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Restoration Project for "Van Ayanis" Fort Temple Area and Documentation of Adobe (Mud-Brick) Buildings Material for Conservation Purposes

Ali Çetin İDİL[1,♠], Mehmet IŞIKLI[2], Alper GÜRER[3], Derya GÜRER[4]

[1]*Şeyh Şamil Mah. 180. Sk 17338 ada C4/5 Daire 3 Eryaman, Ankara/TÜRKİYE*
[2]*Atatürk Üniversitesi Edebiyat Fakültesi Arkeoloji Bölümü, Protohistorya ve Önasya Arkeolojisi A.B.D. 25240 Erzurum/TÜRKİYE*
[3]*Ordu Blv. Turunç Apt. No:40/3 Afyonkarahisar /TÜRKİYE*
[4]*Ordu Blv. Turunç Apt. No:40/3 Afyonkarahisar /TÜRKİYE*

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ABSTRACT

The target of this study is to systematically collect soil based adobe blocks that are obtained as the result of the excavations and to develop the methods of examination of that material.

In line with this target, within the scope of the restoration project for the temple, which has been exposed in Ayanis Fort excavations, which is 500 m northern of Van Province, Ayanis/Ağartı Village, the geological and chemical structure of the soil based adobe blocks has been analyzed with SEM/EDS and XRD methods, the adobe material combination has been interpreted and preliminary intervention principles and restoration project have been prepared for the excavation pits with the purpose of in-situ conservation/ freezing.

Keywords: *Van, Ayanis, Ağartı, Fort, Soil, Clay, SEM/XRD, Adobe, Material*.

1. INTRODUCTION

The roots of the buildings, which are constructed with soil based adobe building material, in which approximately 30-40% of the world population is still living, extends to the Neolithic Periods (1000-3000 B.C.) [1]. Another building that is constructed with adobe building material is Ayanis Fort, which is located 500 m northern of Van Province, Ayanis/ Ağartı Village, which is estimated to be constructed between 685-645 B.C. (Figure 1, 2).

This study covers the examination of morphological, chemical and mechanical values of the adobe material used in the construction of the temple walls in Ayanis Fort, which has been exposed in the excavations performed in the past years, by using two samples. The geological and chemical structures of those soil based adobe blocks have been analyzed with SEM/EDS and XRD methods and the combination of adobe bricks has been interpreted. The study has been carried out in the form of preparing in vitro mixtures and applying those mixtures in vivo in various areas of the excavation area.

As the result of those analysis and assessments, preliminary intervention principles and restoration project have been prepared in the excavation works with the target of in situ conservation / freezing of the material within the scope of the restoration project of the temple, which has been exposed in Ayanis Fort excavations.

♠Corresponding author, e-mail: alicedil@hotmail.com.tr

2. AYANİS FORT EXCAVATION AND CONSERVATION APPLICATIONS

Ayanis Fort excavations have been commenced in 1989 under the leadership of Prof. Dr. Altan Çilingiroğlu within the scope of "Van Project" of Istanbul University Faculty of Literature and Ege University [2]. The excavations, which have been carried out until 2012 have been taken over by Van Museum Directorate as of 2013. The scientific consultant is Ass. Prof. Dr. Mehmet Işıklı.

Ayanis Fort is located 38 km northern of Van, 500 meters northern of Ayanis/ Ağartı village, which is located on the eastern shore of Van Lake, and is at a distance of 20 km to Alaköy, which is close to Van- Erciş road. The fort, which is approximately 300 m inwards from Van Lake and whose in-wall dimensions are approximately 400 x 150-200 m, is located on a rocky location having an altitude 225-250 m from the lake level and 1866.0 m from the sea level. [2,3]. The works related with Ayanis Fort excavations have been carried out in two areas as *"fort"* and *"outer town "*. The settlement area of Ayanis Fort, which is surrounded by walls, cover an area of approximately 6 hectares, while basing on the stoneware findings detected in the studies performed around the fort, it is understood that the external city related with the fort is spread to a wide area reaching up to 80 hectares [4]. It is considered that the water need of the city and the fort is provided from the spring at Pınarbaşı, which is in the northeast of the fort [5].

Ayanis Fort is one of the 5 Urartu forts, which are known to be had built by Rusa the 2nd, son of Argişti (Rusahinili Eiduru-kai/ Rusa city across Süphan Mountain) (685-645 B.C.) [6]. Among the obtained written documents, seals, bullae, bronze shields, helmets, pikes, nail heads, inscriptions on two disks made of bronze obtained on the eastern door of the ranked hall, a broken inscribed tablet and the inscription on the bronze sword obtained near the rank pillar numbered 4 and the construction inscription on the southern wall door have confirmed our information on the founder of the city and the fort [7-9]. Ayanis Fort extends up to 659 B.C with a dendrochronology sample obtained from the trees within the areas numbered VI [10-13] however, the dendrochronology studies including other areas of the fort show that the fort's construction has been commenced within a period between 677-673 B.C. [14-16].

Within the fort, studies have been carried out in: Area numbered 1 [19] (Monumental gate of the citadel), Area numbered 2 [17] (The Eastern Fortification Walls), Area numbered 3 [2] [18] (The Southern Fortification Walls), Area numbered 4 [3] (The Eastern Storage Rooms), Area numbered 5 [17] (The Temple Area including Haldi Temple and Pillared Hall), Area numbered 6. [20,21] (domestic structures!). Area numbered 7 [18] (Western Storage Rooms). In the outer city, excavation works have been carried out in Pınarbaşı and (Güney) South Hill [22] (Fig 2).

