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Full Length Research Paper

Dimension stones used in Central Anatolia: Some of their geological and mechanical properties

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It is aimed to study physical and chemical features of the samples from dacite-andesite quarries and travertine quarries of Konya and its surroundings. The dacites and andesites are the main products of the Neogene volcanism observed in Konya while the travertines are well exposed as chemical-sedimentary rocks where the young sediments were exposed at the outskirts of Konya plain. These rocks (dacite, andesite and travertines) have been extensively used as dimension stones in and around the city of Konya, Turkey. In terms of dry weight loss (dwl- an experiment assessing the resistance of the rocks against salt) values, the weakest rocks were created from a dacite quarry at Sağlik. On the other hand, the andesites from Gölcük are probably the most suitable dimension stones for external uses (for example outdoor stairs and pavements), as indicated by having the highest uniaxial compressive strength (UCS) value (mean 90.7 Mpa). The travertines from the Mut region are the most fragile rocks with their 26.1 Mpa values indicating that preventing the uses of outdoor purposes.

Key words: Konya, Turkey, covering rocks, dry weight loss, volcanites, travertines.

INTRODUCTION

Physical and chemical characteristics of natural rocks as well as mineralogical features have been widely examined. Particularly, relationships between physical-chemical parameters and mineralogical compositions of the rocks were the focuses of the works (Winkler, 1966; Duzgoren-Aydin et al., 2002a; Duzgoren-Aydin et al., 2002b; Malpas et al., 2001; Benavente et al., 2001; Moon and Jayawardane, 2004; Benavente et al., 1999; Zedef et al., 2007). Salt caused decay in carbonate stones in SW France is displayed by Cardell et al. (2003). Cerimele and Cossu (2007) have attempted to detect decay zones of stony materials by color images. Iron-bearing microsyenites could be much more soluble in the alkaline environment compared to neutral and acidic environment (Quick and Sirivivatnanon, 2008). Alternatively, Primerano et al. (2000) stated that the strong primary acidity into the atmosphere could intensely destroy calcareous materials in the monument stones. The effects of biological activities on marble stones were investigated by Cappitelli et al. (2007) in Milan Cathedral and the results have exhibited that the microorganisms are the main agent for alteration. Similar findings were reported by Ascaso et al. (2002) for marble stones used in Jeronimos Monastery, Lisbon by Flores et al. (1997) from historic monuments at Alcala de Henares, Spain. Biodeterioration of stones were well reviewed by Warscheid and Braams (2000). Quick and Sirivivatnanon (2008) have shown that the siderite secondary minerals in microsyenites of Mt. Gibraltar quarry (New South Wales, Australia) is subject to alteration to iron oxides/hydroxides through oxidation processes. With its 38257km^2 land area (larger than Belgium), the Konya province is the largest one in Turkey. In terms of

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Figure 1. Location of the studied samples. Note that the rocks of Sağlik, Sefaköy and Gölcük are of volcanic origin (dacite and andesite), Altinekin, Gödene and Mut rocks are travertines (sedimentary origin).

urbanization, industrialization and population growth, the city of Konya is also one of the fastest growing districts in the country. Parallel to this, construction of new streets and buildings and redesign-reconstruction of old streets are required to be surface covered, and these require more and more artificially or naturally produced dimension rocks. For instance, in northern side of the city, a newly build 12 km long and 20 m wide street pavement is completely covered by dacites. Until the year 2012, it is planned that more than 45000m^2 dacite will be used each year for pavement covering in the city of Konya. For this purpose, the dacite quarry in Sağlik (25 km west of Konya) was open by a private company in 2007. In this region the volcanic rocks, predominantly dacite and andesite, are exposed over the Paleozoic and Jurassic rock units.

