

The Early Neolithic impressed pottery from the Gruta do Caldeirão (Tomar, Portugal)

William K. Barnett *

Abstract

Physical analyses of Early Neolithic pottery from Gruta do Caldeirão, using visual examination, optical petrography and re-firing techniques, was undertaken to try to determine technology and provenience. Vessel 1, a cardial decorated pot stratigraphically clustering below the impressed and incised pots (vessels 2 to 7) from layer Ea, was also found to be compositionally different from them. It has a finer appearance and a unique thin red exterior and dark core; the epicardial vessels are characterized by thinner walls and less dense pastes; all of them were fired at relatively low temperatures. Comparison of the non-plastic mineralogy of grains among the sherd and clay sample thin sections showed that, while the epicardial pottery may have been produced locally, the cardial pot was probably manufactured with clays collected from later Quaternary alluvial deposits such as the Tagus estuary.

Resumo

A cerâmica do Neolítico antigo da Gruta do Caldeirão foi analisada mediante técnicas de exame visual, petrografia óptica e re-cozimento, com o objectivo de tentar determinar tecnologia e proveniência. O vaso 1, com decoração cardial e localizado estratigraficamente sob os vasos impressos e incisos (2 a 7) da camada Ea, revelou-se igualmente diferente sob o ponto de vista da composição. Trata-se de uma peça menos grosseira e única no que respeita à secção — núcleo escuro e capa externa vermelha muito fina; os vasos epicardiais caracterizam-se por paredes menos espessas e pastas menos densas; todos

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foram cozidos a temperaturas relativamente baixas. A comparação da mineralogia dos grãos não-plásticos a partir de lâminas delgadas dos cacos e de amostras de barros locais mostrou que, ao contrário da cerâmica epicardial, o vaso cardial foi provavelmente manufacturado com argilas de depósitos aluviais quaternários do tipo dos do estuário do Tejo.

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Abstract

Physical analysis of Early Neolithic pottery from Tejo estuary, Portugal, using X-ray diffraction, optical petrography and thin-section techniques, was undertaken to determine technology and provenance. Vessel 1, a cardial, decorated with stratigraphically alternating bands of impressed and raised pots (series 2 to 5) from layer 1a, was also found to be compositionally different from them. It has a thin appearance and a unique thin red exterior. The dark cores, the epicardial vessels are characterized by brown walls and low degree pattern. All of them were fired at relatively low temperatures. Comparison of the petrographic micrology of grains among the third and clay sample thin sections shows that, while the epicardial pottery may have been produced locally, the cardial pot was probably manufactured with clay collected from later Quaternary alluvial deposits such as the Tejo estuary.

Resumo

A análise física de cerâmica neolítica antiga do Estuário do Tejo, Portugal, usando difração de raios X, petrografia óptica e técnicas de lâminas delgadas, foi realizada para determinar tecnologia e proveniência. O vaso 1, do tipo cardial, decorado com faixas estratigráficas alternadas de bandas de impressão e relevos (série 2 a 5) da camada 1a, também foi encontrado a ser composicionalmente diferente delas. Tem uma aparência fina e uma única parede exterior vermelha escura. Os núcleos escuros, os vasos epicardiais são caracterizados por paredes de baixa qualidade e padrões de baixa qualidade. Todos os vasos foram cozidos a temperaturas relativamente baixas. A comparação da mineralogia dos grãos entre as lâminas delgadas de amostras locais e de amostras de cerâmica epicardial mostra que, enquanto a cerâmica epicardial pode ter sido produzida localmente, o vaso cardial foi provavelmente fabricado com argilas de depósitos aluviais quaternários do tipo dos do estuário do Tejo.

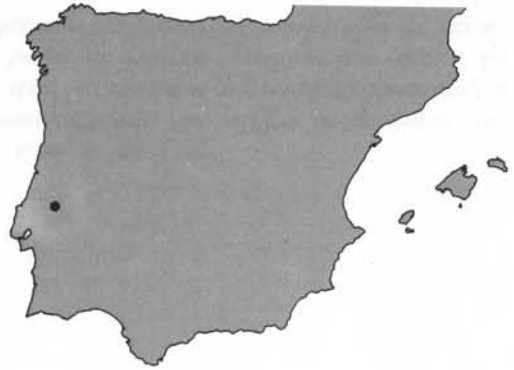
1. Introduction

Much recent work in ceramic analysis has resulted from a disillusionment with those who interpreted ceramic styles as societal entities, a recent expansion of techniques and methods of ceramic analysis and a resurgence of ethnographic studies intended to determine the social and economic correlates of ceramic variation. The contributions of this research are already numerous even though there has been only one attempt to structure the diverse range of information and ideas into a particular approach¹. Recent symposia have been largely devoted to new approaches to stylistic variation and to a closer examination of problems of the production and distribution of prehistoric ceramics². Analyses of the physical aspects of clays and ceramic materials are beginning to supply a technological framework for applied research, ethnographic studies are being used to create social and economic models of pottery production, distribution and style, and new analytical techniques are being used to apply these models to archaeological assemblages.

The latter type of analysis is undertaken below with an initial evaluation of a small assemblage of Early Neolithic pottery from the Gruta do Caldeirão in central Portugal. Using optical petrography and physical analysis techniques to characterize physical variation, it attempts to determine diffe-

¹ ARNOLD, D. — *Ceramic Theory and Cultural Process*, Cambridge, University Press, 1985.

² HOWARD, H.; MORRIS, E. (ed. lit.) — Oxford, BAR, 1981 (BAR, International Series; 120); NELSON, B. A. (ed. lit.) — *Decoding Prehistoric Ceramics*, Carbondale, Southern Illinois University Press, 1985; OLIN, J.; FRANKLIN, A. (ed. lit.) — *Archaeological Ceramics*, Washington, Smithsonian Institution Press, 1982; PLOG, S. — *Stylistic Variation in Prehistoric Ceramics*, Cambridge, University Press, 1980; RICE, P. M. (ed. lit.) — *Pots and Potters: Current Approaches in Ceramic Archaeology*, Institute of Archaeology, University of California, 1984.



rences in provenience and manufacturing technology. By analyzing data from pottery and clay samples with stylistic and contextual information, it is possible to assess current ideas about the nature of ceramic variation during the Early Neolithic in Portugal. This paper not only proposes a new approach to the study of prehistoric pottery, but demonstrates the ability of this approach to improve our knowledge of the Early Neolithic.

2. Archaeological Background

Since artifact suites in Portugal are similar to those in the Mediterranean proper, scholars have tended to incorporate Portugal into the western Mediterranean sphere of Neolithization. Two hypotheses developed for other areas of the western Mediterranean have therefore been extended to the Atlantic coast of Iberia. Bosch-Gimpera³ concluded that all Early Neolithic pottery types in Portugal represented a group of parallel and distinct traditions of different archaeological cultures. In a later synthesis of museum collections, Guilaine and Ferreira⁴ closely followed Guilaine's typologies from southern France and proposed an initial cardial pottery phase followed by a phase of impressed and incised "epi-cardial" pottery and finally by undecorated wares associated with Portuguese megaliths.

