PETROGRAPHIC CHARACTERISATION OF AN *OPUS SECTILE* FOUND IN THE ROMAN TOWN OF POLLENTIA (ALCUDIA, MAJORCA, SPAIN)

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Abstract
This paper presents the preliminary results of the petrographic characterisation of the stones used in an *opus sectile* pavement discovered at Pollentia (Alcudia, Majorca, Spain). The importance of this element basically lies on its relation with a large building in the area of the Forum and the fact that it is the first one of its kind to be found in recent excavations at this Roman town. The materials are white limestones and black/grey lutites. In order to identify the provenance of these materials, the same island of Majorca and the nearby island of Minorca were the first to be considered. Indeed, white limestones are abundant at Majorca, while the nearby Minorca presents a higher number of Paleozoic outcrops that could be considered as potential sources for the black/grey materials. Thus, the first step consisted on the analysis and comparison of the Paleozoic stones used at the *opus sectile* and those from Minorca's outcrops. Some samples from a Roman site at Minorca were also included on this analysis due to their potential similarity to the samples from Pollentia. On the other side, the provenance of the white limestones is still on its earlier stages and in progress. Nevertheless, the bibliographic references on the Majorca geology and the first characterization (macroscopical and microscopical) of the white limestone strongly point at a local origin; thus providing the basis for the next step (survey, location and sampling of the outcrops) of the further research that we will undertake.

Keywords
Petrographic characterization, local stones, phyllites, lutites, white limestone, *opus sectile*, Pollentia, Majorca, Minorca.

Introduction

The maritime town of Pollentia (Alcudia, Majorca, Spain) (Fig. 1), with the legal status of colony according to Mela (*Chorographia*, II,124-125), was the largest of the Balearic cities in the Roman and Late Roman periods (Arribas *et al*. 1973, 1978; Doenges 2005).

Archaeological excavations developed since the beginning of the 20thcentury have brought to light part of the Forum with several temples and an *insula* of *tabernae*, a residential neighbourhood with three *domus* in the northern part of the town, a theatre in the South, several necropolises, at least two portions of two town walls, among other remains.

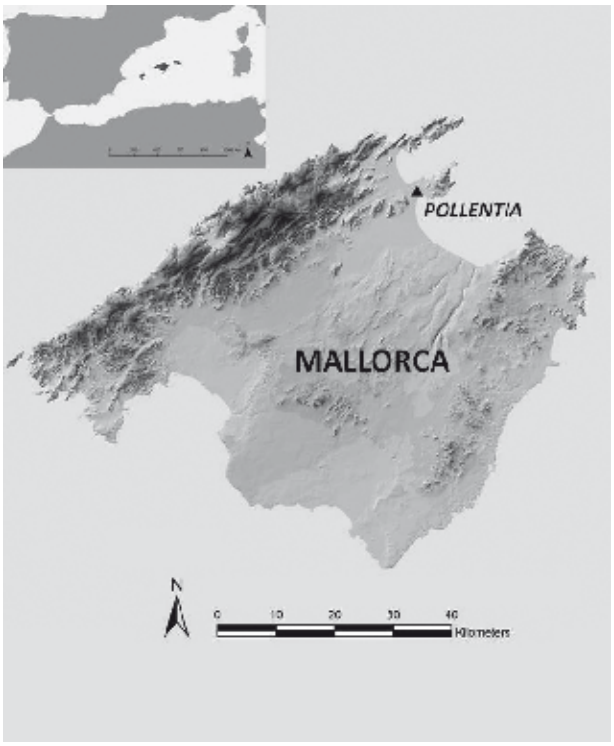

Fig. 1. Location of the Roman town of Pollentia in the island of Majorca.

Recent work in the Forum has provided a complete stratigraphical sequence of its occupation and a better understanding of the urban organisation of the town. The construction of the Forum began in the decades 70-60 BC, functioning as such until the end of the 3rd century AD, when it was destroyed by a large fire. Nevertheless the area was restructured and occupied in Late Antiquity and the medieval period (Orfila 2000; Orfila *et al*., 1999, 2005, 2006). Since 2002 archaeological excavations have focused on the eastern part of the Forum aiming at discovering the end of the forum square and its structure on its eastern side. In this area, a black and white *opus sectile* associated with the remains of a large building was discovered.

As seen in past excavations, the construction of structures and pavements in Pollentia was normally undertaken using local materials. Since the mosaic was formed by hexagonal fragments of black/grey stone and equilateral triangles of white limestone that are not normally used in the town it was necessary to characterise

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them and locate potential source areas. For the second type of pieces (triangular, white) the idea was first to check if they were homogeneous indicating a same origin, and secondly, to identify its provenance. This brief contribution presents the results of the petrographic characterisation of these materials.

