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Case Study

Ankara Temple (Monumentum Ancyranum/Temple of Augustus and Rome) restoration

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ABSTRACT

Temple of Augustus and Rome, also referred as Monumentum Ancyranum (Ankara Temple), is located near Haci Bayram Mosque in Ulus, Ankara. The temple which was built on behalf of Phrygian God 'Men' in 2nd century BC has been destroyed. The temple whose remains are present, on the other hand, was built for Roman Emperor 'Augustus' (Gaius Octavius) in 25 BC in the name of a commitment sign by King Pilamenes, the son of King Amintos, of Galatia. The positions of the 4 columns in the doorways and 2 columns in the rear sides are recognizable. Currently, only the sidewalls and ornamented door part are remaining. The original testament of Augustus in Temple of Rome, which is written in Latin and Greek and is telling the achievements of Augustus, is imitated in the mosque that is neighboring the wall of Monumentum Ancyranum. Some parts of the patina are spilled because of the climatic parameters (wind, heat, precipitation, and frost). As a result of the petrographic analysis made on the spilled parts of patina, it is concluded that the temple, which has a great importance in the world history, has to be restorated. As a result of the analyses (scanning electron microscope (SEM) analysis, EDS, and X-ray diffraction (XRD) analysis), inner and outer sides of Naos are being constructed without mortar. In the parts, which are broken from the main body, calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) are detected. Besides, it is observed that the main body of the temple is mainly consisting of calcium mineral. If this temple will be restored in the future, it is important to watch out for the calcium mineral property of the building.

1. Introduction

The temple of Augustus and Rome in Ankara is located a walking distance away from the first Grand National Assembly of Turkey building (Museum of Independence War) that the founder of the Turkish Republic, Mustafa Kemal Ataturk, and his companions has established; the temple is in the middle of the triangle of Anafartalar Avenue, Çankiri Avenue and Bent deresi. The Haci Bayram-i Veli Mosque, which was constructed by Islam Sufi and professor Haci Bayram Veli and his followers in 15th century, lies just near the temple. On 23 April 1920, before the inauguration of the first Grand National Assembly of Turkey, Mustafa Kemal Ataturk and the attendants prayed in Haci Bayram-i Veli Mosque. The hill where the

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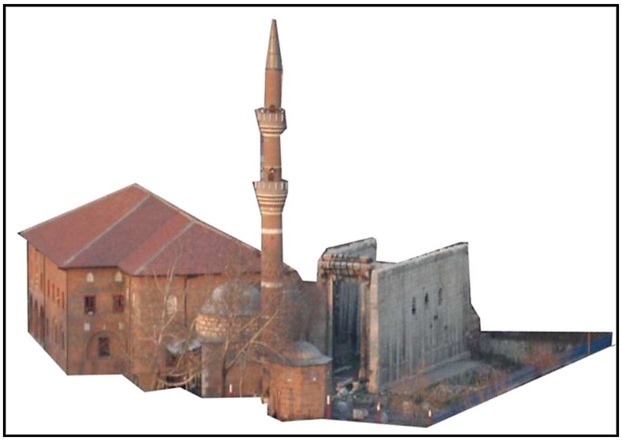

Fig. 1. The Temple of Augustus and Rome, Ankara; Haci Bayram-i Veli Mosque (Yurttagül, 2008).

people made their vows in history is crowded by hundreds of local and foreign visitors every day because of its spiritual energy (Fig. 1).

The temple of Augustus and Rome was built as a temple in the new administrative center, Ankara (Ancyra), after the Roman invasion in Galatia Region in 25 BC. The temple was dedicated to Emperor Augustus and the local goddess of the city, 'Roma'. After the death of Augustus, Romans inscribed a memorial on the walls of the temple both in Latin and Greek with red colored letters. The memorial, "*Res Gestae divi Augisti*", is known as 'Ankara Memorial' in Turkish. The inscription is an imitation of the original copy which was written by Augustus himself and was inscribed on 2 bronze columns in his mausoleum in the city of Rome. The mentioned original copy was destroyed centuries ago. The copy in Ankara Augustus Temple was preserved until now. The inscription is one of the most important documents of Roman period and it does not only present the achievements and accomplishments of Augustus, but also describes the institutional change, *res publica*, in the empire (Fig. 2).

