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Analyzing technical choices: improving the archaeological classification of Late Republican Black Gloss pottery in north-eastern Hispania consumption centers

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Codi de camp canviat

Abstract

In order to improve archaeological classifications of Late Republican Black Gloss pottery, an assemblage from two consumption sites in north-eastern Hispania has been physicochemically characterized to identify its provenance and to gain an idea of its manufacture process. The study has been organized according to a multiphase sampling (Buxeda and Madrid 2016, 20). In the first phase, chemical characterization by means of Wavelength Dispersive X-ray fluorescence (WDXRF) and mineralogical characterization by means of X-ray diffraction (XRD) were performed. In the next phase, a subsample was microstructurally characterized by means of Scanning Electron Microscopy (SEM), thanks to which the sintering/vitrification stage of the matrix and the gloss were determined.

The combination of both disciplines, archaeology and archaeometry, enables us to identify four meaningful ceramic groups: Campanian A, Cales 1, 2, and 3. The study also allowed us to infer that all of them must be related to the Campanian region and assignable to three different chronological periods. The Campanian region thus seems to have been the primary source that supplied the settlements considered. The study also allows us to appreciate that the classification criteria used by the archaeologists working at those sites reflect the technical choices made by the potters and that, in many cases, they can only be detected and therefore interpreted by means of archaeometry.

Keywords

Campanian A, Campanian B, Middle Cales, Late Cales, Hispania, Archaeometry

ACKNOWLEDGMENTS

This article would never have been possible without the generous support of York University through the award of a SSHRC Small Research Grant to finance the research project entitled *Cultural Contacts Between Central Italy and Spain: An Archaeometrical Approach from Ancient* Ilduro. X-ray fluorescence analysis, X-ray diffraction analyses and SEM examinations were undertaken at the Centres Científics i Tecnològics de la Universitat de Barcelona (CCiTUB). Finally, we would like to thank Joaquim Garcia (Archaeologist of Mataró City Hall) for the archaeological classification of the pottery studied in this article.

INTRODUCTION AND OBJECTIVES

This article focuses on Late Republican Black Gloss pottery from the ancient sites of *Ilduro* and *Iluro* (in the modern-day municipalities of Cabrera de Mar and Mataró), located in the north-east of the Iberian Peninsula. The study integrates archaeological analyses and archaeometric research in order to develop a more accurate way to classify ceramics and to relate them to their areas of provenance. At the same time, the study of some aspects of the manufacturing process is in fact a procedure of reverse methodology that will provide a scientific explanation to why archaeologists participating in the excavations at *Ilduro* and *Iluro* classify the pottery in one way or another.

The study is part of a wider project focusing on some complex domestic spaces of a Late Republican settlement (mid-2nd - early 1st century B.C.E.), and their material culture (Sinner 2015). The houses under study were located near the public baths, forming an impressive neighbourhood that seems to occupy one of the most privileged spaces within the urban layout. Therefore, a household archaeology study of these domestic spaces will reveal some of the cultural and economic practices, consumption patterns, and other relevant aspects of their inhabitants' lives. Within this framework, the main objectives of this study are to:

1. Identify meaningful ceramic groups (Buxeda and Madrid 2016, 6) present in the sample analysed.
2. Compare the analytical results with the macroscopic classifications carried out by the archaeologists, which have traditionally resulted in the following groups: Campanian A, Campanian B (Etrurian), Middle Cales, and Late Cales.
3. Identify their provenance and provide information on some technical aspects (estimated equivalent firing temperatures, microstructure developed during firing, and characteristics of the gloss)~~the technology used for their production~~.
4. Relate the meaningful ceramic groups identified by archaeometric research with their archaeological contexts in the settlements of *Ilduro* and *Iluro* and organize them chronologically.
5. Compare the provenance of the ceramics under study with those from previous studies in order to gain a clearer idea of the trade networks between the Italian Peninsula and north-eastern Hispania. Special attention will be paid to the evidence from the Roman colony of Cosa, since the University of Barcelona conducted a project there and we had the opportunity to participate in the archaeometric studies of the fine ware (Terra Sigillata and Black Gloss), to see whether artefact distribution follows the same pattern inside and outside the Italian Peninsula (Madrid and Buxeda 2013).

With all these objectives in mind, we present the archaeometric study of 56 Late Republican Black Gloss pottery sherds. In the first phase, in order to study the bulk composition of the material nature of the individuals, chemical characterization by means of WDXRF and mineralogical characterization by means of XRD were performed. In the next phase, a subsample of individuals was taken from those studied in the first phase, which were microstructurally characterized by means of SEM, thanks to which the sintering stage of the matrix and the gloss were determined. The use of SEM also allowed us to observe other specific characteristics of the gloss such as thicknesses, quality of the barbotine slip used for its preparation, as well as the degree of adherence to the matrix. These features greatly affect the visual appearance of the vessels, which is one of the main factors used by archaeologists when conducting Black Gloss pottery classification.

THE SAMPLE AND ITS ARCHAEOLOGICAL CONTEXT

The late 3rd and early 2nd centuries B.C.E. witnessed great changes in indigenous Iberia, particularly as regards territorial organization and the production and consumption patterns that developed after the Second Punic War and the arrival of Roman forces in the Peninsula in 218 B.C.E. Such phenomena are clearly detectable in the political and administrative center of Laietanian territory, ancient *Ilduro,* a settlement originally located within the valley of Cabrera de Mar, in modern coastal central Catalonia (Spain), which was later relocated 6 km to the north to what today is the modern city of Mataró (Fig. 1).

Throughout the 2nd and early 1st centuries B.C.E., Laietanian territory underwent a complex process of colonization (Sinner 2015). Despite the lack of archaeological and historical evidence from the first half of the 2nd century B.C.E., remarkable transformations can be detected in the area during the second half of the century, involving the Roman promotion of the main *oppidum* of the Laietani at Burriac hill. Because of this process, a settlement with marked Italic architectural characteristics, as witnessed in the residential sectors of Can Benet and Can Mateu, developed at the foot of the Iberian town.[1] The abandonment of this young settlement early in the 1st century B.C.E. may have coincided with the foundation of the new city of *Iluro*, to which Pliny (*NH* 3.4.22) refers in his description of Hispania Citerior as an *oppidum civium Romanorum*. Furthermore, the lack of comments in the literary sources with regard to the events that might have led to all these rapid changes in the region makes the study of archaeological finds and material remains crucial to our understanding of the culture of the Laietani and their evolution as a society.

Ilduro

Two different contexts, both of them belonging to the Late Republican settlement, were selected for sampling with a total of 40 sherds (71 % of the sample).

The Can Mateu sector corresponds to several buildings located immediately to the south of the bath complex of this urban settlement (Garcia et al. 2000a: 36-37; Martín and Garcia 2002: 200-201). The remains have been interpreted as residential structures divided in two different groups (Sinner 2015: 15-16). Excavations in 1997-98 affected only four of the southernmost rooms, which proved to have been used for domestic purposes at least between the third quarter of the 2nd and the first quarter of the 1st century B.C.E. On the basis of their overall plan and pattern of inter-communication, it seems that these structures formed part of a minimum of three large buildings and were not small individual units. The rooms are of different size, with clay floors and perimeter walls that, in some cases, serve as retaining walls to contain the surrounding terrain. A total of nine sherds (16 % of the total sample), dating back to a period between 125 and 90/80 B.C.E., are analyzed in this article (CMT001-CMT009) (Table 1).