While Guilaine⁵ has demonstrated that cardial pottery appeared earlier than other wares in most of the western Mediterranean, neither of the above temporal or geographic models may adequately account for the nature of

³ BOSCH-GIMPERA, P. — *Civilisation Mégalithique Portugaise et Civilisations Espagnoles*. "L'Anthropologie", 71, 1967, p. 1-48.

⁴ GUILLAINE, J.; FERREIRA, O. V. — *Le Néolithique Ancien au Portugal*. "B.S.P.F.", 67, 1970, p. 304-322.

⁵ GUILLAINE, J. — *The Earliest Neolithic in the West Mediterranean: a New Appraisal*. "Antiquity", 53, 1979, p. 22-30.

Early Neolithic ceramic variation. Regional overviews of site distributions, for example in Spain⁶, seem to support neither strict stages nor ethnic boundaries. These problems have dominated recent discussion on the interpretation of Early Neolithic materials in Portugal⁷, where the situation is even less clear.

Sites with Early Neolithic pottery in Portugal have so far been found exclusively in littoral and estuarine zones in the central and southern areas (figure 1). Arnaud⁸ has noted that, in general, cardial and epi-cardial pottery from Portuguese sites rarely occur together and that cardial pottery has not yet been found in middens that contain *cardium* shells. He proposes that an initial dispersed appearance of cardial pottery in a few areas was gradually supplanted by more extensively distributed impressed wares. Although these patterns are as yet scanty, and may have been affected by temporal, geographic, environmental, economic or contextual factors, they do provide an initial set of empirical observations.

Little information exists to establish a chronological framework for these sites. Most material comes from collections that were excavated without context or radiocarbon dates and have only been studied stylistically⁹. Dates extrapolated from sites in other areas of the Mediterranean suggest a date of about 5000 B.C. for the first appearance of pottery¹⁰. The nearest radiocarbon dates for Early Neolithic sites have come from the Cueva de la Dehesilla near Cadíz¹¹ and also support a date of at least 5000 B.C.

The only absolute dates from Portugal relevant to the study of the Early Neolithic have come from the radiocarbon dating of Mesolithic shell middens and the thermoluminescence dating of pottery from several megalithic tombs and Calcolithic hill-top settlements. The midden of Moita do Sebastião is traditionally considered the *terminus ante quem* of the Mesolithic because it produced no pottery. Radiocarbon dates from its base¹² are close

⁶ CHAPMAN, R. — *The Later Prehistory of Western Mediterranean Europe: Recent Advances*, in WENDORF, F.; CLOSE, A. (ed. lit.) "Advances in World Archaeology", vol. 4, NEW YORK, Academic Press, 1985, p. 115-187.

⁷ FERREIRA, O. V.; LEITÃO, M. — *Portugal Pré-histórico: Seu Enquadramento no Mediterrâneo*, Lisboa, Publicações Europa-América, 1981; GONÇALVES, V. — *Para um Programa de Estudo do Neolítico em Portugal*. "Zephyrus", 28-29, 1978, p. 147-162; SILVA, T.; SOARES, J. — *Pré-história da Área de Sines*, Lisboa, Gabinete da Área de Sines, 1981.

⁸ ARNAUD, J. M. — *Le Néolithique Ancien et le Processus de Néolithisation au Portugal*, in BOUSQUET, J., (ed. lit.) "Le Néolithique Ancien Méditerranéen: Actes du Colloque International de Préhistoire, Montpellier 1981", 1982, p. 38.

⁹ GUILLAINE; FERREIRA — *op. cit.* (v. nota 4).

¹⁰ GUILLAINE — *op. cit.* (v. nota 5).

¹¹ ACOSTA, P. — *Neolítico Inicial en el Sudoeste Hispano: La Cueva de la Dehesilla (Cadíz)*, in GUILLAINE, J., (ed. lit.) "Premières Communautés Paysannes en Méditerranée Occidentale", Montpellier, 1983, p. 175-176.

¹² ROCHE, J.; FERREIRA, O. V. — *Seconde Datation par le C14 de l'Amas Coquillier Mésolithique de Moita do Sebastião (Muge)*. "Comunicações dos Serviços Geológicos de Portugal", 56, 1972, p. 471-474.

to the date of 5000 B.C. proposed for the earliest pottery in the western Mediterranean. The nearby middens of Cabeço da Amoreira and Cabeço da Arruba have slightly later dates but have yielded small amounts of pottery¹³. Although these three sites are all considered Mesolithic, the latter two may have been contemporaneous with the appearance of traditional Neolithic *fossil directeurs*. The Mesolithic sites of Medo Tojeiro and Samouqueira along the Alentejo littoral have produced radiocarbon dates of 3500 and 3240 B.C., respectively¹⁴ that overlap the hypothesized arrival of pottery. Whereas a few fragments of pottery, ground stone and microliths were reported from Medo Tojeiro, the artifacts from Samouqueira are indistinguishable from those in earlier sites¹⁵. The appearance of pottery, therefore, does not seem to be associated with any economic shift.

Guilaine¹⁶ has proposed a date of 4000 to 3800 B.C. for the appearance of un-decorated wares that mark the transition to Middle Neolithic agricultural villages in the western Mediterranean. In Portugal similar wares are associated with early megalithic tombs¹⁷ which have been dated to 3700 to 3900 B.C. in northern Portugal¹⁸. Thermoluminescence dates on un-decorated pottery from the Middle Neolithic passage graves of Gateira and Gorginos¹⁹ are, however, earlier than Guilaine's date for these wares. Undated but more "primitive" tombs may be even earlier. Both Whittle and Arnaud²⁰ and Guilaine²¹ caution that these thermoluminescence dates have yet to be compared to calibrated radiocarbon dates.

What few dates are available seem to place Portuguese Early Neolithic sites in the fifth millennium, B.C. This conclusion is, however, based on three assumptions. First, that the radiocarbon dates for Moita are accurate and represent a Mesolithic endpoint. Second, that early passage graves were a temporal rather than a geographical transition from sites with Early Neolithic pottery. Third, that dates from Spain and France associated with Early Neolithic pottery can be extrapolated to Portugal. A great deal of temporal

¹³ WHITTLE, E. H.; ARNAUD, J. M. — *Thermoluminescent Dating of Neolithic and Chalcolithic Pottery from Sites in Central Portugal*. "Archaeometry", 17 (1), 1975, p. 5-24.

