5. ASIA PACIFIC International Modern Sciences Congress

July 16-18, 2021

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FULL TEXTS BOOK

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IKSAD GLOBAL PUBLISHING HOUSE

Issued: 02.08.2021

ISBN: 978-625-7464-02-4

INFRARED THERMOGRAPHY FOR PRE-DIAGNOSIS IN MONUMENTS BUILT FROM PYROCLASTIC BUILDING STONES

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Abstract

Scientific bases and diagnostic studies are important for the preservation of the present condition of the monuments. These studies consist of visual deterioration studies in the laboratory and in the field. However, the limited number of samples taken from historical buildings for laboratory studies cannot represent the whole structure. In order to overcome this problem, non-destructive test (NDT) techniques, which have become widespread recently, offer significant advantages both in the laboratory and in-site. Infrared thermography, one of the NDT methods, is a method used to detect both surface and sub-surface defects. This method is widely preferred in the literature because it is practical, inexpensive, and easy to use. In this study, the weathering process in pyroclastic rocks that are weak and sensitive to atmospheric processes was investigated. For this purpose, the types and origins of deterioration observed in the Sirçalı Madrasa (Konya, Turkey), which is on the UNESCO tentative list, were investigated by means of infrared thermography. In the study, it was determined that there were temperature differences in the capillary and infiltration regions of the monument. These differences increased the deterioration of the monument and caused the development of contour scaling, flaking, deposit and moist area types. The findings obtained from the study showed that infrared thermography method is a practical method for preliminary evaluation in the current situation analysis of historical buildings.

Keywords: Infrared thermography, monument, Sırçalı Madrasa, Portal.

1. INTRODUCTION

It is very important in the preservation and transfer of cultural heritage to future generations, but as a result of atmospheric processes, the building blocks that make up the cultural heritage are partially or completely weathering (Fener and İnce, 2015). Diagnostic studies are carried out to determine the deterioration of these monuments and to plan restorations. In these studies, non-destructive testing (NDT) techniques can be a solution when sampling from the building blocks that make up the monuments is limited and/or not possible. Infrared thermography, one of the NDT methods, is a method used to detect both surface and sub-surface defects. Infrared thermography method has recently been used to detect cracks (Paoletti et al., 2013) and deposit (Korkanç et al., 2019) in historical buildings. However, it was used for the first time in this study to determine the deterioration types. For this purpose, infrared thermography determinability of the deterioration observed in the Sırçalı Madrasa Portal (Konya, Turkey) was investigated.

2. MATERIALS AND METHODS

The experimental research in this study was carried out in two stages as in-site and in laboratory. In laboratory studies, index (porosity, dry density, P-wave velocity and capillary water absorption) and strength (uniaxial compressive strength and Schmidt hammer rebound test) properties were determined according to the relevant standards (ISRM, 2007; TS EN-1925, 2000; ASTM D7012, 2014; ASTM D5873, 2014). A thin section according to TS EN-12407 (2019) was prepared in order to determine the petrographic and textural properties of the rock from which the Portal was made. The thermal imaging process on the portal of the monument was obtained using the Flir E5 brand thermal camera, which can measure between -20 and +400 °C. In addition, the weathering types observed in the Portal were defined according to ICOMOS-ISCS (2008).

3. DESCRIPTION OF THE SIRÇALI MADRASA

Anatolia is located in the west end of Asia. It is a geography that has been the cradle of civilizations through the history of the mankind. To the south of this region is the city of Konya (Figure 1), which was the capital of the Anatolian Seljuk state. Konya is a city of remarkable cultural and architectural texture. The architectural works reaching the present day such as the Alaaddin Mosque, Sırçalı Madrasa, Karatay Madrasa, Ince Minareli Madrasa and Mevlana mausoleum have been put under protection along with the other Seljuk monuments in the historical city center under the title of 'Konya-A capital of Seljuk civilization' in the tentative list of the UNESCO. Sırçalı Madrasa was built in 1242 (Figure 2). The monument is a two-storey madrasah with an open courtyard, two iwans. Tile mosaic decorations can be seen on the courtyard porches and the main iwan façade. Sırçalı Madrasa portal is framed with borders dominated by geometric ornaments (Figure 3). There are niches with stalactites surrounded by geometric borders on the right and left of the door. At the corners, there are two rows of corinthian capped colonnades with corrugated stems.

