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Multicolored Mosaic Tesserae Used in the Girmil Church, East Gerasa, Jordan: A Microfacial Analysis and Provenance Determination

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Abstract

The present research aims at investigating the provenance of the tesserae of the Girmil Church located to the southeast of Gerasa, north Jordan. Six colored tesserae representing the five colors forming the mosaic floor images were collected and investigated both macroscopically by lenses, and microscopically by a polarized-light microscope to determine their lithology and microfacies. The six samples are two tesserae of a very pale brown (white) color of two sizes and four tesserae of yellow, strong brown, bluish black and dusky red colors. Because of the absence of geochemical databases on the rocks of the region, the collected data was compared to the published data on the limestone lithology and microfacies of the Gerasa area. The results show that the mosaic tesserae were most likely of local limestone sources, and they agree well with previous research results that examined the source of mosaic tesserae of ancient churches. They might also indicate the appropriateness of the local stones to design the mosaic floors irrespective of whether the churches were built inside or outside the city center. It is likely that Gerasa mosaics at that time were designed by the same mosaicists, or by mosaic products of the same workshop.

Keywords: Mosaic Tesserae, Girmil Church, Gerasa, Provenance, Miocrofacies.

1. Introduction

Provenance studies of archaeological materials are among the major fields of archaeological science, conservation, and art history. Mosaic floors and other building stones represent some of the widespread archaeological materials that have remained well-preserved since antiquity. Although considerable provenance studies were mainly focused, during the past decades, on archaeological white and colored marbles used in the archaeological sites of Jordan, little attention was paid to the provenance of mosaic and other building stones. Al-Bashaireh (2011), Al-Bashaireh and A-Housan (2015), Al-Bashaireh and Bedal (2017), and Al-Bashaireh (2018) analyzed white and colored marbles from different archaeological sites in Jordan aiming to determine their provenance. The results indicated that all the high quality marbles used for building or carving sculptures were imported mainly from Asia Minor or Greece. Al-Bashaireh and Lazzarini (2016) study of the basalt and granite columns used in the Cruciform church of Abila (north Jordan) concluded that the basalt was local, while the granite was imported from Asia Minor. In Jordan, studies of mosaics have only focused on their artistic, archaeological and conservation aspects (Nassar and Al-Muheisen, 2010; Turshan, 2010; Nassar, 2013; Arinat, 2014 and 2016). Haddad (1999) investigated mosaic production technologies and the sources of the raw materials used in their construction at both Madaba and Yajouz (Jordan) during the Byzantine period. She used petrographic analyses to compare mosaic tesserae with limestone samples collected from the limestone outcrops' surroundings of the two cities. She concluded that the most common stone used for the mosaic floors was the local limestone because of its suitable hardness, solidity, and multiple colors.

Khrisat et al. (2011) proposed a comprehensive approach for the conservation of the mosaic floor of the saints Cosmas and Damian Church built in 533AD. Petrographic analyses of the tesserae, which were performed to characterize and conserve them properly, indicated their local geologic source. Hamarneh (2015) investigated the provenance of mosaic tesserae scattered at different parts of the Qasr Mushatta (built around 743-744 AD), by petrographic and scanning electron microscopic analyses. Her results indicated that the tesserae were made of local limestone.

The most common and efficient method that was performed to match mosaic tesserae to their quarries is the microfacies characterization (Flügel and Flügel, 1997; Flügel, 1999, 2004; Tasker et al., 2011; Šmuc et al., 2017). Moreover, combined petrographic and geochemical analyses were performed (Capedri et al., 2001; Allen and Fulford, 2004).

