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Petrographic Analysis of a Globular Amphorae assemblage from the settlement of Rocchicella (Mineo).

Author: Veronica Testolini. Affiliation: University of Sheffield.
e-mail: vtestolini1@sheffield.ac.uk

The ceramic assemblage of Rocchicella, dated to the 6th-7th and 9th century, has been analysed for the PhD project: Ceramic technology and social change in Sicily from the 6th to the 11th centuries A.D. (Testolini Forthcoming). One hundred and twenty-four samples were selected and thin sections prepared and analysed with a polarising microscope by the author at the Department of Archaeology, University of Sheffield. The 124 samples were grouped on the basis of type of clay and inclusions and described using Whitbread's (1995) method. This section presents only the analysis of 17 globular amphorae found in Rocchicella in contexts dating to the 9th century (Arcifa 2016; Arcifa et al. 2015), and sheds new light on two Sicilian fabric groups (Fabric 2 and 3) present in a large proportion of the pottery dated to this 9th century phase. Eleven fabric groups were identified for Rocchicella 9th century phase, and 8 groups include globular amphorae samples (Testolini Forthcoming), demonstrating that these amphorae, although small in number, came from different Sicilian and extra-insular workshops.

Sicilian geology includes a sedimentary area in the west, important igneous outcrops in the east, and a metamorphic area in the north-east corner (Messina area) (Lentini et al. 2016). Such a combination of geological formation is comparable to several places in the Mediterranean, and for this reason it is difficult to establish where ceramic products are produced merely on a geological basis. Therefore, it was essential to take into account not only geological literature or comparisons, but also archaeological parallels to provenance the globular amphorae. Archaeological thin sections were compared with clay source thin sections (Montana et al. 2011), published thin sections analyses regarding Sicilian production centres (Cuomo di Caprio 1995; Alaimo et al. 1998; Alaimo et al. 2002; Alaimo et al. 2004; Barone et al. 2004; Alaimo et al. 2010; Barone et al. 2012; Giarrusso et al. 2014; Rizzo et al. 2014; Vaccaro et al. 2015; Montana et al. 2016), and archaeological ceramics studied within the author's PhD research. Moreover, the archaeological context, the typology, and the association of all these elements were taken into account to give a provenance interpretation.

Fabric group 2. Basic igneous sand. 47 out of 124 samples. 3 amphorae.

Microstructure			Groundmass			
Voids	**Packing**	**Inc. shape-size**	**Colour homogeneity**	**Colour PPL**	**Colour XP**	**Optical activity**
5%-10%	FF: Single to Double Spaced CF: Open Spaced	rounded to sub-rounded coarse sand	dark areas in the core	brown to grey	brown to very dark	usually optically inactive, very active margins.

Inclusions		
c:f:v	**Bimodal**	
	Coarse fraction	**Fine fraction**
c:f:v 0.8 mm = ca. 5:85:10	Inc. size: from 0.25mm to 1.2mm mode=0.7 mm Dominant fresh plagioclase. Common quartz, basalt with a clear porphyritic structure and pyroclasts. Basalt contains plagioclase, clinopyroxene (some recognisable as augite), common opaques, no olivine. Few fragments of sandstone and tuff. These basalts are compatible with tholeiitic basalts, characteristic of Rocchicella hill.	Dominant quartz and feldspars with few mica.

Table 1. Petrographic description of Fabric 2. Abbreviations: FF= fine fraction; CF= coarse fraction.

Figure.1. Drawing of storage amphora, inv.1032/46, sample RO 55. (Longo 2016, 36)

Figure 2. storage amphora inv. 1032/46. Sample RO 55. (Longo 2016 37)

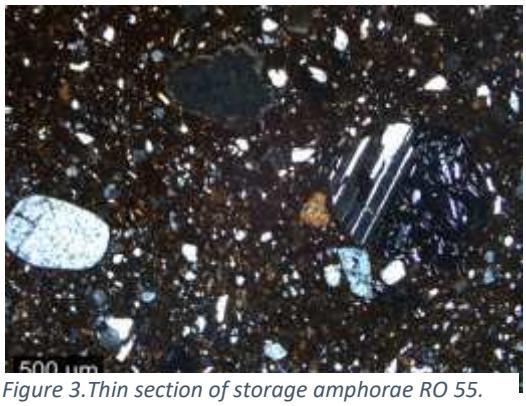

Figure 3.Thin section of storage amphorae RO 55. XP, x5.

