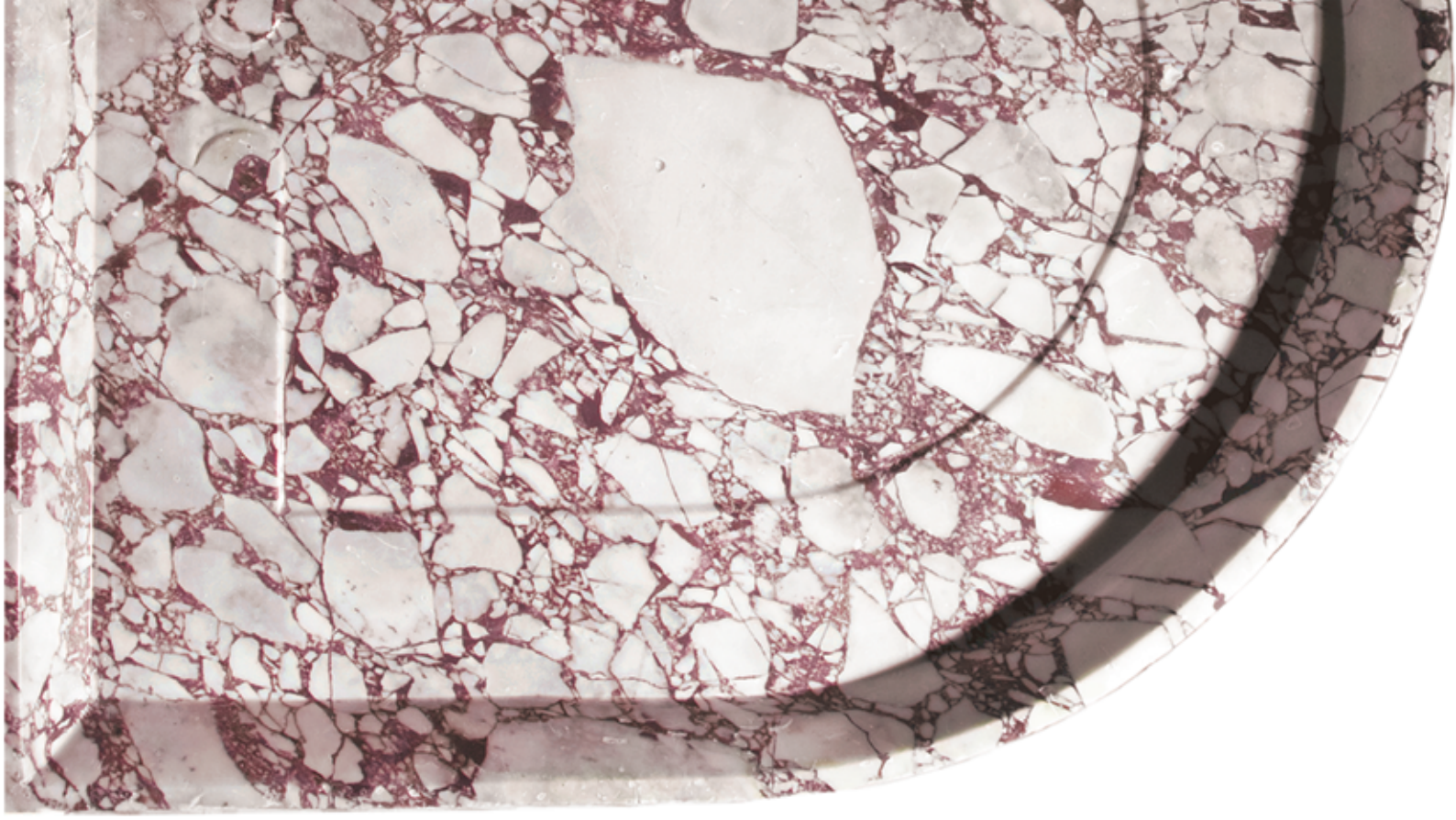
Building Materials and the Ancient Quarries at Thamugadi (East of Algeria), Case Study: Sandstone and Limestone

Rezkallah, Younès; Marmi, Ramdane



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CONTENT

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BUILDING MATERIALS AND THE ANCIENT QUARRIES AT *THAMUGADI* (EAST OF ALGERIA), CASE STUDY: SANDSTONE AND LIMESTONE

Younes Rezkallah[1] and Ramdane Marmi[2]
[1] École doctorale d'archéologie, Université de Paris1 Panthéon-Sorbonne, Paris, France
(younes.rezkallah@gmail.com)
[2] Laboratoire Géologie et Environnement, Université de Constantine 1, Constantine, Algeria
(marmi_ramdane@yahoo.fr)

