 1992). Even though the comparison is tempting given similar architectural features such as obscurity and freshness in particular. In fact, this function could be further investigated regarding crevices. They too are often found near or inside the settlements and even inside houses. This aspect argues in favour of a domestic use. Very few potteries were retrieved inside those natural structures. Crevices often displayed features similar to the architecture of lowland storage substructures (railings, stairs, covered top etc.).

In addition, storing practices should be further explored inside the houses of the limestone plateaus contexts Some excavated domestic houses indeed enclose a significant number of high capacity vessels (Boussargues, Argellier, Hérault: Coularou *et al.* 2008; and Les Vautes, Guilaine and Escallon 2003, La Rouvière, Galant 2000, 2010 and Lefeuvre 2006, to start with). The need for underground cellars could be subdued by the presence of storage in superstructures. This would evidence different mental conception and uses of spaces.

Foodstuff is as biological as it is social. It is necessary for sustenance but also dictated by social conceptions (Fischler 1979; 1988). Studying the food habitus is a valid mean to define the culture and the societies that practice it. Storing is considered as an essential part of the Neolithic's diet (Testart *et al.* 1982) and has often been reduced to the storing of barely processed grains and other raw produces. This study shows that the storage of processed food, such as liquids, and possibly fermented, needs to be further explored.

