European Journal of Technique

journal homepage: https://dergipark.org.tr/en/pub/ejt

Vol.14, No.2, 2024

Research Article

The Impact of Locally Available Materials on Architectural Heritage: Preliminary Findings from the Güzelşeyh Pavilion, Türkiye

Felat Dursun[1,2*]

[1*]Department of Conservation and Restoration of Cultural Heritage, Izmir Institute of Technology, Izmir, Türkiye
[2] Department of Mining Engineering, Dicle University, Diyarbakir, Türkiye (e-mail: felatdursun@gmail.com; felatdursun@iyte.edu.tr)

ARTICLE INFO

Received: Sep.., 30. 2024
Revised: Nov., 03. 2024
Accepted: Nov., 08. 2024

Keywords:
Basalt
Limestone
Local material
Stone conservation
Güzelşeyh Pavilion

Corresponding author: *Felat Dursun*

ISSN: *2536-5010* | e-ISSN: *2536-5134*

DOI:https://doi.org/10.36222/ejt.1558833

ABSTRACT

Understanding how local stones shaped material selection in historical structures is crucial for preserving architectural heritage and guiding conservation strategies. The current study examines the role of local materials in the construction and preservation of the Güzelşeyh Pavilion (GP), situated in the Çınar district of Diyarbakır, Türkiye. GP is unique not only for its use of basalt and limestone but also for combining these locally sourced stones into its architectural elements. This preliminary research assesses the pavilion's current condition and proposes possible stone sources for conservation. Located at the meeting point of volcanic rocks and Eocene limestones, the pavilion uses basalt for load-bearing elements and limestone for both decorative and structural components. The contrast between dark basalt and light limestone enhances its aesthetic appeal, while their combined application strengthens its durability. Fieldwork and laboratory studies, including mineralogical, petrographic, and geochemical analyses, were conducted to investigate the materials and their sources. Site investigations revealed that the pavilion, now largely in ruins, has suffered different forms of decay, particularly in its limestone components compared to the basalt. The analysis suggests nearby volcanic units as a probable source for the basalt, reflecting characteristics that closely match those of the region. Similarly, the limestone appears to align with materials sourced from quarries in Bağacık village, suggesting these quarries as a possible source for the pavilion's limestone. By identifying these sources, the study offers practical guidance for conservation architects working to ensure the long-term preservation of the site.

1. INTRODUCTION

Using locally available materials in historic structures has long been an essential architectural practice, reflecting cultural identity, sustainability, and environmental adaptability across diverse regions [1–3]. These materials (often known as locally sourced, locally extracted, locally quarried) are typically resources either naturally found or produced from raw materials within the region. For centuries, communities have utilized local resources to construct functional structures that reflect regional traditions and respond to environmental conditions. Materials like stone, timber, wood, bamboo, brick, and adobe have been valued not only for their durability and aesthetic properties but also for their ability to resist local environmental pressures while enhancing sustainability across various regions [4–9].
It is known that ancient builders did not simply choose these materials for convenience; their selections were guided by a deep understanding of the materials' behavior under different environmental and structural loads. This expertise, refined over generations, informed construction techniques that maximized the resilience and efficiency of structures [17–20]. Generations of accumulated knowledge allowed communities to create building techniques specifically suited to their local environment. As a result, their shelters, religious structures, and monuments were durable and designed to work in harmony with the region's climate and geological conditions.
Stone holds a unique position among building materials, not only for its durability, strength, and adaptability but also as one of the most abundant resources available on the Earth's surface. Its role in architecture is unmatched, as it not only provides structural stability but also contributes to the cultural identity of civilizations across time [10–12]. Their accessibility often dictated architectural choices, with stones sourced from nearby quarries to minimize transportation challenges. However, the use of stone was not based solely on practical considerations; it also reflected the cultural values of the communities. This deep connection between material and heritage is evident across numerous ancient cultures, where stone became the foundation of their architectural

achievements. For example, the Nabataeans expertly carved the city of Petra into the red sandstone cliffs of modern-day Jordan, using the soft but strong stone to create impressive facades that have lasted through centuries of weathering [13–14]. Similarly, the city of Mardin in southeastern Türkiye is renowned for its distinctive limestone architecture, where locally quarried limestone, well-suited to the semi-arid climate, provides both insulation and durability for historic buildings [15]. In Italy, Roman structures like the Colosseum were built primarily with local stones like travertine and volcanic tuff, indicating the Romans' skill in using these materials for both strength and aesthetic appeal [16].

The relationship between natural stone and architectural heritage extends beyond material availability. Abundant local stone fostered a tradition of skilled craftsmen, including stone carvers and masons. In Mardin, the skilled stone carving traditions reflect the community's deep knowledge of limestone's workability and weathering properties, enabling artisans to create buildings that are both durable and artistically impressive [15].

Sourcing building stones for conservation projects has long been a challenge. Conservation architects frequently consult geologists on how and where to obtain compatible materials [3]. Even when suitable stones are locally available, factors like urbanization, industrialization, or legal protections can limit extraction. Despite these obstacles, the geology of a region still plays a key role in shaping the landscape and determining stone availability. Variations in rock types—igneous, sedimentary, metamorphic—along with morphology, petrography, tectonic activity, topography, and durability, provide diverse materials that influence architectural practices.

Considering the locally available stone materials, the convergence of different geological units—refers to the meeting or interaction of distinct rock formations, such as volcanic, sedimentary, or metamorphic units, within a specific region—not only shapes the surface topography but also allows for the formation of different natural stone types within proximity. This practice is particularly evident in structures built near geological boundaries, where the proximity of different geological units allowed for the use of various stone types. In this context, the Güzelşeyh Pavilion (GP), located between Diyarbakır and Mardin, serves as a unique example of how local geology influenced material choices.

