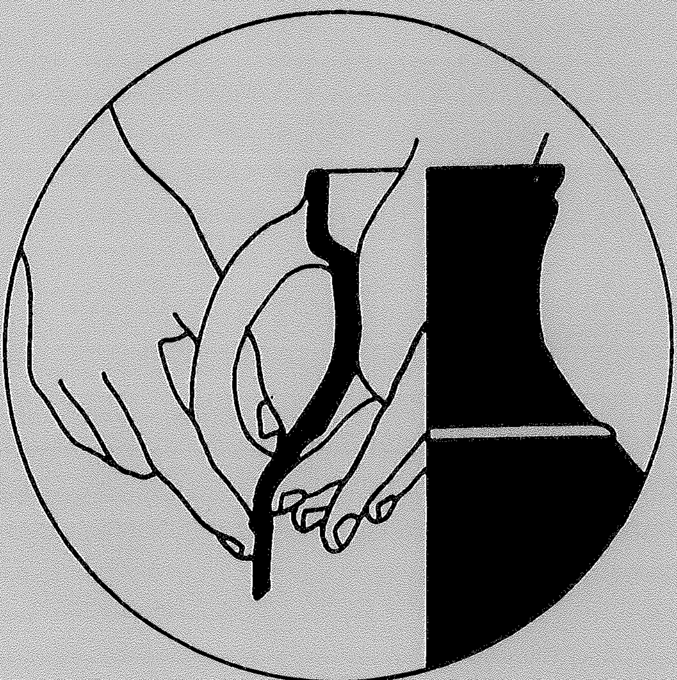
NEWSLETTER

Department of Pottery Technology

VOLUME 7/8 - 1989/1990



UNIVERSITY OF LEIDEN — THE NETHERLANDS

NEWSLETTER

DEPARTMENT OF POTTERY TECHNOLOGY

UNIVERSITY OF LEIDEN

VOLUME 7/8 - 1989/1990

Address:
Reuvensplaats 4
POB 9515
2300 RA LEIDEN
The Netherlands

ISSN 0168-7913

Editor:

A. van As

Service within the Institute:

P. Deunhouwer
A.E.A. van Driel
Mrs. C.C.A. Franken-Burggraaff
J.J. Hoff
E.P.G. Mulder
J. Pauptit

Translation/correction:

P. de Kok
Mrs. S. Mellor
Mrs. E. Perlin

The staff of the Institute of Pottery Technology wishes to announce to the readers of its *Newsletter* that on the 24st August 1989 at a special function in the Leiden Museum of Antiquities Professor H.J. Franken, the founder of the journal, was honoured with the order of Independence of the Hashemite Kingdom of Jordan (1st class). He received the order and its insignia at the hands of her Royal Highness Princess Sarvath el Hassan. The citation referred to his important services to the Archaeology of Jordan over many years. We are sure that all readers of the journal will join us in acclaiming this well merited honour.

CONTENTS page

H.J. Franken

"FORM IS THE ESSENCE OF A CERAMIC VESSEL"

A. Frendo has published an appreciation of H.J. Franken's 'Method of Ceramic Typology' (Frendo 1988). There is one expression in his article which requires scrutiny, since it seems to contain valuable clues to the understanding of Frendo's position. Frendo gives no proper explanation of what he means by the thesis: "shape (or form) is the essence of a ceramic vessel". He points out that this is derived from the philosophy of Aristotle, and he explains how it is applied in practice. The four steps of application which he quotes are not relevant for the following inquiry into the meaning of the Aristotelian expression, as used by Frendo.

Since Frendo does not give the Aristotelian meaning of this sentence, one at first assumes that it can be read as a normal English sentence with a meaning. However, when the words are given some thought one finds that they constitute a false statement and thus a meaningless sentence.

Since it appears to be a general statement, one could substitute 'nose' for 'ceramic vessel'. Here we discover all sorts of problems. Cats' noses and dogs' noses have their own distinct shapes, all different from men's noses, but do they not all 'essentially' function in the same way, apart from the fact that dogs sometimes dig with their noses and humans usually do not? How much tolerance is there in the concept of 'shape'? A similar question, related to shape being the essence of something, is that of the shape of a flower with its ovary turning into a fruit, or a child growing up, or a caterpillar turning into a butterfly. What seems to be a simple statement cannot be explained by simple common sense.

More problematic is the expression 'essence', which is clearly meant seriously by Frendo. One might think of a few instances where the statement would appear to be realized in reality. There are creators of art pottery, whose ambition it is to produce artistic shapes, regardless of the pot's other functions. Thus one finds teapots, made to be looked at but not to be used for serving tea. In such cases someone might say that the shape is the 'essence' of the pot, but is shape the essence of a book? Is the shape of the Bible the essence of the Bible?

Essence is not a property of an object or, as an archaeologist would say, it is not an attribute. Objects have attributes from which one can make a choice in order to determine their classes or their nature, but 'essence' is what our mind attaches to an object as a label. Since we do not talk much about the essence of things, it may help to point to the use of the adjective 'essential'. We say that something is an essential part of a construction, either mental or material, because without that part the construction will not function as we want it to. An engine is an essential part of a car, but only as long as we want the thing to be able to run. Further, it is essential to have enough petrol in the tank of a car when somebody wants to drive it, but when the car is not used, or broken down or abandoned, there does not have to be petrol in it. Objects do not possess essences, although it is sometimes claimed, in other contexts, that they do.

This would be enough to decide the issue. "Form is the essence of a ceramic vessel" is a meaningless expression in modern English and should not be used in archaeology.

One may ask however, what does the expression mean in Aristotelean philosophy? It means rather more than can be guessed from Frendo's explanation. The words 'form' and 'essence' occur in the works of Plato and are continually found in the writings of classical philosophers such as Plotin. These expressions were taken over by the Christian theologians, and remained in use until the end of the Middle Ages. Only then were they slowly abandoned and replaced by other concepts, in agreement with growing understanding of the nature of natural phenomena.

The reason they were abandoned becomes clear when their real meaning is exposed, the 'real' meaning being the one they were given in philosophy in the ancient world, in this case Aristotelian philosophy. The following lines are an attempt to show that, in a different world from ours, such terminology seemed to make sense. People interested in the history of ideas will be acquainted with the subject, which is dealt with in most books on the history of philosophy.

There was in antiquity nothing like a purely logical or a rather secular and loose meaning of such words, in any sense we would know of in daily life, when using such words. There are no important concepts in classical or antique Christian philosophical thinking which are not connected with the notion of fulfilment in an ultimate order, whether conceived merely as freedom of material being, as reconciliation with God in heaven, or as any other metaphysical system of thought. Thus these words have a distinctly religious connotation.

The extended meaning of the expression 'form' in Aristotelian philosophy consists of two elements. The 'form' of material objects is never complete. Only in God is 'form' completed, fulfilled or perfected. The other added element is that form on earth creates in the human mind love for God. "What is it that makes the soul want to love God?" asks St. Augustine and the answer comes from the animals who 'shout': "look at us, He made us", from which St. Augustine concludes that their answer was their form, (*Confessiones*, ch.10,9). It is not surprising that St. Thomas of Aquinas cultivated this meaning of 'form' in his theology.

This is, in short, the history of the meaning of 'form'. The term fell into disuse when scholars began to have a better understanding of the material world. It was only in Catholic seminaries, where the scholastic doctrines were cultivated and transmitted undisturbed by modern developments that, on the authority of St. Thomas, Aristotelian metaphysics and logic continued to be taught. Occasionally this teaching was taken into the outside world as an explanation of certain phenomena. Russell, in his *History of Western Philosophy*, complains about this: "Throughout modern times, practically every advance in science, in logic, or in philosophy has had to be made in the teeth of opposition from Aristotle's disciples" (Russell 1981: 212). In this book Russell deals extensively with the Aristotelian doctrines and its terminology.

'Essence' in Aristotelian thought must be read in a similar way. It denotes that without which something loses itself, so to speak. Take away the shape of a ceramic vessel and the thing is no longer what it was. Or as Frendo puts it: "Without its shape a ceramic vessel would not exist - there would simply be an amorphous piece of fired clay" (Frendo 1988: 121). There could not be an amorphous piece of fired clay left, had there not first been a fired pot. In the statement it is supposed that the shape of the pot has somehow been removed: shape is like a cover one can remove so that its content collapses into an amorphous mass, but a rather more normal event in daily life is that a pot falls and is smashed. If we choose to consider the completed and undamaged ceramic body to be the essence of the vessel, then the essence is lost when the pot breaks, and one would certainly not be worried about the possibility that, in some way, there was still an unhappy, empty shape. However, to suggest this would be to misunderstand the background from which Frendo argues. To give priority to the ceramic body above its shape is not acceptable in scholastic theology, because shape is embedded in the teleological stream which ends up in the perfect form of God, and something is given its essence only when it is given its shape.

From this it must be concluded that Frendo's Aristotelian thesis on form being the essence of an object is yet another sortie by medieval scholasticism into the secular world, and in this case into archaeology.

Attempts to preserve the word 'essence', as indicating an attribute of objects, are still found outside scholastic philosophy. Quinton (in Bullock and Stallybrass 1977: 213) when discussing 'essentialism,' writes about 'beliefs'. Essence is defined by him as follows: "The essence can be said to be the *defining properties* of a thing or a kind." This is still close to the ancient definition of the word. He illustrates this by writing: "It is, thus, part of the essence of a ship that it is designed to float on water; but its having sails rather than an engine or carrying cargo rather than passengers is accidental or *contingent*". It would seem that this reveals the weakness of the concept. It is debatable whether the design is about making an object capable of floating, or about making an object capable of carrying a load of some description across water, for which all kinds of measures have to be taken, including making sure that the law of Archimedes is properly applied. Moreover, ships may have been designed to float, but there are notorious instances of carefully designed ships that were launched and which sank straight away. A sunken ship is no longer a ship: it is a wreck, but there are also cases of wrecked ships that did not sink; they floated until someone picked them up and towed them into a harbour. No matter what one would like to call the essence of a ship, it remains a mental concept and is not an attribute of the object itself.

The archaeological activity of describing excavated objects lies somewhat outside of the ordinary world of material research. The shape of an object is not something that is discussed outside art classes, architectural offices, circles of people designing the bodies of new motor cars, and archaeology. Laboratories take samples of materials and ignore the shapes of the materials from which the samples are taken. Laboratories in which works of art are restored analyse the materials as well as the construction methods of ancient objects, an activity which of course includes looking at their shapes.

On the other hand, modern philosophical expressions for material objects are clumsy. Consider, for example, 'bundle of events', which is a description of the physical state of things. In archaeology the idea that an object has attributes is accepted. The well-known remark that an object has an almost infinite number of attributes only serves to make people aware of the dilemma in choosing only those attributes that are useful for one's purpose. In the case of artifacts the advice is given to select attributes connected with the human activity which caused the artifact to come into existence. "Archaeologists agree that those attributes which can only have been produced on the raw material by human action are the attributes most worthy of careful study." (D.L. Clarke 1968: 16). This human action was based on practical ancient knowledge and experience concerning the workability of raw materials. Tracing such knowledge is useful in many ways. The study of the attributes of pottery reveals such knowledge. Ancient craftmanship is not an attribute of an object, but it is a legitimate part of the study of ancient cultures. The shape of a vessel often tells something about this background, but there are many other attributes pointing to that aspect. Usually they are not observed or they are wrongly interpreted, witness the qualification (often found in pottery descriptions of the Near East) 'wheelmade', which has become a normal expression to indicate a regular shape and a smooth surface, but says nothing about the use of the wheel.

In Frendo's view shape is an attribute of a vessel. It still is in modern thinking. A convenient definition of attributes is to say that all that can be observed about an object belongs to its attributes. If it is observed by laboratory testing that a ceramic body contains 20% lime, then this is a attribute of the object. The observation that a ceramic body contains 20% lime can be interpreted in terms of workability of the raw material used by the potter. Twenty per cent lime restricts the possibilities of applying a glaze to a shape made from such clay. Twenty per cent lime in a clay body also influences the colour of the fired product. It may reduce the possibility of making a really hard ware. These are some conclusions drawn from the observation of an attribute.

Frendo's dogmatic approach to pottery studies does not offer the means for explaining the shape of a vessel. There are still archaeologists who think it strange that one should want to explain shapes of vessels. Yet ceramic vessels have preserved attributes that indicate what a potter could do with the raw materials, and what he could not do with them. It would be difficult to deny that attributes preserving information about the production of pottery belong to the field of archaeological studies. The following is an example of the need to observe attributes that are traces of the manufacturing methods. It is perfectly clear that observation of shape alone is not enough to separate locally made pots from pottery brought in from elsewhere, not 'foreign' imports, but pottery made in the region of the site. At the Iron Age I site of Deir ᶜAlla three groups of pottery have been distinguished beside the local production, on the basis of technological analysis (Franken/Kalsbeek 1969). They are three distinct groups, and they almost certainly come from three different areas, but the idea that there could have been a local trade in pottery was so 'unexpected', that subsequent archaeological surveys in the area did not follow this up. We still don't know where the centres of the production are located.

Such local imports cannot be found as long as 'shape' is the only set of attributes to be studied, since shapes by themselves can be assembled in any combination of production and provenance. They still remain just a collection of shapes, but products from different workshops may have been 'sold' on the same market, from where they were evenly distributed over the households of the users. Some pottery in an assemblage may have been made locally and some of it may have been bought from itinerant pottery traders (Franken 1987). In the ancient Near East this was almost certainly the case for cooking pots in many periods.

Every ceramic vessel preserves attributes from which its manufacture can be deduced. To find such attributes one must know something about potting. People ignorant of the craft of potting overlook those attributes. When we are looking for traces of manufacture and trying to interpret them, it often becomes clear that a vessel's shape can only partly be explained from observing attributes indicating the construction. Two other elements have always played a part in that history. One is the nature of the raw materials (to be expressed in terms known in the craft of potting and not in chemical terms in the first instance) dictating certain methods of construction. Usually one can deduce some information about the kind of clay that was used to make a certain pot. The other feature is the traditional knowledge of the potters. Trying to find out more about this traditional knowledge requires a survey of a potting tradition over longer periods, and is partly a matter of induction.

References

Bullock, A. and A. Stallybrass (1977), *The Fontana dictionary of modern thought*, London.

Clarke, D.L. (1968), *Analytical archaeology*, London.

Franken, H.J. (1987), Potmaking in antiquity and the 'ceramic horizon' in archaeology. In: A. van As et al., *Contributions to the study of pottery technology*, Publicatie van het Gallo-Romeins Museum, no.34, Hasselt: 43-48.

Franken, H.J. and J. Kalsbeek. (1969), *Excavations at Tell Deir ᶜAlla*, Leiden.

Frendo, A.J. (1988), H.J. Franken's method of ceramic typology: An appreciation. *Palestine Exploration Quarterly*: 108-129.

Russel, B. (1980), *History of western philosophy*, London.

H.E. LaGro
H. de Haas

SUGAR POTS: A PRELIMINARY STUDY OF TECHNOLOGICAL ASPECTS OF A CLASS OF MEDIEVAL INDUSTRIAL POTTERY FROM TELL ABU SARBUT, JORDAN

After the spread of Islamic authority in the Middle East new agricultural products were introduced at a wide scale in many areas, i.a. the Jordan Valley. A new plant, which became to play an important role as a cashcrop was sugar cane, of which the sugar was destined for local consumption and the European markets. Sugar cane was extensively grown in the Jordan Valley from the eleventh century onwards till well into the fifteenth century. The sugar itself was produced in specialised factories, where sugar cane was pressed and its juice reduced by boiling. The result, a thick syrup, was then poured into sphero-conical shaped sugar pots, wherein it was left to solidify (Fig. 1). The remaining syrup could be let out via a hole in the bottom of a sugar pot to drip into a syrup jar (Fig. 2).

The following study is about the first class of this pottery: the sugar pots and is based on material, which has been found during two seasons of excavations at Tell Abu Sarbut in the central Jordan Valley, Jordan[1] (de Haas et al. 1991). This study concentrates on technological aspects, which are related to the way the pottery was produced. Other aspects like chemical composition of the clays and the range of firing temperatures will be published in subsequent studies.

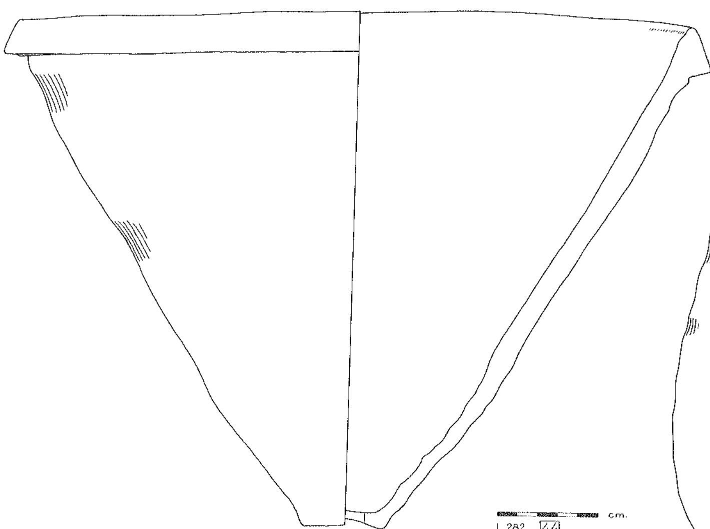


Fig. 1. Sphero-conical sugar pot.

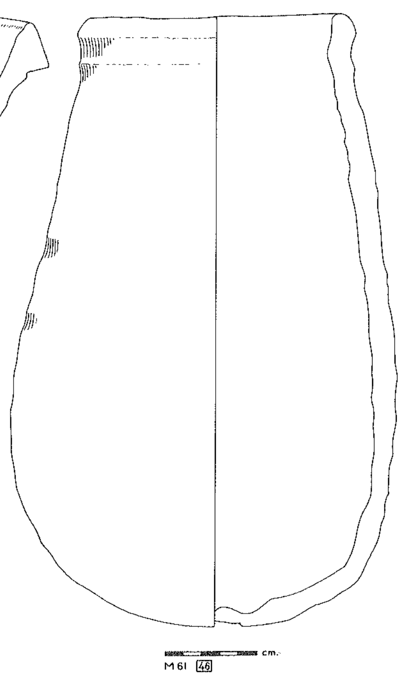


Fig. 2. Syrup jar.

Sugar pots

This class of pottery has some features which are directly linked to their usage in the sugar factories. A sphero-conical shape together with a smooth inside gives this pottery a *self discharging* quality. This implies that in theory it should be possible to remove the lump of sugar from the form after solidifying. This was not always successful and extensive deposits of sherds are usually found in the direct vicinity of the sugar factories, indicating a substantial breakage during the production process of the sugar. At the same time the adapted shape of the sugar pot and the efforts to obtain a smooth surface on the inside indicate that these pots were meant to be reused and therefore represent a certain economical value. Usually they are provided with a solid rim. It is basically an industrial product without decoration and the potter was clearly not interested in spending much time to neatly finish his work, which is often marked with smudges and other irregularities.
Sugar pots, and syrup jars for that matter, are not only found in the direct vicinity of the factories but also in villages, where they were part of the household repertoire.

Methods of production of the pottery

During the excavation all rim fragments, bases and body sherds with indications about the manufacturing process were kept. In Leiden these were divided into groups, which represent different production methods as regards construction as a whole. Subsequently they were subdivided according to the way the rim was made. The total number of sherds involved amounts to about 4400.

During our study two main ways of constructing the pot were discerned, which are called A and B.

SP I/A (Fig. 3)

These pots were probably thrown in combination with the use of coils of clay[2]. First the upper half of the pot was formed, which was then left to dry till the clay was leather-hard. The inside was carefully scraped with a rib. Then the form was put upside-down and closed, after which a hole was pierced in the base. Because it was then closed, the potter did not have the possibility to scrape the inside, leaving turning marks in the interior lower part of the pot. These usually indicate throwing, but could in this case also result from the pressure to fit the coils of clay together. A second consequence of this method is the change in angle of the wall at the point where the potter started to form the second part. This gave the whole the shape of a bell. In general the thickness of the wall is even, although it tends to get thinner in the part that was finished upside-down. The outside is not smoothed.

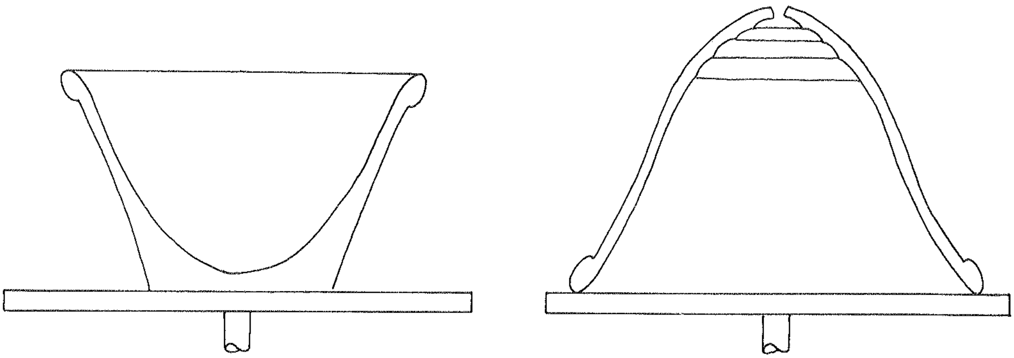


Fig. 3. SP I/A.

In a following study we hope to publish the results of some radiographical studies, which might give additional information on wether this method employed coils, throwing or a combination of both.

SP I/B (Fig. 4)

In this case a lump of clay was put on a wheel and given a disklike shape. At the edge, maybe on a low ridge, coils were placed on top of each other, which were luted. This process was continued until the desired height was achieved. Then the top of the wall was made thinner to make a folded rim. The inside was scraped with a rib and a hole was pierced in the base. After the clay had become leather-dry, the pot was turned upside-down and the lower half of the pot was scraped at the outside to even the thickness of the wall. This resulted in a rather straight, conical shape. Sometimes the hole is not exactly in the middle of the base because the pot was not centered completely (see below). In some cases traces of clay on or near the rim indicate the place where lumps of clay were used to support the vessel, and keep it in place. The

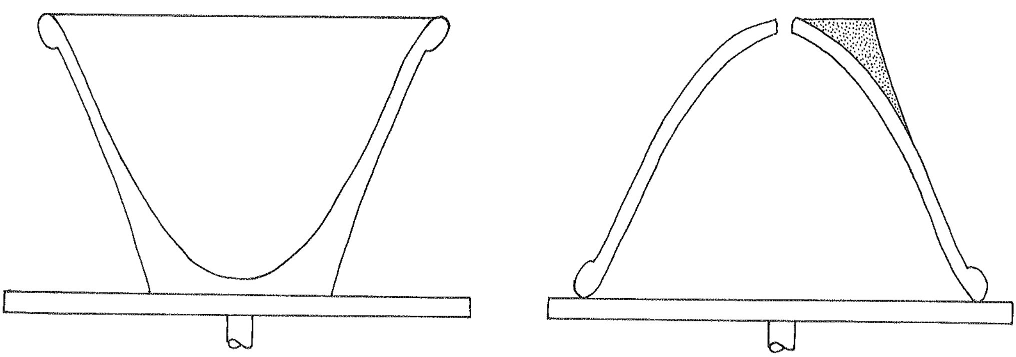


Fig. 4. SP I/B.

scraping on the inside did not always completely take away the adhesion line between the coils. Then the horizontal indention between them was filled with clay slip, which has a larger shrinking factor then the clay used to construct the pot. This results in one long and thin horizontal crack or a number of small vertical cracks in the slip filling. The lines of fracture of the sherds of this type are frequently parallel to the rim, an indication that coils were used.

Classification of the rims

General remarks

A classification based on rims, as presented below, is necessitated by an insufficient number of complete profiles and shapes found during the present excavations at Tell Abu Sarbut. As stated above, the sugar pottery is an industrial product. Time is an essential element in the production and any time-consuming way would be avoided as long as the result was in accordance with the specifications or requirements of the sugar production. The rough finish of the sugar pot implies that a classification based on shape alone would result in many groups, which do not have clear delineations. Therefore we have opted for a study of the methods, which are used to produce the pot as a whole, followed by a subdivision of the rims according to the method, which was used to form the rim and produced a distinct shape. Within this usually still visible method the potter used a variety of ways to actually finish the rim. Sometimes the initial way it was formed was obliterated by these finishing touches, which are to be considered as individual traits of the potters rather than methods, which can vary from production centre to production centre or change in the course of time.

Rims (technique A)

Folded outside
(total number of sherds: 896)

A fold was not only made to strengthen the rim. It could also be used to even the height of the vessel. This could result in a rim with a large fold where the rim stuck out first, next to a small fold, at places where the rim was low. Therefore the height of the fold was not used as a criterium to differentiate. Before the fold was made the thickness of the upper part of the wall was reduced to facilitate the folding.

SP I/A/01 (subtotal: 58; Fig. 5a-b)

The rim was folded but not completely pressed against the body of the vessel. The fold finishes below the thinning of the wall, causing the edge to stand out somewhat. The top of the rim after folding is sometimes rounded.

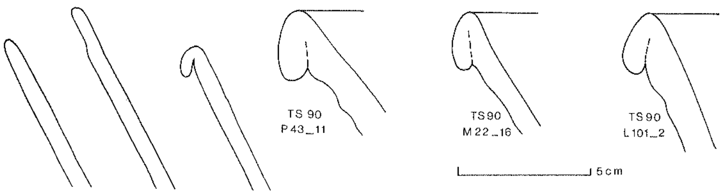


Fig. 5. a: Reconstruction; b: SP I/A/01.

SP I/A/02 (subtotal: 190; Fig. 6a-b)

The rim was folded and pressed firmly against the body. Sometimes the lower part of the rim has been smoothed against the wall. The top of the fold is rather flat. A slight indention can be observed, which was left by fingers pressing the fold downwards.

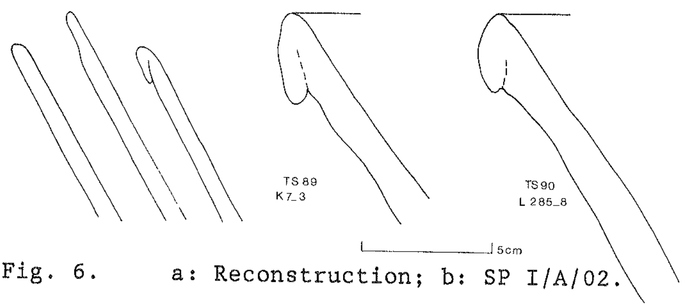


Fig. 6. a: Reconstruction; b: SP I/A/02.

SP I/A/03 (subtotal: 153; Fig. 7a-b)

The rim was folded. Then the top part of the fold was pressed between two fingers, causing a groove along the outside of the rim. The outside of the fold was sometimes pressed against the wall, causing a flat part. This was probably done to ensure that the fold was tightly sealed against the wall. Underneath the fold a small line of clay slib, which was forced out from between the fold and the wall can at times still be visible.

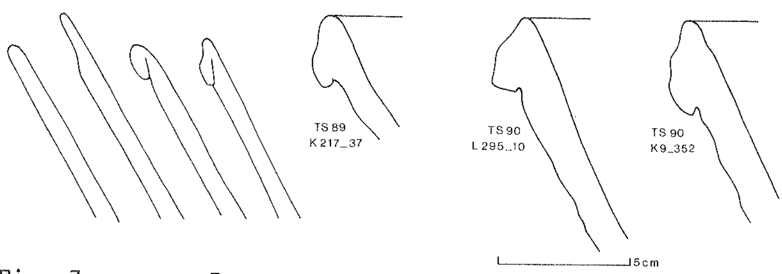


Fig. 7. a: Reconstruction; b: SP I/A/03.

SP I/A/04 (subtotal: 102; Fig. 8a-b)

Formed as SP I/A/03. The lower part of the fold was smoothed against the wall of the vessel. At some instances the upper part of the fold had become so thin that this part was folded in its turn. The transition point between the inside of the pot and the rim has a sharp edge.

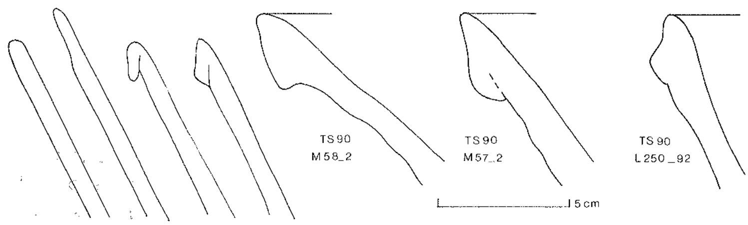


Fig. 8. a: Reconstruction; b: SP I/A/04.

SP I/A/05 (subtotal: 93; Fig. 9a-b)

The rim was folded and pressed against the wall. Then the outside was pressed between two fingers, while the pot turned, which resulted in a sharp edge. This pressing included the complete outside of the rim, hardly or not at all leaving a flat part. The top of the folded rim is sharp as in contrast to rounded, caused by the pressure of the fingers.

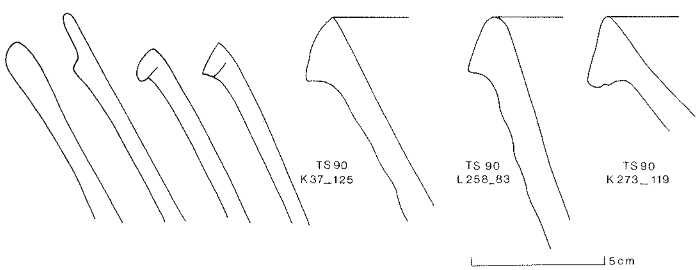


Fig. 9. a: Reconstruction; b: SP I/A/05.

SP I/A/07 (subtotal: 52; Fig. 10a-b)

The top of the wall was rounded before the fold was made and pressed outwards against the outside of the wall. No finishing touch was given underneath the fold, leaving the rounded shape intact.

SP I/A/08 (subtotal: 125; Fig. 11a-b)

Before the fold was formed the wall was made thin, to about one fourth of the original thickness. The thinned part was rather short, so that the fold rests on the wall more than stretching over the wall. The upper part of the wall is usually thicker. This could be caused by downwards pressure, when the fold was made on top of the wall.

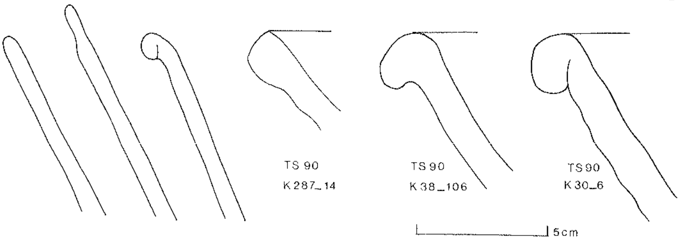


Fig. 10. a: Reconstruction; b: SP I/A/07.

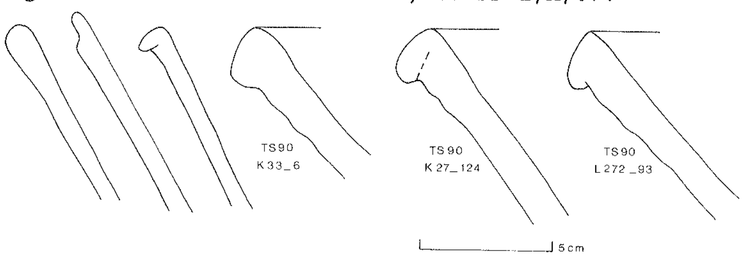


Fig. 11. a: Reconstruction; b: SP I/A/08.

SP I/A/09 (subtotal: 123; Fig. 12a-b)

The rim was folded outwards and smoothed against the wall, nearly incorporating it. Only a small groove visible at the fracture of the rim indicates the original fold. The potter obviously did not deem a sturdy fold necessary.

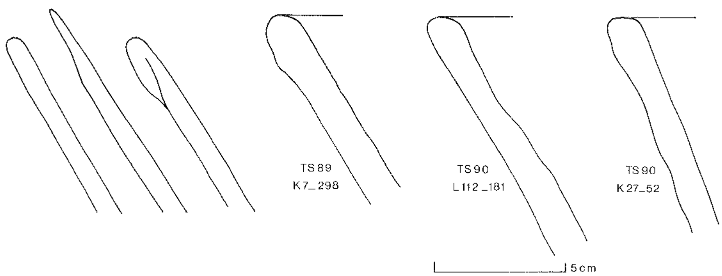


Fig. 12. a: Reconstruction; b: SP I/A/09.

Rims folded inside
(Total number of rims: 529)

The upper part of the wall was made thinner and the top was rounded neatly, after which the rim was folded inside. Then the potter scraped the inside, sometimes leaving a small groove where the fold joins the inside of the wall. This groove was filled with clay slip.

SP I/A/10 (subtotal: 421; Fig. 13a-b)

The rim was folded inside. The transition point of the inside wall and the rim is edgy. The rim in section has the form of a drip.

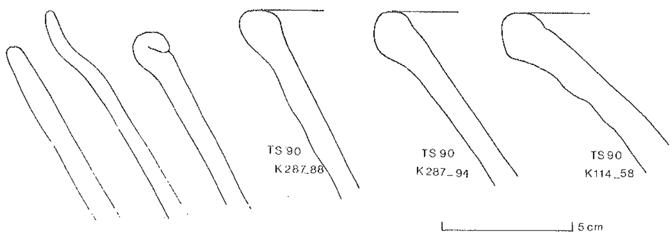


Fig. 13. a: Reconstruction; b: SP I/A/10.

SP I/A/11 (subtotal: 108; Fig. 14a-b)

The rim was folded inside. Then the transition point of the inside of wall and the rim was rounded outwards, causing the lip of the rim to point outwards, nearly horizontally. In section the rim retains the form of a drip, with a thickening on the outside.

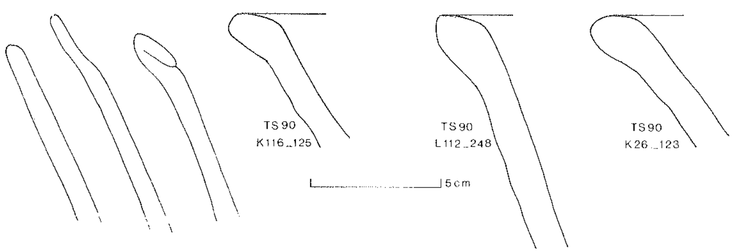


Fig. 14. a: Reconstruction; b: SP I/A/11.

Formed between two fingers
(total number of rims: 260)

Here the potter kept and pressed the upper part of the wall between two adjoining fingers to finish the rim. These could have been the index finger and the middle finger, but a combination of the middle finger and the ring finger is possible as well. The top of the rim can show a slight thickening, which is caused by the downward pressure and the difference in distance between the knuckles and the pasterns of the fingers.

SP I/A/20 (subtotal: 93; Fig. 15a-b)

The rim has been finished straight with a rounded or flattened top, which shows a small thickening.

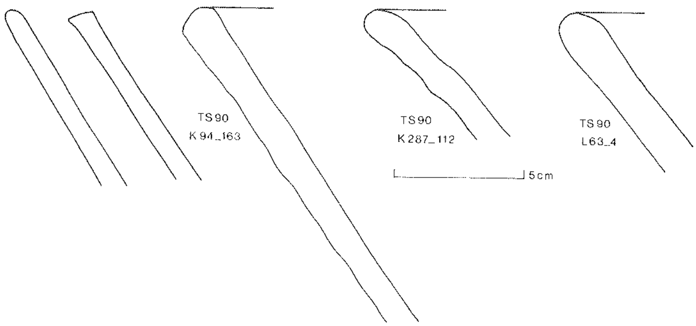


Fig. 15. a: Reconstruction; b: SP I/A/20.

SP I/A/21 (subtotal: 167; Fig. 16a-b)

In this case a finishing touch has been given to the rim by bending the wrist downwards, while the fingers remain in the same position, causing the lip of the rim to point outwards.

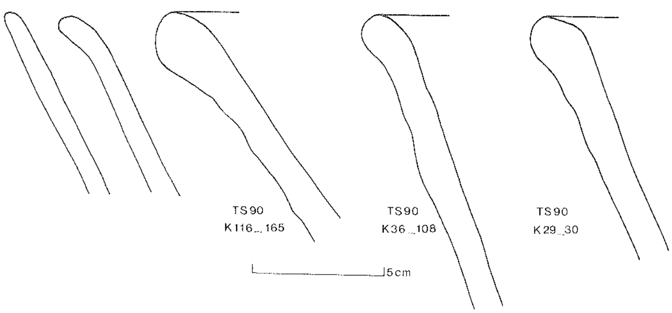


Fig. 16. a: Reconstruction; b: SP I/A/21.

Rim made with coil
(total number of rims: 727)

A coil of clay was put against the outside wall and was then incorporated by smoothing and pressure. The coil can be put at various places against the wall: at the same level of the top of the wall, underneath the level of the top or sticking out above the top. These various locations result in a number of rim varieties. Adding a coil of clay which sticks out above the level of the top could be an indication that the original level was not sufficiently horizontal and that it was used to egalize this. Sometimes the adhesion point of the coil is nearly on top of the wall, comparable to a complete buildup in coils. A general aspect of this group is an inside that has been scraped in such a way that it slightly hollowed out on the inside, directly underneath the rim, without however loosing the *self discharging* quality.

SP I/A/30 (subtotal: 133; Fig. 17a-b)

A coil was added on the level of the top of the wall. On top the surface is square and flattened with a small indention indicating the location where the coil meets the wall. The lower part of the coil was smoothed.

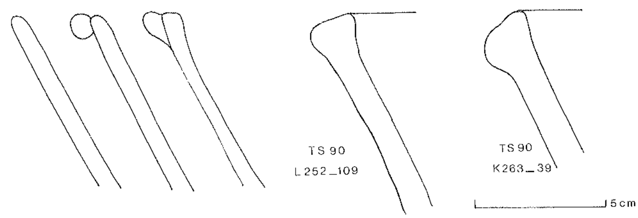


Fig. 17. a: Reconstruction; b: SP I/A/30.

SP I/A/31 (subtotal: 149; Fig. 18a-b)

The coil was put against the wall just below the level of the top and it was pressed against it with a finger or rib pointing downwards and outwards. The lower part of the coil was smoothed against the wall.

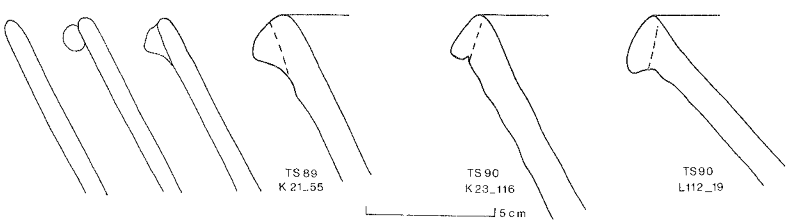


Fig. 18. a: Reconstruction; b: SP I/A/31.

SP I/A/32 (subtotal: 109; Fig. 19a-b)

The coil was put against the wall sticking out above the level of the wall. A finger or rib was pressed on the coil and the top of the wall, pointing downwards and inwards. This sometimes caused a sharp edge at the transition point of the inside of the pot and the rim. The lip of the rim points out horizontally.

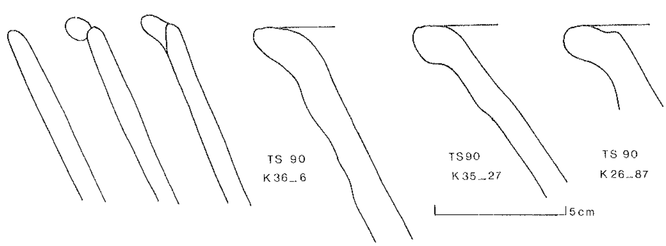


Fig. 19. a: Reconstruction; b: SP/I/A32.

SP I/A/33 (subtotal: 255; Fig. 20a-b)

A coil of clay has been put against the wall below the top and is still visible, although the coil was probably rather thin. The lower part of the coil was neatly smoothed.

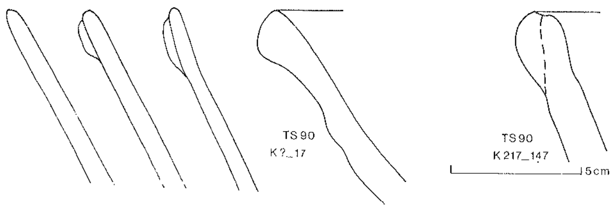


Fig. 20. a: Reconstruction; b: SP I/A/33.

SP I/A/35 (subtotal: 13; Fig. 21a-b)

A broad and thin coil has been put against the outside of the wall below the level of the top and has been flattened against it nearly completely.

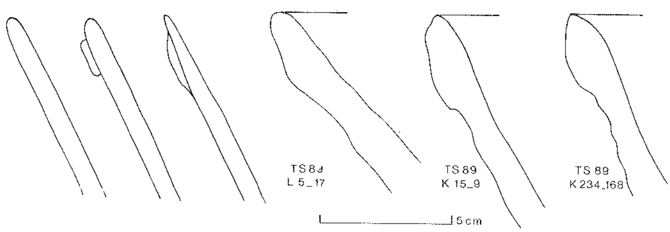


Fig. 21. a: Reconstruction; b: SP I/A/35.

SP I/A/36 (subtotal: 68; Fig. 22a-b)

A coil was put against the outside of the wall above the level of the top. After smoothing the coil, the rim was pushed outside, causing the lip of the rim to point outwards.

