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Determination of the Type and Origin of Stone Tesseras Used in Antiochian Mosaics, Museum Hotel Example

Hatay Mozaiklerinde Kullanılan Taş Tesseraların Türü ve Kökenin Tespiti, Müze Otel Örneği

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Abstract

This study was carried out to determine the type and resources of stone tessera taken from parcel no 4642 (Museum Hotel) mosaics in Hatay province. Archaeometric analysis was performed on 60 tessera samples belonging to 6 different mosaics. In the scope of the study, color analysis, P-XRF and petrographic thin section optical microscopy analysis were performed on tessera samples. As a result of the analyzes, the color components of the tesserae were documented. According to the results of P-XRF analysis; main, artifact, transition and presence of rare earth elements were determined. At the same time, because the majority of tessera is composed of limestone, it is determined that there are high Ca elements in their structures and these results support the results obtained by petrography analysis.

According to petrography analysis; the majority of the tessera are limestone, siltstone, clay stone and radiolarite rock species and just one rock type is not determined. It is concluded that these rock types are found in Antakya and surrounding of the region. When the tissue characteristics of tesserae samples were evaluated, it was seen that the tesserae belonging to the limestone species had micritic and sparitic texture and the other rock types had crystalline and clastic texture. When the hardness levels of tesserae samples were examined, it was found that the hardest tesserae was tesserae of the radiolith rock type (4,5- 5 mohs) and the others were generally (2- 3 mohs).

Keywords: *Antioch, Museum Hotel, Mosaic, Color Analysis, P-XRF, Petrographic Analysis.*

Öz

Bu araştırma Hatay ili 4642 nolu parselde (Müze Otel) ele geçen mozaikleri oluşturan taş tesseraların türü ve kökeninin tespit edilmesi amacıyla yapılmıştır. Araştırma kapsamında izinli olarak alınan 6 mozaiğe ait toplam 60 adet tessera üzerinde renk analizi, P-XRF ve petrografik ince kesit optik mikroskop analizi gibi arkeometrik analizler yapılmıştır. Ayrıca P-XRF analizi sonuçlarına göre; ana, eser, geçiş ve nadir toprak elementlerinin varlığı tespit edilmiştir. Aynı zamanda tesseraların büyük çoğunluğu kireçtaşından oluştuğu için yapılarında oldukça yüksek oranlarda kalsiyum (Ca) elementinin olduğu belirlenirken bu sonuçlar petrografik ince kesit optik mikroskop analizi ile elde edilen sonuçları destekler niteliktedir.

Petrografik ince kesit optik mikroskop analizine göre; tesseraların büyük çoğunluğunu kireçtaşı olduğu az sayıda tanetaşı, silttaşı, kiltaşı ve radyolarit kayaç türünden oluştuğu ve bu kayaç türlerinin araştırma alanı olan Antakya ilçesi ve civarında bol miktarda bulunduğu sonucuna ulaşılmıştır. Tessera örneklerinin doku özellikleri değerlendirildiğinde, kireçtaşı türüne ait tesseraların mikritikve sparitik dokuya sahip oldukları, diğer kayaç türlerinin ise kristalize ve kırıntılı bir dokuya sahip oldukları görülmüştür. Tessera örneklerinin sertlik derecelerine bakıldığında, en sert tesseranın radyolit kayaç türüne ait tesseranın olduğu (4,5- 5 mohs) diğerlerinin ise genel olarak (2- 3 mohs) sertliğinde olduğu tespit edilmiştir.

Anahtar Kelimeler: *Antakya, Museum Otel, Mozaik, Renk Analizi, P-XRF, Petrografik Analiz.*

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This research was conducted with the aim of determining the type and origin of the stone tesseras of the mosaics found in the parcel no. 4642 of Hatay province (Museum Hotel). Although Hatay is considerably rich in terms of mosaics, it has been observed that the studies on mosaics are not at a sufficient level in the literature. We believe that this study on the mosaics found in Hatay shall also contribute to filling such gap in the literature.

Color analysis (chromametric analysis), Portable X-ray Fluorescence Spectrometer (P-XRF) analysis and petrographic analysis, which are among the types of archaeometry analysis, were conducted on tesseras within the scope of this research. As is known, the science of archaeometry provides information about the structural, chemical components of the materials obtained through archaeological studies such as all kinds of structures, artifacts, tools, etc. and enables us to attain significant knowledge about the type and origin, the period to which it belongs or was made of the material that is examined.

The aim of this study is to determine the types of stone tesseras used in Hatay Mosaics and to have information about the possible sources of stones. Such archaeometry studies increase our knowledge about mosaics and is also conducted successfully with the development of archaeometry in Turkey (Akyol - Kadıoğlu 2011: 265-281).

Historical Background and Examples of the Selected Mosaic

The mosaics found in the Hatay region generally date back to the Roman and Early Byzantine periods (Hopkins 1948: 91). These are the artifacts made during the Antonine Dynasty and the Severan Dynasty between the 2nd and 3rd centuries AD in which especially the classical and competent artifacts of Roman art were produced (Hatay Valiliği 2011). During this period, the number of mosaic artifacts and the areas covered by them increased considerably. In that period, the Roman villas, baths and other public buildings were almost completely decorated with mosaic artifacts. Covering the triclinium floors of the Roman villas, which were the foremost among civilian buildings, with mosaics was a tradition in those years.

The subjects used in mosaics were generally inspired by mythology and literature. Dionysus and his procession are the most depicted among the Gods. Another feature of the mosaics of this period is that the opus tesselatum or opus sectile technique was used in the background and overall, while the opus vermiculatum technique is used in emblema and designs (Dunbabin 1999: 298).

The mosaics from which the subject of the study referred to as tesseras were taken, are obtained through a total of 6 mosaic artifacts found in the Museum Hotel construction area in Antakya city center. One of these artifacts belongs to the Roman period and the others date back to the Early Byzantine period between the 5th and 6th centuries AD The mosaics were generally made by using the opus tesselatum technique and geometric patterns (Fig. 1).

Material and Method

Material

Necessary permissions have been taken from the Hatay Archaeology Museum Directorate in order to sample and to conduct research.[1] Samples were taken

1 We would like to thank Mrs. Nalan Çopuroğu Yastı and Mrs. Demet Kara for providing permission for the allowing this study.

