MINERALOGICAL AND PETROGRAPHIC ANALYSES OF TILES (*TEGULAE*) FROM THE LATE ROMAN NECROPOLIS OF PRIAMAR, SAVONA (LIGURIA, NW ITALY)

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Abstract: *Analyses by optical microscopy and XRD were carried out on tiles (*tegulae*) from the Late Roman necropolis of Priamar (Savona, NW Italy), which show homogeneous shape and dimensions. Several fabrics have been recognised. Most artefacts can be referred to a few productions of the local area, but others are characterised by volcanic inclusions incompatible with the regional geology. SE France could be the source of that production, probably traded by sea. The heterogeneity of fabrics, as well as their casual distribution among the tombs, suggest the recycling of tiles taken from various pre-existing buildings.*

Keywords: *Archaeometric analyses, Roman tiles, Savona, local productions, long-distance imports*

INTRODUCTION

The Late Roman (4th-7th c. AD) necropolis on the top of the Priamar hill of Savona, the ancient *Savo* (western Liguria, **Fig. 1**), now included in a 16th c. fortress, is composed of 87 tombs. Some African amphorae were used for children's burials, but in most cases Roman flat tiles (*tegulae*) were utilised. The tiles show fairly homogeneous shape and dimensions (ca. 50-60 cm x 30-40 cm); no stamps are present (*Lavagna* 2000). The ceramics of the necropolis are thought to come from the abandoned *municipium* of *Vada Sabatia* (Vado Ligure), which lies a few kilometres to the west of Savona and is still poorly investigated by archaeologists.

Archaeometric analyses were carried out in order to obtain information about provenance and production techniques of the tiles. All the *tegulae* were studied by stereomicroscopy and 20 representative samples were submitted for thin section analysis. X-ray powder diffraction analyses were also performed on 6 samples aimed at obtaining further information about mineralogical composition and firing temperatures.

Several fabrics have been recognised, which are randomly distributed in the necropolis and even in the *tegulae* of the same tomb. Most artefacts can be referred to a few productions of the local area, but others show inclusions incompatible with the local and, in some cases, regional geology.

Abundant metamorphic sandy grains ("surface sand") can generally be observed on one surface of the tiles of all groups. That component, which must not be confused with paste inclusions, reveals the diffuse technique of sprinkling sand on the bottom of the moulds in order to facilitate the separation of the raw tiles. Sometimes the "surface sand" is not completely similar in texture and composition to paste inclusions/temper.

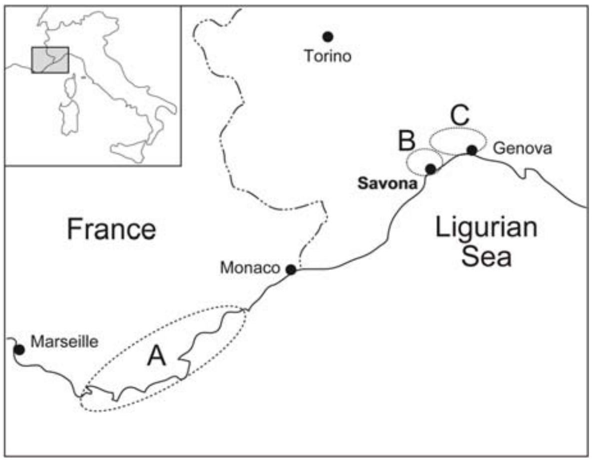

Fig. 1 Geographic sketch map showing location of Savona and geological sectors recorded in the text. A: Maures and Esterel Massifs; B: Savona Massif; C: Voltri Group.

It could be due to the fact that the manufacturing places (probably close to alluvial or marine "surface sand" sources) were distant from the clay raw material outcrops.

THE GROUPS OF FABRICS

Major groups

Group 1. Thin section analyses: 5672/PL7724b, 5673/PL7758b, 5674/PL7790, 5675/PL36838, 5677/7731b, 5678/PL36855, 5679/PL36557, 5686/PL34367b, 5687/PL36756, 5688/PL37185, 5692/PL37504, 5693/PL38015.