The Can Benet sector was excavated between 1999 and 2013 uncovering two perpendicular streets that separate a group of modest-looking households lying north of a street –which runs E–W– from the remains of a luxurious *domus*, of which eight rooms and more than 200 m^2 of built surface are known. Six of these spaces were paved with *opus signinum* incorporating black-and-white tiles as ornament (Martín and Garcia 2007, 70; Martín 2017, 319-325). The chronology of the house was divided into three phases. The initial construction of the *domus* and adjacent buildings dates to 135/125 B.C.E. A second phase dates to the start of the 1st century B.C.E., while the abandonment of the area dates to c. 80/70 B.C.E (Martí 2009, 375-376). The 31 sherds (55 % of the total sample) from Can Benet analyzed in this article belong to the last moment of occupation of this residential neighbourhood (CBN001-CBN031) (Table 1). All the sherds were recovered from an ovoid pit (SU 1069) that was used as a dump. The filling of this pit (SU 1068) provides an excellent picture of the material culture used by the inhabitants of the Can Benet sector at the time of its abandonment around 80 B.C.E.

Iluro

Three different contexts were selected for sampling 14 sherds (25 % of the total of the sample) from the Roman town of *Iluro*, all of them corresponding to the first phase of its occupation dating back to 80/70 B.C.E. (ILR001-ILR014) (Table 1). From Na Pau Street, the samples come from two modest-looking rooms also identified as domestic spaces (A1 and A2) (Garcia 2014: 351-352). The second context is Plaça Gran no. 8,

[1] The authors of this article understand that the Late Republican settlement and the Iberian *oppidum* at Burriac, which coexisted for at least three quarters of a century (during the second half of the 2nd century B.C.E. and the first quarter of the 1st century B.C.E.), functioned as a single urban entity economically (Sinner and Martí 2012; Sinner 2017) and linguistically speaking (Sinner and Ferrer 2016). Therefore and, based on the current data available, both sites are included in this paper as belonging to ancient *Ilduro*. A similar interpretation in: Olesti 2010, 29, footnote 14, 2017: 434. A detailed study of the *oppidum* at Burriac in Zamora 2006-2007; for a description of the main sectors of the Late Republican settlement, see: Martín and Garcia 2007; Sinner 2015, 13-20; Martín 2017.

where two phases of occupation were identified. The samples analyzed can be linked with the construction of at least one domestic space. The samples (except of ILR011) can be associated with the construction of the aforementioned space and were recovered from the filling of the wall trenches (SU 1154 and 1134) and from the strata used to level the terrain on which the pavement was laid (SU 1123). Finally, various excavations carried out in the area of Plaça Gran uncovered the remains of a domestic building interpreted as a luxurious *domus* composed of several rooms. Four areas were totally or partially excavated, uncovering three rooms paved with different elaborate techniques: *opus signinum*, *opus spicatum*, and a mosaic; the last and largest space formed two sides of a colonnaded portico also paved with *opus signinum* (Clariana and Juhé 1997; Garcia 2014, 203-208). The samples analyzed can be related to the construction of the house, for which several dates have been suggested, so far the most feasible option being an uncertain moment in the first or second quarter of the 1st century B.C.E. (Clariana and Juhé 1997, 133-159, Garcia et al. 2000a, 47).

ARCHAEOLOGICAL CRITERIA TO CLASSIFY THE SAMPLE

As will be discussed below, Late Republican Black Gloss pottery has long been the subject of discussion and debates among classical archaeologists. The abundance and importance of these ceramics, since they can be considered as the first mass-produced Roman fine wares, and their efficiency as a method of relative dating thanks to their typological classification and morphological evolution, has contributed to developing a whole area of research around them in classical archaeology. Fortunately, the Black Gloss products recovered from the sites of ancient *Ilduro* and *Iluro* were archaeologically studied in detail in 1998 as part of a workshop dedicated to the production of Black Gloss pottery in the Mediterranean and its commercialization in the Iberian Peninsula (Garcia et al. 2000b), and later (more generically) in other volumes devoted to these ceramics (Principal and Ribera 2013). Therefore, an accurate comparison between the tools and the criteria used in the archaeological and archaeometric classification is possible for this specific case. In the following lines, we will summarize the main morphological characteristics and chronologies of each type as described by the archaeologists with the naked eye to later compare them with those proposed in this article.

Campanian A

Five periods of production –primitive, archaic, early, middle, and late– can be differentiated among these ceramics with an origin in the Bay of Naples. These phases occurred between the late 4th century B.C.E. and the 1st century B.C.E, but only two of these moments are relevant for this study due to their chronology, namely the middle, also known as classic (180-100 B.C.E.), and the late (*c.*100-40 B.C.E.) phases. The main features to differentiate the later products from the earlier ones were the quality of the gloss and the characteristics of the clay, which is described as "*arcilla calcárea, de color rojo o rojo-marrón, dura, porosa, con alguna vacuola y pequeñas partículas de mica plateada*"[2] (Principal and Ribera 2013, 109), even if the calcareous nature of the paste cannot be assessed without the archaeometric characterization of the material. In the late products, the clay has a darker red color close to burgundy and the gloss is poorly applied, sometimes displaying different tonalities and in many cases a matt finish far from the intense black gloss characteristic of the earlier ceramics. The decorative program is also restricted to basic concentric grooves and sometimes circles painted in white (Garcia et al. 2000b, 59). The introduction date of late Campanian A in the Laietanian territory is unclear, but it seems to have taken place during the last quarter of the 2nd century B.C.E., it being the most common type of Campanian A in the area under study by the first decade of the 1st century B.C.E. This pottery was still to be available on the market until the transition to the Common Era, although in very small amounts (Garcia et al. 2000b, 60). It is relevant to mention that, while studying the same type of ceramics from the archaeological site of *Baetulo* (20 km south of *Ilduro*), the criteria and descriptions to differentiate middle Campanian A from late Campanian A are similar but not identical. In Badalona (*Baetulo*), two groups of late Campanian clays are described: the first is almost identical to the one described above, and is represented by a dark red clay close to burgundy and a gloss with intense metallic reflections. However, additional characteristics are described to define late Campanian A ceramics, including a group with a clay that has a tendency to be orange in color and another that has a

[2] "calcareous clay, red or red-brown, hard, porous, with some vacuoles and small particles of silver mica"

gloss with a tonality close to brown (Grau et al. 2000, 72). This is just an example to show how, independently of how accurate archaeological descriptions can be, there is always an important degree of subjectivity in their description and therefore in their classification, which can vary (to a greater or lesser extent) from person to person. The same happens with all the groups described below although we will not reproduce each different description given.

Black Gloss Pottery of Type B

In their detailed study of these ceramics, a division into four main categories was suggested by Garcia et al. (2000b, 62): Campanian B should only include those wares made on the coastline of Etruria. The ceramics made in the territories of Campania (including Cales) were labeled as Cales or Calenan pottery. The term Arretine was used to cover those Black Gloss ceramics made in the territories of modern Arezzo. Finally, a last group including all the types that do not belong to any of the aforementioned groups was suggested (group B or type B productions). For the interest and relevance of our study, we will here focus on the first two groups (Campanian B or Etrurian and Cales).

While discussing the Black Gloss wares produced in the area of Etruria, those defined by Taylor (1957) as type II from Cosa (Campanian B), it is important to highlight that some authors have mentioned the need to revise their attributions. They believe that this pottery reached the territory of the Laietani throughout the 1st century B.C.E., but in very small amounts: *"En cuanto a los materiales del siglo I a.C. clasificados como Campaniense B etrusca, creemos que es del todo imprescindible una revisión de estos, ya que pensamos que la mayoría no tienen este origen sino que provienen de la Campania septentrional, probablemente del área de Cales."*[3] (Garcia et al. 2000b, 61).

Morphologically speaking, these ceramics can be defined as having light brown (sometimes pinkish) fine calcareous and very well purified clays (even if it is only possible to assess these features by means of analytical techniques), very similar to those later employed in Arretine *sigillata*. The gloss is black, thick, shiny (sometimes it can be slightly bluish), and is always uniform and well distributed over the vessel thanks to the immersion technique. Above all, most archaeologists will describe these ceramics as of high quality (Principal and Ribera 2013, 61-62).