This research examines the provenance of tesserae samples collected from the mosaic floor of Girmil Church located about 2.5km to the east of Gerasa, Jordan (Figures 1 - 2). The analysis of the provenance of the tesserae samples sheds light on the production technology of the mosaic floor, contributes much to the understanding of the use and trade patterns of raw materials in mosaic manufacture, and helps select appropriate stones to repair and conserve the mosaic floor. In addition, it will enhance the knowledge whether the peripheral regions of Gerasa managed the same natural

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resources utilized at the city center. The current research represents a collaborative study between the disciplines of archaeology, archaeometry, conservation, and geology that allowed the provenance analyses of the tesserae based on their macro- and micro-facies.

2. Mosaics of Girmil Church

The church is located at the Girmil area, which is a local name given to the place, about 3kms to the east of Gerasa and few hundred meters to the north of the small village of Hud (Figure 1).

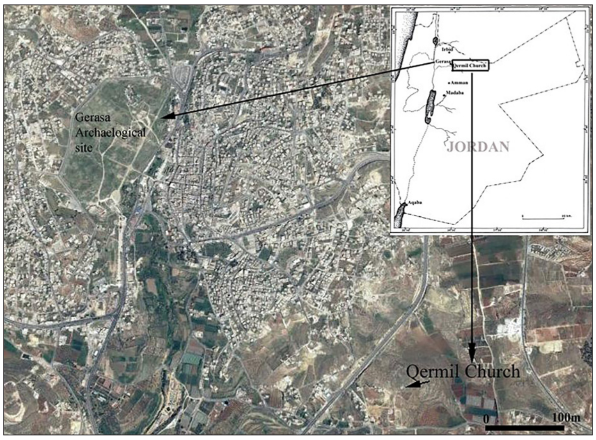

Figure 1. Location map of Gerasa and Girmil Church.

Figure 2. The mosaic floor of the Girmil Church and below: the plan of the site including the church (Photos courtesy of Dr. Harahsheh).

The church was uncovered by a salvage excavation directed by the Department of Antiquities of Jordan after extensive archaeological thefts (Harahsheh and Abu Azeizeh 2014). The church is surrounded by different archaeological features including walls, water cisterns and wells, graves carved into solid rocks, small quarries, etc. It is most likely that the church was destroyed by the 747AD earthquake, while its stones were reused in agricultural activities such as fencing. The church is composed of one hall and a rectangular apse measuring 15m long and 6m wide, in addition to other adjacent rooms from the west. According to the archaeological artifacts uncovered, the site was used during several periods starting from the Roman till the Islamic periods.

Based on an inscription uncovered in front of the nave, the mosaic floor was added as a donation in 591AD (Figure 2). It occupies an area of 48m^2 (8mX6m) and is beautifully decorated with human, floral, faunal, and geometric designs of several colors: very pale brown or yellowish white, yellowish brown (commune) or strong brown, yellow, brick red or dusky red, and dark grey (black) or bluish black (Harahsheh and Abu Azeizeh, 2014).

3. Brief Description of the Geology of Gerasa Area

The whole area of Gerasa is covered with sedimentary rocks of the Early to Late Cretaceous age (Figure 3). Most of these rocks are carbonates and belong to Ajlun and Belqa Groups. Outcrops of the Kurnub Group form the basal part of the Cretaceous sequence, and consist mainly of clastic fluvial quartz sandstones with yellowish, shallow, sandy marine carbonates and marly sandstone intercalations at the top of the sequence (Quennell, 1951). The Ajlun Group overlies the Kurnub Group and comprises five shallow marine carbonate formations of marl to limestone lithologies (Masri 1963). These five formations are arranged from the bottom (oldest) to the top (youngest) as follows: Naur nodular Limestone, Fuheis Marl, Hummar cavernous dolomitic recrystallized Limestone, Shuayb Marl, and Wadi As Sir Limestone.