More than three quarters of the tiles of the necropolis are characterised by a Group 1 fabric. Macroscopically, pastes of Group 1 generally show a homogeneous red to orange-yellow colour (with yellow lumps when carbonate clay inclusions are present) due to homogeneous

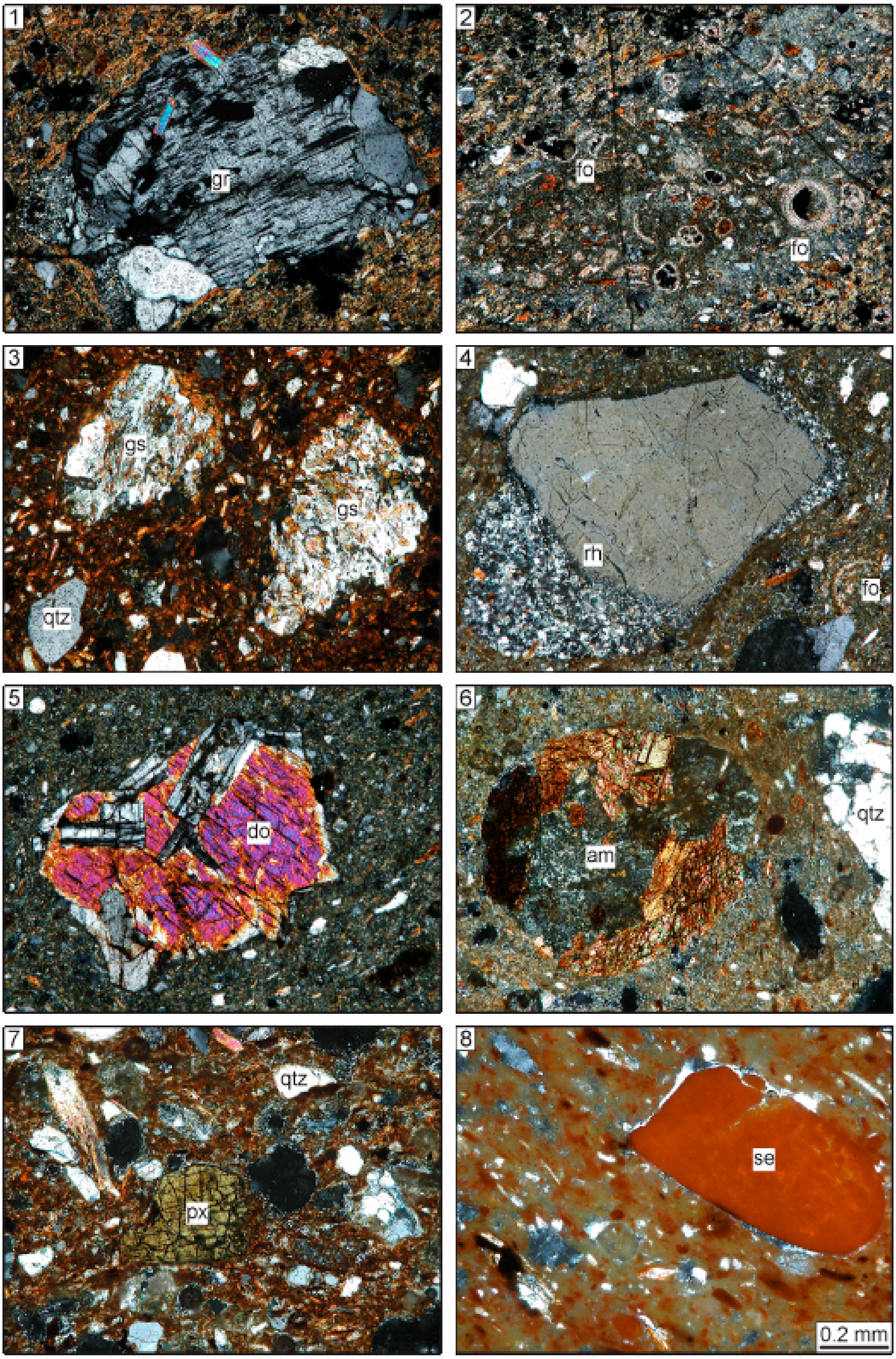

Fig. 2 Thin section microphotographs of analysed fabrics (crossed polars). 1, 2: 5674 (Gr. 1); 3: 5673 (Gr. 1); 4, 5: 5691 (Gr. 2); 6: 5676; 7: 5695; 8: 5694; am: amphibolite; do: dolerite; fo: microfossil test; gr: metagranitoid; gs: greenschists facies metabasic rock; px: pyroxene; qtz: quartz; rh: rhyolite; se: serpentinite.