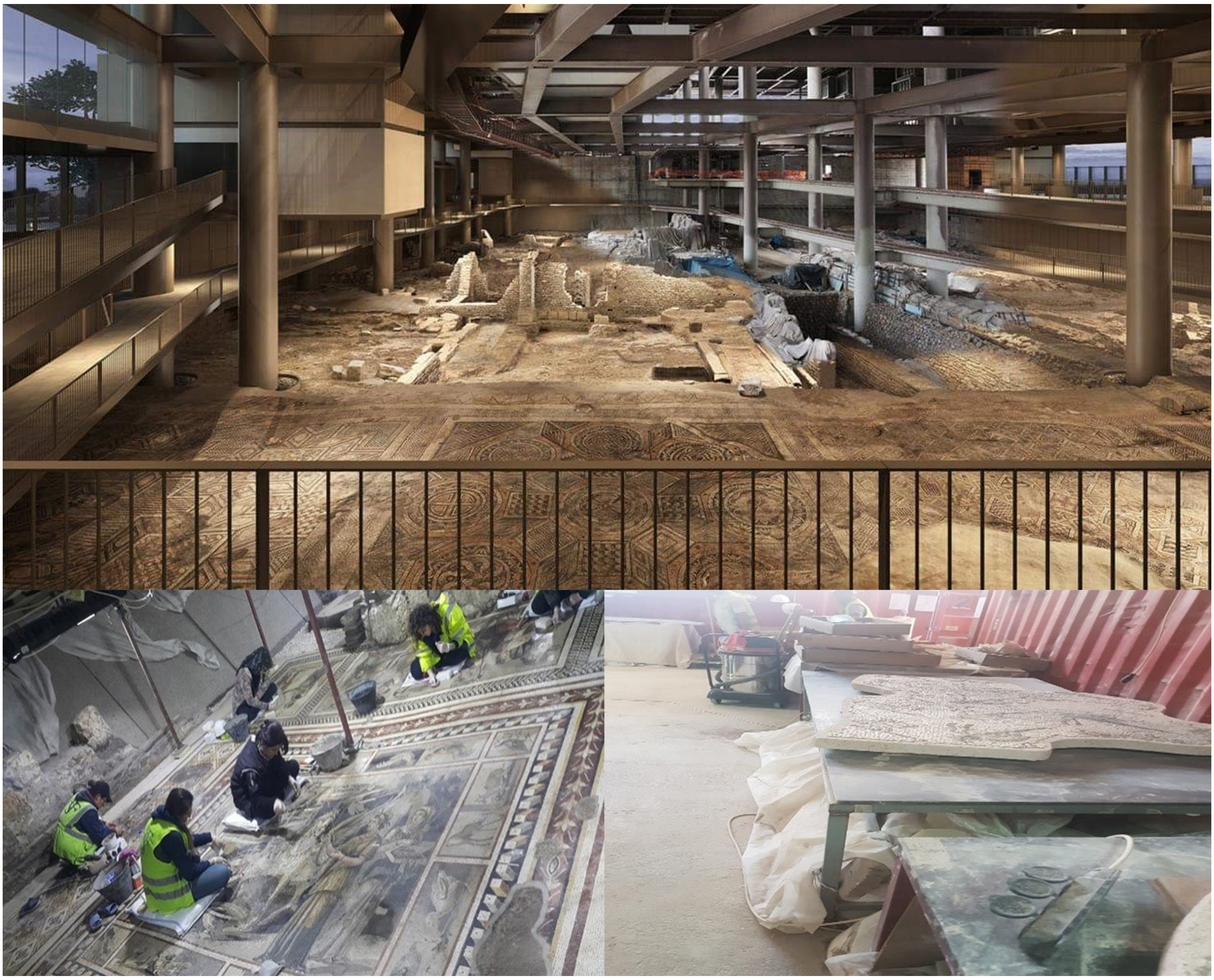

Figure 1
Mosaics in Hatay Museum Hotel.

from the tesseras obtained from amorphous mosaics in the excavation area and classified as shown in Figure 2. While collecting the samples, attention was paid to obtain representative samples from different mosaics and regions and different colors. The total number of tessera samples taken and analyzed is 60 (Table 1, Fig. 2)[2].

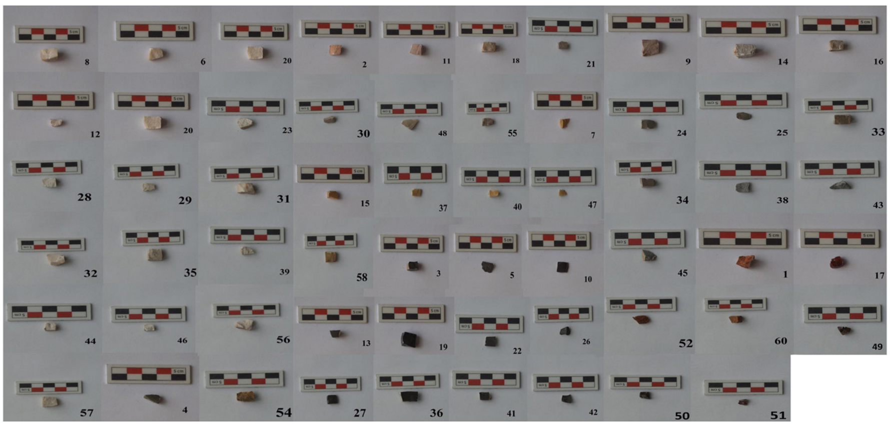

Figure 2
Photos of stone tesseras classified by color.

2 This article has been produced from the thesis titled "Determination of the Type and Origin of Stone Tesseras of Mosaics Captured in Parcel No. 4642 (Museum Hotel) in Hatay Province" by Fatima Kavşut, Batman University Institute of Science, Archaeometry.

Tessera Photo No	Mosaic to which it belongs	Petrography code	CIE Color Result	Tessera Photo No	Mosaic to which it belongs	Petrography code	CIE Color Result
1	L8 Clear Cut Area	hmm-ts1	Red	**31**	6- 14 Clear Cut Area	hmm-ts30	Cream
2	L8 Clear Cut Area	hmm-ts21	Cream	**32**	6- 14 Clear Cut Area	hmm-ts12	White
3	L8 Clear Cut Area	hmm-ts2	Cream	**33**	6- 14 Clear Cut Area	hmm-ts55	Cream
4	L8 Clear Cut Area	hmm-ts22	Black	**34**	6- 14 Clear Cut Area	hmm-ts45	Grey
5	L8 Clear Cut Area	hmm-ts39	White	**35**	6- 14 Clear Cut Area	hmm-ts13	Black
6	L8 Clear Cut Area	hmm-ts23	White	**36**	6- 14 Clear Cut Area	hmm-ts31	White
7	L8 Clear Cut Area	hmm-ts3	Black	**37**	6- 14 Clear Cut Area	hmm-ts46	White
8	L8 Clear Cut Area	hmm-ts4	Green	**38**	6- 14 Clear Cut Area	hmm-ts56	White
9	L8 Clear Cut Area	hmm-ts24	Grey	**39**	6- 14 Clear Cut Area	hmm-ts32	White
10	Geometric mosaic	hmm-ts40	Yellow	**40**	6- 14 Clear Cut Area	hmm-ts14	Grey
11	Geometric mosaic	hmm-ts5	Black	**41**	6- 14 Clear Cut Area	hmm-ts15	Yellow
12	Geometric mosaic	hmm-ts6	White	**42**	6- 14 Clear Cut Area	hmm-ts33	Grey
13	Geometric mosaic	hmm-ts25	Grey	**43**	Large geometric mosaic	hmm-ts47	Yellow
14	Geometric mosaic	hmm-ts26	Black	**44**	Large geometric mosaic	hmm-ts57	White
15	Geometric mosaic	hmm-ts41	Black	**45**	Large geometric mosaic	hmm-ts58	Yellow
16	Geometric mosaic	hmm-ts52	Red	**46**	Large geometric mosaic	hmm-ts34	Grey
17	Geometric mosaic	hmm-ts7	Yellow	**47**	Large geometric mosaic	hmm-ts16	Grey
18	Mosaic number 5	hmm-ts8	White	**48**	Large geometric mosaic	hmm-ts17	Red
19	Mosaic number 5	hmm-ts27	Black	**49**	Large geometric mosaic	hmm-ts35	White
20	Mosaic number 5	hmm-ts42	Black	**50**	Large geometric mosaic	hmm-ts48	Cream
21	Mosaic number 5	hmm-ts9	Grey	**51**	Large geometric mosaic	hmm-ts49	Dark Red
22	Mosaic number 5	hmm-ts60	Red	**52**	Large geometric mosaic	hmm-ts59	Black
23	J 12 Clear Cut Area	hmm-ts10	Black	**53**	Large geometric mosaic	hmm-ts36	Black
24	J 12 Clear Cut Area	hmm-ts11	Cream	**54**	Large geometric mosaic	hmm-ts50	Dark Red
25	J 12 Clear Cut Area	hmm-ts28	White	**55**	Large geometric mosaic	hmm-ts51	Dark Red
26	J 12 Clear Cut Area	hmm-ts43	Grey	**56**	Large geometric mosaic	hmm-ts18	Cream
27	J 12 Clear Cut Area	hmm-ts53	Black	**57**	Large geometric mosaic	hmm-ts37	Yellow
28	6- 14 Clear Cut Area	hmm-ts29	White	**58**	Large geometric mosaic	hmm-ts19	Black
29	6- 14 Clear Cut Area	hmm-ts44	White	**59**	Large geometric mosaic	hmm-ts38	Grey
30	6- 14 Clear Cut Area	hmm-ts54	Yellow brown	**60**	Large geometric mosaic	hmm-ts20	White

Table 1
Samples taken from the mosaics for archaeometry analysis, the mosaics they were taken and their colors.