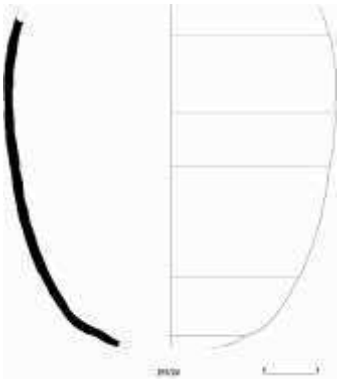

Figure 4. Drawing of transport amphora, inv. 293/24, sample ROT 10. (Longo 2016, 36)

Figure 5. Photograph of transport amphora, inv. 293/24, sample ROT 10. (Longo 2016, 37)

Figure 6. Thin section of transport amphora ROT 10. XP, x5

Figure 7. Jug waster, inv. 1032/5, sample RO 13.

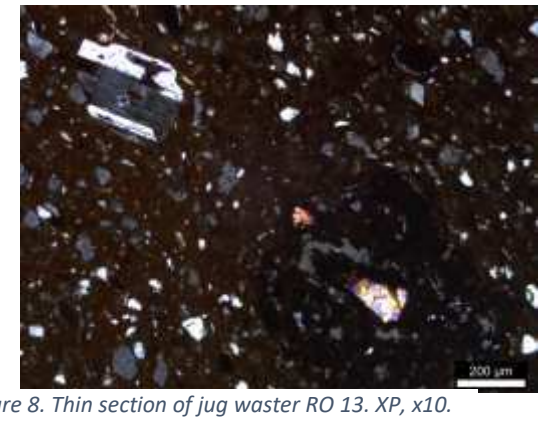

Figure 8. Thin section of jug waster RO 13. XP, x10.

Petrographic characterisation of wasters was central in establishing the local origin of Rocchicella Fabric 2, as Etna and Hyblean volcanism are very difficult to tell apart, even when performing chemical analysis of pyroxenes (Barone et al. 2010, 723). Rocchicella ceramic wasters contain fresh plagioclase, volcanic glass, holocrystalline basalt with opaques and porphyritic basalt with a glassy matrix, and few sandstone fragments - all these elements are compatible with the geology of Rocchicella hill (Grasso et al. 2004), and the surrounding environment. The Caltagirone River flows less than 2 km away from the site. The area located north-west of the site is characterised by sandy deposits. Therefore, the clay employed in local ceramic production, if collected near the river basin, could contain quartz sand and sandstone. In addition to this, the high percentage of vessels manufactured with Fabric 2 found on the site (47 out of 124) confirms the local provenance of this basic igneous sand fabric group. Of the 70 samples dated to the 9th century, 25 showed Fabric 2, three of these samples are globular amphorae. For these 3 globular amphorae, a provenance from Catania has been excluded because of the homogeneity of the fabric group that is comparable with wasters. Typological differences with the amphorae published for Catania could not be considered as Rocchicella amphorae are dated to a later period (Malfitana et al. 2016, 579;841).fabric 2.

Fabric group 3. Highly fossiliferous marine clay. 24 out of 124 samples. 2 amphorae.

Microstructure			Groundmass			
Voids	**Packing**	**Inc. shape-size**	**Colour homogeneity**	**Colour PPL**	**Colour XP**	**Optical activity**
3% to 5%	Closed Spaced	Sub-angular coarse silt and fine sand	homogeneous. Oxidised	grey	light brown	From inactive to active

Inclusions
Unimodal
From 0.04mm to 1mm, mode=0.1mm Dominant microfossils (Foraminifera, echinoderm spines, ostracods, shells). Frequent quartz and micrite. Few to common opaques.