¹⁴ LUBELL, D.; JACKES, M. — *Mesolithic-Neolithic Continuity: Evidence from Chronology and Human Biology*, in "Actas da I Reunião do Quaternário Ibérico", Lisboa, 1985.

¹⁵ ID. — *Ibid.*

¹⁶ GUILLAINE, *op. cit.* (v. nota 5).

¹⁷ ID. — *Premiers Bergers et Paysans de l'Occident Méditerranéen*, Paris, Mouton, 1976, p. 165; ARNAUD — *op. cit.* (v. nota 8).

¹⁸ JORGE, V. O. — *O Megalitismo do Norte de Portugal* in "O Neolítico e o Calcolítico em Portugal: Actas da I Mesa Redonda", Porto, G.E.A.P., 1979, p. 83-102.

¹⁹ WHITTLE; ARNAUD — *op. cit.* (v. nota 13).

²⁰ ARNAUD — *op. cit.* (v. nota 8).

²¹ GUILLAINE, J. — *La Chronologie du Néolithique Ibérique*. "Travaux de l'Institut d'Art Préhistorique", 22, 1980, p. 231-243.

overlap may exist not only between the Early and Middle Neolithic sites, but also between “Mesolithic” middens along the coast and the use of megalithic tombs towards the interior²² and may invalidate the concept of an Early Neolithic “period”. Additional work is necessary before the relationship between pottery styles, Mesolithic sites and megaliths can be clarified.

Recent efforts at the Gruta do Caldeirão have been an initial step in providing better contextual information as well as specialized research on the Early Neolithic in Portugal. It has provided the best assemblage for analysis simply because it is the first stratigraphically excavated site in Portugal containing Early Neolithic deposits. Radiocarbon dates from Caldeirão are now in the process of being calculated. Caldeirão is also one of the only known inland Early Neolithic sites. Studies of pottery and other materials from the cave have produced data that contribute to research on the Early Neolithic in Portugal.

3. Gruta do Caldeirão

The cave of Caldeirão is located on the edge of a fault-blocked Jurassic limestone plateau eight kilometers north of Tomar, facing south above a small tributary valley of the Nabão River. The site would have provided a good location for observing animal movements as it is well protected and has a good view of the drainage below²³. The cave itself is a corridor two to three meters wide that curves sharply to the left into the “front room”, then to the right to the “back room”, following the fracture lines of the rock. The entrance slopes inward, forming a natural sediment trap. The Holocene sediments in the cave slope downward from the entrance into the front room, then attain a more horizontal aspect, each layer increasing in depth towards the interior. The two layers containing Early Neolithic pottery and other materials, Ea and Eb, lie under approximately one meter of later deposits and can be distinguished from upper layers because they are lighter in color and slightly concreted. The lithics that occur throughout layer Eb appear to be related to Solutrean industries²⁴. The Early Neolithic materials found in the back room of layer Eb may have been due, therefore, to the intrusion of later materials before and possibly during the deposition of layer Ea.

²² WHITTLE; ARNAUD — *op. cit.*, p. 9 (v. nota 13).

²³ ROWLEY-CONWY, P. — *The Animal Bones from Gruta do Caldeirão: Preliminary Report*. “Arqueologia na Região de Tomar”, supl. n.º 1 of Boletim Cultural e Informativo da Câmara Municipal de Tomar, 1985.

²⁴ ZILHÃO, J. — *Gruta do Caldeirão: relatório dos trabalhos arqueológicos realizados no ano de 1985*. (unpub.).

The human remains in layer Eb are associated with cardial pottery and perforated shells whereas the layer Ea burials are accompanied by epicardial pottery, perforated shells, ground stone axes and stone beads. Whereas the front room contains most of the domestic debris and evidence for fire, the back room was primarily used as a necropolis. Excavation of this room produced evidence of multiple burials in layer Ea and at least one burial in layer Eb. Five to seven individuals have so far been identified from the Early Neolithic levels²⁵. The pottery and human remains are horizontally dispersed near walls in layer E and exhibit little vertical displacement, suggesting that the deceased were placed in recesses in the walls but not buried²⁶.

A preliminary study of the fauna from the Neolithic levels at Caldeirão²⁷ shows that rabbit and deer dominate the faunal assemblage (the former numerically and the latter in estimated meat weight). Many of the deer remains, however, may be intrusive from underlying Pleistocene deposits. Remains of domestic sheep/goats are present in layers Ea and Eb in the back room. Two pig phalanges were also recovered from layer Ea, but have not been irrefutably classified as domesticated pig. Based on the faunal remains, Rowley-Conwy concludes that this site was probably a combined hunting and pastoral camp in the Early Neolithic.

It appears that the Early Neolithic deposits in Caldeirão can be divided into a front habitation area associated with hunting and pastoralism and a back area that was used primarily as a necropolis and that produced most of the pottery. The association of most vessels with human remains and other artifacts typical of Early Neolithic burials, therefore, must be taken into account when interpreting the ceramic data. Explanations must also consider the implications, based on faunal analysis, that the site operated primarily as a pastoral and hunting camp during the Early Neolithic.

4. Sample

Of the 153 pottery sherds associated with the Early Neolithic deposits at Caldeirão, seven decorated vessels have been identified from 77 of the sherds. Half of the sherds from the Early Neolithic layer, then, are associated with one of these vessels. Four vessels were known by the end of the 1984 field season. Another three were discovered during extensive excavation of the Early Neolithic levels in 1985. Several un-decorated vessels were not studied due to poor representation.

²⁵ LUBELL, D. — Personal communication.

²⁶ ZILHÃO, J. — *Escavações Arqueológicas na Gruta do Caldeirão*. "Boletim Cultural e Informativo da Câmara Municipal de Tomar, 7, 1984, p. 160.

²⁷ ROWLEY-CONWY — *op. cit.* (v. nota 23).

Vessels were selected for study because they bore decoration typical of the Early Neolithic or because they were well-represented. Identification of the various vessel groups was part inferential, based on visual examination of color, surface treatment, thickness, shape and coarseness. Of the seven vessels identified from the Early Neolithic levels at Caldeirão, the cardial vessel (vessel 1) is stylistically similar to a single comb decorated sherd (vessel 2). The decorative and morphological features of vessel 1 fits patterns for Franco-Iberian²⁸ and Portuguese²⁹ cardial wares.

All epi-cardial vessels bear different designs made with different tools, although all vessels appear to have been impressed with a single tool. Furthermore, all are relatively thin-walled but coarse grained and dark (usually dark gray or black) except for vessel 5, which is a thick walled reddish pot. Vessels 1 and 3 were especially well represented and it was possible to get some idea of their size and shape. One undecorated sherd from each vessel group was selected for thin section analysis, with the exception of vessel 2, which was represented by only one sherd and, therefore, could not be sampled.