This study aims to define how the local availability of different lithological units is reflected in the GP's architecture and suggest proper material sources for its conservation.

2. STUDY AREA

The subject of this study is the GP, located in the Çınar district of Diyarbakır province, Turkey. The pavilion has been officially protected by the Diyarbakır Regional Board for the Conservation of Cultural Heritage since June 6, 1990 [21]; however, notable work on the site has been limited. Aside from Meltem-Tekin's [22] conservation-focused documentation and Yariş's [23] study on ornamentations, the site has received little significant attention to date. There is no clear documentation identifying the exact date of construction or the builders of the GP [24–27]. However, the Diyarbakır Regional Board suggests that the pavilion was built approximately 150 years ago by Assyrian stonemasons from Mardin, though the evidence supporting this claim remains uncertain. An Ottoman-period document from 1898, cited by [26], indicates that the building was used as both a madrasa and a pavilion in the early 20th century. Another perspective is proposed by art historians, including [23–24], who suggest that considering the ornamentations and construction techniques, it was likely built during the Ottoman period and initially served as an inn or postal relay station. All the evidence suggests that the structure has existed since at least 1855 [22], [26].

The structure, originally constructed using traditional masonry techniques, has unfortunately fallen into a state of partial ruin over time due to prolonged neglect (Figure 1). The pavilion consists of the ground floor and the first floor. The ground floor was used as a madrasa, and the upper floor was used as a pavilion [23]. The ground floor, rectangular and aligned east-west, is accessed through two entrances in the same direction. These entrances lead to a central corridor flanked by 16 rooms. While the rooms on the west side remain relatively intact, those on the east side have collapsed in places with damage extending to the foundation level (Figure 1). The first floor, oriented perpendicular to the ground floor, was originally accessed by a staircase, which has since been demolished. This floor consists of two rooms in a rectangular form along the north-south axis and a central space [23]. The upper cover of the rooms has been completely demolished (Figure 1), and portions of the floor have also collapsed. This transition is significant as it reveals how the building's original fabric changed over time.

Basalt served as the foundational material on the ground floor, used on the flooring and in load-bearing walls due to its strength. On the first floor, dressed limestone became the dominant material, contributing to the building's decorative carvings, ornamentation, and arches, which enhanced its aesthetic value. The most common ornamentations in the building are those with plant and geometric patterns. Although these decorative elements are concentrated on the first floor, it is possible to see remarkable ones carved in limestone on the exterior facades (especially on corner borders, portals, arches, windows, and hood molds) [22–23] (Figure 1).

3. MATERIALS AND METHODS

This preliminary study was conducted in two primary phases: field surveys and laboratory analyses. The fieldwork involved site inspections and material sampling. During the site inspections, the geological context of the site and its surrounding areas were investigated by examining the distribution, boundaries, and characteristics of geological units. Accessible outcrops were visited to assess the sources of construction materials. Additionally, the conservation state of the pavilion was assessed to determine the application of natural building stones and identify major forms of decay. To characterize and identify the materials used in the construction of the pavilion, four representative locations were selected for sampling.

A total of 5 samples were collected, including one basalt sample from the pavilion (Sample 1), one sample from the basalt quarry near the pavilion (sample 2), one limestone sample from the pavilion (Sample 3), one limestone sample from the Bağacık Village (Sample 4) and one limestone sample from the Zerzevan Castle outcrops (Sample 5). The second phase focused on laboratory analyses, which included mineralogical, petrographic, and chemical characterization of the collected samples.

Figure 1. Façade views and principal construction materials of the GP (Bottom right image sourced from [22]

Five thin sections were prepared for petrographic examination of the limestone and basalt samples collected from the pavilion and potential material sources. An optical microscope equipped with a camera system was used to perform modal analysis and assess grain size, texture, and rock classification. The major oxide compositions were determined through X-ray Fluorescence (XRF) analysis. All petrographic and chemical analyses were conducted at the Institute of Mineral Research and Exploration (MTA) Laboratories in Ankara, Türkiye.

4. GEOLOGICAL SETTINGS

The GP is located in the transition zone between volcanic and sedimentary terrains. Understanding this geological setting is crucial for contextualizing the site's location and construction materials. Figure 2 provides geological maps of the region and site derived from those prepared by the Mineral Research and Exploration General Directorate [26–28]. These maps illustrate the distribution and age of rock units, enhancing our understanding of the geological composition and the location of the GP.

The study area is situated along the northern margin of the "Arabian Platform" (Figure 2 a), characterized by a Paleozoic succession with clastic and carbonate layers and a Mesozoic succession predominantly composed of carbonates. This platform is tectonically overlain by northward-verging ophiolitic nappes [29-30]. A distinct structural feature in the region is the presence of numerous east-west trending fold axes aligned parallel to the northern thrust fault. These structural sequences are unconformably overlain by Neogene to Quaternary sedimentary and volcanic layers. Figure 2 b illustrates the local geology near the study area, where exposed rock units include Eocene limestones and continental sedimentary deposits from the Neogene to Quaternary periods, interlayered with volcanic rocks. Among these, only the Eocene limestones and volcanic rocks have been used as building materials in the GP. The following sections detail these two units.

Eocene Limestone: This limestone is the oldest exposed unit within the study area and represents the youngest layer of the Arabian Platform sequence (Figure 2 b). The limestone appears in shades ranging from light cream to beige and is generally massive, with medium to thick bedding; however, in some areas, it also exhibits a porous structure. The unit includes thin to thick layers of cream and beige dolomite and several levels of cherty limestone. Widespread across southeastern Turkey, this unit has a thickness exceeding 300 meters [27]. The Eocene limestone, used as a building stone in the construction of the GP, is also found in the Roman castrum of Zerzevan Castle, located approximately 20 km south of the pavilion. This same limestone was used for the fortifications and other structures within the castrum [31]. However, this unit can show color and textural variations even in areas close to the study location.