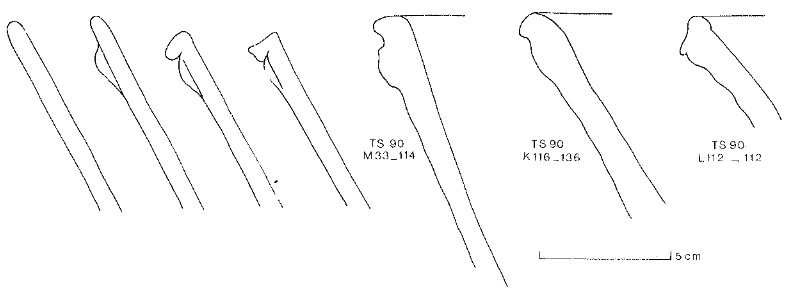
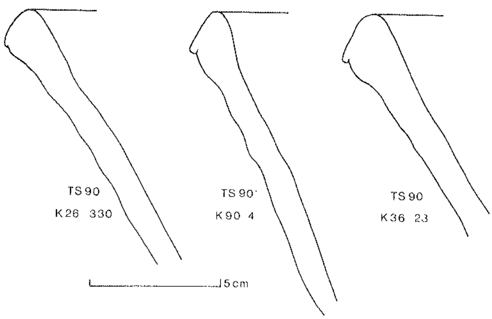


Fig. 22. a: Reconstruction; b: SP I/A/36.

Rim formed by pushing clay down



SP I/A/40 (subtotal: 101; Fig. 23)

With a finger or a rib placed on top of the wall the clay was pushed downwards and outwards, giving the outside of the rim an edge.

Fig. 23. SP I/A/40.

Varia

The following groups of rims, A/50 and A/51, have a shape of which the technical details are not clear. Probably they were formed by adding a coil and therefore would belong to group SPI/A/3x. If a separate coil was not used, the shape was formed by other methods.

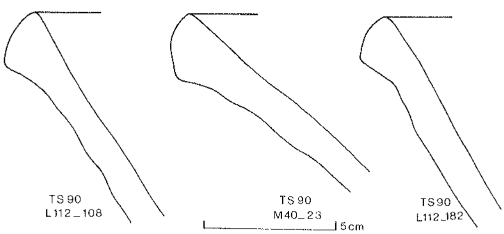


Fig. 24. SP I/A/50.

SP I/A/50 (total number of rims: 200; Fig. 24)

This rim was either formed with the aid of a coil or was folded. After either way the outside is smoothed very carefully, especially on top of the rim, obliterating all traces of previous work.

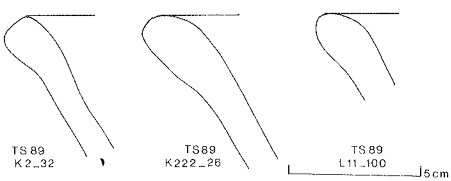


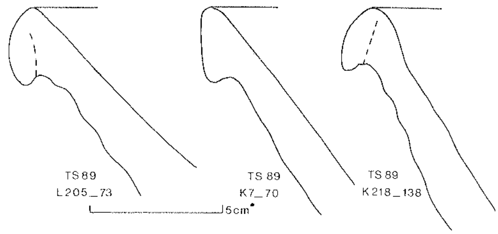
Fig. 25. SP I/A/51.

SP I/A/51 (total number of sherds: 59; Fig. 25)

The rim could have been formed between two fingers, like SP I/A/2x. Another possibility is that a coil was added well above the level of the top of the wall and was smoothed subsequently in such a way that the coil is no longer visible. The lip of the rim points outwards, nearly horizontally.

Rims (technique B)
(total number of rims: 252)

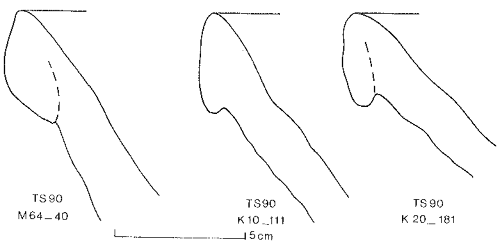
Within technique B only one rim shape is discerned for which two different rim forming methods could have been used, i.e. the folded rim or simply a coil, which has been put against the outside of the wall and was rounded on top. Most rims seem to have been folded but a small indention in some cases on top of the rim could indicate the use of a separate coil. It could however also be a rupture of the clay resulting from the folding.



SP I/B/01 (subtotal: 103; Fig. 26)

The fold or coil on the outside of the wall was not completely pressed against it.

Fig. 26. SP I/B/01.



SP I/B/02 (subtotal: 149; Fig. 27)

The fold or coil was pressed completely against the wall. The rim itself is not completely horizontal.

Fig. 27. SP I/B/02.

SP I/Y

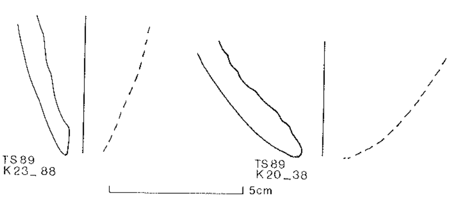
Group SP I/Y contains a number of sherds, which can not be attributed to one of the previous groups.

SP I/Z

The indication SP I/Z is used to indicate rims which belong to the class of sugar pots, but could not be ascribed to any of the groups due to their small size or state of preservation.

Bases

A number of bases has been found, which belong to the class of sugar pots. They can be divided into three groups.



SP I/K (Fig. 28)

This base has been finished upside-down and has a rounded form. It belongs to SP I/A.

Fig. 28. SP I/K.

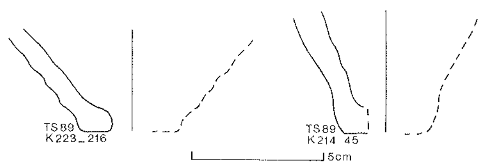


Fig. 29. SP I/L.

SP I/L (Fig. 29)

This base has been finished upside-down with a small flat surface in which traces of pressure made when closing the base are still visible. It belongs to SPI/A.

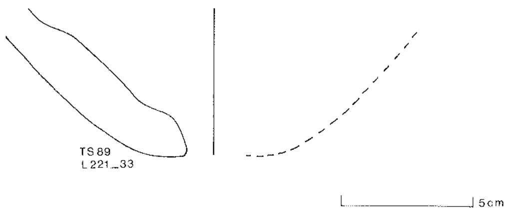


Fig. 30. SP I/M.

SP I/M (Fig. 30)

This base has no signs of having been closed upside-down. Traces of extensive scraping are visible at the outside of the lower half of the pot. The pot was not always placed perpendicularly to the centre of the wheel during the scraping. Therefore one side of the wall was made thinner than the other. It belongs to SP I/B.

Notes

1. The syrup jars will be subject of a subsequent study. A first study into sugar pots and syrup jars was done by H.J. Franken and J. Kalsbeek who studied material from Tell Abu Gurdan (Franken and Kalsbeek 1975: 143-154).

2. To be compared with sugar pot type 2 in Franken 1975, Fig. 41.

References

Franken, H.J. and J. Kalsbeek (1975), *Potters of a medieval village in the Jordan Valley*, Amsterdam.

Haas, H. de, H.E. LaGro and M.L. Steiner (1991), Second and third seasons of excavations at Tell Abu Sarbut, Jordan Valley (preliminary report). *Annual of the Department of Antiquities, Jordan*.

A. van As
M.-H. Wijnen

NEOLITHIC AND EARLY CHALCOLITHIC POTTERY FROM ILIPINAR (PHASES X-VIII) IN NORTHWESTERN ANATOLIA

Introduction

In the present article we will discuss the shape and technique of Neolithic and early Chalcolithic pottery found at Ilipinar, a multi-period mound (hüyük) in the plain of Lake Iznik in northwestern Anatolia (Fig. 1). As other archaeological surveys in the area have indicated, this is one of the few sites where the habitation period can be dated to at least the early fifth millennium B.C.

Archaeological investigations have been carried out at Ilipinar since 1987. These excavations have had two main aims. The principal objective of the excavations was to study the development of early farming cultures in the border area between Anatolia and the Balkans, or, in a wider context, between the Near East on the one hand, and Southeast and

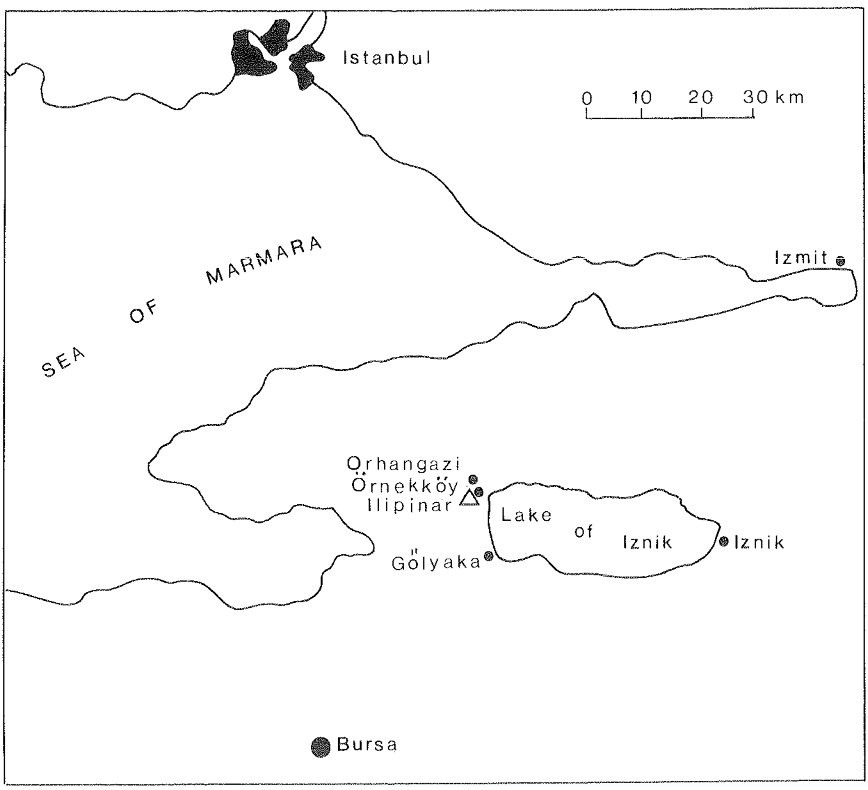


Fig. 1. The south-eastern littoral of the Sea of Marmara.

Central Europe on the other. The second objective was to focus attention on the Prehistoric chronology of northwestern Anatolia; an area which, due to various circumstances, has so far been neglected as far as archaeological fieldwork is concerned (Roodenberg 1989/90:61).

At the request of dr. J. Roodenberg, the initiator of the Ilipinar project, the Department of Pottery Technology in Leiden has carried out the technical analysis of the Neolithic and Chalcolithic pottery from Ilipinar during spring 1989 and 1990. During a preparatory visit to Ilipinar in 1988 (van As and Wijnen 1988) it was decided that a record should be made of the repertoire of the shapes used, in order to obtain a complete picture of the development of Neolithic and Chalcolithic pottery excavated from this site.

The two main areas of research centred on (a) the correlations between the different technical features, (b) the possible relations between shape and technical features. In addition, the actual development of the pottery during this particular period was investigated.

In this article we will discuss the Neolithic and early Chalcolithic pottery (Ilipinar, phases X to VIII), which was analysed in 1989[1]. In the following *Newsletter*, the results from the early and late Chalcolithic pottery (Ilipinar, phases VIII to V), analysed in 1990, will be commented upon. The results from the complete investigation will be published in *Anatolica*. Research into the shape and decorations of the pottery, as well as a comparative study of the Neolithic and Chalcolithic pottery from Ilipinar and pottery from later periods, is being carried out by L. Thissen (Thissen 1989/90).

The set of data

During the first period of the investigation, all three thousand and four diagnostic sherds were analysed. These sherds came from a section twenty meters long and more than five meters high cut along the artificial scarp on the south side of the hüyük (Roodenberg 1989/90: 68, 69). The sherds from this section belong to the following Ilipinar phases: phase X (levels 12 - 8), dating from 7150 until 7000 B.P.; phase IX (levels 7 - 5), dating from 7000 until 6900 B.P. and, presumably, phase VIII (levels 4 - 3), dating from 7000 until 6900 B.P. (Roodenberg 1989/90: 74, 77, fig. 2). In addition, 526 sherds from phase IX, taken from square AA13, and 164 sherds from phase VIII, taken from square X12, were investigated. For the specific location and stratigraphy of the excavation squares AA13 and X12 we refer to Roodenberg (1989/90: 71, fig. 1).

Methods

The following features were recorded for each sherd, apart from the lot number and stratum: the colour on the inside, outside and the core of the sherd (according to the Munsell Soil Color Charts, henceforth MSCC); the colour of the sherd after it had been refired under standardized conditions (i.e. in an electric oven, at 800°C, for half an hour); the hardness of the sherd (using the Mohs' scale); the thickness of the sherd, and the characteristics of the shape. Furthermore, the non-plastics in fresh and polished breaks from a number of sherds, were studied using a stereo microscope (x40). In order to determine the exact quantities of the non-plastics present, a reference collection of test bars of fired clay was used. The bars contained known quantities of non-plastics, given here in percentage of volume. For the precise identification of the non-plastics, a number of thin sections was analysed[2]. In order to be able to answer questions about the origin of the clay, clay samples were taken in the immediate vicinity of Ilipinar. Whenever possible, traces of shaping and decoration techniques were also recorded. All the data collected were fed into a data base system. These data were then analysed using a SSPC/PC+ programme. This enabled us to establish the relation between the different features of the sherds and to determine the development of the pottery over the different phases (see p. 35).

The technical analysis

Raw materials

During the Neolithic and Chalcolithic period in Ilipinar, potters probably used raw materials taken from the direct surroundings of the site. It is worth noting in this respect that in the vicinity of the excavation site are clay beds which are still used by a potter in nearby Örnekköy today (see p. 69).

Macroscopic analysis

On macroscopic grounds, a number of groups of non-plastics can be distinguished within the sherd repertoire analysed.

Only during the earliest period of habitation in Ilipinar (phase X, levels 12 - 8) organic material was added to the clay which already contained a certain amount of sand. The burnt fibres, which can be recognized by the small cavities in the break and at the surface of the sherd have a maximum size of 5 mm and a minimum size of 0.5 mm. The number in which they occur varies, but they are very dominant in the sherd and are clearly visible. The total quantity of non-plastic material (both organic and mineral) amounts to approximately ten to fifteen percent.

Organic temper has a number of remarkable techno-functional advantages (Skibo, Schiffer, and Reid 1989): "organic matter in the paste can act as a binder, providing more strength to the wet clay and the unfired vessels. An organic tempered vessel is slightly less effective for heating its contents than mineral tempered pots, although it is equally resistant to thermal shock, and it is much more susceptible to abrasion. Organic tempered pots, however, have a significant advantage over similar mineral tempered vessels in lightness". On the basis of their tests, together with ethnographic data Skibo, Schiffer, and Reid

(1989) propose "that organic material was a temper of choice that reflects transitory settlements and an expedient technology".

Most of the sherds contain sand which was already present in the clay. As far as one can determine without using thin sections, the non-plastic material in this group seems to consist of several minerals and different sorts of rock. Those that are most striking are: schist, quartz, quartzite, limestone, gneiss, shale, feldspar, and jasper[3]. There are also grains present in the sherds of which it is not clear, without using thin sections, whether they are small pieces of iron or pieces of grog[4]. Several sizes of grains occur together. The grains of metamorphous limestone and quartzite usually have an angular shape and sharp edges. Shale and quartz are also angular but they are not well rounded. Generally speaking, the different sorts of schist have a moderate to poor rounded shape. The small pieces of iron or grog are diverse in shape. The quantity of grains within this group, containing mixed sorts of sand, varies from large (twenty to forty percent) down to small (fifteen to twenty percent). In the first group, the fractions of coarse sand (600 μm - 1000 μm), very coarse sand (1000 μm - 2000 μm), and gravel (2000 μm - 4000 μm) occur more frequently than the fractions of fine sand (150 μm - 250 μm), very fine sand (75 μm - 150 μm), and very coarse silt (38 μm - 75 μm). The second group mainly consists of the fractions of fine sand to very coarse silt (38 μm - 75 μm). Apart from the categories containing large and small quantities of sand an intermediary category can be distinguished which consists of a moderate amount of sand (twenty to thirty percent) and a prevalent grain size of 250 μm to 600 μm.

A third category of sherds, apart from mixed sand or mixed sand and organic material, also contains grains of limestone which are visible on the surface of the sherds. During the heating process, at approximately 750 °C, limestone is gradually converted into quick lime, forming carbon dioxide gas. During the cooling process, the remaining forms of calcium absorb water and expand, as a result of which the wall of the pot may crumble or even turn to powder. Consequently, in this category of sherds, crumbling occurs around the grains of limestone on the surface of the pot. Because this pottery was generally fired in a reducing atmosphere the grains of limestone have taken on a yellowish colour. The structure of these grains is similar to particles of coagulated powder. As a result, the destructive effect of the limestone grains is smaller when compared to limestone which was heated in oxidizing conditions. After all, when limestone is reduced, the conversion to calcium oxide is not complete.

Finally, in the repertoire analysed also consists a small category of sherds which contained twenty to thirty percent of mainly calcareous sandstone. This was particularly apparent after the sherds had been refired in oxidizing conditions at 800°C for half an hour. The grains of limestone were then quite obvious and the sherd turned to powder after some time.

Analysis of the thin sections (by C. Overweel)

The analysis of eighteen thin sections gave the following information about the clay and non-plastics.

As Table A on page 26 indicates, the greater part of the analysed potsherds from Ilipinar were made from a sericite bearing clay. The non-plastics include small grains of quartz with a size ranging from 0.02 to 0.08 mm. Apart from these, fragments of schist occurred. Most of these particles ranged in size from 0.2 to 0.8 mm. In some cases, grains of 1.2, 2.3, and even 3.1 mm were found.

The schist fragments are divisible into two groups. One group contains the quartz-feldspar schists which do not show a clear pattern of layers. In this group, the feldspar consists of albite. Apart from this, we also often noted epidote. The other group contains epidote-mica schists with a clearly layered pattern. The main components of these schists were muscovite or biotite, quartz, epidote, chlorite; they also contained magnetite as a sub-component. Because each form of schist gradually changes into the other form, and both forms occur next to one another in the same rock, these two forms have been joined together in the Table presented here. The mono-mineral types of grain, which are a result of the disintegration of the schist fragments, were also included in the same group.

Apart from the non-plastics discussed above (i.e. the quartz grains ranging from 0.02 to 0.08 mm, the two forms of schist, and the grains resulting from the disintegration of the schists) each analysed sherd produced from a sericite clay, also contained grog. That is the reason why the non-plastics and grog have been brought together under the same heading in the Table. The sherds differ from each other in the respect that they either do or do not contain micrite.

Micrite is a micro-crystalline sort of calcareaous sandstone which consists of very small particles with a maximum diameter of 0.01 mm. Remainders of micrite which were found in some hollows of the sherds indicate the burning of this fine granular, calcareous sandstone which probably occurred during the refiring tests.

Under the microscope, the sericite clays can be observed as a dense filty surface of fine granular muscovite. It is coloured red because of the presence of haematite (Fe_2O_3) generated during the firing process by oxidation of the iron minerals present in the clay.

The isotropic sort of clay mentioned in the Table looks homogeneous. The red colour of this clay is darker. The dark red homogeneous mass contained some muscovite flakes. The two sherds which were made from the isotropic clay contained the same non-plastics as those sherds from the sericite clay.

The Table also mentions a third type of clay, which contained sericite and micrite. Sparite is the prevalent non-plastic in this sericite-micrite clay. Sparite is a pure crystalline calcite which is coarser grained than micrite. In the case presented here, these are single or multiple calcite crystals with a size ranging from 0.1 to 1.2 mm. Apart from the sparite fragments occasionally one of the non-plastics from the main group of our Table was found.

Table A

Analysis of the thin sections

Clay	non-plastics		
Sericite	quartz, grains*, schists**, grog, samples 1-15	micrite samples 3(b), 7, 8(b), 12(a), 14(b)	sparite
Isotropic (c)	samples 16,17	-	-
Sericite + micrite	-	-	sample 18

*Grains: mono-mineral grains: epidote, quartz, albite, quartzite and magnetite.
**Schists: quartz-feldspar schists, epidote-mica schists.

(a) = sporadic; (b) = burnt out calcite; (c) = containing muscovite

Sample	Phase	Level	Macroscopic
1	X	10	sandy
2	IX	5	sandy
3	X	12	medium sandy
4	X	8	sandy
5	X	12	medium sandy
6	X	11	chaff
7	X	11	chaff
8	X	11	white chalk
9	X	10	sandy
10	X	11	chaff
11	X	10	little sandy
12	IX	AA13	sandy + yellow grain
13	IX	AA13	little sandy
14	VIII	X12	medium sandy + yellow grain
15	VIII	X12	sandy
16			(clay used by the present potter
17			of Örnekköy - medium sandy)
18	X	8	white chalk

Technique

It was not an easy task to determine the shaping technique used for the production of the pottery, because in almost every case the pottery was burnished during the final phase of production. The traces of the shaping process which might have been visible were thus erased. In spite of this, however, a number of remarks about the shaping techniques which were used can be made.

Shaping technique

All pottery analysed was handmade. The following methods could be distinguished.

1. Pinching

A hole was made in a piece of clay held in one hand. The hole was made using the thumb of the other hand. Next, the wall was made thinner by pinching the clay between the thumb and other fingers. In this way, the shape gradually became wider. During this process the small pot was turned while it was supported by the palm of one hand. This shaping technique can be recognized by the traces left by the fingerprints during the pinching process. The size of these small pots is limited by the size of the potter's hands.

2. Building the pot in sections

In general, the first section of the pot to be produced was the base.

a. Flattening

A piece of clay was flattened, either between both hands or on a flat surface. As a result, a flat or slightly curved base was obtained.

b. Mould

When using a mould made of porous material, the soft clay, which is pressed into it, will not stick to the mould but can easily be separated from the mould. A fairly dry, as well as a relatively soft clay, can be used in such a mould. Good results can be obtained with both a very poor clay and a moderately plastic mixture. The thickness of the sherd can be kept well under control.

After the bottom section of the pot had been produced, the remainder of the object was made using coils of clay. In spite of the final polishing process numerous traces of coils were found, notably the horizontal cracks or slight thickenings where the coils had been joined together.

Finishing procedure

In order to obtain an equal thickness of the wall, the pottery was scraped while it was still in a leather-hard condition. As a result, the joints of the coils of clay were pressed even closer together. The surface of the object, which had become rough during the scraping process, was sometimes smoothed by rubbing it with the hands or by carefully tapping it. After this, or immediately after the scraping process, the surface of the pot was coated with slip made from the same clay as was used for the pot itself. Sometimes the inside and outside of the pot were covered with a layer of slip from a different sort of clay than the one which was used to make the actual object. In such cases the final colour is often somewhat different. After the object had been left to dry, it was polished. The extent to which the pot was dried determined the gloss on the object.

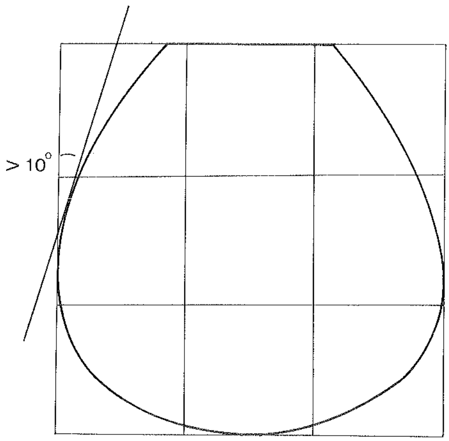
The pots were often provided with handles. These usually were lugs. They were made from a small piece of clay which was attached to the surface. In order to attach the handle properly, the surface was often roughened by cutting it slightly with a sharp object. After the pre-shaped handle had been attached, a small coil of clay was worked around the handle. This was then smoothed in order to produce a handle which would become part of the wall without any sharp edges indicating the joints. These handles were usually joined horizontally and were often pierced with a round piece of wood. These handles were attached before the pot was burnished. They would therefore be polished together with the object. Another type of handle which was produced, but which does not occur very often, was made from a small curved coil of clay which attached to the pot. The standring of the pottery and plastic decoration were produced the same way.

The occasional bulges on the rim, which are generally considered to be part of the decoration, might be the result of repairs which were carried out because cracks had occurred at right angles with the rim. After the wall of the pottery had been produced using coils of clay, the wall of the pot was made thinner by pinching it between the thumb and fingers. As a result, the clay from each coil was stretched slightly and the joints between the coils were pressed more firmly together. When using this technique, however, the rim of the pottery tends to crack easily because it dries quickly.

The repertoire of pottery analysed contained a number of sieves. The holes were usually produced by piercing the wall from the outside when the clay was still in a leather-hard condition, in such cases the potter would have to apply some counterpressure from the inside. Sometimes, when the surface was polished, these holes were refilled.

Decorations

Four types of decorations were distinguished: lines incised into the clay, impressions of the fingernails, excised decorations, and appliqué decorations. The decorative lines were incised anytime shortly before, during or after the polishing procedure. If they are incised before, the line is tight and has a serrated edge. If the lines are cut after, they become smooth due to the polishing procedure and there are no notches. The impressing of the fingernails was done after the pot had been polished. Other decorations were made by removing clay from the surface when it was still in a leather-hard condition. This was carried out both before and after polishing. So-called appliqué decorations also occur. In such cases, pieces of clay were applied to the surface of the pottery purely for decorative effect.



Firing technique

The blackish/brown colour of most of the sherds, leads one to conclude that the pottery was fired in reducing to neutral conditions. When the sherds were refired under oxidizing conditions at 800°C for half an hour, all of the sherds turned red through and through (10R-5YR 5-7/6-8).

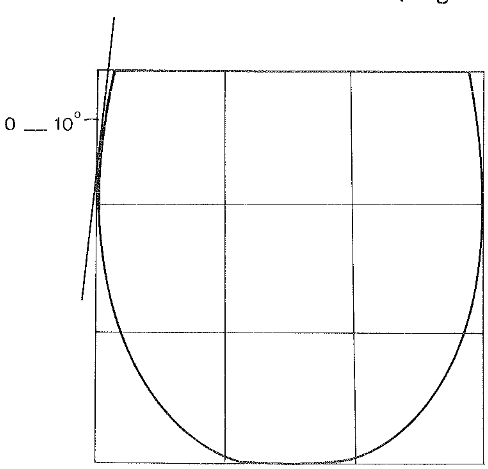
Fig. 2. Restricted pot: type 1.

The analysis of the shapes

Some six possible basic shapes could be distinguished in the material analysed:

1. (Restricted) pots
The inward angle of inclination of the wall is more than ten degrees. The ratio between the diameter of the mouth and the depth of the pot is in a minimal proportion of two to three (Fig. 2).

2. Restricted bowls
The inward angle of inclination of the wall is between zero and ten degrees. In general, two types can be distinguished:
a. A deep bowl with a diameter and depth in the ratio of approximately one to one (Fig. 3a).
b. A shallow bowl with a diameter and depth in the ratio of between three to two and two to one (Fig. 3b).



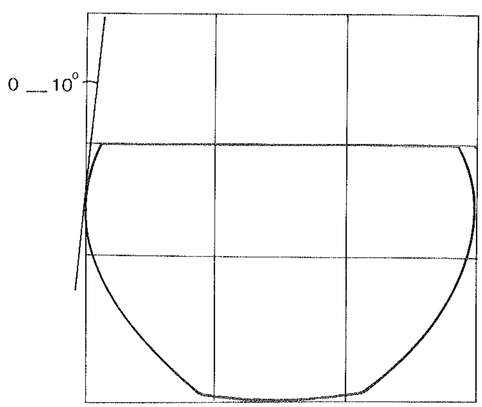


Fig. 3. a. Restricted bowl: type 2a; b. type 2b.

3. Unrestricted bowls

The outward angle of inclination of the wall ranges from ten to zero degrees. In general, two types can be distinguished:

a. A deep bowl with a diameter and depth in the ratio of approximately one to one (Fig. 4a).

b. A shallow bowl with a diameter and depth in the ratio of between three to two and two to one (Fig. 4b).

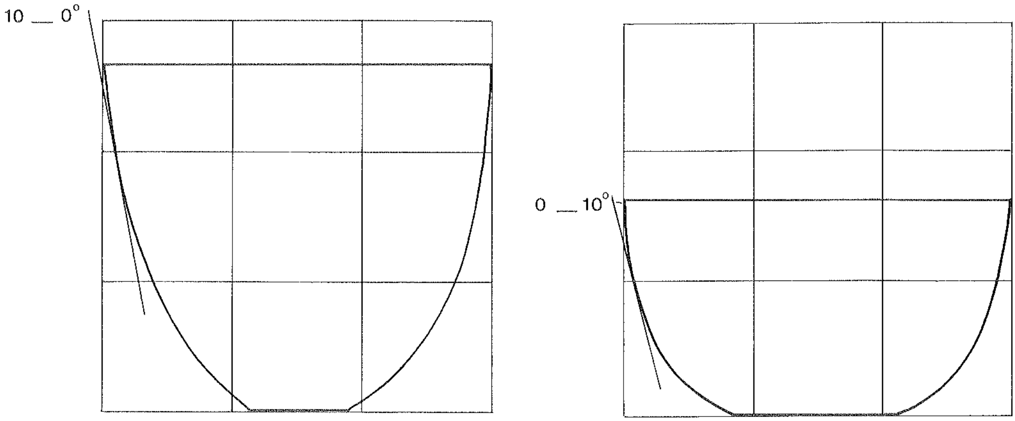


Fig. 4. a. Unrestricted bowl: type 3a; b. type 3b.

4. Dishes

The outward inclination of the wall ranges from ten to sixty degrees. In general, two types can be distinguished:

a. Platters with a diameter and depth with a maximal proportion of two to one (Fig. 5a).

b. Basins/Trays with a diameter and depth with a minimal proportion of three to one (Fig. 5b).

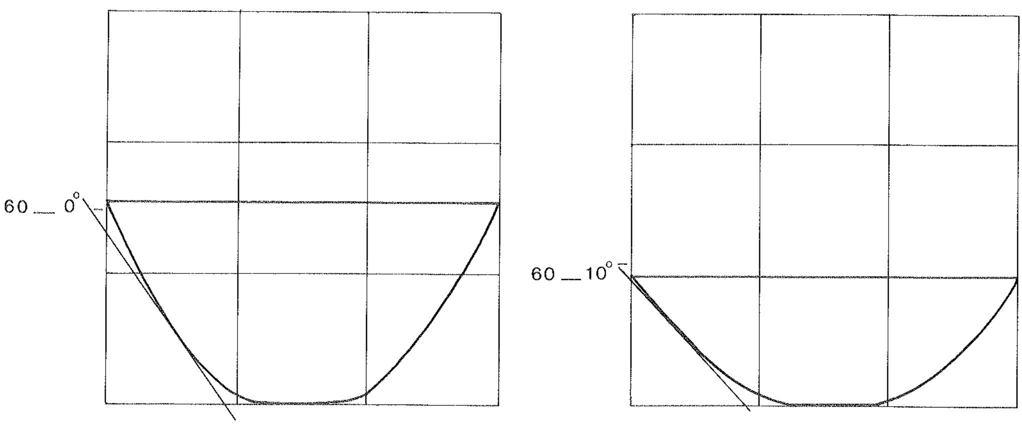


Fig. 5. a. Dish: type 4a; b. type 4b.

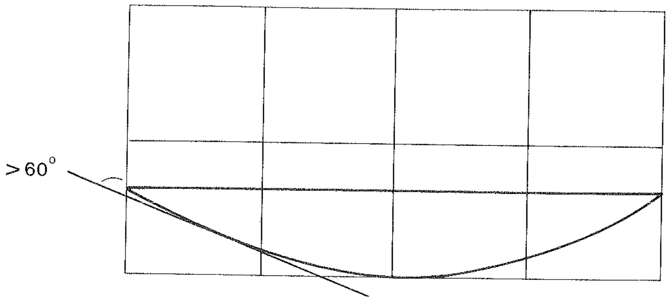


Fig. 6. Plate: type 5.

5. Plates

The outward inclination of the wall is more than sixty degrees. The ratio between the diameter and depth is in a minimal proportion of four to one (Fig. 6).

6. Collared jars

This is a pot with a prominent neck which is more than five centimeters high (Fig. 7).

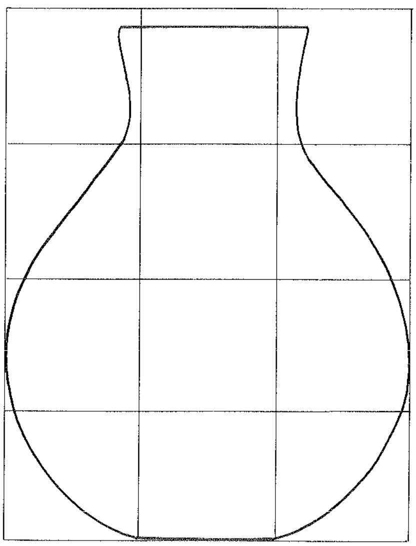


Fig. 7. Collared jar: type 6.

The miniature forms of these basic shapes have been treated as a separate category.

With respect to the categories 2a, 2b, 3a, and 3b one should note that it is often not possible to determine from rimsherds whether a pot was of a deep or a shallow type. Resulting from the (reconstructed) complete pots it was decided, however, that the deep types occurred much more often than the shallow types. In cases of doubt about the origin of the sherd, preference was given to the qualification *deep*.

The number of shapes in the repertoire of pottery sherds analysed in 1989 turned out to be less varied. Only some four basic shapes could be distinguished: (restricted) pots, restricted bowls, unrestricted bowls, and, rarely, dishes. Little was known about the actual pot shapes, because only a few pots were found which could be reconstructed and these were invariably closed bowls which had a fairly flat base. The mouth of these bowls was not completely circular.

The most prevalent thickness lies between four and seven mm, followed by a group of pots where the wall thickness is between seven and ten mm. The very thin-walled pottery has a wall thickness of less than four mm. Pottery with a wall which is more than ten mm thick only occurred occasionally.

The various shapes will now be discussed in more detail. The changes through the different levels will be dealt with in the paragraph concerning the statistical processing of the data (see p. 35).

1. Pots

The pot is a closed shape (Fig. 8). Within this category, three types can be distinguished. The first type has a straight rim. The thickness of the rim changes very little towards the lip. The lip has a more or less circular shape (hole mouth jar, Fig. 9a). In the second type, the rim has been bent outwards just below the lip (Fig. 9b). In the third type of pots, the rim was bent outwards at approximately two to three centimeters below the lip, which actually created a pseudo-collar (Figs. 9c and 10). Real collars, which were stuck to the wall at a sharp angle, were seldom found in the repertoire analysed. The diameter of the mouth varies from five to twenty-four centimeters. In some cases pierced handles, produced from small lumps of clay, were found attached to the shoulder section of the pots.

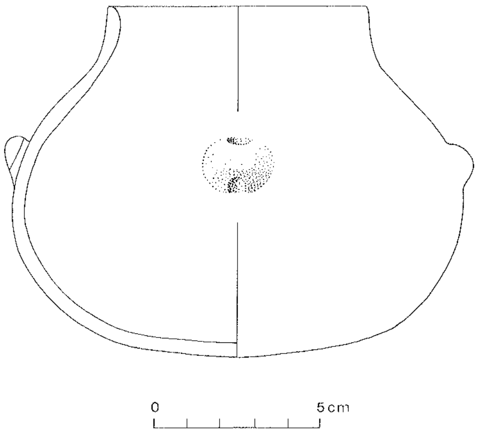


Fig. 8. Pot.

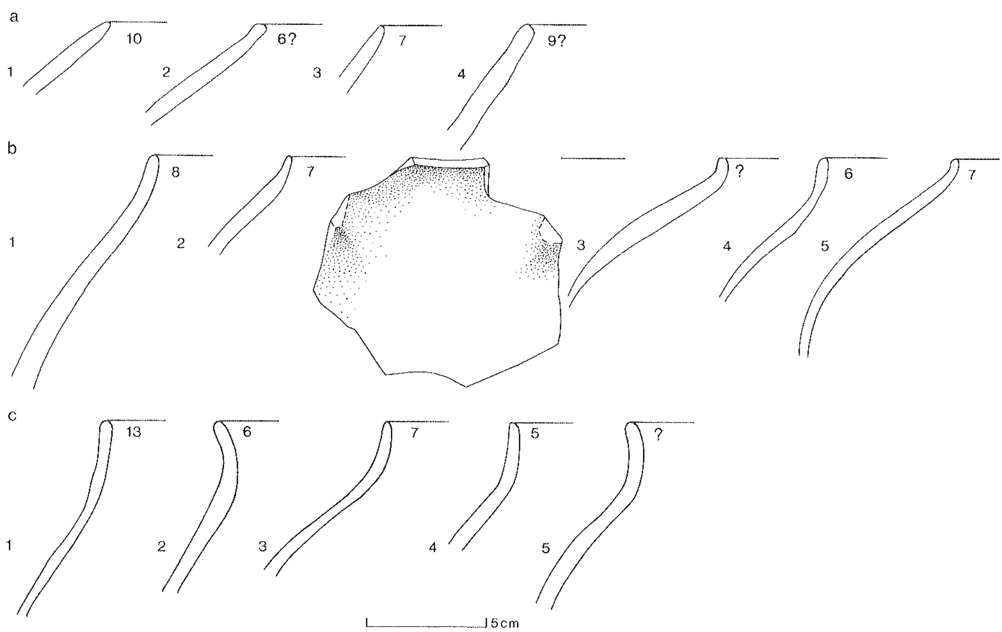
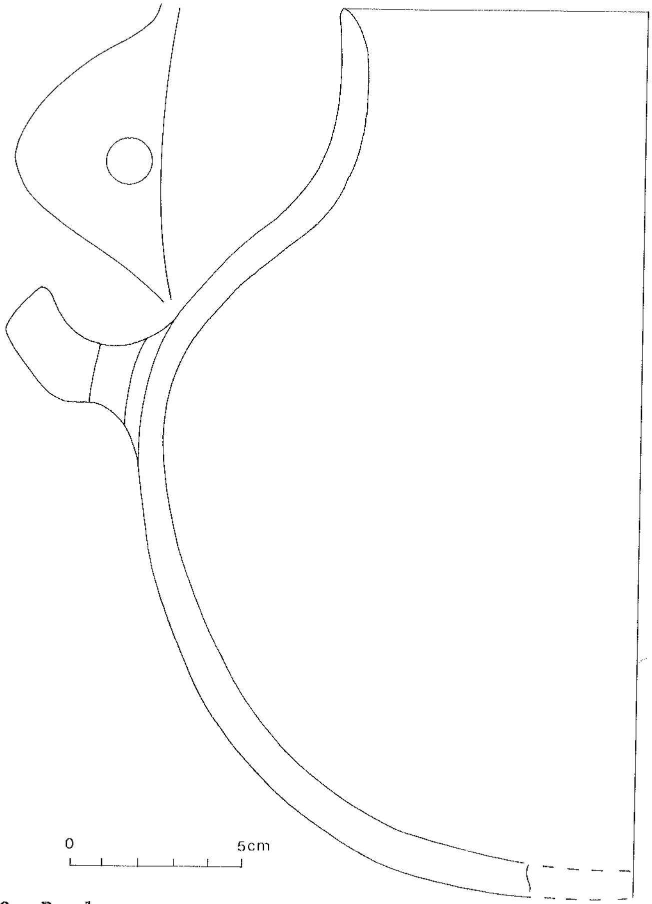


Fig. 9a-c. Three types of pot rims.



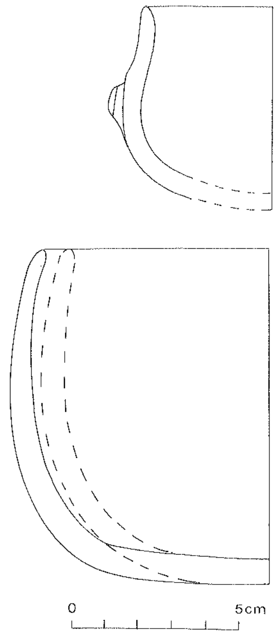


Fig. 11a-b.
Bowl-shaped ware.

Fig. 10. Pot with a pseudo-collar.

2. Bowls

Bowl-shaped ware can be divided into closed and open shapes (Figs. 11a and b). Both these shape categories consist of three types. The first type has a more or less straight wall and a round lip, which is either thinner or thicker than the rest of the wall (Fig. 12a). In general, the profile of the wall has been rounded. In a small number of cases, the wall has a sharp angle several centimeters below the rim, a so-called carination. With the second type of bowls, the rim just below the lip has been bent outwards or folded downwards (Fig. 12b). With the third type, the rim has been bent outwards some two to four centimeters below the lip (Figs. 12c and 13). If this curve is strong, an S-shape will occur, if not, a pseudo-collar will be produced. In a number of cases the rim which was bent was initially thickened, but becomes thinner again closer to the lip. Collars with sharp angles seldom occur.

If one assumes that the mouth of the pottery is more or less circular, which is not always the case, then the diameter of the mouth varies from between five and thirty centimeters.

