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Reconstructing production technology and distribution, using thin section petrography: A pilot study of Roman pottery production in the Pontine region, Central Italy

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ABSTRACT

This paper explores aspects of production and distribution of local Roman pottery from the Pontine region, Central Italy, based on ceramics recovered in surveys carried out within the 'Minor Centres' project. The aim of this project was to investigate the role of minor centres in local economies of Roman Central Italy. Ceramic fabrics from waster pottery, recovered from three such centres and one rural site, were studied in thin section, and compared with pottery from consumption sites in the area. This study was complemented by clay prospection, which was carried out with the aim to identify potential clay sources used for Roman pottery production. The results show that the local pottery at each site is characterised by a unique compositional signature, and demonstrate that potters in the Pontine region exploited local raw materials. Furthermore, the results indicate that local products were distributed within a radius of 25 km, and that the 'Roman' traditions of paste preparation, as identified in this study, appear to result from long-lived traditions of paste preparation techniques.

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1. Introduction

The Groningen Institute of Archaeology (GIA) has conducted archaeological fieldwork in the Pontine region, Central Italy, since the 1970's, when it was a partner in the excavation at Satricum (Fig. 1). Since the 1980's, the GIA extended its research with field surveys, site mappings and geo-archaeological examinations within the context of the Pontine Region Project (Attema, 1993; Attema et al., 2010; Attema et al., 2011). Ceramic analysis played an important role from the start. Petrographic analysis on pottery from Satricum and from surveys around Lanuvium, Setia and Signia provided valuable insights into regional pottery traditions between the Bronze Age and the Republican era (Attema et al., 2001/2). From 2001 onwards, the project focused on the coastal area between Antium and the Astura River, and examined pottery production sites, including the Roman villa of Le Grottacce (Attema et al., 2003; De Haas et al., 2008; Tol and De Haas, 2013).

In the current phase of the project, research focuses on Roman minor centres in the framework of the 'Fora, stationes and sanctuaries: the role of minor centres in the economy of Roman Central Italy' project (henceforth Minor Centres project). The term 'minor centres' encompasses

different types of sites, which served as central places for administrative tasks, religious functions, craft production and exchange (Tol et al., 2014). The project aims to assess their role within local and regional economies, and combines geophysical prospection and field survey with extensive ceramic studies. This integrated approach specifically aimed to highlight the productive functions of such sites.

The results indicate that Roman pottery production took place at four locations. Three sites are located in the lower Pontine plain, including Forum Appii, Ad Medias and site 12317, whereas site 11232 is situated on the coast (Fig. 1). The production activity at the sites has been dated between the late Republican and early Imperial periods (see Tol and Borgers, 2016 for a discussion of the evidence).

A further objective of the project is to understand the technology of Roman pottery production in more detail, and to gain insight in the regional distribution of the local products. To this aim, a programme of thin section analysis was carried out on waster products from the four sites and on similar pottery from various consumption sites. This study was complemented by a clay sourcing campaign, which was carried out with the aim to identify raw materials that may have been used for Roman pottery production.

This paper presents the results of the petrographic analysis. Section 2 introduces the archaeological sites and samples, and Section 3 focuses on the methods used. Section 4 presents the fabrics of the pottery wasters, and compares them with the raw material samples and pottery from

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Fig. 1. Map of the Pontine region, Central Italy, with its main sites, roads and rivers.

regional consumption sites. Section 5 discusses aspects of production technology and distribution of local Roman pottery in the Pontine region.

2. Archaeological sites and samples

The Pontine region is situated 60 km south of Rome. It consists of a large plain, which is bounded by the Alban Hills and the Lepine Mountains to the north and east, and by the Tyrrhenian Sea to the west. The Via Appia and Via Severiana were important roads for transport and traffic during the Roman era. The Astura River, and the Decennovium and Rio Martino canals served as waterways for transport and drainage (Fig. 1).

For this study, pottery wasters were selected from four production sites, identified during the Minor Centres project. Two sites, Forum Appii and Ad Medias, are situated on the Via Appia and the Decennovium canal. Site 11232 lies on the Via Severiana near the Tyrrhenian coast, whereas site 12317 is located on the Rio Martino canal (Fig. 1). Direct evidence for ceramic production, including pottery wasters, kiln debris, kiln structures and unused clay slabs, was identified at each of the four sites (De Haas, 2011; Tol and Borghers, 2016).