Abstract

This research deals with the study of two types of building materials (sandstone and limestone) used in the Roman city of *Thamugadi* founded in 100 AD (the present Timgad), and the ancient quarries from which they had been extracted (inside a perimeter of 25 km). The fieldwork survey conducted in the ancient quarries of Thamugadi revealed sites that were previously unknown. Petrographic studies led to the identification of three sandstone lithotypes and five limestone lithotypes among the building materials sampled from fourteen monuments of the city. The survey of rock outcrops led to the identification of two main sandstone lithotypes and quarries: (T1) Djelfaoune and (T2) Mechta Rebaa. Nine limestone lithotypes and four main groups of open cast quarries or exploitation sites have been identified: Djebel Afia-Lambèse-Ain Drinn, Taouint Abderahman, Medjeba-Berbaga, and Lerdham-Elghar Nithviren-Ain Cherchar.

Keywords
building materials, *Thamugadi*, quarries

Introduction

The ancient Roman colony of Thamugadi (*Colonia Marciana Traiana Thamugadi*)[1], the present-day Timgad, is located 35 km to the east of Batna and 21 km to the east of Lambaesis (the present Lambèse) in northeastern Algeria. It was founded in 100 AD, by the emperor Trajan and the project was conducted by the third Augustan legion (L.III.A), commanded by Lucius Manatius Gallus (GSELL 1911).

A strategic location was chosen, not so far from the Roman road that connected Lambaesis to Theveste (present-day Tébessa). Six Roman roads cross at Thamugadi (Fig. 1).

It was built on a small plain with an average altitude of a thousand meters (1040 m in the north and 1080 in the south). The early settlers were probably about 250 persons and the original plan was a square of 360 m sides. Quickly it became a strong and prosperous colony, which grew speedily and became a famous city. From the first half of the second century, new buildings and monuments were constructed in the eastern and western suburbs, outside of the original plan (COURTOIS 1951; LASSUS 1966).

The archaeological site and its monuments are among the most famous and attractive sites excavated in North Africa[2]. Large studies have been devoted to them, and one can find a significant amount of literature devoted to these monuments. Unfortunately, that is not the case for the building materials. Studies of these materials are primarily focused on the building techniques and largely ignore the study of the materials themselves and their provenance (REZKALLAH 2003).

Moreover, the ancient quarries presented here and their materials remained unknown until the present work and were never studied before. These sites and other similar ones played an important role during antiquity and they should be inventoried and studied in order to take their own place in the archaeological atlas of Algeria (REZKALLAH 2017).

Geological view

Timgad is situated in the center of the sedimentary basin that bears the same name. In the geological series, the basin essentially belongs to the Cretaceous and the Neogene (Miocene and Pliocene); however, gypsiferous Triassic formations can be observed in some abnormal positions (MARMI 1995).

The rocks of the Cretaceous (Upper Cretaceous) are represented essentially by limestone and marls but

1 CIL.VIII.17842-43= ILS 6841.

2 The first excavations date back to 1880 and continued till 1955. The excavations results were regularly published, particularly in BCTH (Bulletin du Comité de Travaux Historiques et Scientifiques).