Table 2. Petrographic description of Fabric 3.

Figure 9. Drawing of transport amphora, inv.1032/39-40, sample ROT 1. (Longo 2016, 40)

Figure 10. Photo of transport amphora, inv. 1032/39-40, sample ROT 1. (Longo 2016, 41).

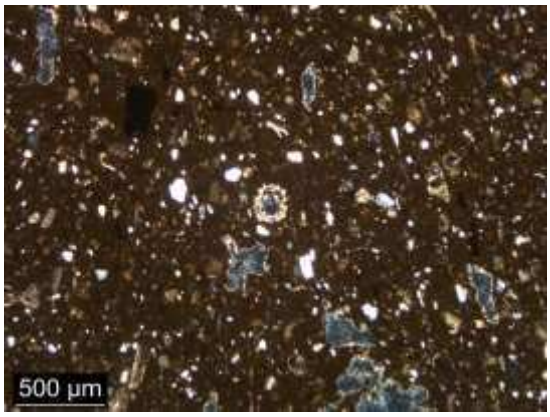

Figure 11. Thin section of transport amphora ROT 1. XP, x5.

Figure 12. Storage amphora, sample RO 2.

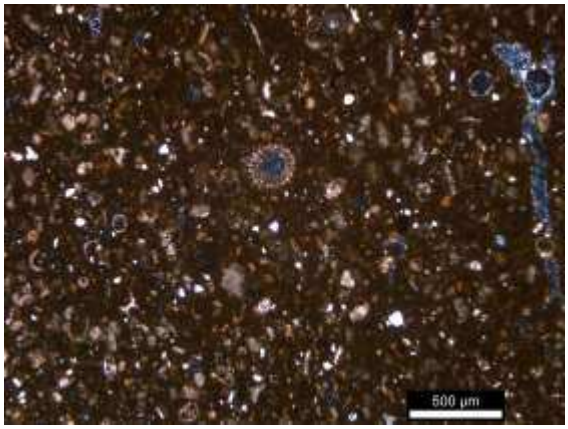

Figure 13.Thin section storage amphora RO 2. XP, x5.

Fabric group 3 is characterised by sub-angular coarse silt and fine sand with dominant microfossils. Highly fossiliferous clays are common in Sicily, although clay surveys and characterisations (Montana et al. 2011) allowed the distinction of some major outcrops on the island. Fabric 3 is not comparable with any of the thin sections from the clay reference collection from the Geology Department at the University of Palermo, although this fabric group is geologically comparable to two thin sections published for the site of Sofiana (Vaccaro et al. 2015, 75, fig.9 thin sections E10396 and F9481), 40 km west of Rocchicella. Such comparisons deserve further investigation. Moreover, for a micropalaeontological characterisation of Fabric 3, a study is being carried out by Dr. Patrick S. Quinn at UCL. It should be noted that jars, jugs and basins from Sofiana kilns are typologically comparable to the vessels manufactured with Fabric 3 found in the site of Rocchicella. The exact location of the production centre has not yet been established, however the abundance of fabric 3 in the assemblage suggests a Sicilian provenance; 24 of the 124 samples from the total assemblage showed fabric 3, and in 13 of the 70 samples from the 9th century.

Fabric Group 4. Quartz rich, marine clay. 3 out of 124 samples. 3 amphorae.

Microstructure			Groundmass			
Voids	**Packing**	**Inc. shape-size**	**Colour homogeneity**	**Colour PPL**	**Colour XP**	**Optical activity**
micro vesicles 3% to 7%	Closed/ Single Spaced	Angular fine sand	Homogeneous	grey	grey	inactive

Inclusions
Unimodal
From 0.08mm to 2mm, mode= 0.15 Dominant quartz. Frequent micrite and shells. Common white mica and biotite.

Table 3. Petrographic description of Fabric 4.