Method

In addition to the colorimetry technique, two different analysis techniques were used in this study. The first method is petrographic analysis, which is quite common in the identification of stone and ceramic and is also known as a destructive method. The other method is known as X-Ray Fluorescence Spectroscopy, which is most widely used in archaeometry analysis of cultural assets since it is non-destructive.

Colour Analysis

The colors of the colored surfaces of the mosaic tessaras were determined using the portable colorimeter (ColorQA Pro System III program). While determining the colors, defining the visible ones such as primary/ accent color or light/ dark color is not sufficient to fully specify them. Various color systems have been created for many areas in response to this requirement. CEI L * a * b * (Commission Internationale de L'Eclairage) color system is the most widely used, most detailed standard color system for documentation purposes (Akyol - Aydın 2016: 413-431).

According to ColorQA Pro System III; the (L) value, which varies between 0 and 100 values, indicates the lightness/ darkness value of the color (Black: 0 and White: 100), (+ a) value indicates the intensity of Red of the color, (-a) value indicates the intensity of Green of the color, (+ b) value indicates the intensity of Yellow and (-b) value indicates the the intensity of blue intensity of the color.

Color analysis of the tesseras, constituting the subject of the research in this study, were carried out in Ankara Hacı Bayram Veli University, Faculty of Fine Arts, Department of Conservation and Restoration of Cultural Heritage Materials Research and Preservation Laboratory (MAKLAB) (Table 2).

X-Ray Fluorescence (XRF) Analysis

It is a method used to determine the chemical composition of the material to be analyzed. X-ray Fluorescence Spectroscopy (XRF) Analysis is an analytical method used to determine the chemical components of all kinds of materials by examining the characteristic X-rays emitted from a sample according to their energies or wavelengths. It performs quantitative and qualitative analysis (Aydal 2017).

X-rays emitted from any X-ray source collide with the electrons in the sample and displace them. As a result of this collision, electrons from the upper or higher orbits fill the empty space. During this filling, a second X-ray with an atom-specific energy level is emitted. This phenomenon is called Fluorescence. Qualitative and quantitative analyzes are made as a result of measuring radiation with a detector (Aktürk 2017).

In this study, Olympus, Delta Premium brand portable Energy Dispersive X-ray Fluorescence spectrometer (P-EDXRF) registered in the inventory of Batman University Department of Archaeometry, was used (Figs. 3-4).

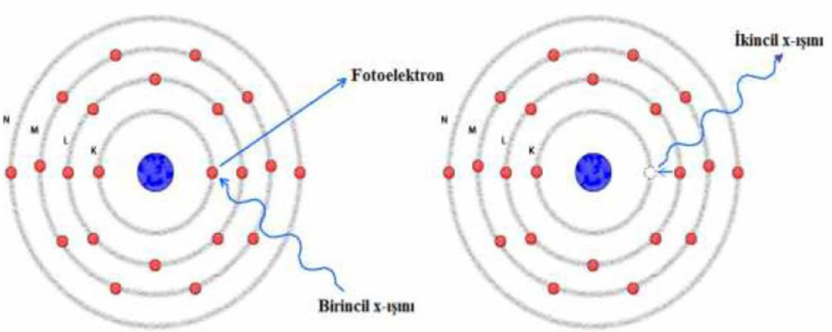

Figure 3
The emergence of X-Ray Fluorescence (XRF) ray (Arslanhan 2016).

Figure 4
P-EDXRF spectrometer used in this study.

The qualitative and quantitative analysis of all the following elements in the geological material mode were analyzed for 140 seconds for each analysis. This mode analyzes two different rays: 40 KV and 10 KV.

The elements that can be detected in the device's Geochem Mode are:

Vanadium (V), Chromium (Cr), Iron (Fe), Cobalt (Co), Nickel (Ni), Copper (Cu), Zinc (Zn), Platinum (Pt), Tungsten (W), Mercury (Hg), Arsenic (As), Selenium (Se), Gold (Au), Bromine (Br), Lead (Pb), Bismuth (Bi), Rb, Uranium (U), Strontium (Sr), Yttrium (Y), Zircon (Zr), Thorium (Th), Niobium (Nb), Molybdenum (Mo), Light Element (LE), Silver (Ag), Cadmium (Cd), Tin (Sn) Antimony (Sb), Magnesium (Mg), Aluminum (Al), Silicon (Si), Phosphorus (P), Sulfur (S), Potassium (K), Calcium (Ca), Titanium (Ti) and Manganese (Mn).

Petrographic Thin Section Optical Microscope Analysis

Petrographic thin section optical microscope analysis describes the study of rocks and minerals using a microscope. Conventionally, petrography was limited to the identification of rocks, minerals and ores and characterization of their features. However, today petrographic techniques are used to analyze many materials other than minerals, such as ceramics, glass, concrete, cement, soils, biomaterials, polymers (Reedy 1994: 115- 116). By determining the origin of the samples, the natural structure of which is already specified, geological detections can be made and it also helps the researcher in determination of materials in restoration works.

This analysis has some advantages. These can be classified in two groups.

1. Since thin section images are taken, it is possible to see the sample (matrix and aggregate structure). Since the size, shape and distribution etc. of the sample in the matrix/ aggregate structure are visible, it provides the opportunity to examine and compare.

2. It gives the ratio of mineral, rock, porosity and aggregate. The rock ratio gives the volcanic rocks (andesite, basalt etc.). Thus, the geological origin of the samples or where they were brought from can be found. Because the geological structure of each region is different and according to this, inferences such as communication and cooperation etc. between societies can be made through the samples that are archaeologically detected to be brought from different places.

Evaluation of Analysis Results

Color Analysis

In order to document the colors of the tesseras more precisely, chromametric analysis was applied and the colors were expressed with L * a * b * color code values.

While the colors were ordered from dark to light, they were also ordered from dark to light according to the tone of the same color. (Table 2).

When Table 2 is evaluated, the distribution of colors is as follows:

Black tesseras; it has been determined that 13 tesseras (hmm-ts13, hmm-ts3, hmm-ts5, hmm-ts41, hmm-ts27, hmm-ts36, hmm-ts42, hmm-ts59, hmm-ts53, hmm-ts10, hmm-ts22, hmm-ts19 and hmm-ts26) are black colored. A single shade has been identified in black.

Red tesseras; it has been determined that 4 tesseras (hmm-ts1, hmm-ts60, hmm-ts17 and hmm-ts52) are red colored. Three different shades have been identified in red.