The Black Gloss pottery from Cales can be divided into four different groups –archaic, early, middle, and late – produced between the 3rd century B.C.E. and the 1st century B.C.E. However, due to the rarity of the first two groups in the archaeological levels of Can Benet and Can Mateu (*Ilduro*) and in the foundational levels of *Iluro* and, considering that they are not represented in our sample, they will not be discussed here (a detailed description can be found in Principal and Ribera 2013, 76-93). We will focus instead on the last two groups –middle and late Cales– since they make up the majority of our sample. The ceramics classified as middle Cales are usually dated between 130/120 B.C.E. and 90/80 B.C.E. Among their main morphological characteristics, two must be highlighted: a hard light brown calcareous clay and a black gloss that is not, however, as intense and thick as in the Etrurian products (Principal and Ribera 2013, 93). The gloss can also sometimes have a matt finish and might show some iridescences –although not as many as in the late Cales products. Another important feature in this pottery is the profile of the base of the vessel, which reproduces the shape of the Etrurian products. However, as the authors point out, it is difficult to be sure that all the materials classified as middle Cales by archaeological methods correspond in fact to this type, due to the similarities shared with Etrurian and late Cales wares. This misclassification makes it difficult to estimate the actual presence of middle Cales pottery in archaeological contexts (Principal and Ribera 2013, 96). Late Cales products, on the other hand, can be chronologically dated between 90/80 B.C.E. and 40/30 B.C.E., their clay usually being defined as calcareous and granular, displaying a wider range of colors from beige and light brown to light pink. The gloss is still black, but not as homogeneous as in the middle Cales products and has a tendency towards blue or violet reflections. In many cases, reddish

[3] " As regards the materials from the 1st century B.C.E. classified as Etrurian Campanian B, we believe that a reexamination of those materials is essential. We are convinced that the origin of most of them was not there; instead, they came from northern Campania, probably from the Cales area."

or greenish spots can also be detected in the gloss, iridescences being far more common (Principal and Ribera 2013, 99). In general, most archaeologists would agree that the late products are of poorer quality.

ARCHAEOMETRIC STUDIES ON LATE REPUBLICAN BLACK GLOSS POTTERY: A BRIEF SUMMARY

The end of the production of the Attic workshops, which had enjoyed a monopoly of the Black Gloss pottery market until the end of the 4th century B.C.E., was to leave a void soon exploited by many new workshops along the Mediterranean coastline. One of the most significant areas to fill this opening in the market was the Italian Peninsula, where production began in Sicily, Magna Graecia, Latium, and Etruria. This pottery, traditionally known as Campanian ware, was produced until the 1st century B.C.E., flooding the markets, especially those of the western Mediterranean provinces. From an archaeological point of view, Campanian ware has been the subject of many archaeological studies to establish its basic typologies and chronology, based on the vessels' form and style (for fundamental studies see Lamboglia 1952, 1960; Morel 1981, 1990, Moret et al. 1985). However, its morphological heterogeneity, together with the large number of workshops involved in this production, does not necessarily tally with the classification into the three categories A, B and C, defined as "preliminar" by Lambloglia in 1952, but which still remain in use nowadays. These categories were mainly made on the grounds of the visual appearance of their pastes; red for Campanian A, pale brown for Campanian B, and grey for Campanian C. These features correspond in fact to the use of clays with low calcium content for the first, and clays with rich calcium content for the elaboration of Campanian B and C categories, although the recipe for the preparation of the pastes can vary from one workshop to another (Picon et al. 1971, Morel and Picon 1994). Before firing, the process is completed by applying a fine particle size barbotine slip made from a non-calcareous illite clay onto the paste, in order to obtain a shiny waterproofing gloss. Finally, as was already explained by Maggetti et al. (1981: 3-4) and confirmed by recent studies (Chaviara and Aloupi 2016, 10-11), a firing process involving an oxidation phase up to 800 ºC, reduction at a maximum of 900-950 ºC, and an oxidation cooling process, will provide the intended product. One of the best explanations of this process can be found in the article published by Gliozzo and collaborators, where a wide selection of publications about the application of glosses can also be found (Gliozzo 2004, 227-228). It is also worth mentioning the studies focusing on the nature of Attic black gloss (Maniatis et al. 1993) and on the clays used for their preparation (Chaviara and Aloupi 2016), which is the origin of Campanian pottery, as Maggetti and collaborators had already been pointed out (Maggetti et al. 1981, 3-4). In this respect and based on current knowledge, it seems that Campanian A was certainly produced in Naples, where two workshops have been found (Laforgia 1988, Morel et al. 1985), and Campanian C is a characteristic product of Sicily, where "imitations" of Campanian A have also been identified (Montana et al. 2013). In the case of what is known as Campanian B, the large number of workshops involved in its production, from the Po Valley plain to the Campanian area, make it even more difficult to distinguish these products; this has led to part of the products being labelled as B-oid since they are considered imitations of "good quality Etrurian" Campanian B. It is also difficult to distinguish among different products from different periods within each one of these categories. In this context, in many cases it is hard to deal with provenance attributions of finds from consumption sites, and it is therefore a greater challenge to address the question of the distribution routes of Black Gloss ware.

In order to shed light on the complex world of Campanian Black Gloss pottery produced in the Italian Peninsula, archaeometric research has come to form an integral part of archaeological studies, especially since the early 1980s. Most of this research has been carried out in the Italian Peninsula itself, both on workshops and on consumption centers, leading to considerable progress as regards our knowledge of the huge number of production centers involved in the manufacture of this pottery (Olcese 2012, 2013) (Fig. 2). In this regard, and according to the current state of knowledge, the majority of the workshops or suggested production areas are most likely to have been located in the north, covering the Po valley, Etruria, and the Emilia-Romagna region. In the Po valley, no workshops have so far been found, although researchers firmly believe that some workshops must have been set up in this area, as a result of the specific chemical composition displayed by many of the pieces analyzed that have been found in the central Padana area (Cremona-Calvatone), Mantua, Milan, Luni, and Piacenza (Bonini, Mello 2000, Frontini et al. 1995, 1998, Maggetti 2005, Schneider 2000).

Archaeometric research has especially focused on Etrurian productions, where Arezzo, Volterra, Adria, Scoppietto, and Chiusi (Marcianella) manufactured high quality Black Gloss known as Campanian B (Comodi and Merletti 2011, Gliozzo et al. 2001, 2003, 2004; Gliozzo and Memmi Turbante 2004; Giorgetti et al. 2004; Harari and Oddone 1984; Pasquinucci et al. 1998). Among them, it is worth highlighting the research carried out at Chiusi. The research on this site includes a broad archaeological study of all the ceramic types made at this center (Pucci and Mascione 2003). Furthermore, archaeometric study enabled researchers to establish the chemical reference groups, shedding light on trade from inland Etruria to the coast and vice versa, and on technical features related to glosses (Gliozzo et al. 2001, 2003, 2004; Gliozzo and Memmi Turbante 2004; Giorgetti et al. 2004). In the Emilia-Romagna region, ancient *Ariminium* seems to have been a production and consumption center at the same time (Mazzeo Saracino et al. 2000; Schneider 2000). Morphological and typological analyses suggest a close relation with the *Latium* productions, the reason why Morel stated that *Ariminium* should be considered as an appendix of Rome (Morel 1990, 147, 155), even if no workshops have yet been found at Rome. Its products could have been commercialized at least to the nearby city of *Suasa*, in the Marches region.

Regarding central Italy, no workshops have so far been found even if archaeometric research together with archaeological studies suggests that several centers might have been working in this area, at least in Rome and Bolsena and perhaps in the area of Ostia (Cuomo di Caprio and Picon 2000; Morel 1990; Olcese 1998, 2009; Olcese and Capelli 2011; Olcese and Coletti 2017).