Figure 14. Drawing of transport amphora, inv 1032/43, sample ROT 4. (Longo 2016, p.42)

Figure 15. Photo of transport amphora, inv 1032/43, sample ROT 4. (Longo 2016, p.43)

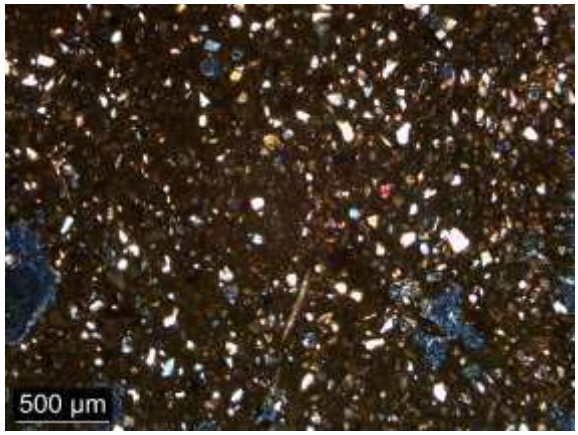

Figure 16. Thin section of transport amphora ROT 4. XP, x5.

Fabric 4 does not match with any other published Sicilian fabric, and has been found only in three globular amphorae within the Rocchicella assemblage. Drawings and photographs of two amphorae representing this fabric are published in Longo (2016, 42–43). The low frequency of this fabric in the assemblage and the shape combined with the presence of mica in the clay matrix, suggest that these amphorae are not Sicilian, even though deposits rich in mica are present in the north-east corner of Sicily.. This ovoid shape is comparable to Cos products (Poulou-Papadimitriou et al. 2015; Poulou-Papadimitriou et al. 2014). Amphorae in Fabric 4 may have been produced in the Aegean, although without a petrographic comparison with wasters or kiln walls the provenance hypothesis cannot be confirmed.

Fabric group 5. Basic igneous, fossiliferous matrix. 2 out of 124 samples. 2 amphorae.

Microstructure			Groundmass			
Voids	**Packing**	**Inc. shape-size**	**Colour homogeneity**	**Colour PPL**	**Colour XP**	**Optical activity**
meso vesicles 3%	Closed Spaced	Sub-rounded, very fine to very coarse sand	Homogeneous	grey	light brown	From inactive to active

Inclusions
Unimodal
From 0.05 mm to 2mm, mode=0.08 Dominant microfossils: foraminifera, echinoderm spines, ostracods. Few gabbro and basalt. Rare ignimbrite.

Table 4. Petrographic description of Fabric 5.

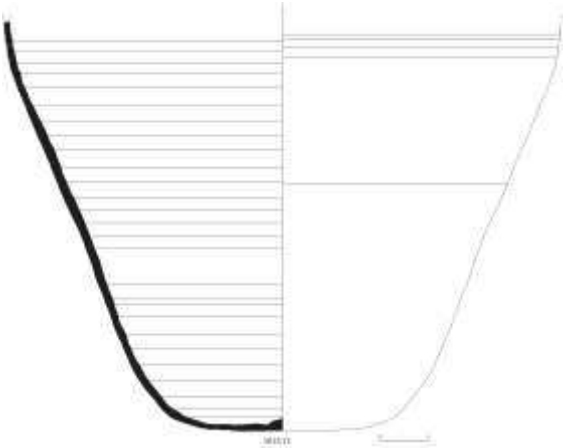

Figure 17. Drawing of transport amphora, inv 1015/12, sample ROT 14 (Drawing executed by Longo).

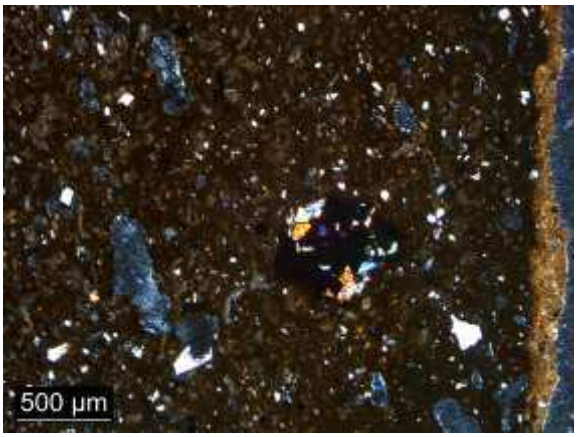

Figure 18. Thin section of transport amphora ROT 14. XP, x5.