Temple of Augustus in Ankara was designed in Corinth order, its dimensions are 36 m $\times$ 54.82 m, it has a *pseudo-dipteral* plan and it was placed on a platform which is 2 m high. In the beginnings of 6th century, Temple of Rome was converted to a church. In the middle of 15th century, before the death of Haci Bayram-i Veli, Haci Bayram Mosque was constructed, one side of which is leaning against the temple. Having undergone changes over time, the mosque and tomb located right next to it are still the capital's most important places of worship.

The Temple of Augustus, which is in the focus of interest of the whole world, was first introduced to the academic society by Busbeck. Busbeck was in the peace committee that Emperor I. Ferdinand sent to Kanuni Sultan Suleyman in 1553–1555. Another attendant in the same committee, Dernchwan, described the temple as a theater and palace in his journal. In 1670, in the time of Laisne, who was sent by the French government to purchase Greek manuscript, the temple was defined as Dervish convent. Tournefort, who arrived in Ankara in 1701, drew the plan of the building and he thought that the building was a residence. Poul Lucas was the first traveler who realized that the Temple of Augustus was a temple in classical order in 1705. In 1735, a British, Pococke, took measurements of the temple and he identified that this place was the Temple of Augustus. In 1835, Texier, drew the temple with the mosque and the residences nearby. In 1836, during his visit to Ankara, Hamilton agreed with the landowners and copied the whole building. In 1861, Guillaume made the building survey of the

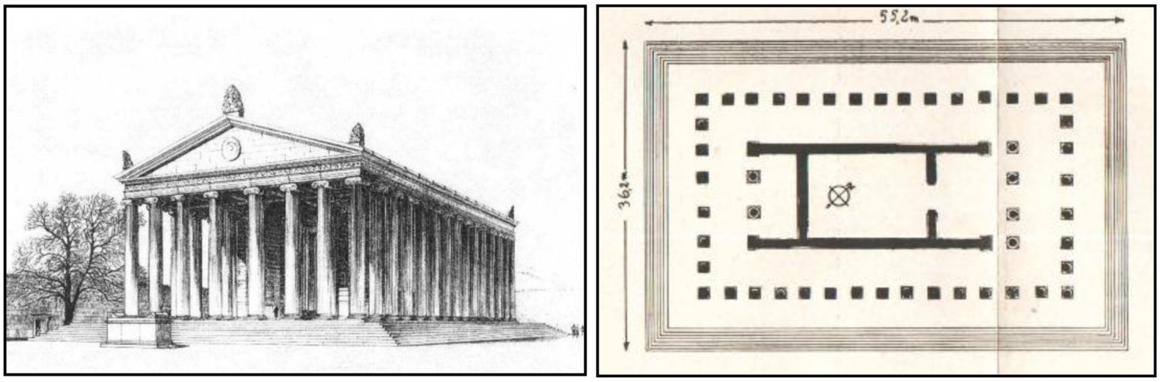

Fig. 2. The Temple in Ankara (Der Tempel in Ankara), (Schede, 1936).

temple. In 1865, historian and philologist Mommsen published the transcript of "*Res Gestae Divi Augusti*". In 1882, manuscripts were studied again under the leadership of Humann. Kranker-Schede made the first archeological excavations in and around the temple in 1926–1928.

After the foundation of the Turkish Republic, at first archeologists of the young Republic started to make scientific researches on this unique temple in the heart of Ankara. Between the years 1936–1938, all architectural designations of the temple were introduced by the researches under the leadership of Dr. Hamit Zubeyir Kosay. The elevation of the temple is lower than today's pavement level because of the modern formation of the area. The columns of the temple which are surrounding the courtyard are slightly visible. After the archeological and restoration studies of 1930, the work was stopped in the area for a long time period.

Considering the importance of the Temple of Augustus, World Monuments Watch declared the temple in the world's heritage list. In October 2001, it was listed as one of the hundred monuments which had to be rescued. The area and the surroundings of the Temple of Augustus in Ankara, which has a history of 2700 years, have been conserved by the directorate of Kültür ve Turizm Bakanlığı Kültür Varlıkları ve Müzeler Genel Müdürlüğü without harming its esthetical properties.