Although handles were only occasionally found on sherds from the rim, one must assume from the great variety of handles that the bowls were

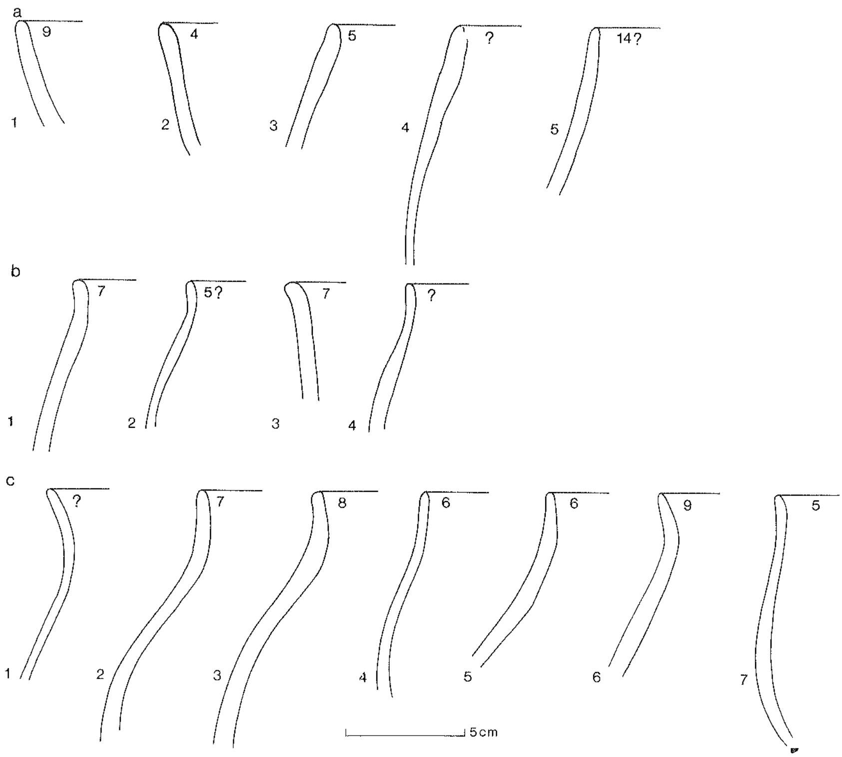


Fig. 12a-c. Three types of bowls.

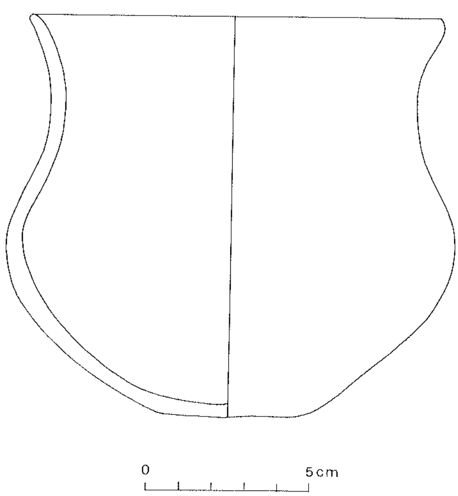


Fig. 13. Bowl.

often manufactured with handles. With the closed shapes these may have been placed at the largest diameter of the bowl. The handles were fixed either vertically or horizontally (Fig. 11a).

3. Dishes

This shape does not occur very often. Generally speaking, the wall is somewhat thinner towards the lip. The lip itself has been rounded. It often turned out to be difficult to measure the diameter. In those cases where it was possible to do so, the average size was twenty-five centimeters.

Base shapes

Sherds from the bases of pottery occurred less frequent in the sample analysed than the number of rim sherds and the even larger number of handles. This might be explained by the fact that rounded bases are not easily recognized as such. Three different types of bases can be distinguished: 1. a flat base with sharp angles towards the wall of the pot (Fig. 14a); 2. a planoconvex base with curved angles towards the wall of the pot (Fig. 14b); and 3. a very low ring under a round base. The third type of base occurred only rarely.

Handles

The number of handles and scars of handles analysed was considerable. In general, one can distinguish four types:
1. Pierced knobs (Fig. 15a),
2. Pierced lugs (Fig. 15b),
3. Flat handles, triangular, curved somewhat, and sometimes ending in a vertical triangle (Fig. 15c),
4. Pierced flat handles (as in three, Fig. 15d).

Statistical processing of the data

A. Non-plastics

As was mentioned in the sub-section "macroscopic analysis" (p. 23), some six different groups of non-plastics could be distinguished:
1. Chaff
2. Large amounts of sand (with quantities between twenty and forty percent, and a predominant grain size ranging from 600 to 2000 µm)
3. Small amounts of sand (with quantities between fifteen and twenty percent, and a predominant grain size ranging from 38 to 75 µm)
4. Medium amounts of sand (with quantities between twenty and thirty percent, and a predominant grain size ranging from 250 to 600µm)
5. White chalk (with a total percentage ranging from twenty to thirty percent)
6. "Yellow grain" (yellow grains of chalk which are visible on the skin surface of the sherds)

Group one mainly occurs in combination with group three, but also in combination with groups two, four, and six. As was mentioned above, the yellow grains of chalk (group six) always occur in combination with one of the other groups. This is the reason why, at first, this group was not recognized as a separate category. Eventually, this group was identified during the description of the finishing techniques.

From the total of 3004 sherds from the section which were analysed, 1773 were analysed for the non-plastics; from the 526 sherds from AA13 this amounted to 418, and from the 164 sherds from X12, 102 were analysed for non-plastics. These were distributed over the following levels of the section discussed here:

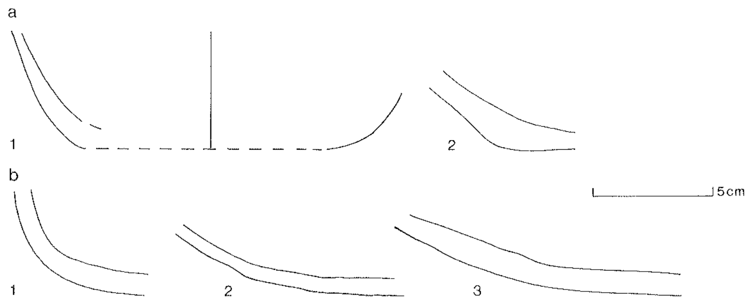


Fig. 14. Bases: a. flat; b. plano-convex.

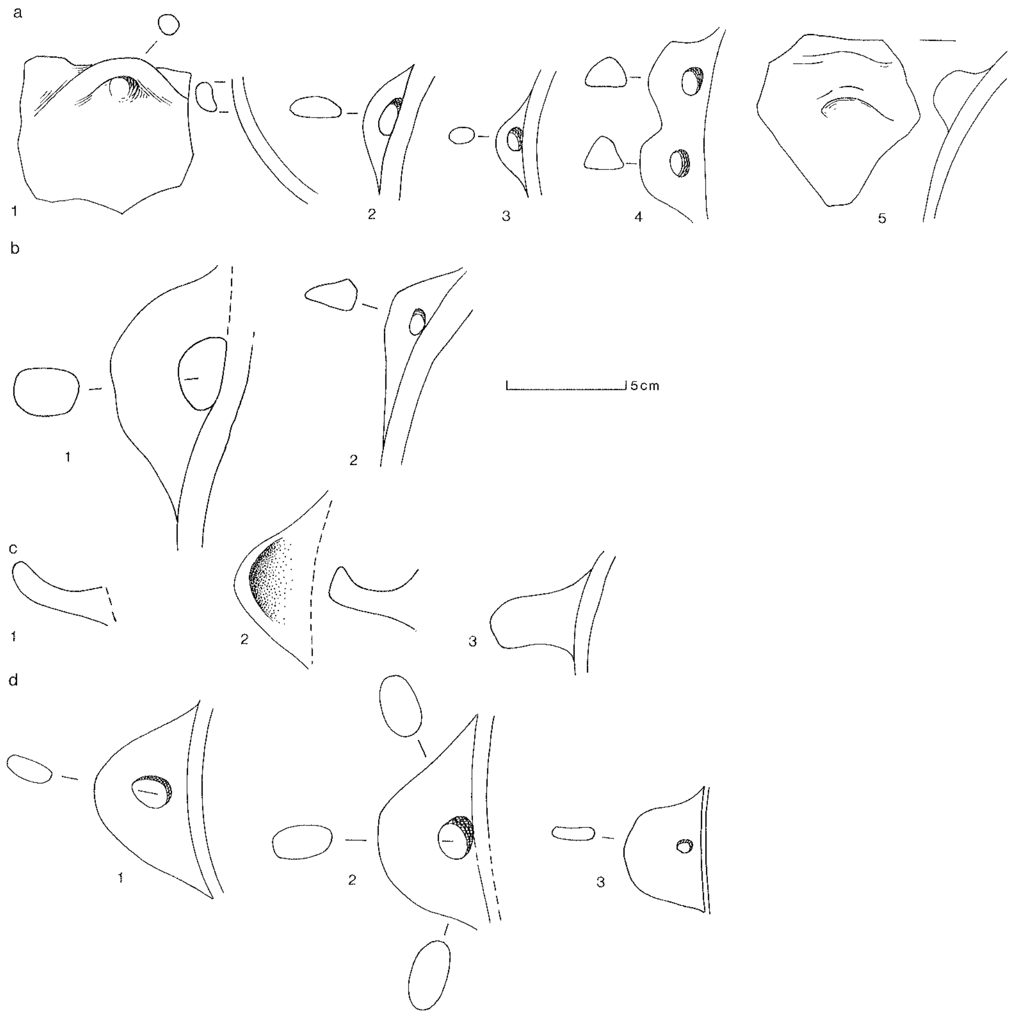


Fig. 15 a-d. Handles.

Table 1.

An overview of the occurrence of diagnostic sherds through levels of the Section and in the samples taken from AA13 and X12

	rim	base	handle	sieve	lid	decorated
level 12	169	9	114	--	3	1
level 11	208	33	157	--	2	1
level 10	143	24	111	1	2	1
level 9	226	32	157	1	1	3
level 8	281	48	200	8	7	1
level 7	139	23	91	8	--	2
level 6	113	20	48	3	--	--
level 5	238	49	107	24	1	3
level 4	77	6	35	1	--	--
level 3	33	5	28	--	--	1
AA13	334	3	173	1	7	11
X12	96	7	46	2	3	10

level 12	179 (59.3%)
level 11	301 (73.9%)
level 10	215 (73.4%)
level 9	256 (57.4%)
level 8	281 (54.1%)
level 7	130 (49.6%)
level 6	106 (56.1%)
level 5	194 (45.5%)
level 4	75 (57%)
level 3	36 (75.4%)

The number of sherds from the section which were analysed for the presence or absence of "yellow grains" was smaller. In addition, the presence of "yellow grains" was not always investigated in relation to other non-plastics.

In the burnt layer of the section analysed here, one may observe a change in the development of the pottery (Table 2). After level eight chaff hardly occurs. There is also a sharp decrease in the amount of "white chalk" in the levels following level eight. However, one should note that, as far as the amount of chaff is concerned, the first decrease occurs as early as level ten and at level eight it decreases

Table 2.

Occurrence of non-plastics through levels; phases Section, AA13 and X-12

	chaff	large amounts of sand	medium amounts of sand	small amounts of sand	white chalk	yellow grain
level 12	91 *51,4%*	37 *20,9%*	37 *20,9%*	2 *1,1%*	11 *6,2%*	3 *1.7%*
level 11	198 *66,0%*	50 *16,7%*	41 *13,7%*	11 *3,7%*	6 *2,0%*	13 *4,3%*
level 10	82 *38,7%*	62 *29,2%*	42 *19,8%*	13 *6,1%*	14 *6,6%*	5 *2,3%*
level 9	111 *45,6%*	74 *30,7%*	35 *14,5%*	16 *6,6%*	6 *2,5%*	30 *11,7%*
level 8	36 *13,7%*	159 *60,7%*	45 *17,2%*	4 *1,5%*	17 *6,5%*	50 *17,8%*
level 7	7 *5,8%*	74 *61,2%*	36 *29,8%*	3 *2,5%*	1 *0,8%*	28 *21,5%*
level 6	4 *3,9%*	79 *76,7%*	20 *19,4%*	--	--	6 *5,7%*
level 5	3 *1,6%*	98 *51,9%*	81 *42,9%*	4 *2,1%*	3 *1,6%*	15 *7,7%*
level 4	1 *1,4%*	48 *64,9%*	17 *23,0%*	6 *8,0%*	2 *2,7%*	2 *2,7%*
level 3	--	16 *44,4%*	14 *38,9%*	4 *11,1%*	1 *2,8%*	--
levels 12-9	482 *51,8%*	223 *24,0%*	155 *16,7%*	42 *4,5%*	37 *4,0%*	51 *5,4%*
level 8	36 *13,7%*	159 *60,7%*	45 *17,2%*	4 *1,5%*	17 *6,5%*	50 *17,8%*
levels 7- 5	14 *3,4%*	251 *60,8%*	137 *33,2%*	7 *1,7%*	4 *0,9%*	49 *11,4%*
levels 4 and 3	1 *0,9%*	64 *58,2%*	31 *28,2%*	10 *9,1%*	3 *2,7%*	2 *1,8%*
AA13	--	143 *42,3%*	156 *49,4%*	16 *5,1%*	1 *0,3%*	175 *52,3%*
X12	--	7 *6,9%*	90 *89,1%*	4 *4,0%*	1 *1,0%*	49 *29,9%*

Table 3.

Occurrence hardness through levels; phases Section, AA13 and X-12

	1	2	3	4
level 12	5 *1,7%*	271 *90%*	22 *7,3%*	3 *1,1%*
level 11	--	343 *90,3%*	35 *9,2%*	2 *0,5%*
level 10	2 *0,8%*	242 *88,9%*	24 *9,5%*	2 *0,8%*
level 9	2 *0,5%*	381 *89,4%*	42 *9,9%*	1 *0,2%*
level 8	1 *0,2%*	447 *89,2%*	50 *10%*	3 *0,6%*
level 7	1 *0,4%*	199 *79%*	45 *17,9%*	7 *2,8%*
level 6	--	150 *83,3%*	27 *15%*	3 *1,7%*
level 5	--	328 *77,2%*	95 *22,4%*	2 *0,5%*
level 4	--	83 *87,4%*	9 *9,5%*	3 *3,2%*
level 3	--	51 *85%*	9 *15%*	--
Section Phase X	10 *0,5%*	1666 *89,6%*	173 *9,3%*	11 *0,6%*
Section Phase IX	1 *0,1%*	677 *79%*	167 *19,5%*	12 *1,4%*
Section Phase VIII	--	134 *86,5%*	18 *11,6%*	3 *1,9%*
AA13 Phase IX	--	428 *81,4%*	97 *18,4%*	1 *0,2%*
X12 Phase VIII	--	130 *79,3%*	33 *20,1%*	1 *0,6%*

Table 4.

Comparison non-plastics - hardness through phases Section, AA13 en X-12

	1	2	3	4
Phase X/section				
Chaff	4 *0,8%*	458 *92,3%*	32 *6,5%*	2 *0,4%*
Large amounts sand	--	308 *87%*	43 *12,1%*	3 *0,8%*
Medium am. sand	2 *0,1%*	188 *95,4%*	7 *3,6%*	--
Small amounts sand	--	44 *95,7%*	2 *4,3%*	--
White chalk	--	53 *98,1%*	1 *1,9%*	--
Yellow grain	1 *1,1%*	83 *88,3%*	10 *10,6%*	--
Ph.IX/section				
Chaff	--	9 *64,3%*	4 *28,6%*	1 *7,1%*
Large amounts sand	--	204 *84%*	37 *15,2%*	2 *0,8%*
Medium am. sand	--	103 *75,2%*	33 *24,1%*	1 *0,7%*
Small amounts sand	--	6 *85,7%*	1 *14,3%*	--
White chalk	--	4	--	--
Yellow grain	--	44 *91,7%*	4 *8,3%*	--
Ph.VIII/section				
Chaff	--	1	--	--
Large amounts sand	--	53 *88,3%*	6 *10%*	1 *1,7%*
Medium am. sand	--	27 *90%*	2 *6,7%*	1 *3,3%*
Small amounts sand	--	10	--	--
Wihite chalk	--	--	2	1
Yellow grain	--	2	--	--
AA13/Phase IX				
Large amounts sand	--	109 *76,2%*	34 *23,8%*	--
Medium am. sand	--	133 *85,3%*	23 *14,7%*	--
Small amounts sand	--	14 *87,5%*	2 *12,5%*	--
White chalk	--	1	--	--
Yellow grain	--	228 *83,2%*	46 *16,8%*	--
X12/Phase VIII				
Large amounts sand	--	4	3	--
Medium am. sand	--	76 *84,4%*	14 *15,6%*	--
Small amounts sand	--	2	2	--
White chalk	--	1	--	--
Yellow grain	--	41 *83,7%*	8 *16,3%*	--

Table 5.

Occurrence wallthickness through levels; phases Section, AA13 en X-12

	0 - 4 mm	4 - 7 mm	7 - 10 mm	> 10 mm
level 12	9 *3,3%*	175 *64,1%*	75 *27,5%*	14 *5,1%*
level 11	9 *2,6%*	201 *58,1%*	118 *34,1%*	18 *5,2%*
level 10	11 *4,3%*	144 *56,5%*	80 *31,4%*	20 *7,8%*
level 9	16 *3,8%*	298 *70,8%*	93 *22,1%*	14 *3,3%*
level 8	23 *4,5%*	340 *66,5%*	133 *26%*	15 *2,9%*
level 7	10 *4,1%*	179 *72,8%*	52 *21,1%*	5 *2%*
level 6	1 *0,6%*	124 *68,9%*	46 *25,6%*	9 *5%*
level 5	15 *3,6%*	292 *69,2%*	99 *23,5%*	15 *3,6%*
level 4	4 *4,3%*	59 *62,8%*	30 *31,9%*	1 *1,1%*
level 3	--	36 *61%*	19 *32,2%*	4 *6,8%*
Section Phase X	68 *3,8%*	1158 *64,1%*	499 *27,6%*	81 *4,5%*
Section Phase IX	26 *3,1%*	595 *70,2%*	197 *23,2%*	30 *3,5%*
Section Phase VIII	4 *2,6%*	95 *62,1%*	49 *32%*	5 *3,3%*
AA13 Phase IX	32 *6,1%*	418 *79,5%*	65 *12,4%*	11 *2,1%*
X12 Phase VIII	5 *3,0%*	111 *67,7%*	47 *28,7%*	--

Table 6.

Comparison non-plastics - wallthickness through phases Section, AA13 en X-12

	< 4 mm	4 - 7 mm	7 - 10 mm	> 10 mm
Phase X/Section				
Chaff	10 *2,1%*	262 *55,3%*	175 *36,9%*	27 (5,7%)
Large am. sand	11 *3,2%*	230 *67,8%*	96 *28,3%*	13 (3,8%)
Medium am. sand	9 *4,7%*	133 *69,6%*	44 *23,0%*	5 *2,6%*
Small am. sand	2 *4,5%*	31 *70,5%*	10 *22,7%*	1 *2,3%*
White chalk	3 *5,8%*	31 *59,6%*	15 *28,8%*	3 *5,8%*
Yellow grain	1 *1,0%*	56 *57,7%*	33 *34,0%*	7 *7,2%*
Ph. IX/Section				
Chaff	--	6 *46,2%*	7 *53,8%*	--
Large am. sand	9 *3,7%*	171 *71,0%*	57 *23,7%*	4 *1,6%*
Medium am. sand	4 *2,9%*	103 *75,2%*	28 *20,4%*	2 *1,5%*
Small am. sand	--	7	--	--
White chalk	--	2	2	--
Yellow grain	--	33 *71,1%*	12 *26,1%*	1 *2,2%*
Ph.VIII/Section				
Chaff	--	1	--	--
Large am. sand	3 *5,1%*	33 *55,9%*	23 *39,0%*	--
Medium am. sand	--	20 *69%*	9 *31%*	--
Small am. sand	--	9	1	--
White chalk	--	3	--	--
Yellow grain	2	2	--	--
AA13/Phase IX				
Large am. sand	6 *4,2%*	111 *77,6%*	23 *16,1%*	3 *2,1%*
Medium am. sand	11 *7,1%*	125 *80,1%*	19 *12,1%*	1 *0,6%*
Small am. sand	4 *25%*	9 *56,3%*	2 *12,5%*	1 *6,3%*
White chalk	--	--	1	--
Yellow grain	15 *5,5%*	221 *80,4%*	32 *11,6%*	7 *2,5%*
X12/Phase VIII				
Large am. sand	--	2	5	--
Medium am. sand	--	62 *68,9%*	27 *30%*	1 *1,1%*
Small am. sand	--	4	--	--
White chalk	--	--	1	--
Yellow grain	2 *4,1%*	29 *59,2%*	18 *36,7%*	--

Table 7.
Occurrence colour outer and inner surface through levels, phases Section, AA13 and X-12

COLOUR OUTER SURFACE

	Dark greybrown	Pink light brown	black	dark red-brown	mottled brown black	light red-brown
level 12	129 *43,1%*	10 *3,3%*	64 *21,4%*	21 *7%*	47 *15,7%*	16 *5,4%*
level 11	154 *39,4%*	17 *4,3%*	82 *21%*	52 *13%*	20 *5,1%*	56 *14,3%*
level 10	122 *43,6%*	8 *2,9%*	39 *13,9%*	26 *9,3%*	21 *7,5%*	48 *17,1%*
level 9	177 *41,2%*	28 *6,5%*	79 *18,4%*	46 *10,7%*	28 *6,5%*	50 *11,6%*
level 8	246 *48%*	20 *3,9%*	85 *16,6%*	67 *13,1%*	31 *6,1%*	29 *5,7%*
level 7	85 *32,9%*	13 *5%*	54 *20,9%*	23 *8,9%*	30 *11,6%*	31 *12%*
level 6	53 *29,1%*	6 *3,3%*	30 *16,5%*	20 *11%*	42 *23,1%*	12 *6,6%*
level 5	134 *31,8%*	16 *3,8%*	100 *23,8%*	45 *10,7%*	78 *18,5%*	20 *4,8%*
level 4	32 *34%*	--	15 *16%*	11 *11,7%*	18 *19,1%*	14 *14,9%*
level 3	13 *22,8%*	--	10 *17,5%*	3 *5,3%*	13 *22,8%*	6 *10,5%*
Ph.X Sec	828 *43,2%*	83 *4,3%*	349 *18,2%*	211 *11%*	147 *7,7%*	199 *10,4%*
Ph.IX/Sec	272 *31,6%*	35 *4,1%*	184 *21,4%*	88 *10,2%*	150 *17,4%*	63 *7,3%*
Ph.VIII	45 *30%*	--	25 *16,7%*	14 *9,3%*	31 *20,7%*	20 *13,3%*
AA13	124 *23,3%*	--	182 *34,6%*	--	136 *25,9%*	25 *4,8%*
X12	74 *45,1%*	10 *6,1%*	67 *40,9%*	--	--	--

COLOUR INNER SURFACE

	Dark grey-brown	Pink/ Light brown	Black	Dark Red-brown	mottled brown black	Light red-brown
level 12	111 *36,8%*	17 *5,6%*	79 *26,2%*	15 *5%*	58 *19,1%*	11 *3,6%*
level 11	167 *42,7%*	18 *4,6%*	80 *20,5%*	22 *5,6%*	57 *14,6%*	25 *6,4%*
level 10	108 *38,6%*	13 *4,6%*	62 *22,1%*	16 *5,7%*	43 *15,4%*	19 *6,8%*
level 9	152 *35,6%*	28 *6,6%*	122 *28,6%*	27 *6,3%*	43 *10,1%*	35 *8,2%*
level 8	230 *45%*	19 *3,8%*	124 *24,6%*	30 *5,9%*	45 *8,9%*	16 *3,2%*
level 7	74 *28,7%*	15 *5,8%*	73 *28,3%*	13 *5%*	43 *16,7%*	18 *7%*
level 6	57 *31,3%*	5 *2,7%*	28 *15,4%*	20 *11%*	57 *31,3%*	8 *4,4%*
level 5	145 *34,5%*	20 *4,8%*	114 *27,1%*	25 *6%*	76 *18,1%*	16 *3,8%*
level 4	38 *40,4%*	1 *1,1%*	21 *22,3%*	4 *4,3%*	14 *14,9%*	12 *12,8%*
level 3	14 *24,6%*	1 *1,8%*	14 *24,6%*	2 *3,5%*	16 *28,1%*	6 *10,5%*
Ph. X Sec	768 *40,3%*	95 *5%*	467 *24,5%*	110 *5,8%*	246 *12,9%*	106 *5,6%*
Ph.IX Sec	276 *32,1%*	40 *4,7%*	215 *25%*	58 *6,7%*	176 *20,5%*	42 *4,9%*
Ph. VIII	52 *34,4%*	2 *1,3%*	35 *23,2%*	6 *4%*	30 *19,9%*	18 *11,9%*
AA13	125 *23,8%*	--	183 *34,8%*	--	159 *30,2%*	19 *3,6%*
X12	83 *50,6%*	8 *4,9%*	59 *36%*	--	--	

Table 8.

Comparison non-plastics - colour outer surface through phases Section, AA13 and X-12

	Dark grey brown	pink/ light brown	black	Dark red brown	mottled brown black	Light red brown
Section	**Phase X**					
Chaff	192 *40,0%*	28 *5,8%*	100 *20,8%*	65 *13,5%*	25 *5,2%*	70 *14,6%*
Large/sand	153 *43,7%*	15 *4,3%*	62 *17,7%*	43 *12,3%*	42 *12%*	35 *10%*
med.sand	86 *46%*	5 *2,7%*	25 *13,4%*	29 *15,5%*	16 *8,6%*	26 *13,9%*
small/sand	18 *41,9%*	2 *4,7%*	5 *11,6%*	1 *2,3%*	7 *16,3%*	10 *23,3%*
white chalk	24 *46,2%*	3 *5,8%*	3 *5,8%*	6 *11,5%*	7 *13,5%*	9 *17,3%*
yellow gr.	47 *46,5%*	1 *1%*	27 *26,7%*	11 *10,9%*	12 *11,9%*	3 *3%*
Section	**Phase IX**					
Chaff	4	1	2	--	3	2
Large/sand	81 *36%*	4 *1,8%*	41 *18,2%*	28 *12,4%*	47 *20,9%*	24 *10,7%*
Med.sand	45 *36%*	8 *6,4%*	16 *12,8%*	11 *8,8%*	33 *26,4%*	12 *9,6%*
Small/sand	1	--	--	--	2	2
White chalk	3	--	1	--	--	--
Yellow gr.	15 *31,3%*	--	15 *31,3%*	4 *8,3%*	10 *20,8%*	4 *8,3%*
Section	**Ph. VIII**					
Chaff	1	--	--	--	--	--
Large/sand	22 *40,7%*	--	6 *11,1%*	6 *11,1%*	13 *24,1%*	7 *13%*
Med.sand.	9	--	1	3	5	5
Small/sand	2	--	--	1	2	1
White chalk	--	--	--	--	1	--
Yellow gr.	1	--	1	--	--	--
AA13						
Large/sand	34 *25%*	1 *0,7%*	45 *33,1%*	7 *5,1%*	43 *31,6%*	6 *4,4%*
Med.sand.	34 *23,3%*	4 *2,7%*	63 *43,2%*	4 *2,7%*	36 *24,7%*	5 *3,4%*
Small/sand	5	--	6	2	3	--
White chalk	--	--	1	--	--	--
Yellow gr.	45 *17,5%*	1 *0,4%*	114 *44,4%*	5 *1,9%*	78 *30,4%*	14 *5,4%*
X12						
Large/sand	2	1	3	--	--	--
Med.sand.	44 *51,8%*	6 *7,1%*	35 *41,2%*	--	--	--
Small/sand	--	--	2	--	--	--
White chalk	1	--	--	--	--	--
Yellow gr.	19 *43,2%*	1 *2,3%*	24 *54,5%*	--	--	--

Table 9.

Occurrence colour core through levels, phases Section, AA13 and X-12

	Black	Light grey	Dark grey brown	Dark red brown	Dark red	Dark yellow
level 12	170 *56,3%*	26 *8,6%*	75 *24,8%*	18 *6%*	10 *3,3%*	--
level 11	184 *47,1%*	54 *13,8%*	96 *24,6%*	29 *7,4%*	19 *4,9%*	--
level 10	125 *44,6%*	26 *9,3%*	82 *29,3%*	32 *11,4%*	7 *2,5%*	--
level 9	198 *46,2%*	63 *14,7%*	100 *23,3%*	26 *6,1%*	21 *4,9%*	--
level 8	246 *48%*	37 *7,2%*	145 *28,3%*	30 *5,9%*	29 *5,7%*	--
level 7	101 *39,1%*	43 *16,7%*	62 *24%*	24 *9,3%*	12 *4,7%*	--
level 6	79 *43,4%*	21 *11,5%*	57 *31,3%*	18 *10%*	6 *3,3%*	--
level 5	208 *49,4%*	76 *18,1%*	90 *21,4%*	30 *7,1%*	10 *2,4%*	--
level 4	24 *25,5%*	15 *16%*	28 *29,8%*	10 *10,6%*	4 *4,3%*	--
level 3	27 *47,4%*	4 *7%*	19 *33,3%*	5 *8,8%*	2 *3,5%*	--
Section Phase X	923 *48,2%*	206 *10,8%*	498 *26%*	135 *7,1%*	86 *4,5%*	--
Section Phase IX	388 *45,1%*	140 *16,3%*	209 *24,3%*	72 *8,4%*	28 *3,3%*	--
Section Phase VIII	51 *33,8%*	19 *12,6%*	47 *31,1%*	15 *9,4%*	6 *4,0%*	--
AA13 Phase IX	291 *55,3%*	43 *8,2%*	147 *27,9%*	34 *6,5%*	--	--
X12 Phase VIII	92 *56,1%*	--	25 *15,2%*	--	9 *5,5%*	37 *22,6%*

Table 10.

Comparison non-plastics - colour core through phases Section, AA13 and X12

	Black	Light grey	Dark grey brown	Dark red brown	Dark red	Dark yellow
Section	**Phase X**					
chaff	323 *64,7%*	40 *8%*	96 *19,2%*	23 *4,6%*	6 *1,2%*	--
Large/sand	158 *42%*	39 *10,4%*	119 *31,6%*	36 *9,6%*	16 *4,3%*	--
Med.sand.	66 *34,4%*	21 *10,9%*	60 *31,3%*	22 *11,5%*	12 *6,3%*	--
small/sand	15 *34,9%*	9 *20,9%*	7 *16,3%*	4 *9,3%*	3 *7%*	--
white chalk	17 *31,5%*	5 *9,3%*	24 *44,4%*	5 *9,3%*	3 *5,6%*	--
yellow gr.	40 *39,6%*	7 *6,9%*	42 *41,6%*	2 *2%*	9 *8,9%*	--
Section	**Phase IX**					
Chaff	3	6	3	--	2	--
large/sand	88 *35,9%*	39 *15,9%*	75 *30,6%*	29 *11,8%*	6 *2,4%*	--
med.sand.	72 *53,3%*	15 *11,1%*	28 *20,7%*	13 *9,6%*	2 *1,5%*	--
small/sand	3	1	--	--	1	--
white chalk	3	--	--	1	--	--
yellow gr.	15 *30,6%*	4 *8,2%*	26 *53,1%*	1 *2%*	3 *6,1%*	--
Section	**Phase VIII**					
Chaff	1	--	--	--	--	--
large/sand	16 *27,6%*	8 *13,8%*	20 *34,5%*	5 *8,6%*	3 *5,2%*	--
med.sand.	10 *35,7%*	2 *7,1%*	8 *28,6%*	3 *10,7%*	2 *7,1%*	--
small/sand	2	--	1	1	--	--
white chalk	1	2	--	--	--	--
yellow gr.	1	--	1	2	--	--
AA13	**Phase IX**					
large/sand	77 *53,8%*	5 *3,5%*	50 *35%*	11 *7,7%*	--	--
med.sand.	93 *60,4%*	18 *11,7%*	32 *20,8%*	9 *5,8%*	2 *1,3%*	--
small/sand	11	2	2	1	--	--
white chalk	1	--	--	--	--	--
yellow gr.	158 *57,7%*	17 *6,2%*	80 *29,2%*	18 *6,6%*	--	--
X12	**Ph. VIII**					
large/sand	3	--	2	--		1
med.sand	53 *58,9%*	--	12 *13,3%*	--	3 *2,2%*	21 *23,3%*
small/sand	1	--	2	--	--	1
white chalk	1	--	--	--	--	--
yellow gr.	29 *59,2%*	--	5 *10,2%*	--	3 *6,1%*	12 *24,5%*

Table 11.

Occurrence surface finish exterior and interior through levels, phases Section, AA13 and X12

Surface finish exterior

	Smooth		Low burnish	
Level 12	20	*6,6%*	278	*92,1%*
Level 11	24	*6,0%*	372	*92,5%*
Level 10	24	*8,2%*	266	*90,8%*
Level 9	12	*2,7%*	428	*96%*
Level 8	30	*5,8%*	481	*92,7%*
Level 7	10	*3,8%*	250	*95,4%*
Level 6	4	*2,1%*	184	*97,4%*
Level 5	14	*3,3%*	404	*94,8%*
Level 4	3	*2,9%*	96	*91,4%*
Level 3	2	*3,3%*	55	*91,7%*
Section Phase X	106	*5,4%*	1825	*89,4%*
Section Phase IX	28	*3,2%*	838	*95,6%*
Section Phase VIII	5	*3%*	151	*91,5%*
AA 13 Phase IX	75	*14,6%*	428	*83,4%*
X 12 Phase VIII	45	*27,8%*	113	*69,8%*

Surface finish interior

	Smooth		Low burnished	
Level 12	77	*25,5%*	190	*62,9%*
Level 11	89	*22,1%*	257	*63,9%*
Level 10	65	*22,2%*	182	*62,1%*
Level 9	78	*17,5%*	319	*71,5%*
Level 8	134	*25,8%*	335	*64,5%*
Level 7	46	*17,6%*	196	*74,8%*
Level 6	27	*14,3%*	155	*82%*
Level 5	43	*10,1%*	363	*85,2%*
Level 4	17	*16,2%*	86	*81,9%*
Level 3	9	*15%*	47	*78,3%*
Section Phase X	443	*22,6%*	1283	*65,4%*
Section Phase IX	116	*13,2%*	714	*81,4%*
Section Phase VIII	26	*15,8%*	133	*80,6%*
AA 13 Phase IX	141	*29,3%*	335	*69,6%*
X 12 Phase VIII	81	*50%*	78	*48,1%*

Table 12.

Comparison surface finish interior-vesselshape through phases Section, AA13 and X12

	Smooth		Low burnish	
Section levels 12 - 9				
Restricted pot	63	*25,2%*	187	*74,8%*
Restricted bowl	110	*20,3%*	432	*79,7%*
Unrestricted bowl	--		1	
Section level 8				
Restricted pot	17	*30,9%*	38	*69,1%*
Restricted bowl	54	*24,3%*	158	*71,2%*
Unrestricted bowl	1		9	
Section Phase X				
Restricted pot	80	*26,2%*	225	*73,8%*
Restricted bowl	164	*21,8%*	590	*78,2%*
Unrestricted bowl	1		10	
Section Phase IX				
Restricted pot	7	*10,6%*	59	*89,4%*
Restricted bowl	34	*9,1%*	340	*90,9%*
Unrestricted bowl	5	*13,9%*	31	*86,1%*
Section Phase VIII				
Restricted pot	4		7	
Restricted bowl	13	*14,9%*	74	*85,1%*
Unrestricted bowl	1		4	
AA 13 Phase IX				
Restricted pot	13	*26%*	37	*74%*
Restricted bowl	51	*23,2%*	169	*76,8%*
Unrestricted bowl	10	*16,7%*	50	*83,3%*
X 12 Phase VIII				
Restricted pot	12	*52,2%*	11	*47,8%*
Restricted bowl	26	*46,4%*	30	*53,6%*
Unrestricted bowl	5	*26,3%*	14	*73,7%*

Table 13.

Comparison surface finish exterior - non-plastics through phases Section, AA13 and X12

	Smooth		Low burnished	
Section Phase X				
Chaff	35	*6,8%*	478	*93,2%*
Large am.sand	24	*6,3%*	355	*93,7%*
Medium am. sand	5	*2,5%*	193	*97,5%*
Small am. sand	1	*2,2%*	45	*97,8%*
White chalk	1	*1,9%*	53	*98,1%*
Yellow grain	3	*3%*	97	*97%*
Section Phase IX				
Chaff	--		14	
Large am.sand	7	*2,8%*	241	*97,2%*
Medium am.sand	2	*2,5%*	135	*98,5%*
Small am. sand	1		6	
White chalk	--		4	
Yellow grain	1	*2%*	48	*98%*
Section Phase VIII				
Chaff	--		1	
Large am.sand	2	*3,2%*	61	*96,8%*
Medium am.sand	--		31	
Small am.sand	1		8	
White chalk	--		2	
Yellow grain	--		2	
AA 13 Phase IX				
Large am.sand	31	*22,5%*	107	*77,5%*
Medium am.sand	16	*10,7%*	133	*89,3%*
Small am.sand	3	*18,7%*	13	*81,3%*
White chalk	1		--	
Yellow grain	31	*11,6%*	236	*88,4%*
X 12 Phase VIII				
Large am.sand	3		3	
Medium am.sand	20	*22,7%*	68	*77,3%*
Small am.sand	1		3	
White chalk	1		--	
Yellow grain	7	*15,2%*	39	*84,8%*

Table 14

Occurrence vesselshape through levels, phases Section, AA13 and X12

	Restricted pot	Restricted bowl	Unrestricted bowl
Level 12	46 *24,2%*	138 *72,6%*	--
Level 11	77 *32,6%*	155 *65,7%*	--
Level 10	59 *38,8%*	88 *57,9%*	1 *0,6%*
Level 9	69 *29,2%*	164 *69,5%*	--
Level 8	55 *19,1%*	213 *73,9%*	10 *3,5%*
Level 7	21 *15%*	106 *75,7%*	12 *8,6%*
Level 6	16 *13,9%*	86 *74,8%*	8 *7%*
Level 5	29 *12,1%*	181 *75,4%*	18 *7,5%*
Level 4	6 *7,7%*	63 *80,8%*	6 *7,7%*
Level 3	7 *21,2%*	26 *78,9%*	--
Section Ph. X	306 *27,8%*	758 *68,8%*	11 *1%*
Section Ph. IX	66 *13,3%*	373 *75,4%*	38 *7,7%*
Section Ph. VIII	13 *11,7%*	89 *80,2%*	6 *5,4%*
AA 13 Phase IX	50 *15%*	218 *65,3%*	53 *15,9%*
X 12 Phase VIII	23 *22,8%*	58 *57,4%*	19 *18,8%*

Table 15.
Comparison diameter rim - vesselshape through phases Section, AA13 and X12

	0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Section	**levels**	**12 - 9**				
Restr.pot	1 *0,9%*	6 *5,3%*	64 *56,1%*	40 *35,1%*	3 *2,6%*	--
Restricted bowl	1 *0,6%*	10 *6,2%*	78 *48,1%*	49 *30,2%*	22 *13,6%*	2 *1,2%*
Unrestr. bowl	--	--	--	--	1	--
Section	**level 8**					
Restr.pot	--	--	6	5	3	--
Restricted bowl	--	1	10	9	3	1
Unrestr. bowl	--	1	--	--	--	--
Section	**Phase X**					
Restr.pot	1 *0,8%*	6 *4,7%*	70 *54,7%*	45 *35,2%*	6 *4,7%*	--
Restricted bowl	1 *0,5%*	11 *5,9%*	88 *47,5%*	58 *31,2%*	25 *13.4%*	3 *1,6%*
Unrestr. bowl	--	1	--	--	1	--
Section	**Phase IX**					
Restr.pot	--	--	6	9	1	--
Restrted bowl	--	7 *6,9%*	49 *48,1%*	41 *40,6%*	3 *3%*	1 *1%*
Unrestr. bowl	--	--	2	4	--	--
Section	**Ph. VIII**					
Restr.pot	--	1	3	4	--	--
Restricted bowl	--	2 *7,4%*	8 *29,6%*	13 *48,1%*	3 *11,1%*	1 *3,7%*
Unrestr. bowl	--	--	1	1	1	--
AA 13	**Phase IX**					
Restr.pot	--	1	5	9	2	--
Restricted bowl	--	--	7	9	2	--
Unrestr. bowl	--	--	3	9	--	--
X 12	**Ph. VIII**					
Restr.pot	--	2	3	6	--	--
Restricted bowl	--	--	3	7	2	--
Unrestr. bowl	--	--	5	4	--	--

Table 16.

Comparison non-plastics - vesselshape through phases Section, AA13 and X12

	Restricted pot		Restricted bowl		Unrestricted bowl	
Section Phase X						
Chaff	88	*31,7%*	189	*68%*	1	*0,4%*
Large am.sand	62	*26,3%*	169	*71,6%*	5	*2,1%*
Medium am.sand	31	*25%*	92	*74,2%*	1	*0,8%*
Small am.sand	18	*52,9%*	16	*47,1%*	--	
White chalk	10	*32,3%*	21	*67,7%*	--	
Yellow grain	18	*33,3%*	35	*64,8%*	1	*1,9%*
Section Phase IX						
Chaff	2		2		1	
Large am.sand	19	*12,6%*	124	*82,1%*	8	*5,3%*
Medium, am. sand	16	*20,5%*	56	*71,8%*	6	*7,7%*
Small am.sand	1		3		--	
White chalk	--		3		--	
Yellow grain	8		15		--	
Section Ph. VIII						
Chaff	--		--		1	
Large am. sand	5	*10,2%*	40	*81,6%*	4	*8,2%*
Medium am.sand	1	*4%*	23	*92%*	1	*4%*
Small am.sand	--		10		--	
White chalk	--		2		--	
Yellow grain	--		--		--	
AA 13 Phase IX						
Large am.sand	19	*17,9%*	65	*61,3%*	22	*20,8%*
Medium am.sand	19	*17,3%*	76	*69,1%*	15	*13,6%*
Small am.sand	2		6		3	
White chalk	--		1		--	
Yellow grain	29	*16,2%*	125	*69,8%*	25	*14%*
X 12 Phase VIII						
Large am. sand	1		4		1	
Medium am.sand	17	*27,9%*	30	*49,2%*	14	*23%*
Small am. sand	--		2		1	
White chalk	--		--		--	
Yellow grain	8	*27,6%*	15	*51,7%*	6	*20,7%*

Table 17.