At Forum Appii, two possible areas of pottery production were identified (Fig. 2A). In the first area, geophysical survey detected five circular anomalies of c. 2 m, which were grouped in two clusters. They have been tentatively interpreted as kilns. Unfortunately, field walking could not cover this area, so it remains unclear if ceramic artefacts were manufactured here (Tol and Borghers, 2016).

In the second area, misfired fragments of tiles, cover tiles and amphorae were identified during field walking. The production activity is tentatively dated to the late Republican era (late 2nd–1st c. BCE), based on associated surface finds (Tol et al., 2014). Geophysical prospection at the site revealed the presence of three kilns various pits, which are likely to comprise waste material (Tol and Borghers, 2016).

The site of Ad Medias is covered by the Casale di Mesa, an 18th century building. Fieldwork and geophysical prospection around the building identified three areas that might be associated with pottery production (Fig. 2B). In the first area, a distinct concentration of fragments of vitrified tiles, cover tiles, amphorae and kiln debris were found during field walking. The amphora fragments include Dressel 1 handles, suggesting a late Republican date. However, geophysical prospection did not detect structural anomalies in the subsoil, and this might be taken to suggest that this place was a dump of a workshop nearby (Tol and Borghers, 2016).

The second and third areas are located to the south of the Via Appia (Fig. 2B). In the second area, geophysical prospection revealed a circular anomaly of c. 5 m, which is likely to represent a kiln. Objects recovered at the site comprise considerable quantities of metal slag and perforated ceramic fragments (Tol et al., 2014; Tol and Borghers, 2016).

In the third area, the results of the geophysical and geological surveys identified a circular anomaly of 100 m by 75 m, consisting of a

Fig. 2. Reconstruction of Forum Appii with indication of the two possible pottery production areas (A), reconstruction of Ad Medias with indication of the three possible pottery production areas (B), site 11232 with indication of the two areas with pottery wasters (C), site 12317 with indication of the anomaly (D).

series of banks and ditches. Very few surface finds were identified in association with it, so its function and date remain uncertain. Nevertheless, given that the ditches contain a compact, anthropogenic clay, it has been suggested that it may have been used for pottery production (Tol and Borgers, 2016).

At site 11232, field walking identified two areas with wasters of ceramic building material, kiln debris, unused clay slabs and large storage jars (dolía) (Fig. 2C). The production activity is tentatively dated to the early Imperial period, based on associated survey ceramics. Geophysical survey identified traces of a rectangular building and four circular anomalies, two of which have been tentatively interpreted as pottery kilns (Tol and Borgers, 2016).

That pottery production was not confined to 'minor centres' is indicated by site 12317 (De Haas, 2011, 98–99). Geophysical prospection revealed the presence of an anomaly of c. 5 m, which might represent the remains of a kiln (Fig. 2D). Finds include kiln debris and waster fragments of dolía. Based on associated surface pottery, the production activity is tentatively dated to the late Republican era (Tol and Borgers, 2016).

A total of 40 ceramic wasters were selected from the four production sites, including tiles, cover tiles, amphorae, and (storage) jars (Table 1).

They provide secure reference material for local ceramic fabrics, and their examination in thin section analysis is a unique opportunity to gain insight in local paste preparation traditions.

In addition, 49 fragments from similar shapes (i.e. tiles, cover tiles, amphorae, and (storage) jars) were selected from small Roman farmsteads, which were identified during field survey of the Minor Centres Project, with the aim to establish distribution patterns of the local products identified.

3. Analytical methods

The 89 ceramic fragments were prepared as standard 30 µm thin sections. They were analysed under the polarising light microscope at the Laboratory for Conservation and Material Studies of the GIA (www.lcm.rug.nl). The fabric grouping and petrographic description have been performed based upon the nature of the inclusions, clay matrix and voids (Quinn, 2013, 73–79). Compositional, textural and shape criteria were used to detect the presence of specific practices, such as clay mixing and the addition of different types of temper (Quinn, 2013, 156–171).

Table 1

A total of 40 pottery wasters from four pottery production sites with their respective petrographic fabrics.