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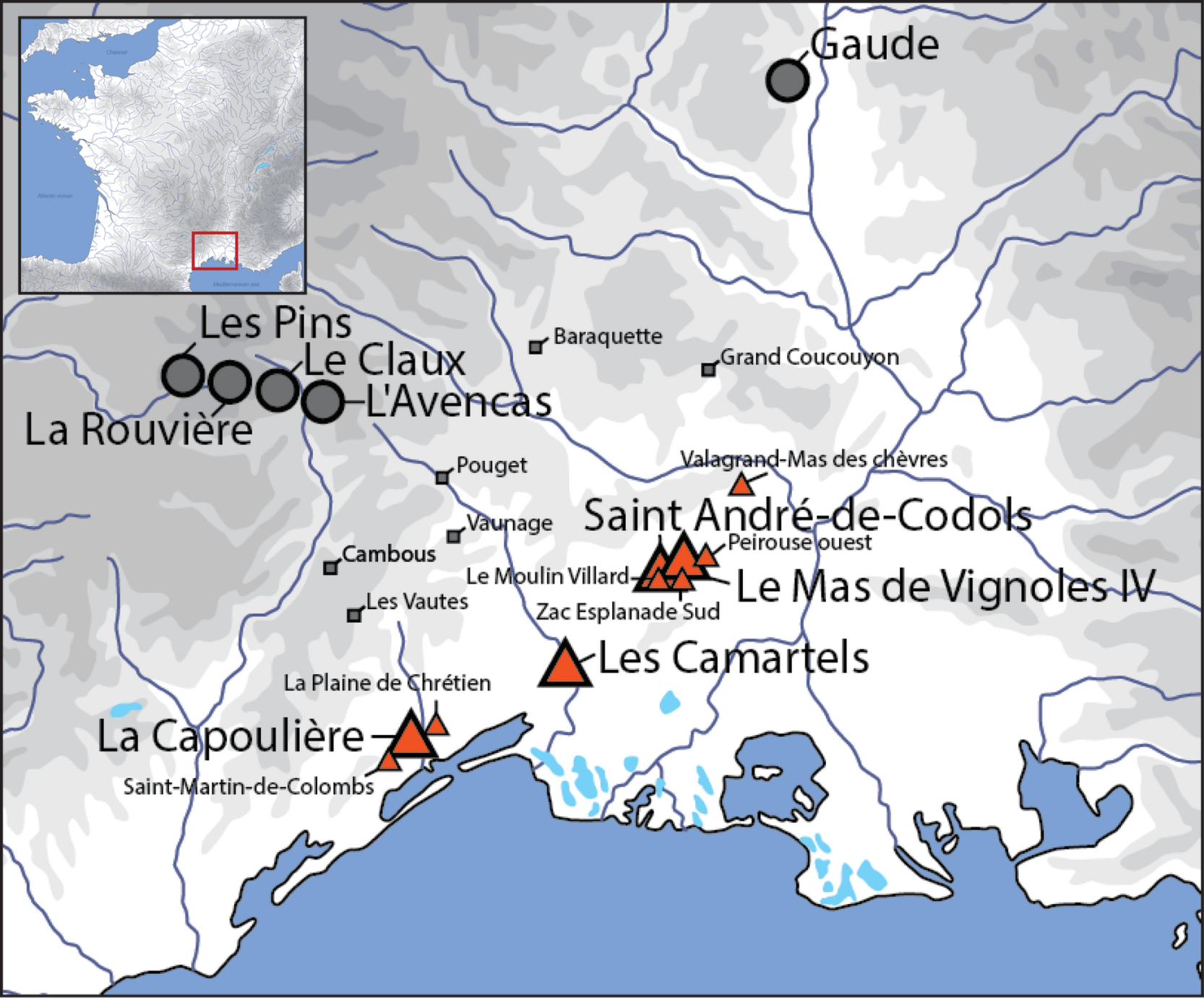
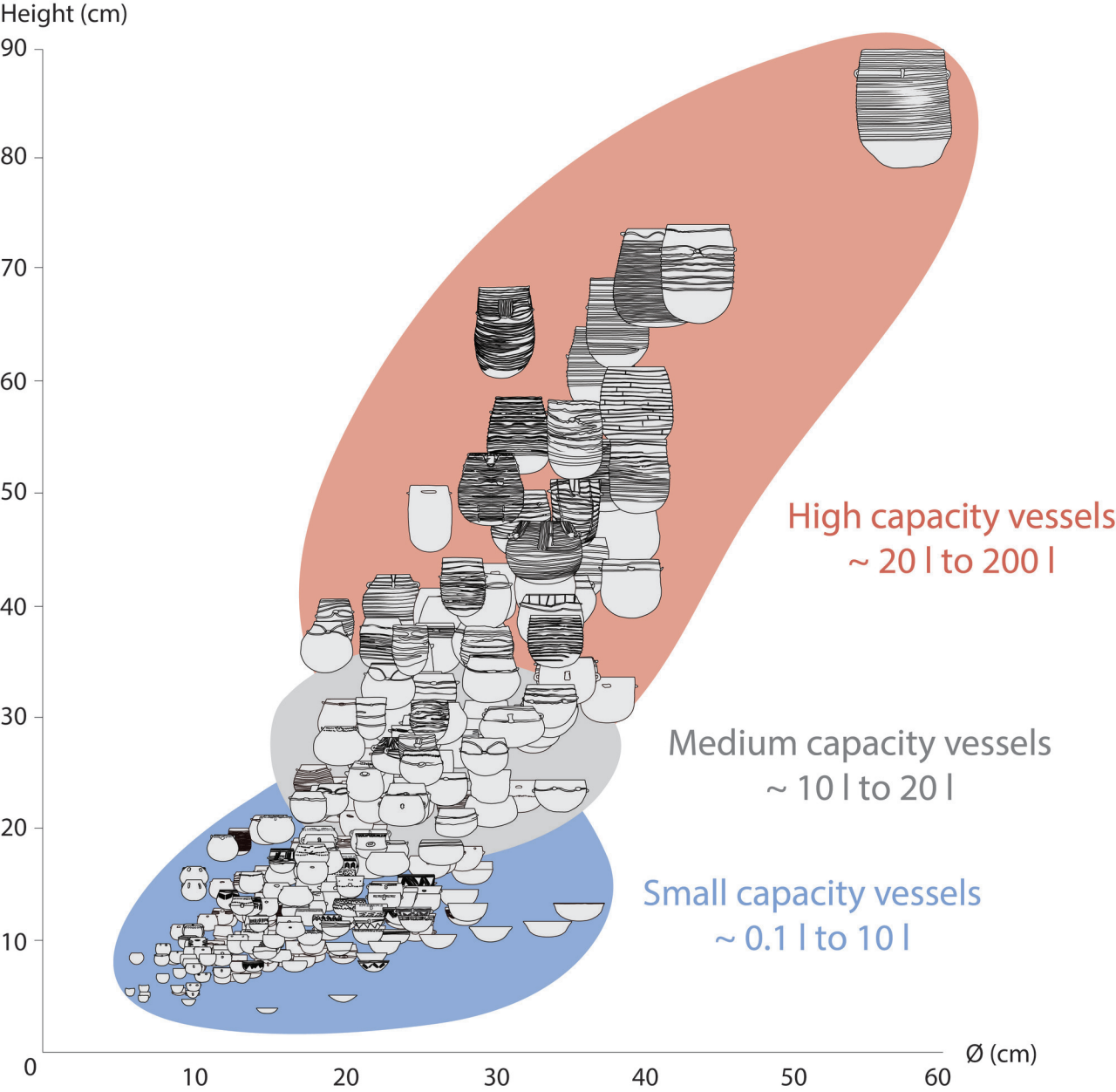