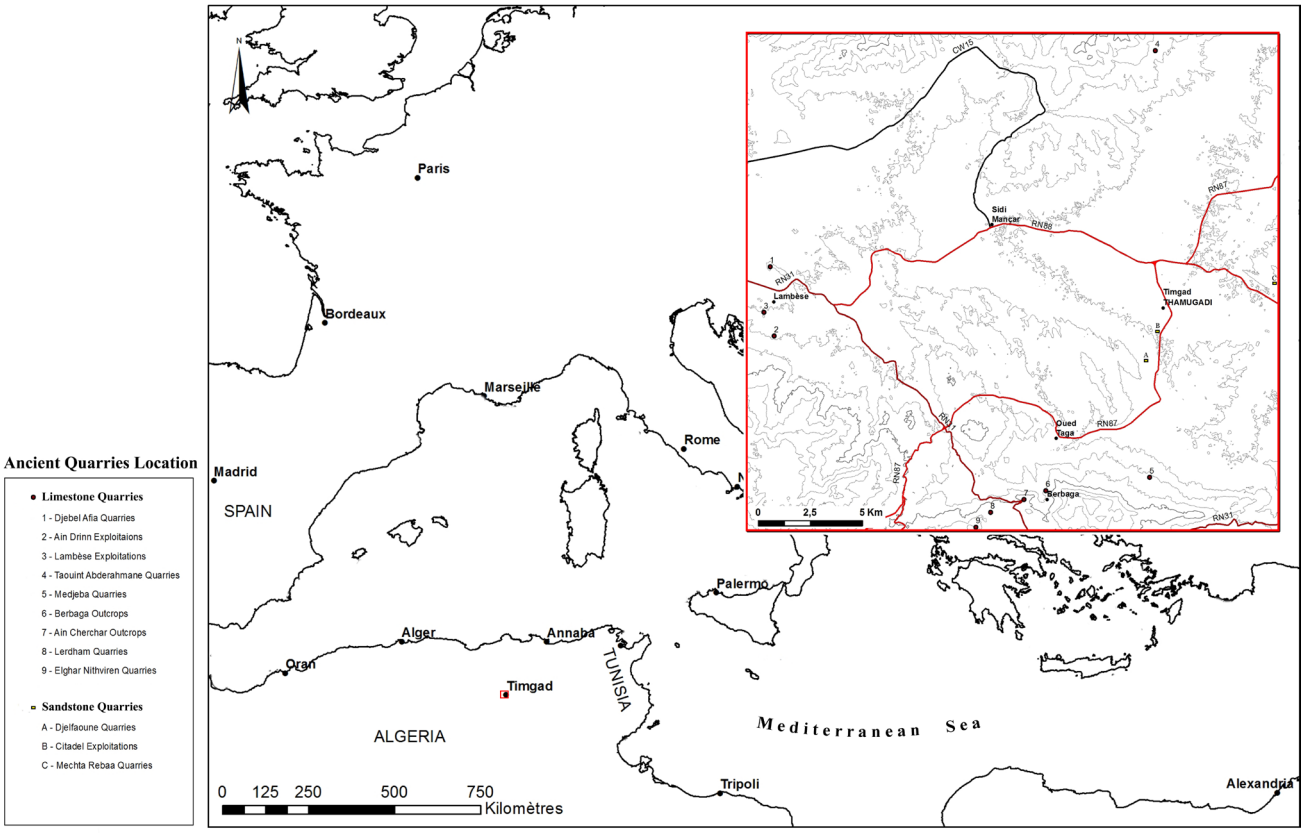


Fig. 1. The location of the ancient quarries of Timgad (ancient Thamugadi)