Production site	Product	Petrographic fabric	Nr. of samples
Forum Appii	Tiles, cover tiles	Colluvial Fabric	10
Forum Appii	Tiles, cover tiles	Clay Mixing Fabric	14
Forum Appii	Amphorae	Fine Clay Mixing Fabric	6
Ad Medias	Tiles, cover tiles	Colluvial Fabric	2
Ad Medias	Tiles, cover tiles	Clay Mixing Fabric	1
Ad Medias	Amphorae	Fine Clay Mixing Fabric	2
Site 11232	Tiles, cover tiles, Storage jars (dolía)	Sedimentary Fabric	3
Site 11232	Tile	Augite Tempered Sedimentary Fabric	1
Site 12317	Storage jars (dolía)	Augite Tempered Colluvial Fabric	1
Total			40

In order to identify the possible raw materials used for Roman pottery production, geological prospection was carried out. Geologically, the Pontine region can be described as a large graben, filled with sediments of various origin. Relevant for the purpose of this study are a) marine, lagoonal and lacustrine sediments that form part of two marine terraces of Late Quaternary age (Borgo Ermada complex) and of Holocene age (Terracina complex) respectively, and b) Holocene fluvial and colluvial deposits, associated with the Terracina complex. In the northwest, these sediments merge with the lower slopes of the Volcano Laziale, and to the north and east, the graben is bordered by a large limestone massif (Sevink et al., 1984). Site 12317 is located on the marine terraces of the Latina level, Ad Medias is situated on the lagoonal deposits of the Borgo Ermada complex, whereas Forum Appii is located on colluvial deposits (Fig. 3).

There are two major types of clay sources in the area. First are clay deposits of marine, lagoonal and lacustrine origin. They are relatively high in swelling clay minerals (smectite), and low in free iron and volcanic minerals. Consequently, they fire to a light buff colour and tend to crack. Their sand content is low, and they mainly consist of quartz,

mica and microfossils. Second are poorly-sorted fluvial and colluvial clay loams to loams, which contain abundant volcanic material (sanidine, clinopyroxene, biotite and leucite), and their weathering products. Consequently, they are high in non-swelling clay minerals (kandite), and fire to a red colour (Sevink et al., 1984).

The term 'marine clay' is used when reference is made to the lacustrine sediments of the Terracina level and the lagoonal sediments of the Borgo Ermada complex in general (including sediments of older marine complexes), and the term 'colluvial clay' is used for both the fluvial and colluvial loam deposits.

Using a geological map of the area (Sevink et al., 1984), the clay sourcing campaign targeted specific areas around the pottery production sites, and 13 samples were collected (Fig. 3; Table 2). Loose sandy deposits that may have represented suitable tempering materials were also collected in two locations.

The clay samples were crushed, re-hydrated and formed into briquettes. They were fired in the laboratory kiln at 800 °C, and thin sectioned. All samples were studied under the polarising microscope, and compared with the ceramic thin sections.

Fig. 3. Geological map of the Pontine region (after Sevink et al., 1984), with indication of the four pottery production sites and geological samples.

Table 2

Geological samples collected and analysed in this study.

Sample	Site	Type	Description	Before firing	After firing
1	Forum Appii	Clay	Colluvial clay	Deep brown	Deep red
2	Forum Appii	Clay	Colluvial clay	Deep brown	Deep red
3	North of Forum Appii	Clay	Colluvial clay	Deep brown	Deep red
4	North of Forum Appii	Clay	Colluvial clay	Deep brown	Deep red
5	Ad Medias	Clay	Lagoonal Borgo Ermada clay	Light-coloured	Buff orange, cracked
6	Ad Medias	Clay	Vertisol in lagoonal Borgo Ermada clay	Light-coloured	Buff orange, cracked
7	Ad Medias	Clay	Mix of lacustrine Terracina clay & lagoonal Borgo Ermada clay	Light brown, homogeneous	Reddish, cracked
8	Ad Medias	Clay	Mix of lacustrine Terracina clay & lagoonal Borgo Ermada clay	Light brown, homogeneous	Reddish, cracked
9	Ad Medias	Clay	Mix of lacustrine Terracina clay & lagoonal Borgo Ermada clay	Light brown, homogeneous	Reddish, cracked
10	Ad Medias	Clay	Mix of lacustrine Terracina clay & lagoonal Borgo Ermada clay	Light brown, homogeneous	Reddish, cracked
11	Ad Medias	Clay	Mix of lacustrine Terracina clay & lagoonal Borgo Ermada clay	Light brown, homogeneous	Reddish, cracked
12	Site 11232	Clay	Unused clay slab from Pliocene marine clay	Light-coloured	Buff white
13	Site 11232	Sand	Clinopyroxene	–	–
14	Site 12317	Clay	Latina clay	Light-coloured	Deep orange, shrank
15	Site 12317	Sand	Sanidine, augite	–	–