In the present state of knowledge, the Campanian area seems to have been the one that exported its products on the largest scale, first with Campanian A, as from the end of the 3rd century B.C.E., and later with the manufacture of Black Gloss pottery at the workshop/s of Cales. Furthermore, it has been demonstrated that Pompeii also produced Black Gloss from the 4th to the 1st centuries B.C.E., probably for local consumption (Schneider et al. 2010; Scarpelli et al. 2014). One of the first studies in this area focused on the nature of the glosses at Cales (Maggetti et al. 1981; Picon 1988), highlighting the differences between "ancient" and "recent" pastes of Black Gloss pottery (from less to more calcium content), and differences in the paste prepared for terra sigillata and Black Gloss pottery at this workshop. The identification of these three different pastes was in line with the differences observed in the chemical composition between their glosses. The authors also remarked on the contrast in chemical composition between the glosses and the sherd matrix, pointing out that CaO is almost absent in the gloss, but is prominent in the content of the body. Finally, technology for their production similar to that used for Attic Black Gloss pottery has been indicated. The most important research was carried out by Morel and Picon (1994), who, besides Campanian A and Campanian B-oid from Cales, also created the reference groups for the Black Gloss pottery probably produced in the Latium area, Campanian B called "type B from Cosa" (although it was never produced in Cosa), and Campanian C from Morgantina (Sicily). More recently, studies on clay samples of different geological origin within the Campania region of Italy to determine possible sources of raw materials used to produce ancient pottery have been conducted (De Bonis et al. 2013).

Other studies worth mentioning are those mainly concentrating on consumption centers, most of them also undertaken in the Italian Peninsula (Fig. 2). Studies on ceramics from Southern Italy have focused on Attic pottery found in Locri Epizephiri (Barra Bagnasco et al. 1981; Mirti et al. 1995) and *Brutium*, Calabria (Preacco Ancona, 1998, Mirti et al., 1998). Research on Calabria demonstrated that regional workshops started imitating Campanian A, B, and C, which arrived from different areas of the Italian Peninsula as well as from Sicily (Mirti et al. 1995, 1998; Preacco Ancona 1998). Analysis also indicated that imports and regional products were in use in Calabria during the 2nd century B.C.E. (Mirti and Davit 2001, 2004).

Regarding Etruria, besides the already-mentioned study carried out by Gliozzo and Memmi Turbante (2004), in which trade routes of Black Gloss products from Etruria and Campania into Etruria are proposed, Tarquinia and Cosa have also been the subject of archaeometric studies (Cuomo di Caprio and Picon 2000). In the case of Cosa, a still ongoing archaeometric program was set up by the University of Barcelona in the framework of a wider project to shed light on the provenance, production technology, and exchange structures of the pottery found in the Roman colony (Roca et al. 2013). The initial stage, which focused on a preliminary assemblage of 13 pieces of Black Gloss ware, offered a complex view, especially taking into account the small sample considered (Madrid and Buxeda 2013). Three different ceramic groups were identified, none of them corresponding with the so-called "type B from Cosa". These groups were related to Etruria, probably Chiusi, the Latium region, and another unknown area.

Outside the Italian Peninsula, studies incorporating archaeometric analyses are very scarce (Fig. 2). The most significant ones are those from Central Europe (Switzerland and Austria), where researchers were able to establish two circuits from which the area was supplied: Calenan Black Gloss products from the west and North Etrurian and Po Valley products from the south (Kaenel and Maggetti 1986; Kysela et al. 2013; Maggetti et al. 1986, 1998; Maggetti 2005; Maggetti and Serneels 2006). Moreover, studies conducted in France gave us a better picture of the imports into Gaul, with Black Gloss types A, B, B-oid, and C being identified (Cuomo di Caprio and Picon, 1994; Picon et al. 1971; Morel and Picon 1994).

In the case of the Iberian Peninsula, where Campanian pottery arrived in large quantities from the beginning of the 2nd century B.C.E., and abundant archaeological work has been carried out in order to classify these products typologically and chronologically (Aquilué et al. 2000; Jiménez 2000, 2002; Marín and Ribera 2001; Palencia and Rodríguez 2014; Sanmarti-Grego 1978; Sanmarti et al. 1996; Vivar 2013; Zamora 1995), almost no archaeometric research has been carried out. Only Empúries (Catalan coast) and La Loba (Andalusia) have been analyzed (Morel and Picon 1994; Picon and Thirion-Merle 2002) (Fig. 2). Based on these studies, Cales and Etruria (type B from Cosa) seem to have been the origin of the ceramics from Empúries. At La Loba, the high levels of alteration of the pottery due to the mining context make it very difficult to identify its origin. Despite this limitation, a provenance in the Campanian area and Etruria (different from type B from Cosa) was suggested. Finally, a study on productions from the island of Ibiza included six samples corresponding to Campanian or Pseudo-Campanian imitations. Those materials were produced during the 3rd century B.C.E. in Ibiza, which at that time was within the Punic sphere of influence (Buxeda and Cau 1998).

In order to contribute to improving knowledge about Black Gloss pottery, the sample includes sherds archaeologically classified as Campanian A, late Campanian A, Etrurian Black Gloss, middle Cales, and late Cales Black Gloss, and some sherds difficult to classify in any of those categories, which were considered local imitations (Table 1).

ANALYTICAL METHODS

Chemical characterization of the 56 individuals was performed by means of Wavelength Dispersive X-ray fluorescence (WDXRF) analysis. The superficial layers were mechanically removed, and the samples were milled in a tungsten carbide cell mill Spex Mixer mod. 8000. The chemical composition was determined from the powder previously dried in an oven during 12 h at 105 °C. The elements chosen are those probably found in the materials analyzed, forming part of that composition. Since we are working with pottery, and pottery is made up of clays, we chose the elements that are more likely to be found in the clays selected for making pottery (illite is one the most important for ancient pottery but also kaolinite, chlorite, and smectite). To determine the major and minor elements, two 30 mm glass bead replicates were made by mixing 0.3 g of dried sample with 5.7 g of lithium tetraborate ($Li_2B_4O_7$) flux (1/20 dilution) and 5 mg of lithium iodide (LiI) release agent. This mixture was homogenized and deposited in a 95%Pt-5%Au crucible and melted in a fully-automatic bead preparation system PANalytical Perl'X-3 at a temperature of 1125 °C. To determine trace elements pressed powder pellets were made using 6 g of specimen mixed with 2 ml of a binding agent solution of n-butyl methacrylate synthetic resin (Elvacite® 2044) in acetone at 20 % by mass. This mixture was manually homogenized in an agate mortar to dryness and placed on a base of boric acid (H_3BO_3) in an aluminum vessel of 40 mm diameter that was subjected to a pressure of 200 kN for a period of 60 s using a Herzog press. The quantification of the concentrations was performed using an Axios^{mAX}-Advanced PANalytical spectrometer with a Rh excitation source calibrated by a suite of 56 international Geological Standards. Interferences were taken into consideration and matrix effects were corrected by using the PANanalytical Pro-Trace software for trace elements. The elements determined were: Na_2O, MgO, Al_2O_3, SiO_2, P_2O_5, K_2O, CaO, TiO_2, V, Cr, MnO, Fe_2O_3 (as total Fe), Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Nb, Mo, Sn, Ba, Ce, W, Pb, and Th. Major and minor elements are expressed as concentrations of oxides in percentage by mass (also referred to as wt %). Trace elements are expressed as concentrations of elements in µg g^{-1} (or ppm —parts per million). Loss on ignition (LOI) was determined by firing 0.3 g of dried specimen at 950 °C during 3 h. Calcinations were carried out in a Heraeus muffle model M-110, by using a heating rate of 3.4 °C min^{-1} and free cooling. Thus, the sum of major, minor, trace element concentrations, and LOI, is located within a range of 98—102 % (Table 2). Although some of the minor (and even major ones like phosphor) and trace elements can be subjected to a regional contamination, much research has been done in the field of alteration and contamination processes on ceramics (Picon 1976, Lemoine and Picon, 1982; Picon and Ricq 1986; Picon 1987, 1991; Buxeda and Cau, 1995; Buxeda, 1999; Schwedt et al 2006, Zacharias et al. 2007, among others). Thanks to those works, the alteration process of some of the most alterable major/minor/trace elements are well-known and can be detectable. Thus, the concentrations of Mo and Sn were discarded because of analytical imprecisions, as were those of Co and W because of the possible contamination from the tungsten carbide cell mill that was used. Similarly, in the present case, P_2O_5 and Pb concentrations were not used in the statistical data treatment because some values were considered erratic and a few individuals were pushed out of their group. Such values can be due to contaminations during burial, for example, in the case of P_2O_5 from organic matter (Buxeda 1999), and in the case of Pb from metallic objects. A detailed description of the method, as well as precision and accuracy, has already been published (Hein et al. 2002).