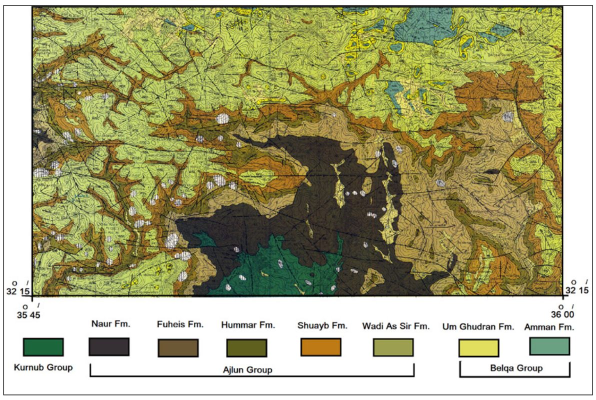

Figure 3. Geological map of the Gerasa area (after Abdelhamid, 1995).

Naur Formation is about 180m thick, and forms three limestone units of grey to yellowish grey marly, fossiliferous (Echinoids and Bivalves) medium to a massive micritic bedded limestone. It mainly outcrops at the area of the Gerasa archaeological site and its surroundings. Fuheis Marl, which overlies Naur Limestone is about 70m thick. It consists of yellowish grey to greenish grey marls intercalated with a nodular fossiliferous limestone, containing Bivalves (Pelecypods), Gastropods, and burrows. Hummar Limestone consists mainly of pink to yellowish grey micritic recrystallized fossiliferous (Bivalves, Gastropods and Forams) dolomitic limestone and ranges in thickness from 40 to 50m. Shuayb Marl overlies the Hummar Formation, and is mainly made of 65m thick yellow to yellowish grey fossiliferous (Bivalves, Gastropods, Forams and Ammonites) marl to marly limestone beds. Wadi As Sir Limestone has a thickness ranging between 70m at the center of the area and 150m at its northwestern parts. The limestone varies from dolomitic at its lower part, to marly at its middle part, and micritic at its upper part. It contains a variety of fossils including Pelecypods, Ammonites, and Gastropods.

The Ajlun Group is overlain by upper Coniacian-Santonian chalks and marls of the Belqa Group (Powell, 1989). It includes mainly deep marine carbonate rocks such as chalk, phosphatic limestone, chert and bituminous marl. The Belqa Group is of the Late Cretaceous to Paleogene age, and is formed of the following formations arranged from the bottom (oldest) to the top (youngest) as follows: Wadi Umm Ghudran Chalk, Amman silicified Limestone, Al-Hisa phosphatic Limestone, Muwaqqar Chalk-Marl, Umm Rijam Chert Limestone. A comprehensive description of the aforementioned formations is given by Powell (1989) and Schulze et al., (2005).

The Wadi Umm Ghudran Chalk is the basal formation of Belqa Group that overlies the older Ajlun Group. It is about 35m thick of yellow to white-grey locally pink grey fossiliferous chalk to chalky limestone with chert concretions near the top of the formation. It contains different types of fossils and fossil fragments including fish fragments, shark teeth, Pelecypods, Ammonites, and Forams. Amman Silicified Limestone and Al Hisa Formation are not differentiated. They consist of 50m to 70m thick of intercalations of chert beds, silicified limestone, limestone, and phosphatic limestone, which contain Ammonites, Forams and Pelecypods. Lenses of Tripoli are found occasionally in the silicified limestone beds.

Both Muwaqqar Chalk and Umm Rijam Limestone are not exposed in the area of the archaeological site, but outcrop poorly in the northeastern corner of the Gerasa geological sheet (Abdelhamid, 1995).

4. Material and Methods

Mosaicists used small and large tesserae of different colors to design the Girmil mosaic floor. Sampling was restricted to six tesserae; only one tessera of each color and one large white tessera were used. The samples were taken from a small dig (lacuna) at the southeastern edge of the mosaic floor in order to maintain its aesthetic values and integrity. The large white tessera was collected from the scattered white large tesserae alongside the south wall of the church. The color of the tesserae was determined by naked eyes and Munsell colour charts, and the macroscopic features were observed with lenses.