The finding of the mosaic of *opus sectile*

In the eastern part of the Forum[1] (Fig. 2) and under an extensive Late Antique and/or medieval necropolis, we have documented the structural remains of a building whose dimensions indicate that it must have been of great importance. This building is only partially known on its north and west sides and it seems that it continues to extend to the east and south under the aforementioned necropolis sediment. Related to this building, an area paved with a mosaic of *opus sectile* was documented.

Indeed, during the 2005 campaign part of this *opus sectile* was already seen while excavating the so called "Necropolis to the East of the temple II". In this sector there was a wide plunder trench[2] which crossed the area from North to South affecting numerous contexts and structures and cutting in the pavement and its preparation (Mas *et al*. 2005, 175 and 178).

Subsequently, in the 2006 campaign, the entire pavement[3] was excavated. The *opus sectile* (Fig. 3) covers a small space, as a threshold or corridor, oriented crosswise to the axis of the building. It is about 4.50 m long (east-west direction) and nearly 3 m wide (north-south direction). About its limits, it is enclosed by a wall on the north[4] and by a canvas wall on the South[5], but its closure at the eastern and western sides could not be established (Mas *et al*. 2006, 89).

As already mentioned, it is composed of a black and white tiles combined in a simple geometric scheme formed by hexagons (black/dark grey stone) and equilateral triangles (white stone) that draw six-pointed stars. The composition is achieved by repeating a scheme based on the alternation of a hexagon and two triangles facing one of its vertices at nine parallel lines[6]. A chromatic contrast that draws a sequence of six pointed white stars (made by six white triangles) with the centre formed by the dark slate hexagon is thus achieved (Fig. 3).

At the northern side of the *opus sectile*, some traces of a narrow stripe of *opus tessellatum*, also in black and white, has been found in situ and attached to SU 6460, which seems to be part of the building. However, towards the south, larger white limestone plates (of approximately two Roman feet long), which could constitute the end of the pavement or a change in design, were documented (Mas *et al*. 2006, 89-90).

To date, the function of the building is unknown since it is still in the process of excavation. However, there is enough structural information to define this construction as a building of a certain scale located on

Fig. 2. Plan of the building under study with the *opus sectile.*

Fig. 3. Photograph from the *opus sectile* pavement.

1. In particular in the E-7, E-8, F-7 and F-8 sectors.
2. Stratigraphic Unit (SU) 6391.
3. SU 6439.
4. SU 6460.
5. SU 6226 6227, 6648 and 6500.
6. The examples of this *opera sectilia* with this pattern are abundant both in Late Republican-Augustan times (as the examples of Campania and other parts of Italy demonstrate) and again in the Late Roman period (especially widespread in the Milan area and the north of Italy) (Guidobaldi 2009, 361-396). The model of the Pollentia pavement matches that of Guidobaldi's Tavola I, A (Guidobaldi 2009, 415). Moreover, remains and negative traces of pavements following this pattern at Empúries and Cartagena (Pérez Olmedo 1996, 116-118, footnote 69-71, plates XX-XXI and 144, footnote 97, pl. XXXIIa).

the east side of the Forum. The *opus sectile* is the first example of this type of pavement documented in modern excavations and with modern methodology; this certainly gives the building a character of some importance.

As regards the chronology of this pavement, excavation has provided very few relevant data. The material uncovered in the preparation is very scarce and only a fragment of Italic amphora and a fragment of Italic Terra Sigillata (or Samian Ware) can suggest an Augustean or 1st century AD *terminus post quem*. It is also noteworthy that the building was refurbished in the 4th century AD. Also, there is no a clear stratum covering the pavement prior to this reform and over the remains of the opus *sectile* there was only a level that has been interpreted as the final abandonment of the sector before the construction of the late antique necropolis. In fact, in the western part of this sector, one of the tombs of this extensive necropolis cut this level of abandonment and the *opus sectile* as well. Thus, so far, it is possible to propose for the mosaic an Augustean or later chronology yet always previous to the 4th century AD (Mas *et al*. 2006, 91). Furthermore, as already mentioned, the model that follows this pavement can also be of Late Republican-Augustan times and of Late Roman date[7].

Paleoroic materials at the Balearic Islands

Even though some authors (Darder 1925; Hollister 1973) had identified the presence of Paleozoic age pebbles as part of Burdigalian conglomerates of the center of Majorca, the existence of Paleozoic outcrops at this island was unknown until the last decade of the 20th century (cf. García Navarro 1965). These materials were identified in the coast cliffs located between Es Port d'Es Canonge and Es Port de Valldemossa, in the northern coast, yet they are very small and are formed by detritic rocks very similar to those of the Minorcan Paleozoic (Ayala *et al*. 1994)[8].

At Minorca, Paleozoic materials belong to the Western Series, formed by siliciclastic turbidites originated in deltaic platforms (Rosell *et al*. 1969). Dark grey micritic limestones crop out at some points around the Favàritx Cape. They belong to the Upper Silurian, Devonian and Carboniferous periods. The stratigraphic series, from bottom to top, is composed by Devonian turbiditic deposits, olistostromes from the transition to the Carboniferous, azoic and monotonous turbidites (Pomar 1979). The Carboniferous turbidites belong to the Tournaisian - Visean (Rosell and Arribas 1989).