Clay samples were collected from the Nabão Valley primarily to determine what kinds of mineralogical and technological parallels could be drawn between the clays and the vessels. Sample T1 comes from a Miocene clay deposit about ten kilometers south of the cave on the west side of the valley. Sample T2 is from the same Miocene deposit but across the valley about a kilometer to the east from a commercial clay quarry. Sample C1 is a late Pleistocene sediment from the interior of Caldeirão. No other clays are currently known from the area, however, no extensive survey for clays resources has yet been carried out. These samples, therefore, may not truly represent the range of clay variation around the site, but must be considered as only a preliminary estimation of local clay resources. Analyses of the ceramics and clays from the Nabão Valley were carried out at the Center for Materials Research in Archaeology and Ethnology at the Massachusetts Institute of Technology, which also kindly provided all the necessary materials and equipment.

5. Methods of Research

This study uses the concepts of production and distribution as a framework for the analysis of the pottery from the Gruta do Caldeirão. The purpose is as much to propose a relatively new approach to the study of ceramic variation as to present preliminary results. The questions asked are concerned with the selection of necessary resources (clay, temper and fuel for example), manufacture of vessels, firing, possibly distribution, use and

²⁸ GUILLAINÉ — *op. cit.*, p. 38 (v. nota 17).

²⁹ GUILLAINÉ; FERREIRA — *op. cit.* (v. nota 4).

finally discard. The bulk of the observations made here are, therefore, not typological but attempt to relate to various aspects of pottery production and distribution by approaching separately each step of the production process.

Choices potters made were affected not only by the range of available resources but also by technical knowledge and skill of the potters and by their functional, social and economic goals in making a pot. The process by which a potter makes a pot can be divided into three basic stages; preparing the body, forming and firing³⁰. The initial stage involves the collection and subsequent manipulation of the clay body. Clays may be ground, sieved or mixed and various materials such as sand, rock, pottery or organic materials added to form an appropriately workable mixture that can be manipulated but will not crack on drying or firing³¹. Clay deposits may also be used as they are found naturally. The type of mixture used will depend on the forming technique used or intended form and function of the pot. For example, clays used for hand building must be much stiffer than those thrown on a wheel but can also support coarse grains. Thick walled vessels may require the support of a coarser tempered paste while thin walled pots may crack if coarse elements are too large or frequent.

After the vessel is constructed it usually must be air dried to remove excess moisture. During the drying process a vessel will go from a plastic through a leather hard to a dry state. Any surface treatments or decorations applied to the vessel while in a particular drying state will leave characteristic marks³². When fired a pot initially undergoes a "water smoking" stage at about 120° C. during which pore water evaporates. Molecularly bound water is lost and the clay mineral structure can begin to sinter (fuse together) at between 400° C. and 850° C., depending on the clay minerals present³³. Different colored cores may develop due to variations in firing temperatures, length of firing, atmosphere and organic content of the clay³⁴. By describing these features of the excavated sherds, it is possible to reconstruct the technological patterns of clay preparation, forming, decoration and firing used by a given society.

Physical analyses are quite valuable in ceramic research because they produce evidence to aid in the reconstruction of the behavior of prehistoric potters through their product³⁵. Optical petrography was selected as the

³⁰ RYE, O. S. — *Pottery Technology: Principles and Reconstruction*, Washington, Taraxacum, 1981, p. 4.

³¹ ID. — *Ibid.*

³² ID. — *Ibid.*, p. 90.

³³ ID. — *Ibid.*, p. 105-106.

³⁴ ID. — *Ibid.*, p. 116.

³⁵ RYE — *op. cit.*, p. 3 (v. nota 30).

primary method of analysis since it allows descriptions of the clay paste, as well as quantitative assessments of the size, shape and distribution of non-plastic mineral inclusions, especially for early ceramics that tend to have coarse bodies³⁶. Petrographic analysis has, therefore, the potential to reveal technological features such as addition or crushing of non-plastics. The ability to determine similarities between pottery and naturally occurring clays is enhanced by the control of these technological variables. By contrast, chemical and elemental methods, which are costly and sometimes require large samples that do not exist from the Early Neolithic, have the potential for much finer source discrimination³⁷.

Petrographic analysis requires the manufacture of thin sections, ultra-thin (30 micron) samples of material attached to a glass slide. Polarized light passed through the sections allows for the identification and measurement of crystals present in the sample. Thin sections could be made directly from the pottery sherds, however, clay samples had to be first fired to harden them. Clay samples were formed into tiles which were fired at both 600° and 800° C. in both oxidizing and neutral atmospheres in order to estimate firing conditions that might have used to produce these vessels. Early open-air firing technologies rarely reached above 900° C. and generally had oxidizing to neutral atmospheres³⁸. Once fired it was possible to make thin sections of clay tiles and analyze them in exactly the same fashion as pottery sherds. Mineralogical counts of the coarse grains in each vessel and clay sample thin section were made at a 30X magnification using a petrographic microscope in order to estimate abundance, size and angularity. These counts were primarily used to identify manipulations of natural clays and then to discuss the possible locations of source deposits.

Thin sections were initially analyzed under a microscope using straight line transects so as to cover all areas of the sherd body. All grains that passed under the cross hairs were noted until a count of 100 was reached. Grains down to 0.06 m.m. in size (very fine sand) were identified mineralogically and placed in sedimentary size categories. All grains below 0.06 m.m. (silts) were tallied as well but not identified. This procedure was followed by a point-count of grains, paste and voids in order to determine the density of these grains in relation to the body.

A small chip was also removed from several of the sherds and re-fired to estimate roughly the original firing conditions. Chips were fired for ten minutes each at 500° C. the temperature at which smudged carbon burns

³⁶ WILLIAMS, D. F. — *Petrology of Ceramics*, in KEMPE, D.; HARVEY, A. (ed. lit.) "The Petrology of Archaeological Artefacts", Oxford, Clarendon Press, 1983, p. 301-329.

³⁷ RICE, P. M. — *Clear Answers to Vague Questions: Some Assumptions of Provenience Studies of Pottery*, in WETHERINGTON, R. (ed. lit.) "The Ceramics of Kaminaljuyu, Guatemala", Penn. State University, University Park, 1978, p. 511-542.

³⁸ RYE — *op. cit.*, p. 98 (v. nota 30); SHEPARD, A. O. — *Ceramics for the Archaeologist*, Washington, Carnegie Institution of Washington, 1957, p. 83-86. (pub. 609).

off. A second firing at 750° C. burned off any remaining carbonaceous materials and a third firing at 850° C. removed any traces of organics and allowed fully oxidized clay color to be more accurately compared. It was hoped that by determining the amount of material lost during each of these firings it would be possible to estimate the original firing atmosphere of the sherds.