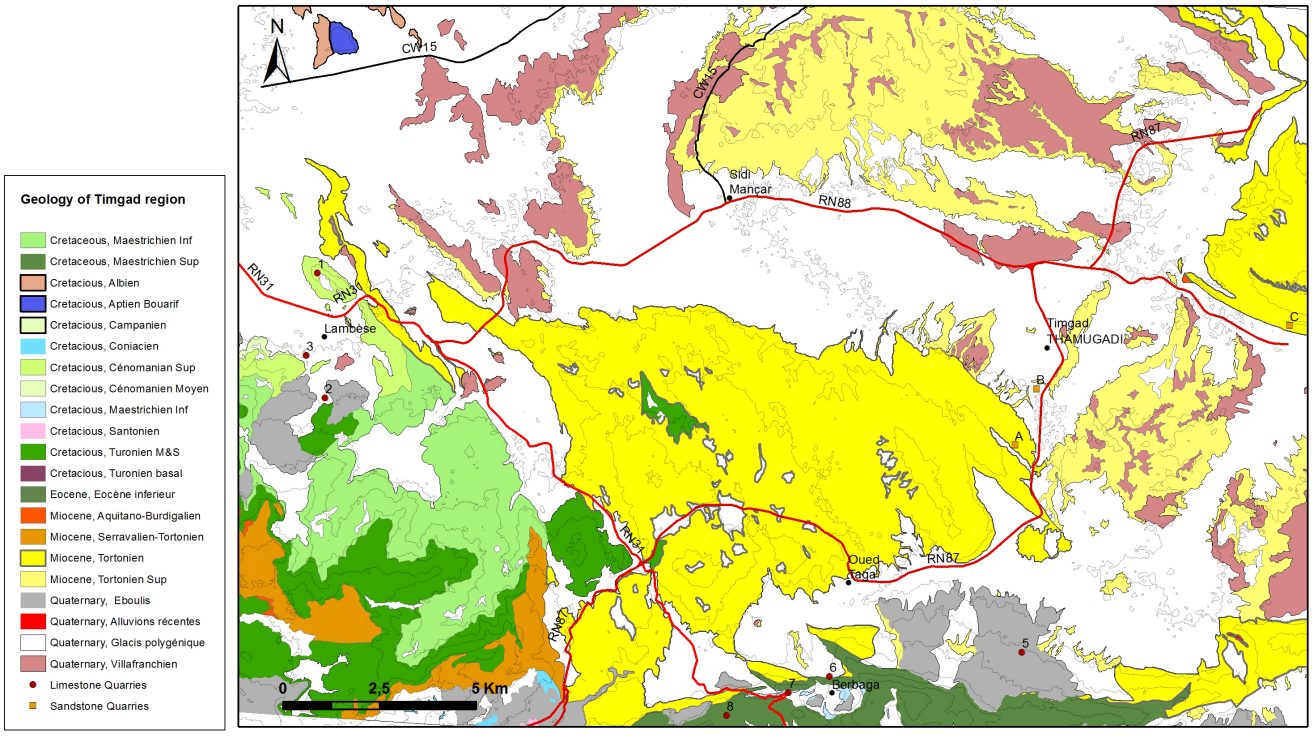


Fig. 2. Geological series in the Basin of Timgad

Fig. 3. The monuments concerned in the sampling and study of and building materials

Fig. 4. The Djelfaoune quarries and sandstone lithotype.
A - The Djelfaoune Sandstone quarries;
B1- Photomicrograph of the T1 sandstone lithotype: subrounded and heterogeneous quartz (PPL, X4);
B2- Iron oxides in T1 lithotype (NPL, x4)

Fig. 5. The Mechta Rebaa quarries and sandstone lithotype.
A - General view of the northern part of Mechta Rebaa quarries;
B1 - Photomicrograph of homogeneous quartz in the T2 lithotype sandstone samples (PPL, x2);
B2- Photomicrograph of the T2 lithotype sandstone with grains of glauconite (NPL, x4)

those of the Miocene are formed of clays and sandstones.

The brittle tectonics (faults, fractures, cracks) induced discontinuities in limestone and sandstone rocks, facilitating the exploitation and extraction of stone materials.

The two main building materials discussed in this paper are abundant near Thamugadi: sandstone in the immediate vicinity of the site and limestone located a few kilometers around the city (Fig. 2).

Archaeological monuments

Due to the large amount of monuments known at Thamugadi, only a few of them have been chosen for this project. Thus, fourteen monuments were selected for the current research (Fig. 3). Then, a selective sampling of sandstone and limestone building materials was done in each monument.

Fig. 6.
General view of the limestone quarries, extraction sites and outcrops around Thamugadi.
A: Djebel Afia quarries;
B: Ain Drinn outcrops and exploitations;
C: Lambese exploitations;
D: Opencast quarries of Taouint Abderahmane;
E: Eastern extraction site in Taouint Abderahmane (red marmoreal sandstone);
F: Medjeba opencast quarries;
G: Berbaga outcrops;
H: Ain Cherchar outcrops;
I: North-western part of Lardham opencast quarries;
J: Elghar Nithviren limestone quarries (Site 2)

The present study concerns the following monuments: a part of the northeastern primitive wall of the colony, the Capitol, the Theatre, the southern great baths, the library, the Curia, the eastern small baths which occupy insula no. 79, tinsula 01, insula 11, insula 12, insula 72, the Cardo maximus, the Decumanus maximus and the forum. The three last sites have provided three different limestone samples of pavement slabs. This concerns the bluish gray limestone of the Forum, bluish limestone including fossils of the two main streets intra-muros (Cardo and Decumanus maximus), and the red marmoreal limestone collected from the scattered pavement in the courtyard of the Capitol. All these monuments date from between the 2nd and 5th century.

Quarries and extraction sites

In order to identify the ancient quarries and extraction areas near Timgad, we conducted an archaeological survey on the outcrops of sandstone and limestone, using a 25 km perimeter around the ancient city (Fig. 1).