Sample Code	L	a	b	Visible Color	Colorimetry Photos
hmm-ts3	12,70	1,72	2,90	Black	
hmm-ts5	13,67	1,70	2,87	Black	
hmm-ts10	10,18	1,71	1,40	Black	
hmm-ts13	15,08	1,47	3,51	Black	
hmm-ts19	6,35	0,001	1,33	Black	
hmm-ts26	7,99	1,23	-0,35	Black	
hmm-ts27	9,30	-0,003	1,56	Black	
hmm-ts36	9,30	-0,003	1,56	Black	
hmm-ts22	12,65	1,67	1,36	Black	
hmm-ts41	12,88	0,47	1,68	Black	
hmm-ts42	11,79	-0,005	1,52	Black	
hmm-ts53	7,28	-0,0005	1,44	Black	
hmm-ts59	12,77	-0,006	1,51	Black	
hmm-ts49	9,18	3,54	5,00	Dark red	
hmm-ts50	7,11	3,34	3,13	Dark red	
hmm-ts51	9,04	7,12	2,83	Dark red	
hmm-ts52	13,65	10,45	8,86	Red	
hmm-ts17	15,39	19,28	13,72	Red	
hmm-ts60	36,62	16,82	22,33	Red	
hmm-ts1	35,91	21,38	22,76	Red	
hmm-ts4	19,54	-0,05	6,43	Green	
hmm-ts54	27,58	7,99	17,87	Yellow-Brown	
hmm-ts24	19,49	1,96	5,02	Grey	
hmm-ts45	19,89	-0,01	1,43	Grey	
hmm-ts25	21,67	1,17	7,49	Grey	
hmm-ts34	21,27	1,54	6,23	Grey	
hmm-ts33	23,37	2,57	7,93	Grey	
hmm-ts38	25,67	1,50	1,22	Grey	
hmm-ts43	26,14	-0,64	3,22	Grey	
hmm-ts16	32,92	3,61	9,93	Grey	
hmm-ts9	34,10	6,91	8,54	Grey	
hmm-ts14	42,12	1,90	6,41	Grey	
hmm-ts21	28,46	3,58	5,39	Cream	
hmm-ts55	28,64	2,08	8,88	Cream	
hmm-ts48	34,84	2,47	12,02	Cream	
hmm-ts30	36,42	2,42	6,75	Cream	
hmm-ts18	39,67	5,13	12,15	Cream	
hmm-ts11	48,12	7,92	12,26	Cream	
hmm-ts15	23,63	10,08	18,40	Yellow	
hmm-ts58	31,83	5,79	16,04	Yellow	
hmm-ts37	31,21	6,49	20,81	Yellow	
hmm-ts47	32,65	6,83	23,90	Yellow	
hmm-ts40	45,89	10,63	30,26	Yellow	
hmm-ts7	51,41	11,65	31,39	Yellow	
hmm-ts46	43,97	0,76	8,47	White	
hmm-ts57	46,44	0,81	9,65	White	
hmm-ts44	47,24	0,81	9,62	White	
hmm-ts35	50,54	1,10	11,44	White	
hmm-ts39	50,58	-0,26	8,51	White	

hmm-ts29	51,45	-0,13	10,96	White	
hmm-ts28	52,55	-0,27	8,44	White	
hmm-ts12	53,92	2,18	10,49	White	
hmm-ts32	53,04	1,79	10,38	White	
hmm-ts56	54,88	1,20	10,71	White	
hmm-ts6	54,25	3,49	12,16	White	
hmm-ts20	56,24	3,75	10,99	White	
hmm-ts8	58,17	3,71	10,91	White	
hmm-ts23	59,42	-0,72	6,90	White	
hmm-ts31	66,15	1,85	10,58	White	

Table 2
Color analysis results of mosaic samples. L: 0/100; Black/White. a: 0/-60; Green and 0/+60; Red. b: 0/-60; Blue and 0/+60; Yellow. Visible Color.

Dark red tesseras, it has been determined that 3 tesseras (hmm-ts49, hmm-ts50 and hmm-ts51) are dark red colored. A single shade has been identified in dark red.

Green tesseras, it has been determined that 1 tessera (hmm-ts4) is green colored.

Yellow- Brown tessera; 1 tessera (hmm-ts54) was found to be yellow brown in color.

Grey tesseras; it has been determined that 10 tesseras (hmm-ts16, hmm-ts9, hmm-ts33, hmm-ts25, hmm-ts14, hmm-ts34, hmm-ts24, hmm-ts43, hmm-ts45 and hmm-ts38) are gray colored. Four different shades have been identified in gray color.

Cream tesseras, it has been determined that 7 tesseras (hmm-ts2, hmm-ts11, hmm-ts18, hmm-ts48, hmm-ts55, hmm-ts30 and hmm-ts21) are cream colored. There is more shade difference in cream. Five different tones were identified in 7 tesseras.

Yellow tesseras; it has been determined that 6 tesseras (hmm-ts7, hmm-ts40, hmm-ts47, hmm-ts37, hmm-ts15 and hmm-ts58) are yellow colored. Three different tones were identified in yellow tesserae.

White tesseras; it has been determined that 15 tesseras (hmm-ts6, hmm-ts35, hmm-ts20, hmm-ts29, hmm-ts8, hmm-ts56, hmm-ts31, hmm-ts12, hmm-ts32, hmm-ts57, hmm-ts44, hmm-ts39, hmm-ts46, hmm-ts28 and hmm-ts23) are in white color. Four different shades of white color are used.

It has been observed that the mosaics are generally made of tesseras consisting of 8 primary colors and 19 different shades.

Petrographic Thin Section Optical Microscope Analysis Results

Petrographic textural and aggregate feautures of Tessera samples were determined by thin section analysis under optical microscope (Table 3). When the textural and aggregate feautures of the Tessera samples are examined, it is found that the samples generally consist of limestone (47 pieces), grainstone (4 pieces), siltstone (3 pieces), claystone (3 pieces) and radiolarite (2 pieces), and one rock type that could not be identified (Figs. 5-6, Table 3).

When we examine the texture features of the tessera samples in Table 3, it is figured that the limestones have micritic and sparitic texture. Limestones are the result of calcite grains sticking together with a filling material. If this filling material consists of 1-4-micron microcrystalline calcite, it is referred to as micritic, if it consists of relatively larger (> 10 µm) and transparent calcite, it is referred to as sparitic.

Table 3
Petrographic textural and aggregate features of Tessera samples classified by color.