4. Results

4.1. Pottery

Five main fabric groups were identified among the local pottery of the four production sites (Table 1). A summary of the main characteristics of

the fabric groups is given below, and the detailed fabric descriptions will be published in the final synthesis of the project.

4.1.1. Colluvial Fabric Group (Fig. 4A)

This fabric group is defined by sand-sized sanidine, augite, biotite, pumice, zeolite and weathered igneous rock inclusions (possibly

Fig. 4. Micrographs of ceramic thin sections in XP: Colluvial Fabric (A), Clay Mixing Fabric (B), Fine Clay Mixing Fabric (C), Augite Tempered Sedimentary Fabric (D), Augite Tempered Colluvial Fabric (E), Fine Clay Mixing Fabric (F). Width of individual images = 5.8 mm.

basalt), set in a red base-clay with fine feldspar and biotite. Some samples present important differences in that they comprise comparatively few coarse inclusions. This evidence might be interpreted as a more or less abundant addition of temper, as suggested by their angular shape and uniform composition in the samples. The firing atmosphere was generally oxidising, although some samples were fired in reducing atmosphere. Also, there appears to exist variability in firing temperature among the samples in this fabric group, as their optical activity varies. This fabric comprises tiles and cover tiles, and occurs at the sites of Forum Appii and Ad Medias (Table 1).

4.1.2. Clay mixing Fabric Group (Fig. 4B)

This fabric group is characterised by sand-sized sanidine, pumice, augite, and occasional weathered igneous rock inclusions (most likely basalt). The samples in this fabric group are characterised by clay mixing. The first clay is defined by sanidine, zeolite and weathered igneous rock inclusions, set in a red clay with fine biotite, whilst the second clay is light-coloured with fine quartz. The red clay appears to be similar to the clay that has been identified in the Colluvial Fabric Group, whereas the second is likely of marine origin. This fabric occurs at the sites of Forum Appii and Ad Medias, and comprises tiles and cover tiles (Table 1).

4.1.3. Fine Clay Mixing Fabric Group (Fig. 4C)

This fabric group is defined by a red clay with well-sorted fine sanidine, quartz, chert and augite inclusions. Occasionally, sand-sized zeolite and weathered igneous rock inclusions (rich in feldspar) can be identified. Heterogeneity in the clay matrix is caused by ferruginous inclusions and micrite, which has been deposited in voids. It would appear that this fabric group is characterised by clay mixing, consisting of a light-coloured clay with calcite and quartz and a red clay. The samples were generally fired in an oxidising atmosphere and at a moderate to high temperature. Some samples show evidence for over-firing near the rim. This fabric comprises amphorae, and occurs at the sites of Ad Medias and Forum Appii (Table 1).

4.1.4. Sedimentary Fabric Group

This fabric group is characterised by fine quartz and augite inclusions, set in a light-coloured clay. One sample presents important differences with the other members of the group because of its numerous sand-sized augite inclusions. Therefore, it may constitute a tempered variant of the main fabric (Fig. 4D). However, all the samples were produced with the same sedimentary clay, in which microfossils can be identified. The samples were fired in an oxidising atmosphere, and at different temperatures, given the variability in optical activity. Some samples are characterised by bloating pores in the matrix, which is suggestive of over-firing. This fabric occurs at site 11232, and comprises tiles, cover tiles and storage jars (Table 1).