Volcanic Rocks: The second type of building stone used in the GP is volcanic in origin and dates to the Neogene-Quaternary period. These volcanic rocks belong to the Karacadağ volcanic complex, which has been widely studied for its mineralogical, petrographic, and geochemical properties [32–36]. Karacadağ volcanism, characterized by basaltic formations with a shield-like morphology, covers a broad area in southeastern Türkiye.

Ercan et al. [33] proposed a volcano-stratigraphic scheme dividing the Karacadağ volcanic activity into three main phases. According to this scheme:

- The first phase, known as the Siverek volcanic complex, dates to the Late Miocene based on K-Ar dating and extends over an area of approximately 10,000 square kilometers to the south and west of Diyarbakır. This phase covers over 80% of the volcanic complex and provides the possible building stones quarried for the GP.
- The second phase, referred to as the Karacadağ volcanics, represents the main formation of the Karacadağ Mountain, which reaches an elevation of 1,957 meters. These volcanics cover around 15% of the complex and include the basalt layers beneath the Diyarbakır City Wall (Figure 2 b).
- The third and most recent phase, known as the Ovabağ volcanics, consists of fresh-looking basalts along the southeastern and eastern margins of the complex. These rocks are distinguished by their dark color, sparse vegetation, and well-preserved morphology, including Aa and Pahoehoe lava flows, lava tubes, and prominent scoria cones on the eastern slopes.

Other exposed units in the area include semi-consolidated to unconsolidated sedimentary deposits, largely of fluvial origin and formed in a continental environment. The alluvial deposits of the Tigris River currently form the eastern boundary of the Karacadağ volcanic complex.

5. RESULTS AND DISCUSSION

5.1. Field observations

Field observations revealed that the pavilion is situated on a hill at an elevation of 686 meters, offering a commanding view over the surrounding plain. The geological characteristics of this location have played a significant role in the choice of the site. The nearby village of Altınakar, to which the pavilion is connected, lies on the floodplain of the Tigris River at a lower elevation of 650 meters (Figure 2). In contrast, the pavilion is located approximately 3 km northwest of Altınakar village, within the basalt outcrops. As shown in Figure 2, this area marks the endpoint of a basalt lava flow. The basaltic landscape, offering a more stable foundation than the floodplain's alluvial deposits, seems to have been a deliberate technical decision in the pavilion's site selection.
The primary building materials of the pavilion are basalt and limestone. The ground floor is mainly constructed from rubble or semi-dressed basalt, with walls varying in thickness from 95 to 105 cm. Limestone is primarily used on the first floor and for specific architectural elements such as wall edges, door frames, floor moldings, and windows. The limestone walls on the upper floor are slightly thinner, with a thickness ranging from 60 to 80 cm, reflecting limestone's unique properties and load-bearing requirements [22].
The basalt blocks in the masonry are irregularly shaped, with average dimensions of 22 cm in height, 25 cm in width, and 20 cm in depth. However, these dimensions can vary significantly depending on their position within the wall and specific structural demands. In contrast, the limestone blocks on the upper floor are typically larger and more uniform, averaging 35 cm in height, 50 cm in width, and 35 cm in depth. These measurements are approximate, as stone sizes often vary due to the adaptive construction techniques applied.

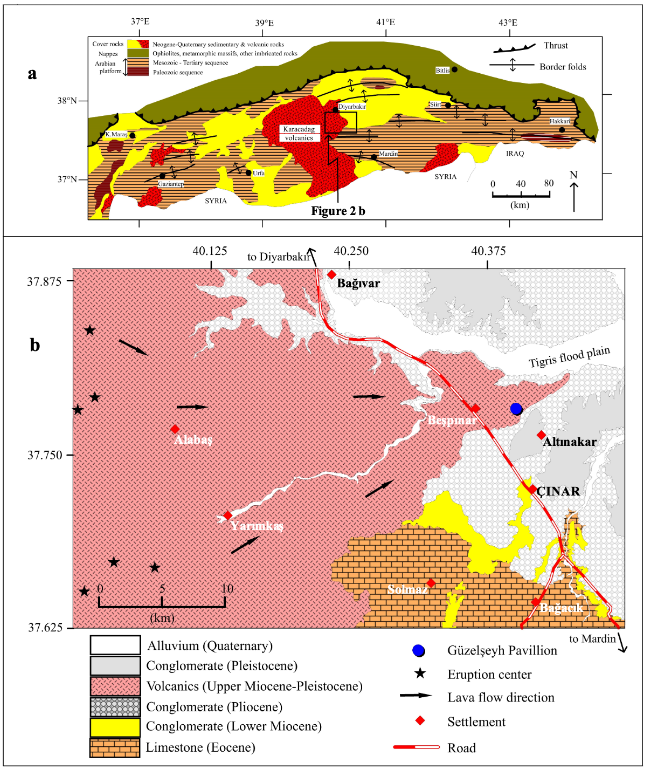

Figure 2. Geological map of the area around the GP [26-28]