Tessera No	Rock Type	Texture	Color	Hardness (Mohs)	Rock and Minerals *
hmm-ts 6, 8, 12	Biosparitic Limestone	Sparitic	White	2,5- 3	C matrix, L, H, Fs
hmm-ts 20	Siltstone	Clastic	White	2,5- 3	C and clay matrix, Q, Ç, Op, Sr, Ms,
hmm-ts 23, 32,56, 57	Biomicritic Limestone	Micritic	White	2,5- 3	It contains a high rate of fossils and fossil shells (75%) in its mainly calcite-containing structure.
hmm-ts 39	Biomicritic Limestone	Micritic	White	2,5- 3	It contains fossils and fossil shells (numulites, alveolina and acilina) in its mainly calcite-containing structure.
hmm-ts 28, 29	Pelagic Limestone	Micritic	White	2,5- 3	It contains a small amount of radiolaria, quartz and opaque minerals in its mainly calcite-containing structure.
hmm-ts 31, 44, 46	Clayey Limestone	Crystallized	White	2,5- 3	It contains aragonite, limonite and slightly opaque minerals in patches in its mainly calcite-containing structure.
hmm-ts 35	Micritic Limestone	Micritic	White	2,5- 3	Mainly calcite-containing structure includes chalcedony and opaque minerals in patches.
hmm-ts 5, 19	Grainstone	Crystallized	Black	2- 2,5	C matrix, Op, clay, Fs
hmm-ts 3	Siltstone	Clastic	Black	2,5- 3	C and clay matrix, Q, Ç, Op, Sr, Ms,
hmm-ts 22, 27, 42	Biomicritic Limestone	Micritic	Black	2,5- 3	It contains a high rate of fossils and fossil shells (75%) in its mainly calcite-containing structure.
hmm-ts 13	Sandy Limestone		Black	2- 2,5	C matrix, Q, Gf, D
hmm-ts 26, 41, 53, 59	Pelagic Limestone	Micritic	Black	2,5- 3	In its mainly calcite containing structure, it contains a small amount of radiolaria, quartz and opaque minerals.
hmm-ts 36	Micritic Limestone	Micritic	Black	2,5- 3	Mainly calcite-containing structure includes chalcedony and opaque minerals in patches.
hmm-ts 10	Biomicritic Limestone	Micritic	Black	2,5- 3	C matrix, clay, Fs
hmm-ts 16	Biosparitic Limestone	Sparitic	Grey	2,5- 3	C matrix, L, H, Fs
hmm-ts 9	Siltstone	Clastic	Grey	2,5- 3	C and clay matrix, Q, Ç, Op, Sr, Ms,
hmm-ts 24, 25, 38, 43	Biomicritic Limestone	Micritic	Grey	2,5- 3	It contains a high rate of fossils and fossil shells (75%) in its mainly calcite-containing structure.
hmm-ts 14	Pelagic Limestone		Grey	2- 2,5	C matrix, R, Ç, Ks
hmm-ts 33	Pelagic Limestone	Micritic	Grey	2,5- 3	Its structure, which mainly contains calcite, contains a small amount of radiolaria, quartz and opaque minerals.
hmm-ts 34, 45	Clayey Limestone	Crystallized	Grey	2,5- 3	Mainly calcite-containing structure includes aragonite, limonite and slightly opaque minerals.
hmm-ts 11	Radiolarite		Cream	4,5- 5	R matrix, Ks, Ol, L, H
hmm-ts 21, 48, 55	Biomicritic Limestone	Micritic	Cream	2,5- 3	It contains a high rate of fossils and fossil shells (75%) in its mainly calcite-containing structure.
hmm-ts 30	Clayey Limestone	Crystallized	Cream	2,5- 3	Mainly calcite-containing structure includes aragonite, limonite and slightly opaque minerals.
hmm-ts 2, 18	Biosparitic Limestone	Sparitic	Cream	2,5- 3	C matrix, L, H, Fs
hmm-ts 47	Biosparitic Limestone	Sparitic	Yellow	2,5- 3	There are fossils and fossil shells (5%) in its structure containing mainly calcite.
hmm-ts 7	Radiolarite		Yellow	4,5- 5	R matrix, Ks, Ol, L, H
hmm-ts 15	Sandy Limestone		Yellow	2- 2,5	C matrix, Q, Gf, D
hmm-ts 37	Pelagic Limestone	Micritic	Yellow	2,5- 3	Mainly calcite-containing structure contains small amounts of radiolaria, quartz and opaque minerals.
hmm-ts 40, 58	Micritic Limestone	Micritic	Yellow	2,5- 3	Mainly calcite-containing structure includes chalcedony and opaque minerals in patches.
hmm-ts 1, 17	Graintone	Crystallized	Red	2- 2,5	C matrix, Op, clay, Fs
hmm-ts 52	Pelagic Limestone	Micritic	Red	2,5- 3	Its structure, which mainly contains calcite, contains high levels of iron hydroxide (limonite) and small amounts of chalcedony and quartz minerals.
hmm-ts 60	Crystallized Limestone	Crystallized	Red	2,5- 3	Mainly calcite-containing structure contains small amounts of aragonite and opaque minerals.
hmm-ts 49, 50, 51	Kiltaşı	Micritic	Dark Red	2,5- 3	Its main clay-containing structure contains small amounts of quartz, chalcedony and opaque minerals.
hmm-ts 54	Crystallized Limestone	Crystallized	Yellow Brown	2,5- 3	Mainly calcite-containing structure contains small amounts of aragonite and opaque minerals.
hmm-ts 4	Crystallized Limestone	Crystallized	Green	2,5- 3	C matrix, Ç, Op

C: Calcite, Ç: Chert, D: Dolomite, Fs: Fossil and Fossil Shells, Gf: Graphite, H: Hematite, Ks: Chalcedony, L: Limonite, Ms: Muscovite, Op: Opaque Minerals, Ol: Opal, Q: Quartz, R: Radiolaria, Sr: Sericite

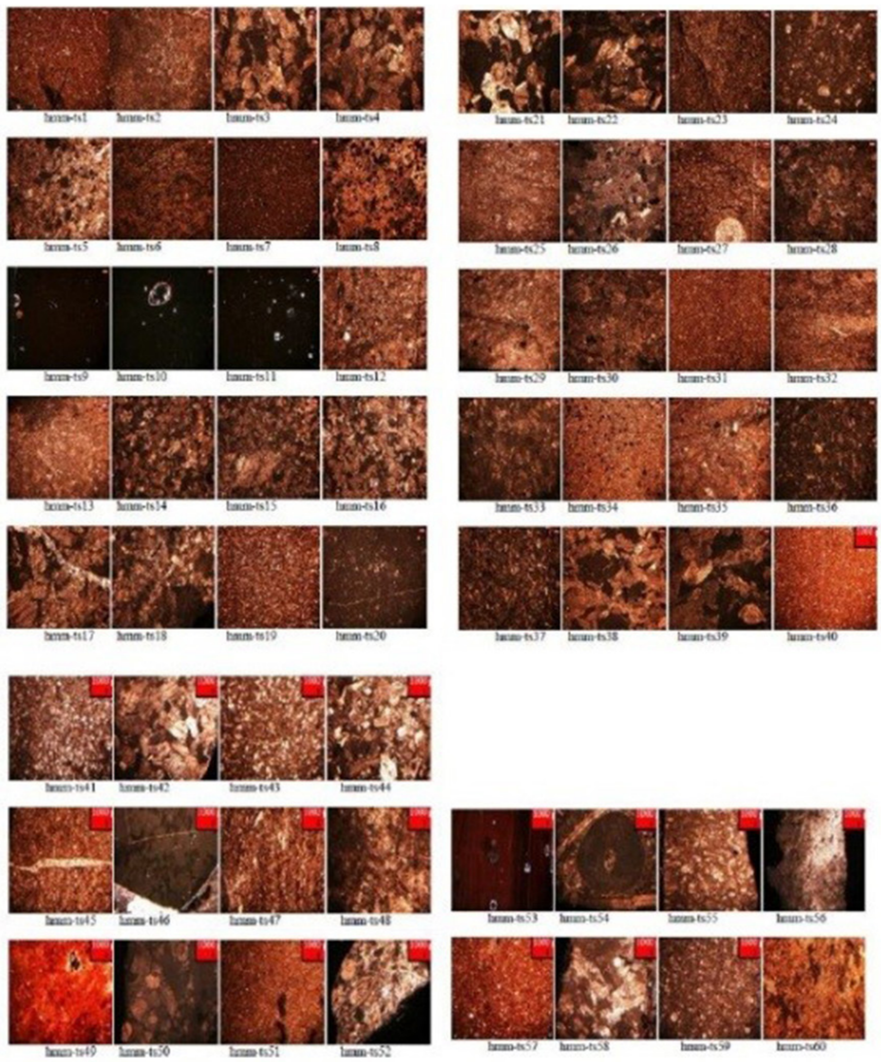

Figure 5
Micro photographs obtained as a result of petrographic analysis.

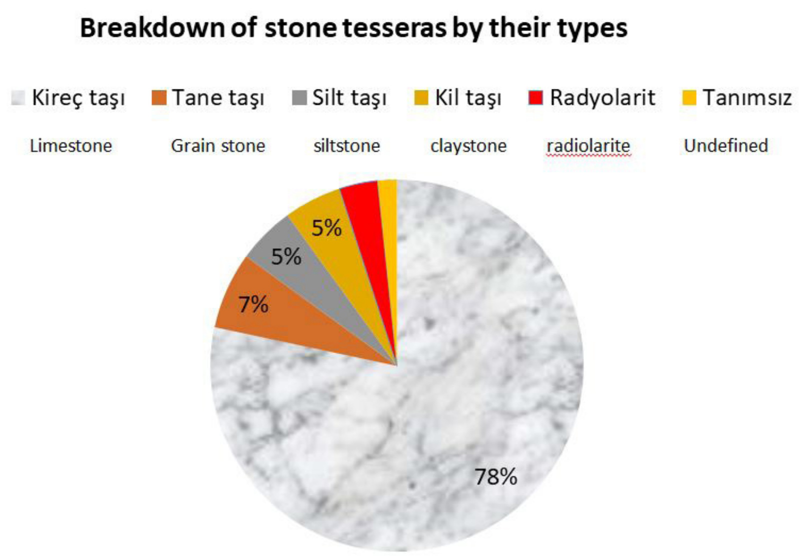

Figure 6
Distribution of tesseras by type.