oxidation and, but for few exceptions, a medium or low degree of hardness. The clay matrix is Fe-rich. In most cases, it is non-vitrified and exhibits an anisotropic behaviour. The fine-grained aplastic inclusions (<200 µm in size) are very frequent. They are mainly composed of angular mineral grains (prevailing quartz, mica, plagioclase, and K-feldspar; accessory amounts of several heavy minerals: amphibole, epidote, sphene, clinopyroxene, rutile, garnet, zircon, and tourmaline) often associated with abundant badly preserved calcareous microfossils (mainly benthonic and planktonic foraminifera) and subordinate quantities of siliceous microfossils (sponge spicules, diatoms, radiolarians). The coarser inclusions are less abundant, rounded to sub-angular, up to few mm in size. They are mainly formed by metagranitoid (**Fig. 2.1**), paragneiss and amphibolite fragments. Fossiliferous carbonate-rich clay lumps (**Fig. 2.2**) up to few mm in size can be observed in several cases, which suggest a possible intentional mixing of two different clays. In sample 5675 poorly sorted medium and coarse inclusions are fairly abundant, but amphibolites are absent. In sample 5673 only, a few serpentinite and greenschist facies (amphibole+albite+epidote) metabasic rock fragments are also present (**Fig. 2.3**).

The "surface sand" shows moderate variability, suggesting different sources of raw materials and manufacturing sites.

Group 1 can be referred to one or few productions in the local area. The various components of the fabrics are well compatible with local Fe-rich alluvial clays, Pliocene marine marls, and sands derived from the Palaeozoic metamorphic basement (Savona Crystalline Massif, Calizzano-Savona Unit; *Vanossi 1991*) outcropping in the coastal belt between Vado Ligure and Albisola (*Giammarino et al. 2002; field B in Fig. 1*). Besides, most of Group 1 fabrics show similarities to those characterising the large-scale late Medieval productions of Savona ("Graffita arcaica tirrenica" and related types; *Capelli et al. 2007*). As for sample 5673, which can be considered as a variant of Group 1, the presence of metaophiolitic fragments points to a possible provenance from the Albisola area, to the east of Savona, where the Jurassic ophiolites of the Voltri Group (*field C in Fig. 1*) are in contact with the Savona Massif (*Vanossi 1991; Giammarino et al. 2002*). A possible source of the raw materials could be found in the sediments of the few torrents cutting both of the rock complexes.

XRD analyses were carried out on three samples of Group 1 (5672, 5673, 5678). The common mineralogical composition consists of quartz dominant on plagioclase and illite/muscovite. Other mineral phases were found in traces: hematite in 5673 and 5678, orthopyroxene in 5672, and tremolitic amphibole in 5678.

Quartz, plagioclase and amphibole are related to primary aplastic inclusions. Hematite derives from the transformation of Fe compounds of the raw alluvial clay under oxidised firing.

No orthopyroxene grain was detected in thin section of sample 5672. Orthopyroxene XRD peaks might be explained with the firing processes involving the transformation (dehydroxylation) of the green amphibole of the local amphibolitic rocks (*Cortesogno et al. 1997*). Amphibole does not result from XRD. However, many amphibole grains are well recognisable under the microscope; they maintain their primary extinction angle, but they are red in colour (plane polarised light) because of oxidation. Specific analyses and experimental work will be needed to better understand the reactions involving these amphiboles, which might lead to a complementary tool for evaluating the firing conditions.

Finally, the phyllosilicate peaks possibly derive from both the illitic clay and the mica inclusions (except for montmorillonite in sample 5678, to be considered as weathering product). Their presence point to firing temperatures <900-950°C (*Cultrone et al. 2001, Buxeda et al. 2002*), as already suggested by the previous observations.