Mineralogical characterization of all individuals was performed by means of X-ray diffraction (XRD). The previously prepared powder specimens were manually side-loaded and pressed with frosted glass in a cylindrical sample holder of 27 mm diameter and 2.5 mm in height (PW 1811/27). Measurements were made using a Bragg-Brentano geometry diffractometer PANalytical X'Pert PRO MPD Alpha-1 (radius = 240 mm) using the Ni-filtered Cu Kα radiation (λ = 1.5418 Å) at a working power of 45 kV and 40 mA, equipped with an X'Celerator detector (active length = 2.122°). Measurements were taken from (5 to 80)°2θ with a 0.026° step size and an acquisition time of 50 s, spinning the sample at 1 Hz. Evaluations of the crystalline phases present in each specimen analyzed were performed by using the PANalytical X´Pert HighScore Plus software package that includes the database of the International Centre for Diffraction Data–Joint Committee of Powder Diffraction Standards, 2006 (ICDD–JCPDS).

Finally, in a multiphase sampling strategy, a subsample of the individuals previously analyzed were sampled for their study under the scanning electron microscopy (SEM), according to the stratification revealed by XRF and XRD analysis in terms of meaningful compositional groups and mineralogical fabrics (Buxeda and Madrid 2016). This subsample is composed of 24 individuals that will be indicated in the technical section below. SEM observations were performed on fresh cross-section fractures passing through the oro-aboral axis of the body wall in order to observe the microstructure, to estimate the degree of sintering and the vitrification state of the matrix, and to enable microanalysis of interesting features. Bulk specimens were fixed on metal specimen stubs using silicone adhesive and the non-conductive ceramic specimens were made conductive. Colloidal silver paint was applied on excess silicone adhesive and lateral sides of ceramic bulk specimen. Then, the specimen surface was coated with a thin carbon film (~ 10 nm) by vacuum evaporation. The observations were made by using a JEOL JSM-6510 in high vacuum conditions. Microanalyses were carried out with an Energy-Dispersive X-Ray spectrometer (EDS) INCA 250 (Oxford Instruments). The observations were performed using an acceleration voltage of 20 kV and a working distance of 15 mm.

CHEMICAL RESULTS

Following Buxeda's developments (Buxeda 1999, 2008; Madrid and Buxeda 2014, 103-104 and references therein), the results of chemical analysis by XRF correspond to a special case, the d+1-dimensional vector space that arises from the *d*-dimensional projective space, the simplex S^d, in which the projective points are represented by homogeneous coordinates with a constant sum k ($k \in R^+$) (R^+: the set of positive real numbers):

$$\mathbf{x} = [x_1, ..., x_{d+1}] \mid x_i \geqslant 0 \; (i = 1, ..., d + 1), \; x_1 + ... + x_{d+1} = k$$

(in this case $k = 100$), and its vector space is the positive orthant, which follows a multiplicative model with a logarithmic intervals metric. Therefore, the original chemical data $\mathbf{x}$ have been transformed using the centered log-ratio transformation (CLR):

$$\mathbf{x} \in \mathbb{S}^d \rightarrow \mathbf{z} = \ln\left(\frac{\mathbf{x}}{\mathrm{g}(\mathbf{x})}\right) \in \mathbb{R}^{d+1}$$

where $\mathbb{S}^d$ is the d-dimensional simplex; $\mathrm{g}(\mathbf{x})$ is the geometric mean of all the d+1 components of $\mathbf{x}$; or the additive log-ratio transformation (alr):

$$\mathbf{x} \in \mathbb{S}^d \rightarrow \mathbf{y} = \ln\left(\frac{\mathbf{x}_d}{x_{d+1}}\right) \in \mathbb{R}_+^d$$

where $\mathbb{S}^d$ is the d-dimensional simplex and $\mathbf{x}_d = [x_1,...,x_d]$. Finally, the isometric log-ratio transformation (ilr) is an isometry in $\mathbb{R}^d$ using an orthonormal basis. The transformation allows a Euclidean space to be obtained, removing the restriction to the constant sum k and avoiding the effects of possible contaminations, in which any standard statistical technique can be applied.

The statistical data treatment of the chemical data was performed on the retained values using R (R Core Team 2014), and the first step was to measure the existing variability in the data set. This variability is the result of how different the chemical data are, and how evenly the chemical differences are related to the retained components (Aitchison 1986). In this case, the total variation is high (vt = 2.26), pointing to a polygenic set (Buxeda and Kilikoglou 2003). The compositional evenness is then measured according to information entropy (H_2), also known as the Shannon index (Shannon 1948), on the $\tau_{.i}$ values in decreasing order (Buxeda and Madrid 2016). The compositional evenness plot (Fig. 3) reveals that most of the variability is linked to the relative concentrations of Cr, Na_2O, Ni, CaO and Nb (for those components, $vt/\tau_{.i} > 0.6$). Information entropy is over 80 % of the total attainable value (H_2 % = 82.42), pointing to a chemical variability linked to a high number of components. Both total variation and evenness are thus indicators of the structure of the data set.

The study of the dendrogram, as a second step of exploring data, shows a structure clearly divided in two meaningful ceramic groups, plus three ungrouped individuals (Fig. 4). The first meaningful ceramic group corresponds to what is known as Campanian A -including the only piece archaeologically classified as late Campanian A- a fine ware made from low calcareous clays (m, 3.84; sd, 0.65, see table 3). It is composed by 12 individuals, archaeologically classified as Campanian A. The three individuals (CBN029, MTR001 and MTR002) that remain ungrouped suggest an origin certainly different from Campanian A, but also different from those individuals grouped on the right side of the graph, within a large group related to the Calenan workshops. In this case, the most interesting result is that among the 41 sherds, part of them had been archaeologically classified as middle Cales, others as late Cales, and a small group as Etrurian ceramics. As discussed above, those different terms involve the assumption of different chronologies and in the case of the Etrurian products, a different place of production. However, according to the archaeometric results, all of them were convincingly made with the same clays, and most likely in the workshops of Cales.

Those results can be compared with the covariance and form biplots (Fig. 5) resulting from the singular value decomposition of the CLR transformed data (Aitchison and Greenacre 2002; Greenacre 2010; van de Boogaart and Tolosana-Delgado 2013). Besides, the relationships between the individuals and the transformed retained components are clearly reflected in those biplots. The resulting covariance and form biplots of the first two principal components explain almost 100 % of the variance (VE = 96.17 %). This is because of the huge compositional differences between Campanian A, spotted on the left of both graphs, and the products from Cales, placed on the right side of the graphs. The components most involved in this discrimination are the same ones revealed in the compositional evenness plot of figure 6: Cr, Na_2O, Ni, CaO, and Nb.