The mapping of the ancient quarries in the region was carried out systematically at the same time as the outcrops were surveyed. A limited budget and time constraints led to the use of a simple GPS (Garmin e-trex version) for mapping quarries, extractions, and sampling sites. Currently, a total of fourteen sites have been identified, and further surveys will probably extend this number. With regard to site selection, there are two

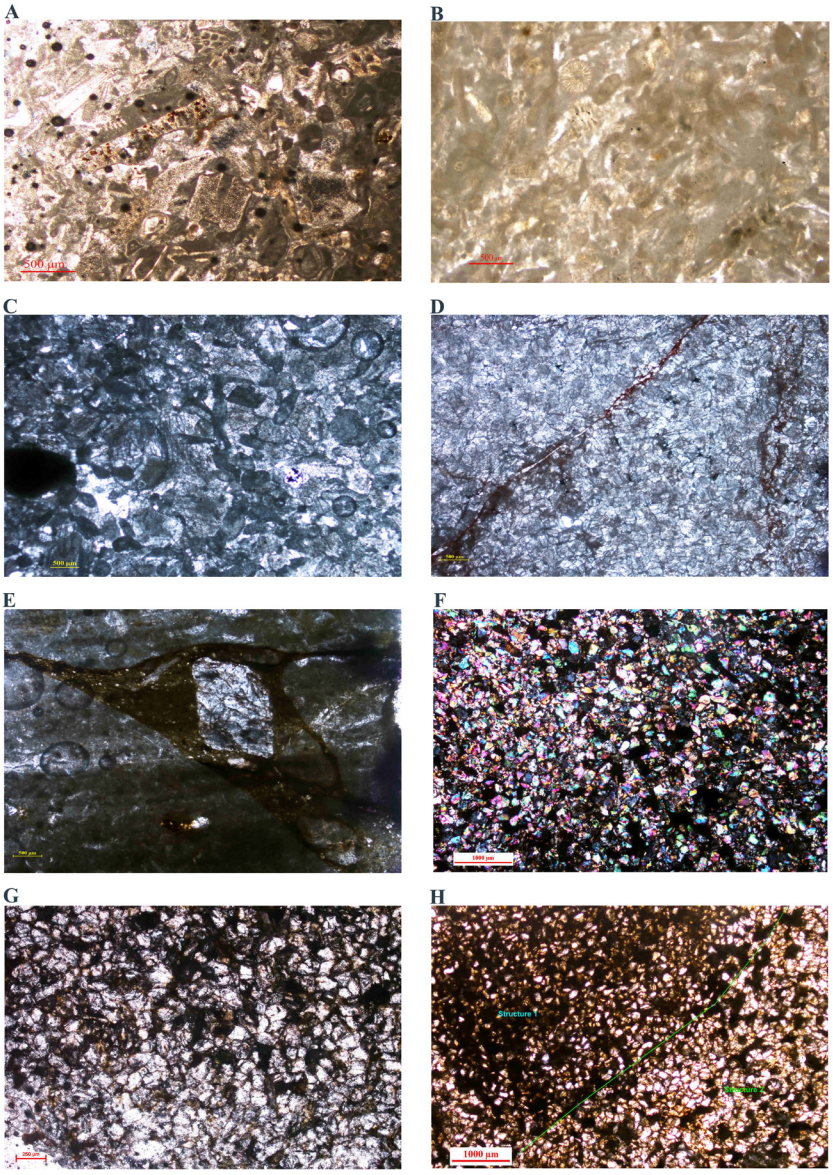


Fig. 7.
Photomicrographs of thin sections of building materials from Thamugadi:
A: Bioclastic limestone C1, full of bryozoans and echinoderms (PPL, x2);
B: Fossil-rich limestone C2 with rounded elements (NPL, x2);
C: Elongated and rounded elements, and calcite spots in the C3 limestone lithotype (NPL, x2);
D: Dolomitic microcrystalline limestone C4, with isometric crystals (NPL, x2);
E: The marmoreal blue limestone C5, with rhombohedral crystals (NPL, x2);
F: Sandstone lithotype G1, with heterogeneous quartz (PPL, x2);
G: Sandstone lithotype G2, with homogeneous quartz (NPL, x2);
H: Laminated sedimentary structures, alternating fine and relatively coarse grains of quartz in the G3 lithotype (NPL, x2)

issues worth mentioning here: 1) unfortunately, some areas remains inaccessible and dangerous; 2) the second, is that the assistance of the local population and some shepherds were of great help to us, as they - more than anyone else- know the outcrops surrounding the ancient city extremely well.

Two main sandstone quarries were identified: Djelfaoune, 2 km in the direction of the south-west and Mechta Rebba, 7 km to the north-east. One small extraction site was also discovered near the Byzantine citadel. The microscopic examination conducted on the samples showed that the rocks are identical as those at Djelfaoune. As the sites are near to each other we prefer to associate them with the same quarries (Djelfaoune) (Fig. 4A).