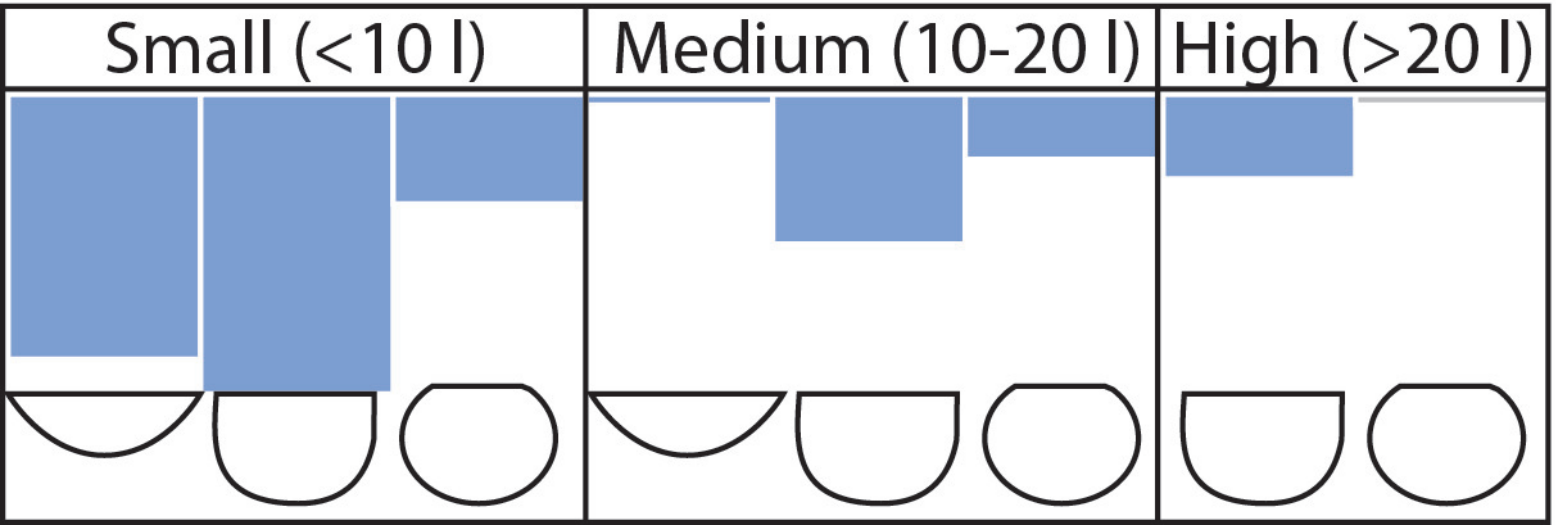
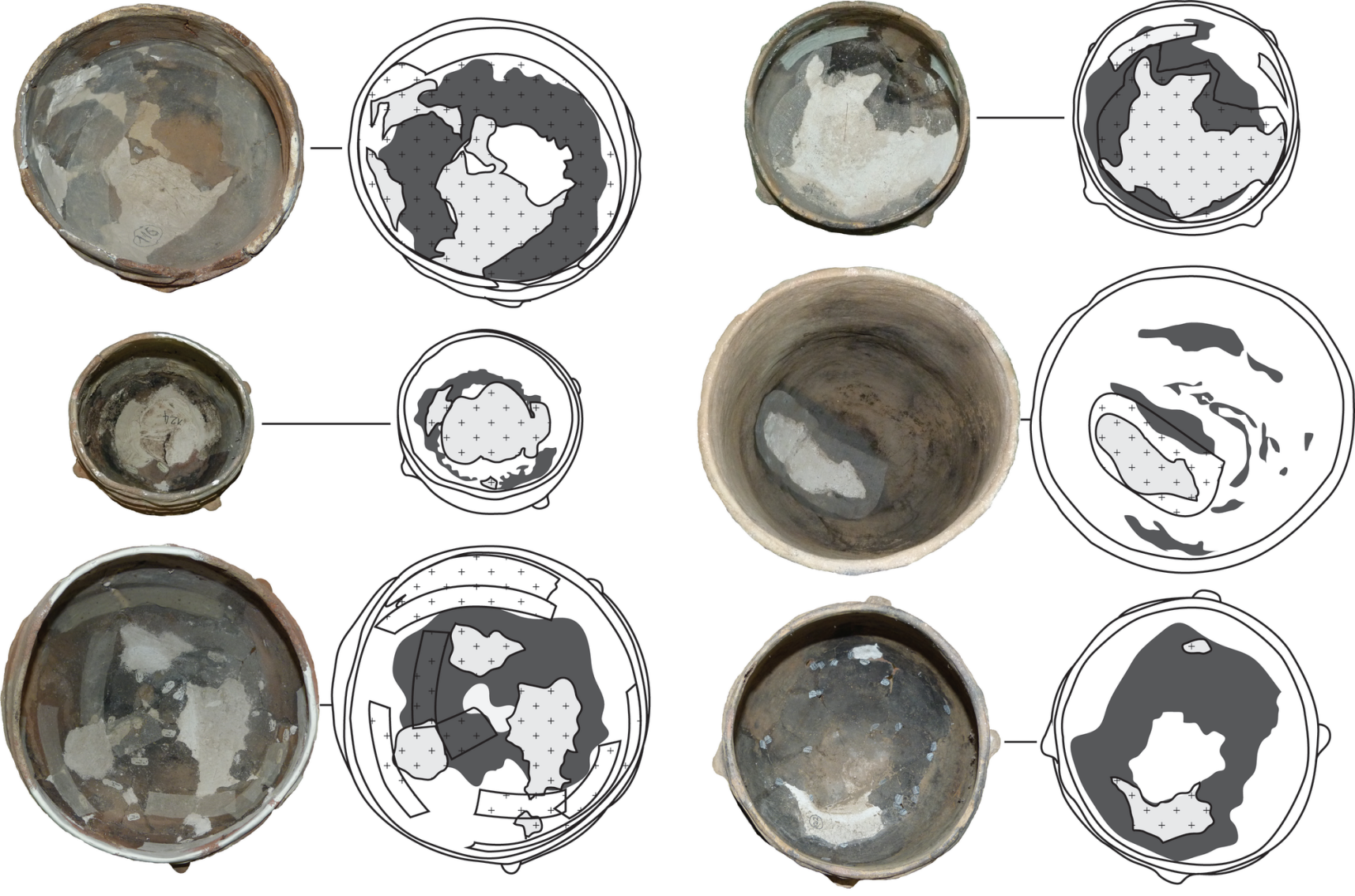
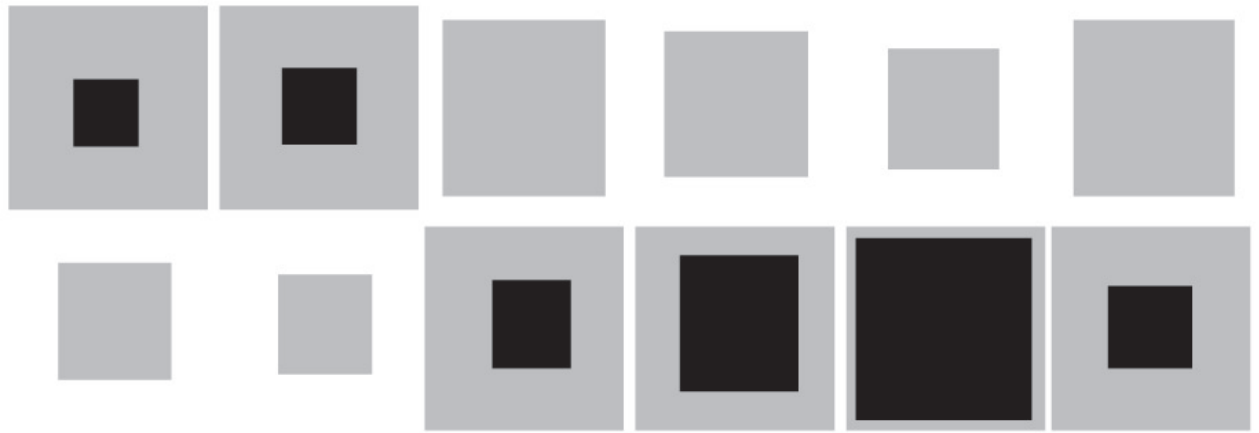