Group 2. Thin section analyses: 5680/PL13162, 5689/PL31310b, 5690/PL13153, 5691/PL31312b, 5696/PL36999.

Macroscopically, the pastes of this Group can be distinguished from the others by their yellow colour. "Surface sand" is present in all samples. The clay matrix is carbonate-rich, sintered (with secondary calcite in pores; samples 5680, 5689, 5696) or non-sintered (5690, 5691). Inclusions are moderately abundant and well-sorted. The groundmass is mainly composed of mica individuals (more abundant in 5690, 5691) and badly preserved calcareous microfossil tests (foraminifera), while quartz is subordinate. The coarser inclusions (up to 1.2-2 mm in size, mostly <1 mm), angular to sub-rounded, are mainly formed by mono- and polycrystalline quartz and acid volcanic rock fragments (rhyolites with quartz fenocrysts and recrystallised groundmass; rarer fine-grained feldspar-rich rocks with altered/oxidised groundmass; **Fig. 2.4**); calcareous microfossils, feldspar, clinopyroxene, biotite, amphibole, epidote are accessory or occasional. Gneiss fragments are very rare, except for sample 5691, where occasional fragments of doleritic basalt (?) are also present (**Fig. 2.5**).

The origin of Group 2, which could possibly be divided into two sub-groups, related to two different productions, can be referred to a distant Mediterranean production centre or area for several reasons:

a) no rocks similar to the volcanic temper of Group 2 fabrics outcrop in the Savona area and, more generally, in the Tyrrhenian side of Liguria (*Vanossi 1991; Giammarino et al. 2002*);

b) the rough regional morphology, characterised by Alpine and Apenninic reliefs and very short streams (the Tyrrhenian-Padan watershed is parallel to the coastline and only a few km distant from it) greatly obstacled an inland transport of large and heavy items;

c) the sea trade of Roman tiles in the Mediterranean and, in particular, in the upper Tyrrhenian area is attested by several archaeological findings (*Menchelli 2003*).

Even if other Mediterranean geological sectors cannot be excluded (for instance the Aegean area) taking into account the petrographic composition of inclusions, southeastern France (field A in **Fig. 1**) is the most probable source area on the ground of both geological and archaeological considerations.

The raw materials are comparable with the rocks of the Variscan basement and the Permian magmatism of the Maures and Esterel Massifs (the temper inclusions) and their Meso-Cenozoic carbonate cover (the carbonate-rich clay matrix) (*Toutin-Morin et al. 1994*). Moreover, along the Provençal coast several Roman shipwrecks carrying tiles probably produced in the Esterel area have been discovered (*Joncheray 1987; Joncheray & Joncheray 2004*).

The XRD analysis carried out on sample 5680 showed the presence of quartz prevailing on Na-plagioclase, tremolitic amphibole, calcite, clinopyroxene, and gehlenite. The first three phases can be referred to as primary inclusions (tridimite is probably localised in the groundmass of rhyolites), while gehlenite and the majority of clinopyroxene are firing phases. Their presence - if we assume that all calcite peaks are due to secondary recrystallisation of calcite as resulting from the thin section analysis - points to equivalent firing temperatures around 950°C (*Buxeda et al. 2002*).

Outliers

Thin section analysis: 5676/PL36551.

The fabric is formed by a carbonate-rich matrix and moderately abundant well-sorted inclusions. The fine-grained fraction (< 200 μm in size) is mainly composed of individual mineral grains (mica prevailing on quartz, feldspar and rarer amphibole, opaque minerals, sphene, rutile, and epidote) associated with numerous badly preserved calcareous microfossils. The coarser inclusions (up to 1.5 mm, mostly to 200-500 μm in size), angular to rounded, are formed by gneiss, amphibolite, micritic limestone fragments and rare quartz and feldspar individuals (**Fig. 2.6**). Several Fe-rich argillaceous rock fragments are present as well.

The similarities between the gneiss and amphibolite inclusions and the rocks outcropping in the Savona Massif point to a probable local origin of this sample, even if the possibility of an import from similar geological areas (for instance Provence) cannot be excluded. However, the compositional and textural features are not similar to those of Group 1, suggesting a different production. The paste was made by adding a well-sorted temper to a marine, carbonate-rich sediment.