4.1.5. Augite Tempered Colluvial Fabric Group (Fig. 4E)

This fabric group is defined by sand-sized augite, pumice, zeolite, and occasional chert and sanidine inclusions, set in a red-base clay with fine feldspar and biotite. The matrix is further characterised by clay pellets and iron-manganese concretions, which appear to be naturally embedded in the red clay. By contrast, augite inclusions appear to have been added, which is suggested by their quantity, size and shape. The ceramics were fired in a predominantly oxidising atmosphere and at a low temperature, as they are optically active. This fabric occurs at site 12317, and it was used for storage jars (Table 1).

4.2. Comparison with raw material samples

It has been possible to identify some of the raw materials used for pottery production at the four sites studied, based upon the ceramic fabric groups and their comparison with the geological samples. Roman potters in the Pontine region seem to have used two main types of clay deposits.

Colluvial red clay, rich in sanidine, biotite, augite, zeolite (and possibly basalt), appears to have been used for several fabric groups, such as the Colluvial Fabric Group and the Augite Tempered Colluvial Fabric Group. The Colluvial Fabric Group is the largest fabric in the assemblage, comprising local tiles and cover tiles from Forum Appii and Ad Medias. The Augite Tempered Colluvial Fabric Group occurs at site 12317, and comprises local dolia. Geological prospection in the area indicates that colluvial clay deposits occur at Forum Appii (Fig. 3; Table 2: geological samples 1–4). Variation in the mineralogy and texture of waster products from Forum Appii and Ad Medias on the one hand, and from site 12317 on the other, suggests that potters sourced this clay at different places.

Colluvial clay appears to have been used as a base-clay for two more fabrics, including the Clay Mixing Fabric Group, used for manufacturing tiles and cover tiles, and the Fine Clay Mixing Fabric Group, used for the production of amphorae at Forum Appii and Ad Medias. Variation in the texture, colour and mineralogy of the clay matrix of these two fabric groups, particularly the presence of micrite, suggests that a fine sedimentary clay of marine origin was mixed in (Fig. 4B). Ad Medias is situated on the lagoonal clay of the Borgo Ermada complex (Fig. 3; Table 2: geological sample 5), and site 12317 on the marine terraces of the Latina complex (Fig. 3; Table 2: geological sample 14). Recent, locally derived soils, including vertisols, are generally very sandy (Table 2: geological sample 6), whereas the clay from the circular anomaly at Ad Medias is comparatively homogeneous and compact (Fig. 3; Table 2: geological samples 7–11). All these clay deposits from the Borgo Ermada and Latina marine terrace complexes and their derived soils were sticky and difficult to wedge, and they cracked or shrank after firing. This evidence suggests that they were not used for the Clay Mixing Fabric Group and the Fine Clay Mixing Fabric Group.

Very fine, sedimentary clay of marine origin appears to have been used as a base-clay for the Sedimentary Fabric Group, comprising local tiles, cover tiles and dolia from site 11232. Unused clay slabs, found among the survey ceramics at the site, are characterised by a light-coloured clay with fine quartz, augite and microfossils (Fig. 3; Table 2: geological sample 12). Their composition appears to be similar to the clay used for Roman tile and amphora production at the villa of Le Grottaacce (De Haas et al., 2008), and they derive from Pliocene marine deposits, which outcrop locally (Ricq de Bouard et al., 1989).

Three out of the five petrographic fabric groups in this study appear to contain intentionally added temper. Loose deposits of poorly-sorted sand-sized grains of sanidine, biotite and augite inclusions were used for ceramic building material belonging to the Colluvial Fabric Group, and for dolia belonging to the Augite Tempered Colluvial Fabric Group. Sandy fluvio-colluvial sediments are abundant in ditches in the vicinity of Forum Appii and site 12317 (Fig. 3; Table 2: geological sample 15). These sediments probably date to the Roman era, and are connected with presumably man-made channels (Sevink et al., 1991). Also, ceramic building material belonging to the Augite Tempered Sedimentary Fabric is characterised by poorly-sorted augite inclusions. This type of grain occurs in the coastal area and near site 11232 (Fig. 3; Table 2: geological sample 13).

4.3. Comparison with pottery from consumption sites

The petrographic analysis indicates that 19 out of 49 ceramic samples from regional consumption sites are similar to the local products characterised and described in Section 4.1 (Table 3). The fabrics of the remaining 30 ceramic samples are compatible with the regional geology but do not match compositionally wasters from the sites characterised in this study.