Gaude
Les Pins
Le Claux
L'Avencas
La Rouvière
Baraquette
Grand Coucouyon
Pouget
Valagrand-Mas des chèvres
Saint André-de-Codols
Vaunage
Peirouse ouest
Cambous
Le Moulin Villard
Le Mas de Vignoles IV
Les Vautes
Zac Esplanade Sud
Les Camartels
La Plaine de Chrétien
La Capoulière
Saint-Martin-de-Colombs
Cave sites with ceramic assemblage (included in the use-wear study)
Arranged crevice (not included in the use-wear study)
Underground cellars (included in the use-wear study)
Underground cellars (not included in the use-wear study)


Height (cm)
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
Ø (cm)
High capacity vessels
~ 20 l to 200 l
Medium capacity vessels
~ 10 l to 20 l
Small capacity vessels
~ 0.1 l to 10 l


LA ROUVIERE
LE CLAUX
GAUDE
AVENCAS
LES PINS

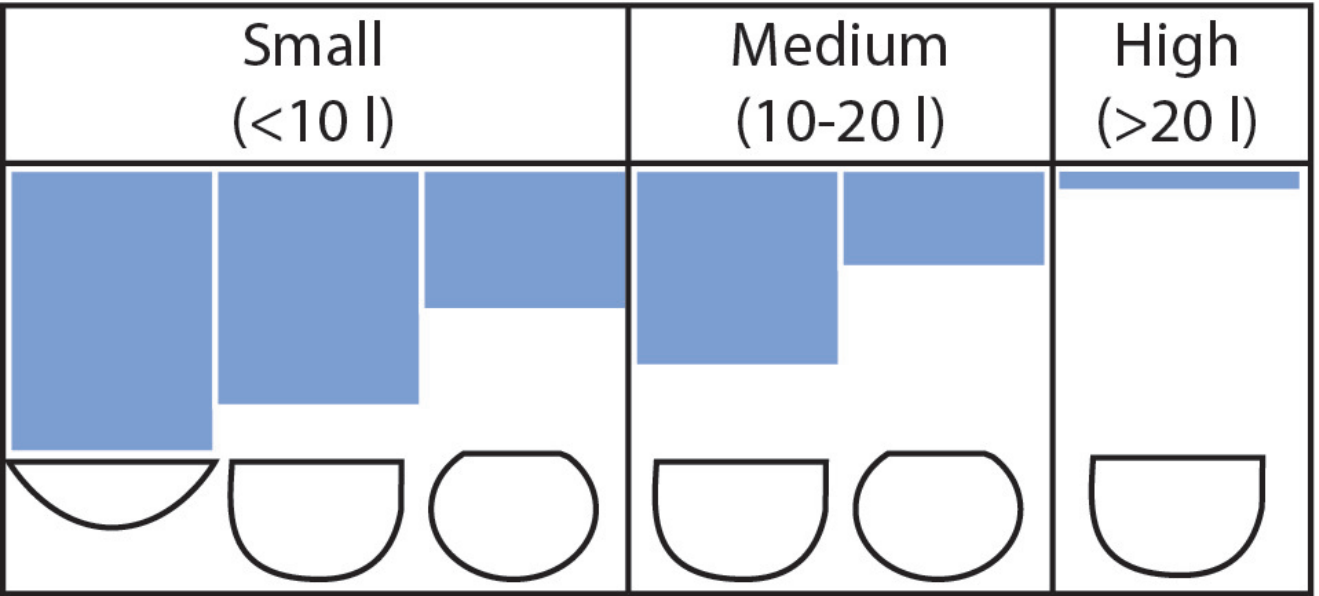

Small (<10 l)
Medium (10-20 l)
High (>20 l)