XRD analysis of sample 5676 identified the presence of abundant quartz and subordinate calcite, clinopyroxene, gehlenite, orthopyroxene, and rutile. Quartz and rutile can be referred to as primary aplastic inclusions. Orthopyroxene probably derives from the transformation of green amphibole, which appears red in the paste after oxidising firing (for discussion see Group 1). Clinopyroxene and gehlenite are firing phases. Taking also into account the lack of phyllosilicate peaks and considering calcite as secondary phase as seen by optical microscopy, equivalent firing temperatures around 950°C could be suggested (*Buxeda et al. 2002*).

Thin section analysis: 5695/PL37855.

The fabric is characterised by a Fe-rich oxidised matrix, including several pluri-millimetric lumps with carbonate-rich matrix, and very abundant well-sorted inclusions (up to 1.5 mm, mostly <300 μm in size; the coarser ones are rounded, the others are angular). They are mainly composed of quartz, mica, feldspar grains, badly preserved calcareous microfossils, acid metamorphic rock (gneiss, fine-grained quartz-micaschists) and micritic limestone fragments. Accessory or occasional components are: amphibolite and chert fragments, zoned green-yellow clinopyroxene, amphibole, rutile, yellow garnet (**Fig. 2.7**). It seems probable that sand inclusions were added as a temper. Besides, an intentional mixing of two types of raw materials (Fe-rich alluvial and carbonate-rich marine clays) cannot be excluded.

The possibility of a production from the Savona area (Group 1 - variant) cannot be excluded by the presence of acid metamorphic inclusions. However, the lack of precise compositional and textural relationships with local sediments and minerals (in particular, zoned clinopyroxene and yellow garnet are not reported in western Liguria), as well as the lack of comparability with reference materials (ceramic productions of all ages; see for instance *Capelli et al. 2007*) might suggest the possibility of an imported production. Provence could be one of the possible sources.

Thin section analysis: 5694/PL12622a.

The paste of sample 5694 is difficult to study in thin section. The matrix is yellow-orange macroscopically and it is totally sintered. Inclusions are abundant, angular to sub-rounded and mostly <200 µm in size (maximum dimension: 1 mm). They are composed of quartz, feldspar, subordinate uncoloured amphibole and clinopyroxene individuals, transformed (red) serpentinite (**Fig. 2.8**) and rare quartz-micaschist (?) fragments and numerous red Fe-rich vitrified grains, which could be interpreted as biotite, amphibole and/or serpentinite inclusions (SEM-EDS analyses will be carried out in order to get a precise characterisation of these components).

A local/sublocal production cannot be excluded for this sample. In fact, serpentinite outcrops characterise the Voltri Unit and the Montenotte Unit, located to the east and to the north of Savona respectively (*Vanossi 1991*).

Quartz dominant on Na-plagioclase, clinopyroxene and forsterite were the crystalline phases identified by XRD analysis. The first three can be attributed to primary aplastic inclusions, while forsterite probably derive from the transformation of serpentine due to firing. The absence of phyllosilicate peaks, as well as the textural features of the fabric, point to equivalent firing temperatures > 900°C (*Cultrone et al. 2001, Buxeda et al. 2002*).

CONCLUSIONS

The thin section analyses point to the presence of various groups of fabrics among the *tegulae* of the Priamar necropolis. They represent several productions coming not only from local and regional areas, but also from a quite distant centre/area, which is possibly located in southeastern France. An uncommon long-distance trade, probably by sea, of tiles in the Roman age is so demonstrated.

The heterogeneity of productions, as well as their casual distribution in the necropolis, suggests the recycling of tiles taken from various pre-existing buildings. The comparative study of the materials, which will be recovered in the excavations of *Vada Sabatia*, supposed to be the source of the tiles of Priamar, could give further information.

Finally, all the studied productions show a good level of technical knowledge, involving intentional choice of raw materials, addition of selected temper, kiln firing with medium or high temperatures and homogeneous oxidation. That knowledge must be related to organised workshops more than to occasional productions.

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