Thin sections were prepared at the workshop of the department of Earth and Environmental Sciences, at Yarmouk University, and studied by optical microscopy (OM) using a Leica 600 polarized light microscope to observe and describe their microfacies types, and classify them accordingly. The classification of carbonate rocks forming the tesserae followed the nomenclature of Dunham (1962).

Because of the absence of geochemical or/and mineralogical databases of the limestone rocks of Jordan, in particular colored rocks, the results and the collected data of the tesserae are compared to published charts, maps, and literature about the geology and microfacies of the sedimentary rocks of the Gerasa area including Bender (1974), Abdelhamid (1995), Abed (2000), schulze et al. (2005) and Abu-Jaber et al. (2009) in order to identify the provenance of the limestone tesserae of the mosaic floor.

5. Results and Discussion

The tessellatum layer does not contain glass or ceramic but limestone tesserae. The tesserae have five colors (given below): very pale brown or yellowish white, yellowish brown (commune) or strong brown, yellow, brick red or dusky red, and dark grey (black) or bluish black. The first and the sixth tesserae are of the same yellowish white limestone, but differ in their sizes which range from small ($1cm^3$) to large (2x2x1.5) cm^3. The tesserae examined are formed of limestones, generally micritic and mostly fossiliferous. The major fossils observed are microscopic Foraminifera, Gastropods, and Bivalves (Pelecypods), while the minor fossils observed are Echinoderms. In some cases, fragments of unidentified species (ghosts) were common. The petrographic description of each individual tessera is presented schematically below based on the sample's number.

Sample 1. Macroscopically, the tessera is a pale yellowish white (10YR 8/1 (very pale brown) homogeneous limestone. Microscopically, the limestone tessera is a micritic wacketone, where the fine micrite (matrix) constitutes about 80% of the slide, and the grains form the remaining 20%. The grains are heterogeneous, randomly scattered, and mainly formed of Forams and shell fragments with some pellets (pelloids). The most shells noticed are Bivalves (or Pelecypods) which vary in size up to 2mm (Figure 4A-B). Fissures are filled with recrystallized sparitic calcite, and partially with well-developed dolomitic rhombs. The absence or very low amounts of impurities (e.g. iron oxides) which, most probable, caused the sample's white color are remarkable. These microfacies are very compatible with the those of the Late Cenomanian Shuayb Formation characterized by the presence of planktonic Forams of globular forms, and an occasional presence of yellowish patches of an organic material; see Schulze et al. (2003): Figure 5, MFT15. These features indicate that Shuayb Formation (Late Cenomanian) is the most likely source of this tessera.