Restorations
Black residues
10 cm

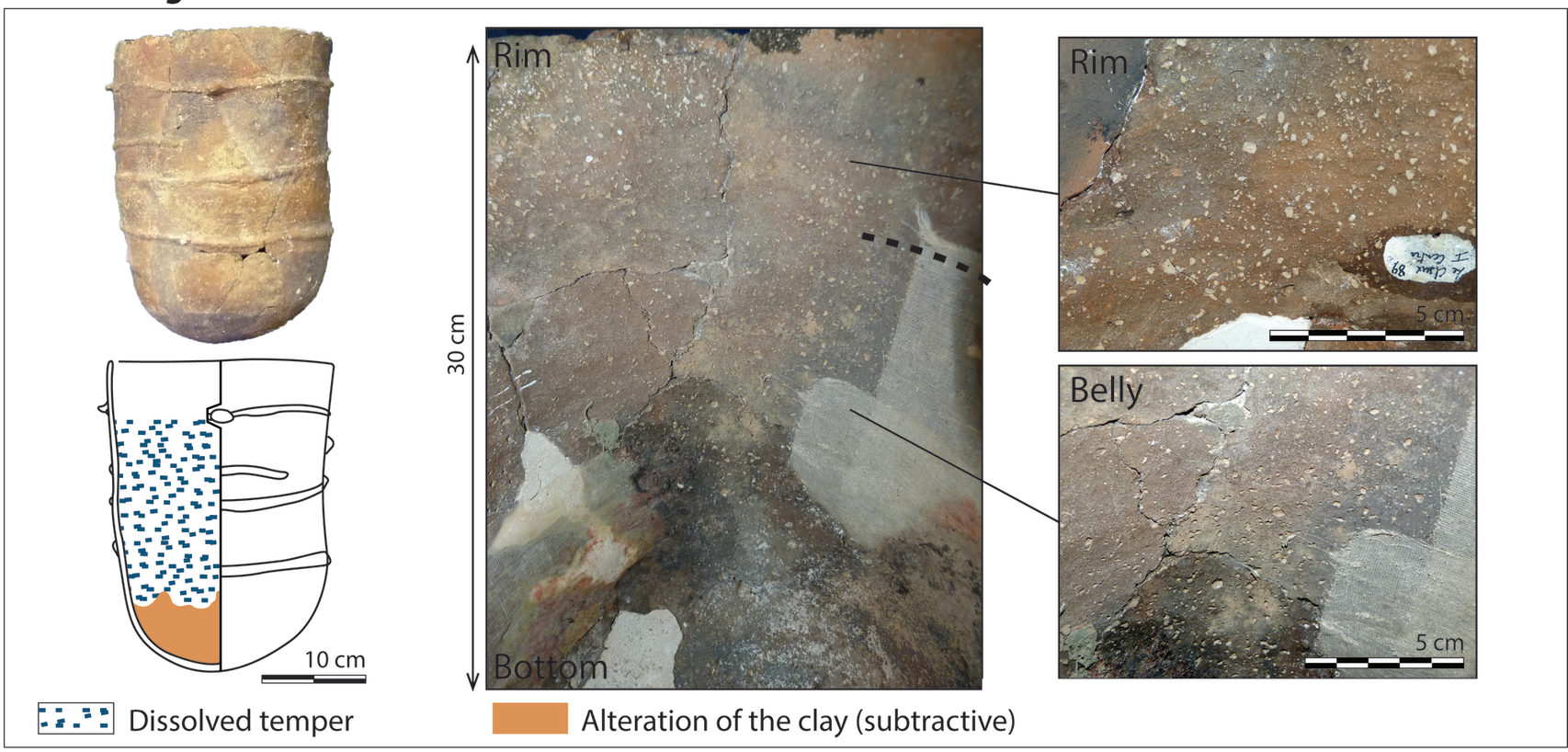


TOTAL NUMBER OF POTTERIES (167)