Ayanis Fort 2013 repair and conservation works have been carried out at the Southern walls, Temple area and Excavation house and warehouse to a great extent (fig. 2). The area, where the repair and conservation works have been carried out in the most intense way is undoubtedly Ayanis Fort Temple Area. For the most accurate repair and conservation application to be performed on the basalt blocks in the Temple Area, different solutions have been applied for test purposes on andesite / basalt stones that are not suitable for use. The restoration of the adobe frames has been commenced with the coating of adobe blocks in the opening area numbered 13 in 2010 excavation period. The in vitro studies performed on adobe conservation in 2013 have been performed in parallel with the international material regulations [23]. Within the scope of those operations, raw soil, medium sized straw and water constituting the haired mortar has been used as the plastering mortar. Local liquid applications have been performed in the adobe frame areas determined in the studies progressing within the scope of experimental archeology. The plastering operation has been performed on the northern wall of the temple, Pillar 1, which is adjacent to it, on Rank 2 that is in the north of Rank 1 and on the southern wall within the Temple area. Thereafter, all of the surfaces of the units, on which plaster is applied, have been coated with geo – textile. Within the scope of the laboratory studies, restoration and conservation studies of small findings have been continued. Within the frame of the rules for the conservation of natural and cultural assets [23], the conservation repair projects of the temple area have been performed

Fig1. Ayanis Fort Tumulus air photograph - (1970s)(from the excavation archive)

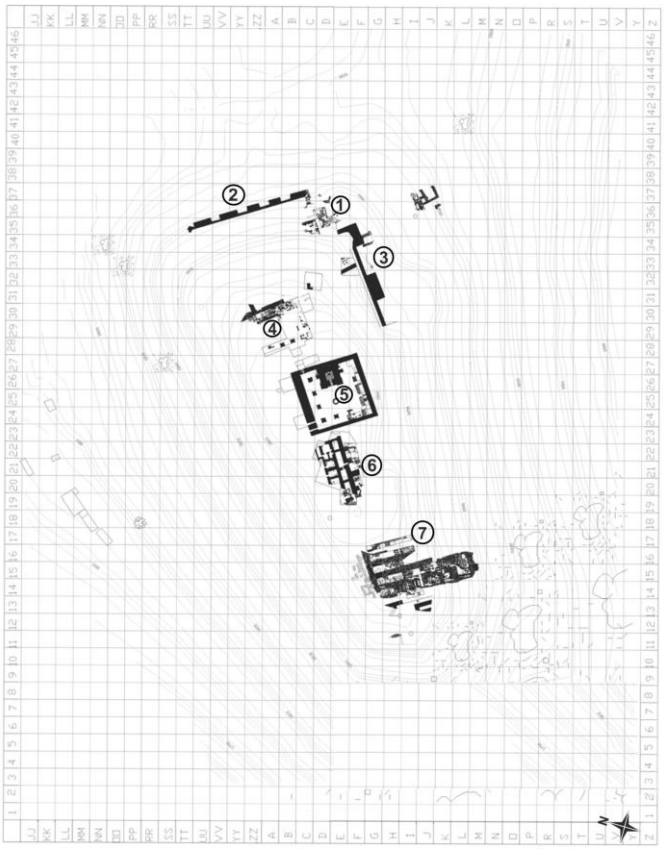

Fig 2. Ayanis Fort (2013 condition)