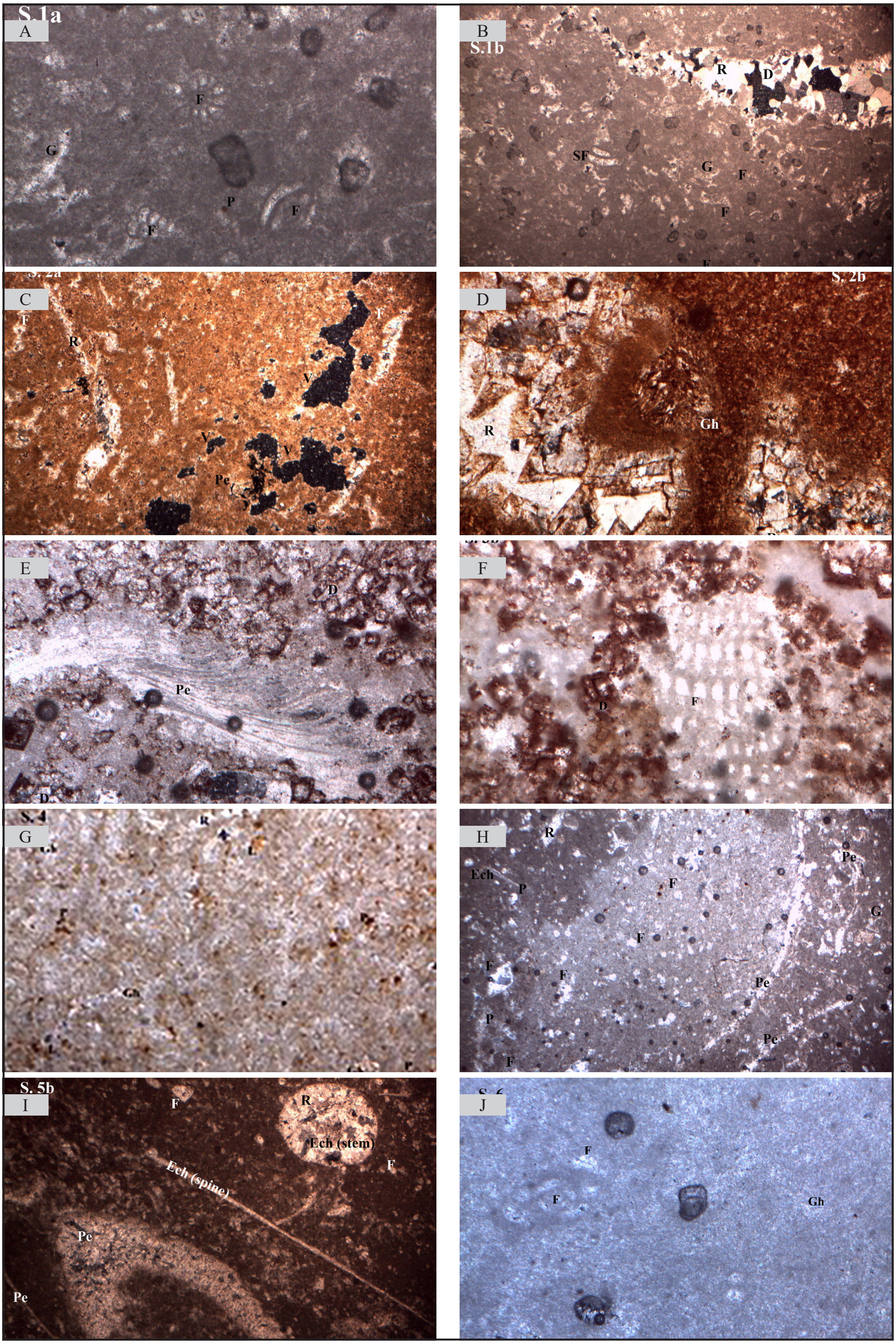

Figure 4. Microphotographs of Girmil tesserae showing the micritic limestone of tesserae and their content of fossils and recrystallized calcite and dolomite rhombs. Sample 1 (4A and 4B), sample 2 (4C and 4D), sample 3 (4E and 4F), sample 4 (4G), sample 5 (4H and 4I), and sample 6 (4J).

Sample 2. Macroscopically, the tessera is a commune or (7.5R 4/6 strong brown), homogeneous limestone. Microscopically, the sample is a micritic wackestone where about 80% of the sample is made of the fine micrite (matrix), and plenty of voids or vuggs filled with a secondary calcite (Figure 4C - D). The sample shows several voids partially filled with dolomitic rhombs forming a cavernous dolomitic limestone. The recrystallized sparite, in many cases, reflects the shape of Pelecypod shells. The sample has Forams and other obliterated fossils and fossil fragments (Ghosts) due to digenetic processes of the rock's material including dolomitization and dissolution which formed the voids. The sample has a mixture of iron oxides present in the form of limonite and hematite forming the commune (strong brown) color. All of these microfacies are similar to those of the Early Cenomanian Naur Formation characterized by a vuggy texture, recrystallization of the micritic matrix (groundmass), and the abundance of Forams and Pelecypod shell fragments; see Schulze et al. (2005: Fig. 4, MFT1 and MFT2), , and Abu-Jaber et al. (2009: 72-74).