The common element to these sites is that the sandstone consists of laminated layers or strata that are separated by thin stratification joints. The average thickness of beds in the Djelfaoune quarries is about 60 cm, while the range of thickness in Mechta Rebaa varies from 30 to 60 cm. This natural stratification allows the rock beds to cleave horizontally and offers cutting facilities to the stone cutters. The inclination of the sandstones bed rocks in Mechta Rebbaa probably offered supplementary facilities (Fig. 5A).

The survey of limestone outcrops allowed the identification of four main groups of open cast quarries and exploitation sites, located a few kilometers around the ancient city (Fig. 6).

The first is the Lambèse group, located 21 km to the west of Thamugadi, and it is represented by two separate sites: the quarries located at the top of Djebel Afia (Fig. 6A), with metric beds, dated to the Upper Cenomanian; the ancient exploitations of Ain Drinn (Fig. 6B) and Haute Lambèse (Fig. 6C), belonging to the Middle-Upper Turonian, located 2.5 km south-west of the Roman military camp of Lambaesis.

The second group is located 23 km to the North of Timgad, and includes the quarries of Taouint Abderahman (Fig. 6D) and extraction sites of the same locality (Fig. 6E). Opened in the Marly limestone outcrops belonging to the Upper Cenomanian, this is also characterized by metric beds.

The third is situated 7-10 km south of the city, and includes the Medjeba opencast quarries (Fig. 6F) and Berbaga outcrops (Fig. 6G). These strata are not indicated on the geological map of Tazoult, since that is a small-scale map on which it is difficult to register all the small details. These are probably of Upper Coniacian age.

The fourth group concerns the open cast quarries of Lerdham (Fig. 6I) and Elghar Nithviren (Fig. 6J), in addition to the outcrop of Ain Cherchar (Fig. 6H). According to the geological map of Tazoult, it appears that this group belongs also to the Cretaceous, and is identified as crystalline massif limestone aged to the Upper Maestrichtian (VILA 1977).

In most cases here, the limestone beds are crossed by vertical and horizontal cracks, giving a lot of facilities for extracting blocks, particularly in the Lardham open cast quarries, where the natural polygonal blocks only need to be dressed to be ready for use (Fig. 6I).

Macroscopy and petrography

The different types of samples of building stone samples were inspected with the aid of a magnifying glass on fresh breaks. This method allows 5 to 15 times magnification, which helps in the identification of some textural details, the selection and making a primary typology classification of samples (COUTELAS 2003).

The thin sections prepared from these samples were analyzed systematically under a polarizing microscope. The thin sections of the samples collected in the monuments of Thamugadi were compared with those prepared from the stone samples that come from the ancient quarries. This method was already applied by other scholars to the study of ancient stones and tesserae (BUGINI, FOLLI 2009; LAPUENTE, TURI *et al.* 2009)

Results and discussion

The mineralogical approach through the petrography of the thin sections prepared from the building materials sampled in the monuments of Thamugadi led to the identification of three sandstone lithotypes (G1-3) (Fig. 7F-G) and five limestone lithotypes (C1-5) (Fig. 7A-E). These lithotypes are discussed in more detail here. The samples collected in the ancient quarries and outcrops allowed the identification of two sandstone lithotypes (T1) for Djelfaoune (Fig. 4B1-B2), and (T2) for Mechta Rebaa (Fig 5B1-B2), each lithotype being paired with the appropriate one identified in the building materials of Thamugadi. The nine limestone lithotypes (Q1-Q9) that were identified in the quarries and outcrops are summarized at the end of this paper (Fig. 8).

Lithotype G1, named light yellowish sandstone on the basis of visual examination, shows a joined middle to coarse grain size quartz under the microscope. The grains are heterogeneous but generally subrounded, although unusual angular grains were also observed. The presence of some glauconite grains and traces of iron oxides were also detected (Fig. 7F). This lithotype is represented essentially by the dressed stone used in the squared-stone masonry of the Capitol and the Theatre. We observe it also in the vertical lacing dressed stones and rubble stones of walls in *opus africanum* of the southern great baths, library, eastern small baths, insula 72, Theatre and Capitol. The petrographic comparisons of the samples collected in the Citadel extraction site and Djelfaoune quarries, show a great resemblance in their structure and mineralogical composition with this lithotype. There is no doubt that G1 sandstone, which constitutes the stone most used as building material in the studied monuments, was extracted from the further quarries, situated near the site. Indeed, this lithotype corresponds perfectly to the first sandstone lithotype T1, identified in the samples collected from the Djelfaoune and Citadel extraction site, as both have the same structure and compounds (Fig. 4B1-B2). As in G1, the grains are also subrounded and heterogeneous, with iron oxides traces and glauconite.