It has been observed that other rock types have a crystalline and clastic texture. When the hardness levels of the Tessera samples are examined, it is understood that the hardest sample is the samples made of radiolite rock (4,5- 5 mohs) and the others generally have (2-3 mohs) hardness.

There are also various minerals, organic matter, clay, fossil, opaque minerals in the texture of the rocks.

When we examine the color and mineral relationship in Table 3, it is seen that grain stone was used to obtain red and black colors, clay stone was used to obtain dark red tessera, biosparitic and biomicritic limestone were used to obtain light colored tessera, palegic limestones were used to obtain both light colored and red and black colored tesseras. The reason of obtaining different colors from the same limestone is because the stones are small and coarse grained. As the grain size gets smaller, the color obtained became darker and as the grain size gets larger, the color obtained became lighter (Fig. 5).

The Origin of Mosaic Tesseras

Limestone is one of the most common sedimentary rocks among the rock types. Limestone is formed by the sedimentation of inorganic substances dissolved in water and its main component is calcite (CaCO3) minerals. Composition of limestone types are similar (Ocakoğlu 2014: 57; Tatar 2015: 295). When the geology-lithology map of Antakya given below (Fig. 7) and the studies in this field are examined, it is found that the limestone rock types in the close vicinity of Antakya have been existing since the Mesozoic period (251-65 million years) (Korkmaz 2006; Özşahin – Özder 2011: 662; Özşahin 2014a: 67; Özşahin 2014b: 88). The grain stone rock type seen in tessera samples is also a kind of limestone. The difference between them is that the limestone texture contains a certain filling material, while grain stone is limestone rocks that do not contain carbonate mud and consist of cemented or uncemented grains (Dunham 1962; Folk 1962). Limestones are classified such as conglomerate, sandstone, claystone based on the size of the material forming the texture and when the geology-lithology map of Antakya given below (Fig. 7) and the studies in this field are examined, it is found that the limestone rock types in the close vicinity of Antakya have been existing since the Mesozoic period (Özşahin - Özder 2011: 662; Özşahin 2014a: 67; Özşahin 2014b: 88). No information could have been obtained showing that grain stone is found in Antakya. However, since there are samples of limestones with different textures, it is thought that grain stone may also exist.

Siltstone and claystone are rock types with similar features. The difference between silt and clay depends on the grain size. Grains in silt are between 63-64 µm in size and clay samples are around <4 µm in size. The difference between siltstone and claystone is the amount of silt or clay material in the rock. Both types of rocks are waterproof (Ocakoğlu 2014: 54- 55). When the geology-lithology map of Antakya given below (Fig. 7) and the studies in this field are examined, it is observed that siltstone and claystone rock types exist in the close vicinity of Antakya (Korkmaz 2006; Özşahin - Özder 2011: 662; Özşahin 2014a: 67).

Radiolarite rock, on the other hand, is a type of rock formed by organic organism residues (radiolaria) (Tatar 2015: 297- 298). When the geology-lithology map of Antakya given below (Fig. 6) and the studies in this field are examined, it is seen radiolarite rock type exist in the close vicinity of Antakya (Korkmaz 2006).

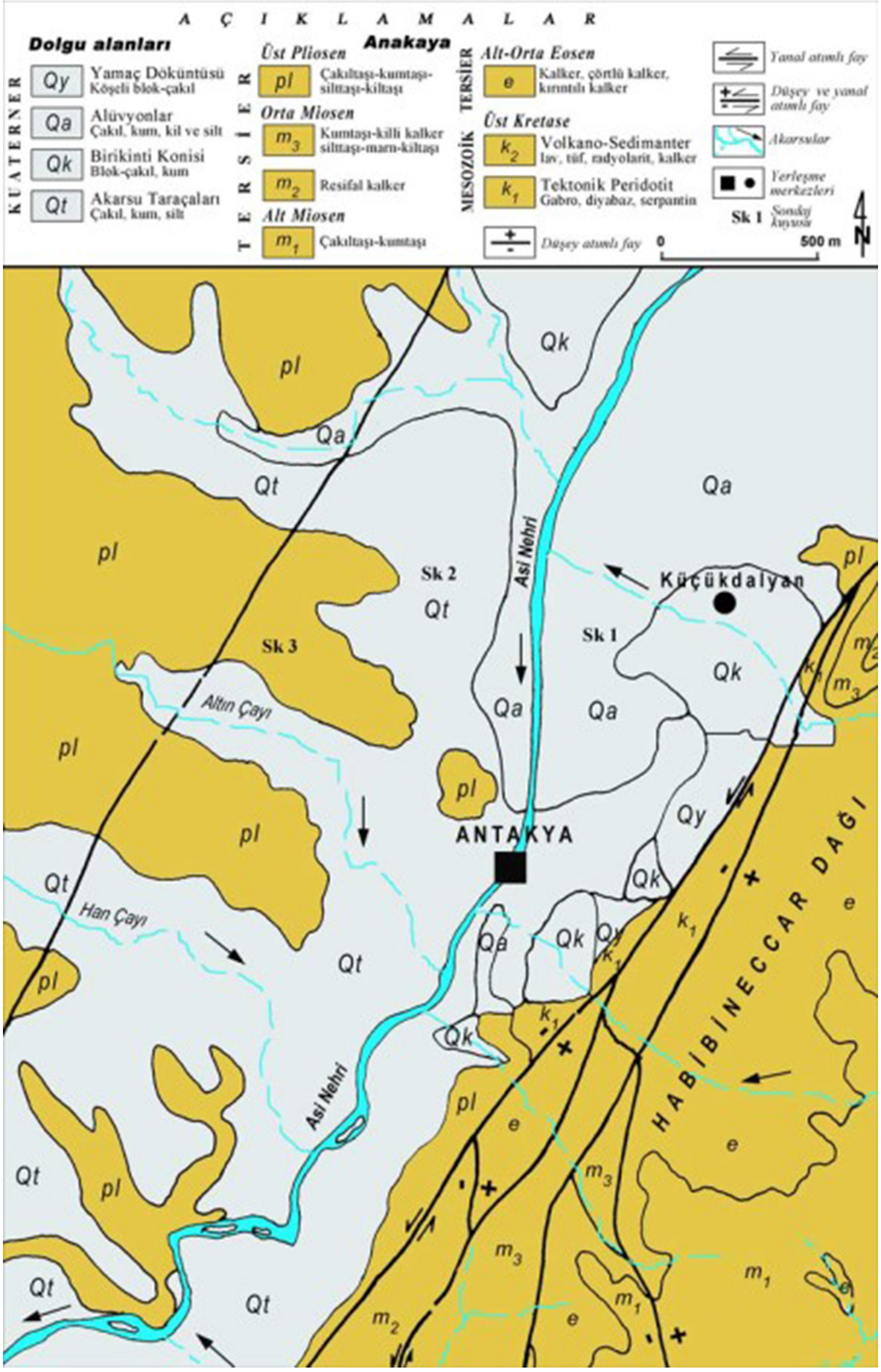

Figure 7
Geology-lithology map of Antakya and its vicinity (Ateş et al. 2004).

Portable X Ray Fluorescence Spectrometer Analysis Results (P-EDXRF)

Petrographic analysis produces more reliable results than P-EDXRF analysis in stone and ceramic analysis. The tesseras that were subjected to petrographic analysis were analyzed by P-EDXRF before petrographic analysis in order to compare the P-EDXRF analyzes with the petrographic analysis results in this study.