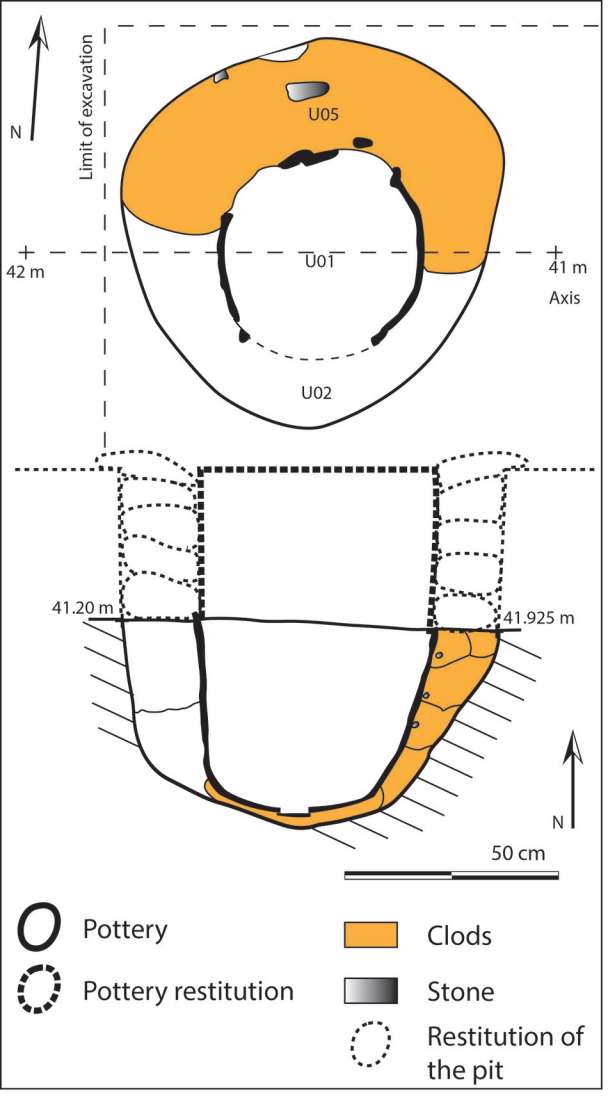
DISSOLVED TEMPER WEAR (69)