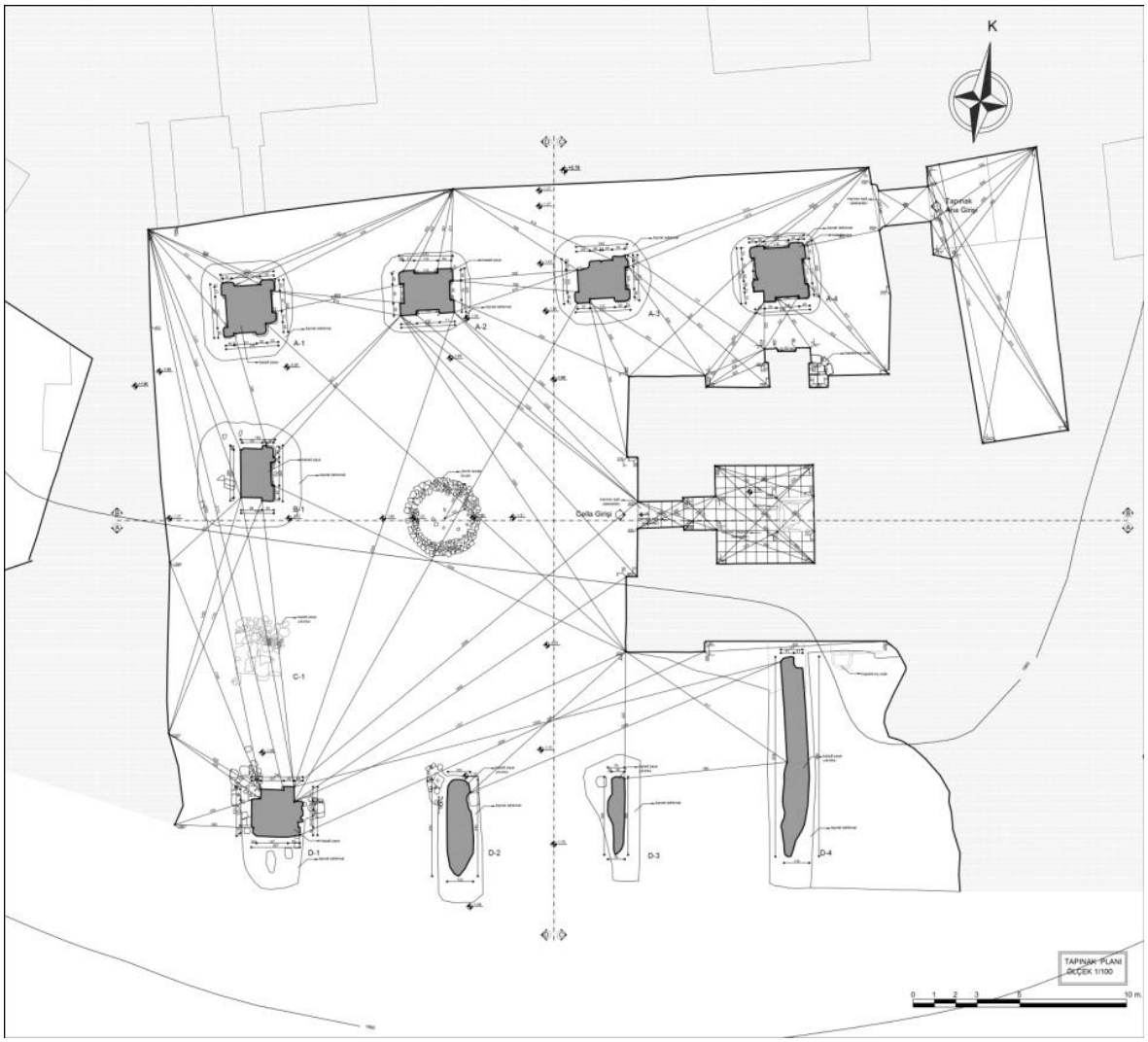

Fig 3. Temple area plan elevation in 2013

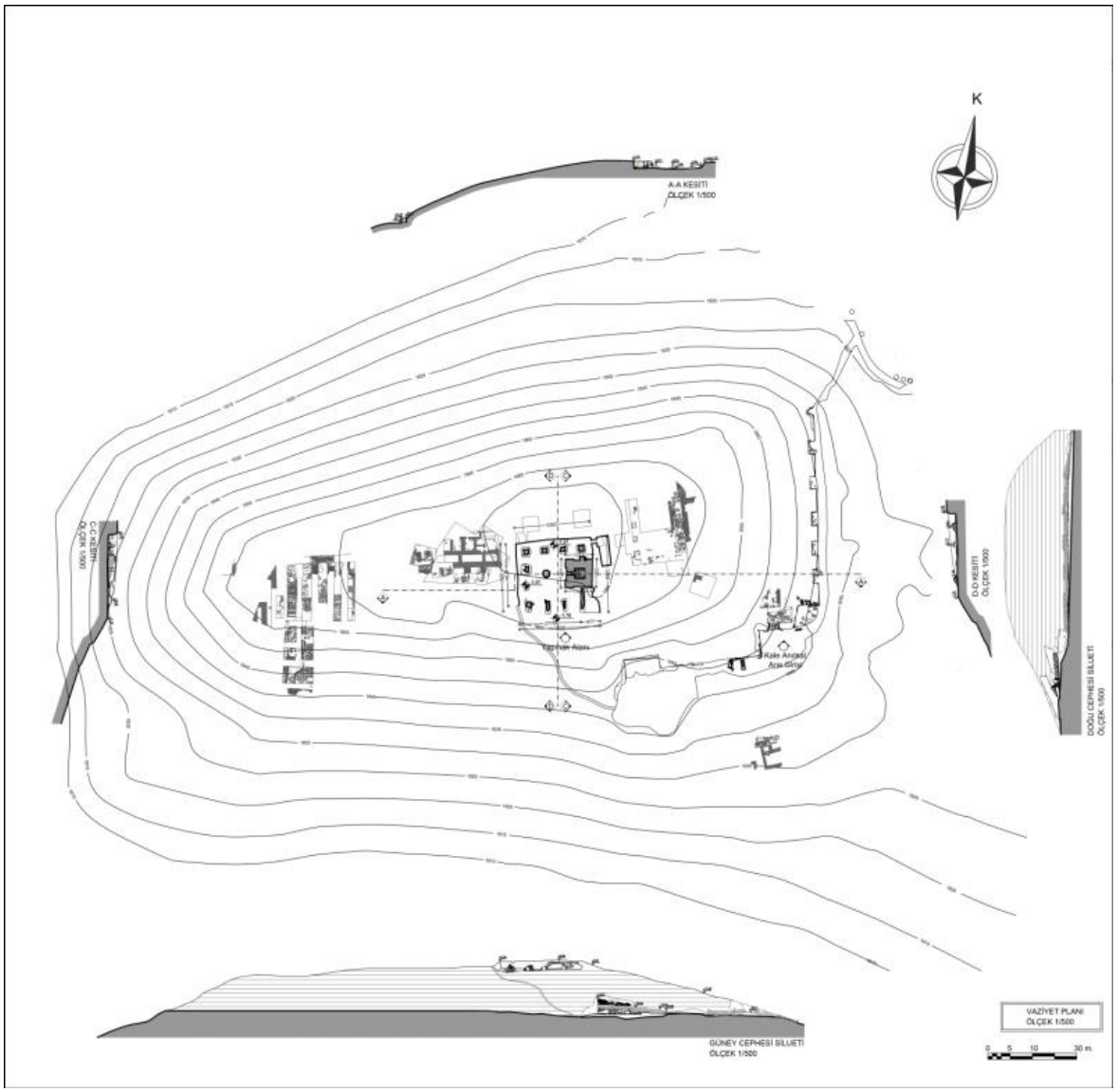

Fig 4. Temple area plan Section and Façade (drawing in 2013).