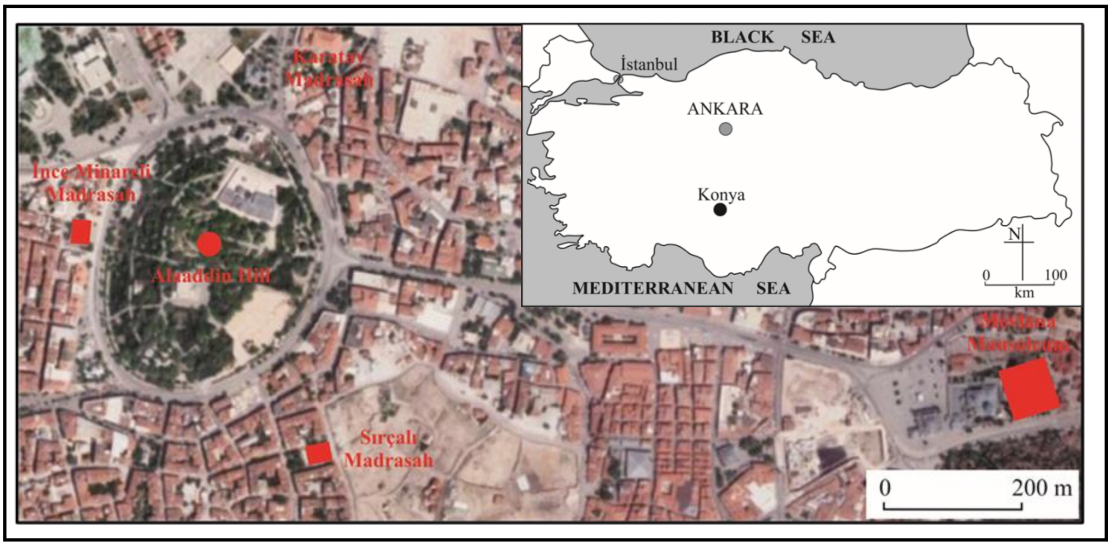

Figure 1. Locations of Madrasas and Mevlana Mausoleum in Konya (Turkey).

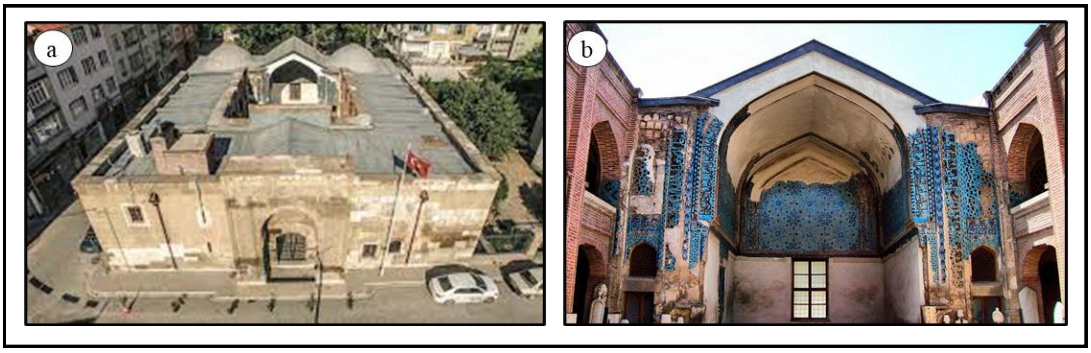

Figure 2. General view of Sırçalı Madrasa.

4. RESULTS

4.1. Geological and petrography features of pyroclastic stone

The portal was built of pyroclastic building stone, which is one of the indispensable building materials among the works that make up the cultural texture of Konya. These pyroclastics belong to the Küçükmuhsine formation and this formation consists of tuff, tuffite, volcanic breccia and volcanogenic sandstone. The age of the Küçükmuhsine formation is Upper Miocene-Lower Pliocene. Pyroclastic stone microscopically includes 41% volcanic glass, 22% plagioclase, 11% hornblende, 9% quartz, 9% rock fragment, 7% biotite, and 1% opaque minerals (Figure 4). The rock shows porphyritic texture properties (Figure 4b). The rock is called crystal tuff according to Schmid (1981) classification (Figure 4c).