Without taking into consideration either Campanian A or the ungrouped individuals, a new treatment focusing on the products identified as Cales was carried out. The goals were: 1) to explore the possibility of there being two different groups related to the two archaeological classifications of middle Cales and late Cales; 2) in the case that different groups could be identified, to compare them with those published by Picon and other scholars (Magetti et al. 1981; Morel and Picon 1994; Picon 1988). If this hypothesis is proved, we could relate the different meaningful ceramic groups provided by the archaeometric analyses with the typologies and chronologies provided by archaeological studies. A new compositional evenness plot (Fig. 6) reveals that variability is very low (vt = 0.1), a characteristic of a monogenetic sample; most of the variability is linked now to the relative concentrations of CaO and Ba, (for those components, $vt/\tau_{.i} > 0.7$). The result of a new cluster analysis can be seen in the dendrogram of figure 7, where an unexpected structure divided in three meaningful ceramic groups can be observed. This structure is clearly related to the CaO content of these three subgroups, increasing from the left to the right.

The first group, Cales-1 is the least calcareous one, and comprises just individuals coming from the earliest archaeological context in our sample, Can Mateu, a phase of settlement in *Ilduro* most likely datable to the last quarter of the 2nd century B.C.E. and certainly prior to 80/70 B.C.E. Archaeologically, all the samples were classified as middle Cales, and forms Lamb. 2 and Lamb. 5 were recognized, the latter being the more common one. The next group, Cales-2, is made of 23 individuals, all recovered from the filling of a pit in Can Benet and dated around 80 B.C.E., except one coming from *Iluro*, which can be dated around 80/70 B.C.E. Archaeologically, 16 of the individuals were classified as middle Cales, three as Etrurian and four as late Cales. Forms Lamb. 1, Lamb. 4, Lamb. 5, Lamb. 8, and Lamb. 10 were identified. Finally, the Cales-3 group comprises seven pieces, all of them from *Iluro* except one from Can Benet. Archaeologically, three of these sherds were classified as late Cales, two as middle Cales, and the other two as uncertain Cales products since the archaeologists were unable to decide whether the sherds belonged to middle or late Cales. Forms Lamb. 1 and Lamb. 5 were distinguished.

The consistency of the groups defined has been further explored through linear discriminant analysis performed on ilr transformed balances (Egozcue and Pawlowsky-Glahn 2005) using the three groups defined, and the first two linear discriminants are plotted (Fig. 8). This plot explains 100 % of the total variation in the 36 grouped individuals. As can be seen, the three groups can be clearly discriminated, confirming the results of the previous treatment. Regarding the ungrouped individuals, except one, the other four could be considered as outliers of Cales, located between the groups Cales 2 and Cales 3, indicating great compositional similarities.

In earlier works studying Black Gloss pottery, two different pastes related to Cales were identified: one called "ancient" (CaO = 9.54 ± 1.39), and another labelled "recent", which must have been related to the sigillata made in Cales, with a higher CaO content (CaO = 13.09 ± 1.35) (Magetti et al. 1981, 199-200; Picon 1988, 222). Subsequently, Morel and Picon (1994) in an analytical study of Etrurian and Campanian pottery gave only one reference group for Cales, the values of which can be placed between the "ancient" and the "recent" ones named above. Comparing these data with our results (Table 3), our Cales-1 agrees with the "ancient" group; Cales-2 reflects Morel and Picon's group, even if some discrepancies were observed, especially regarding some trace elements such as Rb, Sr, and Ba; and Cales-3 matches well with the group labelled as "recent".

Those chemical results explained above were compared with the results obtained from the study of the Black Gloss samples found at the Roman colony of Cosa, where Black Gloss ware was widely distributed from the 3rd to the 1st centuries B.C.E. One of the strata from this site enabled us to recover almost 200 Black Gloss sherds, most of them dated between the 2nd and the 1st century B.C.E., coinciding with the same period that Black Gloss reached the sites analyzed in this study (Madrid and Buxeda 2013; Roca et al. 2013). As shown in the dendrogram (Fig. 9), the 41 sherds from Cales[4] form a homogeneous group,

[4] Campanian A was not considered since none of the individuals analyzed from Cosa belongs to that category of pottery

while individuals MTR001 and MTR002 remain ungrouped. In contrast, the individual CBN029 now joins a small group of samples for which there is no doubt that an origin in the Etrurian area should be suggested.

The obvious disagreement between the archaeological and the archaeometric results (Table 4, Fig. 10) arises because, as seen above, the archaeological classification is carried out on the grounds of the visual appearance of the samples: the thickness of the gloss and its color and the matrix color and texture. As discussed in greater detail below, all those features are the result of a technical procedure starting with the clays that will be used to produce the paste, forming, the application of a layer that becomes a gloss after a single firing, and finally firing. This process entails different degrees of complexity depending on the intended final product; some variances in the process must have resulted in visually different final products.

MINERALOGICAL AND MICROSTRUCTURAL CHARACTERIZATION

Chemical results show that the individuals analyzed correspond to ceramics technically considered as low calcareous (CaO < 5 %-6 %) and calcareous (CaO > 5 %-6 %). In terms of phase transformations –i.e. decomposition of primary phases and crystallization of firing ones–, and densification during firing –through sintering and, possibly, vitrification– inducing microstructural changes (Maggetti 1981; Maniatis and Tite 1981; Maniatis et al. 1981; Tite et al. 1982; Heimann and Maggetti 2014), low calcareous ceramics develop less high-temperature phases than calcareous pottery and a denser microstructure with a quick formation of a vitreous phase. As is shown in the triangle ceramic phase diagram $CaO(+Fe_2O_3+MgO)$-$SiO_2+Al_2O_3$ (Fig. 11), the Campanian A group is placed in the limit of the anorthite-mullite-quartz and quartz-anorthite-wollastonite thermodynamic equilibrium triangles due to its low calcareous character, the individuals from Cales together with the Etrurian sample and the two ungrouped individuals being placed in the quartz-anorthite-wollastonite triangle, a characteristic of calcareous ceramics.

During the firing process, ceramics undergo mineralogical phase transformations and densification of the microstructure depending on their composition (at the atomic, mineralogical, and petrological level) (Buxeda and Madrid 2016), firing temperature, the duration of firing, and the firing atmosphere (Heimann and Maggetti 2014). From those variables, only the composition can be partially determined. Firing temperature and firing atmosphere can only be tentatively estimated after the evaluation of the possible changes undergone for a given composition. However, there is no way to estimate, for ancient pottery, the duration of firing and, because of that, only the equivalent firing temperature (EFT) can be estimated (Roberts 1963). The knowledge derived from experiments on ceramics and clays of similar composition provides complementary information of the general trend of changes undergone by different types of pottery under different firing conditions (Maggetti 1981, 1982; Maniatis and Tite 1978; Maniatis et al. 1981, 1983; Buxeda 1999; Buxeda et al. 2002; Tsantini et al. 2004; Madrid 2006; Heimann and Maggetti 2014).

Accordingly, mineralogical and microstructural characterization will be explained together based on the chemical results.