It is necessary to work on conservation excavations, landscaping arrangements, restoration and conservation studies to determine the urgent actions to preserve the Temple of Augustus. By the fund provided by DOSIM Directorate, archeological excavation studies were executed between 15 September 2008 and 24 December 2008. The purpose of these excavations was cleaning and displaying the areas which were excavated in 1930, interpreting the old data with the newly discovered archeological data, analyzing the static structure of the soil that walls of the temple sit, detecting problems of wall binding properties and problems with checking of archeological stratigraphy and radiographic scanning in the highly elevated area of Ulus. On the other hand, for the first time in Turkish museology history Museum of Anatolian Civilizations broke grounds with Temple of Augustus excavations. The studies in and around the temple were published daily in the Museum of Anatolian Civilizations webpage. Thus, the data were shared with the public and the scientific world (Yurttagül, 2008; Doğan, 2004).

The Temple of Augustus and Rome is one of the most important and prioritized historical monuments of Turkey which has the urgent need for restoration. The details can be seen in the pictures below (Figs. 3–9) (Aslan, 2013).

2. Previous studies

2.1. Studies related to the Temple of Augustus and Rome

Within the project named, Conservation Project of Temple of Augustus in Ankara, Özen and Zararsız (2009) made analysis researches. In the first phase, element analysis of two different deterioration products (black and yellow skin) were analyzed with portable nondestructive XRF machine. In the second phase, the same analysis has been made for the manuscript paint which was under serious danger of disintegration. The comparison between the spectrum of painted and unpainted parts indicated that the main difference between the two different parts was that the painted part was more ferrous. This result indicated that the red colored paint was composed of iron oxide. Besides the paint analysis, the same machine was used to compare the spectrums of yellow layered parts and the white layered parts. The calcium amounts for yellowed layered parts seemed to be lower whereas the ferrous and lead amounts were higher. In addition, in the yellow layered parts, it is observed that calcium amount is double the black layered part. Thus it is concluded that yellow deterioration product is a protective layer against the atmospheric deteriorations (Özen and Zararsiz, 2009).

Kadıoğlu and his colleagues (2009) used GPR (Ground Penetrating Radar) method to investigate the presence of archeological remains in and around the temple. They also studied on the reasons of angular deflection of the north sidewall of the temple. They also researched the presence of the remaining ferrous binding instruments which combines the

Fig. 3. Hacı Bayram-ı Veli Turbeh.

Fig. 4. Temple of Augustus and Roma.

Fig. 5. Temple of Augustus and Roma.

structural units. For that purpose, they collected ground penetrating radar data in and around the temple and they collected profile data alongside the northern wall which is neighboring Haci Bayram Mosque. According to the collected data, they started excavation activities in the place called, Temple East 2, and they realized that the excavations results and GPR results match each other (Kadıoğlu et al., 2009).

Sırt (2011) studied various techniques to evaluate the deterioration on the historical stone buildings by various microorganism species. For that purpose, she studied on marble and andesite samples on Temple of Augustus. To measure the enzymatic activity, she used Fluorescein Diacetate (FDA) hydrolysis method which was used to determine microbial activity on soil. She realized that dark stains were widely seen in the Temple of Augustus. Her study proved that FDA hydrolysis, microflora and MPN methods are effective methods to evaluate biological deteriorations on the historical stones (Sırt, 2011).

In 1997, Botteri and Fangi (2002) started their research on surveying and conservation activities in Monumentum Ancyranum under the project named Trieste University Ancyra Project. That study includes the reports of interdisciplinary (history, archeology, photogrammetry, and architecture) researches on Temple of Augustus which is the most important Roman temple standing in Ankara. Under the leadership of P. Botteri, a group of experts from different universities of Italy

Fig. 6. Pool with fountain.

Fig. 7. Deteriorations (external walls).

conducted a interdisciplinary study. The data which were obtained from the surveying studies were explained briefly. The tachometric and photogrammetric researches were done in two phases. The first phase was done until 1997 and it was restricted only to the epigraphs. The second phase was done in 2000 and it covered the whole temple (Botteri and Fangi, 2002).

Wallace (2000), in his study, presented the manuscript which was carved with the painted colors on the wall of Temple of Augustus in Ankara. The author added an introduction, comments, grammar notes and keywords in his study. The text includes Roman Emperor Augustus' achievements, his activities, and his attempts to reach power. The Latin text was translated into English by the author (Wallace, 2000).

Fig. 8. Menderes motif on the exterior walls.

Fig. 9. Deteriorations and Wrecks on the northern side walls.