3. RESEARCHES PERFORMED ON ADOBE BUILDING MATERIAL AND ON ADOBE

The states, international organizations are searching for methods to increase the strength of soil – based building materials. The purpose is to prevent the communities becoming homeless in the archeological areas, more sensitivity is shown on soil based building materials (adobe) and organizations such as UNESCO, ICCROM, Paul Getty Institute are developing experimental projects about conservation and repair.

The use of adobe on the lands of our country is not different. However, the used material shows changes in accordance with regions. In the archeological areas, different building material mixtures are witnessed. It is a fact that the number of researches on the conservation / consolidation of the building materials made of adobe is very low. Although being simply interpreted within the current information technology, adobe is a building material that has reached until today and has been used at Van and Ayanis Fort in Eastern Anatolia.

There are many applied projects of Getty Conservation Institute about adobe. They are presented as adobe-90. Furthermore, a long period research project has been carried out on the adobe consolidation at historical Selden Fort in cooperation with New Mexico State Monuments Museum. Three chemical applications have been performed in a few stages on the adobe samples taken from the places where fort walls and accommodation locations exist [27]. In 1942, the hardening of soil has been ensured by using alkyl silicate in the oil wells. Its impact and continuity has been observed for twenty five years, therefore the idea of its application at critical points in the soil architecture has emerged and adopted by many countries [25].

In 1960s, Iraq-Italian Restoration and Conservation Center has carried out researches on the conservation of adobe in cooperation with ICOMOS and ICCROM [26]. The result obtained from that is the necessity of taking and cataloging the samples in a systematic way and performing the chemical and physical analysis of the adobes [27].

In 1968, conservation – purpose studies have been performed in Iraq in archeological areas in relation with the conservation of uncooked soil materials and the method of jetting ethyl silicate on vertical surfaces has been applied. The deteriorations that occurred in time have been followed and published [34]. In 1969, ethyl silicate has been used as 'consolidants'. Large scaled field tests in vivo have been performed within Seleukeia archeological area. As the result of ethyl silicate application at that place, it is expressed that the chemical used for creating a hard layer on the surfaces has not been very effective [1].

The adobe conservation and consolidation works that are performed in an informed way have been commenced for the first time in Yezd city of Iran with a symposium held in 1974. The symposium held in METU in 1980 [29] has been followed by the symposium performed in Southern America [27] in 1984.

4. MATERIAL ANALYSIS APPLIED IN AYANİS CASTLE – TEMPLE AREA

Two samples taken from the walls of the temple have been analyzed for examining the morphological, chemical and mechanical values of the adobe material used in the construction of the temple walls at Ayanis Castle, which has been exposed through excavation.

4.1. Method of Analysis

SEM – EDS device has been used for the determination of crystal forms and element combinations in the soil – sourced construction materials taken from Ayanis excavations. Whole rock plate has been prepared by sampling so as to constitute a sample, and grinding and then sieving through the sieve with ASTM number 230 (0.062 mm mesh).

XRD – whole rock analysis has been performed on dust plate prepared by using grinded sample for XRD examinations. All rock minerals, types and relative amounts that can be detected within the detection limits of the device have been determined with XRD analysis (2% by weight).

4.2. Details and Interpretation of Analysis

With X ray refraction XRD method full rock analysis, mineral combination and the types and relative abundance of the minerals contained in that combination have been determined in semi – quantitative way (Table 1).

Table 1. XRD – whole rock and clay analysis result for adobe sample.

Sample No	XRD Whole rock mineral combination (wt%)				XRD mineral combination			
	Quartz	Feldspar group		Calcite	Smectite	Illite	Chloride	Caolenite
		Albite	Andazine					
1	9	8	48	18	6	4	3	3

The representative samples that are taken and prepared from various parts of the adobe sample have been placed on carrier and dried for 2 hours in drying oven at 60C degrees for the examination of morphologic internal structures, determination of the crystal forms and element combinations they contain and for analysis with scanning electron microscope SEM/ EDS. These samples have been coated with 200 Å thick gold by using Polaron E5100 series II coating device and have been JEOL examined. The sample has a chaotic and "non-uniform" internal structure morphologically (Fig 5). In accordance with the results of XRD and SEM/EDS analysis, the sample consists of feldspar crystals and quartz gravels that are distributed within the clay matrix (Fig 6,7,8). For example, besides the feldspar mineral, which is dominant in whole rock mineral combination, quartz crystals and calcite mineral (Fig 9) in canal – vein shape, which is considered to have formed in secondary ways (biological activity) are found.