Local tiles from Forum Appii and Ad Medias (Colluvial Fabric Group and Clay Mixing Fabric Group) were found on three rural farmsteads, whereas local amphorae (Fine Clay Mixing Fabric) were found on four Roman farms within a radius of 5 km (Fig. 5; Table 3).

Table 3

Local products identified on regional consumption sites.

Product	Petrographic fabric	Consumption site	Nr.
Tiles, cover tiles	Colluvial Fabric	Site 12317, within settlement of Ad Medias, and site 14062	3
Tiles, cover tiles	Clay Mixing Fabric	Site 14047	1
Amphorae	Fine Clay Mixing Fabric	Site 14047, site 14038, site 14044, and site 14012	4
Coarse ware (frying pan)	Fine Clay Mixing Fabric	Site 14047, within settlement and off-site near Ad Medias, site 14018	8
Tile	Augite Tempered Sedimentary Fabric	Forum Appii	1
Storage jars (dolia)	Augite Tempered Colluvial Fabric	Site 14046 and 101848 (isolated find)	2
		Total	19

It should be noted that the fabric of a frying pan, of which several fragments were found on consumption sites in the region (Tol and Borgers, 2016), appears to be similar to the fabric of the amphorae produced at Forum Appii and Ad Medias (Fine Clay Mixing Fabric; see respectively Fig. 4F and C). The variation in the colour and texture of the clay matrix suggests a compositional similarity, even if confidently matching these fine fabrics in thin section is difficult. In addition, given that most fragments were found on sites near Ad Medias suggests that this site was the most likely place of manufacture (Fig. 5; Tol and Borgers, 2016).

Local dolia from site 12317 (Augite Tempered Colluvial Fabric) were identified on two sites within a radius of 10 km, and one tile from site 11232 (Augite tempered Sedimentary Fabric), and at Forum Appii, some 25 km inland, at least one tile produced in the coastal area was identified.

5. Discussion

Based on the first results of our research on local Roman pottery production and distribution in the Pontine region, aspects of production

technology will be discussed, and distribution patterns of the local products tentatively inferred.

5.1. Technology of local pottery production

Geological fieldwork confirmed that the Pontine region provides a good setting for pottery manufacture, since a wide range of raw materials is locally available. Indeed, Roman potters sourced many of the raw materials locally, such as at Forum Appii and site 11232, or from a distance up to c. 8 km, such as at Ad Medias and site 12317 (Fig. 3).

The compositional matches between the ceramics and the geological raw materials seem to indicate that Roman potters in the region used different types of raw materials. The choice of raw materials is likely to have been determined to some extent by their availability, and suggests a good knowledge of the resources in the landscape. For instance, potters at Forum Appii and Ad Medias used red-firing colluvial clay for the manufacture of ceramic building material (Colluvial Fabric), whereas those active at site 11232 used a buff-firing marine clay, dated to the Pliocene, for their tiles and cover tiles (Sedimentary Fabric and Augite Tempered Sedimentary Fabric).

Fig. 5. Map with distribution of local fabrics in the Pontine plain.

The occurrence of common fabrics, such as the Colluvial Fabric and the Sedimentary Fabric, seems to indicate that potters chose specific raw materials. Indeed, previous work by the GIA on Archaic pottery suggests that potters used similar raw materials repeatedly. More specifically, petrographic analysis of local pottery from Satricum (Fig. 1), dated to between the 9th and 5th c. BCE, indicates that a change took place from red-firing fabrics to orange and buff-firing fabrics during the late 6th c. BCE (Attema et al., 2001/2). The evidence suggests that potters at the site initially used red-firing colluvial clay for the manufacture of coarse wares, and introduced a light-coloured marine clay in later times. Very important to this study is that the results also show that potters mixed these two types of clay, suggesting two things: first, the variety of recipes used for the pottery wares indicates that there was no strong link between fabric and shape, and secondly, clay mixing appears to have been a long-lived paste preparation tradition, given that it was adopted during the Archaic and Roman periods.