Campanian A

The study of the XRD diffractograms of the 12 individuals of Campanian A (ILR001, 3, 11, 12 and 13; CMT001 and 7; CBN013, 14, 16, 18 and 19) allowed the identification of four fabrics[5] (F1 to F4), i.e. different categories of association of crystalline phases (Table 5). The four fabrics present alkali feldspar, plagioclase, quartz, and hematite, but just the first two (F1: CMT001, F2: ILR003, 11 and 13; CMT007, CBN013, 14, 16, and 18) show illite-muscovite and intense peaks of analcime, a sodium zeolite (Fig. 12, A and B). Analcime has usually been observed as a secondary phase for non-severe overfired calcareous pottery (temperatures above 950/1000 ºC <1050 ºC; over 1050 ºC calcareous pottery is severely overfired, close to collapse), as will be outlined below (Buxeda 1999; Schwedt et al. 2006). In the present case, however, due to the low calcareous pottery and the intense illite-muscovite peaks, analcime should most

[5] Fabric is the final product of a paste after firing. In this respect, a paste can end in more than one different fabric (Buxeda and Madrid 2016, 36)

likely be assigned to a primary phase and therefore related to the area from where the clays used to make this pottery were extracted, reinforcing their origin in Naples. In firing experiments conducted on "A production" pottery, whose proposed origin is in the area of the Bay of Naples because of the presence of volcanic glass from Mount Vesuvius in the paste, analcime decomposed below 800 °C (Madrid 2006, 216-219). However, the study by SEM helps us to observe differences between individuals of F1 and F2. In the case of the former, the microstructure corresponds to the sintering stage of initial vitrification (IV), (Fig. 14, A) in agreement with an EFT below 800 °C, but, in the case of F2, layers of smooth surfaced areas are already visible indicating a sintering stage of initial-extensive vitrification (IV-V) (Fig. 14, C). This agrees with the lowest intensity in the peaks of analcime and with the almost complete decomposition of illite-muscovite, which preserves only one visible peak (Fig. 12, B). In these circumstances and taking into account that these ceramics underwent a reducing stage, an EFT of about 800 ºC must be estimated. For its part, fabric F3 (ILR012) still shows one peak of illite-muscovite (Fig. 12, C), but in this case, analcime has disappeared completely. The study by SEM indicates a sintering stage of extensive vitrification with wider layers of smooth surfaced areas (Fig. 14, E). All this evidence together enables us to estimate an EFT in the range 900-950 °C. Finally, illite-muscovite completely disappears in the diffractogram of fabric F4 (ILR001, CBN019) (Fig. 12, D). In this case and in agreement with SEM observations that show a total vitirification (TV) stage of the matrix, an EFT >950 ºC /1000 ºC can be estimated (Fig. 14, G). Regarding the glosses (Table 6), they exhibit thicknesses between 10 and 20 µm and good adherence to the matrix. The glosses of F1 and F2 show a laminar aspect and many unmelted inclusions, most of them iron oxide particles, because of incomplete vitrification (Fig. 14, B, D). On the other hand, glosses of F3 and F4 exhibit a total vitrification stage even if some very small particles are still visible (Fig. 14, F, H).

Cales

Cales 1

Cales 1 (CMT003, 4, 5, 6, 8, and 9) is the least calcareous subgroup of Cales wares identified in this study and, in accordance with the archaeological context, the oldest of the three Calenan groups recorded at *Ilduro*. The mineralogical analyses of the diffractograms allowed us to identify three fabrics representing three different EFT (Table 5): F1 (CMT003, 4 and 9) exhibits alkali feldspar, plagioclase, quartz, hematite, calcite, pyroxene, and illite-muscovite. Diffractograms of fabric F2 (CMT005 and 6) and F3 (CMT008) exhibit the same mineral phases except for illite-muscovite, which is almost decomposed for F2 and totally decomposed for F3, in this latter case together with the total dissociation of calcite. The two mineral phases that can provide evidence about the EFT are pyroxene and hematite. Both can be a primary phase, but when not, they can crystallize above 800 °C or 850 °C. However, in our case, since hematite and pyroxene are observed in all individuals without differences in their peaks, their presence fails to provide indications to estimate the EFT. Therefore, the only useful mineralogical evidence is the existence of illite-muscovite, which is usually present in EFT up to 950 °C-1000 °C clearly pointing to an EFT below this range in the case of F1, around 950 – 1000 °C for F2, and in excess of 950 °C-1000 °C for F3. However, the microstructural study of F1 shows a sintering stage of initial vitrification (IV), with some areas where layers of smooth surfaces are visible (Fig.14, I), enabling an EFT around 850 °C to be specified. In the case of F2 and F3, not many differences between their bodies can be observed, corresponding both with an initial/extensive vitrification (IV/V), less vitrified stage than expected when illite-muscovite is totally decomposed (Fig.14, K). We think that this disagreement between SEM observations and XRD is the result of reducing conditions in firing, which accelerate decomposition of primary mineral phases and the formation of the sintering/vitrification stage. Thus, the EFT should be estimated in both cases in the 900-950 ºC range, in accordance with SEM observations and with the development of phases in reducing conditions (Maniatis et al. 1983). Regarding the glosses (Table 6), they exhibit thicknesses between 8 and 10 µm (Fig. 14, J and L), and characteristics from F2 (Fig.14, L), well vitrified with almost non-visible inclusions or porosity and a good adherence to the matrix, which leads us to propose an EFT in the range of 900-950 ºC to have been intended by the potters. In this respect, products from F1 (Fig. 14, J) show that the temperature is still not high enough for the vitrification of the gloss, whereas products from F3 show a melted gloss with gas bubbles, being probably at the upper limit of the proposed range of EFT. This gloss is ultimately too thin and reveals the matrix.

Cales 2

This group, for which a more recent arrival date than Cales 1 can be supposed based on the archaeological data, is made with a more calcareous paste although the use of a similar EFT sometimes results in a comparable final product difficult to differentiate with the naked eye (Fig. 10). In this case, mineralogical study by XRD allowed us to identify three different fabrics (Table 5): F1 (CBN002, 4, 5, 6, 21 and 24), F2 (CBN001, 3, 7, 9, 11, 15, 23, 26 and 30), F3 (CBN008, 10, 12, 25, 27, 28, 31 and ILR004). Most of the individuals are included in F2 and F3, suggesting a greater control of the production process by the potters. F1 exhibits alkali feldspar, plagioclase, quartz, hematite, calcite, illite-muscovite, and pyroxene (Fig. 13, A). As in the case of Cales 1, hematite and pyroxene might be primary phases not allowing an EFT to be estimated. For its part, F2 shows a reduction in the peaks of calcite and the identification of gehlenite, a firing phase that crystallizes above 850 °C - 900 ºC (Fig.13, B). Finally, F3 shows the total decomposition of illite-muscovite (Fig.13, C), which in reducing conditions would indicate an EFT about 950 ºC. Additionally, study by SEM shows an IV/V sintering stage for F1 (Fig.15, A), enabling us to specify an EFT in the range of 800 °C - 850 °C. In the case of F2 the higher EFT estimated by XRD agrees with a V sintering stage, the same observed for F3 (Fig.15, C), even though a developed stage of vitrification would be expected since illite-muscovite is, in this case, totally decomposed. However, as we have seen in the previous case, the reducing conditions accelerate the process of decomposition of the primary phases and development of new firing phases and the sintering stage. For this reason, the EFT must be estimated in the 900-950 ºC range. Regarding the glosses (Table 6), they exhibit greater thickness than Cales 1, around 15 μm, and a good adherence to the matrix (Fig.15 B and D), providing a total vitrification gloss and fulfilling its main performance characteristic, waterproofing the pottery. Those glosses corresponding to F1 display many still unmelted iron oxide particles. As the temperature increases, the particles disappear. When the temperature is high, the result is a shiny gloss than can be confused with Etrurian products, as happened with CBN010 (Fig. 10) by the archaeologist who classified the products analyzed in this article. More difficult to explain is the confusion of CBN015, which presents the typical middle Cales appearance (Fig.10). On the other hand, the poor preservation of the gloss that occurred in CBN026 (Fig. 10), probably because the EFT is lower than the previous ones preventing a good adherence to the matrix, led to confusion in its classification by archaeologists as late Cales. In accordance with those observations, we suggest that an EFT in the range 900 ºC - 950 ºC would be the intended temperature for Cales 2, similar to Cales 1.