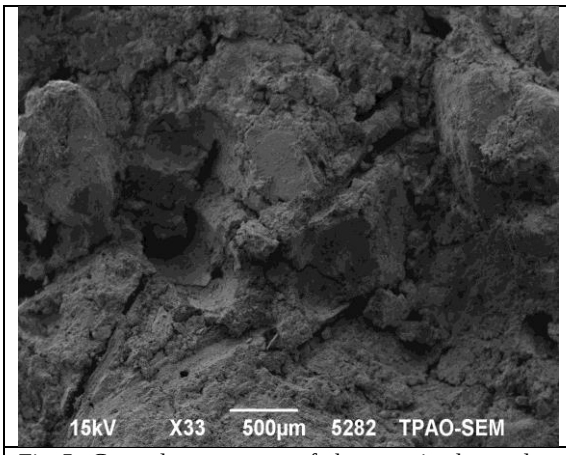

Fig 5. General appearance of the examined sample on scanning electron microscope (SEM) (SEI: secondary electron image).

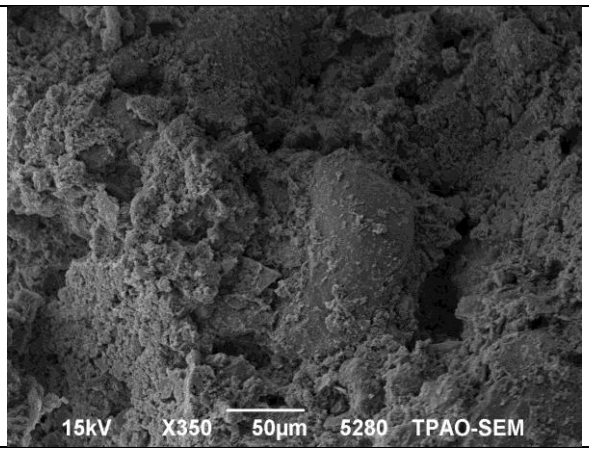

Fig 6. General appearance of the examined sample on scanning electron microscope (SEM) (SEI: secondary electron image).

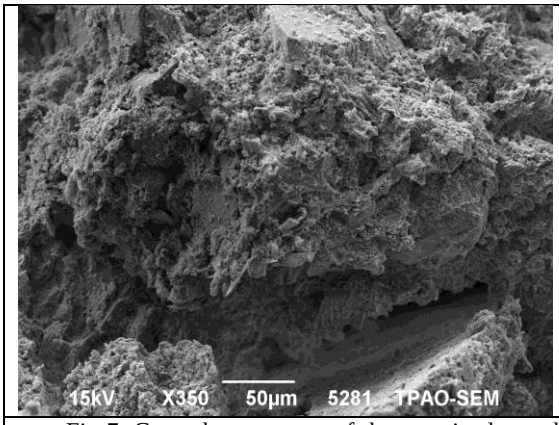

Fig 7. General appearance of the examined sample on scanning electron microscope (SEM) (SEI: secondary electron image).

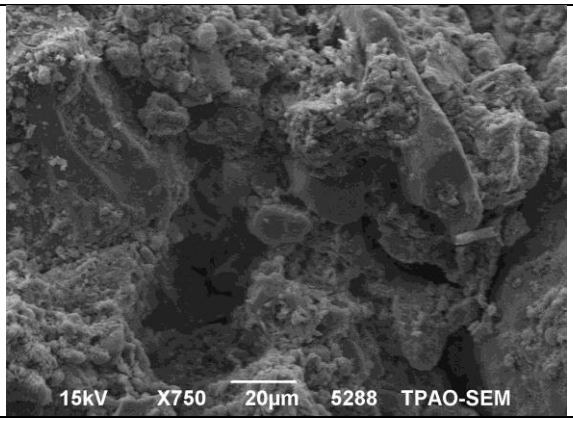

Fig 8. General appearance of the examined sample on scanning electron microscope (SEM) (SEI: secondary electron image).

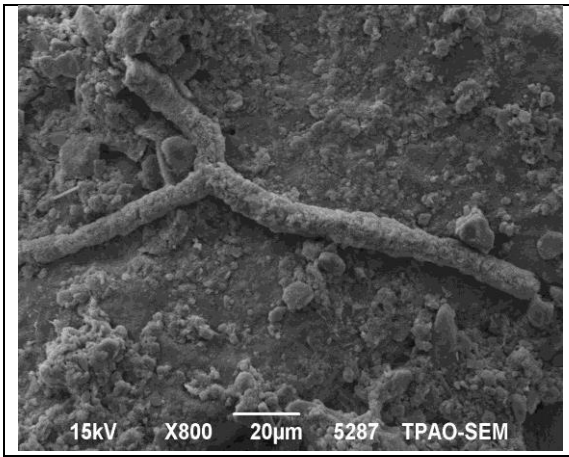

Fig 9. Calcite canal, which is considered to have occurred as the result of biological activity