In their study, Caner and Böke (1989), observed calcium oxalate on the original marble surfaces of Temple of Augustus which is located in a polluted area in Ankara. After the outer layer had been exfoliated, calcium oxalate was found on the new layer (Caner and Böke, 1989).

Caner and colleagues (1989a) investigated the effects of air pollution on the marbles of the Roman Temple of Augustus in Ankara. They examined samples taken from the exfoliations by X-ray powder diffraction, optical microscopy, scanning electron microscopy, microscopy coupled to an edax system and limited chemical analysis. They described gypsum formation as a result of the study. They discussed deterioration in relation to Temple of Augustus. Atmospheric parameters and pollution data were evaluated. The building of a roof to protect against rain and snow was suggested as an immediate precaution (Caner et al., 1989).

3. Materials and methods

3.1. Material

Some parts of the patina were split from the interior and exterior surface of Naos because of the climatic parameters (wind, heat, precipitation, and frost). These were used as sample in the experiment.

3.1.1. The preparation of samples which are used in the research (Maden, 2013)

All kinds of sample preparation processes are done with modern equipment in Turkish Republic Ministry of Energy and Natural Resources, MTA Mineralogy and Petrography Analysis Laboratory Unit.

- The production of thin section and polished section for optic microscopic (petrographic analysis) analysis.
- The production of polished thin section for fluid inclusion analysis.
- Granulation of sample for XRD analysis.
- Element microscopy, hot runner and polishing for organic petrography analysis.
- The production of polished thin section for SEM, gold and carbon coating.

Note: The above process and grinding process are carried out by Turkey directorate general of mineral research and exploration samples (MTA). Sample sizes change according to the characteristics of the equipment in MTA (Fig. 10).

3.2. Method

Under the command of the administrator of Turkish Republic Ministry of Energy and Natural Resources, General Directorate of Mineral Research and Exploration, Mineralogical Researches Division, scanning electron microscope (SEM) and EDS, and X-ray diffraction (XRD) analysis have been made meticulously.

3.2.1. Experimental studies

Turkish Republic Ministry of Energy and Natural Resources, MTA Mineralogy and Petrography Analysis Laboratory is accredited according to TS EN ISO IEC 17025 standards. The experiments which were done according to ASTM standards in the study are explained step by step below.

3.2.1.1. Scanning electron microscope analysis (SEM). Scanning electron microscope is a technique which enables to produce high definition image with a focused beam of electrons. By the help of this technique, morphological, elemental and structural information can be gathered from low focus to high focus (300,000× or more) (Maden, 2013).

Fig. 10. Buehler analysis machine.

Table 1
The data of climatic parameters belonging to Ankara (1960–2012).

ANKARA	January	February	March	April	May	June	July	August	September	October	November	December
Average temperature (°C)	0.3	1.8	6.1	11.3	16.1	20.2	23.5	23.3	18.7	13.1	7.1	2.7
Average highest temperature (°C)	4.3	6.4	11.7	17.2	22.2	26.6	30.2	30.2	26.0	19.9	12.8	6.6
Average lowest temperature (°C)	−3.0	−2.2	1.0	5.7	9.7	13.0	16.0	16.0	11.9	7.4	2.5	−0.6
Average sun taking (h)	2.5	3.5	5.2	6.3	8.4	10.2	11.3	10.6	9.2	6.4	4.4	2.3
Average rainy days	11.7	11.0	10.9	12.0	12.5	8.6	3.8	2.8	3.8	7.1	8.6	11.8
Monthly total rainy days (kg/m^2)	41.8	36.9	38.7	49.0	51.2	35.4	14.5	10.9	18.5	30.2	33.9	46.9
Highest temperature (°C)	16.6	19.9	26.4	30.6	33.0	37.0	41.0	40.4	36.0	32.2	24.4	19.8
Lowest temperature (°C)	−21.2	−21.5	−19.2	−6.7	−1.6	4.7	6.8	6.3	2.5	−3.4	−10.5	−17.2

Table 2
The highest values of the climate parameters of Ankara Province (1960–2012).

Daily total maximum rain amount	11.06.1997	88.9 kg/m^2	Daily fastest wind	12.01.1968	115.6 km/h	The highest snow	05.01.2002	30.0 cm

Under high vacuum conditions, secondary electron (SE), back-scattered electrons (BSE) or mixed (SE + BSE) signal visions are gathered and photographed. In addition, nonstandard qualitative elemental analysis (SEM–EDS) is made on the inspected sample with X-ray mapping.