Lithotype G2, or the dark yellowish sandstone, is slightly different in its color from G1, but it is difficult to differentiate them. However, petrographic examination shows homogeneous grains of quartz and scattered glauconite. The elements are fine grain size and subrounded torounded (Fig. 7G). Iron oxides are present as traces as in G1. The G2 lithotype is found in the vertical slab stones used for the separation between the upper and lower stands of the theatre, and in the building of some external parts of walls in *opus mixtum* in the insulae 11 and 12. The samples of squared rubble used in the construction of the primitive wall of the colony also show the same material. As in the case with lithotypes G1 and T1, the concordance between G2 and T2 recognized in the samples of Mechta Rebaa quarries is clear (Fig. 5). The T2 lithotype shows the same size and subrounded to rounded homogeneous quartz, with scattered glauconite and iron oxide traces (Fig. 5B1-B2).

Geologically, the inclination of the strata on the outcrops is an advantage for extracting great slabs, and probably such detail would not have been be ignored by Roman architects (Fig. 5A).

The third lithotype, G3, is a brown sandstone, characterized by laminated sedimentary structures,

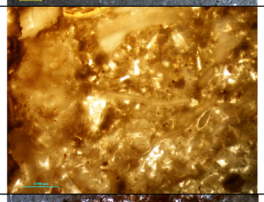
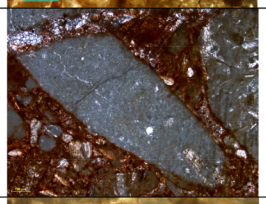
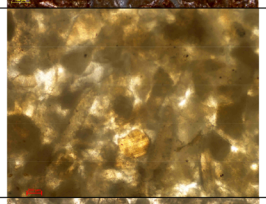
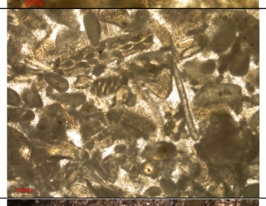
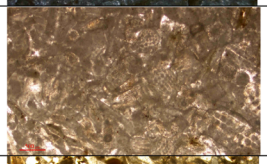
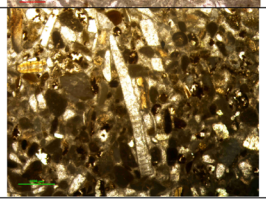
Simplified Name	Origin & Map Location	Litho-type	Microscopic definition	Geological age	Identification in building materials	photomicrograph
Bluish hard Limestone	Djebel Afia Quarries (n°1)	Q1	Micritic Limestone with calcite recrystallization filling the microcracks	Upper Cenomanian	No	
Gray Limestone with Fossils	Ain Drinn and Lambèse Exploitations (n°2 and 3)	Q2	Bioclastic Limestone with Annelids	Middle-Upper Turonian	No	
Marmoreal Red Limestone	Taouint Abderahmane Quarries (n°4)	Q3	Microconglomerate Limestone with ferruginous facies	Superior Cenomanian	No	
Bluish Gray Limestone of Taouint A.	Taouint Abderahmane Quarries (n°4)	Q4	Bioclastic Limestone with spherical elements	Superior Cenomanian	No	
Bluish Gray Limestone of Medjeba	Medjeba Quarries (n°5)	Q5	Bioclastic Limestone with Biseriates	Upper Cenomanian	No	
Bluish Gray Limestone Of Berbaga	Berbaga Outcrops (n°6)	Q6	Bioclastic Limestone with Bryozoans	Upper Cenomanian	lithotype C1 (Pavement Slabs Cardo & Decumanus Maximus)	
Whitish Beige Limestone of Ain Cherchar	Ain Cherchar Outcrops (n°7)	Q7	Bioclastic Limestone with Large Debris of Lamellibranches	Upper Maastrichtian	No	
Bluish Gray Limestone of Aghrout Lerdham	Lerdham Quarries (n°8)	Q8	Bioclastic Limestone Rich with Fossils and more or less Rounded Elements	Upper Maastrichtian	Lithotype C2 (Pavement Slabs from Forum)	
Whitish Beige Limestone of Elghar Nithviren	Elghar Nithviren Quarries (n°9)	Q9	Bicolastic Limestone with Calcite Ranges	Upper Maastrichtian	Lithotype C3 (rubble stones from Insulae 12 & 72, Library and Capitol	

Fig. 8. Limestone lithotypes from the quarries of Timgad region: summarized results

alternating fine and relatively coarse grains of quartz (Fig. 7H). The iron oxides are more important than in the two previous types, explaining the brown color of this stone.