The most likely source of the basalt used in the construction of the pavilion is thought to be the basalt units observed in its immediate vicinity. In addition to basalt, the region and its surroundings offer limestone units that are well-suited for use as building materials. Notably, limestone outcrops in Bağacık Village, located about 15 km south of the site (Figure 2,6), and the historically significant Zerzevan Castle, situated roughly 20 km southeast, stand out as prominent sources of stone for construction. As mentioned in previous sections, field studies revealed that basalt and limestone were applied in different forms in the structure (i.e., as rubble and cut stone). The primary reason for employing limestone as cut stone is its suitability for carvings and motifs that enhance the building's aesthetic and historical value. Additionally, limestone is easier and more efficient to work with than basalt, offering advantages in terms of both time and labor.
Early written and photographic documents from the registration records confirm that basalt was extensively used for the ground floor during the original construction. However, in later periods, certain sections of the building were modified with the addition of limestone, particularly in areas where basalt had originally been used. These changes, likely made during repairs and renovations, introduced limestone for architectural features such as door and window frames, wall edges, and sections of the vaults. Limestone was also added to parts of the ground floor, especially at the portal and the corners of the walls. Meltem-Tekin and Oğuz [22] also noted these modifications, pointing out the repeated use of limestone in various parts of the structure during different renovation phases.

The type, extent, and distribution of decay forms were analyzed as part of the field studies. Although the current abandoned state of the building limits a comprehensive assessment, an attempt was made to describe the weathering forms observed in the remaining standing sections (Figure 3). It was observed that the basalt, especially in areas in contact with the ground, showed signs of decay, including discoloration, chipping, and blistering due to water exposure. On the other hand, the limestone exhibited more severe deterioration, primarily characterized by significant material loss.

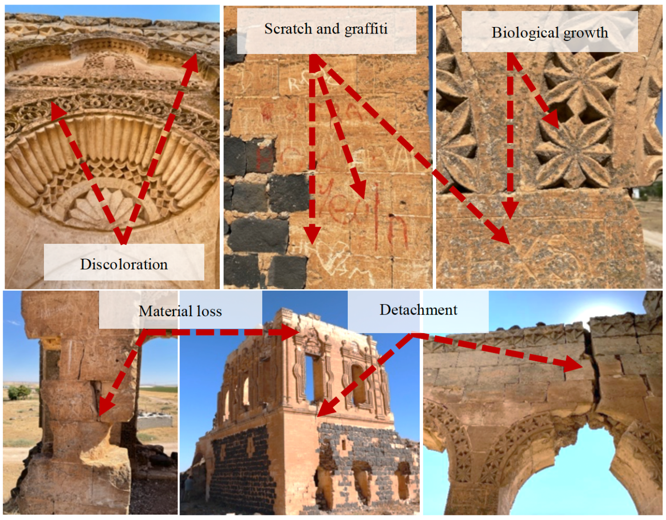

Figure 3. Some of the decay forms observed in Güzelşeyh (Bottom right image sourced from [22])

Additionally, the limestone showed signs of chipping, fading, erosion, discoloration, deposits, fractures, cracks, scratching, and biological colonization (Figure 3). Although less common, efflorescence was also noted at certain lower elevations. The forms of decay observed affected not only the building stones but also the iconic reliefs. Damage from both human activities and atmospheric conditions has accelerated the deterioration process. Today, this damage combines with other forms of decay, further threatening the surviving parts of the structure.

5.2. Mineralogical, petrographic and geochemical characteristics

Based on the field studies and petrographic investigations, the materials used in the GP are classified as basalt (massive and vesicular) and limestone. The thin section images, illustrating the textural and structural characteristics of the samples, are shown in Figure 4. At the same time, the XRF results, detailing the major oxide composition (in weight percent, wt%), are summarized in Table 1.

In the hand specimen, Sample 1 (basalt from the structure) shows some local signs of weathering, while Sample 2 (basalt from a nearby quarry) appears unaltered. Both samples display a dark grey to black color, typical of basalt, with a fine-grained, dense texture and no visible large crystals, consistent with the characteristics of massive basalt.

The thin sections of the basalts (Figure 4 a, b) reveal a mineral composition primarily made up of plagioclase, pyroxene, and olivine. Plagioclase forms the dominant groundmass in the form of lath-shaped microlites. However, Sample 1, taken from the structure, shows some signs of alterations, particularly in the forms of iddingsite and carbonatization.

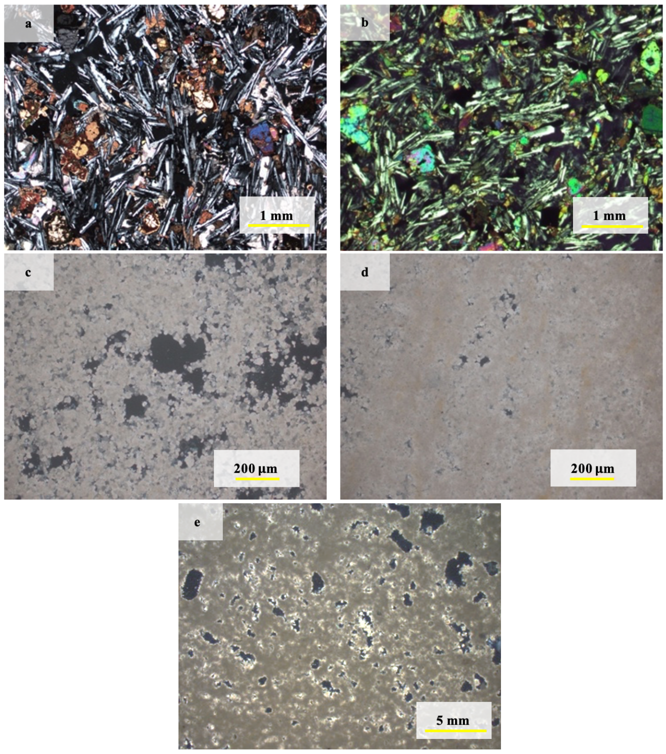

Figure 4. Photomicrograph illustrating the mineralogical and textural characteristics of (a) sample 1: basalt used in the structure, (b) sample 2: basalt sampled from the quarry, (c) sample 3: limestone used in structure, (d) sample 4: limestone sample from Bağacık Village, (e) sample 5: limestone sample from the vicinity of Zerzevan Castle (under cross-polarized light (XPL)