3.2.1.2. X-ray diffraction (XRD analysis). XRD is a technique which is used to introduce small particle sized minerals according to their crystal structural properties if it is impossible to do that with optical microscopes. In this technique, the sample which will be analyzed, is grinded and is turned into powder form and it is analyzed with the XRD analysis instruments. XRD analysis which is made in the division, is done with the instruments Bruker D8 Advance, Panalytical X'Pert Powder and Philips PW 1830 (Maden, 2013).

In standard, qualitative XRD analysis, samples are analyzed with Ni filtered, X-ray tubed instruments under 2–70 °C. The produced X-ray diffractograms are evaluated according to ASTM-295 standards.

With standard XRD analysis, enrichment process is applied for undefined clay typed minerals and qualitative XRD detailed clay analysis is made. In this method, after standard analysis process, the enriched samples are analyzed with Ni filtered Cu X-ray tubed instruments between 2 and 40 °C as normal, with ethylene glycol, oven-dried (550 °C). The obtained X-ray diffractograms are evaluated according to ASTM 295 standards. The quantitative rates of minerals (quantitative XRD analysis) are calculated by using Rietveld method. With the applied method, the necessary corrections of peak values (Rietveld Refinement) on the diffractograms which are obtained from high definition Pixel based detectors, are made by using the database of crystalline structure files. The percentage values of minerals are given with the rates of standard deviations.

3.2.2. Climatic parameters belonging to Ankara

Statistical data belonging to Ankara between the years 1960 and 2012 is obtained from Turkish State Meteorological Service (Table 1) (http, 2013).

According to the information from the General Directorate of Meteorology, Republic of Turkey Ministry of Forestry and Water Affairs, the average lowest temperature in Ankara between the years 1960 and 2012 is −21.5 °C and the highest is +41.0 °C; the average monthly total rainfall is 51.2 kg/m^2 (Table 1). In addition, the highest daily rainfall total is 88.9 kg/m^2 on 11.06.1997, the fastest wind is 115.6 km/h on 12.01.1968, and the highest daily snow is 30.0 cm on 05.01.2002 (Table 2). Therefore, Naos's walls are under the influence of these climate parameters (temperature, wind, precipitation, and frost) for centuries. This situation causes freeze-thaw on the patina layer, and as a result, the surface is eroded by spalling. Plus, wind, temperature difference and rainfall accelerate spillages from the layer of patina. Building materials and chemicals to be used in the restoration of this historic sanctuary should be selected taking into account climatic parameters of the capital Ankara.

4. Findings and discussion

4.1. Scanning electron microscope analysis (SEM) and EDS findings

As seen in Fig. 1, SEM analysis was performed and Energy Dispersive X-ray Spectroscopy (EDS) analysis was performed for the points 1 and 2. The results are shown in Figs. 12 and 13.

The photographs of scanning electron microscope SEM were taken with the scale 1 cm for 2 μm. It is taken with 300,000× lens and more zooming (Fig. 11). The technique is used for taking high definition image with a focused beam of electrons. By the help of this technique, morphological, elemental and structural information can be gathered from low focus to high focus. Under high vacuum conditions, secondary electron (SE), back-scattered electrons (BSE) or mixed (SE + BSE) signal visions are gathered and photographed.

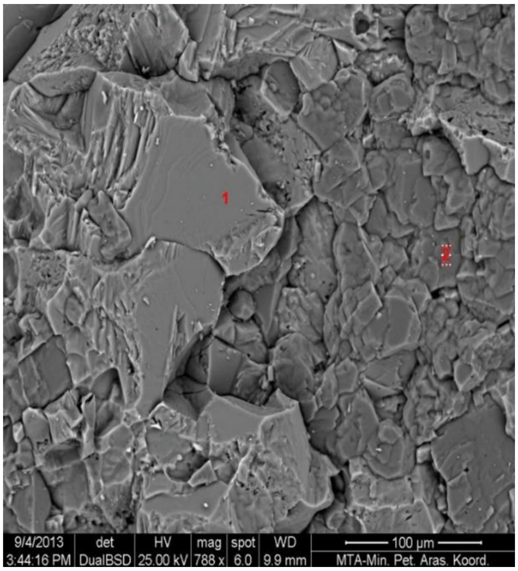

Fig. 11. SEM analysis (1, 2) photograph.