The assemblage

The macroscopic observation of the stones used at the *opus sectile* seemed to suggest a great uniformity on the Paleozoic materials. Thus, these were the first to be approached.

On the other hand, given that Paleozoic materials are present both in Majorca and Minorca at this first stage, the field survey focused on the most large and easy to access ones, which are found at this second island[9]. Moreover, the existence of a Late Antique site at Illa del Rei, on the harbour of Maó (Minorca) where geometric pieces elaborated with grey/black stone very alike to the Pollentia *opus sectile* one were found also supported a possible origin in Minorca. Therefore, the field survey and sampling to locate potential geological sources centred on the north sector of Menorca (Fig. 4).

Eleven samples were petrographically analysed: five from the *opus sectile* of Pollentia, (three Paleozoic stones and two limestones), four from various outcrops of Minorca (three Paleozoic stones and 1 turbidite) and 2 Paleozoic stone fragments from Illa del Rei archaeological site (Table 1).

Methodology

The analysis consisted in the macroscopic characterisation with a stereoscopic binocular and the petrographic characterisation by optical microscopy by thin-section analysis using a Nikon Eclipse polarised light microscope 50iPOL. The microphotographs were taken with a Nikon Coolpix 5400 camera attached to the microscope using a Nikon Coolpix MDC Lens adapter.

In order to achieve the objectives the following steps were followed:

– Sampling and petrographic characterisation of the materials used to form the *opus sectile*.

– Geological field survey, sampling and petrographic characterisation of Minorcan paleozoic materials compared with the ones used for the *sectile*.

– Comparison of the samples from the *opus sectile* with reference samples. The Paleozoic materials were compared with geological like samples collected in Minorca in order to confirm or dismiss a possible Minorcan provenance for the archaeological samples.

Additionally, the white limestones from the *opus sectile* were also petrographically analysed as a first step of their study. It consisted in trying to identify the limestones that crop out at the Balearic Islands (especially Majorca), which have been widely described at the geologic literature, that could be their potential source area.

7. See previous footnote.

8. Gelabert (1998) notes the existence of one single outcrop. It is mainly formed by dark pelites alternated with sand levels, greywackes and microconglomerates. In the sand levels, there is occasional parallel lamination. These materials are affected by subparallel to stratification schistosity, although the degree of visible metamorphism is very low or almost inexistent (Rodríguez-Perea and Ramos 1984; Fornós and Gelabert 1995).

9. Indeed, the Paleozoic outcrops at Mallorca are significantly smaller and on areas of very difficult access (seashore high cliffs).