Visual examination, thin section and re-firing analysis all contributed to the study of the technology of the vessels from Caldeirão. Forming features were primarily visible through visual examination of the sherds, especially at cut sections. Thin section analyses, especially mineralogical counts, were valuable in determining the resource used to produce the pottery, the presence of added material or sieving, and fabric density. Re-firing data contributed to the better understanding of firing atmospheres. Through these analytical techniques, therefore, it was possible to discover how clays were manipulated to produce the Early Neolithic pottery from Caldeirão and from where clays might have come.

6. Results

Figure 2 shows the vertical distributions of vessel fragments along the axis of deposition of the cave from the entrance to the interior. It is apparent in this scheme that the distribution of sherds from vessel 1 cluster significantly below those of the other vessels, in the Pleistocene deposits. This intrusion may have been caused by intentional burial or by later burrowing by animals, but clearly places vessel 1 in an lower stratigraphic context. Badgers and foxes prefer to dig in earth softened by previous digging or the presence of organic materials. Remains of these animals as well as evidence for root action are present. The deposition of vessel 1 appears to have been certainly followed by disturbance since some fragments of vessel 1 were also observed well into layer Ea, the layer dominated by epi-cardial sherds.

The deposition of layer Ea appears to have followed this first burial phase and is characterized by the development of an ebulis cone in the back room that helped separate the burial phases³⁹. In contrast, the major parts of the distribution of vessels 3 and 5 are firmly in layer Ea and closer to the front of the cave. As mentioned above, there may have been some additional post-burial disturbances that spread various fragments towards the rear of the cave. Vessels 2, 4 and 6 may have been associated with burials farther back in the cave since fragments of them have been found in square 010, behind the known area of disturbance. These three vessels, however,

³⁹ ZILHÃO — *op. cit.* (v. nota 24).

are not represented by large numbers of sherds and their distributions may not be accurate. Vessel 7 is alone at the front of the cave and was probably not associated with any burials although it is of Early Neolithic style.

It is possible to determine only two separate periods of Early Neolithic occupation based on the stratigraphic relationships of the ceramic vessels. The earlier one is clearly associated with vessel 1, the later with the rest of the vessels. Vessel 1 was found to be compositionally different from the epicardial vessels as well. Vessels 1, 2, 4 and 6 appear to be associated with burial events, whereas vessels 3, 5 and 7 may relate more closely to habitation activities near the entrance.

Analysis of the percentage of paste in each vessel shows vessel 1 to have rarer coarse inclusions than the other vessels, giving it a "finer" appearance. Paste percent, shown below (table 1), is the percent of clay matrix counts from each point count:

TABLE 1

Vessel	1	3	4	5	6	7
Paste %	81	52	39	53	73	54

Non-plastic inclusions in vessel 1 are almost exclusively small (less than 0.5 m.m.) angular quartz fragments, whereas all other vessels regularly contain larger (up to 2 m.m.) coarse grains. Mineralogical descriptions (table 2) of the coarse grains in vessel 1 indicated that it contains, in addition to apparently naturally occurring iron-rich clay particles and quartz grains, angular fragments of both a brown and a yellow/gray clay. The mineralogy of the two clay fragment types are also similar to each other and to the clay matrix.

Whereas one type of clay inclusion might have been due to the partial crushing of an unmodified clay source, the occurrence of a second clay may have been due to the addition of burnt fragments of clay or pottery (grog) from the same clay bed. Whereas the yellow fragments were the result of natural mixing, the brown fragments were a previously burned clay (possibly pottery) that was added to the clay body. These fragments, visible only through thin section analysis, contributed to the "fine" appearance of this vessel.

Vessel 3 has relatively thin walls, a fine grained paste and is decorated with faint incisions. Most of its coarse grains are rounded and angular siltstone fragments and very angular quartz, feldspar and larger granite (quartz and feldspar) fragments (table 2). The granitic inclusions, since they are quite angular, may have been ground and added for temper. Without comparing this sample to a known clay source it is, however, impossible to tell. One organic fragment, a small (.37 m.m.) plant stem, was also obser-

TABLE 2
MINERALOGY OF THIN SECTIONS

Inclusion	Vessel						Clay			
	1	3	4	5	6	7	T1-1	T1-2	T2-2	C1-1
Quartz	33	39	65	29	40	10	55	49	20	45
Feldspar	—	16	3	38	36	—	11	6	—	2
Calcite	—	—	—	—	—	76	1	—	—	28
Musco.	—	—	—	—	—	1	3	4	32	1
Biotite	—	—	—	6	2	—	—	1	12	—
Leucite	—	—	—	1	—	—	12	18	—	—
Limest.	3	—	—	—	2	7	8	14	—	3
Siltst.	—	35	3	1	—	—	10	—	—	—
Granite	—	6	—	18	12	—	—	—	—	—
Unk. Iso.	—	—	—	—	—	—	—	—	—	11
Br Clay	31	—	26	5	8	4	—	4	20	5
Gr Clay	20	—	—	—	—	—	—	—	—	—
Fe Clay	12	3	—	2	—	—	2	—	16	—
Organics	—	1	—	—	—	—	—	4	—	5
Silts	105	202	—	112	134	93	146	122	776	260
Point Counts:										
Inclus.	19	42	39	44	23	39	40	35	12	27
Paste	81	52	39	53	73	54	59	64	83	72
Voids	0	6	22	3	4	7	1	1	5	1

ved. Vessel 4 contains definite evidence of grog tempering. Clay fragments seen in thin section were not only very angular but showed interior gradations of color which indicate that they came from a previously fired clay.

Vessel 5 is the only large, thick-walled pot from the assemblage. It is decorated with three lines of fingernail impressions below the rim. Its non-plastic component is mostly granitic (table 2), but there is no evidence of any peculiar angularity associated with material that would have been crushed and added. The non-plastic mineralogy of vessel 6 is so similar to that of vessel 5 that may they have come from the same area. Vessel 6 is, however, much more thin-walled and may have been produced with an additional processing step. It contains few grains larger than 1.0 m.m. and a high amount of grains in the 0.5 to 0.25 m.m. range. This variability may be due to a difference in sources or to preparation of the same source by sieving since grinding would have produced much more angularity among the grains.

Vessel 7, a comb decorated vessel, is the only one from the mouth of the cave. It is also unique because it has an abnormally large amount of angular calcite fragments (76% of the non-plastic inclusions). This is much higher than any other sample, even the one made from the clay from the cave where calcite occurs naturally (table 2). It may, therefore, have been added as a temper.

The vessels were probably formed by hand; the clay rolled into long rope-like pieces and coiled around to form the walls. The sherd from vessel 5 contains a pattern of connected elongate voids running in an S-shape from the interior to the exterior. This separation of the clay body is characteristic

of a break between coils and strong evidence of the use of coiling, at least for this pot. All other vessels show slight variations in wall thickness characteristic of coiling⁴⁰. More obvious signs of coiling such as cracks or breaks between coils were probably removed by later surface treatment.