This type of stone is attested in some blocks used in insula 01, Curia and foundations of the external wall of the Capitol. Unfortunately, no extraction site for the G3 lithotype can be proposed as no matching lithotypes were found.

Five limestone lithotypes (C1-5) were identified among the samples of building materials collected in Thamugadi.

The first one, C1, is the bluish limestone including fossils (Fig. 7A). It is a bioclastic limestone, full of bryozoans, echinoderms, gastropods, sea urchin spines and lot of rolled oolithic elements. It was used as pavement slabs for the two main streets (Cardo maximus and Decumanus maximus) and as rubble stones for the small masonry in the library. These bioclasts are comparable to those observed in the bioclastic limestone sample of Berbaga Q6, but the rounded elements are not comparable (Fig. 8). This means that no final conclusion can be drawn based on the current data. Further thorough surveys in these outcrops and, if possible, in the northern upstream of Djebel Bouarif, could lead to a positive conclusion about the origin of this lithotype.

The second lithotype, C2, is a bluish gray limestone. It is also a bioclastic stone, and - like C1 - is rich with fossils, but the other elements here are more or less rounded than in C1 (Fig. 7B). The samples of this type come either from the pavement slabs of the Forum, or from some rubble stones of the southern great baths and insula 72. This lithotype shows similarities with the fossil contents of lithotype Q8, belonging to Aghrout Lerdham open cast quarries (Fig. 8). Based on these results, we think that Aghrout Lerdham produced the stone slabs used for paving the Forum.

The third lithotype C3, is a whitish beige colored bioclastic limestone. It is represented essentially by rubble stones sampled from the external wall of the Capitol, from small masonry walls in insulae 12 and 72, the library, and in the eastern small baths. These rubble-stones are fragmentary parts of architectonic elements, such as capitals or columns, reused here for building purpose. Under the microscope, this type is characterized by elongated and rounded elements, and calcite spots (Fig. 7C). The comparison of this type with the thin sections of stones collected in the ancient quarries and limestone outcrops, shows that it looks like the bioclastic limestones of Elghar Nithviren Q9 (Fig. 8).

The C4 lithotype was identified in samples of the red marmoreal limestone, which was used as pavement slabs in the courtyard of the Capitol. The microscopic examination shows a dolomitic microcrystalline limestone, with automorphic and isometric crystals. It contains microfissures filled out with calcite and iron oxides. No fauna or bioclastic elements can be observed here (Fig. 7D).

The marmoreal blue limestone sampled from fragments of columns, reused as small blocks in the Capitol, offers another lithotype C5, which is a bioclastic limestone including very coarse elongated shell debris. Impregnated with few iron oxides and contains rhombohedral crystals, it is probably a dolomite (Fig. 7E).

Unfortunately none of the nine lithotypes found in the ancient quarries and limestone outcrops correspond to these two last types.

Conclusion

The sampling done in the selected monuments of Thamugadi did not provide definitive results about all the different varieties of stones used for building in this Roman colony. However, it did allow for the identification of the two main stone varieties used either for building or paving. The sandstone was frequently used as building material (dressed stones, slabs, blocks and rubble) and as pavements of secondary street, while the limestone was widely used for paving the two main streets, also the Forum, and in rare case as rubble.

The historians and archaeologists think that the choice of this site for a colony was dictated by military considerations, such as the strategic features of the site and the abundance of water resources. Considering the important use of the sandstone in the buildings, the abundance of those materials extracted in nearby quarries and the extraction facilities offered by the outcrops, we conclude that the geology also influenced that choice

The fieldwork surveying conducted in the ancient quarries of Thamugadi revealed sites that were previously unknown. The petrographic and laboratory studies led to the identification of the Djelfaoune and Mechta Rebaa sandstone quarries that provided the city with two different varieties of rocks.

Among the ancient limestone quarries identified, only Aghrout Lerdham and Elghar Nithviren seem to have furnished limestones to the city. As the identified building materials that belong to Elghar Nithviren lithotype are represented by reused fragments of architectonic elements, we think that this quarry was exploited for this reason (architectonic elements). The limestone variety of the Berbaga outcrops shows some similarities with the bluish limestone used for the pavement slabs of the Cardo and Decumanus maximus.

Further geochemical investigations (chemical analysis, stable isotops, etc) and mineralogical ones (X-RD) will complete the present study and bring new elements for the ancient stones database of the region.

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