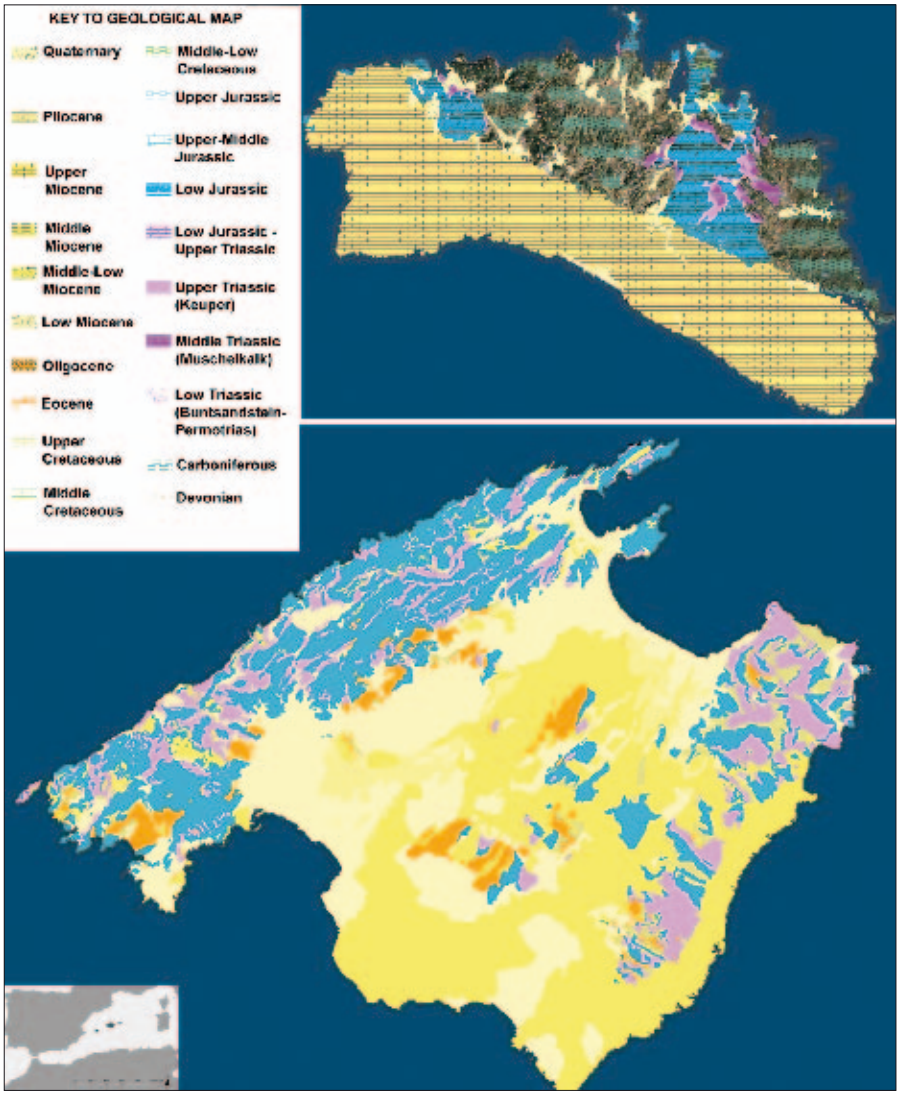

Fig. 4. Geological map of Majorca (below) and Minorca (above).

Sample	Type of stone	*Locus* of finding or sampling	Observations
POL-0458	Lutite	Pollentia, SU 6379, Majorca	Archaeological sample (floor tile, *opus sectile*)
POL-0459	Lutite	Pollentia, SU 6379, Majorca	Archaeological sample (floor tile, *opus sectile*)
POL-0460	Limestone	Pollentia, SU 6379, Majorca	Archaeological sample (floor tile, *opus sectile*)
POL-0461	Limestone	Pollentia, SU 6379, Majorca	Archaeological sample (floor tile, *opus sectile*)
POL-0462	Limestone	Pollentia, SU 6379, Majorca	Archaeological sample (floor tile, *opus sectile*)
MAO-0463	Phyllite	Illa del Rei, Maó, Minorca	Archaeological sample
MAO-0464	Phyllite	Illa del Rei, Maó, Minorca	Archaeological sample
MAO-10291	Phyllite	Illa del Rei, Maó, Minorca	Geological outcrop sample
CFV-10278	Phyllite	Favàritx Cape, Minorca	Geological outcrop sample
CFV-10279	Phyllite	Favàritx Cape, Minorca	Geological outcrop sample
CFV-10283	Phyllite	Favàritx Cape, Minorca	Geological outcrop sample

Table 1. Sampling of the materials from the *opus sectile* from Pollentia (Majorca), from several outcrops in Favàritx Cape (Minorca) and from the Late Antique site of Illa del Rei.

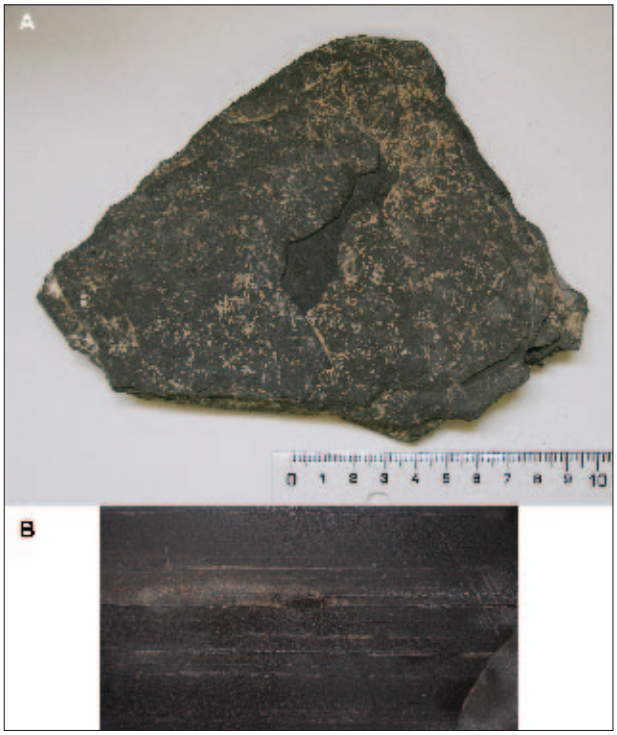

Fig. 5. Sample POL-0458: the *opus sectile* piece (A) and of its laminar texture (B).