The clay matrix of Fabric 5 is very similar to that of Fabric 3, but the presence of basic igneous rocks which are not clearly added as temper (unimodal size distribution) suggests a different clay deposit from that used in Fabric 3. Fabric 5 is compatible with Sicilian igneous geology. However, only two poorly preserved vessels, dated to the 9th century, are manufactured with this fabric, and so its provenance remains difficult to suggest.

Fabric group 6. Medium grade metamorphic. 4 out of 124 samples. 4 amphorae.

Four globular amphorae from the Rocchicella assemblage belong to Fabric 6 (Longo 2016, 42–43) and were found next to each other in the same room (Arcifa 2016, 25). The medium grade metamorphic geology and their shape comparable to survivals of LRA 1 (Poulou-Papadimitriou et al. 2014) suggest a provenance from the Asia Minor coast. Further comparison with thin sections of production in the Aegean and surrounding coasts will clarify the source.

Microstructure			**Groundmass**			
Voids	**Packing**	**Inc. shape-size**	**Colour homogeneity**	**Colour PPL**	**Colour XP**	**Optical activity**
micro vesicles 1%	Closed Spaced	Sub-angular very fine sand	Homogeneous	brown	dark red	Slightly active to active

Inclusions
Unimodal
From 0.05mm to 0.96mm, mode= 0.1mm Dominant quartz. Common biotite and white mica. Few amphibole, micaschist and amphibolite.

Table 5. Petrographic description of Fabric 6.

Figure 19.Drawing of transport amphora, inv. 1032/52, sample ROT 7 (Longo 2016, 42)

Figure 20.Photo of transport amphora, inv. 1032/52, sample ROT 7. (Longo 2016, p.43)

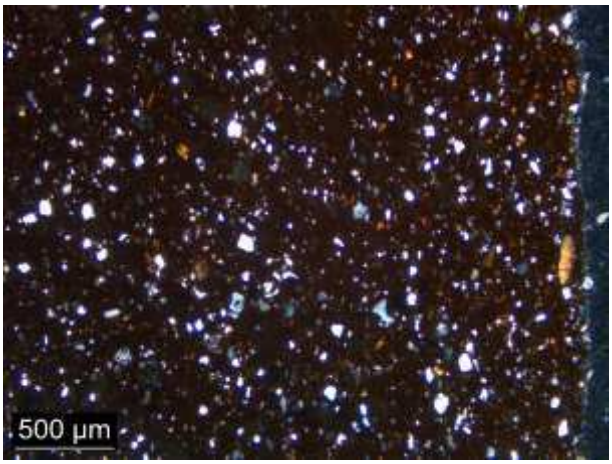

Figure 21. Thin section of transport amphora ROT 7. XP, x5.

Four amphorae from the Rocchicella assemblage belong to Fabric 6 (Longo 2016, 42–43) and were found next to each other in the same room (Arcifa 2016, 25). The medium grade metamorphic geology and their shape comparable to survivals of LRA 1 (Poulou-Papadimitriou et al. 2014) suggest a provenance from the Asia Minor coast. Further comparison with thin sections of production in the Aegean and surrounding coasts will clarify the source.

Fabric group 7: Metamorphic and acid igneous. 2 out of 124 samples. 2 amphorae.

Microstructure			Groundmass			
Voids	**Packing**	**Inc. shape- size**	**Colour homogeneity**	**Colour PPL**	**Colour XP**	**Optical activity**
meso vesicles 1%	CF: Open Spaced FF: Single Spaced	sub-rounded, medium sand	homogeneous	dark brown	brown	slightly active

Inclusions		
c:f:v	**Bimodal**	
	Coarse fraction	**Fine fraction**
c:f:v 0.08 mm = ca. 5:94:1	From 0.16 to 1mm, mode=1mm Common alkali feldspars, quartz, few micaschist and acid igneous rocks, rare amphibole.	Dominant quartz and feldspars, few biotite and white mica.