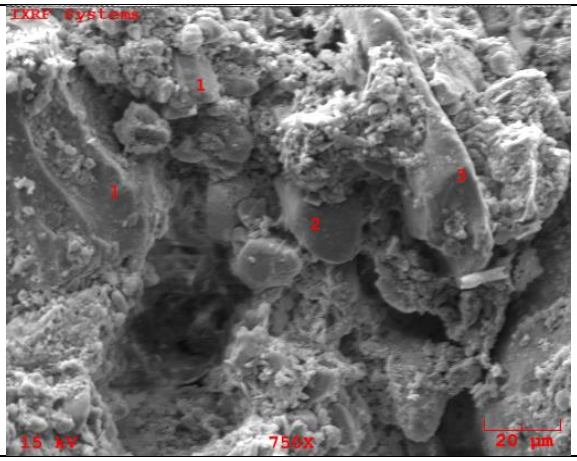

Fig 10. In the examined sample, SEM image of the crystals, for which energy dispersion spectrometer (EDS) and X-ray microanalysis have been performed (SEI)
Point numbered 1 feldspar crystal, point numbered 2 quartz crystal, point numbered 3 clay matrix

In the element analysis performed in EDS system in accordance with point, the following elements have been detected in rank of abundance among the "feldspar" crystals (fig. 10): O (oxygen), Si (silicon), Al (aluminum), K (potassium) and Mg (magnesium) elements (Fig 13). Furthermore, as the result of EDS analysis performed on the calcite core that is thought to have formed as the result of biological activity, it has been determined that this point consists completely of calcium and carbonate elements (Fig 14,15).

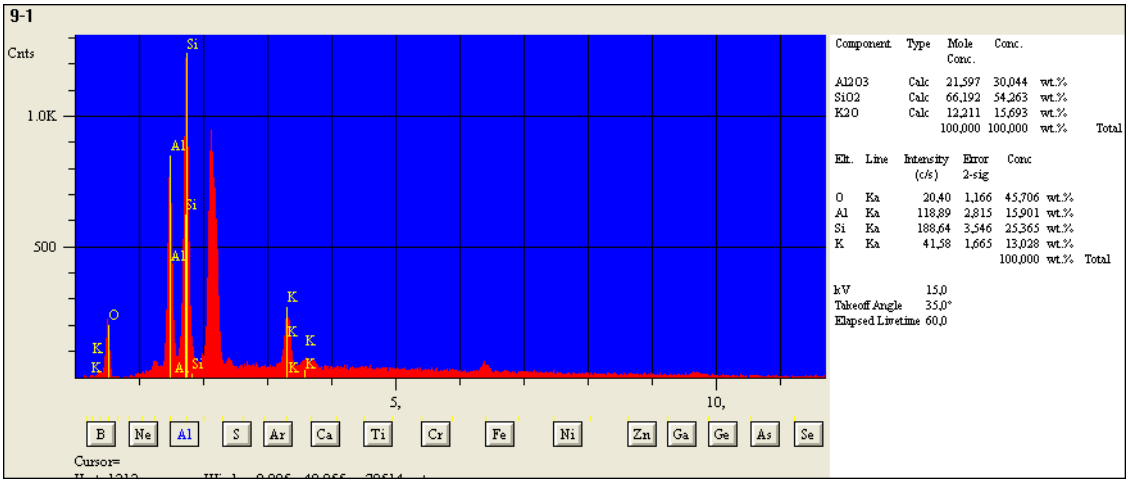

Fig 11. Spectrum of the semi – quantitative microanalysis performed from "K – Feldspar" crystal contained in the examined sample in accordance with the point (point numbered 1 in Fig 10) (EDS spectrum) and the results of analysis

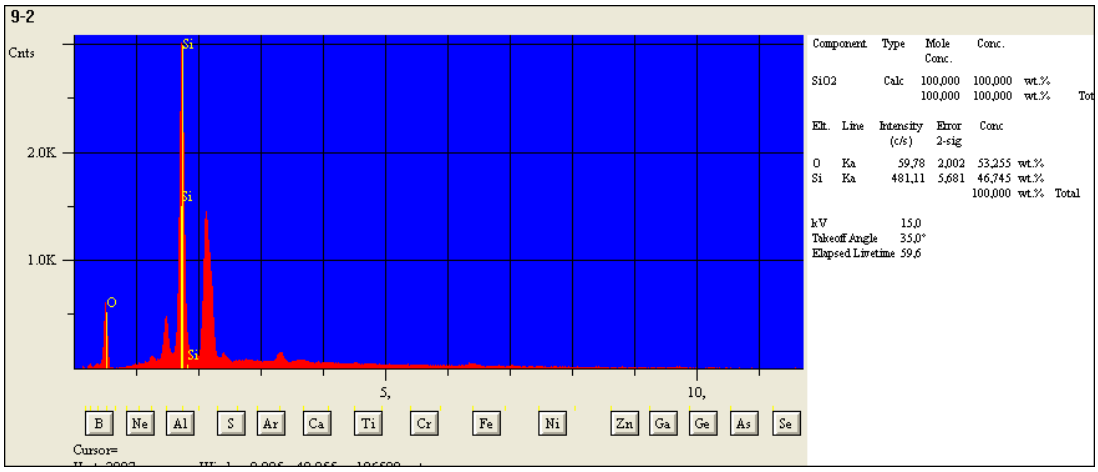

Fig 12. Spectrum of the semi – quantitative microanalysis performed from "quartz" crystal contained in the examined sample in accordance with the point (point numbered 2 in Fig 10) (EDS spectrum) and the results of analysis.