The volcanic rocks mainly erupted in Neogene, in the region covers an area of approximately 1500 km^2 between the Konya, Beyşehir and Seydişehir triangular. The travertines, quarried from Altinekin, Mut and Gödene areas, have been also widely used as a dimension stones for a number of building facades, curbstones and pavements in and around the province of Konya. Travertine stone quarried from the Gödene district, SW Konya; had been extensively used between 16 and 19th centuries as a dimension stone, and was commonly known as 'Gödene stone'. The Gödene travertines were used in many historical buildings, mosques and monuments of Seljuk and Ottoman era. These rocks are being still largely used in some municipal and private buildings for facing purposes. In the present study we studied the dacite, andesite and travertine stones collected from Konya and Karaman provinces (Figure 1). The goal of this study is to study that the stability of the rocks used as pavement and surface covering agents in the city of Konya. To do these, we choose three travertine quarries (Altinekin, Gödene and Mut), two dacite (Sefaköy and Sağlik) and one andesite (Gölcük) quarry in Central Anatolia.

REGIONAL SETTING OF THE ROCK UNITS AND THEIR FORMATION

The Konya province can be divided into two geographic realm, one is a plain (known as Konya plain) situated in

the central part of the province, and the other, mountainous relief which generally found in the vicinity of the outer rim of the Konya plain. The plain is typically surrounded by metamorphic and volcanic rocks of different composition, age and scale. The metamorphic rocks formed in the rim are usually limestone, dolostone, schist, phillites and metaporfirites while the volcanites are characterized by dacitic-andesitic ignimbrite (welded tuffs) erupted during the Late Miocene to early Pliocene (Kurt et al., 2005). The volcanic rocks formed in the area named as 'Erenler-Alacadag volcanics' in the related literatures. These volcanic rocks are interpreted as a product of old subduction related subalkaline volcanism originated from a molten continental crust (Kurt et al., 2005; Dagistan, 1996). The occurrence of travertines strongly depends on the dissolving of the carbonates (such as limestones and dolostones) by percolating meteoric water. When this water becomes saturated in Ca-(bi) carbonate the precipitation of $CaCO_3$ (travertine) would happen as the drop in pressure and/or change in temperature in the fluid responsible for travertine formation. The rocks are usually porous with numerous cavities. If the fluid is pure, travertine is white, but often it is colorful due to impurities (other than carbonate minerals). The travertines of Altinekin, Gödene and Mut a product of precipitation from $CaCO_3$ saturated water. The travertines and dacite-andesites subjected to this study are formed in outer part of the Konya Plain. Both the travertines and dacitic-andesitic rocks of Konya ascribed as geologically young (2 to 14 million years) rock units.

METHODOLOGY

For mineral identification, conveniently used x-ray diffraction (XRD) and optical microscopes were used. For XRD analyses the 250 mesh powdered samples were prepared. For the optical microscope analyses, the thin sections were studied. For the assessments of the dry weight loss (DWL), the Spanish standard test UNE-EN (12370) was applied for this work. The other extensively used tests are American standard test ASTM (C-88 and C-128) and the German standard test DIN (52111). In these tests, the quantification of salt weathering of the samples has been measured by assessing the dry weight loss (DWL) of the rocks. These tests have three main stages: total immersion (stage-1), drying (stage-2) and cooling (stage-3). In this study, we applied the Spanish standard test for DWL assessments. In this test, the samples were 7 cm cubes and a 14% w/w Na_2SO_4 solution was used. In the stage-1, clean and dry rock samples were introduced into a container and covered with the solution at 20°C for 4 h. In stage 2, the samples were taken out of the container and settled into the oven at 60°C for 16 h. After these, the samples were taken out from the oven and leaving for cooling (stage 3) for 4 h. This cycle comprises one whole day (24 h) and the similar procedure was repeated for 15 days (total 15 cycles). The solution has to be changed every five cycles as the samples lose weight. After 15 days, the tested samples were carefully cleaned with pure water to eliminate salt. The samples were then dried until a constant weight was realized. At the end of this stage, the dry weight loss (DWL %) is calculated. The yield loads (YL) and uniaxial compressive strength (UCS) tests were done in accordance with ISRM (International Society for Rock Mechanics)'s suggested standards.