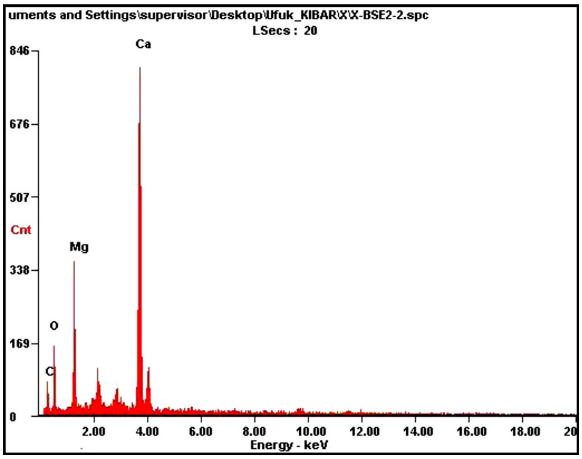

Fig. 12. EDS analysis graphic.

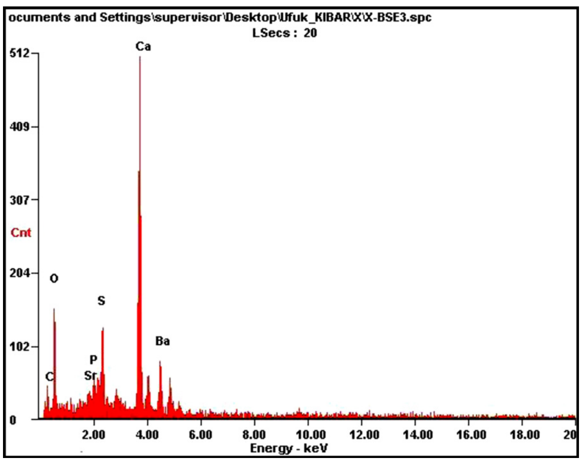

Fig. 13. EDS analysis graphic.

Table 3
EDS atomic percentages.

Elements	Atomic percentage
C	29.86
O	40.37
Mg	12.80
Ca	16.96
Total	100.00

Table 4
EDS and atomic percentages.

Elements	Atomic percentage
C	24.47
O	52.27
Sr	0.67
P	1.73
S	4.08
Ca	14.00
Ba	2.79
Total	100.00

In the regions which include that structure, the particles are mostly arranged homogeneously, the shapes of them are cornered and fractured and the dimensions are in micrometers. The distances between these particles are seen to be narrowed. The dimensions are around 0.35–0.91 μm. In addition, spherical and closed spacing particles are seen along with geometrical shaped particles.

Another property which is seen in the SEM photographs is that the particles, which have different sizes and shapes, have similar color tones. Although some particles are dark gray in color, in some regions light gray and white particles are also seen. This situation is obvious in all successive analysis. The image which is seen in the SEM photographs is a typical cytsalline structural shape which is also defined in the literature. A homogenous structure is observed, the particles are observed to be in a tight form, large cavities and large particles are not observed.

In addition, nonstandard qualitative elemental analysis (SEM–EDS) is made on the inspected sample with X-ray mapping (Figs. 12 and 13).

EDS analysis was applied by focusing on a point of 2 μm and it is applied by searching an area of (50 μm × 50 μm). This procedure is applied in a depth of 2.5 μm. In this analysis, the pure structure of the experiment sample is observed. In Tables 3 and 4, atomic percentages which were obtained from EDS analysis are given.