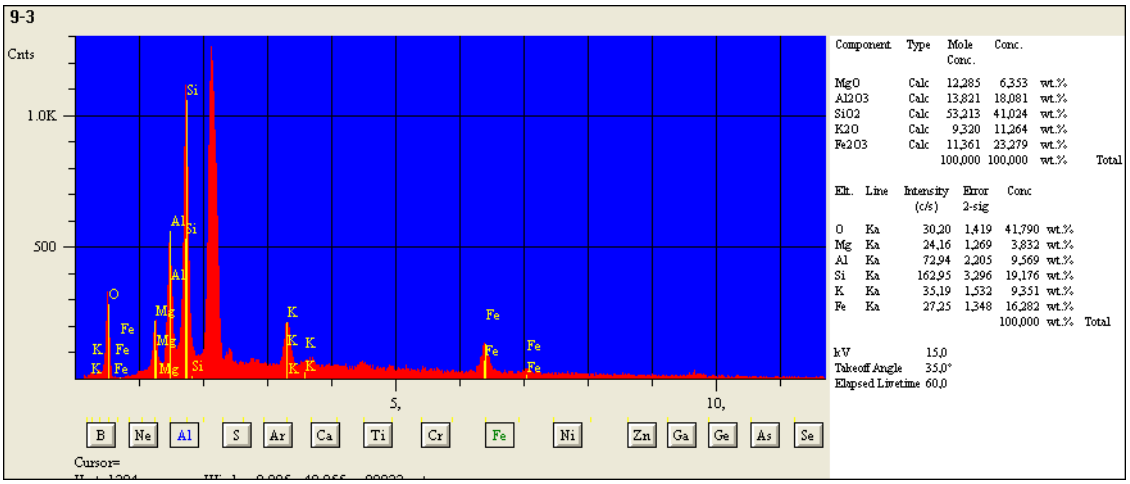

Fig 13. Spectrum of the semi – quantitative microanalysis performed from “clay matrix” contained in the examined sample in accordance with the point (point numbered 3 in Fig 10) (EDS spectrum) and the results of analysis.

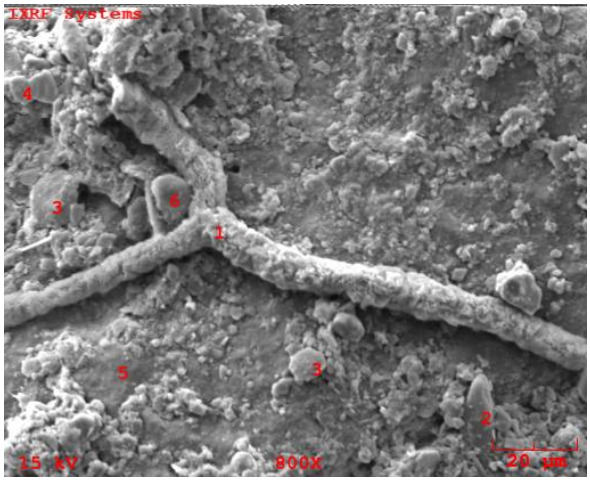

Fig 14. In the examined sample, SEM image (SEI) of the crystals, for which energy dispersion spectrometer (EDS) and X-ray microanalysis have been performed; point numbered 1, calcite crystal,

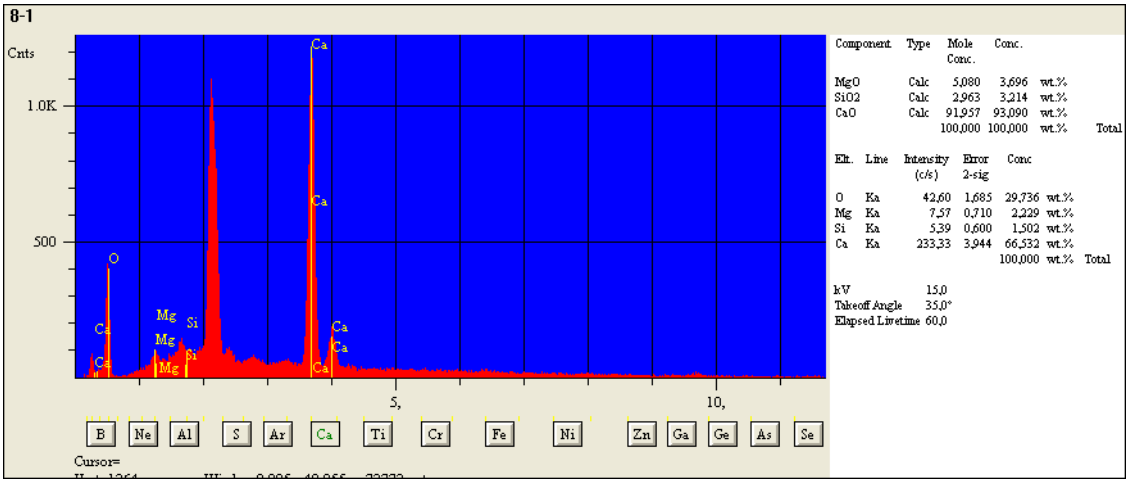

Fig15. Spectrum of the semi – quantitative microanalysis performed from the “calcite” crystal contained in the examined sample in accordance with the point (point numbered 1 in Figure 14) (EDS spectrum) and analysis results.