Occurrence rimshape through levels, phases Section, AA13 and X12

	Straight	Thinned	Bent outwards	Thicke-ned	Bent 2-3 cm below lip	Collar
Level 12	16 *9,2%*	4 *2,3%*	131 *75,7%*	7 *4,0%*	7 *4%*	--
Level 11	31 *14,9%*	15 *7,2%*	117 *56,3%*	15 *7,2%*	21 *10,1%*	2 *1,0%*
Level 10	26 *17,8%*	13 *8,9%*	82 *56,3%*	6 *4,1%*	10 *6,8%*	3 *2,1%*
Level 9	36 *16,7%*	15 *6,9%*	121 *56%*	6 *2,8%*	32 *14,8%*	1 *0,5%*
Level 8	32 *13,5%*	10 *4,2%*	105 *44,3%*	7 *3%*	70 *29,5%*	6 *2,5%*
Level 7	23 *17,8%*	4 *3,1%*	64 *49,6%*	1 *0,8%*	32 *24,8%*	2 *1,6%*
Level 6	9 *8,0%*	12 *10,7%*	30 *26,8%*	4 *3,6%*	52 *46,4%*	4 *3,6%*
Level 5	33 *14,2%*	20 *8,6%*	79 *34,1%*	1 *0,4%*	88 *37,9%*	15 *6,5%*
Level 4	6 *8,3%*	10 *13,9%*	13 *18,1%*	--	23 *31,9%*	3 *4,2%*
Level 3	2 *9,1%*	1 *4,5%*	1 *4,5%*	--	18 *81,8%*	--
Section Phase X	141 *14,4%*	57 *5,8%*	556 *56,7%*	41 *4,2%*	140 *14,3%*	12 *1,2%*
Section Phase IX	65 *13,7%*	36 *7,6%*	173 *36,6%*	6 *1,3%*	172 *36,4%*	21 *4,4%*
Section Ph. VIII	8 *8,5%*	11 *11,7%*	14 *14,9%*	--	41 *43,6%*	3 *3,2%*
AA 13 Phase IX	38 *11,1%*	42 *12,3%*	1	26 *7,6%*	216 *63,2%*	7 *2,0%*
X 12 Ph. VIII	15 *15,2%*	27 *27,3%*	--	1 *1,0%*	40 *40,4%*	13 *13,1%*

Table 18.

Comparison vesselshape - rimshape through phases Section, AA13 and X12

	Straight		Thinned		Bent outwards		Thickened		Bent 2-3 cm below lip	
Section Phase X										
Restr.pot	26	*9,3%*	7	*2,5%*	184	*65,5%*	13	*4,6%*	51	*18,1%*
Restr.bowl	90	*14,7%*	41	*6,7%*	366	*59,8%*	28	*4,6%*	87	*14,2%*
Unrestr. Bowl	3		1		4		--		2	
Section Phase IX										
Restr.pot	6	*9,7%*	3	*4,8%*	28	*45,2%*	--		25	*40,3%*
Restr.bowl	41	*12,0%*	20	*5,9%*	134	*39,3%*	4	*1,2%*	142	*41,6%*
Unrestr. bowl	12		7		13		1		4	
Section Phase VIII										
Restr.pot	2		--		1		--		9	
Restr.bowl	4	*7,4%*	9	*16,7%*	10	*18,5%*	--		31	*57,4%*
Unrestr. bowl	1		1		3		--		1	
AA 13 Phase IX										
Restr.pot	--		1		--		1		42	
Restr.bowl	29	*13,7%*	32	*10%*	1	*0,5%*	18	*8,5%*	142	*67,5%*
Unrestr. bowl	8	*13,8%*	12	*20,7%*	--		7	*12,1%*	31	*53,4%*
X 12 Phase VIII										
Restr.pot	1		2		--		--		10	
Restr.bowl	10	*21,3%*	15	*31,9%*	--		1	*2,1%*	21	*44,7%*
Unrestr. bowl	3		7		--		--		9	

Table 19.

Occurrence baseshape through levels, phases Section, AA13 and X12

	Flat		Plano-convex		Standring	
Level 12	5		5		--	
Level 11	14		18		1	
Level 10	20		5		--	
Level 9	14		17		--	
Level 8	18		30		--	
Level 7	6		15		--	
Level 6	7		13		--	
Level 5	10		37		1	
Level 4	3		2		1	
Level 3	2		2		1	
Section Phase X	71	*48,6%*	75	*51,4%*	1	*0,7%*
Section Phase IX	23	*24,7%*	65	*69,9%*	1	*1,1%*
Section Ph. VIII	5		4		2	
AA 13 Phase IX	2		--		1	
X 12 Phase VIII	1		5		1	

Table 20.

Occurrence handles through levels, phases Section, AA13 en X12

	Pierced knobs		Pierced flat h.		Flat handle	
Level 12	70	*61,4%*	41	*36%*	1	*0,9%*
Level 11	96	*61,1%*	57	*36,3%*	3	*1,9%*
Level 10	71	*64%*	39	*35,1%*	1	*0,9%*
Level 9	95	*60,5%*	56	*35,7%*	5	*3,2%*
Level 8	116	*58%*	76	*38%*	5	*2,5%*
Level 7	66	*72,5%*	17	*18,7%*	7	*7,7%*
Level 6	37	*77,1%*	8	*16,7%*	3	*6,3%*
Level 5	83	*77,6%*	13	*12,1%*	11	*10,3%*
Level 4	24	*68,6%*	3	*8,6%*	7	*20%*
Level 3	21	*75%*	1	*3,6%*	4	*14,3%*
Section Phase X	418	*56,6%*	269	*36,4%*	15	*2,0%*
Section Phase IX	186	*75,6%*	38	*15,4%*	21	*8,5%*
Section Ph. VIII	45	*71,4%*	4	*6,3%*	11	*17,5%*
AA 13 Phase IX	117	*67,6%*	41	*23,7%*	11	*6,4%*
X 12 Phase VIII	41	*89,1%*	2	*4,3%*	3	*6,5%*

Table 21.

Comparison handles - non-plastics through phases Section, AA13 en X12

	Pierced knob	Flat handle	Pierced flat h.
Section Phase X			
Chaff	95 *49,7%*	4 *2,1%*	90 *47,1%*
Large am.sand	92 *72,4%*	2 *1,6%*	31 *24,4%*
Medium am.sand	42 *70%*	--	10 *30%*
Small am. sand	7	--	2
White chalk	14	--	11
Yellow grain	18 *58,1%*	1 *3,2%*	12 *38,7%*
Section Phase IX			
Chaff	2	--	1
Large am.sand	44 *78,6%*	4 *7,1%*	8 *14,3%*
Medium am.sand	24 *75%*	1 *3,1%*	7 *21,9%*
Small am.sand	--	1	1
White chalk	--	--	--
Yellow grain	14	2	2
Section Ph. VIII			
Chaff	1	--	--
Large am.sand	12	4	2
Medium am.sand	11	3	--
Small am. sand	3	1	--
White chalk	2	--	--
Yellow grain	1	--	--
AA 13 Phase IX			
Large am. sand	23 *69,7%*	2 *6,1%*	8 *24,2%*
Medium am.sand	29 *74,4%*	2 *5,1%*	7 *17,9%*
Small am. sand	1	1	--
White chalk	--	--	--
Yellow grain	66 *73,3%*	5 *5,6%*	19 *21,1%*
X 12 Phase VIII			
Large am. sand	1	--	--
Medium am. sand	21	1	--
Small am. sand	--	--	--
White chalk	1	--	--
Yellow grain	12	2	2

Table 22.

Occurrence lids through levels, phases Section, AA 13 and X12

	Flat round lid	High lid
Level 12	3	--
Level 11	2	--
Level 10	2	--
Level 9	1	--
Level 8	5	2
Level 7	--	--
Level 6	--	--
Level 5	--	1
Level 4	--	--
Level 3	--	--
Section Phase X	13	2
Section Phase IX	--	1
Section Phase VIII	--	--
AA 13 Phase IX	--	7
X 12 Phase VIII	--	3

even more considerably. Level eight is also striking because of the high percentage of the group defined as "large amounts of sand". This is also the case for levels seven and six, but in the following higher levels the percentage of this group decreases somewhat (although it remains the largest group), while the percentage for the group called "medium amounts of sand" increases.

The material from AA13, which as far as its phase is concerned, coincides with the levels seven to five of the section analysed here (see, however, also Thissen 1989/1990: 83), contains a higher percentage for the group defined as "medium amounts of sand" than for the group called "large amounts of sand". For the sample taken from X12 this percentage is considerably higher. The group called "white chalk" is almost completely absent in the samples taken both from AA13 and X12.

B. Hardness

As was mentioned in the paragraph called "Methods", hardness was measured using the Mohs' scale. One may conclude that hardness number two is always the prevalent group (Table 3). In the section analysed here, there is a change after level eight; that is, the percentage of material with hardness number three increases and the percentage of the group with hardness number two decreases. In both AA13 and X12 there is a higher percentage of samples with hardness number three than in the levels seven to three of the section discussed here. This, however, is not a notably large difference.

A comparison with the non-plastics (Table 4) indicates that the percentage of hardness number three for almost all the material in the non-plastic group called "large amounts of sand" is higher than in the other groups. This result may have been caused by the particular method used to measure the hardness. That is, it was measured on the surface of the sherd. The grains of sand which were present in the sherd may thus have influenced the test results (see also Schneider 1989: 11, 22).

C. Thickness of the wall

For the analysis of the thickness of the wall, four different groups of thickness were distinguished:

1. smaller than 4 mm
2. between 4 and 7 mm
3. between 7 and 10 mm
4. larger than 10 mm

In all phases (Table 5), the group which occurs most frequently is group two, followed by group three. One can, however, observe a change in the section before level eight. In the levels twelve to ten, the percentage for group two is lower than for the levels nine to three (see also below). For the sample taken from AA13, the percentage for group two (and group one) is considerably higher than for the levels seven to three taken from both X12 and the section.

From a comparison with the non-plastics (Table 6) it is clear that there is a relationship between the presence of chaff and the thickness of the wall. In this group, the percentage for group three is higher than in the other groups. This may be caused by the fact that, because fibrous organic material had been added to the clay, scraping of the wall (see "Technique" p. 27) was more difficult than with clays where mainly fine mixed sand occurred.

Generally speaking, the group containing large amounts of sand has a somewhat thicker wall than the group called "medium amounts of sand". This is not illogical because finer sand enables the potter to produce a thinner wall.

The group called "yellow grain" does not seem to have a regular pattern. This may be caused by the fact that the combination with other non-plastics is also irregular.

D. Colour of the inner and outer surface

The colour of the inner and the outer surface as well as of the core was determined by using the MSCC. On the basis of this, some fifteen colour groups were hypothesised. The actual analysis, however, resulted in less than fifteen different colour groups. The most prevalent groups are (not given here in the order of actual occurrence):

1.	Black	(10R-10Y 2-5/0-1)
2.	Light Grey	(10R-10Y 6-7/0-1)
4.	Light reddish brown	(10R-2,5YR 6/2-4)
5.	Light brown/pink	(5YR and yellower 6-7/2-4)
6.	Dark reddish brown	(10R-2, 5YR 2-5/2-4)
7.	Dark greyish brown	(5YR and yellower 2-5/2-4)
12.	Mottled brown/black (group one and seven)	

Groups 10 and 11 occur only as core colour.

10.	Dark red	(10R-2,5YR 2-5/6-8)
11.	Dark yellow	(5YR and yellower 2-5/6-8)

In the whole section, group seven (dark greyish brown) is the most prevalent colour (Table 7). After level eight there is a rather strong decrease in the percentage of this colour group, whereas the percentage for group twelve (mottled brown/black) increases. This was found on both the inner and the outer surface.

The sample taken from AA13 gives a completely different picture. Here, the highest percentage is found for group one (black), followed by group twelve (mottled brown/black) and only then do we find group seven. Again, this is the case for both the inner and the outer surface. In X12 the mottled colour category is almost completely absent. Here group seven is the most prevalent, followed by group one. It is striking to note that the percentage for black on the inner surface is somewhat lower than on the outer surface.

Although, generally speaking, there is little similarity between the section, AA13, and X12, a comparison with the non-plastics (Table 8) indicates that the occurrence of "yellow grain" results in a higher percentage for the colours black or mottled brown/black for all phases, including AA13 and X12. This is caused by the reducing firing atmosphere which was used (see "Macroscopic analysis", p. 23).

For phase X the presence of chaff results in a somewhat higher percentage of sherds with a uniform, black surface but a relatively low percentage for the mottled brown/black surface. This phenomenon could not be explained.

E. Colour of the core

Black is the most prevalent colour found in the core for the whole of the section (Table 9). The percentage seems to decrease slightly after level eight but this does not result in a higher percentage of another colour. In both AA13 and X12 the percentage for a black core is higher than in samples from the section. In AA13 and X12 it is more than fifty percent. Apart from that, however, X12 shows a fairly high percentage of completely oxidised cores (groups ten and eleven, which add up to more than twenty-five percent). This was not found in the section, nor in AA13.

A comparison (Table 10) indicates that for phase X, where chaff is frequently found, a black core occurs much more often than with other groups (sixty-five percent compared to thirty-five to forty percent).

This was to be expected, because the added fibrous substances will be carbonized during the firing process. For the group called "medium amounts of sand" the percentage of black cores, in the phases IX and VIII of the section as well as in AA13 and X12, is higher than for those of the group called "large amounts of sand". In none of the samples analysed was there a higher percentage of black core for the group "yellow grain" than in the other groups, which is contrary to what was found on the outer surface of the sherds. This, however, was to be expected because the colour of the outer surface is determined by the reducing atmosphere during firing which does not necessarily result in a black core.

There does not seem to be a clear relationship between the thickness of the wall and the colour of the core, nor is there a clear relation between the colour of the surface and the colour of the core.

F. Surface finish

Seven different types of surface finish were distinguished:

1. smooth
2. rough
3. low/middle shining burnish
4. high shining burnish
5. added slip layer
6. self slip, smooth
7. self slip, burnished

Groups five, six, and seven occurred only sporadically. They were therefore not included in the present analysis.

For the samples taken from the section (Table 11), the percentage of group three for the exterior surface finish was invariably high (more than 90 percent), from level seven this even increases. For the interior surface finish, the percentage of group three increases after level seven onwards. The percentages of group three in the samples taken from AA13 are somewhat lower than those of the section, but those from group one are somewhat higher. The percentages found in the samples taken from X12 differ very strongly from those taken from the section. As far as the interior surface finish is concerned, group one is even somewhat larger than group three.

It must be stated, however, that, in general, the burnish gloss of the material from the section was low. As a result, it was not always easy to distinguish between smooth and low burnish. These results depended on light conditions and residus of dust on the skin of the surface.

As was to be expected on technological grounds, one can observe a certain relation (with the exception of phase IX from the section) between the shape of the pottery and the finish of the surface on the inside (Table 12). Although low burnish is the most prevalent group, the restricted pot has a smooth inner surface fairly frequently, whereas this feature occurs less frequently with unrestricted bowls.

There appears to be no obvious relationship between surface finish and the amount of non-plastics (Table 13). For phase X of the section the percentage of the category "smooth" for both the groups called "chaff" and "large amounts of sand" is somewhat higher than in the other groups. Whereas, generally, for the groups "medium amounts of sand" and "yellow grain" the percentage of low burnish is somewhat higher than in the other groups. Those groups which contain reasonable amounts of white chalk almost always belong to the low burnish group. Note that both chaff and large amounts of sand create difficulties for the burnishing process; in order to obtain a reasonably satisfactory result the pot would first have to be provided with a layer of slip.

G. Shape

The shapes of the objects could be determined from a number of the sherds analysed. These were as follows: 1708 (56.9%) of the samples taken from the section; 334 (63.5%) taken from AA13, and 101 (61.1%) of the samples taken from X12.

Although the restricted bowl is the shape which occurs most frequently for the whole of the section, there is an obvious change from level eight onwards (Table 14). From level eight onwards the percentage of restricted pots decreases from approximately thirty percent to nineteen percent or lower. The percentage of restricted bowls increases from approximately sixty-five percent to seventy-five percent, whereas at this point the unrestricted bowl is introduced (increasing upto a maximum of approximately 8.5 percent).

The distribution differs in both AA13 and X12 from those of the levels seven to three of the section. The percentage of restricted bowls in AA13 is lower and the percentage of unrestricted bowls is higher. In X12 the percentage of both restricted pots and unrestricted bowls is higher than for those taken from the section. The percentage of restricted pots, however, is lower.

As hardly any complete pots were found, the best method for discussing the size of the pottery is by referring to the diameter of the rim. In total some seven groups were distinguished, with diameters between: zero to five cm, five to ten cm, ten to fifteen cm, etc. Group seven (thirty to thirty-five cm) was not found in the samples discussed here. The determination of the diameter was, however, not always possible. Small fragments of the rim, for example, may be the cause of too large a margin of error, whereas determination of the size of the diameter with the very frequently occurring oval rims was often difficult.

A comparison of the diameter groups and the shape of the vessels indicates that (Table 15) groups three (ten to fifteen cm) and four (fifteen to twenty cm) are the most prevalent. In the samples of the section, however, there is a change after level seven. In phase X the percentage of group three is highest for all pot shapes, whereas in all other phases including AA13 and X12 group four is the most frequent. Groups two and five only occur in fairly low frequencies. Groups one and six occur only sporadically.

There appears to be no apparent relationship between the use of certain groups of non-plastics and the shape of the vessels (Table 16). In phase X the percentage of restricted pots for the group called "chaff" is somewhat higher than for the groups containing large and medium amounts of sand. This is also the case for the relatively low number of occurrences of groups containing small amounts of sand and those containing white chalk.

H. Rim shapes

As was mentioned previously, some eight different rim shapes were distinguished. The eight shapes were specified in more detail during the notation of the shapes, but were then combined again for the actual analysis. The different shapes are:

1. straight
2. bent outwards immediately below the lip
3. thinned
4. thickened
5. bent outwards some two to three cm below the lip
6. collar
7. ledge
8. rolled lip

Groups seven and eight occurred sporadically and were not considered in the present analysis.

It is obvious that the shape of the rim which was bent outwards occurs most frequently (Table 17), even if groups one, three, and four are joined together. One may observe a change, however, from group two to group five. Of all the shapes that could be distinguished, group two occurs most often in level twelve. The percentage of group two then decreases but is always (also in the absolute sense) the most prevalent in levels eleven to nine. The percentage decreases further, although it is still highest in levels seven and eight. In the following levels it decreases even further. From level six onwards, group five occurs most frequently. In AA13 just one sherd was found which belonged to group two, no sherd belonging to this group was found in X12. The percentage of group five was high in AA13 (63%), but somewhat lower for X12 (40%). Furthermore, X12 contains a relatively high percentage of group six.

There proves to be a certain relationship between the shape of the vessel and the shape of the rim (Table 18). It is clear that for all phases (including AA13 and X12) the percentage of restricted pots with a rim that was bent outwards is considerably higher than that for restricted bowls with a rim which was bent outwards. For unrestricted bowls this percentage is lower. This may be the result of the production method which was used (that is, when the vessel is built up using coils of clay the tendency arises to widen the higher section of the pot), but it is also possible that it is the result of a certain sense of shape.

I. Base shape

Four different shapes were distinguished:
1. foot
2. straight/flat
3. rounded
4. flat/concave

Group one only occurred sporadically. The complete sample contained relatively few bases, the sample from the section contained 251 (8.4%) base fragments, those from AA13 contained three of these (0.6%), and X12 seven (4.3%). One cannot exclude the possibility that the plano-convex shapes of the base (group three) were the most prevalent and that fragments of these were not always recognised as being base fragments and were thus categorised as being sherds from the wall. This almost seems to be acknowledged by the fact that in both AA13 and X12 group three is virtually completely absent, whereas the base shapes which were found belong either to group one or two. Consequently, the results of the analyses relating to the fragments of the bases are of limited value.

Although the results of this analysis (Table 19) may be called doubtful, it seems as if from level eight onwards there is a shift from group two to group three. The number of base shapes which were also analysed for non-plasics is too small to state anything conclusive about a possible relationship between the use of non-plastics and the shape of the base.

J. Handles

Of all the different types of handles which were described above, the pierced knobs and the (pierced or non-pierced) flat handles occurred most often. The pierced knob is the most prevalent in the whole section (Table 20). One can observe, however, an apparent change at level seven. From level seven onwards the percentage of this type of handle increases as does the percentage of flat handles, while the percentage of pierced flat handles decreases. The samples taken from AA13 differ somewhat in this respect (the samples contain a lower percentage of pierced lugs), whereas X12 showed a remarkably high percentage of pierced knobs.

A comparison with the non-plastics (Table 21) indicates that in all the phases, and for almost each group of non-plastics, the ratio between pierced knobs and (pierced) flat handles has a minimum of two to one, whereas the proportion is one to one when the object contains chaff. This relation must be one of the most important causes for the observed change described in the paragraph above.

K. Lids

Fragments of lids were found throughout the whole sample, although the total number of lids in the sample analysed was not large. Two types

can be distinguished:
1. The flat round lid, which has the shape of a disc and may be provided with four holes near the edge, set in a rectangle (Fig. 16a).
2. The "basin" shaped high lid. In most cases this sort of lid is produced with four small delicately pierced lugs on the bend carination of the rim (Fig. 16b). This type may also have decorations.

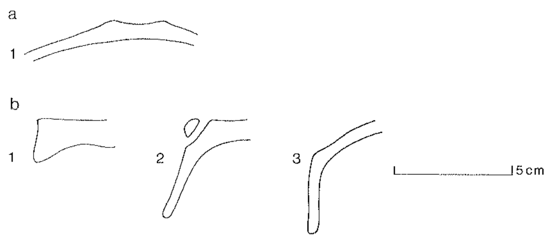


Fig. 16. Lids: a. flat round lid; b. "basin" shaped high lids.

What seems to have occurred is that the type one lid was eventually replaced by the type two lid (Table 22). Furthermore, the lids do not seem to be related to a certain category of non-plastics. The group of flat lids occurs in the "chaff"-group as well as the groups containing small, and medium amounts of sand, and in the "yellow grain"-group. High lids occur in the three different groups of sand as well as in the group containing yellow grain (both high lids from level eight in the section were not examined for non-plastics).

L. Sieves

Fragments from sieves and colanders were found throughout the sample analysed. These are fragments from pots which had been pierced in order to produce small holes, placed closely together (see also "Technique" p. 27).

Most of the sieve fragments described here (Table 1) were not analysed for non-plastics. Those fragments which were analysed indicated that there is a relation between the non-plastics and the sieves. Of the twenty-one sieve fragments which were analysed, sixteen belonged to the group containing large amounts of sand, four belonged to the "medium"-group, and one belonged to the group called "yellow grain".

M. Decorated pottery

Although this investigation was mainly concerned with pottery which had not been decorated (basically because the number of decorated sherds from these phases was small), those sherds which showed decorative aspects were included in the analysis.

Sherds taken from the deepest levels of the section showed various decorative aspects, mainly plastic decorations (pellets and "U"-shaped appliqués were found in a total of twelve fragments). One sherd from level seven had incised decoration. In AA13, eleven decorated fragments were found (which were decorated using incisions, impressions of the fingernails, and appliqué). The samples taken from X12 contained ten fragments, most of which were decorated with incisions (amongst others fingernail impressions) (Fig. 17).

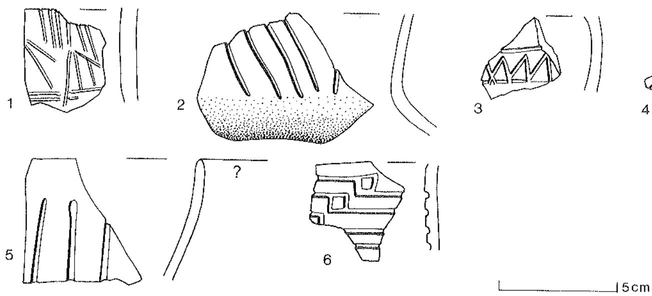


Fig. 17. Decorated sherds.

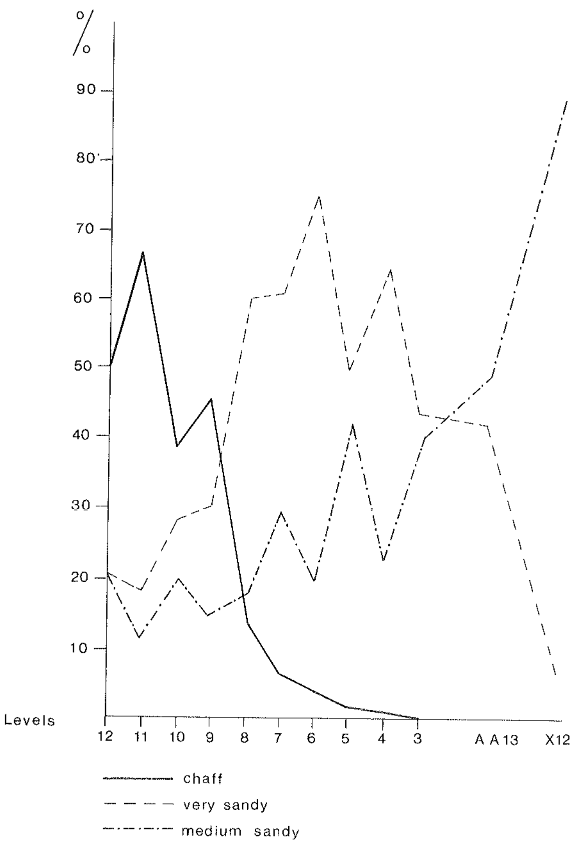
Discussion

In the section analysed here one can observe a certain development. One must conclude, however, that, contrary to what was expected, it is not possible to indicate an apparent caesura in the samples. At the onset of the investigation it seemed as if there would be a change after level eight, which is the burnt layer. There is indeed a sharp decrease in the amount of chaff after this level, until eventually it disappears completely, but it must be stated that a strong decline in the "chaff"-group already occurred before level seven. In a number of cases, other changes which were noted occurred in previous levels, and were most prominant in level eight itself.

Contrary to what was expected, the results from the analysis of AA13 cannot be reconciled with the results from the levels seven to five from the section. Similarly, the results from X12 cannot be reconciled with those of levels four and three. This is less striking for the latter category, because from the beginning it was not at all obvious that these levels indeed coincided with X12, because it was suspected that certain contaminations were present. How the X12 samples can be fitted in with the other results can only be concluded after the results from the material analysed in 1990 become available. The 1990 material contains samples from building phase VIII which consisted of considerably more fragments than the number of samples from X12 which were analysed in 1989.

The differences between AA13 and "phase IX" of the section are remarkable. Either the development of building phases and pottery phases do not run parallel, or there is another cause for the discrepancy. A large part of the material from AA13 was taken from a habitation area, contrary to levels seven to five of the section. It will be obvious that the character of the pottery can also be determined by the nature of its use. This may well have been different between the two areas.

One can, however, not exclude the possibility that AA13 belongs to a different phase than levels seven to five from the section. After all, at first one assumed that the area where the section was found had been abandoned for some time after the fire, which caused level eight to be deposited, had occurred (Roodenberg 1989/1990: 76). The analysis of the pottery gives us reason to doubt this assumption. One of the arguments of the original theory was the disappearance of chaff from the pottery. As was mentioned above, the analysis indicated that even before the fire there was a sharp decrease in the amount of chaff, whereas chaff had only completely disappeared from the sample material in level three. Even if one maintains the assumption that the low percentage of the chaff-group in the higher levels is caused by vertical movements of the sherds, one can still not deny the gradual decrease of the percentage of the chaff-group from levels eleven to eight (Fig. 18).
One explanation for this might be the following.



As was mentioned in the paragraph "Macroscopic analysis" (p. 23), the Skibo, Schiffer, and Reid-theory (1989) stated that the use of organic material could be a feature of transitory settlements. One might conclude from this that the first settlement at Illipinar was either built by people which, upto that time, had had a transitory life style, or that this first settlement itself still had a transitory character. Whatever may have been the exact cause, the settlement was soon given a permanent character. Pottery manufacturing techniques only gradually change and this may explain why the habit to mix the clay with chaff continued to be in use for some time. In due course, however, this method was no longer applied; perhaps because it was much easier to use sand during the production phase. It is simple to mix the clay with sand, whereas it is much harder to

Fig. 18. Non-plastics groups through the levels of the section and in AA13 and X12.

mix clay with dry chaff. In order to properly mix the chaff with the clay, water must be added, and if care is not taken, lumps are created. One other reason may be that the potter tried to produce a product with a lesser degree of porosity.

When considering the other gradual changes, it is clear that the most notable is the slow change in shape types. The analysis has indicated that this is not directly related to the absence of the chaff-group. A possible cause may be the gradual change in the use of the pottery. The change, however, is too slow for it to serve as a phase boundary.

Consequently, resulting from the analysis of the pottery discussed here, there are no clear indications within this sample for any discontinuation. The gradual changes which occur in the pottery coincide with the changes which were noted in tools made from bone or rock (Roodenberg 1989/1990: 69). This does not make the task of relating both pottery phases and building phases any easier. A certain continuity in the section as far as the artefacts are concerned does not immediately exclude the possibility that there, indeed, are two or more building phases in the section. AA13, stratigraphically speaking, cannot be directly linked to either the section or X12/X13; although the excavator assumes that the remains of the buildings which were excavated from AA13 belong to building phase IX, immediately preceding the buildings from X12/X13 (Roodenberg 1989/1990: 71, 76). Possibly this conclusion was based on C14 datings. Going deeper into block WXY/12-13 will hopefully render more insight into the way in which pottery phases and building phases can be related to each other.

Notes

1. The investigations were carried out between 11 May and 11 June 1989 at the excavation house of the Ilipinar expedition at Gölyaka, and they were financed by the Foundation for Archaeological Research (ARCHON) which is part of the Netherlands Organization of Scientific Research (NWO). Staff members working on the project were: Dr. A. van As, A.E.A. van Driel, L. Jacobs, E.P.G. Mulder, M.J. Paus, and Dr. M.-H. Wijnen.

2. The analysis of these thin sections was carried out by Dr. C. Overweel.

3. The macroscopic identification was carried out by comparison with rock fragments and simple tests, such as the hydrochloric acid test.

4. It is virtually impossible to distinguish between pieces of iron and grog using a macroscopic analysis (Schneider 1989: 25).

References

As, A. van and M.-H. Wijnen (1988), An exploratory visit to Ilipinar, Turkey. *Newsletter Department of Pottery Technology Leiden* Vol.6: 41-46.

Roodenberg, J., C. Thissen and H. Buitenhuis (1989, 1990), Preliminary report on the archaeological investigations at Ilipinar in NW. Anatolia. *Anatolica* XVI: 61-144.

Schneider, G. (ed), (1989), Naturwissenschaftliche Kriteria und Verfahren zur Beschreibung von Keramik, *Acta Praehistorica et Archaeologica* 21: 25.

Skibo, J.M., M.B. Schiffer and K.C. Reid (1989), Organic-tempered pottery: an experimental study, *American Antiquity*, Vol.54, no.1: 122-146.

A. van As
M.-H. Wijnen

THE POTTER FROM ÖRNEKKÖY (TURKEY) - SOME OBSERVATIONS*

On June 10, 1989 and June 3, 1990 the authors visited the potter in the village of Örnekköy near Ilipinar Hüyük as part of their research on Neolithic and Chalcolithic pottery found at Ilipinar (see this edition of the *Newsletter* p. 21), in order to obtain more information about the quality of the local clay. Presently, we will list some observations which we made during these visits.

Ahmet Öztürk is sixty-three years of age and was born in the important potters' town of Konya. Here, his father and grandfather before him also followed the same profession. Ahmet started working in his father's pottery when he was eight years old. In 1945, when he was eighteen years of age, Ahmet left for Örnekköy for reasons of accomodation. There, he set up his own pottery where he is still working today, together with his son and daughter-in-law.

Ahmet is the only person who can actually throw the pots. He does so using a kick wheel. He is used to sitting somewhat next to the wheel at an oblique angle (Fig. 1). He will throw the small and medium sized shapes from one piece of clay. The large jars are produced in stages. In

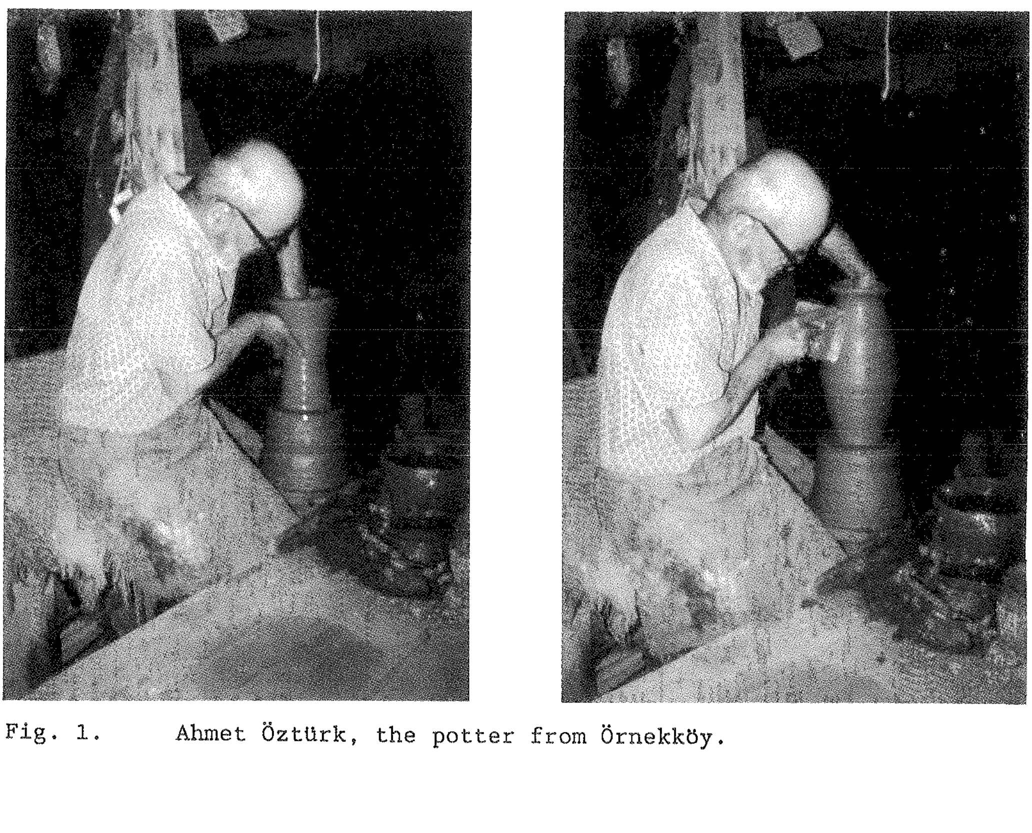
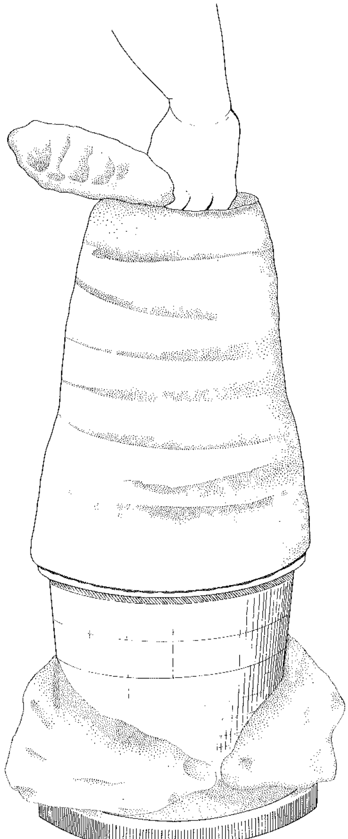
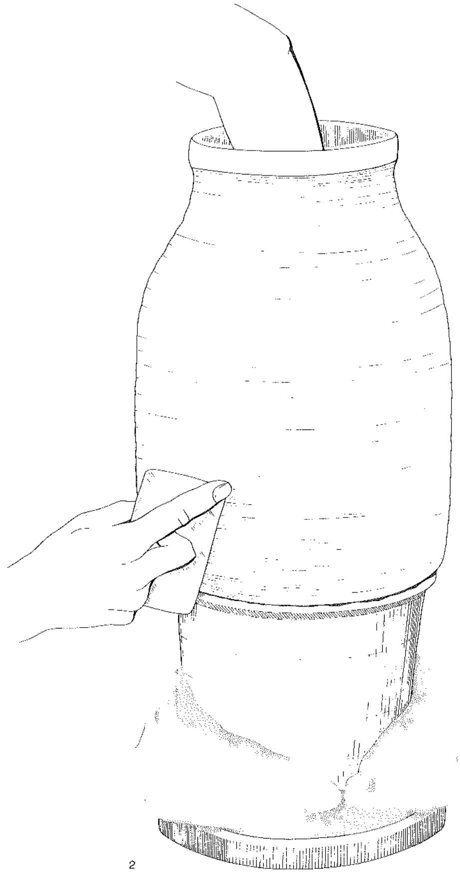


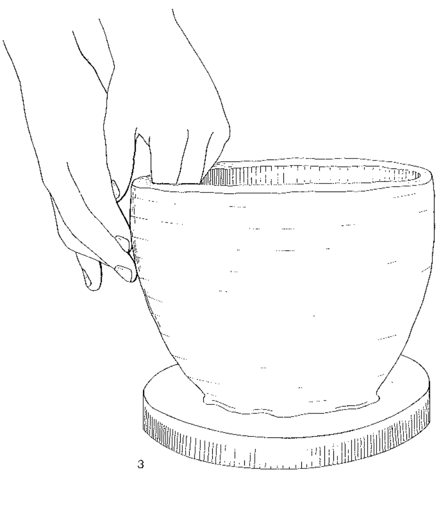
Fig. 1. Ahmet Öztürk, the potter from Örnekköy.



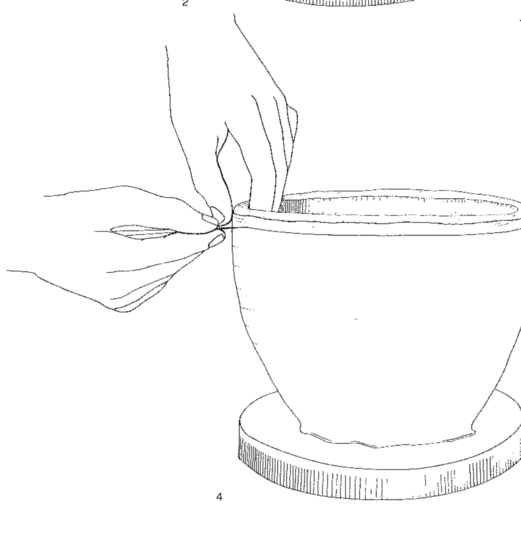
1



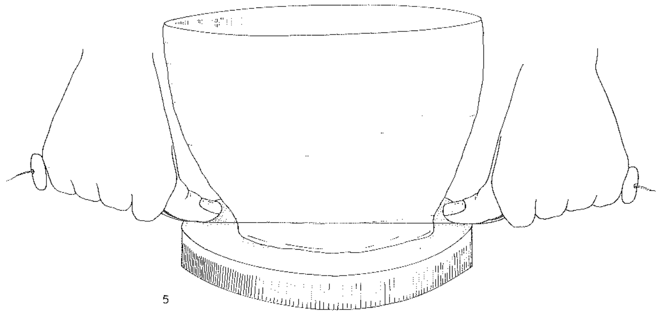
2



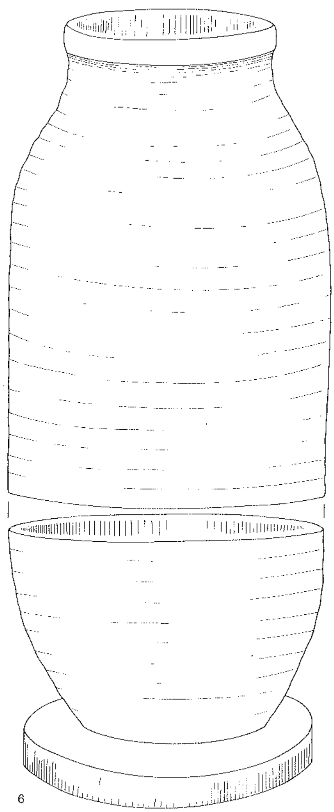
3



4



5



6

Fig. 2. Throwing large jars in stages.

1,2. Throwing the upper section.
3-5. Throwing the lower section.
6. Sticking the two sections together.

order to do this, Ahmet will first place a bowl on the wheel. He will produce the upper section of the jar using coils of clay (Fig. 2: 1). The coils are fixed together by spreading the clay making vertical movements with his hands. Next, he will quickly finish this section while turning the object and subsequently shaping the rim (Fig. 2: 2). When this has been completed, he takes the upper section of the jar away from the bowl and leaves it to dry. In the mean time he will throw the lower section of the jar (Fig. 2: 3-5). When both sections have dried sufficiently, he will stick them together (Fig. 2: 6).

The pottery is fired in an up-draught kiln. The entrance to the actual fire chamber is situated on the outside of the workshop. The pottery chamber, in the shape of a beehive, is three meters square and two meters high (Fig. 3). The pottery is stacked into the kiln from inside the workshop. Ahmet uses both wood and olive seeds to make the fire. One load of wood will keep the fire burning for approximately five hours.

Ahmet uses local clays in order to produce the pottery. These can be used without any temper being added. Before the clay is kneaded, it is rolled in a machine in order to break the more coarse, non-plastic particles, which are always present in natural clays, into smaller particles (Fig. 4). The clay is stored next to the pottery workshop. Although, according to Ahmet, all clay sites in the immediate vicinity are suitable to make pottery, Ahmet prefers clay taken from one specific site not far from Ilipinar Hüyük (Fig. 5). The owner of the site, whom Ahmet introduced to us, indicated that the top layer of the clay is very calciferous and therefore not suitable to be used for the production of pottery.