RESULTS AND DISCUSSION

Microscopic examinations showed that the volcanic rocks of Gölcük-Sefaköy (andesite) and Sağlik (dacite) regions mostly include plagioclase, volcanic glass, biotite, clinopyroxene, amphibole and quartz minerals. On the other hand, the travertine rocks of Altinekin and Gödene have dominantly micrite and sparite. The travertines belonging to the Mut region entirely composed of sparite. The x-ray difractometre analyses also confirmed the presence of these minerals on the rock samples studied. The rock types, their colors, mineral components as well as location of the studied samples were displayed on Table 1. The overall results for dry weight loss (DWL), yield loads (YL) and uniaxial compressive strength (UCS) was displayed in Table 2. As can be seen from the table, the dwl values of Mut and Gödene travertines and Sefaköy andesites are zero. The dwl values of Gölcük andesites, Sağlik dacites and Altinekin travertines are 0.67, 12.3 and 0.95% respectively. The weakest rocks against the effect of salt alteration are Sağlik dacites which has 12.3% dwl values. On the other hand almost all the other rocks are very strong against salt effect resulted from atmospheric influence (they can be used for building facades-covers and partly as pavement rocks). The Gölcük andesites have the highest uniaxial compressive strength values (90.7 Mpa) which means that these rocks are the most resistive media against external impacts. Uses of Mut and Gödene travertines have the highest risks for external uses as they have the lowest values of uniaxial compressive strength (26.1 and 53.2 Mpa respectively). The yield loads of the samples range between 137.2 to 373.8 kN. The highest values represent the Gölcük andesites while the lowest value belongs to the Mut travertines. It can be interpreted that the most resistant rocks against any external load originated from by any means are Gölcük andesites. In terms of yield loads, the weakest rock units are the travertines of Mut. There has been no clear correlation between the DWL, YL and UCS values of the rocks.

The brittle fracture specifications and nonlinear elasticity properties of the rocks are the most important features affecting the yield loads of the rocks (Smirnov and Bobryakov, 1971). For precise correlations, fracturing systems and elasticity properties of the rocks needs to be further investigated.

CONCLUSIONS

Inferred conclusions from this study mainly are against

Table 1. The rock types, color, mineralogical composition and location of the samples.

Samples	Rock type	Color	Minerals*	Location
SK	Dacite	Pale purple	Plagioclase (38%), amphibole (13%), volcanic glass (38%), clinopyroxene (15%), opaque minerals (2%), volcanic glass (38%).	Sefaköy
GK	Andesite	Pink	Plagioclase (45%), biotite (8%), amphibole (17%), volcanic glass (27%), clinopyroxene (2%), opaque minerals (1%).	Gölcük
S	Dacite	Grey to purple	Plagioclase (35%), biotite (5%), amphibole (15%), volcanic glass (30%), clinopyroxene (2%), opaque minerals (1%), quartz (12 %).	Sağlik
A	Travertine	White	Micrite (74%), sparite (15%), fossils (10), quartz (1%).	Altinekin
M	Travertine	Beige	Sparite (100%).	Mut
G	Travertine	Beige-gray	Micrite (80%), sparite (20%).	Gödene

*Mineralogical composition represents average ratio of minerals observed on polarizing microscope for each group of samples. Each group represents three samples, excepting the group S, which includes two samples. The identification of the minerals is also confirmed by XRD.

Table 2. Dry weight loss (DWL, %), yield loads (YL, kN) and uniaxial compressive strength (UCS, Mpa) values of the rocks studied.

Samples	DWL	YL	UCS
SK	0	295.2	75.8
GK	0.67	373.8	90.7
S	12.3	246	59.3
A	0.95	321	64.9
M	0	137.2	26.1
G	0	265.8	53.2

Note: The values represent three samples with the exception of the sample S which comprises two samples.

the effect of salt alteration, the weakest rocks can be the Sağlik dacites with its 12.3% DWL values. The other rocks can be interpreted that they are very strong against salt effect resulted from atmospheric influence, and thus, they can be used in the buildings as facades-covers and partly as pavement rocks. The rocks of andesites from Gölcük quarry have the highest uniaxial compressive strength values (90.7 Mpa) and this allows that the rocks can be safely used for any external purposes. The Mut and Gödene travertines have the highest risks for this purpose as they have the lowest values of uniaxial compressive strength.