Iddingsite formation, a process where olivine transforms into iron oxides and clay minerals, occurs when olivine is exposed to moisture and oxygen over time. During this transformation, magnesium is typically removed from the olivine structure as part of the alteration process, leading to a reduction in the original magnesium content of the rock [37–38]. In addition, carbonatization is observed, which involves the chemical alteration of the basalt whereby carbonate minerals form in the voids and spaces between plagioclase laths (Figure 4 a, b). This process occurs when calcium interacts with carbon dioxide (CO_2) and water, forming calcium carbonate ($CaCO_3$), which can precipitate within the rock [39]. Limestone, which naturally contains calcium carbonate, likely accelerated the carbonatization of the basalt by providing a ready source of calcium, especially in the presence of moisture and environmental CO_2 [40-41]. Sample 2, while showing fewer signs of alteration compared to Sample 1.

The XRF analysis (Table 1) aligns partially with these petrographic observations, highlighting the chemical differences between Sample 1 and Sample 2. Sample 1 shows a higher CaO content (11.9 wt%) compared to Sample 2 (7.27 wt%), reflecting the presence of carbonates introduced during the carbonatization process. This process is likely influenced by the combined use of limestone and basalt as building materials, where the calcium content of the limestone accelerates the carbonatization of basalt. The interaction between these materials, especially in the presence of moisture and CO_2, has promoted faster carbonate formation within Sample 1.

Here, it is worth noting that, due to the preliminary nature of this study and the limited number of samples, these findings require further validation. Therefore, attributing the observed CaO variation solely to this combination of materials does not fully capture the complexity of the differences noted. While alteration clearly contributes to the CaO increase, the variation also likely reflects primary magmatic characteristics of Karacadağ Volcanism, which is known for its CaO variability [42]. This suggests that both alteration processes and the original magmatic composition play a significant role in the CaO levels observed in Sample 1.

TABLE I. Chemical composition (wt%) of samples analyzed by XRF

Oxides (wt%)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Al_2O_3	12.6	13.72	0.4	0.3	0.2
CaO	11.9	7.27	29.2	30.2	33.7
Fe_2O_3	14.6	14.41	0.1	0.1	0.1
K_2O	1.1	1.08	< 0.1	0.1	< 0.1
MgO	8.5	9.63	21.1	20.4	18.7
MnO	0.2	0.17	<0.1	<0.1	<0.1
Na_2O	2.6	3.3	0.2	0.1	0.4
P_2O_5	0.4	0.33	<0.1	<0.1	<0.1
SiO_2	42.4	47.68	1.8	2.1	0.6
TiO_2	2.5	2.4	<0.1	<0.1	<0.1
LoI	2.75	-0.1	46.9	46.5	45.8

In terms of MgO, Sample 1 has a slightly lower content (8.5 wt%) compared to Sample 2 (9.63 wt%). While the MgO reduction in Sample 1 may indicate alteration of olivine through iddingsite formation, the difference between Sample 1 and Sample 2 (nearly 5%) suggests that primary magmatic variations may also contribute, rather than alteration alone. The MgO content in Karacadağ basalts varies significantly based on magmatic origin [42], which should be considered alongside alteration effects. Both samples display similar Fe_2O_3 content (14.6 wt% and 14.41 wt%), indicating the stability of iron-bearing minerals like pyroxene and olivine. The SiO_2 content is higher in Sample 2 (47.68 wt%) than in Sample 1 (42.4 wt%), suggesting that Sample 2, having undergone less alteration, still holds more of its original silica-rich composition. The Loss on Ignition (LOI) is considerably higher in Sample 1 (2.75 wt%), confirming the presence of volatile components, such as carbonates formed during the alteration process.

The results suggest that Sample 1 and Sample 2 likely originate from the same volcanic source. However, their varying degrees of alteration, influenced by both environmental factors and primary magmatic composition, set them apart.

The petrographic analyses of the three limestone samples collected from the structure (Sample 3), Bağacık Village (Sample 4), and a quarry close to the Zerzevan castle (Sample 5) indicate considerable similarities as carbonate rocks, yet certain variations are observed in terms of texture and mineral content (Figure 4 c, d, e). In both the hand specimens, Samples 3 and 4 show more remarkable similarity to each other compared to Sample 5. Samples 3 and 4 hand specimens are more compact, with fewer visible voids and a massive appearance than Sample 5. Both share a light-yellow color and a fine-grained texture; in contrast, Sample 5 is visibly more porous and lighter in color, with a yellowish-white tone and a slightly different texture in the hand specimen.

The petrographic analysis of the three samples reveals that all of them are classified as limestone. Despite this shared classification, minor differences in texture and mineral content are observed across the samples. Samples 3 and 4 exhibit a clastic texture with fine-grained carbonate minerals and micritic cement as a binder (Figure 4 c, d). The voids present in these two samples are related to dissolution processes, with Sample 3—taken from a structure—showing a higher degree of porosity. This is likely due to long-term environmental exposure and weathering (Figure 4 c). Dolomite is present in both samples as scattered grains within the micritic matrix, with Sample 3 displaying more visible alteration features than Sample 4. In contrast, Sample 5 is also a limestone but differs due to its cryptocrystalline to microcrystalline texture and a more porous appearance. Some of these voids are partially filled with secondary carbonate minerals (Figure 4 e). This suggests that Sample 5 has undergone a different diagenetic process compared to the first two samples, with more calcite crystallization occurring in its pore spaces. Additionally, Sample 5 is noted for its lighter color and visibly more porous hand specimen, setting it apart from the more compact appearance of Samples 3 and 4.