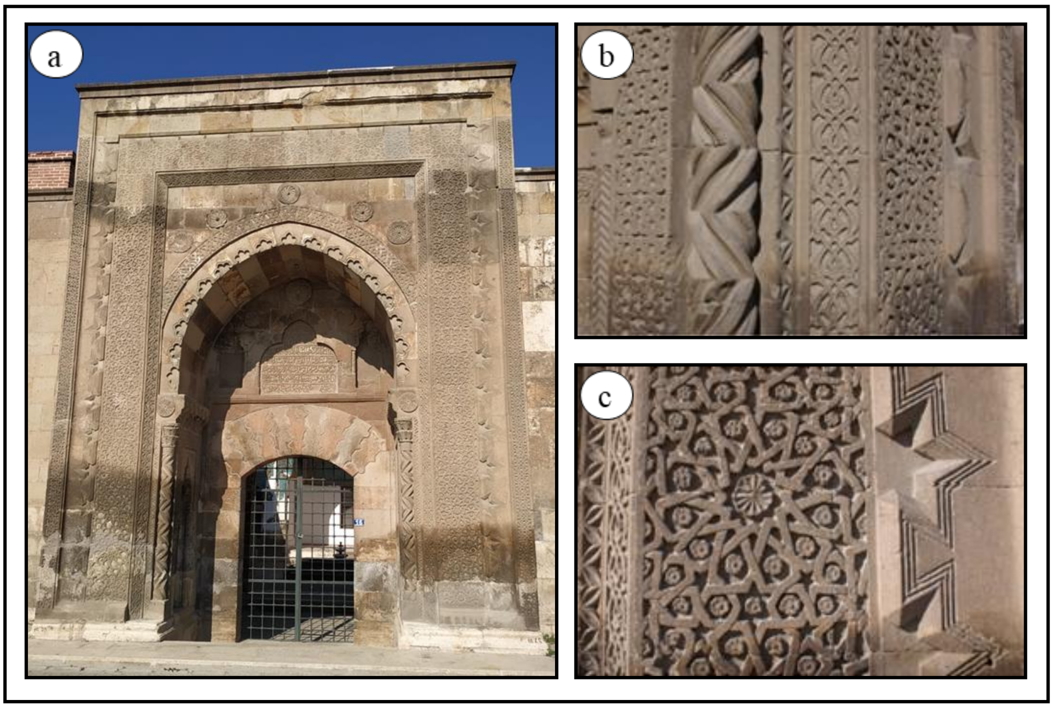

Figure 3. a) General view of Sırçalı Madrasa Portal, b-c) detail view of the Portal.

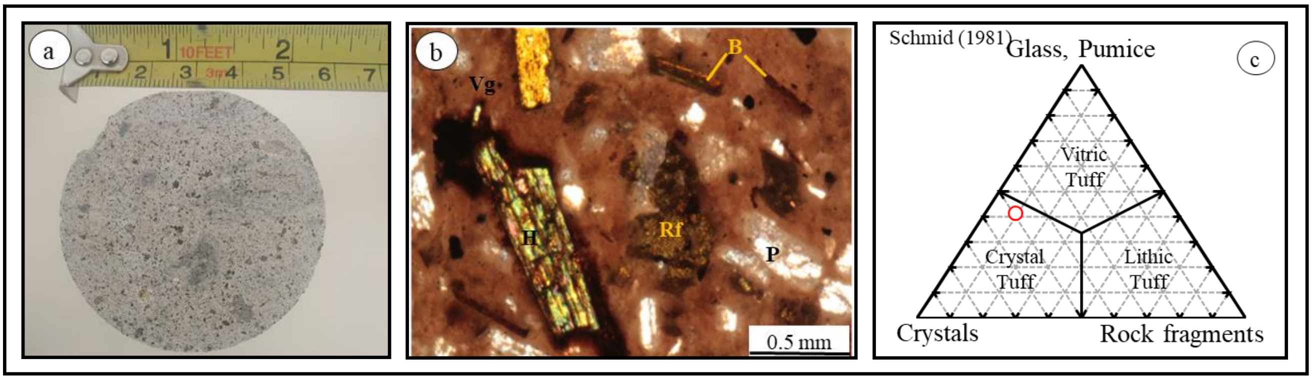

Figure 4. Building stone; a) macroscopic appearance, b) thin section view, (B: biotite, H: hornblende, P: plagioclase, Rf: rock fragment, Vg: volcanic glass) (cross nikol), c) Schmid (1981) classification diagram of the rock.

4.2. Index and strength properties of building stones used in the portal

Index and strength properties of Portal's stone are given in Table 1. The density($\square_d$) and porosity (n) values of the building stone are 1.90 g/cm^3 and 24.7%, respectively. The capillary water absorption (C) test results of the samples used in this study 96.85 g/m^{2}s$^{0.5}$. According to Snethlage's (2005) C classification, the sample are classified as highly absorbing rock.

Table 1 Index and strength properties of the building stone ($\square_d$: dry density, n: porosity, Vp: P-wave velocity, C: capillary water absorption, UCS: Uniaxial compressive strength, SHR: Schmidt hammer rebound test).