All of the vessels under study had been decorated with incisions or impressions. The cardial vessel also bore plastic additions in the form of handles and "mamelons". Impressions were applied while the pot was in the plastic state on the cardial pot and vessel 5 as were the incisions on vessel 7. Vessels 3 and 4 were incised while in a leather state and vessel 6 was incised while in a completely dry state. All but vessel 4 show obvious signs of burnishing, but the grainy surface of this vessel may have been due to post-depositional weathering.

The reddish surface color of the cardial pot and vessel 5 are due to the presence of oxidized iron. Hematite-rich clays, naturally red in color, may have been purposely selected to achieve the proper color. The red color may however also have appeared when carbon deposited in a smoky fire began to burn off at a much lower temperature. If so, the firing of these pots reached at least 600 C., the minimum temperature for the oxidation of iron⁴¹. It is also possible that chemical reactions to soils during burial may have begun to oxidize the iron contained in the clay. Inspection of cross-sections of cardial pottery shows that the reddish color is restricted to a very thin band on the outside surface of the pottery. Vessel 5 exhibits these same characteristics, only with thicker and less well defined exterior borders. Without comparison to clay samples known to be representative of the source of these clays, it is difficult to select either of these options.

Cardial pottery chips had a high (16 percent) weight loss during the initial 500 degree C. re-firing due to the loss of carbon in the paste. Carbon deposition, which can occur in a smoky fire and could have been easily produced intentionally by smudging⁴², may have occurred during the firing of this vessel. Low firing temperatures may have also accounted for the presence of carbon in the body of vessel 1. Clays with high organic contents can also produce a black core⁴³. Gallart Martí⁴⁴ suggests a low firing temperature for cardial pottery from Cova de l'Or based on the presence of dark cores.

The other four vessels, numbers 3, 4, 6 and 7, are all black in color throughout. The most likely source of this black color is from the intentional penetration of carbon from a smoky fire into the vessel (smudging) after

⁴⁰ RYE — *op. cit.*, p. 67 (v. nota 30).

⁴¹ ID. — *Ibid.*, p. 108.

⁴² SHEPARD — *op. cit.*, p. 88 (v. nota 38).

⁴³ RYE — *op. cit.*, p. 108 (v. nota 30).

⁴⁴ GALLART MARTÍ, M. D. — *La Tecnología Cerámica*, in MARTÍ OLIVER, B., et al. "Cova de l'Or", vol. 2, València, 1980, p. 169. (Servicio de Investigación Prehistórica; 65).

the water smoking stage when the fabric of the pots would have been opened to absorb material. Re-firing of a sherd fragment from vessel 3 showed that it lost a significant amount of carbon at 500 C. Smudging was, therefore, possibly practiced in the production of later wares. The high calcite content of vessel 7 would have probably precluded its firing above 750 C. since at that temperature calcium carbonate begins to decompose to CaO and produce carbon dioxide gas that would destroy the pot⁴⁵.

Since most vessels do not show areas of basal blackening that would be bound to occur if used over a fire, they may have been primarily containers and not cooking vessels. Only vessel 5 shows exterior color variations that could have been due to using the pot in a fire. Vessel 7 has a similar porous, thick body as vessel 5 and, since it is found in the habitation area of the cave, may have been used for domestic purposes as well. It seems reasonable to cautiously suggest from the general form of all the vessels that they were designed as containers, but there is in general a poor relationship between specific vessel shape and function⁴⁶. It is also not known whether or not the vessels from the burials had actually been used for other than funerary purposes.

Comparison of the non-plastic grains among the sherd and clay sample thin sections provided a measure of provenience evaluation. This information is summarized in figure 2. Two possible sets of associations were discovered, between vessels 5 and 6 and between vessel 7 and clay C1. Both vessels 5 and 6 contain fairly large fragments of granite and smaller fragments of granitic minerals (quartz, feldspar and biotite) in approximately the same amounts. Several important differences do exist between the two mineralogical suites. The inclusion to paste ratio that is much higher in sample 5 than sample 6 is probably due to technological considerations. There is also a concentration of mineral grains in vessel 6 between 0.5 and 0.25 m.m. in size. Despite these differences, it is possible that the same clay was used to fashion both of these pots. Larger grains could have easily been picked out of the clay used for vessel 6. Such a fine paste may also have been desired to produce a smoother surface or the much thinner walls of vessel 6.

The non-plastic mineralogy (table 2) may also indicate that two separate sources were selected (possibly intentionally) for each pot or that the vessels come from the same bed but in two different areas. Mineralogical variability of this nature within one clay bed can vary over a distance of a few centimeters to a few kilometers. It is also possible that similar granitic sands were added to the clays for these vessels. The coarse grains in vessel 6 do show a size distribution common for a well-sorted medium sand, whereas the distribution for vessel 5 is poorly sorted. Although this information may be used to argue that vessel 6 was made from an unmodified clay, without

⁴⁵ RYE — *op. cit.*, p. 33 (v. nota 30).

⁴⁶ SHEPARD — *op. cit.*, p. 224 (v. nota 38).

information of the variability of the source for these vessels, it is impossible to select between the alternative explanations.

Vessel 7, from the mouth of the cave, does have a very similar mineralogy to clay sample C1 from the cave. Both contain quartz, calcite, muscovite and iron rich clay particles (table 2). There are, however, important differences between the two samples. As mentioned above, there are high amounts of angular calcite fragments in vessel 7. If this material had been added as temper, it would account for the high amount of angular calcite fragments and the depressed quartz counts for this vessel.

There are other significant differences. The clay from the cave contains a significant amount of amorphous silicate organics and an unknown fine-grained isotropic material not found in the vessel (table 2).

It is unlikely, therefore, that the vessel was produced from the cave clay itself, although it may have been produced locally. Unfortunately, the local geology, a Jurassic limestone, extends to the coast some 80 kilometers away (fig. 1). It is therefore impossible to assess the provenience of this vessel at present. Granitites such as those found in vessels 3, 4, 5 and 6 form the interior highlands to the east (fig. 1) but may have occurred as alluvial sands along any of the major east-west drainages to the north or south. Paleozoic schists, graywackes, quartzites, conglomerates and metavolcanics of the central massif begin abruptly ten kilometers to the east of the cave across a fault zone. The erosion of this Paleozoic basement may have provided some of the mineral suites found in later facies to the west, although it is unlikely that the larger granitic grains would have been transported out of the region of local occurrence.