Table 6. Petrographic description of Fabric 7.

Figure 22. Drawing of the base of transport amphora, inv. 293/21, sample ROT 13. (Drawings executed by Longo)

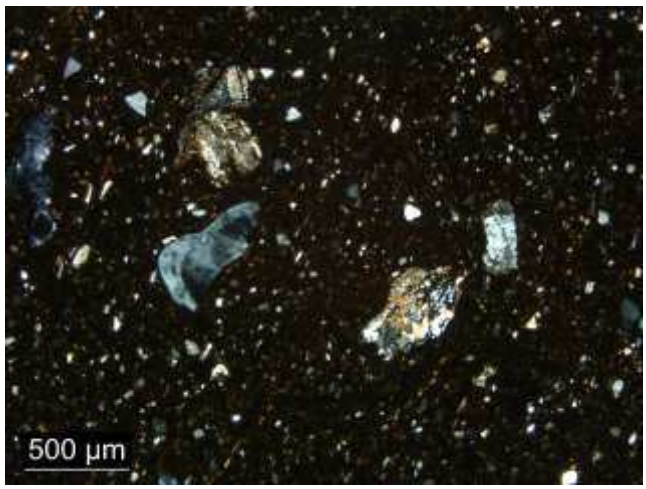

Figure 23. Thin section of transport amphora ROT 13. XP, x5.

Fabric 7 is bimodal, but probably un-tempered, as fine fraction and coarse fraction show the same mineralogical compositions. The geology is compatible with the north-east corner of Sicily and Calabria although as for previous fabric groups without a petrographic comparison with the production of known or assumed production centres, its provenance remains uncertain, and an Aegean provenance cannot be excluded. Only vessels found in 9th century layers show this fabric.

Fabric group 8. Fine fabric with clay mixing and K-feldspars. 1 out of 124 samples.

Microstructure			Groundmass			
Voids	**Packing**	**Inc. shape-size**	**Colour homogeneity**	**Colour PPL**	**Colour XP**	**Optical activity**
meso-vughs	Double Spaced	Sub-rounded, very fine sand	homogenous	brown	light brown	inactive

Inclusions
Unimodal
From 0.05 to 1.3mm mode=0.07 Dominant quartz. Common white mica. Few meta quartzite, K-feldspars with a perthitic texture, and textural concentration features that suggest clay mixing.

Table 7. Petrographic description of Fabric 8.

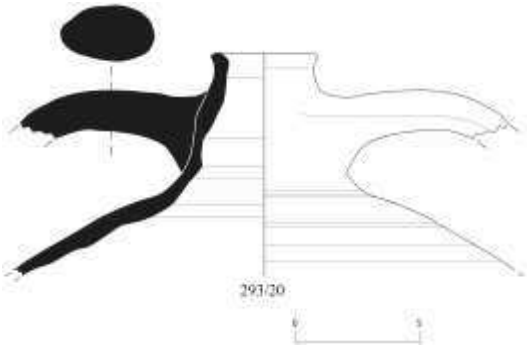

Figure 24. Drawing of transport amphora, inv. 293/20, sample ROT12. (drawing executed by Longo).

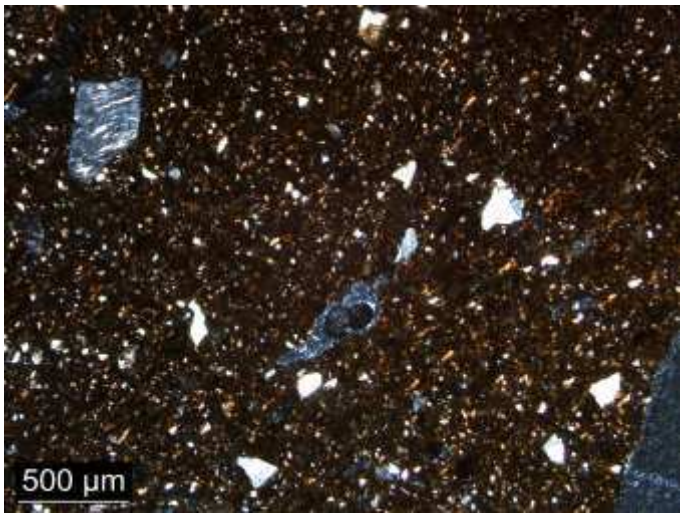

Figure 25. Thin section of transport amphora ROT12. XP, x5.