Sample 3. Macroscopically, the tessera is a brick red (10R 3/4 dusky red) hard limestone. Microscopically, the sample is a dolomitic limestone of a brick-red color. Dolomitization produced dolomite rhombs randomly-scattered in certain zones of the micritic matrix. The matrix forms about 60% of the sample, while the benthic Forams, Pelecypods of different lengths, up to more than 1mm, and Dasycladacean Algae fossils (Figure 4E-F), form the rest of the sample. The brick-red color of the sample is most likely caused by the fine ferric oxide (Hematite Fe_3O_4) particles dispersed in the fine matrix. All of these diagenetical features and microfacies indicate a clear origin of the tessera from the Hummar Formation of Early Turonian which is characterized by a red color wackstone to a packstone, intensive dolomitization, cavernous texture, and the presence of Echinoids, benthic and planktonic Forams, and other fossil fragments; see Schulze et al., 2005: Figure 4, MFT6, and Abu-Jaber et al., 2009: 72-74, and Figure 7.

Sample 4. Macroscopically, the sample is a yellow colored (10YR 8/6 yellow) compacted limestone. Microscopically, it is formed of a homogeneous marly micritic wackstone. The fine micrite forms about 60% of the sample, and the rest is filled with fossils and fossil fragments. Diagentic processes caused the recrystallization of the micritic matrix into sparite which obliterated most of the sample's fossils, forming unidentified fossils (ghosts). The presence of fine particles of limonite (hydrated iron oxide), dispersed in the matrix, most likely produced the sample's yellow color. The severe diagenetic changes of the sample's materials and fossil content prohibit tracing it back to its exact source, i.e limestone formation. However, the sample's marly composition, richness in fossils (although altered), and yellowish iron oxide strongly indicate the Shuayb or Fuheis Formation as a source of this tessera since both have similar features (Abed, 2000; Schulze et al., 2005; Al-Tamimi et al., 2001; Abu-Jaber et al., 2009: 72-74).

Sample 5. Macroscopically, the tessera is a dark grey to black or grey (2-2.5/5PB bluish black) compacted limestone. Microscopically, the sample is formed of a homogeneous micritic fossiliferous packstone, where the fine matrix makes about 50% of the sample, and the recrystallized sparite fills the voids and replaces the shells' material. In addition to the presence of organic matter and pellets, Forams, Pelecypods, and Echinodal, fragments of stems and spines are the most grains present in the sample. Some Pelecypods and Echinoidal fragments are about 5mm long (Figure 4H -I). It is worth noting that planktonic Forams are more abundant than the benthic ones. The abundance of planktonic Forams indicates a deeper marine depositional environment which preserved the dark colored organic (bituminous) matter, and has, most likely, generated the tessera's black color. These microfacies are consistent with the Late Cenomanian Shuayb Formation formed of a micritic wackstone to Packstone which comprises large Echinoidal fragments, Gastropod, and Ostracod fragments. In addition, it is dominated by Pelecepod (Bivalve) fragments. The sample's microfacies (Figure. 4H -I) are similar to those of Shuayb Formation presented in Schulze et al. (2005: Figure 5, MFT11 and MFT12).

Sample 6. Macroscopically, the tessera is a pale yellowish white (10YR 8/1 very pale brown) and homogeneous compacted limestone. Microscopically, the sample is a micritic homogeneous massive wackstone. Micrite forms about 85% of the sample, and is affected by diagenetic processes including dissolution and recrystallization. While the dissolution of the micrite formed micro voids, its recrystallization into sparite of different sizes has obliterated most of the sample's fossils forming unidentified fossils (ghosts) (Figure 4J). However, benthic Miliolids and planktonic Forams were observed. It is most likely that the absence or low amounts of fossils and impurities of iron oxides in the sample produced its yellowish white color. The similarity of these microfacies to those of the Early Cenomanian Naur Formation, most likely, indicates that this formation is the provenance of this tessera; see Schulze et al. (2005: Figure 5, MFT7). Naur Formation is a micritic wackstone characterized by the abundance of Peloids, shallow-water benthic Forams such as Miliolids, and the characteristic Chrysalidina Gradate form (Schulze et al., 2005: 508, Abu-Jaber et al., 2009: 72-74).