The XRF analysis provides further insight into the composition of the samples and helps to clarify the differences observed in the petrographic study (Table 1). Samples 3 and 4 both contain significant amounts of CaO and MgO, indicative of substantial dolomitization. Sample 3 has 29.2 wt% CaO and 21.1 wt% MgO, while Sample 4 contains 30.2 wt% CaO and 20.4 wt% MgO. These values align with the petrographic evidence of dolomite in both samples, further supported by the clastic texture and the fine distribution of dolomite grains within the micritic matrix. The slightly higher MgO content in Sample 3 reflects its greater dolomite presence, which corresponds to the higher degree of alteration observed in the petrographic analysis. The XRF results reinforce these observations by showing similar CaO and MgO concentrations in Samples 3 and 4, further supporting their close relationship in terms of mineral content and dolomitization (Table 1). Sample 5, however, diverges both petrographically and chemically, with higher calcite content, fewer dolomite phases, and greater porosity, indicating a different diagenetic history. Thus, when considering both the petrographic and XRF analyses, it is clear that Samples 3 and 4 exhibit a much closer relationship to each other in terms of texture, mineral content, and diagenesis, while Sample 5 stands apart due to its calcite-rich composition, greater porosity, and different textural features.

5.3. Possible sources for stone materials

Selecting the most appropriate stone materials is crucial for any conservation or repair work on the GP. Even when replacing a single stone, it is essential that the new material aligns perfectly with the original in terms of texture, color, and composition. This careful matching is vital to preserve both the aesthetic and structural integrity of the pavilion, as mismatched materials can lead to further deterioration or compromise the historical authenticity of the structure. Following established practices in heritage conservation, the identification of suitable stone sources becomes a key element in ensuring the long-term sustainability of conservation efforts [43-44].

Based on the mineralogical, petrographic, and geochemical characteristics of the stone samples, two primary stone groups emerge as possible candidates for conservation works. For the basalt used in the pavilion, geological investigations confirm that the structure is built upon a basalt unit from the Karacadağ volcanism, the only source of basalt in the region.

Figure 5. Limestone-built structures and potential quarry sources in Bağacık village

Petrographic and geochemical analyses have revealed that Sample 2, collected from the massive basalt layers of the Siverek phase of the Karacadağ volcanic complex, shows similar characteristics to the basalt used in the pavilion. The dense, fine-grained texture and mineral composition—primarily plagioclase, pyroxene, and olivine—indicate that the basalt in the pavilion is likely derived from the same volcanic activity phase, making it a possible option for future repairs.

The limestone used in the pavilion is part of a widespread Eocene-aged carbonate formation in the region. However, despite the formation's overall continuity, the sediments display lateral variations. In this context, two specific levels with building stone potential were identified—one near Zerzevan Castle and the other in Bağacık Village. Petrographic and geochemical analyses identified Sample 4 from Bağacık as a potential match for the pavilion's limestone. This sample shares key characteristics, such as color, texture, and mineral composition—including dolomite content—making it a possible choice for future repairs. Moreover, field observations confirm the presence of quarries in Bağacık that historically supplied building stones for local structures, like the village houses (Figure 5).

6. CONCLUSION

This study examined the role of locally sourced materials in shaping the architectural features of the GP, located in the Çınar district of Diyarbakır, Türkiye. The primary objectives were to investigate the influence of the region's geology on the selection of building materials, assess the current condition of the pavilion, and propose potential stone sources for future conservation efforts. Situated at the intersection of volcanic and sedimentary terrains, the pavilion reflects the practical use of basalt and limestone in its construction. Field observations revealed that basalt was primarily used for structural elements such as the foundation and walls, while limestone was selected as the principal building material for the upper floor and decorative elements. Field studies identified various types and distributions of decay affecting the building's basalt and limestone components. Basalt, particularly near the ground, exhibited decay in the form of discoloration, chipping, and blistering due to water exposure. At the same time, the limestone showed more extensive damage, including material loss, erosion, and biological colonization. Human activities and atmospheric conditions have accelerated these decay processes, posing additional risks to both the building stones and carved reliefs. The combined effects of these factors continue to endanger the remaining parts of the structure. Mineralogical and geochemical analyses suggested that the basalt used in the pavilion may originate from basalt units of Karacadağ Volcanism, while the limestone resembles samples from Bağacık Village, indicating potential sources for the pavilion's limestone. However, these findings are preliminary and require further validation due to the limited number of samples and analyses. Findings from this study reveal the need to use compatible materials in conservation efforts to preserve the pavilion's structural stability and historical integrity. By identifying possible sources of basalt and limestone, future research can provide essential recommendations for local authorities, architects, and conservators tasked with maintaining the site. Comprehensive investigations involving systematic sampling (both from the structures and geological units) and advanced analytical techniques, including isotope analyses, will enhance our understanding and support more effective conservation strategies.

ACKNOWLEDGEMENT

The author sincerely thanks the Zerzevan Castle Excavation Team for their invaluable guidance and support in discovering this structure during a field study. The author is also grateful to Prof. Dr. Vedat Toprak (METU) for his valuable contributions to the development of the geological section of this study. Special appreciation is extended to the anonymous reviewers, whose thoughtful feedback and suggestions significantly enhanced the quality of this manuscript.

REFERENCES

[1] F. Hafner, "On the perspective of the availability of ornamental rocks for the conservation of monuments," Zeitschrift der Deutschen Gesellschaft fur Geowissenschaften, vol. 158, no.4, pp. 695–700, 2007.