When the textural and aggregate features of the tessera samples were examined, it was determined by petrographic analysis that the samples were generally composed of limestone (47 pieces), grain stone (4 pieces), siltstone (3 pieces), Clay Stone (3 pieces) and radiolarite (2 pieces) rock types.

When we analyze the P-EDXRF analysis results of limestones, the following ratios have been observed; calcium (Ca) 88%, silicon (Si) 8%, magnesium (Mg) 1%, aluminum (Al) 1% and the total of other trace elements is 2% (Table 4).

When we analyze the P-EDXRF analysis results of the grain stones, the following ratios have been observed; calcium (Ca) 88.6%, silicon (Si) 4.6%, magnesium (Mg) 4.5%, aluminum (Al) 0.87% and the total of other trace elements 2% (Table 4).

When we analyze the P-EDXRF analysis results of silt stones, the following ratios have been observed; calcium (Ca) 95.9%, silicon (Si) 2.1%, magnesium (Mg) 0.45% aluminum (Al) 0.58% and the total of other trace elements 1% (Table 4).

When we analyze the P-EDXRF analysis results of radiolarite stones, the following ratios have been observed; calcium ratio (Ca) 88%, silicon (Si) 8.4%, magnesium (Mg) 0.95% aluminum (Al) 1.03% and the total of other trace elements is 2% (Table 4).

The chemical composition proportions of clayey limestones differed from others. Calcium (Ca) ratio has decreased significantly compared to other stone groups with an average of 74.4%. Silicium (Si) increased with an average of 16.9 % compared to other groups (Table 4).

Table 4
P-EDXRF analysis results of stone tesseras.

Tessera No	**Mg (%)**	**Al (%)**	**Si (%)**	**P (%)**	**S (%)**	**K (%)**	**Ca (%)**	**Ti (%)**	**Cr (ppm)**	**Mn (ppm)**	**Fe (%)**	**Cu (ppm)**	**Sr (ppm)**	**Pb (ppm)**	**Petrography Results**
hmm-ts1	14	1,1	4,17	0,28	0,05	0,09	**78,63**	0,05	0,04	0,027	1,48	0,002	0,02	0,001	Grain stone
hmm-ts2	0,66	0,5	1,99	0,22	0,06	0,08	**96**	0,06	0,02	0,014	0,35	0,001	0,01	0,001	BiyoSparitic Limestone
hmm-ts3	ND	0,2	0,91	0,11	ND	ND	**98,45**	0,05	0,02	0,009	0,21	0,002	0,01	0,002	Siltstone
hmm-ts4	0,76	0,8	12	0,23	ND	0,12	**85,17**	0,1	0,01	0,01	0,56	0,002	0,14	0,002	Crystallized Limestone
hmm-ts5	1,6	0,7	7,7	0,54	0,19	0,12	**88,69**	0,15	0,01	0,01	0,21	0,002	0,02	0,002	Grain stone
hmm-ts6	0,87	0,5	3,19	0,16	0,1	0,04	**94,51**	0,1	0,01	0,023	0,29	0,002	0,21	0,001	BiyoSparitic Limestone
hmm-ts7	0,8	1,4	10,3	0,31	ND	0,27	**86,05**	0,14	0,01	0,01	0,61	0,002	0,14	0,002	Radiolarite
hmm-ts8	1,05	1,6	17	0,34	ND	ND	**75,14**	0,11	ND	0,386	4,34	0,003	0,02	0,002	BioSparitic Limestone
hmm-ts9	ND	0,7	2,41	0,33	ND	0,06	**95,9**	0,09	0,01	0,029	0,33	0,002	0,15	0,001	Siltstone
hmm-ts10	0,95	0,7	5,99	0,29	1,1	0,15	**89,98**	0,09	0,01	0,008	0,5	0,003	0,16	0,007	BioMicritic Limestone
hmm-ts11	1,1	0,7	6,47	0,41	0,55	0,1	**90,05**	0,08	0,01	0,013	0,31	0,002	0,16	0,005	Radiolarite
hmm-ts12	ND	0,3	1,15	0,35	0,13	ND	**97,89**	0,06	0,01	0,008	0,09	0,002	0,01	0,002	BioSparitic Limestone
hmm-ts13	0,97	0,6	5,55	0,3	0,13	0,07	**91,85**	0,08	0,01	0,012	0,26	0,002	0,15	0,006	Sandy Limestone
hmm-ts14	0,72	0,6	1,54	0,3	ND	0,07	**96,55**	0,06	0,01	0,007	0,14	0,001	0,01	0,003	Pelagic Limestone
hmm-ts15	0,76	0,9	2,64	0,28	0,05	0,04	**94,81**	0,07	0,02	0,012	0,37	0,003	0,01	0,008	Sandy Limestone
hmm-ts16	ND	0,8	2,32	0,37	0,04	0,23	**96**	0,09	0,01	0,01	0,15	0,002	0,01	0,01	BioSparitic Limestone
hmm-ts17	1,19	0,4	1,65	0,41	0,11	0,02	**95,83**	0,06	0,02	0,007	0,24	0,002	0,01	0,004	Grain stone
hmm-ts18	1,01	0,8	3,42	0,52	0,04	0,2	**93,6**	0,11	0,01	0,01	0,21	0,001	0,01	0,004	BioSparitic Limestone
hmm-ts19	1,73	1,2	4,72	0,36	0,09	0,02	**91,38**	0,07	0,01	0,013	0,39	0,002	0,02	0,009	Grain stone
hmm-ts20	1,36	0,9	3,06	0,59	0,05	0,17	**93,42**	0,07	0,01	0,011	0,33	0,002	0,02	0,009	Siltstone
hmm-ts21	0,96	1,1	4,3	1,04	0,87	0,19	**90,49**	0,07	0,01	0,031	0,5	0,007	0,03	0,327	BioMicritic Limestone
hmm-ts22	0,86	1	3,3	0,18	0,09	0,01	**94,06**	0,07	0,01	0,014	0,3	0,003	0,05	0,012	BioMicritic Limestone
hmm-ts23	0,56	1,1	24,3	0,49	ND	ND	**72,87**	0,07	0,01	0,007	0,57	0,003	0,05	0,003	BioMicritic Limestone
hmm-ts24	0,85	0,8	2,36	0,24	ND	0,07	**95,13**	0,07	0,01	0,019	0,35	0,001	0,11	0,001	BioMicritic Limestone
hmm-ts25	ND	0,4	2,83	0,3	0,03	0,07	**95,61**	0,05	0,02	0,022	0,41	0,002	0,21	0,001	BioMicritic Limestone
hmm-ts26	1,36	1,1	3,33	0,1	0,04	ND	**93,78**	0,06	0,01	0,008	0,22	0,001	0,01	0,002	Pelagic Limestone
hmm-ts27	0,55	1	17,8	0,71	0,09	0,15	**78,98**	0,09	0,01	0,009	0,46	0,024	0,06	0,006	BioMicritic Limestone