Micas, feldspars, and especially silicate minerals may have survived alluvial transport from the highlands during the Jurassic and Miocene to form the present plateaux that begin a few kilometers away in the Nabão. For example, quartz grains, as well as rare feldspar and mica grains, are found in the primary Jurassic clay from Caldeirão. Only the silicates, however, would have survived the secondary erosion of these sedimentary beds that formed the later Quaternary alluvia such as the Tagus estuary. These beds may have been the source for vessel 1, which contains mostly quartz and clay fragments. This information, however, can only be used to eliminate the possibility of local production and suggest areas for further examination, it cannot yet be used to indicate production areas for Caldeirão pottery.

7. Conclusions

The remains of the cardial pot cluster in the lower stratigraphic unit were deposited significantly before the other vessels. It and impressed vessels 2, 4 and 6 are associated with burials. Vessels 3, 5 and 7 came from the habitation area. The epi-cardial wares show a great deal of difference in their stylistic, manufacturing and provenience aspects. Whereas the cardial pot contains almost exclusively quartz grains, the epi-cardial wares contain minerals indi-

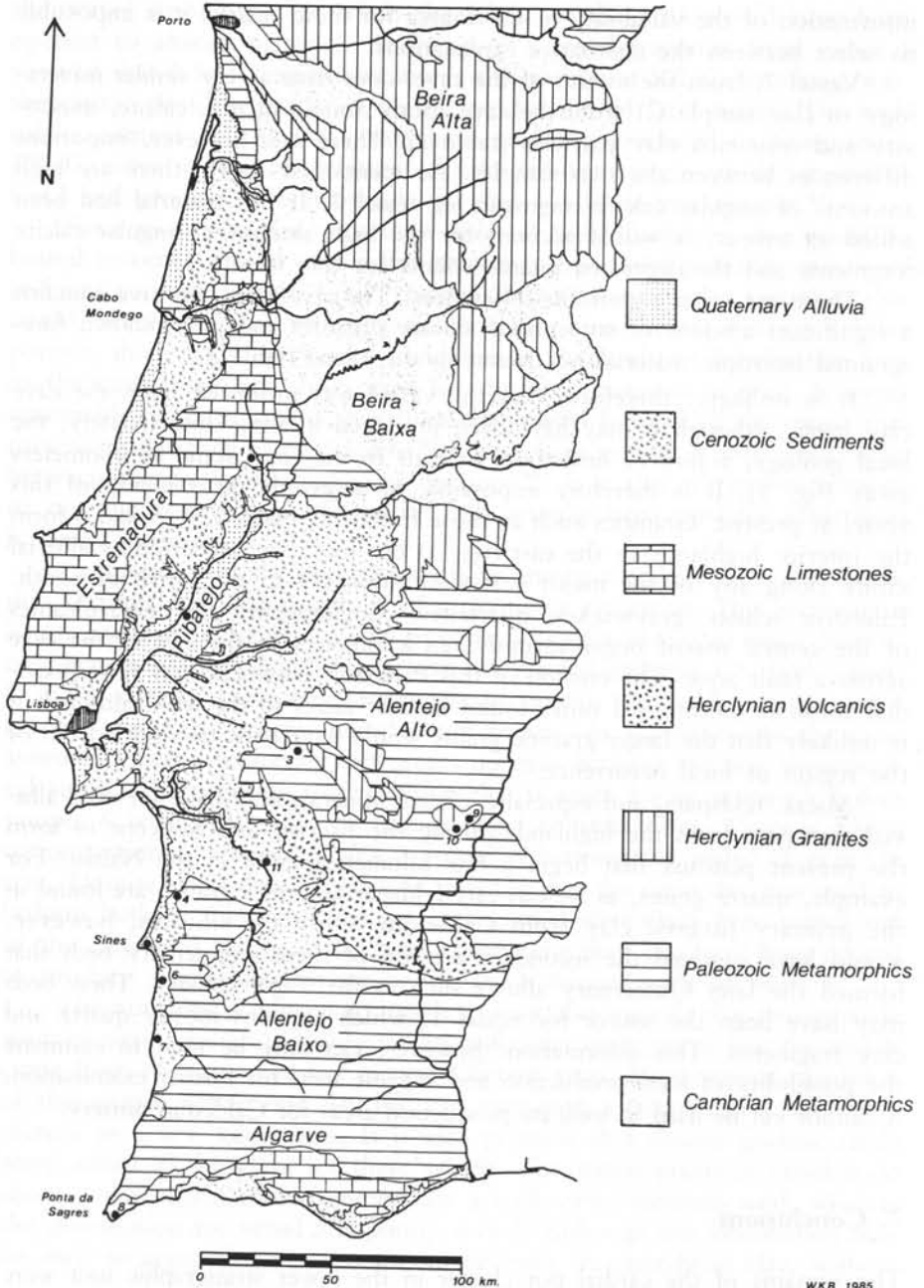


Fig. 1 — Surface Geology of Portugal (after REAL — op. cit. (v. nota 58). Sites: 1, Caldeirão; 2, Muge; 3, Escoural; 4, Salema; 5, Vale Pincel I; 6, Samouqueira; 7, Medo Tojeiro; 8, Cabranosa; 9, Gateira; 10, Gorginos; 11, Cabeço do Pez.

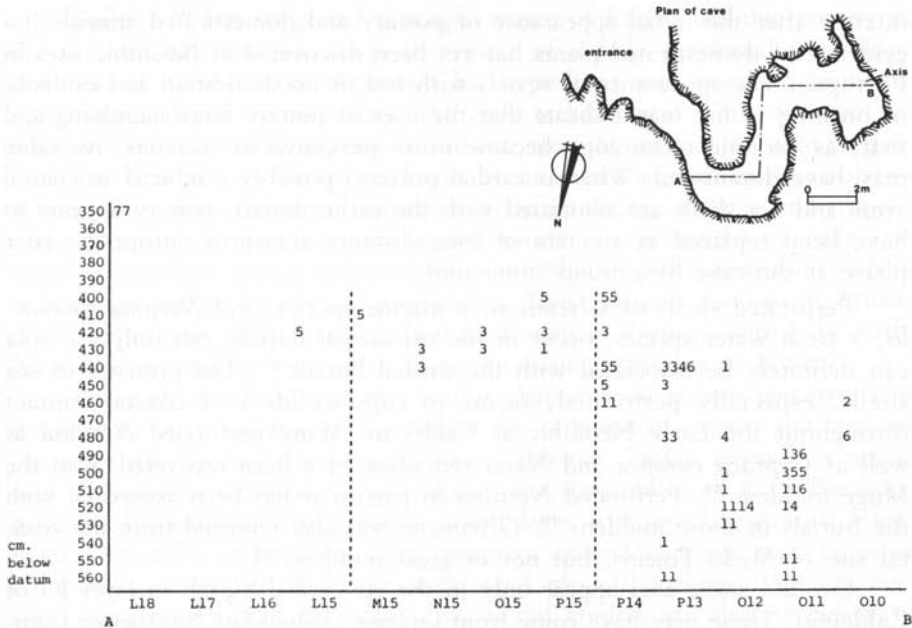


Fig. 2 — Vertical distributions of decorated sherds by excavation unit along axis of deposition. Numbers represent vessel number. Vertical lines are changes in the axis direction.

cative of various inland granitic and in one case limestone geologic facies. Vessel 7, the only pot that contains minerals characteristic of the immediate geology, may have been manufactured locally. The unique thin red exterior and dark core of vessel 1 may have been due to a number of factors. Thinner walls and less dense pastes characterize the other vessels, as does intentional smudging to produce a black surface. Vessels 1, 4, 6 and 7 show possible evidence of the manipulation of a natural clay body. The firing of vessels 1, 3, 4, 6 and 7 may have been controlled to produce a specific effect.