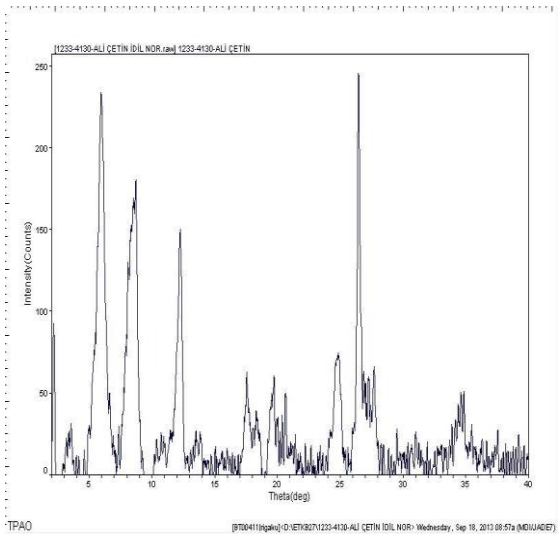

Fig 16. XRD – Whole rock dyphractogram of the examined sample.

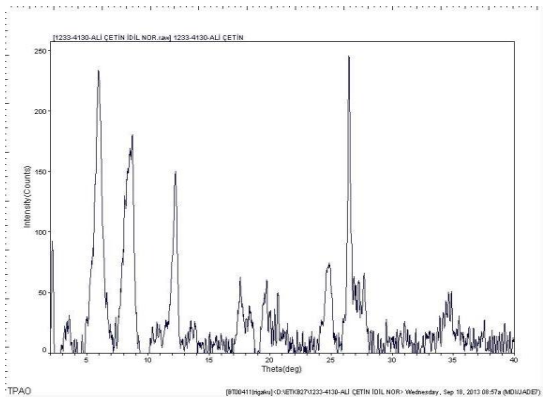

Fig 17. XRD – clay – normal shooting dyphractogram of the examined sample.

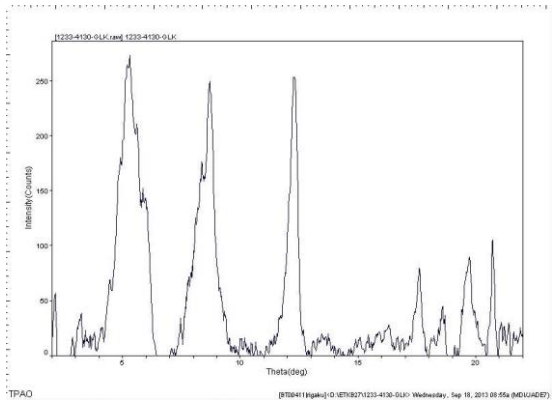

Fig 18. XRD – clay – ethylene glycol shooting dyphractogram of the examined sample

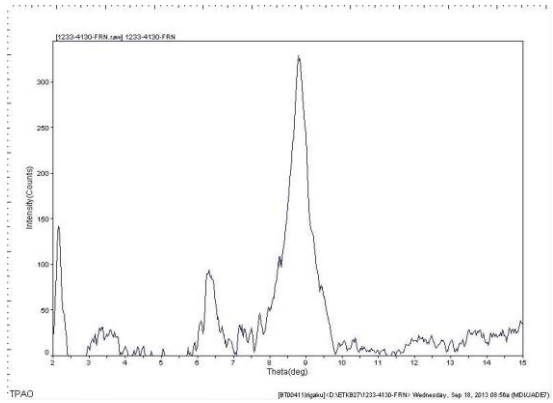

Fig 19. XRD – clay – kilned shooting dyphractogram of the examined sample

5. DISCUSSION AND CONCLUSION

As understood from the two adobe samples that have been examined, it is considered that the Urartian artists have chosen the material in accordance with the purpose of use where they knew the geology of the close surrounding [28], and prepared it by processing.

In case of surface applications and consolidation operations, where the drainage and side surfaces of the adobe brick are important, not only the types, but also the solutes and concentrations of the chemicals have to be tested in vitro for the consolidation operations.

It is expected that the systematic analysis and examination method that has been applied here on the soil based building material adobe bricks that are exposed as the result of the excavations, will be developed and compared being applied on many samples. Aside from this, different methods have to be searched in the examination of the adobe material.

The ceramic findings obtained from the excavations performed at Ayanis fort emphasize the cultural – architectural and socio-economic changes during and after the Urartu period [24]. For this reason, systematic sampling has to be performed against the possibility of existence of different productions in the preparation of the adobe building material.

In the excavations, geo textile covers have been used against rain, melted snow water, temperature changes,

water vapor and condensation problems. Various tests have been performed for the consolidation of the soil based building materials and the problem of consolidation of chemical materials and clay material remains to be solved. The limits of this study and parallel documentation with the named target and in compliance with the conservation and repair principles determined under the international regulations, studies have been performed on the conservation- repair projects of the temple and restoration project has been prepared by taking precautions against the destructions caused by the nature and the human being [21]. The chemical bonds that the chemical product/ products that are decided to be used for conservation purposes created with the feldspar group [31] will directly affect the conservation of the adobe material.

Seismic studies will be performed at Ayanis Fort, destruction caused by the small particles carried by the wind on the fort walls and on vertical areas will be measured, C^{14} determination of lime formation on and around the organic plant as determined by SEM/EDS within the adobe material will be performed with benzene method and the formation of lime and wood material will be examined in the following studies [32]. The research on the specific adobe mixture and main soil diversity prepared by continuing the studies on the samples that will be cataloged taking into consideration the geomorphologic structure of the locations around Van [28,33] Ayanis will be continued.

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CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

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