[2] R. Přikryl and Á. Török, "Natural stones for monuments: their availability for restoration and evaluation," Geological Society, London, Special Publications, vol. 333, no. 1, pp. 1-9, 2010.

[3] G. Lott, "Sourcing stone for the conservation and repair of historical buildings in Britain," Quarterly journal of engineering geology and hydrogeology, vol. 46, no. 4, pp. 405-420, 2013.

[4] O. A. Nwoke and B. O. Ugwuishiwu, "Local bamboo and earth construction potential for provision of affordable structures in Nigeria," International Journal of Sustainable Construction Engineering and Technology, vol. 2, no. 2, 2011.

[5] H. Danso, "Building houses with locally available materials in Ghana: benefits and problems," International Journal of Science and Technology, vol. 2, no. 2, pp. 225-231, 2013.

[6] M. Gomez-Heras, B. J. Smith, and H. A. Viles, "Oxford stone revisited: causes and consequences of diversity in building limestone used in the historic centre of Oxford, England," Geological Society, London, Special Publications, vol. 333, no. 1, pp. 101-110, 2010.

[7] A. Devos, G. Fronteau, O. Lejeune, C. Sosson, E. Chopin, and V. Barbin, "Influence of geomorphological constraints and exploitation techniques on stone quarry spatial organisation: Example of Lutetian underground quarries in Rheims, Laon and Soissons areas," *Engineering Geology*, vol. 115, no. 3-4, pp. 268-275, 2010

[8] M. García-Rodriguez, M. García-Rodriguez, and M. Gomez-Heras, "Sierra de Guadarrama (Madrid, Spain): bridging the gap between geology and architecture," *Special Publications*, vol. 416, no. 1, pp. 101-112, 2016.

[9] F. Diri Akyıldız, N. Şahin Güçhan, and Y. D. Aktaş, "Construction processes and techniques in traditional Birgi houses: a typical Ottoman settlement," Journal of Architectural Conservation, vol. 30, no. 1, pp. 77-102, 2024.

[10] J. R. Senior, "The selection of dimension and ornamental stone types used in some northern monasteries—the exploitation and distribution of a natural resource," In: R. Gilchrist and H. Mytum (Eds.), Archaeology of Rural Monasteries, British Archaeological Reports (British Series), vol. 203.i, pp. 223–237, 1989.

[11] D. Ergenç, E. Caner Saltık, and T. Topal, "Antique stone quarries in Turkey: a case study on tuffs in the Temple of Apollon Smintheus," Geological Society, London, Special Publications, vol. 416, no. 1, pp. 133-144, 2016.

[12] A. Almssad, A. Almusaed, and R. Z. Homod, "Masonry in the context of sustainable buildings: A review of the brick role in architecture," Sustainability, 14(22):14734. https://doi.org/10.3390/su142214734, 2022

[13] C. R. Ortloff, "The water supply and distribution system of the Nabataean city of Petra (Jordan), 300 BC–AD 300," Cambridge Archaeological Journal, vol. 15, no. 1, pp. 93-109, 2005.

[14] S. M. Rababeh, How Petra Was Built: An analysis of the construction techniques of the Nabataean freestanding buildings and rock-cut monuments in Petra, Jordan, BAR Publishing, 2005.

[15] F. Dursun, "From quarry to monument: considering Mardin stone (SE, Türkiye) as the symbol of architectural and cultural heritage," Geoheritage, vol. 16, no. 3, pp. 1-19, 2024.

[16] L. C. Lancaster, "The process of building the Colosseum: the site, materials, and construction techniques," Journal of Roman Archaeology, vol. 18, pp. 57-82, 2005.

[17] J. P. Protzen, "Stonemasonry of the Incas," in Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures, H. Selin, Ed., Dordrecht: Springer, 2014.

[18] D. Jackson, J. Fleming, and A. Rowe, "Enabling the transfer of skills and knowledge across classroom and work contexts," Vocations and Learning, vol. 12, no. 3, pp. 459-478, 2019.

[19] M. Vatan, "Evolution of construction systems: Cultural effects on traditional structures and their reflection on modern building construction," in *Cultural Influences on Architecture*, IGI Global, 2017, pp. 35-57.

[20] R. Bellopede and A. Quartulli, Natural Stone and World Heritage: Itria Valley and Alberobello, Apulia Region, Italy, CRC Press, 2024.

[21] Diyarbakır Regional Board, Archive of Registration Records, Diyarbakır Regional Board for the Conservation of Cultural Heritage, 1990.

[22] M. Tekin Bayram, The Conservation and Restoration Proposal of Diyarbakır Güzelşeyh Pavilion, M.Sc. thesis, Dept. of Architecture, Dicle Univ., 2022.

[23] S. Yariş, "Ornament features of Güzelşeyh Pavilion," Palmet Dergisi, vol. 2, pp. 106-128, 2022.

[24] İ. Yıldız, Z. Erdal, and D. Yıldız, "Cultural assets in Çınar district," in A District at the Crossroads of Civilisations: Çınar, Y. K. Haspolat, Ed., Çınar District Governorship Publications, 2015.

[25] M. Tekin Bayram and G. Oğuz, "Documentation of the Güzelşeyh Pavilion in Çınar, Diyarbakır," in Built Environment Assessments, H. Demir Kayan, Ed., Nobel Publications, 2022.

[26] S. Bağırsakçı et al., "Diyarbakır-Ergani ve Çınar Alanın Jeolojisi," Ankara, 1995.

[27] E. Yılmaz and O. Duran, "Lexicon: A guide for stratigraphic nomenclature of the autochthonous and allochthonous units in the southeast Anatolian region," Turkish Petroleum Corporation Educational Publication, 1997.