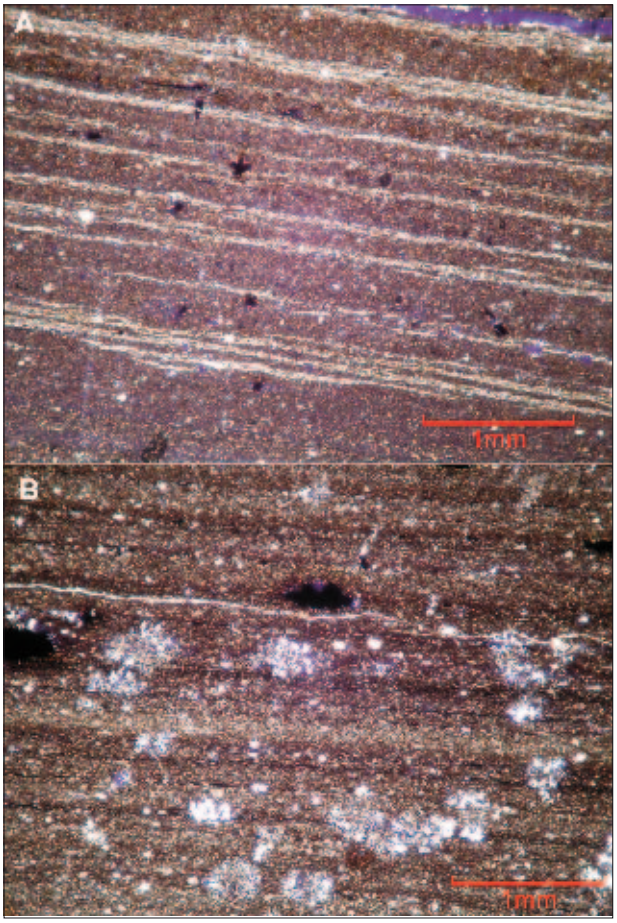

Fig. 6. Microphotograph of sample POL-0458 (A) and of sample POL-0459 (B); plain light.

Results

The analysis of black material (lutites) from the pavement of *opus sectile* (POL-0458 and POL-0459) (Fig. 5), reveals that the materials used are relatively homogeneous. From a macroscopic point of view, they can be described as a dark grey lutites with foliated texture. The thin-section shows a rectilinear and clear foliation. Quartz is arranged parallel to the foliation and it is present in small crystals and infilling veins. There are also occasional small muscovite-chlorite and biotite flakes parallel to the foliation. There are fracture planes infilled by secondary calcite, which evidences a diagenetic process. Sample POL-0459 shows sedimentary parallel bedding and some diagenetic silification with the formation of calcite and dolomite crystals (Fig. 6).

MAO-0463, MAO- 0464 and MAO-10291 samples, from the excavations of the Late Roman complex of Illa del Rei, show different traits. Sample MAO-0463 is a fine-grained phyllite with shiny mica flakes (muscovite) (Fig. 7, A) while the degree of metamorphism of sample MAO-464 locates it in an intermediate point between slate and a phyllite (Fig. 7, B). On the other hand, sample MAO-10291 presents features that belong to a phyllite-schist as it shows a slightly coarser grain size as well as larger and clearer mica flakes than the previous samples (Fig. 7, C).

Reference samples collected in Paleozoic outcrops from Favàritx Cape (CFV-10278, CFV-10279, CFV-10283) show significant differences compared to the archaeological material from Pollentia. Although they are not very homogenous, these are from more undulating and less penetrative foliation materials where, microscopically, a remobilization of the material that would indicate a hectic deposition of high-energy typical of turbiditic zones can be observed (sample CFV-10283) (Fig. 8). They all belong to the phyllite group.

Eventually, the petrographic features of the archaeological samples of Pollentia and their comparison with the reference materials of geological outcrops led to reject a provenance on the island of Minorca for the material used in our *opus sectile*.

On the other hand, the white tiles of the *opus sectile* were made of limestones with a very alike macroscopic appearance, despite the surface crust: a common, homogeneous beige colour. Sample POL-0460 (Fig. 9) is a fine and compact biomicritic limestone, according to Folk (1959, 1962) classification, and a wackstone according to Dunham (1962). The bioclastic content is composed by very thin plactonic bivalve shells (ostracods), which are common on the Mesozoic pelagic limestones. The matrix shows small rounded sparite areas (radiolarians mouldings). Similar materials have been described in Majorca by Alvaro *et al.* (1990) and were assigned to Jurassic. Sample POL-0461 (Fig. 10) is a fine-medium, heterogranular and compact microsparitic limestone. According to Dunham's (1962) classification, it is a grainstone and an intrasparite according to Folk (1959,