Only one amphora within Rocchicella assemblage is manufactured using fabric 8. Fabric 8 is lithologically related to Fabric 7, but there are differences: the presence of K-feldspars with perthitic texture might suggest an acid igneous environment, although the clay matrix of Fabric 8 is richer in mica than that of Fabric 7. This amphora may be manufactured in north-western of Sicily, but in a different workshop from ROT13, although this kind of geology is compatible with other production areas in the Mediterranean, for example in the Aegean islands, or the Asia Minor coast.

Fabric group 9. Phyllite, mica and plagioclase. 1 out of 124 samples.

Microstructure			Groundmass			
Voids	**Packing**	**Inc. shape-size**	**Colour homogeneity**	**Colour PPL**	**Colour XP**	**Optical activity**
3% meso planar voids	Double Spaced	Very coarse. silt to very fine sand	Heterogeneous	Dark brown to black	Light brown to dark brown	Inactive

Inclusions
Unimodal
From 0.03mm to 0.5mm mode=0.05 Dominant quartz. Few phyllite and white mica. Rare biotite schist and alkali feldspars.

Table 8. Petrographic description ofFabric 9.

Figure 26. drawing of transport amphora, inv. 1032/57, sample ROT 9. (Longo 2016, 42).

Figure 27. Photo of transport amphora, inv. 1032/57, sample ROT 9. (Longo 2016, 43).

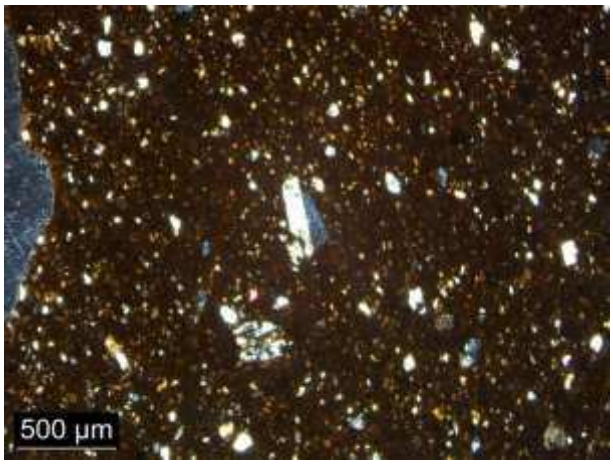

Figure 28. Thin section of transport amphora ROT 9. XP, x5.

Fabric 9 is present in only one amphora from Rocchicella assemblage. The fabric is manufactured from a clay of metamorphic composition, with some alkali feldspar. This globular shape is attested in Otranto (Imperiale 2015) and Paros (Diamanti 2016). The Paros workshop produced such globular shapes (Diamanti 2016, 692, pictures c-d) and amphora ROT 9 could have been produced on the island, as it is geologically compatible with the description published for Paros production centre (Diamanti et al. 2014, 191). However, no thin sections were published for the latter workshop and so such an ascription requires future confirmation.

Forming method observations

Macroscopic observation of the reconstructed artefacts, coupled with observation in thin section of inclusions and the orientation of clay domains allowed a hypothetical reconstruction of the forming method employed in the manufacturing of the transport and storage amphorae analysed. All the amphorae analysed in this work, with concave and convex bases (comment typology to be found in

Longo 2016), are wheel thrown in three or four sections. Amphora bases were thrown upside down; then placed on the wheel using support. The body, shoulder and neck sections were then thrown in sections. This suggests that, regardless of their varied origins, all these 9th century amphorae were formed following a similar procedure in different parts of the Byzantine Empire.

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