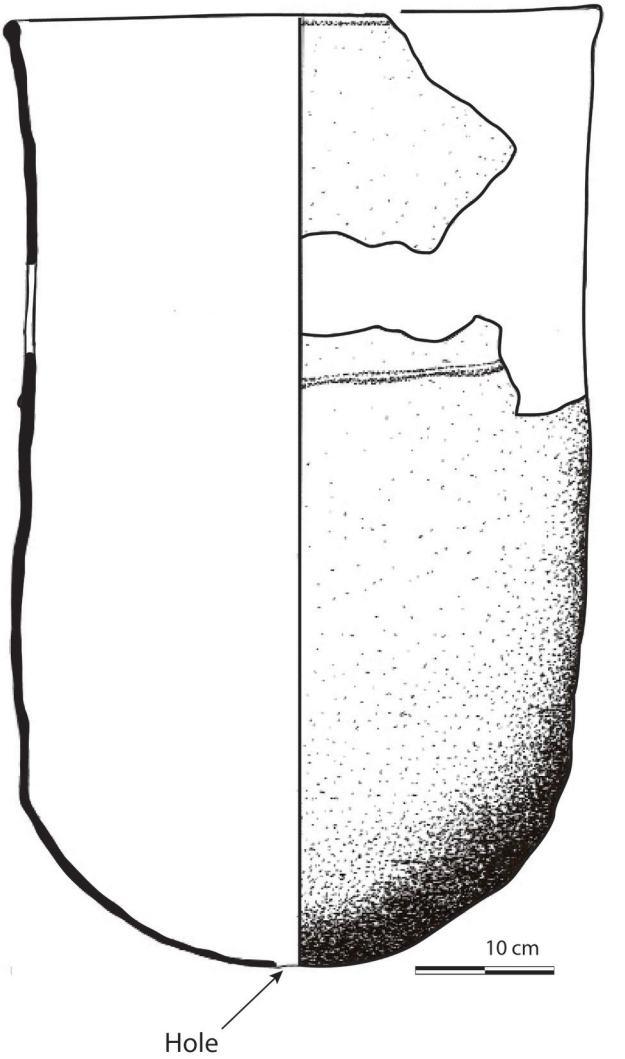


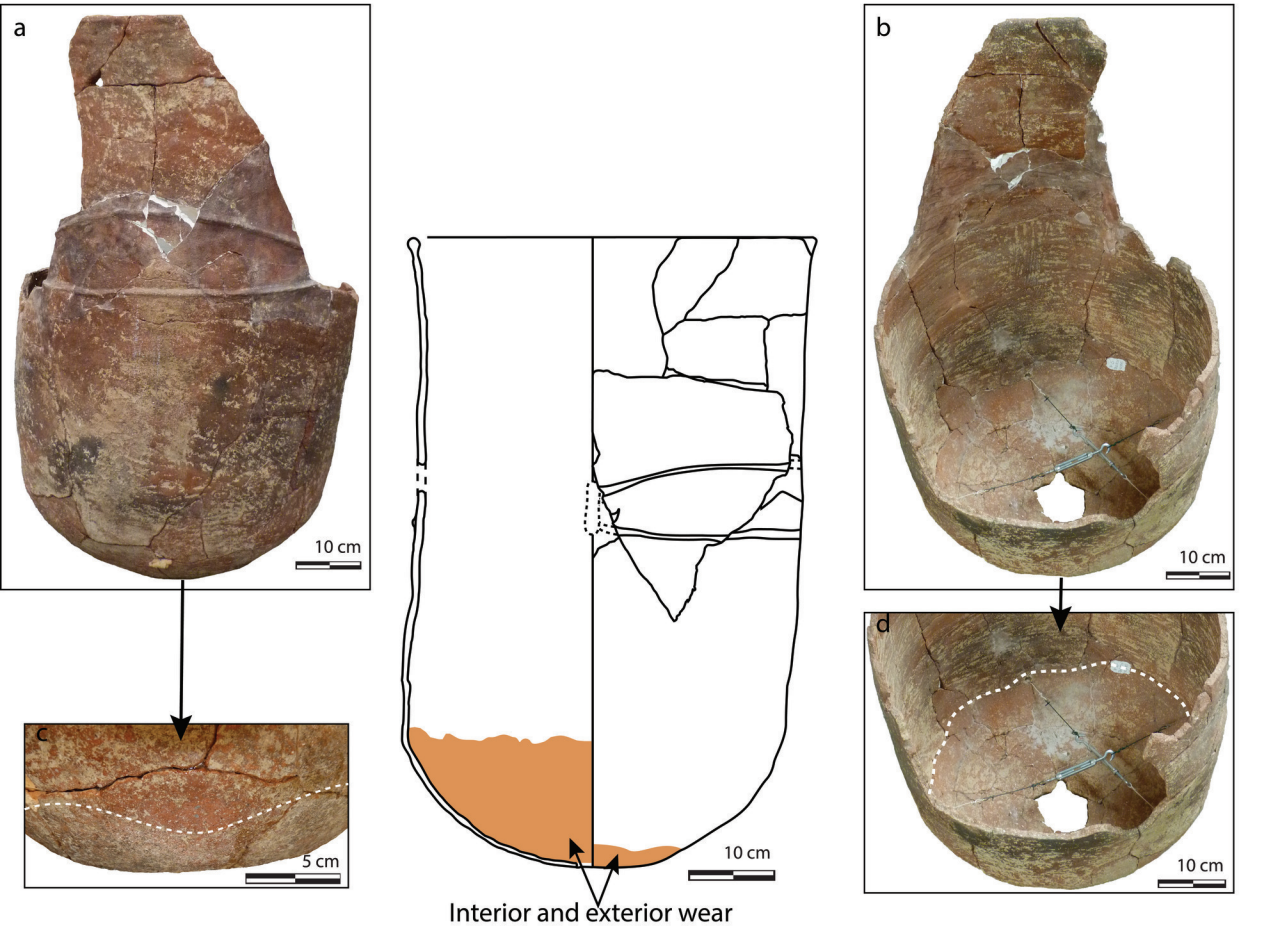
Archaeological

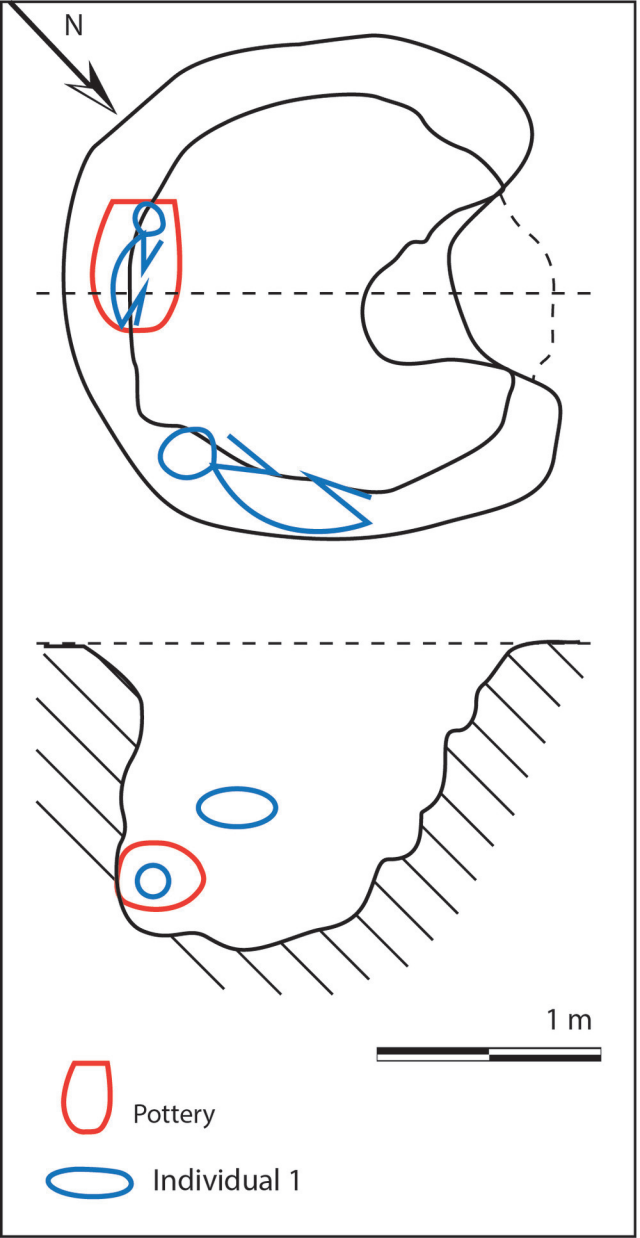


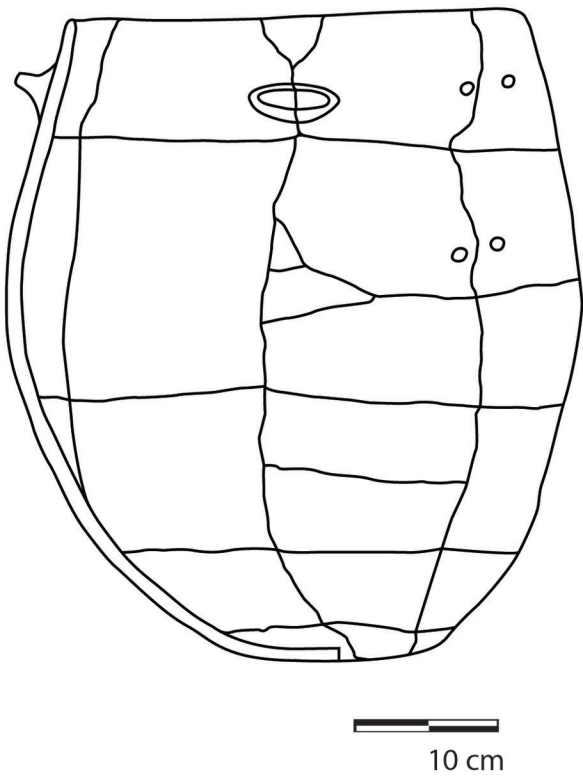
Experimental

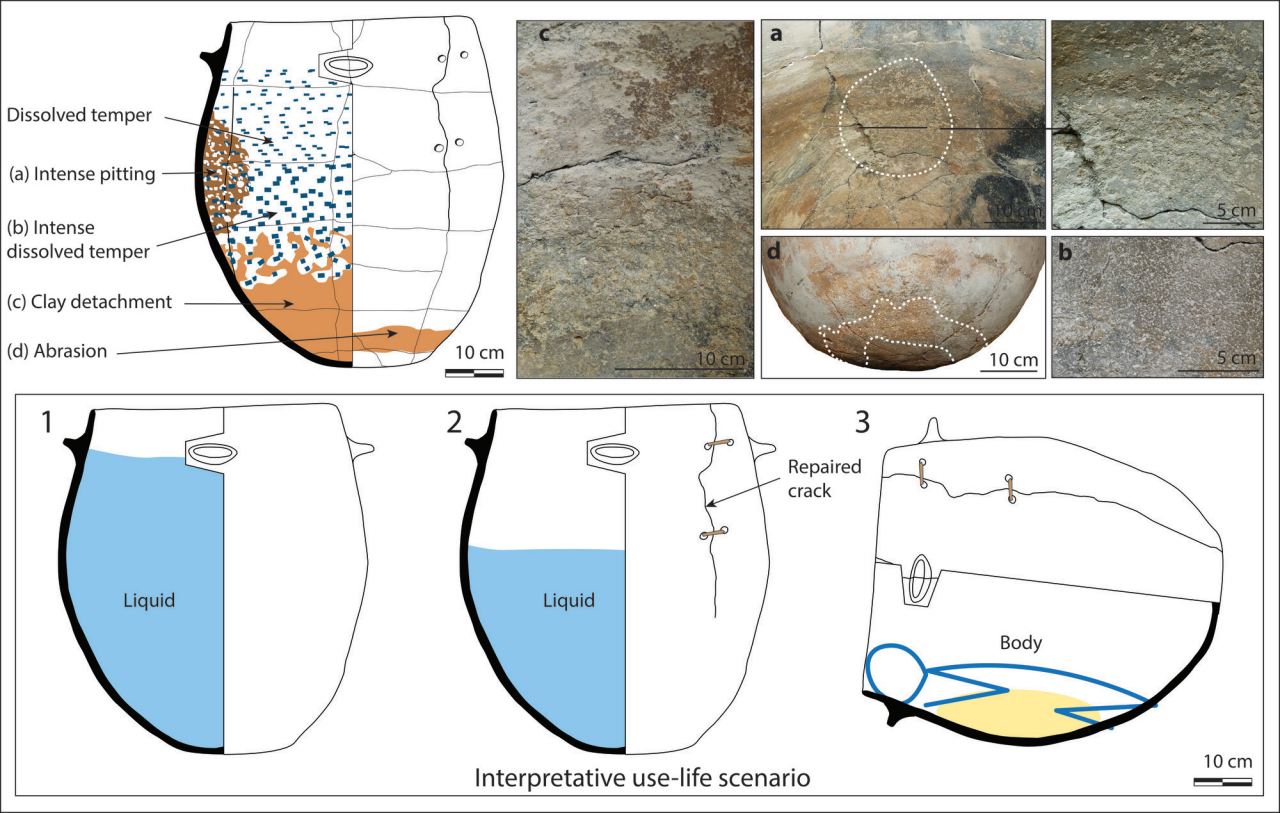

N
Limit of excavation
U05
U01
U02
42 m
41 m
Axis
41.20 m
41.925 m
N
50 cm
Pottery
Pottery restitution
Clods
Stone
Restitution of the pit


10 cm
Hole


a
10 cm
b
10 cm
c
5 cm
d
10 cm
10 cm
Interior and exterior wear


N
1 m
Pottery
Individual 1


10 cm


Dissolved temper
(a) Intense pitting
(b) Intense dissolved temper
(c) Clay detachment
(d) Abrasion
10 cm
c
10 cm
a
10 cm
5 cm
d
10 cm
b
5 cm
1
Liquid
2
Liquid
Repaired crack
3
Body
10 cm
Interpretative use-life scenario