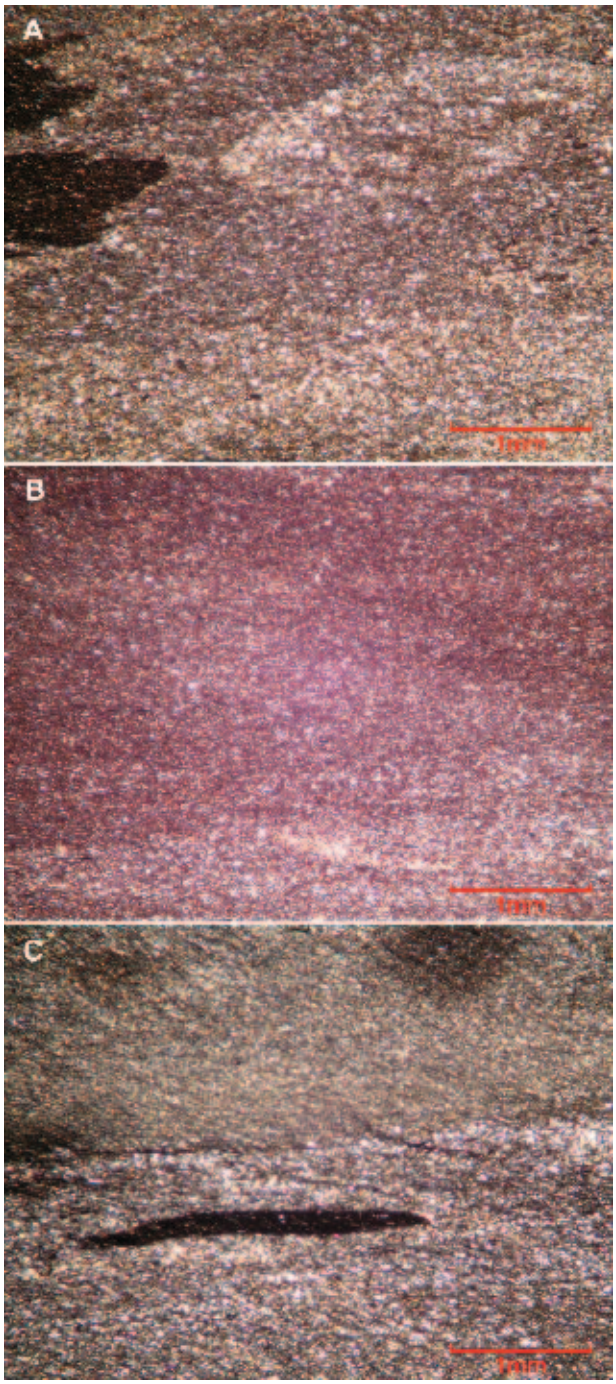

FIG. 7. Microphotograph of sample MAO-0463 (A), sample MAO-0646 (B) and sample MAO-10291 (C); plain light.

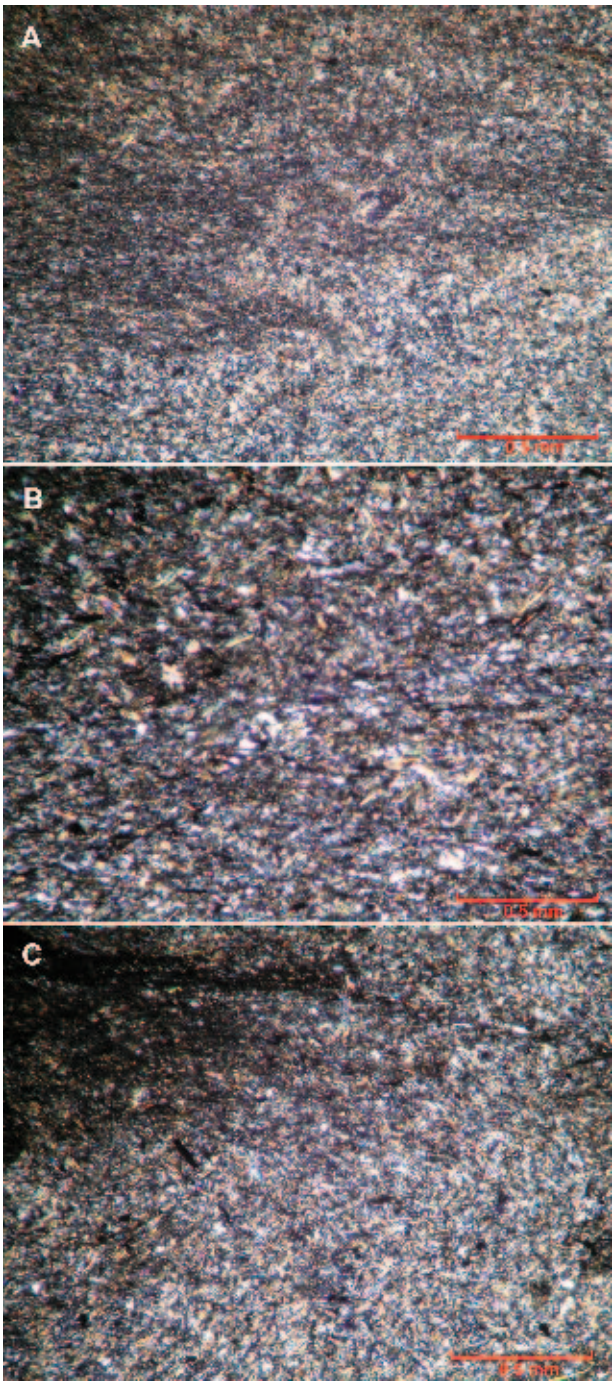

FIG. 8. Microphotograph of sample CFV-10278 (A), sample CFV-10279 (B) and sample CVF-10283 (C); crossed polars.