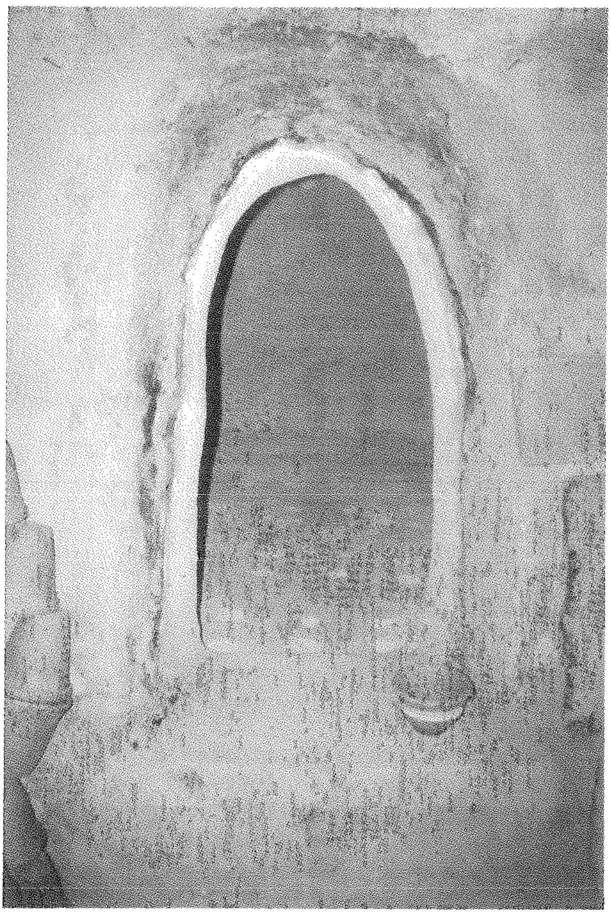


Fig. 3. The pottery chamber of the up-draught kiln.

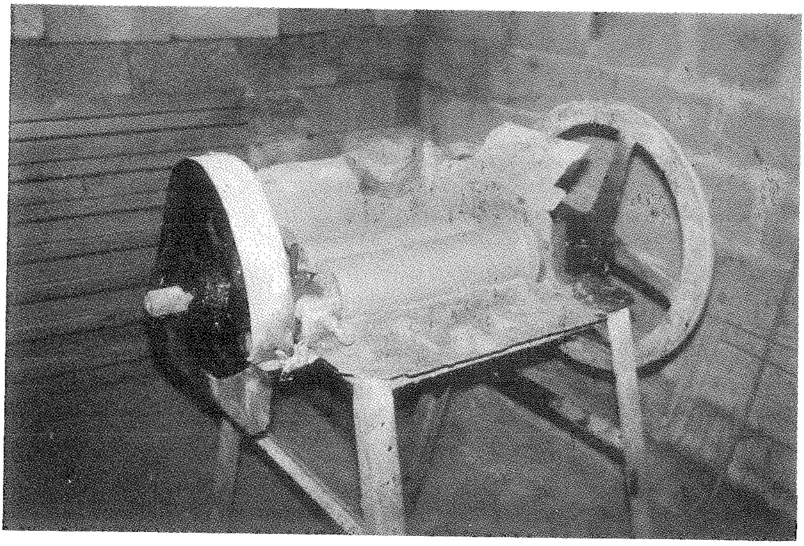


Fig. 4. A machine in order to break the more coarse, non-plastic particles in the clay.

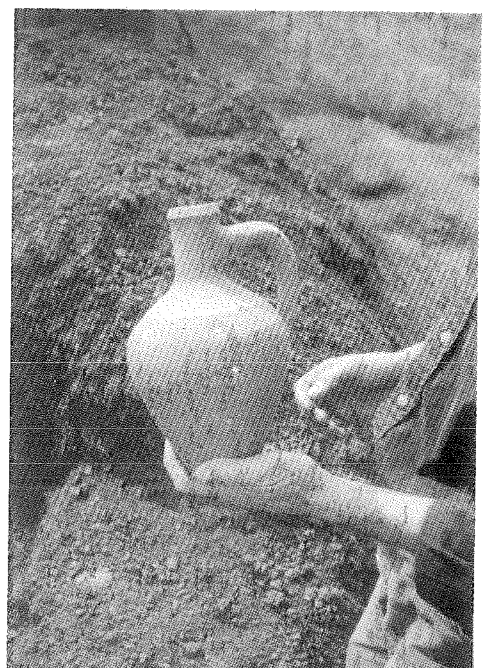


Fig. 5. Clay site in the immediate vicinity of Örnekköy.
Fig. 6. Water jar which contains small particles of limestone.

Because of the occurrence of coarse particles of limestone, the pottery would, after all, soon crack (see also p. 24). On top of that, according to Ahmet, the top layer contains a large amount of plant roots etc. This is the reason why Ahmet Öztürk prefers to take his clay from the deeper layers. In Ahmet's workshop we found a number of water jars which contained small particles of limestone. The skin of the wall was indeed cracked where these particles occurred (Fig. 6). According to Ahmet this had been a mistake. The clay, which had been mixed with very calciferous material, was not to have been used to produce pottery.

For decorative purposes, instead of the local clay, Ahmet uses a white baking clay from Kutaya (Fig. 7). One part of the pottery produced by Ahmet and members of his family is sold to a middleman from Istanbul who frequently comes to Örnekköy to collect a batch. Another part is sold at the market in nearby Orhangazi. It is hard labour and earnings are low.

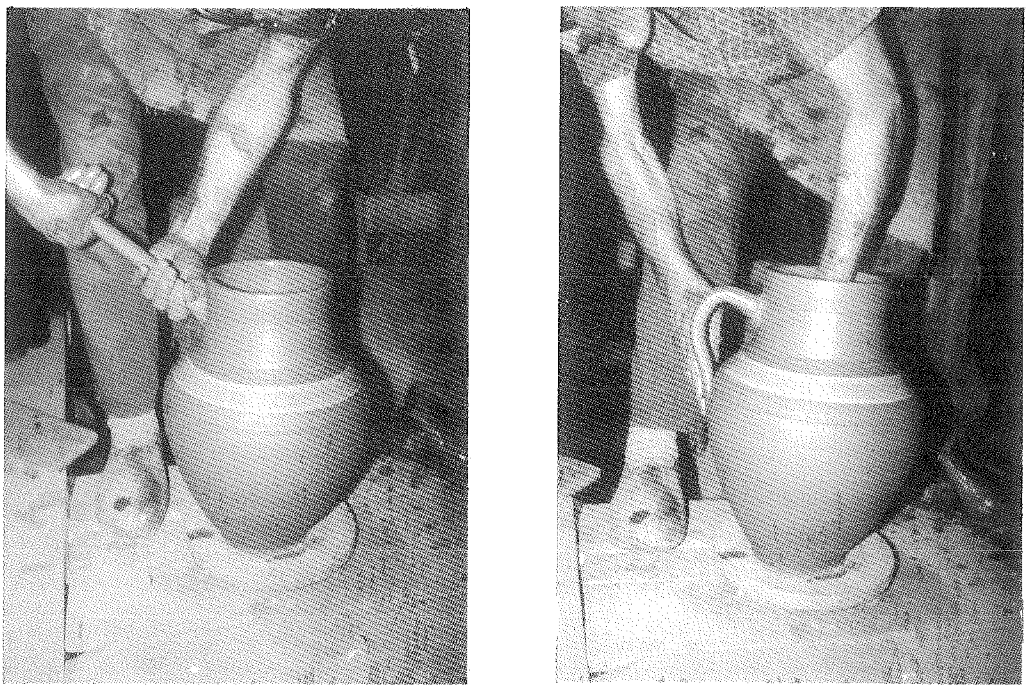


Fig. 7. Attaching a handle on a jar decorated with a white-baking slip.

* We wish to thank L.C. Thissen who acted as interpreter during our visit to Ahmet Öztürk.

M. Beatrice Annis
L. Jacobs

COOKING WARE FROM PABILLONIS (SARDINIA): RELATIONSHIPS BETWEEN RAW MATERIALS, MANUFACTURING TECHNIQUES AND THE FUNCTION OF THE VESSELS

Contents

I THE INVESTIGATION

1 Introduction

The place occupied by Pabillonis in the traditional ceramic production of Sardinia (Fig. 1) between the 1920s and the 1970s[1] was that of a production centre specializing in the manufacture of cooking pots. The term 'specialization' seems to be applicable to this centre and its production in more than one way. When a concept with several implications is used to define a production, as is the case with 'specialization' (Brumfield and Earle 1987: 1-9), distinctions should be made. As Prudence Rice has correctly suggested (1981; 1987: 180-191; 1989), in order to define and archaeologically identify craft specialization, one should at least distinguish "site specialization", "producer specialization" and, in the case of ceramics, "resource specialization".

The fact that Pabillonis was the only village on the island where cooking vessels were manufactured justifies the use of the term "site specialization" to define the production of this centre. The kitchen ware made in Pabillonis was famous all over Sardinia - in the first place for its resistance to thermal shock, but also for its light weight and practical shape. On the island, the village was better known by the appellation *sa bidda de is pingiadas* (the pan village) than by its proper name. This unique position had consequences for the scale of the production, that is, the amount and kind of pottery made, and, above all, for the ratio of the number of producers and the number of consumers, both of which are important criteria for determining whether it is justified to use the term specialization in defining a production (Rice 1989).

The organizational form of the production of Pabillonis was a "rural workshop industry" (Peacock 1982: 38-43); distribution was entirely in the hands of middlemen. The potters were independent part-time specialists: they worked all the year round, seasonal fluctuations in their outputs being due to climatic conditions and the farming activities practised besides pottery making. The poor soil and the archaic cultivation methods employed in this part of Sardinia were responsible for the meagre harvests; pottery production was therefore quite important for the economy of the village. For the potters it was a supplementary but irreplaceable source of income (Annis and Geertman 1987).

The resistance to thermal shock of the vessels was generally attributed to the properties of the raw materials[2]. According to the producers and the distributors - of Pabillonis but also of other centres on the island - it was essentially the peculiar properties of the combination of clay and temper used that made the products of this village so unique: we could be dealing with a case of "resource specialization" here (Rice 1987: 191; 1989).

It is this particular aspect that is the subject of the research discussed on the following pages. The aim of the technological analyses which were carried out according to the usual methods of the Institute for Pottery Technology (van As 1984), was to investigate the properties of the raw materials from a potter's point of view and to establish the relation

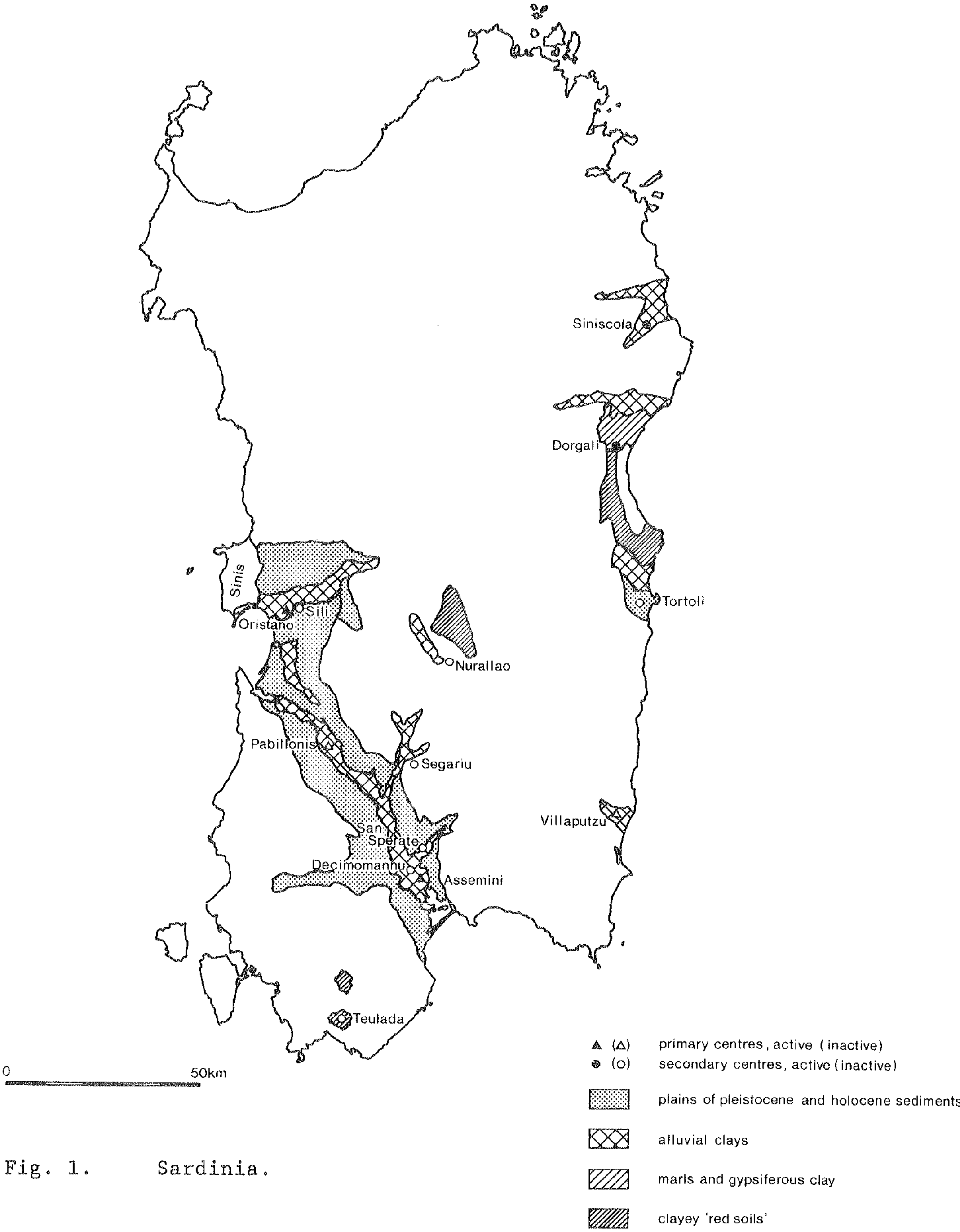


Fig. 1. Sardinia.

ships between these properties, the manufacturing technique and the function of the product. We were particularly interested in finding out whether the materials used at Pabillonis indeed possessed the 'special' qualities attributed to them. Because if this were the case, it would mean that some factor connected with the physical environment was largely responsible for the village's monopoly position in Sardinia as a production centre of cooking pots. The ethnographical and archaeological literature discusses several examples of production centres where the presence of raw materials with exceptional properties has been decisive - although never solely responsible - for the centre's specialization (see for example Shepard 1965; Arnold 1971; Bishops and Rands 1982, quoted by Rice 1989; Peacock 1982: 79-80; Child 1988).

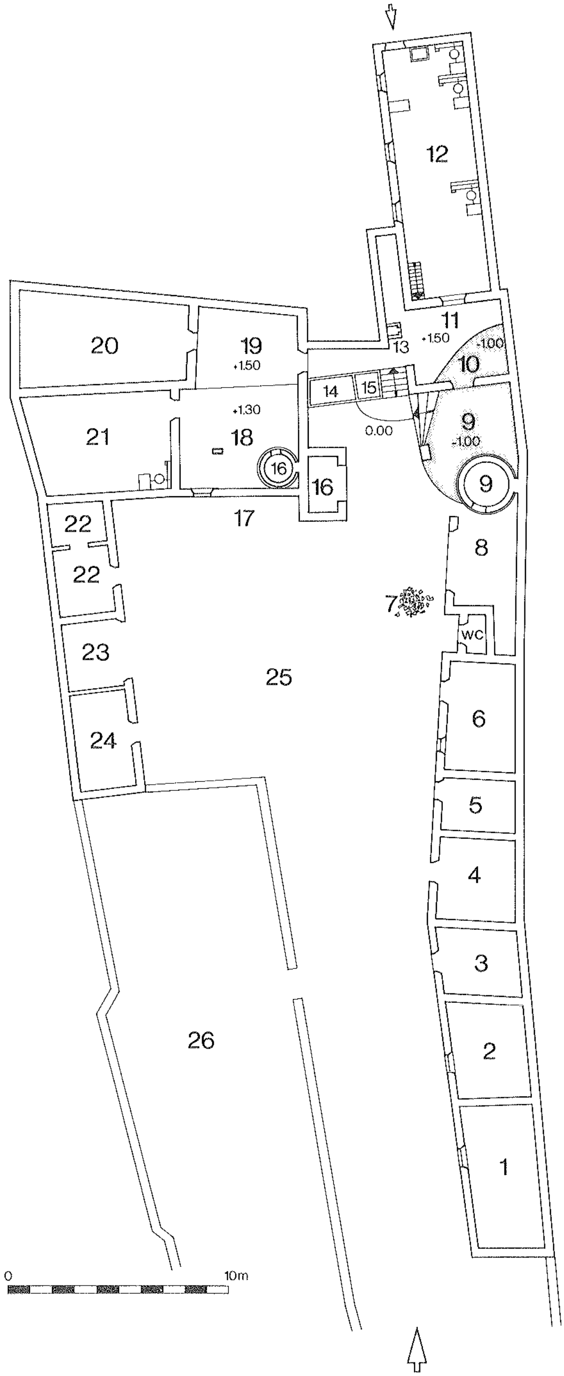
2 Ethnographical documentation

We visited Pabillonis for the first time in 1980, seven years after the traditional production of cooking pots had come to an end. In 1973 the last potter, the owner of a small workshop where he had worked alone, had abandoned the craft. The information provided on the ceramic production in the present article and in previous publications is largely based on oral information and, to a lesser extent, on a few written sources and on material remains[3].

As for this last aspect, during our investigations we made a discovery which has been of fundamental importance for the technological research discussed below. In search of traces of the extinct production we discovered that one of the two main workshops of the village had remained almost intact since it was abandoned in 1968. We found ourselves in a semi-archaeological situation. All the equipment was still *in situ* and, in addition to complete and broken pots, we found prepared clay (samples of which were examined in our analyses) and all the ingredients required to prepare the glaze. Only a few of the several rooms of the workshop (which was built of mud bricks) had been damaged when part of the roof had collapsed (Figs. 2; 3; 4). We also found the administration files of 1930-1953 of this workshop, which in its most active period had four wheels and two kilns. The files in question have been discussed in a previous article (Annis and Geertman 1987).

II TECHNOLOGICAL ANALYSIS

The information obtained at Pabillonis was not conveyed to Loe Jacobs, who in reconstructing the manufacturing technique and analysing the clays and tempers based himself exclusively on the samples. It was decided not to familiarize him with the data gathered in the ethnographical research so as to avoid influencing him. This approach, we hoped, would also enable us to assess the efficiency of the methods used in an archaeological situation.



Legend:
1. 'house of the earth for soaking'
2; 3; 5. rooms for farming equipment
4. store of fired vessels
6. 'house of the earth for crushing'
7. heap of sherds and discarded pots
8. room for glazing
9. large kiln
10. basement (store)
11. storage of fuel
12. workshop with three wheels
13. oven for baking bread
14. water tank
15. well
16. small kiln
17. storage of fuel
18. drying room
19. room for glazing and drying
20. equipment for vine growing and wine production
21. workshop with one wheel
22. pigsty
23; 24. stable
25. courtyard
26. vegetable garden

Fig. 2. Pabillonis, plan of the abandoned workshop.

Fig. 3. Pabillonis, abandoned workshop, from right to left: room for glazing (8), large kiln (9), storage of fuel (11); entrance to the workshop (12).

1 **Sherds**

1.1 The samples

The sherd research was carried out under the conditions of an archaeological investigation: it was assumed that there was only a limited number of samples available from which conclusions regarding the manufacturing technique and the properties of the raw materials could be drawn. The investigated sherds came from the production centre and from a few places in the distribution area. The bottom of sherd No. 4, a virtually complete pan which was found in a village approximately 70 km northwest of Pabillonis, shows signs of secondary reduction, extending up to the core of the sherd in places. There are still patches of soot at the surface. The pot also shows signs of use on the rim and inside the pot, on the bottom. Other sherds of the collection show similar patches of soot and signs of use.

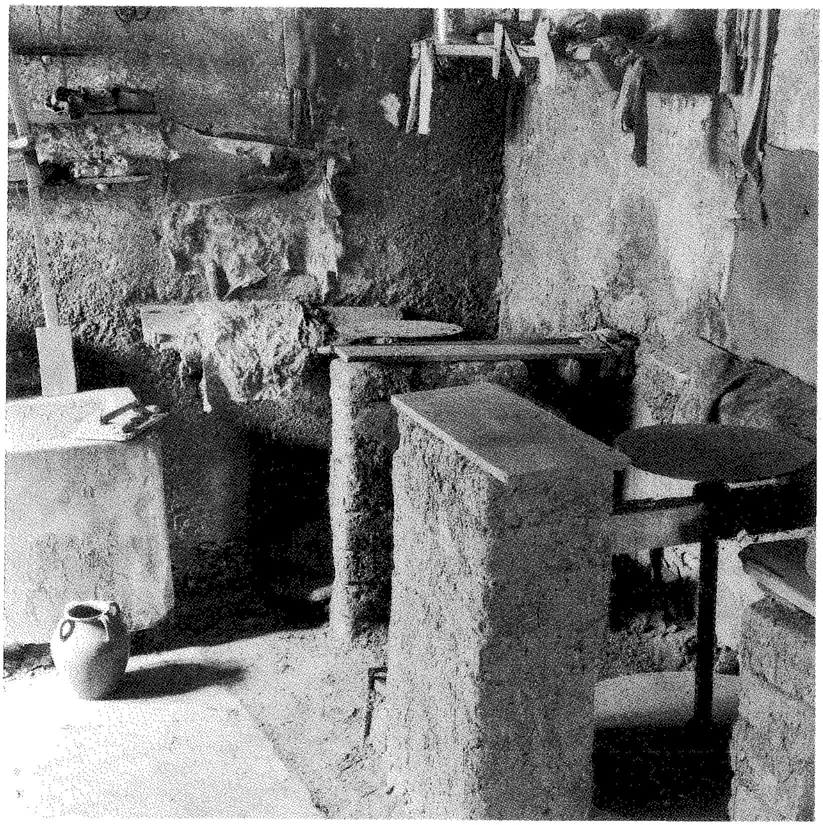


Fig. 4. Pabillonis, abandoned workshop, room 12: two of the three wheels and wetting tank.

1.2 Fabric

1.2.1 Macroscopic description

The pots were made of an iron-bearing clay and had been fired in an oxidizing atmosphere (1.4.1). The glaze adheres very well to the the pot and is quite clear, smooth and homogeneous. This generally indicates biscuit firing followed by glost firing and compatible thermal expansion coefficients of the clay body and the glaze (Rhodes 1973: 241-249; Hodges 1976: 202). The clay contains non-plastic inclusions of various dimensions, including quartz grains of up to about 1000μ. Inclusions of up to 4-5 mm occur sporadically; these are mostly angular and sub-angular. The largest non-plastics were not deliberately added to the clay. Inclusions of such dimensions are not desirable in throwing thin-walled pottery of the kind manufactured at Pabillonis: it appears to be very difficult to throw the wall thinner than about 2x the diameter of the dominant particle size. Moreover, inclusions of such dimensions can cause problems during firing, particularly if their thermal expansion coefficient is substantially higher than that of the clay (Rye 1976; Jacobs 1983). Quartz and flint grains in particular are known to expand considerably at the temperature of 573°C and to shrink to a corresponding extent at the same temperature when they are allowed to cool. For these reasons the presence of inclusions of more than 1000μ is to be considered undesirable. Some of the sherds contain small lumps of undissolved clay ascribable to insufficient soaking.

1.2.2 Macroscopic analysis of the non-plastic inclusions

With the aid of a binocular microscope (magnification 10-40x) the quantity and quality of the non-plastic inclusions was determined in order to enable comparison of the individual sherds and of the sherds with the clay samples. Moreover, it is well known that the shape and the size of the inclusions and also the amount and the sort of non-plastics can greatly affect not only the performance of the clay during firing, but also the functional characteristics of the products (Kingery 1955; Franken and Kalsbeek 1969; Steponaitis 1984; Bronitstky and Hamer 1986). The quality and quantity of the inclusions was found to be the same in all of the sherds. Quartz, both the colourless and the milky variety, was found to occur the most. Feldspar grains were also encountered but in much smaller amounts. Remarkable is the great abundance of silver to light brown muscovite plates, varying in size from very fine to coarse. All samples also contained black grains (presumably basalt), iron oxide concretions and unidentified cream-coloured grains, but in very small quantities only (Table 1.2.2).

1.2.3 HCl test

The fresh cross-section of sherds 1, 2, 3 and 4 was dabbed with concentrated HCl in order to determine the presence of any calcium compounds (e.g. calcite). The samples were inspected with a microscope (magnification 10x) but no signs of any reactions were observed. It was therefore concluded that the sherds contained no calcium compounds or other substances that spontaneously react with hydrochloric acid.

1.3 Reconstruction of the forming technique

The forming technique was reconstructed on the basis of the results of the visual inspection of the sherds. This examination revealed the following two prominent features:

1. the thin, well-controlled wall thickness that was more or less the same all over the pot (approx. 7-9 mm), also in the case of large vessels (Fig. 5);

	SORT	predominant size	form	special features	sorting	total %
sherd 1	1. colourless quartz/ feldspar	250μ < . < 1000μ <250μ	angular sub-angular		moderate	
	2. milky quartz/ feldspar	< 500μ	angular sub-angular	most quartzes		25μ < . < 150μ 10%
	3. iron oxyde	various < 1000μ	sub-rounded	combined with quartzes		150μ < . < 180μ 2%
	4. black grain	< 250μ	sub-rounded sub-angular	sometimes foamy		600μ < . < 1000μ 3%
sherd 2	1. colourless quartz/ feldspar	250μ< . <1000μ <250μ	angular sub-angular		moderate	
	2. milky quartz/ feldspar	250μ< . <2000μ	angular sub-angular	most quartzes	moderate	25μ< . <150μ 8%
	3. iron oxyde	< 1000μ	sub-rounded		ill-sorted	150μ < . <100μ 2%
	4. black grain	< 1000μ	sub-rounded		ill-sorted	600μ <. <1000μ 5%
sherd 3	1. colourless quartz/ feldspar	250μ < . <1000μ <250μ	angular sub-angular		moderate	
	2. milky quartz/ feldspar	<500μ	angular sub-angular	most quartzes	moderate	25μ< . <150μ 8%
	3. iron oxyde	<500μ	sub-rounded	combined with quartzes	ill-sorted	150μ< . <180μ 4%
	5. tufa	ca. 1000μ	angular sub-angular	sporadic		600μ< . 1000μ 3%
sherd 4	1. colourless quartz/ feldspar	250μ< . <1000μ	angular sub-angular			
	2. milky quartz/ feldspar	<2000μ	angular sub-angular	most quartzes		25μ< . <150μ 8%
	3. iron oxyde	<500μ	sub-rounded			150μ< . <180μ 4%
	4. black grain	<200μ	sub-rounded sub-angular			600μ< . <1000μ 3%

Table 1.2.2. Pabillonis, sherds: macroscopic analysis of the non-plastics.

Legend:

1. Colourless quartz: angular and sub-angular, irregular fracture. Feldspar: pink/white, cleavable, softer than steel.
2. Milky quartz: grey/white, with iron oxide veins, hackly/irregular fracture. Feldspar: pink/white, cleavable, softer than steel.
3. Iron oxide: concretions.
4. Basalt? (could be scratched with a needle).
5. Tufa.

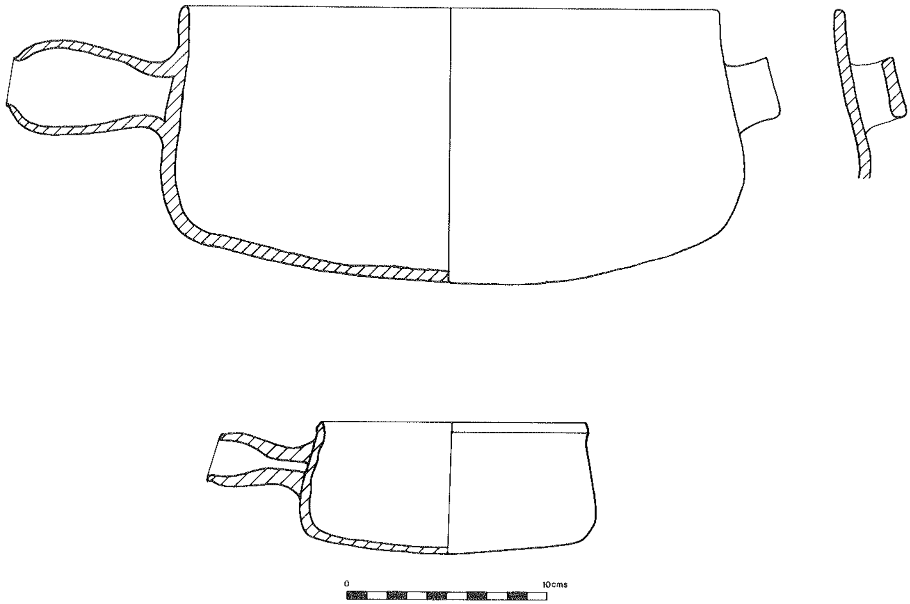


Fig. 5. Pabillonis, large and small casserole.

2. the torsion marks on the inside of the pots, which in some places corresponded to the direction of the fracture pattern and indicated anti-clockwise turning on a fast wheel.

The pots were assumed to have been formed upside-down. No conclusions could be drawn from the 'navel' in the center of the bottom though, because it was not or not clearly visible in the case of the investigated sherds. However, the forming technique could be inferred from the combination of the following observations:

- the profile of the rim appeared to be the result of a V-shaped groove made in the wall of the pot with the aid of a rib (Fig. 6). Such an incision not only facilitated the cutting of the vessel from the wheel-head, but also indicated the line along which it was to be cut;
- the transition from the wall to the bottom was gradual rather than abrupt;
- the rather thin, regular, wall-thickness, particularly of the base, also suggested that the pot had been shaped upside-down; it would be difficult to obtain such a wall-thickness by scraping (Fig. 5);
- the lack of marks of dry scraping on the bottom, which would certainly have been present in a number of cases if the pots had been thrown the right way up and had been scraped at a later stage;
- a clay containing fairly coarse grains is rather unsuitable for scraping in leather-hard condition: the grains get caught behind the scraper and produce grooves and pits in the surface;

The conclusion was that the pots in question were thrown upside-down; the rim was shaped and finished at a later stage and the 'navel' was flattened. A thin, well controlled wall-thickness is an advantage in the case of cooking pots in view of the thermal shock they are subjected to during

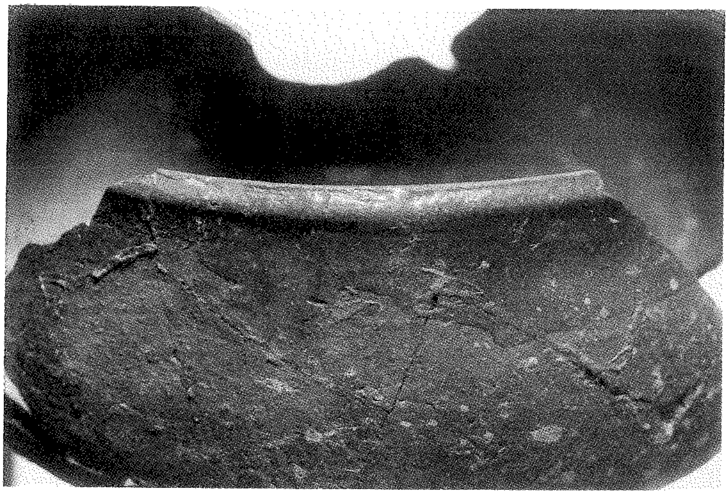


Fig. 6. Pabillonis, cooking pan, profile of the rim.

use. The thinner the wall-thickness, the faster and more equally the heat is distributed and, consequently, the smaller the risk of the pot cracking. Another advantage in this respect is the regular shape of the pot, without angles or sharp curves, which minimizes strains caused by heating (Kingery 1955; Rye 1976; Braun 1983; Bronitsky 1986; Rice 1987: 229; 368-369). The assumed upside-down forming method is therefore in accordance with the intended function of the pots.

1.4 Reconstruction of the firing technique

1.4.1 Colour

Six sherds, from pots produced both in the large workshop and in the small one, were subjected to colour analyses. Sherd No. 2* was assumed to have belonged to the same pot as sherd No. 2; the sherd referred to as st is an unglazed waster used in the large workshop as a support in setting the kiln.

Method

The colour of the cross-section of the sherds was determined with the aid of the MSCC. The readings were carried out by the same person, under constant lighting. Of each sherd the following were inspected: 1) the internal (glazed) surface; 2) the core; 3) the external surface. After the original colours had been determined, the sherds were refired in a neutral or slightly oxidizing atmosphere, at several different temperatures, increasing 50°C at a time, from 750°C to 1000°C. The sherds were inspected after each 50° increment in the firing temperature.

Of the different readings only those are reported that are thought to provide some indications on the original firing conditions: the original colour and the changes in Hue, Value and Chroma due to oxidation and vitrification (Table 1.4.1).

Comment

Five of the six sherds originally had perfectly and homogeneously oxidized cores, as indicated by the high Value and Chroma readings. This means that the iron-bearing clay was fired at a sufficiently high temperature, for a long enough time, in an atmosphere that permitted both the complete combustion of the organic matter and the oxidation of the iron (Shepard 1980: 21, 216; Rice 1987: 335).

The dark colours observed on the outside of some of the sherds became lighter after the first refiring at 750°C; this means that these dark colours are attributable to secondarily deposited organic matter: either from the smoke produced in the last phase of the firing process or from fouling due to use (Shepard 1980: 220).

The colour of the core remained virtually unchanged up to 900°C. When the temperature was increased from 900 to 950°C the Value and Chroma readings decreased in the case of four of the sherds, that is, the sherds became darker, which indicates the beginning of vitrification (Shepard 1980: 23; Grimshaw 1971: 915). In addition, the Hue reading of these sherds changed from YR to R. Such changes, accompanied by appreciable shrinkage at the same temperature, indicate that the original firing temperature has been exceeded.

A further decrease in Chroma on heating to 1000°C is a sign of further decomposition of the clay minerals (Hodges 1976: 196). As is known, a glazed surface affects the vitrification of the clay body (Rhodes 1973: 87-88; Hamer 1983: 30-31); in the case of the glazed surfaces the Chroma readings decreased already after refiring at 750°C and 800°C.

The colour assumed by the fabric pointed to a maximum original firing temperature of 900°C. However, colour readings must always be considered in relation to apparent porosity and shrinkage behaviour (Rye 1981: 119-120; Rice 1987: 426-429). In the case of our present research, conclusions drawn from colour readings could also be checked by comparing them with the results of clay analyses (2.4.2).

1.4.2 Apparent porosity

After each 50°C increase in the refiring temperature the apparent porosity of the sherds was determined (Table and Fig. 1.4.2).

1.4.3 Shrinkage

In order to obtain further insight into the original firing temperature, the moment was recorded at which the sherds first started to shrink and the behaviour of the glaze was investigated. To enable reliable determination of the first signs of shrinkage, a sherd must measure at least 10 cm; only sherds 1, 2, 3 and st met this requirement. Sherd st*, another unglazed waster used as a support in setting the kiln, was included in the determination so as to obtain more results.

All of the sherds showed clear shrinkage, ranging from 0.5 to 2%, on refiring at 900°C. At 950°C sherds 1, 2 and 3 showed 3% shrinkage while

SAMPLE		original	750°C	800°C	950°C	1000°C
1	external surface	5Y 6/3 pale olive	2.5YR 5/4 reddish brown	-	2.5YR 6/6 light red	10R 5/3 weak red
	core	2.5YR 5/8 red	-	-	-	10R 6/4 pale red
	glazed surface	7.5YR 4/4 brown	5YR 4/4 reddish brown	-	-	-
2	external surface	5Y 4/1 dark gray	2.5YR 5/4 reddish brown	-	2.5YR 6/6 light red	10R 6/3 pale red
	core	2.5YR 5/8 red	2.5YR 6/8 light red	-	10R 5/6 red	10R 6/4 pale red
	glazed surface	7.5YR 6/6 reddish yellow	5YR 4/4 reddish brown	-	-	-
2*	external surface	5YR 4/3 reddish brown	2.5YR 5/6 red	-	-	10R 6/3 pale red
	core	2.5YR 5/8 red	-	-	-	10R 5/3 weak red
	glazed surface	7.5YR 4/4 brown	5YR 4/6 yellowish red	5YR 4/4 reddish brown	-	-
3	external surface	5Y 6/3 pale olive	2.5YR 6/8 light red	-	-	10R 6/4 pale red
	core	2.5YR 5/8 red	2.5YR 6/8 light red	-	10R 5/6 red	10R 5/4 weak red
	glazed surface	7.5YR 4/4 brown	5YR 4/6 yellowish red	5YR 4/4 reddish brown	-	-
4	external surface	7.5YR 5/8 strong brown	-	2.5YR 5/8 red	-	10R 4/6 red
	core	2.5YR 4/6 red	2.5YR 5/8 red	-	10R 5/6 red	10R 5/3 weak red
	glazed surface	5YR 5/8 yellowish red	7.5YR 4/4 brown	-	5YR 4/4 yellowish red	- -
st	external surface	2.5YR 6/6 light red	-	-	-	-
	core	2.5YR 5/8 red	-	-	10R 5/6 red	-
	internal surface	2.5YR 5/8 red	-	2.5YR 4/8 red	10R 6/4 pale red	-

Table 1.4.1. Pabillonis, sherds: determination of colour.

SAMPLE	750°C	800°C	850°C	900°C	950°C	1000°C
1	10.87	12.51	12.79	12.73	11.78	8.86
2	10.81	12.11	12.36	12.54	11.55	9.05
2*	9.14	10.82	11.43	10.86	9.92	7.84
3	10.91	12.62	13.9	12.76	10.92	9.16
4	9.59	15.26	14.73	13.18	10.72	8.60
st	12.86	14.45	14.99	14.58	12.17	9.93

Table 1.4.2. Pabillonis, sherds: apparent porosity percentages.

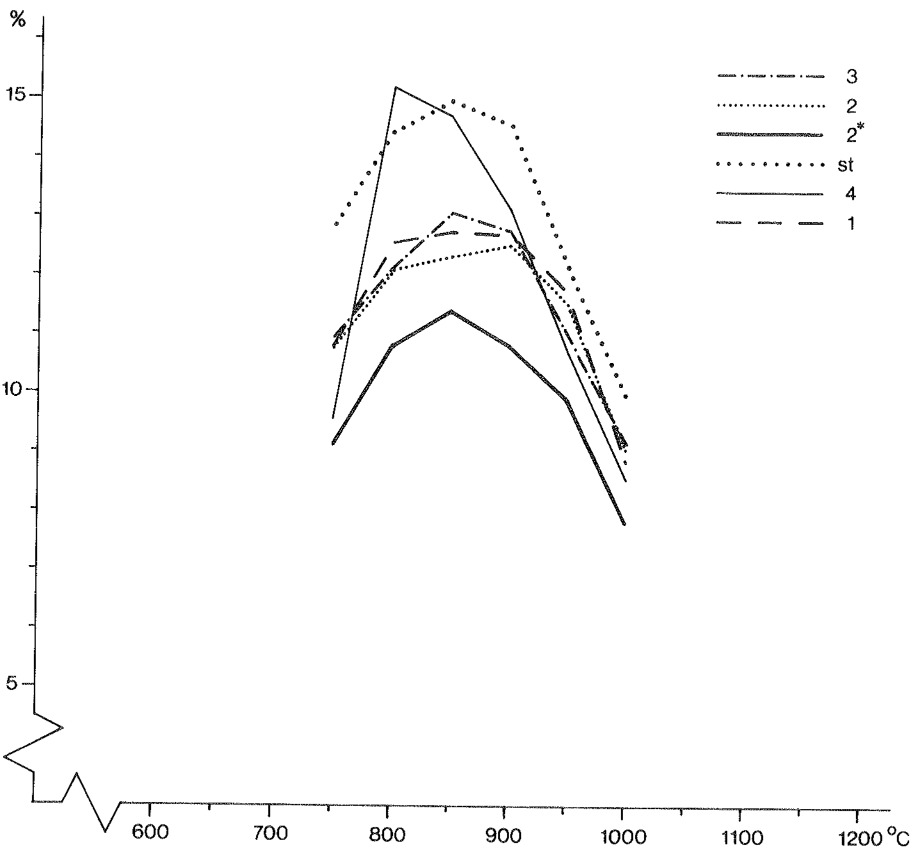


Fig. 1.4.2. Pabillonis, sherds; diagram of the apparent porosity percentages.

sherds st and st* showed only 1%. The fact that samples st and st* shrunk less is logical but it should be noted that they were measured in vertical instead of in horizontal direction.

1.4.4 Behaviour of the glaze

At 800°C the glaze became viscous. Between 800 and 850°C the glaze ran evenly over the surface of the clay, reaching its maturing point (Rhodes 1973: 87; Hodges 1976: 47). Scratches made in the glaze before refiring were sealed at this temperature. At 900°C the glaze fused completely.

Summary of the results:

Sherd	800°	850°	900°	950°	linear measuring distance
1	-	-	1%	3%	horizontal 10 cm
2	-	-	2%	3%	horizontal 10 cm
3	-	-	1%	3%	horizontal 10 cm
st	-	-	1%	1%	vertical 10 cm
st*	-	-	0.5%	1%	vertical 10 cm
	glaze became viscous	glaze started to run	sherd started to shrink; glaze fused completely	sherd became dark	

1.4.5 Estimation of the original firing temperature

A comparison of the results obtained in the determinations of the colour, the porosity, the degree of shrinkage and the behaviour of the glaze leads to the conclusion that the original glost firing temperature was around 850°C, the temperature at which the glaze started to run. The porosity of the sherds decreased clearly after 850°C (that of sherd No. 4 already after 800°C). The biscuit firing temperature may have been slightly higher, which is practice so as to avoid the formation of bubbles in the glaze due to the release of gases from the body: the colour of the core started to change after 900°C and the samples started to shrink after 850°C.