$\square_d$-g/cm^3	n-%	Vp-km/s	C-g/m^{2}s$^{0.5}$	UCS-MPa	SHR
1.90	24.50	2.60	96.85	32.50	26

4.3. Investigation of the portal using a thermal camera

Deteriorations in the Portal were defined according to the methods suggested in ICOMOS-ISCS (2008). The main types of deterioration determined observationally in the monument are presented on Figure 5.

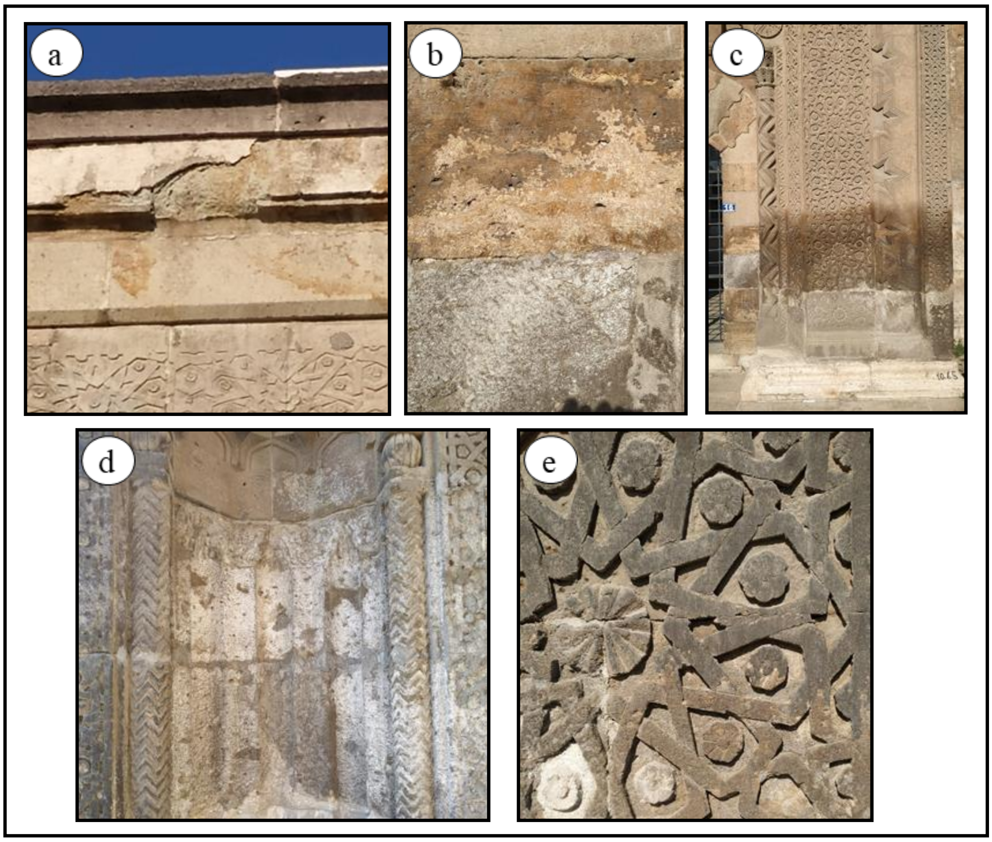

Figure 5. Common weathering types in the Sırçalı Madrasa Portal: a) contour scaling, b) flaking, c) moist area, d) salt crust, e). black crust.

For the thermal examination of the portal, firstly, the general view of the portal was taken by means of a thermal camera (Figure 6). The surface temperature of the portal was determined between 26.2 ^{o}C and 50.9 ^{o}C. In the next step, detailed thermal images were obtained from the regions where the deteriorations were found (Figure 7). In the thermal images, the regions with black crust were found to be 10 ^{o}C hotter (Figure 7a). In the thermal camera, it was determined that the regions containing the salt crust were approximately 20 ^{o}C colder (Figure 7b). The temperature in the flaking areas is 2-3 ^{o}C lower than the rest of the monument (Figure 7c). Moist areas in thermal images were determined to be at lower temperatures (Figure 7d).

Figure 6. Thermal and normal image of the portal.