1962). It presents medium size dolomite crystals, well distributed throughout the matrix, and recrystallised bioclasts. The presence of nummulites enables to identify it as an Eocene limestone. These materials have been described by Ramos-Guerrero *et al.* (1990) as limestones from Galdent (Llucmajor, in southern Majorca). These limestones have a low amount of detritic minerals but abundant miliolids, echinoderms, algae as well as some nummulites. They belong to the Upper Priabonian.

In contrast, sample POL-0462 (Fig. 11) is a pelitic biosparite according to Folk (1959, 1962), and a grainstone according to Dunham's (1962) classification. The matrix is basically sparry with low porosity. The skeletal fraction consists primarily in pellets and abundant clasts of fossils, including simple miliolids, bryozoans, crynoids, algae and other remains of foraminifera. There are also some poorly rounded detrital quartz grains. The bioclastic fraction suggests that this material originated in an area of calm sea with low energy and movement. It belongs to the Cretaceous. In the Low Cretaceous materials of Majorca, there are similar stones (Valanginian-

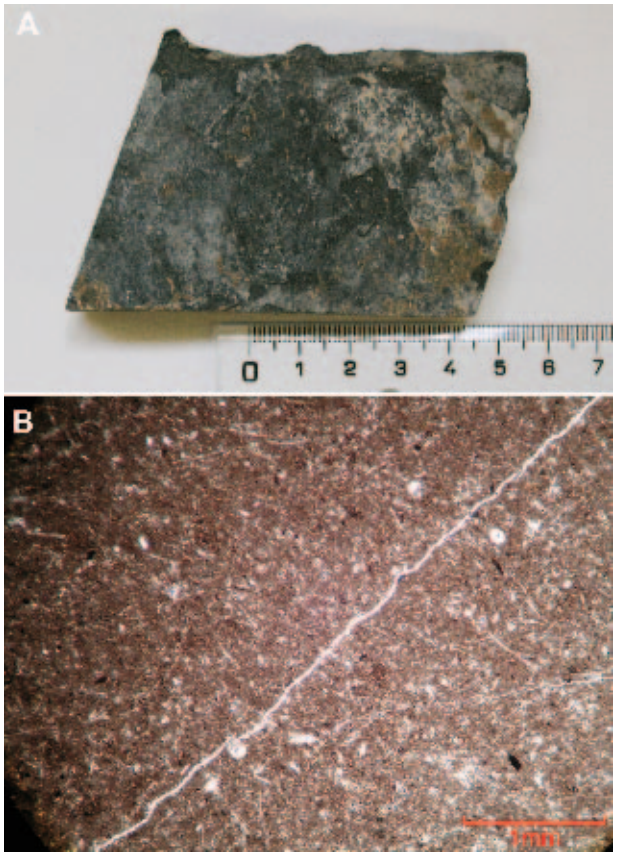

Fig. 9. Sample POL-0460: the *opus sectile* piece (A) and microphotograph in plain light (B).

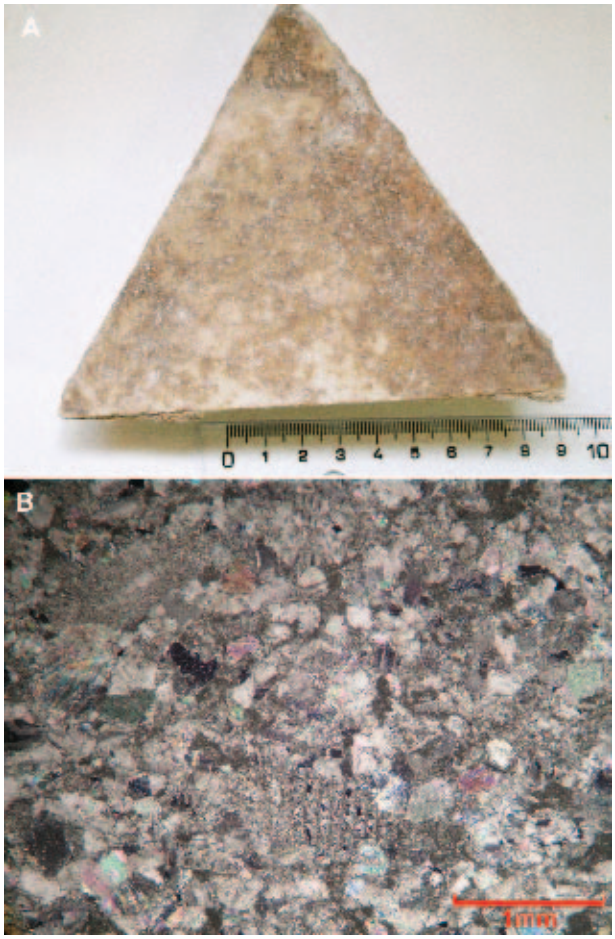

Fig. 10. Sample POL-0461: the *opus sectile* piece (A) and microphotograph in crossed polars (B).