2 Clays and Tempers

The potters of Pabillonis distinguished two types of 'earth': the *terra de obrezzu* (earth for soaking), i.e. clay, and the *terra de pistai* (earth for crushing), i.e. temper. The former was extracted from June to September from the beds in the region between the rivers Riu Bellu and Riu Trottu to the south of the village (Fig. 7) - an uncultivated area used by transhumant shepherds which was often flooded before the land reclamation projects[4]. The clay beds lay beneath an approximately 40-cm thick layer of topsoil and extended to 1 m beneath the surface. The clay was both very accurately mined and selected. The topsoil was carefully removed and each large lump of clay was taken to a previously cleaned plot where it was cut into smaller pieces. Whenever one of this small pieces was found to contain limestone or too much sand the entire lump was immediately discarded[5].

The temper was obtained from the banks of the river Bellu, along the river's southerly course. It was dug in the middle of the summer from the lowest strata of the river banks, called *mraxis arrubius* (red banks). These were dry in the summer only, when the water level was lowest. In this same period the flint used for the glaze was collected from the riverbed. After an initial drying period on the site from where they had been dug, the two materials were transported to the workshops by cart. For every 15 cartloads of clay there were 2 cartloads of temper.

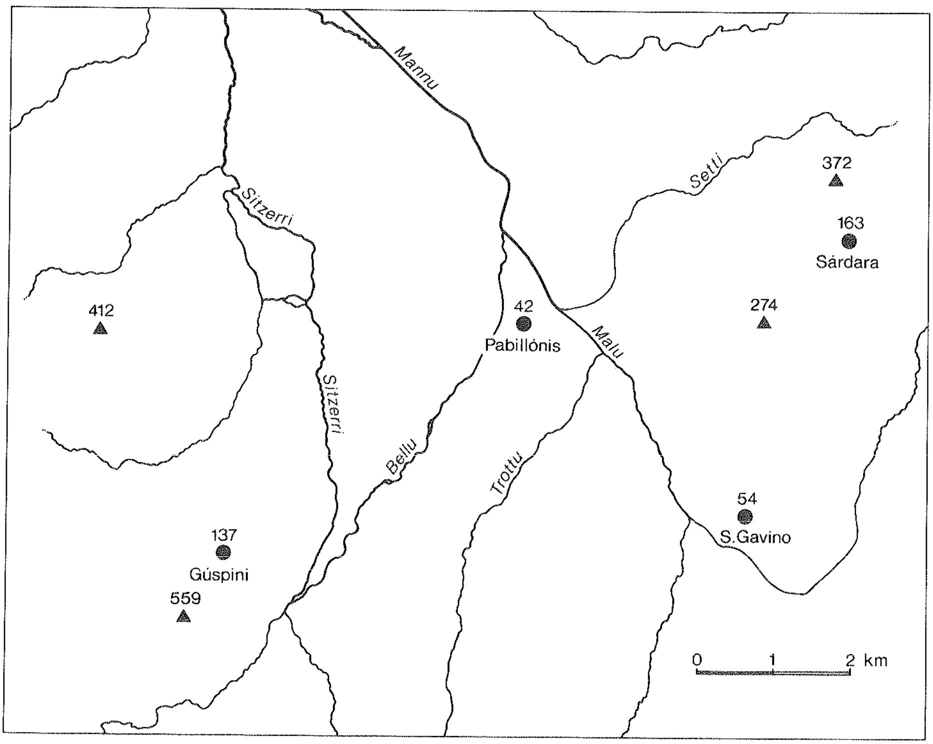


Fig. 7. Pabillonis, map of the region.

2.1 The samples

The clay and temper samples were obtained from the owner of the aforementioned large workshop and the potter of the small workshop who was the last to give up pottery production. The former obtained the clay from his own beds near the village while the latter had to purchase it from a landowner in the Guspini region, paying some money for each cartload. So, although the samples came from the same area to the south of Pabillonis, they were dug from different beds. No essential differences were found between the two clays , but the analyses showed that they each possessed some distinctive properties.

A number of clays and clay bodies were subjected to various tests in order to obtain insight into the properties of the raw materials. It was hoped that the results would help to explain the potters' preferences for particular manufacturing techniques and certain characteristics of the products. One of the main questions in the case of Pabillonis was why the potters added temper ('earth for crushing') to the basic clay ('earth for soaking'). Several reasons are conceivable, which are relate to the manufacturing technique employed and the function of the product (Franken and Kalsbeek 1969; Shepard 1980: 24-31; Rye 1976; 1981: 31-36; Jacobs 1983; Bronitsky 1986; Rice 1987: 229-330; 366-367).

The following samples were used in the determinations of the properties affecting the performance of the clays:

Lc 1 — natural clay from the large workshop

Lcb 2 ex — clay body from the large workshop prepared at the Department for Pottery Technology (D.P.T.): the clay was soaked and only the coarsest inclusions were removed

Lct 3 — clay prepared and tempered at the large workshop

Lct 4 — slurry from the large workshop intended for reuse[6]

Sc 5 — natural clay from the small workshop

Scb 6 ex — clay body from the small workshop prepared at the D.P.T: the clay was soaked and only the coarsest inclusions were removed

Sct 7 ex — clay body from the small workshop prepared at the D.P.T: the clay was allowed to settle and then mixed with 20% very fine temper from the same workshop after the removal of all of the coarse inclusions

2.2 Macroscopic analysis of the non-plastic inclusions

Fifty grams (dry weigth) of each of the samples (Lc 1, Lcb 2 ex, Lct 3, Lct 4, Sc 5 and Sct 7 ex) were sifted using sieves of different mesh sizes to obtain a grain size distribution. Each fraction was expressed as a percentage of dry weight (Table 2.2). The amounts and kind of non-plastic inclusions were determined with the aid of a binocular microscope (magnification 10 and 40x) in order to enable comparison of the individual clay types and of the clays with the sherds. The histograms of Fig. 2.2 give an impression of the grain size distribution of each sample.

2.2.1 The clays

Lc 1: clay from the large workshop

Clay Lc 1 contained mainly inclusions of up to 2000μ. Larger inclusions occurred only sporadically: 10-15 times per kg of clay (dry weight).

The non-plastics consisted mainly of different sorts of quartz: mostly milky quartz, a smaller amount of colourless quartz and even less rose quartz. There were also small quantities of feldspars (plagioclase), basalt, iron oxide concretions (including small quartz grains) and moderate amounts of muscovite and biotite plates.

Sc 5: clay from the small workshop

Clay Sc 5 contained largely sharp/angular and sub-angular, irregularly shaped and ill-sorted grains. The diameters of the inclusions ranged from less than 38μ to (occasionally) more than 10 mm. Sizes of up to 2000μ again predominated. However, the fraction of 38-150μ was relatively small; considerably smaller than the same fraction of Lc 1.

Sample Sc 5 was found to contain more or less the same sort of non-plastics as Lc 1, the only difference being that Sc 5 contained only very few muscovite plates.

Discussion

The graphical representation of the grain size distribution shows little difference between Lc 1 and Lct 3; the amount of inclusions of < 38μ is slightly greater in the case of Lc 1, while the 38-75μ, 125-150μ and 180-250μ fractions are larger in the case of Lct 3. Both substances contain approximately 10% inclusions of > 250μ. In view of the low weight of muscovite, Lct 3 in fact contains more non-plastics of 125-250μ. A comparison of Lc 1 and Lcb 2 ex, the same clay prepared in the laboratory, shows that the sedimentation process leads to a reduction in the > 250μ fraction and also in the 75-125μ fraction. The fraction of < 38μ is larger in the case of Lcb 2 ex. A comparison of Lct 3 and Lcb 2 ex shows that the clay allowed to settle in the laboratory also contains less medium/coarse sand than that prepared at Pabillonis. The slurry Lct 4 corresponds most to Lcb 2 ex although it contains an even smaller amount of coarse inclusions, which is logical considering the way in which it was obtained. Remarkable is the fact that, contrary to the expectations, the fraction of < 38μ of Lct 4 is also smaller than that of Lcb 2 ex. This is in agreement with the water absorption (2.3.2) and the sedimentation behaviour (2.3.4) of this material. Moreover, in spite of its low coarse inclusions content, Lct 4 shrinks slightly less than the other samples (see 2.4.4). Presumably the fraction of < 38° of this clay body contains considerably less clay than silt. The 38-150μ fraction presumably includes the temper. These data, and in particular the comparison of the natural clay with the clay/temper blends, show that the potters aimed at a raw material with a

SAMPLE	grain size	dry weight %	muscovite
Lc 1	< 38μ	76.28	moderate
	38μ< - <75μ	5.22	
	75μ< - <125μ	5.94	
	125μ< - <150μ	0.74	
	150μ< - <180μ	0.70	
	180μ< - <250μ	1.12	
	>250μ	10.00	
Lcb 2 ex	<38μ	80.46	moderate
	38μ< - <75μ	5.22	
	75μ< - <125μ	3.70	
	125μ< - <150μ	2.00	
	150μ< - <180μ	1.10	
	180μ< - <250μ	1.74	
	>250μ	5.78	
Lct 3	<38μ	71.46	fairly abundant
	38< - <75μ	7.30	
	75μ< - <125μ	4.56	
	125μ< - <150μ	3.42	
	150μ< - <180μ	1.30	
	180μ< - <250μ	2.28	
	>250μ	9.68	
Lct 4	<38μ	79.14	abundant
	38μ< - <75μ	6.72	
	75μ< - <125μ	5.86	
	125μ< - <150μ	2.48	
	150μ< - <180μ	1.04	
	180μ< - 250μ	1.26	
	>250μ	3.50	
Sc 5	<38μ	88.58	sporadic
	38μ< - <75μ	2.36	
	75μ< - <125μ	1.30	
	125μ< - <150μ	0.44	
	150μ< - <180μ	0.38	
	180μ< - <250μ	0.64	
	>250μ	6.30	
Sct 7 ex	<38μ	89.90	very abundant
	38μ< - <75μ	2.20	
	75μ< - <125μ	4.12	
	125μ< - <150μ	1.60	
	150μ< - <180μ	1.04	
	180μ< - <250μ	0.90	
	>250μ	0.24	

Table 2.2. Pabillonis, clays: grain size distribution.

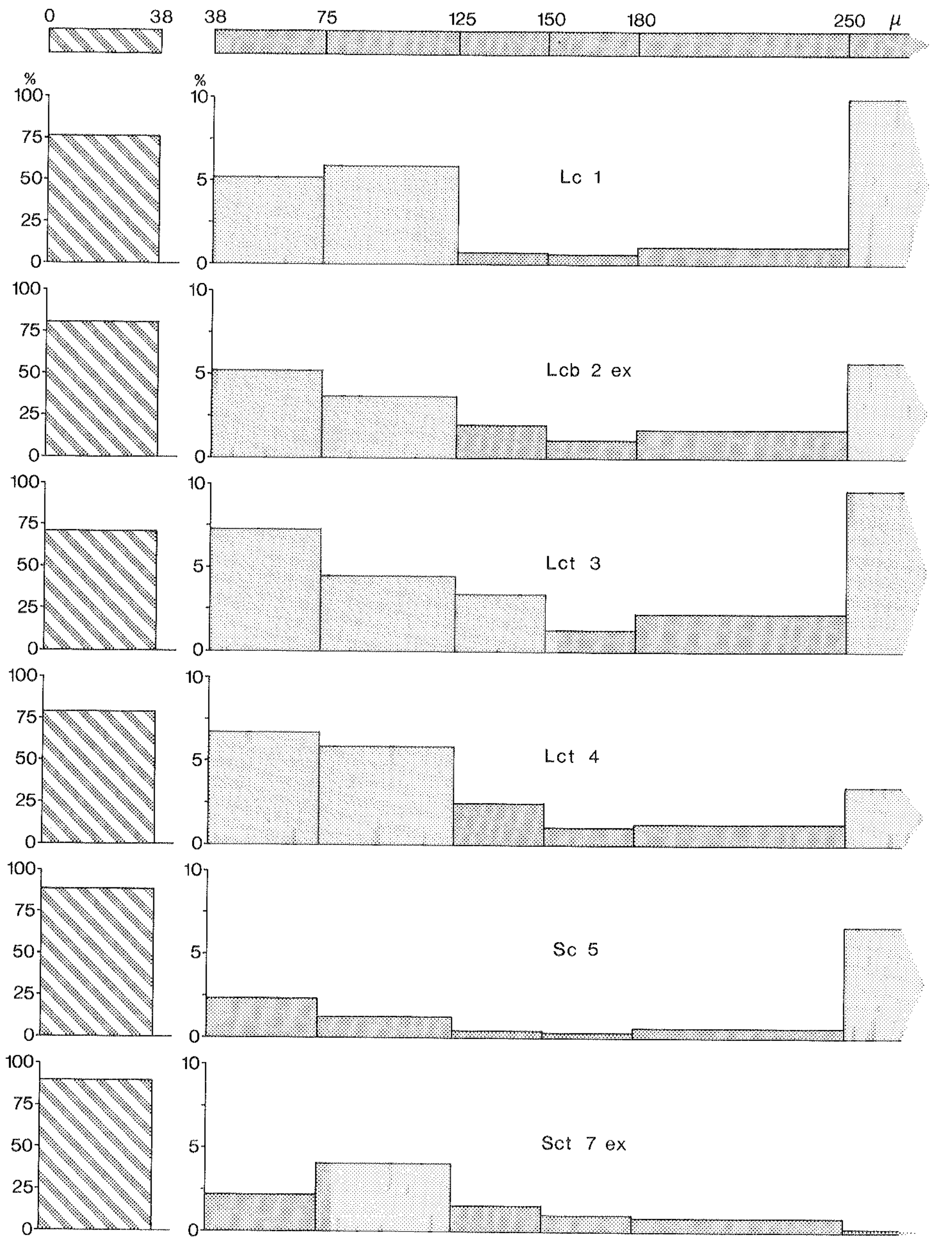


Fig. 2.2. Pabillonis, clays: histogram of the grain size distribution.

large amount of non-plastic inclusions in the 'fine sand'-'coarse silt' fraction of the Wentworth-Lane classification.

A comparison of Sc 5 and Lc 1 shows that the former contains 13% more inclusions of <38μ, which partly explains the difference in plasticity between the two clays. Sc 5, however, contains less inclusions of 38-75μ and 75-125μ, which means that this clay requires a fine temper. The clay body Sct 7 ex (Sc 5 sedimented and then mixed with 20% temper) contains a considerably smaller amount of inclusions of >250μ. The greater amount of inclusions of 75-125μ is the result of the addition of the 'earth for crushing', a part of which is also to be found in the <38μ fraction.

The clays with the highest coarse inclusions contents are of course the natural clays Lc 1 and Sc 5 (muscovite plates are usually >250μ). Sct 7 ex of course contains only a small amount of non-plastic inclusions of >38μ: the muscovite temper constitutes only 1/6 part by weight and all the coarse inclusions have been removed in the sedimentation procedure. Lcb 2 ex was also allowed to settle but in the sedimentation process this clay, more so than Sc 5, tended to form a thick slurry in which the coarse inclusions remained suspended. This explains why the amount of non-plastics of >250μ is greater in the case of Lcb 2 ex than in the case of Sct 7 ex.

2.2.2 The tempers

Sample Lt: the temper used at the large workshop

Dry lumps of sample Lt were ground with the aid of a wooden pestle so as to avoid cracking the inclusions. The aim was to determine the muscovite/quartz inclusions ratio and to obtain a particle size distribution. This fabric was somewhat easier to grind than the lumps of dry clay due to the fact that the temper consisted largely of sand. Thanks to the presence of a certain amount of clay, the lumps were firm and not crumbly though. An easier way of obtaining a fine fraction is to soak this substance in water.

Hundred grams of the ground material was rinsed through a sieve in order to remove the fraction of <38μ. The residue was separated through sedimentation, dried and weighed. Three fractions were obtained.

The total weight of the three fractions was 50.34 g. This means that 49.66 g of 100 g of the temper used at the large workshop consisted of inclusions of < 38μ. The three fractions were further analysed with the aid of a binocular microscope (magnification 10x).

Comments on the fractions obtained through sedimentation

For clarity's sake it should be pointed out that platy and granular non-plastics are to be specified separately because the shape of the inclusions affects the sedimentation rate.

The <u>coarse fraction</u> was found to consist largely of quartz and feldspar grains and muscovite plates. The amount of quartz/feldspar clearly exceeded the amount of muscovite in both weight and volume. As the specific gravity of quartz is virtually the same as that of muscovite, conclusions may be drawn from a comparison of the volumes too. In spite of the fact that the volume - and consequently also the weight - of the quartz grains clearly exceeds that of the muscovite plates, the muscovite is nonetheless a determinant constituent of the temper thanks to its shape and (larger) surface area. The weight ratio (which is more or less the same as the volumetric ratio) of the muscovite and quartz in the coarse fraction obtained through sedimentation was visually estimated and was found to be about 1/10 : 9/10. The quartz/feldspar grains of this fraction were predominantly angular and sub-angular and their size ranged from 250 to 4000μ. The fraction contained relatively few very coarse inclusions (of between 2000 and 4000μ) though. The muscovite plates in this fraction were between 1000 and 2000μ, with the odd exceptions of up to 4000μ.

The medium fraction also contained quartz and feldspar grains and muscovite plates. The angular grains were between 75 and 250μ. This fraction contained a greater amount of muscovite plates: the coarse inclusions settled out faster, which means that that fraction contained relatively little muscovite. Most of the plates measured up to 500μ; some were up to 1000μ. Quartz still predominated but the muscovite/quartz volumetric ratio of this fraction was about 1/4 : 3/4.

The quartz/feldspar grains of the fine fraction were between 38 and 75μ. These grains were also angular and sub-angular. The muscovite plates were again on the whole larger, up to about 250μ. The quartz/muscovite volumetric ratio of this fraction was also 1/4 : 3/4.

The distribution (coarse, medium and fine) obtained through sedimentation of the fraction of >38μ was as follows:

coarse	23.15%	(grains of up to 4000μ; plates of up to 4000μ);
medium	11.76%	(grains of up to 250μ; plates of up to 1000μ);
fine	15.43%	(grains of up to 75μ; plates of up to 250μ).

The muscovite/quartz weight ratio is about 1/4 : 3/4. On visual inspection, the fraction appeared to contain more muscovite though, because of the shape and the glossy appearance of the plates. The addition of 20% temper therefore implied the addition of 5% muscovite and 15% quartz. From what has been said above it will be clear that the amount of muscovite increases or remains the same as the fraction decreases. This means that there is reason to assume that at least 1/4, possibly even a greater part, of the fraction of <38μ consists of muscovite.

Although more quartz was added than muscovite when the clay was tempered, the muscovite plates contributed greatly to the cohesion of the clay when it was thrown on the wheel. The platy form of the mineral favours the binding of the clay and is therefore a particular advantage in the case of short clays. The addition of an equal amount (i.e. 20%) of exclusively granular temper would presumably lead to problems with respect to the workability of the clay due to insufficient cohesion, which is already poor in the case of these relatively short clays.

The following survey shows the fractions of the Lt sample obtained by rinsing it through sieves:

Grain size	Wt. %	Vol. % muscovite
>1000μ	3.58	10
600-1000μ	3.47	
250-600μ	7.14	25
180-250μ	4.09	
150-180μ	4.19	
75-150μ	19.47	25
38-75μ	8.40	
<38μ	49.66	

Sample St: the temper used in the small workshop

This material was also fairly easy to grind. The sample was fractionated by rinsing it through sieves. The temper was found to consist largely of small quartz grains and muscovite plates. The quartz grains were mainly 38-150μ. On the whole, they were angular and irregularly shaped. Some of the muscovite plates in the sample were much larger, measuring up to 1000μ.

The following survey shows the fractions of the St sample obtained by rinsing it through sieves:

Grain size	Wt. %	Vol. % muscovite
>1000μ	—	—
600-1000μ	0.27	
250-600μ	5.15	60
180-250μ	18.65	
150-180μ	6.84	
75-150μ	20.61	7
38-75μ	5.99	
<38μ	42.49	

A comparison of the grain size distributions of the two tempers shows that the fraction of >1000μ is entirely lacking in the case of the temper of the the small workshop. This material moreover appears to contain a greater amount of inclusions of 180-250μ. Another difference concerns the muscovite content: the medium and fine fractions of the temper of the large workshop contain virtually the same amount of muscovite, whereas with the temper from the small workshop the greatest amount of muscovite is to be found in the medium fraction.

The muscovite content of each fraction was first determined with the aid of a binocular microscope, after which the total amount of muscovite inclusions of >38μ was calculated. This was found to be about 25% in the case of the temper from the large workshop and for the small workshop it was about 30%. This means that the addition of 20% temper to the clay of the large workshop implied the addition of 15% quartz/feldspar and only 5% muscovite, whereas the 20% temper added in the small workshop consisted of

13% quartz/feldspar and 7% muscovite.

The potters of Pabillonis complained that crushing the temper was a heavy, time-consuming and unhealthy task. We found it fairly easy to grind the material, that is, provided that the coarse quartz grains contained in the temper were not to be ground too. Such grains must be either removed by sieving or ground. The latter option indeed implies hard work and it is not clear why the potters went to such great efforts when they could equally well have removed the large inclusions by sieving or via sedimentation.

2.2.4 HCl test

The aim of the HCl test was to trace any calcium compounds, for example calcite. Samples Lc 1, Lcb 2 ex, Lct 3, Lct 4, Sc 5 and Sct 7 ex did not react with undiluted hydrochloric acid (HCl).

2.3 Plasticity and Workability

The degree of plasticity of a clay determines the clay's workability but is also an important factor with respect to the function of the pot due to the inversely proportional relationship of the degree of plasticity of the clay and the resistance to thermal shock of the product (Bronitsky 1986).

Plasticity depends on a large number of physical and chemical factors (Grimshaw 1980: 496-504), which can only be determined separately. By themselves, the results of the individual determinations do not give a sufficient indication of the degree of plasticity. This essential property of a clay can in fact only be determined quantitatively, by measuring the relationships between the various factors (Grimshaw 1980: 507-517; Rye 1981: 20-21; Bronitsky 1986; Rice 1987: 58-63). The main aim of the tests carried out in this investigation was not to determine the degree of plasticity of the individual clays but to assess certain properties which affect the workability of the various samples.

2.3.1 pH test

The acidity of a clay is an important factor as far as plasticity is concerned because it is determined by substances that bring about flocculation of the clay particles (Rice 1987: 76-78). In extreme cases the acidity has a great influence on the clay's capacity to absorb water. Clays with a very high concentration of alkaline substances (for instance Na, K, Li) and also clays containing Ca can absorb much less water; in other words, they become liquid sooner and have therefore a shorter workability range. Acid clays, on the contrary, can absorb more water and usually have a wider workability range. The pH values must be considered in relation to the water absorption and Atterberg values (2. 3. 2 and 2. 3. 3).

Method

Two different scales were used in the determination of the pH of the samples:
a first scale of 6.0 6.4 6.8 7.0 7.2 7.6 8.0 (where 6.0 is acid, 7.0 is neutral and 8.0 is basic) and a duodecimal scale of 1,2; 3,4; 5,6; 7,8; 9,10; 11,12 to evaluate the results obtained.

Measurements carried out to check the results showed that the values used in the two tests correspond as follows:

1		acid
2		
3		
4	= 6.0	
5	= 6.8	
6	= 7.0	neutral
7		
8	= 7.2	
9	= 7.6	
10	= 8.0	
11		
12		basic

6.4 lies between 4 and 5, while 7 lies between 7.0 and 7.2. The measuring range of the duodecimal test is larger. The test results indicate neutral clays. Nevertheless, the clays soon reach the point of saturation (2.3.2). This is due to the clays' thixotropic character (2.3.6).

2.3.2 Water absorption

The determination of the amount of water required to bring clays and clay bodies into a plastic condition is also a means for obtaining an understanding of the properties affecting the performance of the clays in question. A clay to which a large amount of water has to be added to make it workable will loose much water in drying and will thus shrink considerably. Such clays are usually fatty. This property has consequences for the preparation of the material, the forming method and the firing. The results of this test and those of the Atterberg test are of course closely connected.

The water content of the various clays and clay bodies of Pabillonis was determined by bringing the dry samples into a condition in which they could be worked on the wheel. On the whole, the amount of water required to reach this condition was found to be between 19 and 25%. The least water had to be added to clay body Lct 3, which was already workable at a water content of 18.88%. Lc 1 absorbed about 2.5% more than the clay bodies from the same workshop. Higher values were obtained for samples Sc 5 and Sct 7 ex. Although the differences between the various samples are not very great they do reflect the different natures of the various substances.

When the thrown pots were left to dry, no cracks were formed in the bottom around the navel of the pots made from the clay to which about 19% water had been added, whereas the clay to which 21.5% water had been added did crack (Fig. 8). Slow drying and adding as little water as possible to the clay helped to prevent the formation of such cracks. In view of the pronounced thixotropic character of the clays (2.3.6), the results of the water absorption determinations are probably a little too high[7].

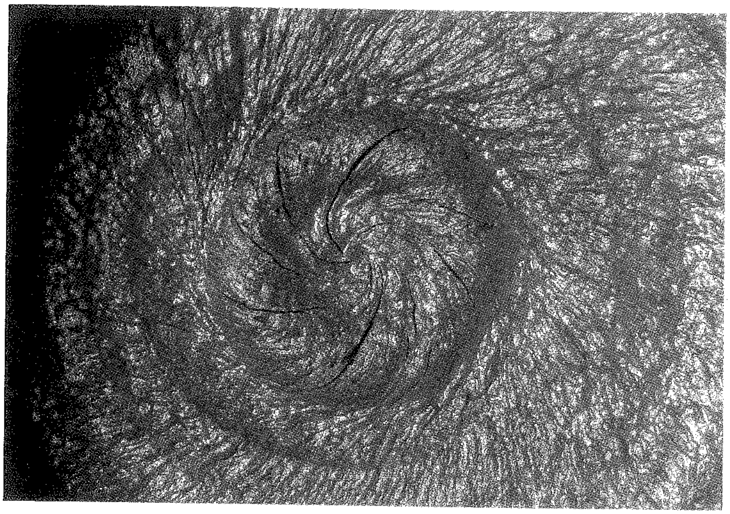


Fig. 8. Reconstruction sample: crack formation around the navel.

Comparisons

Sample	PH	Water content in plastic condition (homogenized)
Lc 1	7.0	21.53%
Lcb 2 ex.	6.0-6.5	21.95%
Lct 3	6.0-6.5	18.88%
Lct 4	6.0-6.5	19.04%
Sc 5	6.0	23.43%
Sct 7 ex.	6.0	25.40%

2.3.3 Atterberg test

The Atterberg test determines the 'rolling out limit' and the 'flowing out limit', i.e. the minimum amount of water that has to be added to a clay to enable it to be rolled out and the maximum amount that can be added before the clay starts to flow. These two values indicate the clay's optimum workability range. The greater the distance between the two values, the longer the clay can be worked before it reaches its point of saturation. Such clays are usually more plastic too.

The following survey shows the amounts of water, expressed in grams, that had to be added to 10 grams of dry clay to reach these limits:

Sample	rolling out limit	flowing out	limit difference
Lc1	1.20	3.60	2.40
Lcb 2 ex	1.40	3.60	2.20
Lct 3	1.40	3.60	2.20
L ct 4	1.40	3.30	1.90
Sc 5	1.40	5.00	3.60
Sct 7 ex	1.30	4.80	3.50

Comments

The table above shows that both the clay and the clay bodies of the small workshop are more plastic than those of the large workshop. This is in agreement with the results of other tests, such as the determination of the water absorption, the sedimentation test and the throwing experiment (2.3.2, 2.3.4 and 2.3.6). The lowest values were obtained for Lct 4, although they do not differ much from those obtained for the other two clays of the large workshop.

2.3.4 Sedimentation test

Method and aim

Fifty grams of dry clay was added to about 1 litre of water. In grinding the clay care was taken that the non-plastic inclusions were not crushed. The amounts and ratios of the inclusions are shown in Table 2.2. The samples were poured into a glass cylinder containing water and were left to soak for 48 hours, after which they were all simultaneously stirred. The solution was fairly thin which means that, in principle all of the inclusions were suspended in the liquid. The sedimentation process was then photographically recorded (Fig. 9). The coarsest inclusions settled out fairly quickly, being deposited at the bottom of the cylinder in less than one minute. As the photographs taken in the first 15 minutes do not give a clear enough impression of the sedimentation process, it was decided to leave the coarsest inclusions that settled out in this period out of consideration. The clearest pictures for comparison were obtained after 26 and 30 minutes (Fig. 9, b, c). What was compared was thus the sedimentation behaviour of the fine particles, the particles that largely determine the degree of plasticity of a clay. The greater the amount of fine inclusions in a blend, the more plastic the clay and the longer it takes to settle: there is thus a direct connection between the sedimentation rate and the degree of plasticity of the clay. It should be born in mind though that the degree of plasticity of a clay is not only dependent on the size of the inclusions but also on their shape and weight (Grimshaw 1980: 496-504; Annis and Jacobs 1986; Rice 1987: 58; 76-78).

Sedimentation test (Fig. 9):

Cylinder	Clay sample	Amount of dry clay
a	Lc 1	50 g
b	Lct 3	50 g
c	Lcb 2 ex.	50 g
d	Sc 5	50 g
e	Sct 7 ex	50 g
f	Lct 4	50 g

The measurements were taken after:

4 minutes
8 minutes
14 minutes
18 minutes
22 minutes
26 minutes
60 minutes[8]

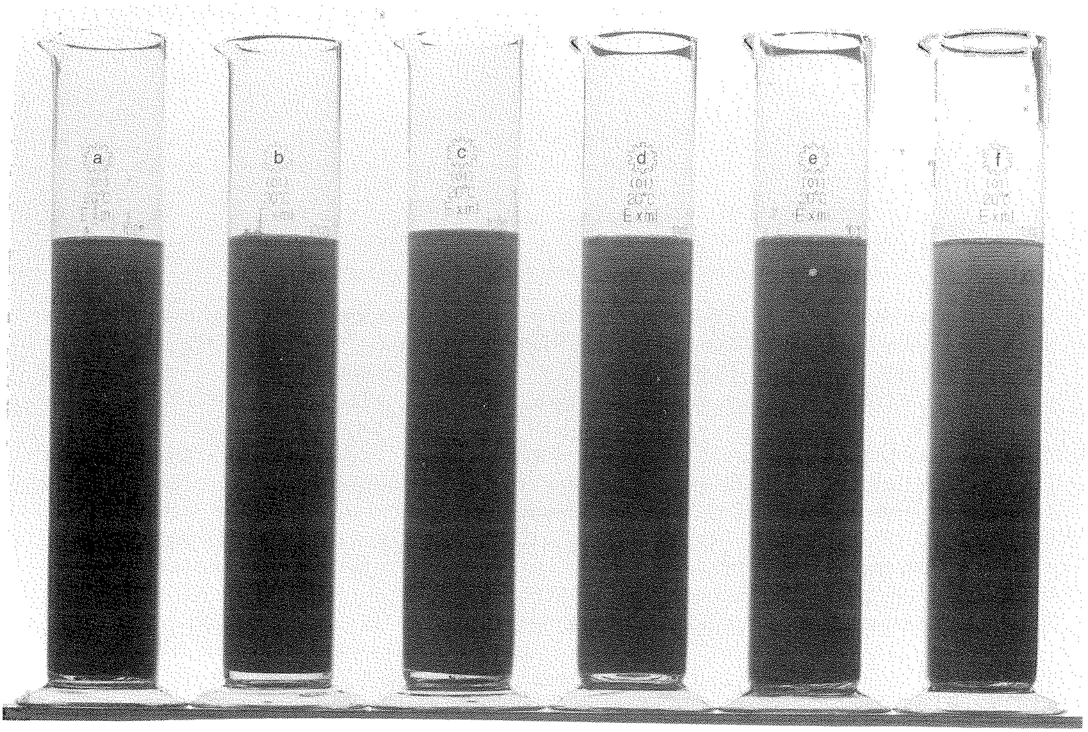
Discussion

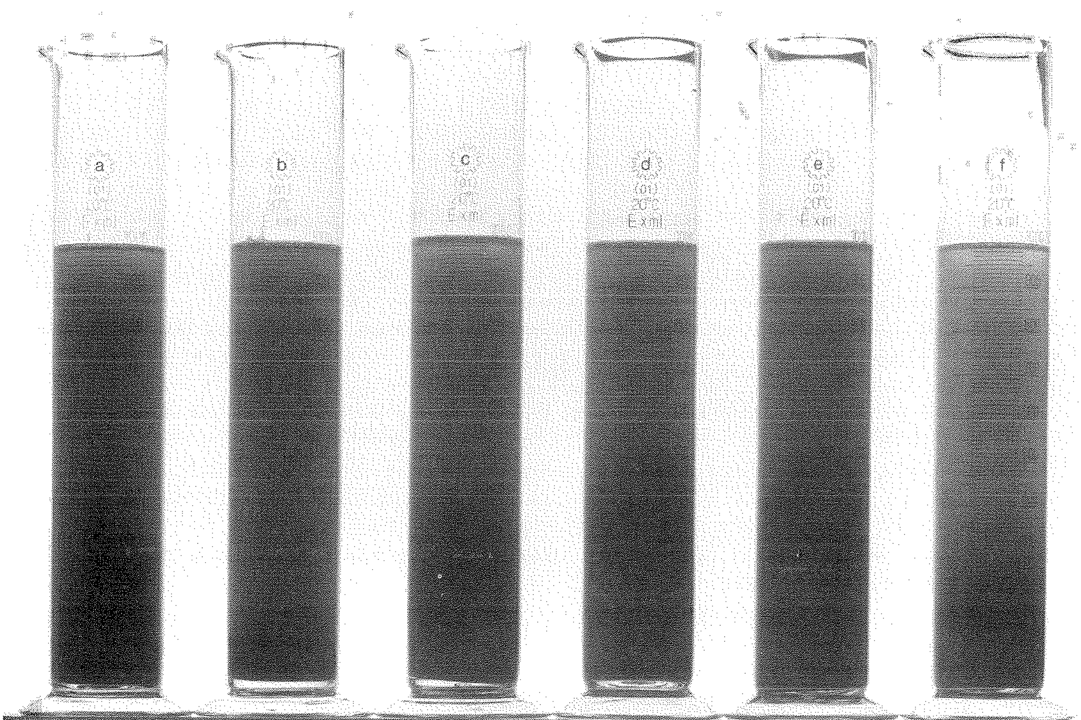
The greater part of the 50 g of dry clay introduced into the cylinders settled within a few minutes. As already mentioned, the photographs of the sedimentation process show particularly the behaviour of the fine clay particles, which largely determine the degree of plasticity of the various samples. The photographs of the top part of the stratification formed in the sedimentation process show whether the fraction of the finest inclusions can be divided into two or more subfractions. Conclusions regarding the composition of the blend can be drawn from the density and the number of sediment layers formed. Certain differences in the performance of the various clays can be explained by comparing the sedimentation behaviour of the individual clays with one another and with the behaviour of other clays whose properties are known.

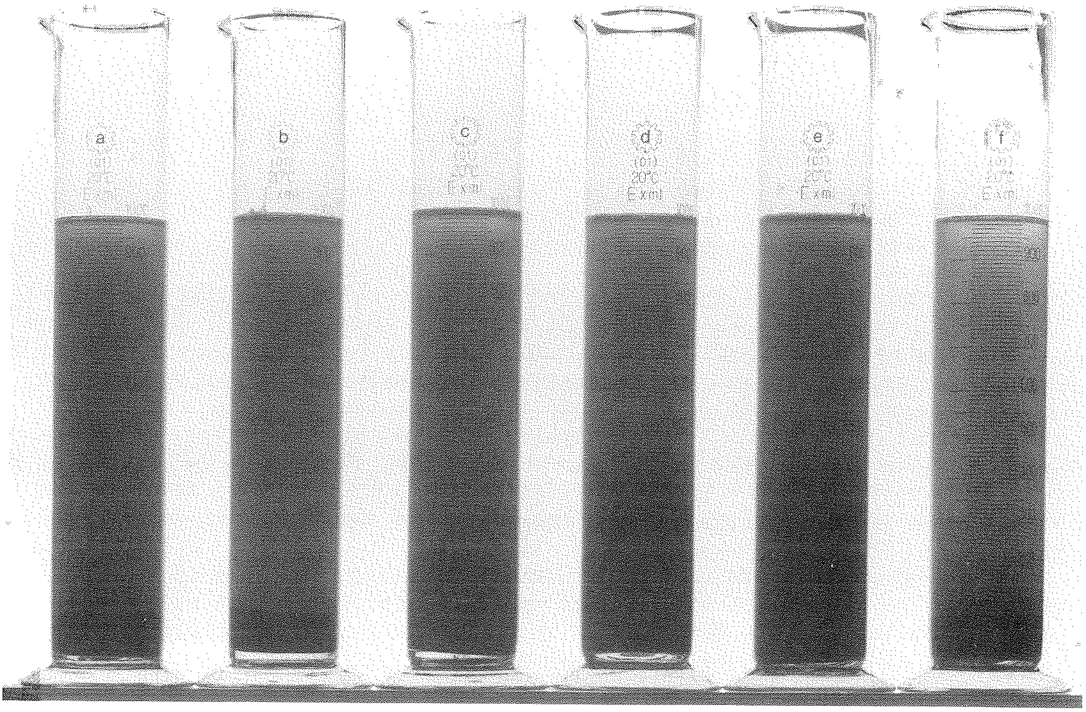
Sample Lct 4 (cylinder f), a substance that was assumed to consist largely of slurry, settled the fastest. This confirms the assumption that the finest clay particles had already been removed from this clay body. The fact that clay body Lct 3 settled slightly faster than natural clay Lc 1 is due to the presence of finely ground temper (approx. 20%) in Lct 3. Apparently it was also the presence of fine temper that affected the sedimentation behaviour of clay body Lct 4 (cylinder f). Sample Lcb 2 ex (cylinder c) took slightly longer to settle than Lc 1, the natural clay, which contained somewhat coarser inclusions. The clay of the small workshop (Sc 5, cylinder d) took only slightly longer to settle than Lc 1; the results of the other plasticity and workability tests also pointed to a greater degree of plasticity for this clay. The sedimentation behaviour of Sc 5 and Sct 7 ex (cylinder e) was virtually the same. This is in contrast with the behaviour of Lc 1 and Lcb 2 ex, but we could not find any explanation for this contradiction.

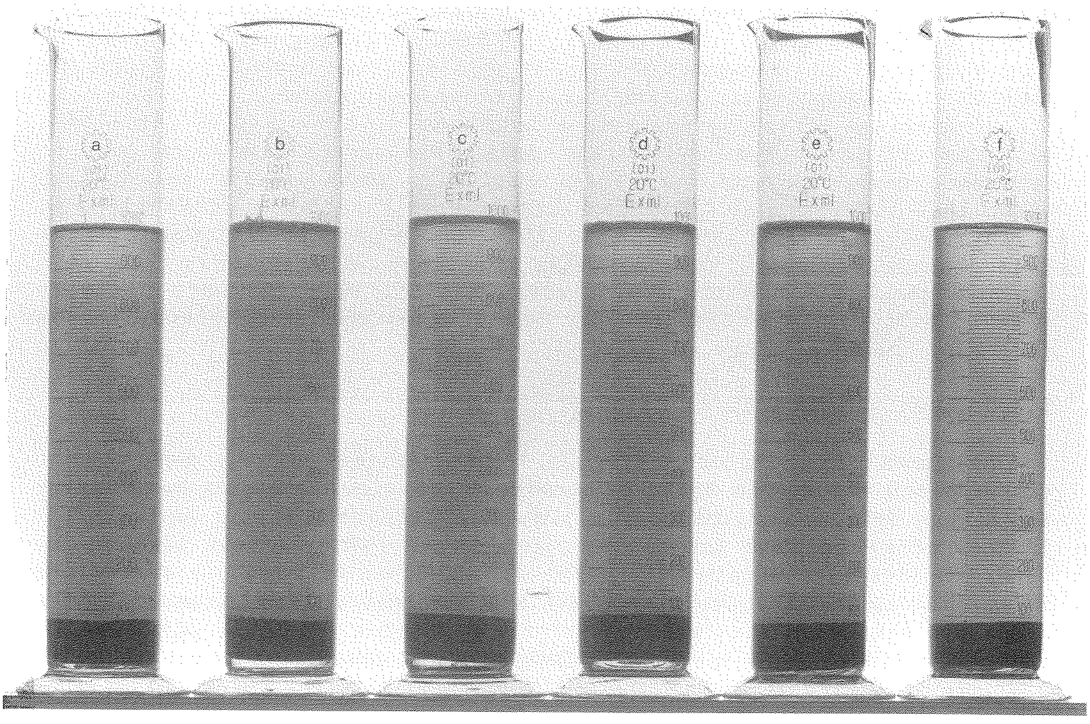
The composition of the stratifications formed in the sedimentation process differed very little: in the case of all of the samples four different layers were distinguishable. The bottom layer contained the coarse non-plastics, the middle two the finer grains while the top layer contained the clay slip. The transition from coarse to fine in the case of the two middle layers was gradual. Samples a (Lc 1), b (Lct 3), c (Lcb 2 ex), d (Sc 1) and f (Lct 4) showed a fairly abrupt transition from the two middle layers to the top layer while e (Sct 7 ex) showed a more gradual transition, which is in agreement with the way in which this blend was prepared in the laboratory.