hmm-ts28	2,27	2,3	6,91	0,13	0,09	0,03	**87,62**	0,07	0,02	0,012	0,54	0,002	0,01	0,003	Pelagic Limestone
hmm-ts29	1,46	1,3	4,47	0,42	0,07	0,23	**91,57**	0,09	0,02	0,014	0,37	0,002	0,02	0,001	Pelagic Limestone
hmm-ts30	1	0,8	2,59	0,19	0,01	0,04	**94,96**	0,06	0,01	0,008	0,26	0,001	0,02	0,003	Clayey Limestone
hmm-ts31	0,96	1,1	4,3	1,04	0,87	0,19	**90,49**	0,07	0,01	0,031	0,5	0,007	0,03	0,327	Clayey Limestone
hmm-ts32	0,86	1	3,3	0,18	0,09	0,01	**94,06**	0,07	0,01	0,014	0,3	0,003	0,05	0,012	BioMicritic Limestone
hmm-ts33	0,56	1,1	24,3	0,49	ND	ND	**72,87**	0,07	0,01	0,007	0,57	0,003	0,05	0,003	Pelagic Limestone
hmm-ts34	0,85	0,8	2,36	0,24	ND	0,07	**95,13**	0,07	0,01	0,019	0,35	0,001	0,11	0,001	Clayey Limestone
hmm-ts35	ND	0,4	2,83	0,3	0,03	0,07	**95,61**	0,05	0,02	0,022	0,41	0,002	0,21	0,001	Micritic Limestone
hmm-ts36	1,36	1,1	3,33	0,1	0,04	ND	**93,78**	0,06	0,01	0,008	0,22	0,001	0,01	0,002	Micritic Limestone
hmm-ts37	0,55	1	17,8	0,71	0,09	0,15	**78,98**	0,09	0,01	0,009	0,46	0,024	0,06	0,006	Pelagic Limestone
hmm-ts38	2,27	2,3	6,91	0,13	0,09	0,03	**87,62**	0,07	0,02	0,012	0,54	0,002	0,01	0,003	BioMicritic Limestone
hmm-ts39	1,46	1,3	4,47	0,42	0,07	0,23	**91,57**	0,09	0,02	0,014	0,37	0,002	0,02	0,001	BioMicritic Limestone
hmm-ts40	1	0,8	2,59	0,19	0,01	0,04	**94,96**	0,06	0,01	0,008	0,26	0,001	0,02	0,003	Micritic Limestone
hmm-ts41	ND	1,1	3,47	0,26	ND	0,14	**94,39**	0,07	0,04	0,011	0,48	ND	0,01	0,003	Pelagic Limestone
hmm-ts42	ND	1,1	3,44	0,16	ND	0,02	**94,61**	0,04	0,08	0,016	0,49	0,002	0,01	0,003	BioMicritic Limestone
hmm-ts43	1,52	0,6	2,56	0,18	0,23	0,15	**94,21**	0,08	0,02	0,011	0,32	0,005	0,07	0,056	BioMicritic Limestone
hmm-ts44	ND	2,4	26,2	0,57	1,02	0,91	**59,99**	0,05	ND	0,533	4,58	0,658	0,05	2,359	Clayey Limestone
hmm-ts45	ND	2,7	34,2	0,53	0,64	1,31	**51,93**	0,07	0,17	0,513	5,09	1,356	0,05	1,007	Clayey Limestone
hmm-ts46	ND	3,3	31,7	1,39	0,22	1,73	**53,87**	0,06	0,01	0,449	5,61	1,328	0,05	0,3	Clayey Limestone
hmm-ts47	1,52	0,5	2	0,66	0,49	0,27	**94,01**	0,1	0,01	0,013	0,33	0,004	0,02	0,039	BioSparitic Limestone
hmm-ts48	1,28	2,1	30,9	0,68	0,78	0,75	**56,29**	0,06	ND	0,55	4,49	0,537	0,05	1,167	BioMicritic Limestone
hmm-ts49	1,27	3,4	5,23	0,28	0,03	0,27	**86,11**	0,21	0,04	0,031	3,07	0,004	0	0,002	Clay Stone
hmm-ts50	ND	1,1	3,47	0,26	ND	0,14	**94,39**	0,07	0,04	0,011	0,48	ND	0,01	0,003	Clay Stone
hmm-ts51	0,53	1,1	18,9	0,32	0,18	0,1	**78,23**	0,08	0,01	0,007	0,46	0,004	0,07	0,001	Clay Stone
hmm-ts52	1,28	1,7	4,28	0,35	ND	0,35	**90,52**	0,11	0,01	0,043	1,31	0,002	0,01	0,003	Pelagic Limestone
hmm-ts53	1,3	0,7	3,18	0,61	0,31	0,26	**92,98**	0,07	0,02	0,014	0,51	0,002	0,04	0,004	Pelagic Limestone
hmm-ts54	ND	0,3	1,13	0,2	ND	0,05	**98,01**	0,07	0,01	0,006	0,15	0,001	0,01	0,001	Crystallized Limestone
hmm-ts55	1,74	0,7	3,51	0,59	0,15	0,18	**92,59**	0,09	0,02	0,01	0,39	0,002	0,02	0,002	BioMicritic Limestone
hmm-ts56	0,81	0,4	1,07	0,16	0,01	ND	**97,24**	0,07	0,01	0,007	0,19	0,001	0,01	0,001	BioMicritic Limestone
hmm-ts57	ND	0,5	1,98	0,23	0,03	0,03	**96,84**	0,06	0,01	0,008	0,21	0,001	0,04	0,001	BioMicritic Limestone
hmm-ts58	ND	0,8	17,4	0,38	0,12	0,03	**80,53**	0,05	0,01	0,007	0,57	0,003	0,05	0,001	Micritic Limestone
hmm-ts59	0,69	0,7	14,8	0,23	0,15	0,07	**82,82**	0,07	0,01	0,005	0,39	0,002	0,06	0,002	Pelagic Limestone
hmm-ts60	0,9	1,2	2,95	0,41	0,08	0,27	**92,54**	0,12	0,01	0,02	1,48	0,003	0,02	0,001	Crystallized Limestone

Conclusion

Color, P-EDXRF and petrographic analyzes were carried out on 60 stone tesseras belonging to 6 mosaics within the scope of this study to determine the type and origin of the stone tesseras of the mosaics unearthed in Hatay province, parcel No. 4642 (Museum Hotel). The following findings have been obtained by evaluating the data as a result of these studies.

As a result of the color analysis, it was concluded that the ratio of white/ black (lightness / darkness) is in the middle according to the color code values of tesseras (L), but it is closer to white, that is, lightness, (a) that there was no green color tone except for 1 tessera and the red color tone was at low levels (b) that blue color was not found in any sample, yellow color was seen in 6 tesseras and light colors were predominant.

According to the results of P-EDXRF analysis; it was determined that the elements Mg, Al, Si, P, S, K, Ca, LE, Ti, Cr, Mn, Fe, Cr, Sr and Pb exist in all tesseras, the elements such as Th, Bi, Hg, Au, W, Sb, Sn, Mo, Nb, Zr, Rb, Se, Br are not identified is some of the tesseras, while in others they were found in trace amounts (<0.001), in addition, some elements were determined in all tesseras, albeit in trace amounts (Y <0.005, Zn <0.02, Ni <0.03 and V <0.025). At the same time, since the stones are limestone, the average of the element calcium (Ca) was determined to be 88%. These high ratios show that tesseras are generally consist of limestones and this finding also supports the results obtained from petrography. P-EDXRF analysis results revealed that tesseras consist of limestone. Petrographic analysis has supported this finding.

According to petrographic analysis, it was concluded that the vast majority of tesseras consist of limestone (47 pieces), a small number of tesseras consist of grain stone (4 pieces), siltstone (3 pieces), claystone (3 pieces) and radiolarite (2 pieces) rock types and that these rock types are abundant in Antakya district and its surroundings, where the research was conducted.

When the textural features of the tessera samples were evaluated, it is found that the tessera belonging to the limestone type have micritic and sparitic texture, while the other rock types have a crystallized and clastic texture.

When the hardness levels of the tessera samples were examined, it was found that the hardest tesseras belonged to the radiolarite rock type was mohs (4,5- 5), while the others were generally 2-3 mohs hard. Various minerals, organic matter, clay, fossil and opaque minerals were also found in the texture of the rocks.

Limestones are classified as conglomerate, sandstone, claystone according to the size of the material forming the texture. When we examine the origins of the limestones that make up the tesseras, it is stated that limestone rock types have been existing in the vicinity of Antakya since the Mesozoic period. No information has been found on the existence of grain stone in Antakya. However, since there are samples of limestones with different textures, it is also considered that more research is required in relation with the existence of grain stone. As a result, it was concluded that most of the stone tesseras required by the craftsman of mosaic were obtained from different colors of limestone locally.

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