Barremian of the Artà region, about 30 km east from Pollentia) (Folch 1986, 364-365).

The limestones used in this type of pavements have been commonly named by some scholars as palombino (Gnoli 1988; Borghini 1989; Guidobaldi and Guidobaldi 1983; Guidobaldi 1985, 2009; Price 2008). However, this name does not apply according to the composition and texture of the rock, but only to its external appearance.

Preliminary considerations

The analysis of black/grey samples from the *opus sectile* of Pollentia –and also from the Late Roma site of Illa del Rei (Minorca)– reveals that they are a set of different materials.

The samples collected in various points of the largest and most representative Paleozoic outcrop at the island of Minorca (Favàritx Cape) correspond to phyllites and therefore are significantly different from our *opus sectile* samples, that can be classified as lutites. Therefore, we must reject a Minorcan provenance for them and turn to the island of Majorca, where Paleozoic materials have been recently described, to check a possible provenance for the stones used at Pollentia. On the other hand, we must stress that the Paleozoic materials used at the Late Roman site of Illa del Rei (Minorca) and the geological samples from Favàritx Cape, also in Minorca, are very alike (phyllites).

Then again, the comparison of the white limestone triangular pieces used at the pavement of Pollentia and Majorca limestones, as described in the scientific literature, suggests that a local provenance is very plausible. Indeed, Ramos-Guerrero *et al.* (1990) describe Puig Galdent limestones as belonging to the Eocene (Upper Priabonian) and having traits that strongly resemble the overall features of sample POL-0461. Likewise, Álvaro *et al.*'s work (1990) enables us to match sample POL-0460 with the Jurassic materials of Mallorca. And last but not least, sample POL-0462 seems to belong to the Lower Cretaceous (Valanginian-Barremian) outcrops that exist at Mallorca (Folch 1986, 364-365, fig. 332).

Nevertheless, further research is needed to identify the source of these materials. Further analysis may help explain the processes and factors involved in their manufacture being one of them whether the raw material used to elaborate this *opus sectile*, that follows a widely-spread pattern, came (together with the pavement pattern) from distant territories or it was reproduced with local stones. Furthermore, if this pavement is of early Roman date, the possibility of these materials being of foreign origin is higher than if it is indeed a Late Roman pavement, when the distribution of *marmora*

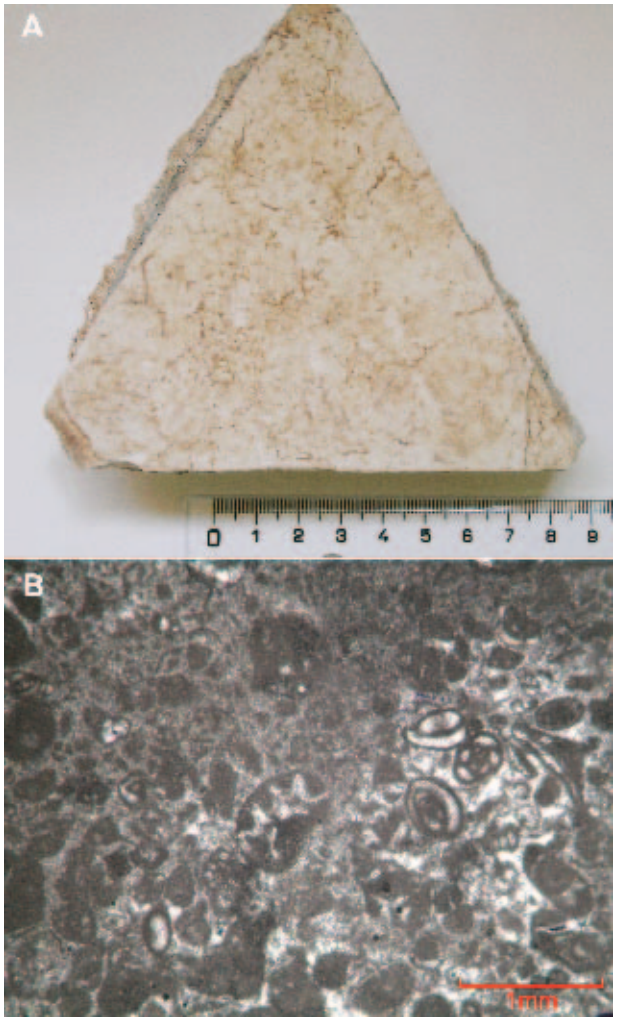

Fig. ii. Sample POL-0462: the *opus sectile* piece (A) and microphotograph in crossed polars (B).

throughout the Empire was less fluid. Thus, it is important to re-evaluate the dating of many of the similar pavements of Hispania take into consideration and to take into account whether their pieces are in a primary position or were reused in the Late Roman horizon[10].

Acknowledgements

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10. This problem has been very well addressed by F. Guidobaldi (2009, 398-399, footnote 91).

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