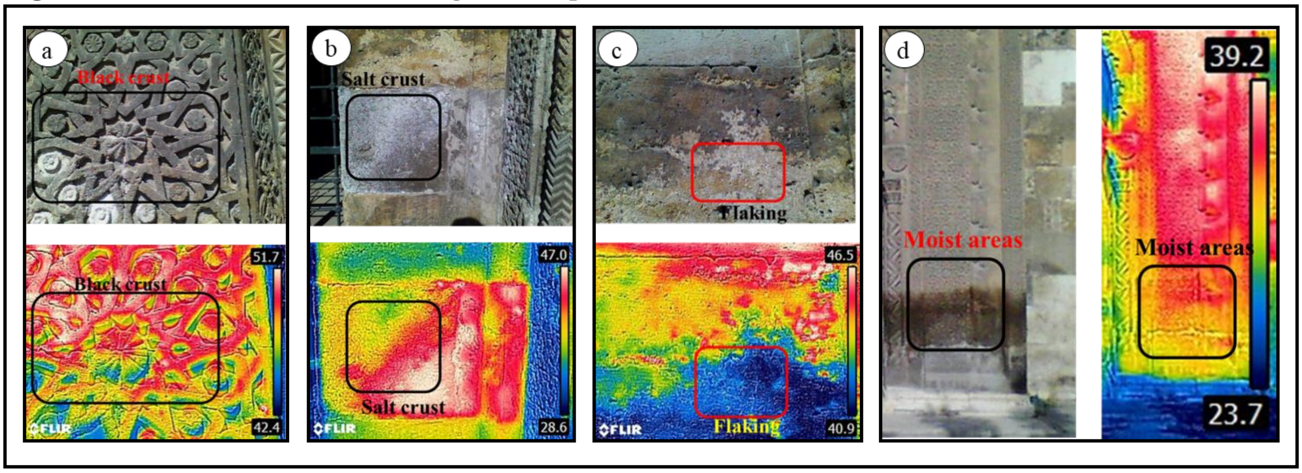

Figure 7. Thermal and normal image; a) black crust, b) salt crust, c) flaking, d) moist area.

5. CONCLUSION

Pyroclastics belonging to the Küçükmuhsine formation were used as building material on the portal of the monument. The rock is called crystal tuff according to Schmid (1981) classification. The building stone is classified as a highly absorbent rock. This feature of the rock accelerated the deterioration process in the building block. As a result of accelerating the weathering process in the monument, deteriorations in contour scaling, flaking, deposit (black and salt crust) and moist area types developed.

In the thermal images of the monument, the deterioration areas showed different warming properties. This made it possible to detect different types of deterioration using a thermal camera.

The findings obtained from the study showed that infrared thermography method is a practical method for preliminary evaluation in the current situation analysis of historical buildings.

References

ASTM D5873 2014. Standard test method for determination of rock hardness by rebound Hammer method. Annual book of ASTM standards. American Society for Testing and Materials, West Conshohocken, pp 1–6

ASTM D7012 2014. Standard test methods for compressive strength and elasticmoduli of intact rock core specimens under varying states of stress and temperatures. Annual book of ASTM standards. American Society for Testing and Materials, West Conshohocken, pp. 1–9

Fener M, İnce İ 2015. Effects of the freeze–thaw (F–T) cycle on the andesitic rocks (Sille-Konya/Turkey) used in construction building. Journal of African Earth Sciences, 109; 96-106.

ICOMOS-ISCS 2008, Illustrated Glossary on Stone Deterioration Patterns, Champigny/ Marne, France.

ISRM, 2007. The Complete ISRM suggested methods for rock characterization, testing and monitoring: 1974-2006. In: Ulusay R, Hudson J (eds) Suggested methods prepared by the commission on testing methods, ISRM Turkish National Group, Ankara, Turkey

Korkanç M, Hüseyinca MY, Hatır ME, Tosunlar MB, Bozdağ A, Özen L, İnce İ 2019. Interpreting sulfated crusts on natural building stones using sulfur contour maps and infrared thermography. Environmental Earth Sciences, 78(13): 1-14.

Paoletti D, Ambrosini D, Sfarra S, Bisegna F 2013. Preventive thermographic diagnosis of historical buildings for consolidation. Journal of Cultural Heritage, 14(2): 116-121.

Schmid R 1981. Descriptive nomenclature and classification of pyroclastic deposits and fragments: recommendations of the international union of geological sciences subcommission on the systematics of igneous rocks. Geology 9:41-43 The Geological Society of America. Boulder

Snethlage R 2005. Leitfaden Steinkonservierung. Stuttgart: Fraunhofer IRB

TS EN-1925 2000. Natural stone test methods determination of water absorption coefficient by capillarity. Ankara: Turkish Standards Institution

TS EN-12407 2019. Natural stone test methods - petrographic examination. Ankara: Turkish Standards Institution