Clay mixing also occurs in fine local products, such as amphorae (Fine Clay Mixing Fabric). Whilst there is little evidence for this practice in thin section, the well-sorted nature of the fine inclusions in the clay matrix suggests that a degree of processing must have been carried out. It is interesting to note that clay mixing has also been identified at other Roman amphora production sites in the region, such as at the villa of Le Grottacce (De Haas et al., 2007/8), and at Cales, Dugenta and Mondragone (Thierrin-Michael and Maza, 2002). At all the aforementioned sites in southern Lazio and northern Campania, the evidence suggests that potters mixed red-firing clay with buff-firing calcareous clay. Often, this practice can be identified on sherds in hand specimen, hence why they are also referred to as 'marbled fabrics' (Thierrin-Michael and Maza, 2002).

The clay pastes used for the manufacture of dolia at site 12317 (Augite Tempered Colluvial Fabric), and tiles at site 11232 (Augite Tempered Sedimentary Fabric) deserve some attention. The addition of augite might be seen as functionally specific, whereby it would have aided the drying process of these large containers and ceramic building material. Alternatively, it might be explained as a culturally specific practice, given that it was added to both colluvial and marine clay deposits (respectively Augite Tempered Colluvial Fabric and Augite Tempered Sedimentary Fabric), and marine deposits (Augite Tempered Sedimentary Fabric). In addition, it should be noted that dolia were produced alongside amphorae and bricks at other regional production sites, including Mondragone (Peacock, 1982, 130). Indeed, it is likely that these types of vessels were fired together, given that their size and thick walls would have required sizeable kilns, which had to be heated slowly (Rye, 1981, 105).

Different kiln shapes occur in Roman Italy (Cuomo Di Caprio, 1979), and the ones that are most frequently identified are either round- or square-shaped. In the authors' view, the kiln shapes at the production sites in the Pontine region can only be interpreted confidently when they are excavated. Nevertheless, using the infrastructural evidence for pottery production as an indication, it might be conjectured that there existed differences in the size and scale of pottery production at the four locations studied. More specifically, the number of kilns and their configuration suggests that pottery production at Forum Appii was large-scale, whereas production at site 12317 seems to have been comparatively small-scale (Borgers et al., 2016).

5.2. Distribution of local pottery

Even if research on the regional distribution of local Roman pottery is in its primary stage, the first results are encouraging, given that each of the five local fabrics was identified on consumption sites (Fig. 5).

Ceramic building material and amphorae produced at Ad Medias and Forum Appii have been found on sites of late Republican date within a radius of 5 km, and local dolia from site 12317 have been distributed to sites c. 10 km further. The Via Appia seems to have played an important role in the transport and distribution of these local products, given

that most of the consumption sites are located on this road (Fig. 5). In addition, previous research on local amphorae from the villa Le Grottacce has indicated that these coastal products were used on various sites in the Pontine plain (Tol and De Haas, 2013, 156, Fig. 12), suggesting that the Via Severiana and the Rio Martino canal may have served as transport routes (Fig. 1).

Ceramic building material similar to the local products of site 11232 has been identified at Forum Appii some 25 km further, confirming that coastal products continued to be distributed to the Pontine plain during the early Imperial period when production at Forum Appii and Ad Medias seems to have ceased. Given that both site 11232 and the villa Le Grottacce are located on the same coastal road (Fig. 1), it might be conjectured that the Via Severiana and the Rio Martino canal continued to play a role in the transport of local coastal products. However, more research on pottery from various consumption sites within this (and preferably a larger) area would be needed in order to confirm whether these products were distributed further away, and which roads or waterways played a role in the distribution of local products from the Pontine region.

6. Conclusions

In this paper, the production and distribution of local Roman pottery in the Pontine region, Central Italy, has been examined, using thin section petrography. The picture that emerges is one in which local potters sourced their raw materials at a distance of c. 8 km for the manufacture of tiles, cover tiles, storage jars and amphorae. The petrographic study also shows the distribution of local pottery at a distance of c. 25 km, suggesting that the main roads and waterways along which the production sites were located played an important role in their transport.

The results described appear to be consistent with previous archaeological work in the region. However, more research would be needed in order to gain insight in the level of (inter)regional exchange of Roman pottery that was manufactured in the Pontine region. In this context, a petrographic study on Roman cooking vessels has started in the area.

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