Fig. 9. Sedimentation tests (p. 104 above) after 18 minutes; (p. 104 below) after 26 minutes; (p. 105 above) after 30 minutes, (p. 105 below) after 60 minutes.


a
b
c
d
e
f


a
b
c
d
e
f


a
b
c
d
e
f


a
b
c
d
e
f

The amount of clay slip in the various samples was approximately (parts by volume):

a	(Lc1)	1/6
b	(Lct 3)	1/4
c	(Lcb 2 ex.)	1/5
d	(Sc 5)	1/4
e	(Sct 7 ex)	1/4
f	(Lct 4)	1/4

The total height of the stratification formed in cylinder e (Sct 7 ex) was slightly greater than that formed in the other cylinders.

In view of the assumed positive correlation between the amount of fine particles in a clay and its degree of shrinkage, a comparison of the sedimentation behaviour with linear shrinkage measurements (especially below about 800°C) could theoretically provide some interesting information. However, considering the fact that both the degree of shrinkage and the degree of plasticity are affected by other factors too, such a comparison of the shrinkage and sedimentation behaviour of clays with slightly different compositions would have a relative value only. According to the aforementioned assumed correlation, the clay of the small workshop (Sc 5) should have shrunk slightly more than the clay of the large workshop (Lc 1). This was not the case though (see 2.4.4): the clay of the large workshop shrunk more at first but expanded slightly between 600 and 650°C (when the bound water was released). Clay Lc 1 did shrink 1% more than Lct 3, the clay body of the large workshop, which is due to the presence of temper in Lct 3. There is a similar correlation between the degree of shrinkage of the clay of the small workshop Sc 5 and that of clay body Sct 7 ex. A comparison of the sedimentation behaviour of the two samples shows that this is also due to the added temper.

A comparison of the sedimentation behaviour of the clays of Pabillonis with that of the clays of Oristano (Annis and Jacobs 1986) and that of reference clay P1037 (a commercial clay with good plastic properties) shows that the clays of Oristano settle faster than those of Pabillonis, which means that they contain less fine inclusions and are consequently less plastic. However, the fact that the clays of Pabillonis took less than 45 minutes to settle completely indicates that they are not very plastic either; the reference clay P1037 shows that very plastic clays take more than two hours to settle.

2.3.5 Green strength test

The green strength of a clay is the resistance of the material to cracking and warping in dried but unfired condition. Cracking and warping are drying defects determined by a number of factors that may be invisible in the unfired product and become apparent only after firing because the firing process accentuates the defects. The green strength is determined by the forces bonding the clay platelets together and is affected by the size, the shape and the 'packing' of the particles, i.e. the way in which they group themselves in drying. This binding power is a property quite distinct from plasticity but the two properties are to some extent related by the fact that they are both dependent on the nature and the amount of colloidal gel matter in the clay. In principle, the green strength and the degree of plasticity are correlated in the sense that the greater the degree of plasticity, the greater the resistance to cracking due to tensile stress will be. However, a high degree of plasticity does not automatically imply a high binding power, nor does a low degree of plasticity imply a low binding power. In the case of pottery fired at a relatively low temperature (of approx. 850°C) there is also a positive correlation between the tensile strength in unfired, dry condition and the tensile strength in fired condition (Grimshaw 1980: 514; Bronitsky 1986; Rice 1987: 67-71).

The green strength per cm^2 of the clays and clay bodies from Pabillonis was determined by subjecting the samples (unfired 1 cm thick clay slabs) to tensile stress, expressed in kg (Grimshaw 1980: 833, Fig. XIII.2; 842, Fig. XII.5, 2), after three hours' drying at 110°C.

The tensile strength of the clays of Pabillonis in unfired condition was found to be high relative to that of other tested clays[9]. As already mentioned above, a high tensile strength of an unfired clay may indicate high tensile strength in fired condition, that is, provided that the clay is fired at a relatively low temperature.

Recent research has shown that the strength of a product that has been subjected to thermal shock varies inversely with the initial strength of the fabric: the stronger the fabric, the greater the difference in temperature required to initiate fracture. The cracks that are formed are however longer and deeper than those formed in the case of an initially weaker fabric. Due to the mechanics of crack propagation, weak fabrics, that is, products with a high density of initial microcracks, are more resistant to thermal stress because initial microcracks minimize crack propagation. As a consequence, such products will survive more repeated cycles of heating and cooling. Several studies have shown that temper and porosity are key factors in microcracking (Rye 1976; Braun 1983; Steponaitis 1984; Bronitsky 1986; Bronitsky and Hamer 1986; Schuring 1986; Rice 1987: 366-370).

The initial strength of the clay of Pabillonis, in itself favourable for the manufacture of pots that can withstand sudden changes in temperature, is less favourable as far as resistance to repeated cycles of heating and cooling is concerned. Because of this, the clay must be tempered.

Remarkable in this respect is the fact that the cooking pots produced at Pabillonis appear to have been fired precisely around 850°C. Higher temperatures would have led to a high degree of sintering (2.4.3 and 2.4.4), resulting in harder, fairly non-porous products.

Measured values

Clay sample	Lc1	Lcb 2 ex	Lct 4	Sc 5	Sct 7 ex
Kg	30	39	33	34	58
	50	40	32	36	65
	43	53	35	41	53
	28	34	32	43	56
	48	43		56	

The following table shows the amounts of water required to prepare the slabs of clay used for the test and the average tensile strength values of the various samples, expressed in kg. The indicated water absorption values are the amounts of water required to reach optimum workability.

Sample	Water content % slabs	Tensile strength (Kg)
Lc 1	21.97	39
Lcb 2 ex	21.95	43
Lct 4	21.09	34
Sc 5	26.31	39
Sct 7 ex	25.40	59

Discussion and comparison with the results of other related tests

Sc 5 and Sct 7 ex have much higher water absorption values than the other samples. In principle, a high water content indicates a plastic clay. The water content of clay Sc 5 is more than 4% higher than that of Lc 1. The table shows that sedimentation hardly affects the clay's capability to absorb water (compare Lc 1 with Lcb 2 ex and Sc 5 with Sct 7 ex). Lct 4 shows the lowest water absorption. This is due to the already mentioned relatively low clay content of this particular blend. A comparison with the Atterberg values (2.3.3.) shows that clays Sc 5 and Sct 7 ex also have considerably higher rolling out limits. The high values of Sc 5 and Sct 7 ex relative to those of Lc 1 and Lct 4 are also in accordance with the observations made during the throwing experiment (2.3.6) and with the sedimentation behaviour of the clays (2.3.4).

As for the green strength, clay Lc 1 appears to be as strong as Sc 5 in spite of the latter's greater degree of plasticity. After the coarse inclusions had been removed, Sct 7 ex was found to have higher green strength than Lcb 2 ex. The fact that Sct 7 ex was the strongest would imply that after the removal of all non-plastic inclusions of over 250µ through sedimentation, clay Sc 5 tempered with 20% very fine muscovite-rich temper should have the highest green strength. None of the sherds was made of such a fabric though.

As far as the grain size distribution is concerned, Sc 5 and Sct 7 ex were indeed found to contain greater amounts of fine inclusions.

2.3.6 Throwing experiments

The performance of the various clays and clay bodies on the wheel was investigated in a number of experiments, in which cooking pots were thrown according to the forming technique inferred from the sherds. In turn, the throwing experiments served to support the reconstruction of the forming technique on the basis of the sherds discussed in Chapter 1.3.

The following clay samples were used in the experiments: Lc 1; Lcb 2 ex; Lct 3; Sc 5; Sct 7 ex. In addition, a reconstruction experiment was carried out using the commercial clay K142.

Samples Lc 1 and Lcb 2 ex

As already mentioned, the unprepared clay contained a fair amount of coarse, sharp non-plastic inclusions, some of which had diameters of up to 10 mm. If such grains are not removed they grate the potter's hands when the clay is thrown on the wheel. They also cause problems when the pot is turned in leather-hard condition. None of the sherds, however, showed any signs of turning.

After the coarse non-plastic inclusions had been removed (sample Lcb 2 ex), the sample was found to be suitable for throwing. The clay of Pabillonis is fairly plastic and, consequently, reasonably workable. When it is in a condition suitable for throwing, the material is rather sticky though. The stickiness soon disappears if the clay is left to dry somewhat but then much more effort is required to throw it. This resistance can be reduced by kneading the clay shortly before use but, if the clay is left to rest, it will soon become stiff again. These phenomena indicate that the clay in question is highly thixotropic (Grimshaw 1980: 473-475; Hamer 1983: 295; Bronitsky 1986). When dissolved in water, clay Lc 1 tends to form a thick slurry in which the non-plastics remain suspended. This behaviour is in accordance with the pronounced thixotropic character of the clay, which makes the removal of coarse non-plastic inclusions via sedimentation a time-consuming undertaking. The thixotropy of a clay can be affected by altering the pH, for example by adding sodium carbonate. However, as this would also affect the plasticity of the material and, consequently, the results of the throwing experiments, it was decided not to take such measures. In spite of the presence of some grit (measuring up to 3-4 mm) in the blend, even after sedimentation, it is still possible to produce fairly thin-walled pottery with this clay[10].

Sample Lct 3

This clay body, which was prepared in Pabillonis, also contained coarse, sharp non-plastics which were a nuisance when the clay was thrown. To avoid damaging the hands when working with such clays, it is possible to use a flat, rounded wooden rib which is held in the right hand to replace the fingers on the outside of the pot. Instead of being set perpendicularly to the wall, at Pabillonis the wooden rib was held flat against the surface of the pot so that grains were not caught behind it. With respect to the other properties too (the tendency to stiffen quickly when left to rest; reasonable plasticity and workability; the tendency to become sticky when water is added), Lct 3 was not found to differ much from Lc 1.

Samples Sc 5 and Sct 7 ex

In the throwing experiment sample Sc 1 was found to be more plastic than Lc 1 and Lct 3. This clay also contained coarse inclusions, which could be removed by means of sedimentation. Unlike the clay of the large workshop, this material settled out well, which means that bringing this clay into a workable condition took less time.

In spite of its good sedimentation behaviour, Sc 5 is also a rather thixotropic clay: it remains soft in kneading and working but soon becomes stiff when left to rest, resulting in a material that is difficult to throw and hence slows down the production rate. As already mentioned, adding water to the clay in an attempt to make it softer has the adverse effect of making the clay sticky and greatly reducing its cohesion. The latter effect involves the risk of the product collapsing on the wheel or of the wall of the pot tearing. Another possible consequence of adding too much water to the blend is excessive shrinkage with the risk of crack formation in drying. Kneading the clay for some time immediately before use or adding fine sand can help to solve these problems: fine sand also helps to reduce the clay's resistance. However, there is a limit to the amount of sand that can be added: too much sand will reduce the cohesion of the blend. The throwing experiments, especially that carried out with Sct 7 ex, showed that the added temper does not only increase the porosity of the product but also makes the clay more workable. As already mentioned, a characteristic of very thixotropic clays is that they soon consolidate, which means that the finished pot can be lifted from the wheel without the risk of it being deformed. This must have been a very favourable characteristic in the production of the wide cooking vessels of Pabillonis.

Sample Lct 4

Clay Lct 4 contained no coarse inclusions, which is fairly logical considering the way in which it was obtained (2.1). In all other respects this blend closely resembled Lcb 2 ex, the clay of the large workshop after the removal of the coarsest inclusions. It bore less resemblance to Sc 5.

Discussion of the throwing experiments

The throwing experiments confirmed that both the clay of the large workshop and that of the small workshop contained coarse inclusions that were a nuisance when the clay was thrown. In the case of both clay types it is essential that the coarse non-plastic inclusions are removed through sedimentation or in some other manner. The sherds, in particular those of small pots, were found to contain only a few coarse grains, which means that the coarsest inclusions at least were largely removed from the clay. The throwing experiments showed that the few coarse grains still remaining in the clay did not present such a great problem.

The clay of the small workshop was found to be more plastic than that of the large workshop, as had already been determined in the previous experiments.

When the pots were dried too quickly problems tended to occur, for example crack formation due to shrinkage, particularly in the bottom around the navel (Fig. 8). The pattern of the cracks formed is typical of pots thrown upside-down. This phenomenon was observed in the case of the clay of the large workshop as well as that of the small one. Sample Lct 3 seemed to be less sensitive to crack formation; this is due to both the temper added to the clay and the clay's low water content. Remarkable is the fact that the removal of the coarse inclusions by no means leads to the formation of more cracks. The addition of fine non-plastic inclusions in fact appears to improve the clay's resistance to cracking, as in the case of Lct 3 and especially Sct 7 ex. The drying rate was found to have a greater effect on the clay's tendency to crack: no cracks were formed in pots that were allowed to dry slowly.

Another way of preventing cracking of the bottom of the pot is to compact the bottom in leather-hard condition. This can be done with the aid of a pestle on a firm, preferably slightly porous and dry surface. The result is a more compact structure of the bottom thanks to the better orientation of the particles. At Pabillonis this treatment would have been quite useful considering the function of the pots. In the compacting process all rings and torsion marks may be obliterated.

2.3.7 Determination of the forming technique

The analysis of the sherds (1.3) led to the conclusion that the pots had been formed upside-down. This conclusion was not based on the presence of a clear navel at the centre of the bottom (which was in most cases not or not clearly visible) but on the torsion marks observable on the inside wall of the pot. No such marks are formed on pots that are thrown the right way up because then the fingertips smooth the wall evenly throughout the entire forming process. The observations made in the throwing experiments confirmed this conclusion.

The following operations were successively performed in the experiment carried out to verify the conclusions, based on the investigation of the sherds:

- a pot was thrown upside-down;
- an indentation was made;
- the pot was cut just beneath the indentation;
- the pot was lifted from the wheel and was set down to dry upside-down;
- after a short drying period the pot was turned the right way up (i.e. while the clay was still soft);
- the bottom was compacted somewhat on the inside;
- the excess clay of the rim was cut away with the aid of a needle, which was held in an oblique upward position;
- the top part of the wall was made a little thinner and the rim was shaped. It is possible that this was done on a moist ceramic or gypsum plate and that the pot was then lifted from the wheel along with the plate and left to dry. Another possibility is the use of a leather-hard chuck;
- the pot was left to dry the right way up;
- the bottom did not have to be compacted on the inside;
- the sealing marks on the exterior of the bottom may have been obliterated in compacting the bottom. Most of the sherds showed no such marks.

Comments

Torsion marks are formed as follows. To ensure that the thin-walled, soft shape does not collapse, the wall is first shaped into a curved cone. At this stage the cone has no top because the shape is still open. The wall is then squeezed further inwards. The fingers remain on the inside of the wall to support it for as long as possible so as to ensure that the wall does not fold in the narrowing process. Then the wall is sealed. The air enclosed in the dome-shaped cone provides the counterpressure required during the operations to follow. As the potter continues to turn the wheel, he then gradually flattens the bottom with the aid of a rib. The rib makes the surface 'dry'. The resistance generated in the process and the narrowing of the wall together produce the torsion marks on the inside of the pot: a kind of wrinkles in the slip coating the inside surface.

An indentation is made in the wall to indicate the line along which the pot is later to be cut from the wheel. The clay is still too soft to be cut at this stage: the flat bottom would sag inwards if the pressure of the air enclosed in the pot were to be relieved by cutting the pot from the wheel and, in spite of the aforementioned thixotropic character of the material, it would be impossible to lift the resultant shape without considerable deformation. That is why the vessel is first cut lower down, so that the air remains in the pot. The shape filled with air is strong enough to be carefully lifted without deformation. The favourable effect of the thixotropic properties of the clay should not be underestimated in this procedure: they make it possible to lift relatively large, thin-walled pots without the risk of the wall being deformed. The pot is first left to dry in the position in which it was thrown, that is, upside-down. This ensures even drying of the wall and prevents the accumulation of water at the bottom.

After this initial drying phase the pot is turned the right way up and is returned to the wheel, where it is placed in a chuck. It is then trimmed along the incision previously made in the wall. The air contained in the pot, which has been slightly pressurized due to the shrinking of the clay, is released. It is not necessary to centre the pot firmly on the wheel because only small strains are generated in cutting the pot and finishing the rim between the fingers. Moreover, a sufficiently wide clay chuck provides all the support necessary in finishing the rim of the leather-hard pot. No traces of this method are later observable on the outside surface of the pot, provided that use is made of a chuck of leather-hard rather than soft clay. The oblique side of the typical profile of the rim is the result of the V-shaped incision previously made in the wall (Fig. 6).

2.4 Firing behaviour

2.4.1 Ceramic change test

The ceramic change test determines the lowest temperature at which a clay is converted into a ceramic product and is consequently no longer soluble in water. This transition, which can be well determined, often takes place below 500°C. The hardness of the product is irrelevant in this determination. If, however, the green strength of the clay is high enough, firing the clay at the ceramic change temperature will in principle result in a ceramic product that is suitable for use. This test determines the lowest possible firing temperature and consequently the clay's tendency to sinter at low temperatures, which is of importance with respect to the strength of the product.

Samples Lc 1, Lct 3, Lct 4, Sc 5 and Sct 7 ex were subjected to the test. All of the samples were found to result in good ceramic products on firing at 500°C.

2.4.2 Colour

After the original colour of the unfired test bars had been determined, the bars were fired at different temperatures, increasing 50°C at a time, from 500°C to 1100°C. The colour of the test bars was determined after each 50°C increment with the aid of the MSCC. The comparison of the colour of the unfired clays with that of the fired fabric gives some indication of the relative amounts and the nature of the impurities contained in the clay. The original colour of the clay of Pabillonis seems to indicate a moderate amount of organic substances; iron compounds give the fabric a reddish-brown colour when it is fired in an oxidizing atmosphere (Shepard 1980: 16-17). Moreover, a comparison of the colour of the clays fired under controlled conditions with that of the sherds can lead to a better understanding of the original firing conditions of the pots (Table 2.4.2).

Comment

Full oxidation, as indicated by the maximum Value and Chroma readings, was reached between 750 and 900°C. Between 950 and 1050°C the colour of the test bars became darker, indicating the beginning of vitrification and the decomposition of the clay minerals (Shepard 1980: 23; Hodges 1978: 196).

2.4.3 Apparent porosity

After each 50°C increment in the firing temperature, the apparent porosity of the test bars was determined according to the same method as used for the sherds. This was done to obtain an impression of the sintering behaviour of the clays and to enable comparison with the apparent porosity of the sherds (Table and Fig. 2.4.3).

2.4.4 Shrinkage

The dry shrinkage and total shrinkage percentages were determined linearly by measuring the test bars over 10 cm. This was done before firing and after each 50°C increment in the firing temperature, from 600 to 1200°C (Table and Fig. 2.4.4). Besides revealing a clay's shrinkage behaviour in drying and on firing at different temperatures, shrinkage diagrams also indicate the temperature at which the clay starts to sinter noticeably. Moreover, they enable comparison of the shrinkage behaviour of different clay samples and can also be used to determine the maturing temperature. Sometimes they even explain why potters found it necessary to adjust the composition of their clay.

Discussion and comparison of the results

The ceramic change test (2.4.1) shows that ceramic products are obtained already at a low firing temperature. The linear shrinkage (Table and Fig. 2.4.4), however, remains virtually unchanged up to 800°C. This indicates that no liquid-phase sintering takes place below 800°C (see the porosity diagram Fig. 2.4.3). In order to obtain a strong product, the clay must therefore be fired at a temperature above 850°C: a firing

SAMPLE	raw	500°C	600°C	800°C	900°C	1000°C	1050°C	1100°C
Lc 1	2.5Y 5/4 light olive brown	2.5YR 4/4 reddish brown	2.5YR 4/6 red	2.5YR 5/8 red	-	2.5YR 4/8 red	2.5YR 4/6 red	10R 5/4 weak red
Lct 3	2.5Y 5/4	2.5YR 4/4	2.5YR 4/6	2.5YR 5/8	2.5YR 6/8 light red	2.5YR 5/6 red	-	10R 4/3
Lct 4	2.5 Y 6/6 olive yellow	2.5YR4/4	2.5YR 4/6	2.4YR 5/8	2.5YR 6/8	2.5YR 5/8 red	2.5YR 5/6 red	10R 5/4 weak red
Sc 5	2.3YR 5/6 light olive brown	2.5YR 4/4	2.5YR 4/6	2.5YR 4/6	2.5YR 5/8 red	-	2.5YR 5/6 red	10R 5/4

Table 2.4.2. Pabillonis, clays: determination of colour.

SAMPLE	600°C	650°C	700°C	750°C	800°C	850°C	900°C	950°C	1000°C	1050°C	1100°C
Lc 1	14.95	16.17	14.39	15.52	14.63	13.52	13.78	11.76	7.62	7.15	2.81
Lct 3	14.29	15.03	13.66	14.50	14.28	13.79	13.96	13.03	9.93	6.18	3.86
Lct 4	16.47	17.70	16.06	16.98	16.41	16.02	16.08	14.87	10.54	8.92	3.70
Sc 5	17.12	18.49	16.39	17.56	16.54	15.10	14.86	11.59	4.35	3.30	1.13
Lcb 2ex						13.22	11.74	9.52	7.39		
Sct 7ex						14.03	11.75	6.86	2.94		

Table 2.4.3. Pabillonis, clays: apparent porosity percentages.

temperature of between 850 and 900°C appears to be favourable in this respect.

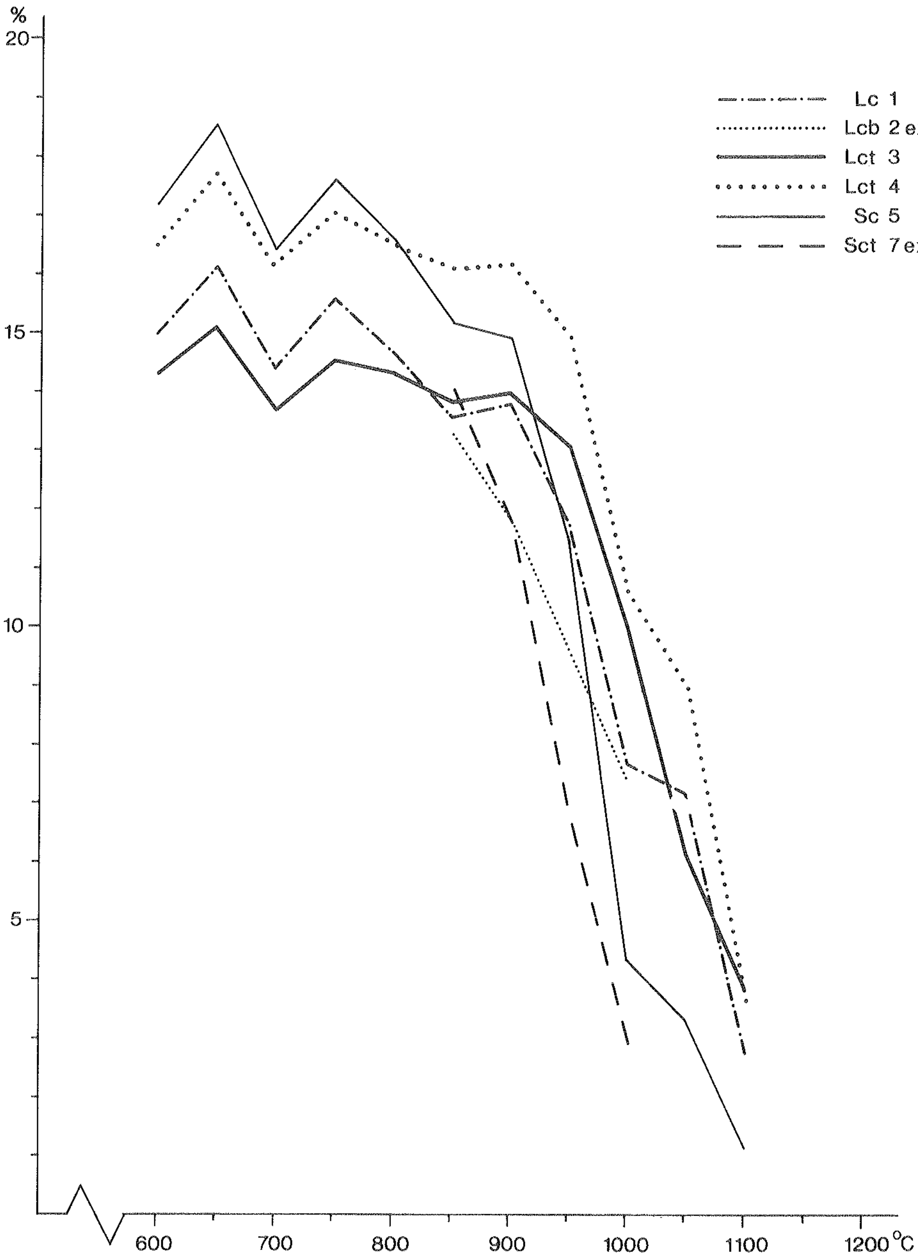


Fig. 2.4.3. Pabillonis, clays: diagram of the apparent porosity percentages.

SAMPLE	dry	600°	650°	700°	750°	800°	850°	900°	950°	1000°	1050°	1100°	1150°	1200°C
Lc 1	7-7.5	7.5	7	7	7	7.5	8	9	9.5	11	12	14	distortion	fusion
Lcb 2ex	6.5	6.5	6.5	6.5	6.5	6.5	7	8	9	10.5	10.5	13	distortion	fusion
Lct 3	6	6	6	6	6	6	6.5	7	7.5	9	10	12	distortion	fusion
Lct 4	6	6	6	6	6	6	7	7.5	8	10	11	13.5	distortion	fusion
Sc 5	7(warps)	7	7	7	7	7	8	9	10	12.5	13	14	distortion	fusion
Sct 7ex	6	6	6	6	6	6.5	7	8	10	11.5	11.5	13	distortion	fusion

Table 2.4.4. Pabillonis, clays: shrinkage percentages.

The clays of Pabillonis do not shrink excessively in drying (Table and Fig 2.4.4). The formation of cracks at the centre of the bottom, around the navel (Fig. 8), can be prevented by minimizing the amount of time used to form the pot (the clay soon reaches its point of saturation) and then drying it slowly. Strictly speaking, there is therefore no need to add temper to the clay to reduce the degree of shrinkage during drying. However, the addition of temper has the favourable effect of making the structure of the body more porous, which enables a more even drying process thanks to the resultant better transportation of water through the wall. Lc 1 and Sc 5 indeed shrink slightly more in drying than Lct 3, Lct 4 and Sct 7 ex. This is due to the fact that the approximately 17% temper contained in the latter clay bodies reduces the original degree of shrinkage by about one sixth, which corresponds to about 1%. This makes it most unlikely that the potters of Pabillonis tempered their clay in order to reduce the degree of shrinkage in drying. A degree of shrinkage of 6 to 7% is to be expected and no measures need be taken to prevent it. The clays must have been tempered for some other reason.

A comparison of the porosity diagrams of the test bars with those of the sherds shows that the porosity of the test bars is on average 3% higher (Figs. 1.4.2 and 2.4.3). Moreover, the porosity of the test bars starts to decrease at a slightly higher temperature than that of the sherds, namely at 900°C. In our opinion this difference is due to the presence of glaze on the sherds, which interacts with the clay so as to increase its tendency to sinter. This interaction would also explain the fact that the porosity of the sherds as a group is slightly lower than that of the test bars as a group: at 850°C the average

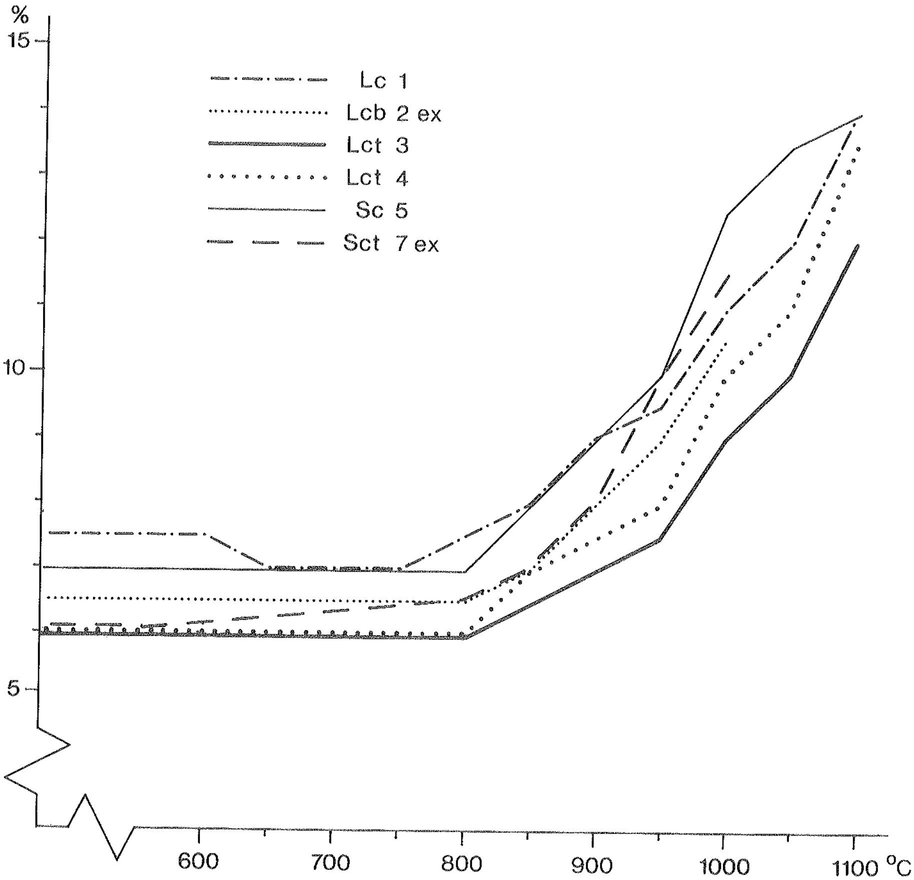


Fig. 2.4.4. Pabillonis, clays: diagram of the shrinkage percentages.

porosity of the sherds is 12-13%, whereas that of the test bars is 15%. In spite of small differences in the absolute values, the porosity of all of the test bars shows more or less the same changes up to 800°C (2.4.3). After 800°C the changes between the individual test bars increase slightly due to the then intensifying sintering. The sintering process intensifies after 900°C. The porosity curves show that the presence of a larger amount of muscovite plates (in samples Lct 3 and Lct 4) does not appear to affect the porosity or the degree of sintering, which is in accordance with the data available on muscovite (see below, p. 120). In the firing process, the weight of the muscovite decreases by only 4-5% due to the evaporation of moisture that is retained in the structure after complete drying.

Heating to 1200°C led to a substantial degree of sintering and, consequently, serious deformation of the fabric. This sintering is partly caused by the grains contained in the temper, as was determined by firing temper that had been rinsed through a sieve. Feldspar grains started to sinter at 1150°C and reached complete vitrification, resulting in a clear, colourless glass, at 1200°C. The low ceramic change temperature also indicates the presence of basic oxides that melt at a low temperature, such as potash and sodium carbonate (K_2CO_3 and Na_2CO_3), which is in accordance with the poor sedimentation behaviour and the pH values of the clays.

2.4.5 Resistance to thermal shock

The potters of Pabillonis claimed that the good resistance to thermal shock and particularly the resistance to thermal stress of their cooking pots was largely due to the amount of temper added to the basic clay. A number of tests were carried out with the natural clays and with various clay and temper blends in order to evaluate this statement and to obtain a better understanding of the properties of the clay and the temper.

As already mentioned, the temper used at Pabillonis appeared to be a mixture of sand and clay containing many muscovite plates. One of our main questions therefore concerned the effect of the muscovite plates on the pots' resistance to thermal stress. A second question was whether a muscovite-rich temper was more effective than , for example, a temper consisting of pure quartz sand or of grog.

In addition to Lc 1 and Sc 5, the natural clays of the two workshops, a number of clay blends containing different amounts and types of temper were tested.

The following substances were used in the tests:

Code	Sample	Number of test bowls
Lc 1	clay from the large workshop	2
Lct 3	clay+temper from the large workshop	3
Sc 5	clay from the small workshop	2
A	clay+temper from the large workshop (2/3+1/3)	1
B	clay+temper from the large workshop (5/6+1/6)	2
G	clay+temper from the small workshop (2/3+1/3)	1
D	clay from the small workshop + quartz sand temper (<600μ; 5/6+1/6)	1
E	commercial clay D 3002+grog (2/3+1/3)	2
F	commercial clay D 3002 (2/3) + temper (1/3) = grog (1/2) + muscovite (1/2)	2

Method

With the aid of a mould, hemispherical bowls were made from the various blends. This technique minimizes differences in the forming process. The wall thickness of each bowl was checked. The bowls were all dried in the same way and were biscuit fired at 875°C. After having been coated with glaze on the inside, the bowls were glost fired at 850°C. In addition, a number of wheel-thrown pots of the same shape as the cooking pots of Pabillonis were fired and glazed in the same way and then subjected to the test.

Three life tests were carried out in a specific order (see below) and were repeated in the same order where necessary, until the samples cracked.

Test of the bowls

The bowls were filled with water and placed over a bunsen burner burning with a constant flame.

1st test: as soon as the water had started to boil the bowl and its contents were immersed in cold water (of 10°C), in upright position.

2nd test: the bowl was placed over the bunsen burner again and was allowed to boil dry in 10 minutes.

3rd test: after the bowl had boiled dry it was filled with cold water (10°C). Once the water had started to boil, test 1 was repeated again.

- each test was tallied;
- the experiment was stopped when the bowl cracked;
- the order of the tests was the same each time;
- both the test bowls and the test cooking pots were subjected to temperature shocks that were greater than any shock they were likely to experience in normal use.

Results

Sample	Number of life tests[11]
Lc 1	*
Lct 3	*
Sc 5	1
A	*
B	*
G	*
D	*
E	*
F	*

Test of the wheel-thrown pots

The wheel-thrown cooking pots were subjected to the same test.

Results

Sample	Number of life tests
Lc 1	6
Lct 3	6
Lcb 2 ex	4
Sc 5	1

Discussion

Both the mould-produced bowl and the wheel-thrown pot made of Sc 5, the untempered clay of the small workshop, appeared to crack already after the first series of tests. This is in accordance with the small amount of non-plastics of between 38 and 150μ contained in this clay (Table and Fig. 2.2).

All of the other substances, on the other hand, were found to result in products that were resistant to thermal shock and thermal stress, although the wheel-thrown pots - the bottom of which was not reinforced by ramming - appeared to be less resistant than the bowls. As already mentioned, a pot's resistance to thermal stress does not only depend on the composition of the clay but also on the shape and the size of the pot and on the manufacturing technique used.

Clay Lc 1, which in its natural form already contained muscovite plates and a greater amount of fine quartz grains (2.2.1), was also found to be resistant to thermal stress. The slight reduction in the resistance to thermal stress resulting from the removal of the coarse inclusions (Lcb 2 ex) is compensated by the effect of the fine muscovite-rich temper added to the clay (Lct 3).

Blends A, B, G and D all resulted in products that showed good resistance to thermal stress: the more than 1/6 part of temper added to the clay did not adversely affect the product's resistance but there was no sense in adding any more temper. A greater porosity can increase a pot's resistance to thermal stress but at the same time it can shorten its life due to the gradual loss of strength characteristic of cumulative thermal fatigue (Rice 1987: 368).

The fact that blends D and E also resulted in pots with good resistance implies that as far as resistance to thermal shock is concerned, both grog and quartz sand have the same positive effect as muscovite. From a purely technological viewpoint the presence of muscovite in the blend is therefore an advantage, but not an essential requirement.

Properties of muscovite

Muscovite is a potassium aluminium silicate ($KAl_2 [(OH, F,)_2 \mid Al\ Si_3O_{10}]$ that is rich in aluminium and is therefore refractory. Strictly speaking, muscovite has poor thermal conductivity and hence also poor heating effectiveness. Poor thermal conductivity implies high heat resistance (Rice 1987: 364): muscovite is used as an insulation material in the electrical industry and is also used for transparent panels in stoves. The specific gravity of muscovite is 2.7/2.8, which is not much different from that of quartz (2.65). The two therefore also have similar densities, that of muscovite being 2.8 and that of quartz 2.5. The linear expansion coefficient of muscovite is 0.3, which is relatively low. However, that of quartz is only 0.04 (as compared with for example 0.8 for flint). Quartz and flint grains are known to expand considerably at a temperature of 573°C though (and to shrink to a corresponding degree at the same temperature when they are allowed to cool). For this reason the presence of in particular coarse quartz grains (of over 1000μ) is certainly undesirable as far as heat resistance is concerned. Muscovite is remarkably elastic: it deforms or strains relatively little in response to applied stresses. The modulus of elasticity of muscovite is between 16 and 21 (as compared with 7 for quartz). The modulus of elasticity (E) , or Young's modulus, is the stress/strain ratio of a given material, where stress is the applied force per unit of area and strain is the change in dimension per unit of dimension. The elastic limit is the maximum stress that a material can sustain and still return to its original form. The high modulus of elasticity of this mineral makes it a very suitable tempering material as far as resistance to thermal stress is concerned because high elasticity values minimize crack propagation (Bronitsky 1986). In this respect the mineral's platy shape is also an advantage (Rice 1987: 407). Another favourable property of muscovite is its moisture absorption behaviour: it does not expand and absorbs no more than 4-5% water. Muscovite has a low endothermal peak. Between 600 and 900°C it very gradually releases the bound water, which means that it can absorb thermal shocks in this temperature range through its damping effect. A disadvantage is that in the same temperature range wafer-thin flakes fly off. Muscovite easily returns to the hydrated phase, which also implies a damping effect also during cooling: when the fired test bowls and wheel-thrown test pots were tapped with a metal object the pots made of clay that was not tempered with muscovite produced a higher sound than the pots that were tempered with muscovite. This damping effect of muscovite increases the flexural or bending strength of pots making them more impact resistant (cf. Wallace 1989).

3 Glaze

The results of the present research once again show that in order to be able to absorb thermal stress a vessel must have a relatively high degree of porosity. However, if a pot contains a large number of continuous pores through the body so much moisture will evaporate through the wall of the vessel when it is placed over a heat source, that it will no longer be possible to bring water to the boil over a moderate flame[12]. Loss of heating effectiveness (the rate at which a vessel placed over a heat source raises the temperature of water) of cooking pots due to a high permeability can be prevented by treating the surface of the pot. Glazing the inside surface, as was done at Pabillonis, is the best way of preventing loss of water and ensuring excellent heating effectiveness (Schiffer 1990).

The effects of the glaze on the resistance to thermal shock may be either favourable or unfavourable, depending on the compatibility of the expansion coefficients of the glaze and the body (Rice 1987: 369): in the case of the cooking pots of Pabillonis the glaze seems to fit the body very well. A glaze coating also facilitated the cleaning of the pots.

A firing temperature of 850°C results in a degree of porosity of about 15%, which is too high for a cooking pot whose surface is to undergo no further treatment.

On the other hand, to enable the application of glaze after biscuit firing, the fabric must be sufficiently absorbent; in this respect a degree of porosity of some 15% is fairly low. That is why the glaze must be applied relatively thickly. As the glaze mixture lacked a certain amount of clay, a binder had to be added. A more porous, absorbent pot could theoretically be obtained by carrying out the biscuit firing at a lower temperature. However, the porosity diagram of the clays of Pabillonis (2.4.3) shows that the apparent porosity at firing temperatures of less than 850°C is hardly any higher than 15%. Moreover, if the biscuit firing is effected at a much lower temperature than the glost firing, there will be a risk of bubbles and other irregularities being formed in the glaze due to the release of gases, such as CO_2, from the clay body during the glost firing. In our experiments the best results, also as far as shrinkage is concerned, were obtained at a biscuit firing temperature of 850-875°C.

3.1 Glaze experiments

The samples of clay, flint and red lead used for the experiment were obtained from the large workshop.

biscuit firing temperature	glost firing temperature
875°	850°

The experiment showed that the glaze must not be applied too thinly. When use was made of exclusively red lead, only the thickly coated patches were properly glazed. The resultant glaze was not uniform due to the unequal extraction of silicic acid from the clay. This is why SiO_2 must be added.

The Seger formula for $PbO.SiO_2$ = 900°C
The subtraction of every 0.1 molecule of SiO_2 decreases the temperature by 20°C, so
PbO 0.8 SiO_2 = 860°C

The molecular weight of red lead is 229;
the molecular weight of SiO_2 is 60
60 x 0.8 = 48

Pb_3O_4	SiO_2	
=229	48	860°C so
=100	21	
=5 parts	1 part	
=83%	17%	

This means that one part of SiO_2 and five parts of red lead together yield a glaze that is suitable for firing at 860°C.

III COMPARISONS AND CONCLUSIONS

Before the results of the technological analyses can be evaluated from an archaeological point of view, they will have to be compared with the information gathered on the properties of the raw materials, the manufacturing technique and the function of the products.

The macroscopic analysis of the sherds revealed the presence of angular and sub-angular grains of large diameters (ranging from 1 mm to, sporadically, 4/5 mm), which raised some questions. Grains of such dimensions are not desirable in the wheel-production of thin-walled pottery of the kind manufactured at Pabillonis. Moreover, they may cause problems in firing. Their presence could only be explained through the analysis of the raw materials, in particular the clay of the large workshop. The latter was found to be a highly thixotropic clay: when soaked in water and left to rest, it formed a thick slurry in which the coarse inclusions remained suspended instead of being deposited. Once this property had been established, a few aspects of the method traditionally used to prepare the raw materials became much clearer, as will be explained below.