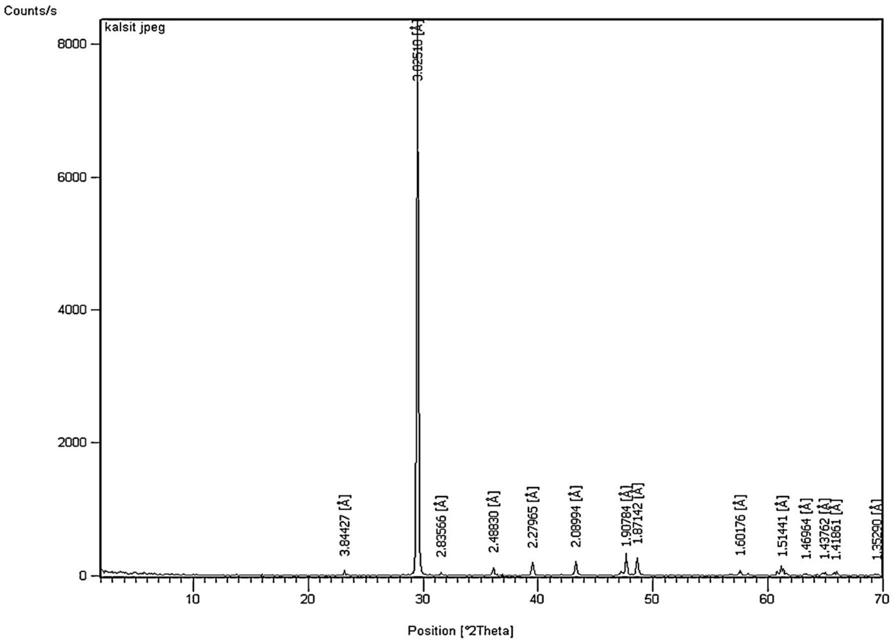

Fig. 14. XRD analysis graphic.

Moreover, EDS analysis indicate that various dissolutions were not formed, thus mainly a pure structure is observed during the analysis.

4.2. X-ray diffraction (XRD analysis) findings

According to the results of XRD analysis in Fig. 14, the exterior and interior of main body of Naos are composed of calcite mineral.

While defining the microstructure of the experiment sample and while examining the crystal structure, X-ray analysis provided important findings. In the process, applying sintering with heat, the experiment samples are monitored from the nucleation phase to the last crystallization phase for crystallization duration and structural changes with XRD. These analysis have lots of benefits for observing different crystalline structures and for defining the appropriate heating conditions as well. Because of the same reason, the similarity between peak points indicates that the structure, which constitutes the sample, is in a pure phase, meaning that it is mainly composed of calcite mineral.

This situation is observed clearly in SEM photographs and it is compatible with XRD results.

5. Results and suggestions

According to the data obtained from Turkish State Meteorological Service, the average temperature in Ankara is lowest at $-21.5\,^{\circ}C$ and highest at $+41.0\,^{\circ}C$. Average of monthly total rate amount is 51.2 kg/m^2 (Table 1). In addition, the daily total maximum rain amount is 88.9 kg/m^2 on 11.06.1997. Daily fastest wind is 115.6 km/h on 12.01.1968. Daily highest snow amount is 30.0 cm in 05.01.2002 (Table 2). Therefore, the walls of Naos are under these climatic parameters (wind, heat, precipitation, and frost) for hundreds of years. This condition leads to freezing and thawing in the patina layer and it causes spilling in the surface. Moreover, wind, temperature differences and rains accelerate the breaking of pieces from patina layer. The construction materials and construction chemicals which will be used for restoration of this historical temple have to be chosen with respect to the climatic parameters of Ankara.

Turkish Republic Ministry of Energy and Natural Resources, MTA Mineralogy and Petrography Analysis Laboratory Unit has made Scanning Electron Microscope (SEM) and EDS (Figs. 11–13), and X-ray diffraction (XRD) analysis (Fig. 14). With respect to the analysis, the main component of the temple is determined to be stone with calcite mineral. According to this determination, the materials and chemicals which will be used in the restoration process, have to have calcite mineral origins or they have to be compatible with calcite mineral.

The pool with fountain (Fig. 6), on the south side of the historical temple, is increasing the moisture rate and it is accelerating the deterioration of the Greek manuscript on the south sidewall of the temple. The original copy of the manuscript was in Rome and it was destroyed centuries ago. Therefore it is very important to keep the only remaining copy. The information given in the manuscript do not only belong to Roman Emperor Augustus, but also include important information about Roman history. Therefore, rather than a fountain, a classical hydrophore (pressurized recirculation pump) where the water is pouring step by step can be used. A pool system where the water is recirculating by machines can be considered.

A solution for roofing, which is compatible with the roofing system in the original building (Fig. 2), can preserve the structure against climatic parameters and it can provide sustainability for the static equilibrium of the building. Such a precaution has to be taken urgently.

The temple, whose importance for world heritage is unquestionable, has to be restorated faithful to its originality. Formation of the temple has to be in accordance with the surrounding structures and the environmental parameters. The historical structure has to be accessible to humanity as a museum, and thus the honor, it deserves in the history, will be given back to it.

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