Cales 3

Cales 3 is the most calcareous group related to Cales identified in this study. In this case, the mineralogical analysis allowed two fabrics (Table 5): F1 (ILR007), F2 (ILR002, 5, 6, 8, 10 and CBN022) to be identified. The diffractogram of the only individual for F1 exhibits alkali feldspar, plagioclase, quartz, hematite, calcite, illite-muscovite, emerging peaks of pyroxene, and gehlenite; the EFT can be estimated in the range of 850 °C –900 °C. However, for most of the individuals an EFT in the 900 °C – 950 °C range can be proposed because of the total decomposition of illite-muscovite and gehlenite and the increasing intensity of the peaks of pyroxene. Observation of the microstructure shows extensive vitrification in agreement with XRD observations (Fig. 15, E and G). The CaO content compared with Cales 1 and Cales 2 provides a pale brown color to the paste. This fact together with an irregular thickness of the gloss (Table 6), which varies from 5 μm to 20 μm (Fig. 15, F and H), enables these wares to be identified by archaeologists with the naked eye as late Cales. However, in those cases where the gloss was as thick as 20 μm and exhibited a good quality appearance, the classification of the vases was harder for the archaeologist; such as the case of ILR006 (Fig. 15, E and F), which was classified as Cales with reservations.

Etrurian Black Gloss

With regard to the only Etrurian individual identified in this study, CBN029 (Table 5), the diffractogram presents alkali feldspar, plagioclase, quartz, hematite, calcite, pyroxene, and low intensity peaks of illite-muscovite, enabling us to estimate an EFT in the range of 850 ° C - 950 °C, developing an initial/extensive vitrification microstructure (Fig. 15, I). The gloss (Table 6) exhibits thicknesses between 10 - 15 µm, many inclusions, most of them corresponding to iron oxide particles, and shows a regular adherence to the matrix (Fig. 15, J). The final product is good quality pottery displaying a shiny black gloss even if the gloss is not preserved in some areas. That may be the result of a thinner gloss than intended together with poor adherence to the matrix. Probably because of that, this sherd was archaeologically classified as middle Cales.

Ungrouped

On the other hand, the ungrouped individuals MTR001 and MTR002 are different to the rest of the sherds analyzed in this study as well as different from each other. The only resemblance is the grey color of the paste and the gloss, very poorly preserved, of both samples. If we look into their mineralogical composition (Table 5), MTR001 presents illite-muscovite, quartz, alkali feldspar, and an intense peak of calcite. No firing phases are present, which would indicate an EFT below 800 °C in agreement with the microstructure which shows a no vitrification (NV) sintering stage and a gloss which still presents some particles because of incomplete vitrification (Fig. 15, K). In contrast, individual MTR002 does not show evidence of illite-muscovite, and pyroxene is well developed as the firing phase and its microstructure reveal an extensive vitrification (V) stage. Besides, examining the gloss (Table 6) reveals that the high temperature led to the formation of bloating pores, a sign of reduction at temperatures above 950 ºC, when the dissociation of Fe-oxides in the gloss layer occurs (Fig. 15, L). Moreover, it presents intense peaks of analcime, which should be considered as secondary phase since this individual is highly fired and analcime is a zeolite with water in its composition. That means that in this case, analcime is not related to a volcanic area such as the case of Campanian A, but just the evidence of a ceramic that underwent a process of alteration and contamination during burial.

CONCLUSION

Thanks to the combination of the archaeological and archaeometric research, four meaningful ceramic groups have been identified: Campanian A, Cales 1, 2, and 3. The one labelled as Campanian A, which is a homogeneous group, matches the archaeological classification. This ware can be defined as having a low calcareous paste, which gives this pottery its characteristic red-color paste. The thickness of the gloss is around 10/15 µm, not completely vitrified but showing good adherence to the matrix. That means that the gloss would not be waterproof, thus failing to achieve the main quality required. However, the good adherence to the matrix may compensate for this manufacturing defect. The three groups from Cales can mainly be differentiated on the basis of their CaO content and defined as calcareous. Cales 1 shows the lowest concentration of CaO, and Cales 3 the highest. The differences observed with regard to the EFT and the features of the glosses are directly related to the archaeological classification made by the archaeologists. Thus, archaeologists have always classified Cales 1 as middle Cales. Cales 2 is the most homogeneous group from a chemical, mineralogical, and microstructural perspective, including the thickness of the gloss. However, smaller variations in the production process lead to what are seen as heterogeneous products by the human eye, since the macroscopic classification performed by archaeologists divides this group between middle Cales, late Cales, and in a few cases Etrurian. Finally, Cales 3, the most recent of the three subgroups, is chemically and mineralogical homogeneous but, once again, heterogeneous at a macroscopic level due to the variations in the thickness of the gloss. Probably for this reason it was classified by archaeologists as middle Cales, when the gloss is thicker, and late, when the gloss is thinner.

Based on the archaeological context of the sample, it has been possible to connect these groups with three different chronological periods. Cales 1 can be associated with the oldest archaeological contexts of the sample analyzed (Can Mateu 125-prior to 80 B.C.E.). Cales 2 would correspond to an intermediate moment, in accordance with the chronology provided by the context of Can Benet (*c.*80 B.C.E.) and would also have reached the Late Republican settlement abundantly during the last years prior to its abandonment, but *Iluro* hardly at all, as it was supplied by Cales 3. Finally, Cales 3 is the most recent of the three groups and, as has already been mentioned, it can possibly be linked with the earliest context of *Iluro* (80/70 B.C.E.). This new proposal of periodization in three different stages for what archaeologists have labelled in the past as middle and late Cales Black Gloss pottery is essential to provide more accurate chronologies to those contexts and structures in which Black Gloss pottery is found. Of course, the exact chronology of each of these three different periods must be refined with future analyses and the existence of other subgroups cannot be discarded. That said, on the basis of the chemical analysis results, their existence is beyond doubt. Greater precision in chronologies will help to improve historical and archaeological interpretations leading to a better understanding of Western Mediterranean cultural history during the 2nd and early 1st centuries B.C.E., a period in which multiple changes occurred constantly and rapidly. Regarding the provenance, two main groups can be seen: Campanian A and Cales. All our samples therefore came from the same region in Italy, Campania, except one from Etruria, and the two grey ones for which no provenance can be assigned for the time being.

Even though it is not the main goal of this article to analyze the trade routes that supplied Black Gloss pottery products in depth, our results, as well as the results of the scholarly publications discussed above, lead one to suggest that the Black Gloss pottery produced in the Campanian area was mostly made to be exported overseas, more specifically, with the intention of supplying the Western Roman provinces. Moreover, it seems feasible that a regional network of workshops located in Etruria and the Po valley could have supplied the north of Italy and Central Europe, especially Switzerland. When the Black Gloss pottery produced in the Campanian territories reached these areas, it was usually as a consequence of a previous overseas exportation, arriving first on the coast of southern France and, from there, redistributed inland. As has been previously suggested, it seems that at least two main circuits can be traced for these two products (Cales and Etrurian): one in which pottery from Cales reached the Mediterranean shores of Hispania and Gaul and from there as far as Bavaria, and another, Etrurian ceramics, in which the vessels were taken across the Alps and supplied the regions of Central Europe. A further argument to reinforce this hypothesis can be obtained from the comparison of the provenance of our Black Gloss pottery with those ceramics analyzed at the Roman colony of Cosa. As demonstrated above, *Ilduro* and *Iluro* were supplied by sea almost exclusively with pottery from Cales, while Cosa seems to have received most of its Black Gloss pottery from workshops located in the Etrurian territories and therefore was most likely to have been using regional networks such as land routes, rivers, and cabotage sailing.

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