Based on these patterns of physical and technological variation it is possible to propose two phases of Early Neolithic occupation at Caldeirão, both of which include burial materials. The earlier phase is associated with cardial pottery but few other items and the later with other impressed wares as well as ground stone tools. Cardial pottery, due to its postulated distant source and supposedly extensive distribution and stylistic uniformity, may have acted as a status item. The later wares may have been associated with group identity at a smaller scale due to their variety of decoration and more localized production, whereas ground stone tools became more desired status items. There also appears to have been a shift in ceramic technology between the two phases at Caldeirão.

These patterns of physical and technological variation among the ceramic remains at Caldeirão seem to indicate that the number of production locales in a given region progressively increased and spread towards the

interior after the initial appearance of pottery and domesticated animals (no evidence of domesticated plants has yet been discovered at Neolithic sites in Portugal). The appearance of vessels with less or no decoration and evidence of burning in fire may indicate that the uses of pottery were increasing and that, as ceramic technology became more pervasive in societies, its value may have diminished. Whereas cardial pottery, possibly produced in coastal areas and sea shells are associated with the earlier burial, pottery appears to have been replaced as an item of long distance transport during the later phase at the cave by ground stone tools.

Perforated shells of *Glycimeris*, a marine species, and *Neritina fluviatilis*, a fresh water species, occur in the epi-cardial burials, but only *Neritina* can definitely be associated with the cardial burials⁴⁷. The presence of sea shells, especially perforated, seems to support ideas of coastal contact throughout the Early Neolithic at Caldeirão. Many perforated *Neritina* as well as *Cypraea europea* and *Nassa reticulata* have been recovered from the Muge middens⁴⁸. Perforated *Neritina* in particular has been associated with the burials in those middens⁴⁹. *Glycimeris* was also reported from the coastal site of Medo Tojeiro, but not in great numbers⁵⁰.

Ground stone axes appear only in the epi-cardial burials in layer Ea of Caldeirão. These may have come from interior Ordovician, Silurian or Cambrian beds found to have been utilized for ground stone tools at the Middle Neolithic site of Feteira⁵¹. Collection of the appropriate materials, therefore, may not have been difficult for the people who visited Caldeirão. Ground stone tools, however, have also been found in Early Neolithic contexts at the Cabo Mondego sites of Várzea do Lírio, Junqueira, and Forno da Cal⁵² and at the southern coastal sites of Cabranosa (Ponta de Sagres)⁵³, Vale Pincel I and Salema⁵⁴; all Early Neolithic sites more than 100 Kilometers from the nearest postulated source (fig. 1). These materials may have arrived at the cave through exchange or the seasonal movements of the hunter/pastoralists thought to have occupied the cave⁵⁵.

⁴⁷ ZILHÃO, J. — *Néolithique Ancien et Paleolithique Supérieur de la Gruta do Caldeirão (Tomar, Portugal): Fouilles 1979-1984*, in "Actas da I Reunião do Quaternário Ibérico", 1985.

⁴⁸ ROCHE, J. — *Les Objets de Parure trouvés dans Les Amas Coquilliers de Muge* "Trabalhos de Antropologia e Etnologia", 17, 1959, p. 407-411.

⁴⁹ ID. — *Ibid.*, p. 408.

⁵⁰ LUBELL; JACKES — *op. cit.* (v. nota 14).

⁵¹ REAL, F. de S. — *Classificação Petrográfica por Análise Macroscópica do Material Arqueológico de Pedra Polida da Gruta da Feteira*, in ZILHÃO, J. "A Gruta da Feteira (Lourinhã)", Lisboa, Dep. Arqueologia, 1984 (Trabalhos de Arqueologia; 1).

⁵² JORGE, S. O. — *Contributo para o Estudo de Materiais Provenientes de Estações Neolíticas dos Arredores da Figueira da Foz*, in "O Neolítico e o Calcolítico em Portugal: Actas da I Mesa Redonda", Porto, G.E.A.P., 1979, p. 53-82.

⁵³ GUILLAIN; FERREIRA — *op. cit.*, p. 306 (v. nota 4).

⁵⁴ SILVA; SOARES — *op. cit.* (v. nota 7).

⁵⁵ See also GEDDES, D. — *Neolithic Transhumance in the Mediterranean Pyrenees*. "World Archaeology", 15 (1), 1983, p. 51-66.

Guilaine⁵⁶ has suggested that appearance of Early Neolithic pottery in the western Mediterranean was the result of a fully developed technology that spread by diffusion. Although his hypothesis was based on primarily morphological and stylistic data, the little technological work done on the pottery from Caldeirão appears to indicate that the technology used to produce the first pottery in Portugal was by no means experimental and shows a familiarity with the basic processes of manipulating, forming and firing a clay. Despite the fact that the earlier phase is represented by only one vessel, there does appear to have been some type of production shift both in technology and in location of production. These patterns seem to fit Arnaud's⁵⁷ hypothesis of increasing inland settlement in Portugal during the Early Neolithic or may be suggestive of an increasing transport of pottery.

Although conclusions drawn in this chapter must remain tentative, it is possible to note and attempt to explain the variation in context and physical characteristics among the pottery from Caldeirão. Future research is necessary to better understand the production and distribution of Early Neolithic pottery. Excavations that produce assemblages with good contextual information must be undertaken. Clay resources around each site must be more completely researched to better understand physical variations seen in pottery samples. Faunal and other specialized studies are also necessary to provide an economic and chronological framework for interpretations. This study does, however, propose some initial conclusions about the nature of Early Neolithic pottery and demonstrates the potential contribution of the physical analyses of pottery from archaeological sites.

⁵⁶ GUILLAINE — *op. cit.* (v. nota 17).

⁵⁷ ARNAUD — *op. cit.* (v. nota 8).

⁵⁸ REAL, F. de S. — *Carta Geológica de Portugal, 1:1 000 000*, Lisboa, Comissão Nacional do Ambiente, 1982.