[28] MTA, "1:100.000 scale geological maps of Turkey, Sheet No: M44, Report No: 68," General Directorate of Mineral Research and Exploration, Geology Department, 2008.

[29] Y. Yılmaz, "New evidence and model on the evolution of the southeast Anatolian Orogen," Geological Society of America Bulletin, vol. 105, pp. 251–271, 1993.

[30] A. I. Okay, "Geology of Turkey: a synopsis," Anschnitt, vol. 21, pp. 19–42, 2008.

[31] F. Dursun, E. D. Oğuz-Kırca, V. Toprak, and A. Coşkun, "Reconstruction of an ancient hill used as an On-Site quarry: Castrum Zerzevan (SE-Türkiye)," Int. J. Architectural Herit., pp. 1–19, 2023. Available: https://doi.org/10.1080/15583058.2023.2268015

[32] A. Haksal, "Petrographie und Geochemie des Schildvulkans Karacadağ," Ph.D. dissertation, Hamburg University, 1981. (Unpublished)

[33] T. Ercan, F. Şaroğlu, N. Turhan, J. I. Matsuda, T. Ui, T. Fujitani, ... and H. Gürler, "Karacadağ volkanitlerinin jeolojisi ve petrolojisi," *Türkiye Jeoloji Bülteni*, vol. 6, pp. 118-133, 1991.

[34] R. Westaway, H. Guillou, A. Seyrek, T. Demir, D. Bridgland, S. Scaillet, and A. Beck, "Late Cenozoic Surface Uplift, Basaltic Volcanism, and Incision by the River Tigris Around Diyarbakır, SE Turkey," Int. J. Earth Sci., vol. 98, no. 3, pp. 601–625, 2009.

[35] M. Lustrino, M. Keskin, M. Mattioli, V. A. Lebedev, A. Chugaev, E. Sharkov, and O. Kavak, "Early activity of the largest Cenozoic shield volcano in the circum-Mediterranean area: Mt. Karacadag, SE Turkey," *European Journal of Mineralogy*, vol. 22, no. 3, p. 343, 2010.

[36] F. Koçbulut, Z. Akpınar, O. Tatar, J. D. Piper, and A. P. Roberts, "Palaeomagnetic study of the Karacadağ Volcanic Complex, SE Turkey: monitoring Neogene anticlockwise rotation of the Arabian Plate," Tectonophysics, vol. 608, pp. 1007–1024, 2013.

[37] P. Gay and R. W. LeMaitre, "Some Observations on Iddingsite," The American Mineralogist, vol. 46, pp. 92-111, 1961.

[38] R. A. Eggleton, "Formation of Iddingsite Rims on Olivine: A Transmission Electron Microscope Study," Clays and Clay Minerals, vol. 32, no. 1, pp. 1-11, 1984.

[39] A. Raza, M. Mahmoud, M. Murtaza, M. Arif, A. Hassan, G. Glatz, ... and A. Al-Karnos, "Experimental investigation of mafic rocks for carbon mineralization prospect," *Energy & Fuels*, vol. 37, no. 8, pp. 5976-5985,2023.

[40] D. Goldberg and A. L. Slagle, "A global assessment of deep-sea basalt sites for carbon sequestration," Energy Procedia, vol. 1, no. 1, pp. 3675-3682, 2009.

[41] H. T. Schaef, B. P. McGrail, and A. T. Owen, "Carbonate mineralization of volcanic province basalts," International Journal of Greenhouse Gas Control, vol. 4, no. 2, pp. 249-261, 2010.

[42] M. Lustrino, M. Keskin, M. Mattioli, and O. Kavak, "Heterogeneous mantle sources feeding the volcanic activity of Mt. Karacadağ (SE Turkey)," *Journal of Asian Earth Sciences*, vol. 46, pp. 120-139, 2012.

[43] P. López-Arce, J. García-Guinea, D. Benavente, L. Tormo, and E. Doehne, "Deterioration of dolostone by magnesium sulphate salt: An example of incompatible building materials at Bonaval Monastery, Spain," Construction and Building Materials, vol. 23, no. 2, pp. 846-855, 2009.

[44] J. Martínez-Martínez, A. Pola, L. García-Sánchez, G. Reyes Agustin, L. S. Osorio Ocampo, J. L. Macías Vázquez, and J. Robles-Camacho, "Building stones used in the architectural heritage of Morelia (México): quarries location, rock durability and stone compatibility in the monument," *Environmental Earth Sciences*, vol. 77, pp. 1-16, 2018

BIOGRAPHY

Felat Dursun is a graduate of Çukurova University (CU), Geological Engineering. He received his master's degree in Mining Engineering at Dicle University (DU) and earned his Ph.D. in Geological Engineering from Middle East Technical University (METU). His Ph.D. thesis was awarded "*The Best Thesis of the Year*" in 2017 by the METU Graduate School of Natural and Applied Sciences. During his doctoral studies, he received a grant to conduct research on historic building materials as a visiting scientist at the Getty Conservation Institute in Los Angeles, USA, from 2014 to 2015. He later received a postdoctoral research grant from TÜBİTAK to continue his research at University College London (UCL), London, UK, between 2022 and 2023. Dr. Dursun specializes in stone conservation, geoarchaeology, site selection, and the physicomechanical characterization of stones used in historic buildings. Dr. Dursun has experience leading both national and international research projects. He is involved in several boards and organizations, including ICOMOS, the Ministry of Culture and Tourism's Scientific Committee, and different archaeological excavation teams. Currently, he serves as an Assistant Professor at Dicle University and as a visiting scholar at İzmir Institute of Technology.