The clay and the temper always had to be stored indoors, in special rooms called *sa domu de sa terra* (the house of the earth) and *sa domu de sa terra de pistai* (the house of the earth for crushing) (Fig. 2). One of the reasons for this was that the large lumps had to be completely dry in order to be broken into smaller pieces, cleaned by hand and then sieved. The sieves used had wide meshes (Fig. 10): no sieves of durable material (such as iron) with narrow meshes were available in the village. Even if such sieves had been at hand it is not certain whether they would have been used because they would have made the sieving far too time-consuming and tedious. Rye discusses similar situations (Rye and Evans 1976: Pl. 1c; 7c,d; 12a,b; 28e; Rye 1981: 17; 36-37). Preparing the temper was considered a particularly heavy and unhealthy task. Before being sieved, it was ground with the aid of a wooden stick. This was done in the 'house of the earth for crushing' to avoid the risk of the temper becoming humid because besides quartz and mica it also contained clay. The large quantities of airborne powder particles produced in the grinding process were inhaled and caused damage to the lungs[13].

The sherds showed the odd lump of undissolved clay attributable to insufficient soaking. This was due to the habit of preparing the clay

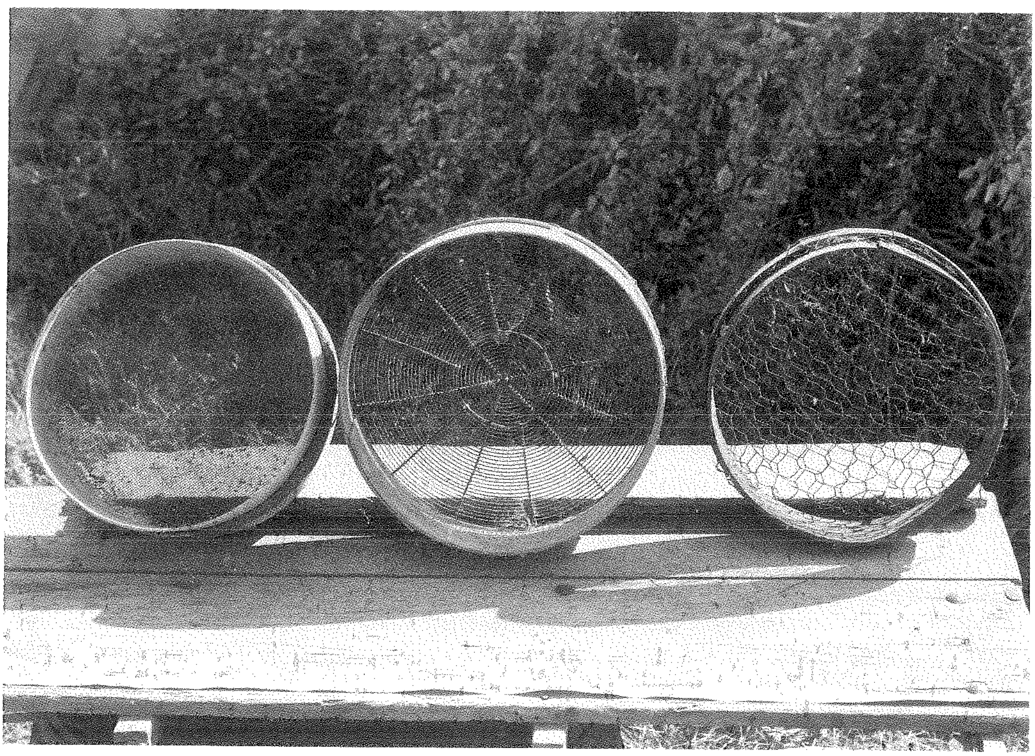


Fig. 10. Pabillonis, sieves for clay (right and middle) and for temper (left).

shortly before use: the amount of sieved clay required for a day's work was poured into a wetting tank in the evening and was solid enough to be lifted out with the hands after one night's soaking. It was then spread out on the floor where it was mixed with the temper and accurately kneaded by foot.

The prepared blend was then left to rest for a few hours before being transferred to the bench. The large workshop owners in particular found the next step of the preparation extremely slow and tiring: it implied removing as many coarse grains as possible by hand. This was done by cutting a lump of clay from the clay ball obtained and kneading it by hand on the wooden bench: it was pushed forwards with the palm of the hand and then drawn back with the fingertip to remove the coarse inclusions. This operation was repeated two or three times. When a certain amount had been cleaned it was shaped into small balls which were kneaded again and then slapped down onto the wheelhead one by one. Finally, there was a hump of clay of some 20/25 kg on the wheelhead. The described work required no specific skills and was usually done by women.

The forming technique reconstructed on the basis of the sherds coincides almost exactly with that described by the potters. The throwing experiments also confirmed that this reconstruction was correct. However, both the analyses and the experiments failed to reveal an important detail of the procedure, which left no traces on the material: all of the pots and casseroles, including the large ones (of 10/12 and 8 l, respectively), were formed from the hump. To this end between 20 and 25 kg of clay, enough to produce half a day's output, was piled up on the wheel[14].

To enable the manufacture of thin-walled large and medium-sized pots, the clay had to be as stiff as possible. The disadvantage of throwing the clay in this condition was that it grated the hands. This could be prevented to some extent by employing a rib (Fig. 4). For smaller pots a wetter clay could be used but in that case too no more water was to be added. All this became apparent in our experiments. The wall thickness of the differently sized pots was to be more or less the same (Fig. 5) - for functional reasons connected with the required resistance to thermal shock but also for reasons of weight: one of the unique characteristics of the pots was their light weight, the total weight of the four pots of one series being just over 2 kg at the most. As already mentioned, the pots were formed upside-down from the hump. In order to save time and keep a regular production rate the potters used to throw one particular size at a time. That is also why they would throw only pots one day and only casseroles another.

The tests showed that attention had to be paid to the drying of the pots; this was done slowly, indoors. A few hours after the pot had been lifted from the wheel and placed upside-down on a wooden table to dry, the bottom of the pot was flattened by patting it with a paddle (Fig. 11). The experiments also showed that the clay tended to harden quickly. After about 12 hours the pot was turned the right way up and the bottom was firmly compacted with the aid of a pebble or a wooden pestle (Fig. 11). Traces of the navel were often obliterated in this process. The potter then returned the pot to the wheel, placing it in a chuck lined with cloth to prevent sticking. On the wheel, the lip was finished and the handles were attached. These finishing operations were usually done first thing in

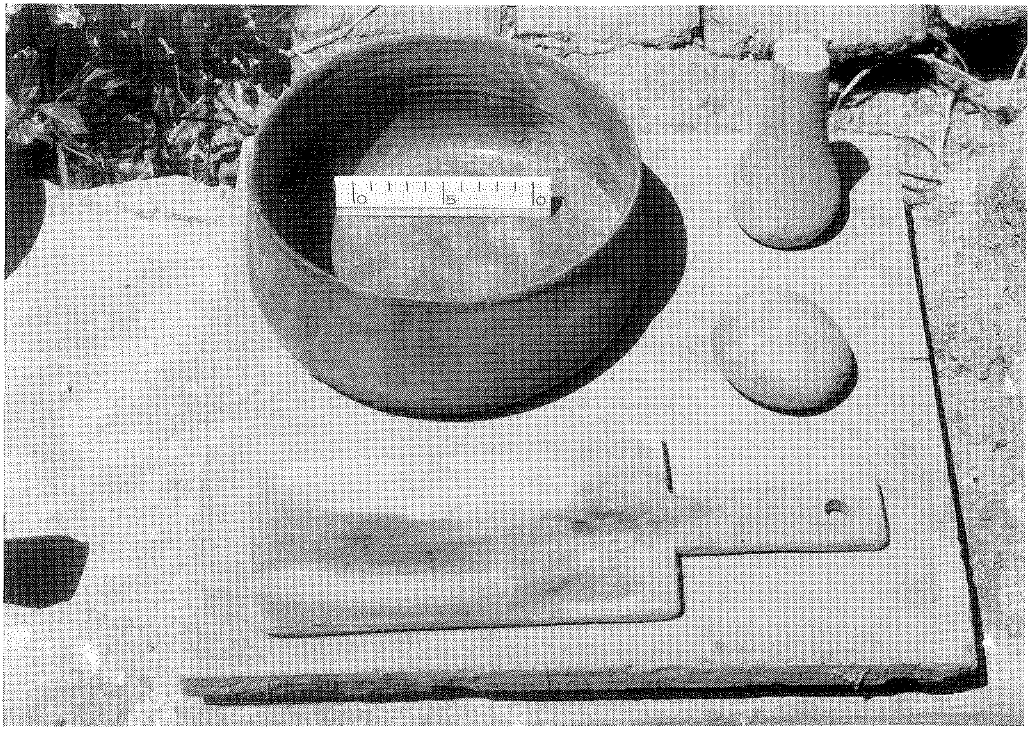


Fig. 11. Pabillonis, paddle, pebble and pestle to flatten and to compact the bottom of the pots.

the morning. The handles were also formed on the wheel. Finally, the pots were left to dry completely. This was always done indoors and could take up to one week in the humid season.

The assumption, based on the appearance of the glaze and the fabric, that the pots were fired twice is also correct and the same applies to the assumed glost firing temperature of less than 900°C: the potters knew that a temperature of about 850°C was required for complete fusion of the glaze. They also knew that they were not to use temperatures of over 900°C otherwise the fabric would sinter too much. The assumption that the biscuit firing temperature was higher than the glost firing temperature is, however, not correct. In Pabillonis the pots were first biscuit fired for between 4 and 6 hours, depending on the size of the kiln, and were then glost fired for between 8 and 12 hours. Three times as much fuel was needed for the glost firing[15]. Clearly, the potters' aim in the first firing was to obtain a product that was sufficiently ceramic to be coated with glaze. The ceramic change test showed that such a product is already obtained at a temperature of 500°C. Firing the pots any longer than strictly necessary would have been a waste of fuel and time. Moreover, the purely utilitarian function of the pots did not require a perfect glaze. The glaze was applied after the first firing, usually to the inside wall of the pot only. Before World War II the glaze consisted of a mixture of galena (lead sulphide, which was ground in a mortar and then passed through a silk screen), flint (which was collected from the bed of the river Bellu and was also ground and passed through a silk screen), and a solution obtained by boiling bran, which was the binding agent. After the 1930s the galena was replaced by red lead (Pb_3O_4). The volumetric ratio of the galena (or red lead) and the flint was about 66% : 33% ("14 pots of galena and 7 of flint"). Expressed in weight it was "10 kg of galena (or red lead) and 2 or 3 kg of flint", i.e. about 83% : 17% for a 'fatty' mixture (a mixture containing relatively much lead) and 77% : 23% for a 'lean' mixture (a mixture containing less lead). These data correspond exactly to the results of our laboratory experiments.

As for the function of the products, all of the potters agreed that the tiring, time-consuming and unhealthy task of adding temper to the clay was absolutely essential because it was the only way of obtaining pots with the excellent resistance to thermal shock for which their products were so renowned. The potters specified a clay/temper ratio of 50/10 kg, i.e. 80% : 20%. In the experiments the clay of Pabillonis was found to have considerable resistance to tensile stress, which implies good initial strength of the material. However, in order to be able to sustain repeated cycles of heating and cooling (thermal stress), the porosity of the fabric must be increased by adding about 20% fine temper. The plasticity of the clays of Pabillonis was good but not excellent. For that reason it was not possible to use a temper consisting exclusively of quartz: quartz sand would have reduced the cohesion of the clay too much. Thanks to its platy shape, muscovite on the contrary has a positive effect on the cohesion of the blend and improves its workability. Moreover, it is elastic and has a damping effect - two favourable properties as far as the resistance to thermal shock and the life of the products in general are concerned. The ratio of clay and temper specified by the potters was found to be correct: a greater amount of temper would not have increased the product's resistance and would instead have made it weaker and more susceptible to thermal fatigue[16].

From what has been said above it may be concluded that the technological analyses to a considerable extent succeeded in determining the properties of the raw materials and the relationships between them, the manufacturing technique and the function of the products. Without the availablity of the raw materials, however, in other words if we had had to depend on the sherds alone, the resultant picture would have been far too incomplete. This once again stresses the importance of taking samples of the raw materials too in investigating the ceramic products of an archaeological site (Franken and Kalsbeek 1969; Jacobs 1983; van As and Jacobs 1988; van As, Jacobs and Wijnen 1988).

To return to the term "resource specialization": the raw materials of Pabillonis do not possess peculiar mineralogical properties; the minerals contained in the clay and the temper are fairly common. It would seem that the village's specialization is not in the first place the result of the unique properties of the raw materials used but rather the consequence of social, economic and historical factors[17].

Two aspects of the pottery production of Pabillonis are particularly remarkable: the pressure under which the potters had to work and the great amount of effort and the health risks involved in the methods they employed. The potters of this village could not depend exclusively on their craft for their living: in Sardinia only little money was paid for a clay pot because it did not last long. The consequence of this was that a relatively great demand had to be satisfied by only a small number of potters, otherwise there would have been no chance whatsoever of any of the producers making a profit. Moreover, the output was considerably smaller in the wet season, from November to April. In this part of the year the potters had to work in the fields too, while in the dry season they worked almost ceaselessly in the workshop. This precluded the possibility of making any changes involving risks or the loss of valuable time. To this should be added the social environment of which the potters formed part: a small rural community that employed remarkably archaic cultivation methods (Le Lannou 1941: 188-189). All in all, these conditions did not favour an innovative attitude. The results of our technological analysis suggest that with some technical modifications such as, for example, simple grinding machines to help in the preparation of the clay and temper, the potters would have been able to omit the most ungrateful and unhealthy steps in the manufacturing process. As already discussed elsewhere (Annis and Geertman 1987: 189-191; Annis in press), technical innovations that were more in line with the production methods of an industrial society would have enabled the craftsmen both to continue the traditional production of cooking ware (for which there was still sufficient demand when they gave up their craft) and to meet the rising demand for new products. The working condition would have been more attractive to the younger generations, which would have ensured the future of the craft.

Notes

1. The period covered in this research on pottery production in Sardinia ranges from the 1920s to the 1980s. At Pabillonis, however, the activity came to an end in 1973.

2. As far as the life span of the pots is concerned, if treated with care a medium-sized pan (3-4 l) that was used every day could last between about ten months and one year (cf. Arnold 1985: 152-157).

3. The information was provided by ex-producers and distributors but also by consumers living in the village itself and elsewhere on the island. The written sources are a few historical records and information on the centre and the production found in archives. My colleague Herman Geertman, who is participating in the fieldwork, provided the graphical and photographical documentation.
Alla popolazione di Pabillonis, all'amministrazione comunale e specialmente a tutti gli informatori desidero esprimere la mia gratitudine per la loro disponibilità e pazienza. Un particolare ringraziamento devo alla famiglia Frau-Piras, da cui sono sempre stata accolta con costante cordialità, e il cui aiuto e collaborazione sono stati di fondamentale importanza per lo svolgimemto di questa ricerca.

4. The land reclamation and reallotment of the Guspini-Pabillonis territory (an area of 34,290 ha) was started in 1934 and was completed after World War II. The work included the canalization of the rivers of the region, which did not have proper beds and regularly flooded the fields of Pabillonis (Le Lannou 1941: 311-314; Terrosu Asole 1982: 1, 69-72).

5. The absence of limestone established in the HCl testing of the fabric and the clay (see Chapters 1.2.3 and 2.2.3) is therefore not a natural characteristic of the raw materials but the result of a strict selection procedure.

6. A barbotine-like substance that stuck to the potter's hands or to the wheel. This was thrown into a large storage vessel and was later used to make 'toys' or it was mixed with the ordinary clay.

7. Usually between 20 and 35% water must be added to clay bodies to obtain the required degree of plasticity (Rye 1981: 21).

8. The same intervals were used as in the tests of the clays from Oristano (Annis & Jacobs 1986).

9. Commercial clays and samples obtained from several archaeological findspots.

10. The opposite of thixotropic clays are dilatant clays: clays that present more resistance in kneading and working but become stiff less quickly when left to rest (Grimshaw 1971:473-475; Cool 1988).

11. The number in the second column indicates the number of times that the whole series of life tests (tests 1-3) was carried out before the pot cracked. The asterisk means that the pot had still not cracked after the entire series had been repeated at least 15 times.

12. A number of experiments were carried out with unglazed test bowls made both from untempered clay and from clay bodies tempered with muscovite. In both cases the water in the bowls did not come to the boil due to the evaporation of water through the wall of the pot. After having been left over the bunsen burner for 20 minutes, the tempered bowls had reached a maximum temperature of 80°C and the untempered bowls a temperature of 90°C.

13. This task involved a great risk of silicosis - more so than grinding flint in a mortar. Even now, the walls of the 'house of the earth for crushing' are covered with a layer of fine powder.

14. In one day of eight hours a potter usually produced fifteen series of four pots of four different volumes, viz. a total of 60 pieces. An experienced potter who worked a few hours more could produce twenty series, viz. 80 pots. See Annis and Geertman (1987) for a quantitative analysis of the production.

15. *Maquis* shrubs obtained from the hills near the village were used as fuel. Rock-rose (Cistus) was preferred.

16. Most of the potters claimed that the temper was added to make the pots 'stronger' so that they would 'last longer'. A few other potters, including the owner of the small workshop who provided one of the samples, claimed that, without temper, a pot was 'useless' because 'it cracked after having been used only two or three times'. The experiments showed that the clay must indeed be tempered in order to obtain good thermal resistance. In the case of the clay of the small workshop, however, it is absolutely essential to add temper because of the peculiar properties of this clay. So, a difference in the information which had seemed negligible at first, in fact turned out to be quite important later on, in the light of the experiment.

17. We are considering carrying out more experiments and extending them to include the clays of other production centres too in order to find out whether those clays are indeed unsuitable for the production of cooking vessels.

References

Annis, M.B. (in press), Organization of pottery production in Sardinia, variability and change. In: R.Vossen (ed), *Töpfereiforschung zwischen Archäeologie und Entwicklungspolitik* (Töpferei- und Keramikforschung Band 3), Bonn.

Annis, M.B. and H.Geertman (1987), Production and distribution of cooking ware in Sardinia. *Newsletter Department of Pottery Technology Leiden* 5: 154-196.

Annis, M.B. and L.Jacobs (1986), Ethnoarchaelogical research: pottery production in Oristano (Sardinia). Relationships between raw materials, manufacturing techniques and artifacts. *Newsletter Department of Pottery Technology Leiden* 4: 56-85

Arnold, D.E.(1971), Ethnomineralogy of Ticul, Yucatan potters: etics and emics. *American Antiquity* 36 (1): 20-40.

Arnold, D.E. (1985), *Ceramic theory and cultural process*, Cambridge.

As, A. van (1984), Reconstructing the potter's craft. In: S.E. van der Leeuw and A.C.Pritchard (eds), *The many dimensions of pottery: ceramics in archaeology and anthropology*, Cingula VII, Amsterdam: 131-164.

As, A. van and L.Jacobs (1988), Report on the activities of the working group on Mesopotamian pottery during the years 1987 and 1988. *Newsletter Department of Pottery Technology Leiden* 6: 1-22.

As, A. van, L.Jacobs and M.-H.Wijnen (1988), Technological research on Neolithic pottery from Sesklo (Greece) - A preliminary report. *Newsletter Department of Pottery Technology Leiden* 6: 23-34.

Bishop, R.L. and R.L.Rands (1982), Maya fine paste ceramics: a compositional perspective. In: J.A.Sabloff (ed), *Analysis of fine paste ceramics: Excavations at Scibal Department of El Petén, Guatemala*, Cambridge (Mass): 283-314.

Braun, D. (1983), Pots and tools. In: A.S.Keene and J.A.Moore (eds), *Archaeological hammers and theories*, New York: 107-134.

Bronitsky, G. (1986), The use of materials science techniques in the study of pottery construction and use. In: M.B.Schiffer (ed), *Advances in archaeological method and theory* 9, Orlando: 209-276.

Bronitsky, G. and R.Hamer (1986), Experiments in ceramic technology: the effects of various tempering material on impact and thermal shock resistance. *American Antiquity* 51: 89-101.

Brumfiel, E.M. and T.K.Earle eds. (1987), *Specialization, exchange and complex societies*, Cambridge.

Child, S.T. (1988), Clay resource specialization in ancient Tanzania: implications for cultural process. In: Kolb, C. (ed) *Ceramic ecology revisited, 1987.*, BAR Int. Ser. 436 (I, II), Oxford: 33-56.

Cool, B. (1988), Over petuntze en nephline syeniet. *Klei, glas, keramiek* 6: 156-157.

Grimshaw, R.W. (1980), *The chemistry and physics of clays and allied ceramic materials* (4th ed), New York.

Franken, H.J. and J.Kalsbeek (1969), *Excavations at Tell Deir 'Alla*, Leiden

Hamer, F. (1983), *The potter's dictionary of materials and techniques*, London.

Hodges, H. (1976), *Artifacts*, London.

Jacobs, L. (1983), Notes about the relation between filler and clay, and filler and shrinkage respectively. *Newsletter Department of Pottery Technology Leiden* 1: 6-12.

Kingery, W.(1955), Factors affecting thermal stress resistance of ceramic materials. *Journal of the American Ceramic Society* 38: 3-15.

Le Lannou, M. (1941), *Pâtres et Paysans de la Sardaigne*. Tours.

Peacock, D.P.S. (1982), *Pottery in the Roman world: an ethnoarchaeological approach*. London.

Rhodes, D. (1973), *Clay and glazes for the potter*, Philadelphia.

Rice, P.M. (1981), Evolution of specialized pottery production. A trial model. *Current Anthropology* 22 (3): 219-240.

Rice, P.M. (1987), *Pottery analysis. A sourcebook*, Chicago.

Rice, P.M. (1989), Ceramic diversity, production and use. In: R.D.Leonard and G.T.Jones (eds), *Quantifying diversity in archaeology*, Cambridge: 109-117.

Rye, O.S. (1976), Keeping your temper under control: materials and manufacture of Papuan pottery. *Archaeology and Physical Anthropology in Oceania* 11: 106-137.

Rye, O.S. (1981), *Pottery technology: principles and reconstruction*, Washington.

Rye, O.S. and C.Evans (1976), *Traditional pottery techniques of Pakistan: field and laboratory studies*, Washington

Schiffer, M.B. (1990), The influence of surface treatment on heating effectiveness of ceramic vessels. *Journal of Archaeological Science* 17: 373-381.

Schuring, J.M. (1986), The Roman, Early Medieval and Medieval coarse kitchen ware from the San Sisto Vecchio in Rome. *Babesch* 61: 158-207.

Shepard, A.O. (1965), Rio Grande glaze-paint pottery: a test of petrographic analysis. In: F.R.Matson (ed), *Ceramics and Man*, Chicago: 62-87.

Shepard, A.O. (1980), *Ceramics for the archaeologist* (10th ed), Washington.

Steponaitis, V. (1984), Technological studies of prehistoric pottery from Alabama: physical properties and vessel function. In: S.E. van der Leeuw and A.C.Pritchard (eds), *The many dimensions of pottery: ceramics in archaeology and anthropology*, Cingula VII, Amsterdam: 79-127.

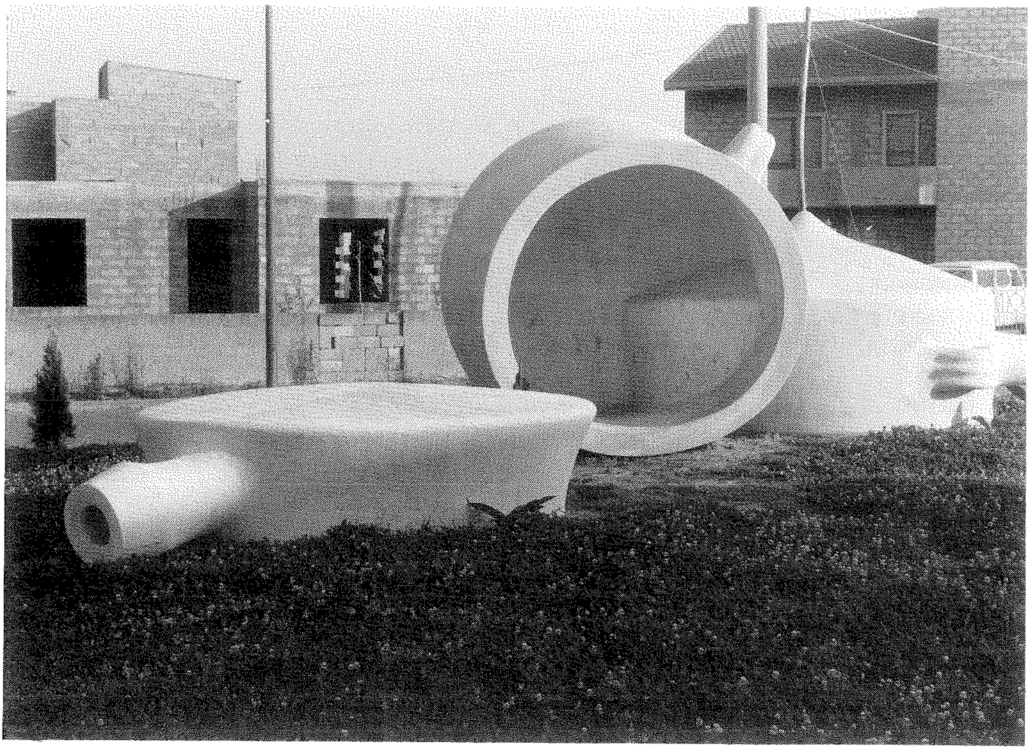
Terrosu-Asole, A. (1982), Il paesaggio di pianura e il mondo contadino. In: M.Brigaglia (ed) *La Sardegna*, Cagliari: 1, 69-72.

Wallace, D. (1989), Functional factors of mica and ceramic burnishing. In: G.Bronitsky (ed), *Pottery technology, ideas and approaches*, Boulder: 33-39.

OMISSION:

Newsletter vol 5 - 1987
M. Beatrice Annis and Herman Geertman, *Production and distribution of cooking ware in Sardinia*, Fig. 17, page 192.

The authors apology for the omission of the sculptor's name in the caption.



Pabillonis, Monument to the potter's craft (sculptor Antonio Ledda, Serramanna).

P.A.R. van Dommelen

ETHNOARCHAEOLOGY IN THE NETHERLANDS
R.M.A. Bedaux et al. (eds): *Ruimtelijke analyse, een ethno-archeologisch perspectief*, Utrecht 1990 (SEAON). A Review.

THE PROBLEM OF SPACE: CONTRASTING APPROACHES TO SPATIAL ANALYSIS

The problem of space

The spatial dimension of variability in the archaeological record has long since been recognized as an important area of examination, regardless of the way in which variability itself is studied (cf. Hodder and Orton 1976; Clarke 1977). Accordingly, spatial analysis has become an integral part of archaeological practice. One of the major stimuli of the rapid development of spatial analysis in archaeology has been the realization of its potential contribution to the study of social organization (cf. Hodder 1978). Since then, spatial analysis at both the intra-site and the inter-site level has generally been regarded as a useful, if not "objective", means to study social organization (Kent 1987a). Simultaneously, anthropological research examined in particular the symbolic ordering of space and the structural oppositions of spatial organization. Such research concentrates on the analysis of both individual buildings (cf. Cunningham 1973) or entire settlements (cf. Douglas 1972 or Lévi-Strauss's classic analysis: 1963 [1977]: 141-147; cf. Tilley 1990a: 76-70). In both cases, however, there has been no discussion of the relationship between spatial ordering and social organization or ideological concepts.

Although there can be no doubt that spatial organization is somehow related to society - much human geography is in fact based on this assumption (Soja 1989: 1-9) -, the *nature* of the relationship has gradually become matter of discussion. Following Lévi-Strauss, who maintained that the relationship was a fairly obvious one (Lévi-Strauss 1963 [1977]: 291), it has often been assumed that by analyzing spatial organization, social structure could be studied in a relatively straightforward way. Others have questioned such a close and direct relationship (e.g. Hodder 1982: 194) and argue for greater variability and subtlety. From this point of view, space itself presents a considerable problem and its relationship to society needs close scrutiny (cf. Hillier and Hanson 1984: 1-5 and 26-33).

As the relationship in question is a crucial one for both archaeologists and anthropologists, the attempt to examine spatial organization from an ethnoarchaeological perspective seems appropriate and some recently published studies (Bedaux et al. 1990; Kent 1987b and 1990b) contribute much to these ends. Perhaps the most striking phenomenon, common to all these studies, is the enormous variety and, in particular, divergence of approaches to spatial analysis. In this short paper I intend to focus on one of these recently published collections of papers (Bedaux et al. 1990) and its representation of two fundamentally different and even incompatible approaches to the problem of space.

A cross-cultural perspective

One of these approaches can be found in three papers of this volume (Newell 1990; Vreede and Krabbenborg 1990; Aarts 1990). Although the introductory paper by Newell (1990) refers to the "theoretical foundation and goals of spatial analysis" (Newell 1990: 5), no coherent theorization of the relationship between social organization and spatial ordering is provided. Nevertheless, remarks such as "the material expression of *ethnicity/mental template/symbolism*" (Newell 1990: 12; original emphasis) or references to the material expression of the level of social organization (Vreede and Krabbenborg 1990: 31) suggest that spatial ordering is regarded as a direct reflection of social organization or at least of certain aspects of it.

Instead of a theoretical foundation, the introductory paper proposes a three-stage "procedure" of spatial analysis that is essentially based on ethnoarchaeological analogy (Newell 1990, 5). Whereas the first stages of analysis are merely formal considerations of site-formation processes and scale of analysis (Newell 1990: 5-7), the final phase is directly concerned with the relationships between society and the use of space. No conceptual framework, however, is proposed but recourse is taken to inference and analogy. The references to the "law of uniformitarianism" and to cross-cultural testing of hypotheses (Newell 1990: 4) furthermore confirm the empiricist and processualist assumptions underlying these three papers. The problems and *impossibility* of the hypothetico-deductive method proper in archaeology have been dealt with at length recently (Gibbon 1989) and these arguments need not be repeated here. The abundant use of statistics, moreover, cannot make up for or mask epistemological shortcomings (cf. Thomas 1978: 238-240).

As far as the use of space is concerned, the uniformitarian assumption implies that, if conditions are similar, a certain spatial ordering will be the result of the same kind of social organization (cf. Kent 1990a). This suggests that spatial ordering is directly related to and in fact constitutes the "material expression" of human behaviour in general. The shortcomings of this approach are well shown in the paper by Vreede and Krabbenborg (1990). Their conclusion that the Athenian Agora's monumental architecture constitutes the "material expression of social processes within Athenian society" (Vreede and Krabbenborg 1990: 53) merely *describes* some relationships between a building policy and historical events but certainly does not *explain* the relationship. In this case, moreover, the symbolic and social meanings of the ordering of a space such as the Athenian Agora are entirely overlooked as a consequence of the passive, processual view of society adopted. The claim of the authors to have "quantified the relationship between society and material culture" (Vreede and Krabbenborg 1990: 32) is therefore meaningless, as they fail to address its nature (cf. Hodder 1985: 5-6).

This approach, that can be parallelled elsewhere (cf. Kent 1987a or 1990a), might be characterized as lacking a conceptual framework of the relationship between the social and the spatial. Cross-cultural ethnoarchaeological comparisons cannot substitute this deficiency and the approach, therefore, can never transcend the level of mere description. The concomitant but implicit assumption is that the use of space is invariably directly related to social organization. The absence of any theorization of the use of space ranks this approach among the ones that fail to recognize the problem of space.

The objectification of ordered space

In contrast to the framework of spatial analysis outlined above, the other approach represented in the volume under discussion (Bedaux et al. 1990) does acknowledge the problematic and multifaceted nature of space. This alternative approach is best expounded in the paper by van Beek (1990; cf. also Donley-Reid 1990). Essential to this approach is the recognition that the ordering of space, as in the case of the Bedamuni longhouse, is more than a passive reflection of behaviour or ideological concepts. The all-too-frequently assumed *priority* of social or symbolic notions with respect to spatial organization is explicitly rejected (van Beek 1990: 93). Instead, the active role of ordered space is reasserted by stressing its autonomy and the influence exerted by it in turn. The author notes that, to a certain extent, ordered space such as the Bedamuni longhouse undoubtedly refers to existing social or ideological concepts but he points out that once space has been ordered, i.e., the house has been built, it also contributes actively to the reproduction and creation of these concepts and thus, effectively, has become a subject of Bedamuni culture as well: this is the so-called process of *objectification* (van Beek 1990: 114-115; cf. Miller 1987: 81-82). The relationship between ordered spaces and social or symbolic notions, therefore, is a dynamic one. Interpretations of objectified ordered spaces may vary and accordingly affect notions of social organization or symbolism that thus may be slightly modified. As a consequence, attributing a single meaning to ordered spaces - or "de-coding" them (Newell 1990: 13) - turns out to be virtually impossible. Spatial ordering may be given numerous meanings that, moreover, are closely connected with the various functions of ordered spaces (van Beek 1990: 94).

This view of the relationships between the use of space and social or symbolic concepts has several serious consequences: firstly, this relationship is no longer assumed to be an invariable or direct one, if the ordering of space is interpreted in terms of objectification. Therefore, secondly, cross-cultural comparisons become extremely difficult, if not impossible. The multiplicity of functions and meanings, their dependence on the individual context and the particular relationships between the use of space and social organization or symbolic concepts of its users can only be understood in their particular, historical context (Hodder 1982: 215-217; cf. Donley-Reid 1990: 115-116). This point is clearly made by van Beek, who strongly rejects the suggestion that the relationships between spatial form and social or symbolic meaning could be more easily distinguished in an ethnographic context (van Beek 1990, 114). The crucial problem is constituted by the polysemous nature of ordered space that is equally difficult to interpret archaeologically or ethnographically (cf. Shanks and Tilley 1987: 103-107).

The multifunctional nature of spatial organization is well illustrated in the final paper (Annis 1990). Although the importance of meaning, social organization and symbolic concepts are fully acknowledged, this paper is strictly limited to functional aspects of spatial organization and their relations to (functionalist) techno-economic organization (Annis 1990: 131-132). This detailed case-study shows the many (functional) aspects that are related to the use of space in ceramic workshops and clearly demonstrates that there can be no simple and direct relationship (Annis 1990: 127-130).

Structured space: a practical perspective

A major implication of this comparison between two contrasting approaches to spatial analysis seems to be that both space itself and the use made of particular spaces should be regarded as problematic. If the use of spaces is to be analyzed as a means of studying society, then the relationship between society and spatial ordering needs to be understood. At the heart of the problem of space, therefore, lies the *nature* of the relationship and its theorization has, as a consequence, become indispensable (cf. Hillier and Hanson 1984: 1-5). In particular, if spatial analysis is to contribute substantially to the understanding of social organization or symbolism, such a theory needs to be firmly grounded in social theory, thus constituting a genuinely social theory of space (Hillier and Hanson 1984: 29-32; Soja 1989: 79-84).

Through the concept of objectification, the use of spaces can be related to social practice, as it provides a theoretical link between two distinct processes that can be founded and elaborated in social theory. In the first place, objectification relates the ordering of spaces to pre-existing social or symbolic concepts and secondly, it links ordered spaces to social behaviour.

These processes have best been described by Bourdieu within the framework of his *theory of practice* (see Bourdieu 1977: 3-9)[1]. He argues that practice - the activities of individual agents - originates within the limits of its *habitus*: this he describes as "a structuring structure which organizes practices and the perception of practices" and constitutes "the principle of division into logical classes which organize the perception of the social world" (Bourdieu 1984: 170). As practice takes place in spaces and makes use of objects, these are given meaning in relation to practice and thus become part of every-day life or practice itself; they also become organized in accordance with the structures of the habitus (Bourdieu 1977: 87-95; Tilley 1990b: 108-112; cf. Bourdieu 1979). This is particularly relevant to the use of spaces, as space is especially effective in separating and ranking agents (Bourdieu 1977: 89). This process is termed *objectification* in a narrower sense of the word.

Secondly, ordered spaces and every-day used objects are important for agents, as *through* these they can learn the "rules" of their habitus (its structures: what is done and what is not done). Again, ordered spaces in particular are useful in this process of "em-bodiment", as these spaces - without strictly determining their usage - serve as a sort of "map" or perhaps mnemonic device of the relationships between agents existing within the habitus (Bourdieu 1977: 87-95; cf. Bourdieu 1979). In this way, practice - or social behaviour - is reproduced that closely resembles, but is not identical with, the practice of previous agents within the habitus. As reproduction cannot be perfect, the relationship between practice and the habitus' structures and ordering of spaces and the use made of them is dynamic and variable over time and related to power struggles within the habitus (cf. Gilsenan 1982: 180-187).

As has been noted several times above, the use of spaces is closely related to the use of material culture and the close resemblance that these preliminary proposals for a social theory of space bear to theories of material culture is also unlikely to have remained unnoticed (cf. Shanks and Tilley 1987: 130-134). Space in fact is an intrinsic feature of material culture, as all material culture exists in space. But far from constituting a neutral or reflecting by-product of material culture, space, as the inherent context of material culture, represents an important counterpart to its form (Miller 1987: 121-124): objects (re-)order space but ordered spaces seriously affect objects. Space, therefore, "is crucial in thinking about culture and ideology because it is where ideology and culture take on physical existence and representations" (Gilsenan 1982: 187).

I would like to thank Dr. Michael Rowlands for his helpful comments on an earlier draft of this paper and during previous discussions.

Note

1. At a general level and more loosely connected to ordered space or material culture, a similar theory has been proposed by Giddens (cf. e.g. Giddens 1984: 5-37 and 163-192; in relation to space, see in particular Giddens 1984: 132-144 and Giddens 1985). For a critique, see e.g. Soja 1989: 138-156.

References

Aarts, M. (1990), Nederzettingssysteem en niveau van sociale organisatie in zuid-Etrurië (700-500 v.Chr.). Het archeologisch testen van een analoog model. In: Bedaux, R. et al. (eds.), *Ruimtelijke analyse: een ethno-archeologisch perspectief*, Utrecht: 61-89.

Annis, M. (1990), Vormen van organisatie en gebruik van ruimte in pottenbakkerswerkplaatsen op Sardinië: een veranderend beeld. In: Bedaux, R. et al. (eds.), *Ruimtelijke analyse: een ethno-archeologisch perspectief*, Utrecht: 118-134.

Bedaux, R., A. van Beek, T. Constandse-Westermann, E. van 't Lindenhout and D. Papousek (eds.) (1990), *Ruimtelijke analyse: een ethno-archeologisch perspectief*, Utrecht.

Beek, A. van (1990), Het huis als object en als subject: vorm en ideologie van het Bedamuni langhuis (P.N.G.). In: Bedaux, R. et al. (eds.), *Ruimtelijke analyse: een ethno-archeologisch perspectief*, Utrecht: 90-117.

Bourdieu, P. (1977), *Outline of a theory of practice*, Cambridge.
Bourdieu, P. (1979), The Kabyle house or the world reversed. In: Bourdieu, P. 1979, *Algeria 1960*, Cambridge: 133-153.
Bourdieu, P. (1984), *Distinction. A social critque of the judgement of taste*, London.
Clarke, D. (1977), *Spatial archaeology*, London.
Cunningham, C. (1973), Order in the Atoni house. In: Needham, R. (ed.), *Right and left: essays on dual symbolic classification*, Chicago: 204-238.
Donley-Reid, L. (1990), A structuring structure: the Swahili house. In: Kent, S. (ed.), *Domestic architecture and the social use of space*, Cambridge, 114-126.
Douglas, M. (1972), Symbolic orders in the use of domestic space. In: Ucko, P., R. Tringham and G. Dimbleby (eds.), *Man, settlement and urbanism*, London: 512-521.
Gibbon, G. (1989), *Explanation in archaeology*, Oxford.
Giddens, A. (1984), *The constitution of society*, Cambridge.
Giddens, A. (1985), Space, time and regionalisation. In: Gregory, D. and J. Urry (eds.), *Social relations and spatial structures*, London.
Gilsenan, M. (1982), *Recognizing islam*, London.
Hillier, B. and J. Hanson (1984), *The social logic of space*, Cambridge.
Hodder, I. (1978), *The spatial organisation of culture*, London.
Hodder, I. (1982), *Symbols in action*, Cambridge.
Hodder, I. (1985), Post-processual archaeology. In: Schiffer, M. (ed.), *Advances in archaeological method and theory* 8, 1-26.
Hodder, I and C. Orton (1976), *Spatial analysis in archaeology*, Cambridge.
Kent, S. (1987a), Understanding the use of space: an ethnoarchaeological approach. In: Kent, S. (ed.), *Method and theory for activity area research - an ethnoarchaeological approach*, New York: 1-60.
Kent, S. (ed.) (1987b), *Method and theory for activity area research - an ethnoarchaeological approach*, New York.
Kent, S. (1990a), A cross-cultural study of segmentation, architecture, and the use of space. In: Kent, S. (ed.), *Domestic architecture and the social use of space*, Cambridge: 127-152.
Kent, S. (ed.) (1990b), *Domestic architecture and the social use of space*, Cambridge.
Lévi-Strauss, C. (1963) [1977], *Structural anthropology*, London.
Miller, D. (1987), *Material culture and mass consumption*, Oxford.
Newell, R. (1990), The theoretical foundations and goals of spatial analysis: the behavioural aproach to settlement diagnosis. In: Bedaux, R. et al. (eds.), *Ruimtelijke analyse: een ethno-archeologisch perspectief*, Utrecht: 3-24.
Shanks, M. and C. Tilley (1987), *Re-constructing archaeology*, Cambridge.
Soja, E. (1989), *Postmodern geographies*, London.
Thomas, D. (1978), The awful truth about statistics in archaeology, *American Antiquity* 43 (2): 231-244.
Tilley, C. (1990a), Claude Lévi-Strauss: structuralism and beyond. In: Tilley, C. (ed.), *Reading material culture*, Oxford: 3-81.

Tilley, C. (1990b), Michel Foucault: towards an archaeology of archaeology. In: Tilley, C. (ed.), *Reading material culture*, Oxford: 281-347.

Vreede, A. and J. Krabbenborg (1990), De Agora van Athene: een ethnoarcheologische case-study. In: Bedaux, R. et al. (eds.), *Ruimtelijke analyse: een ethno-archeologisch perspectief*, Utrecht: 25-60.