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REFERENCES

Ascaso C, Wierzchos J, Souza-Egipsy V, de los Ríos A, Delgado Rodrigues J (2002). In situ evaluation of the biodeteriorating action of microorganisms and the effects of biocides on carbonate rock of the Jeronimos Monastery (Lisbon), Int. Biodeterior. Biodegradation, 49(1): 1-12.

Benavente D, Garcia del Cura M A, Bernabeu A, Ordonez S (2001). Quantification of salt weathering in porous stones using experimental continuous partial immersion method. Eng. Geol., 59: 313-325.

Benavente D, Garcia del Cura M A, Fort R, Ordonez S (1999). Thermodynamic modelling of changes induced by salt pressure crystallisation in porous media of stone. J. Crystal Growth, 204: 168-178.

Cappitelli F, Principi, P, Pedrazzani R, Toniolo L, Sorlini C (2007). Bacterial and fungal deterioration of the Milan Cathedral marble treated with protective synthetic resins, Sci. Total Environ., 385(1-3): 172-181.

Cardell C, Delalieux F, Roumpopoulos K, Moropoulou A, Auger F, Van Grieken R (2003). Salt-induced decay in calcareous stone monuments and buildings in a marine environment in SW France, Constr. Building Mater., 17(3): 165-179.

Cerimele M, Cossu R (2007). Decay regions segmentation from color images of ancient monuments using fast marching method. J. Cult. Herit., 8(2): 170-175.

Dagistan H (1996). Sedimentology of the pyroclastic rocks in Kayadibi-Sadiklar (Hatunsaray-Konya) area. (Unpublished MSc Thesis, Turkish with English abstract) Dept. of Geology, University of Selcuk (Konya-Turkey), p. 53.

Duzgoren-Aydin NS, Aydin A, Malpas J (2002a). Distribution of clay minerals along a weathered pyroclastic profile, Hong Kong. Catena, 50: 17-41.

Duzgoren-Aydin NS, Aydin A, Malpas J, (2002b). Re-assesment of chemical weathering indices: case study on pyroclastic rocks of Hong Kong. Eng. Geol., 63: 99-119.

Flores M, Lorenzo J, Gomez-Alarcon G (1997). Algae and bacteria on

historic monuments at Alcala de Henares, Spain. Int. Biodeterior. Biodegradation, 40: 241-246.
Kurt S, Akgul B, Kurt H (2005). The Petrographical and Geochemical Investigation of the Volcanic Rocks in Saglık- Erenkaya (West of Konya) Region, Firat University, Int. J. Sci. Technol., 17(1): 190-204.
Malpas J, Duzgoren-Aydin NS, Aydin A (2001). Behaviour of chemical elements during weathering of pyroclastic rocks, Hong Kong. Environ. Int., 26: 359-368.
Moon V, Jayawardane J (2004). Geomechanical and geochemical changes during early stages of weathering of Karamu Basalt, New Zealand. Eng. Geol., 74, 57-72.
Primerano P, Marino G, Di Pasquale S, Mavilia L, Corigliano F (2000). Possible alteration of monuments caused by particles emitted into the atmosphere carrying strong primary acidity. Atmosph. Environ., 34(23): 3889-3896.
Quick GW, Sirivivatnanon V (2008). Predicting iron staining of siderite-bearing microsyenites intended for dimension stone use. Construction and Building Mater., 22(3): 257-263.
Smirnov VV, Bobryakov A P (1971). The plasticity characteristics of rocks: J. Min. Sci., 7 (2): 144-146.
Warscheid T, Braams J (2000). Biodeterioration of stone: a review International Biodeterioration & Biodegradation. 46 (4): 343-368.
Winkler EM (1966). Important agents of weathering for building and monumental stone. Eng. Geol., 1: 381-400.
Zedef V, Kocak K, Doyen A, Ozsen H, Kekec B (2007). Effect of salt crystallization on stones of historical buildings and monuments, Konya, Central Turkey. Building Environ., 42: 1453-1457.