The different colors of the limestone tesserae depend on their textures and compositions. The bituminous micrite and content of fossils are the reason behind the dark grey or black color, while the absence of impurities (mainly iron oxides), and low amounts of bituminous materials make the limestone brighter and yellowish white. Besides, the different types of iron minerals dispersed in the fine matrix of the limestone tesserae form a variety of colors from yellowish brown to brick red (or dusky red). In fact, the limonite mineral (hydrous basic iron oxide) produces yellow colors, and the hematite (iron III oxide) produces brick red or dusky red colors, while the presence of both limonite and hematite produces the yellowish brown (commune) colors.

The similarity of the results of the present study to those of the study of Khrisat et al. (2011) perhaps suggest that mosaicists utilized the same local raw stones for the construction of mosaic floors of both churches despite their locations inside the archaeological center or the rural Girmil site. The mosaic tesserae of the Girmil Church are well-preserved suggesting a high quality for the stones, which are hard and of low porosity. It is most likely that the presence of multi-colored and high quality limestones, which outcrop within the Gerasa area, provided suitable choices of raw materials for the construction of mosaic floors. The limestone formations used for the tesserae have similar characteristics and outcrop in different locations in the Gerasa area such as Suf and Asfour (Abu-Jaber et al., 2009); therefore, it is not possible, with the present data, to determine the exact quarries that produced the studied tesserae. An ongoing project, which is still in its initial stage, suggests a distinction between Gerasa limestone quarries by geochemical characterization. The success of this new project will help determine the exact location of each kind of tessera, by matching their geochemical signatures.

The spread of Christianity during the Byzantine period and the construction of new churches probably increased the demand for, and the production of mosaic tesserae. It is possible that this pattern of mosaic production and this class of artifacts indicate that specialized workshops or craftsmen cut these tesserae, and skilled mosaicists constructed the mosaic floors.

5. Conclusions

This research is concerned with the application of microfacies characteristics to the question of mosaic stones provenance. The microfacies of six tesserae representing the stones of the mosaic floor of the Girmil church, in southeast Gerasa, revealed their local source. The limestone formations of the Ajlun Group (Shuayb, Naur, Hummar, and Fuheis), dating from the Cenomanian till Turonian and covering the Gerasa area, are most likely the source of the tesserae samples. Two of the tesserae are distinguished by their dusky (brick) red and the bluish black colors owing to their content of iron oxide (Hematite) and bituminous matter, respectively. They and the yellow and strong brown tesserae are used to design the faunal, floral, and geometric decorations in the white background of the mosaic floor made of the white tesserae.

The results show that the local rock sources were capable of supplying all the necessary colored raw material which the mosaicists of the Girmil Church required to design the mosaic floor. The results of this study concord with those of Khrisat et al. (2011) and Hamarneh (2015); see the introduction. Both studies concluded that local limestone sources were used in the production of the tesserae of the saints Cosmas and Damian Church built in 533AD at the archaeological site of Gerasa and the Qasr Mushatta built around 743-744 AD. The use of local sources to produce the tesserae concords with the abundance criterion which assumes that the majority of a collection of archaeological materials found in an archaeological site are usually made locally of local raw materials. The results reveal that the peripheral region of Girmil managed the same natural stone resources utilized at the city center because of the presence of raw materials in the Gerasa area and the close distance of Girmil to the Gerasa center. The use of similar materials probably indicate that the same mosaicists were involved in the construction of the Gerasa churches inside or outside the city center, or the presence of central mosaic workshops that provided the same products for the construction of mosaic floors. However, recent data do not support these theories, which require a more detailed research.

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