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Evaluation of strength parameters and quality assessment of different lithotype levels of Edremit (Van) Travertine (Eastern Turkey)

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ABSTRACT

Travertine deposits have an economic value due to their chemical composition and widespread use in the construction industry. Travertines reveal different lithotypes depending on their depositional process and this can affect mechanical and engineering properties of travertine. Edremit travertine displays various structural features in lateral and vertical distributions. In this study, Edremit travertine is firstly differentiated into three different levels such as crystalline crust, shrub and reed based on the mechanical, physical properties and field observations. A strength map of different lithotypes is prepared and crystalline crust level is investigated for using in marble industry. For this purpose, the long-term performance/durability of crystalline crust travertine is investigated against various environmental processes by using several accelerated weathering tests. Accordingly, compared to the crystalline crust other levels of travertine (shrub and reed) are much more affected from atmospheric conditions. Among these levels, the crystalline crust level is recommended to be used as marble according to laboratory test results whereas other levels are appropriate for cement industry.

1. Introduction

Travertine is well known with its anisotropy and heterogeneity, which leads to complexity in the rock mass behavior. Travertine is defined in the form of limestone because of its calcium carbonate composition and known as fresh water carbonates that are precipitated by organic and inorganic periods (Chafetz and Folk, 1984). Both water types containing either hot or cold $CaCO_3$ are effective in the formation of the travertine. However, differences can be observed between travertines that are formed by cold water sources and the ones that are formed by hot water sources. These differences may be in terms of physical, mechanical and structural properties of travertines that have direct impact on the bearing capacity and using of dimension stone.

Travertine levels have different shapes and engineering properties as well as high strength crystalline crust with very low strength shrub and reed in Edremit (Van, Turkey) region (Fig. 1). The travertine in the calcium carbonate ($CaCO_3$) composition is providing it to be resolved together with the effect of water and get into the reaction easily together with compositions such as sulfide dioxide. It is also known that the rocks with carbonate get into a fast deterioration period under acidic effects (Akın, 2008). Therefore, it is very important to determine the resistance of Edremit travertine against physical, chemical and atmospheric effects and identify its use as a construction material.

As a marble and cement material, the evaluation of physical and mechanical properties of travertine is important. In the literature, there are numerous studies focused on the physical and mechanical properties of travertine (Akın, 2008, 2010; Török and Vasarhelyi, 2010; Akın and Özsan, 2011; Çobanoğlu and Çelik, 2012). In this study, the geological, physico-mechanical and durability properties of travertines from Edremit region are discussed. For this purpose, field studies and sample collection are performed in the study area (Fig. 1). Some studies are conducted to expose the changes in chemical, physical, and mechanical properties of travertines under various atmospheric effects. Quality assessment tests of travertine in the Edremit are performed in accordance with accelerated weathering tests, and the test results are presented. The long-term durability of rock material against several environmental situations can be assessed by means of accelerated weathering tests in the laboratory (Martin et al., 1992; Park et al., 1998; Ondrasina et al., 2002; Prikryl et al., 2003; Topal and Sözmen, 2003; Sousa et al., 2005; Van et al., 2007; Akın, 2010). Finally, industrial potential of travertine is determined in the study area and this material is investigated within the long-term performance/durability of travertine against various environmental

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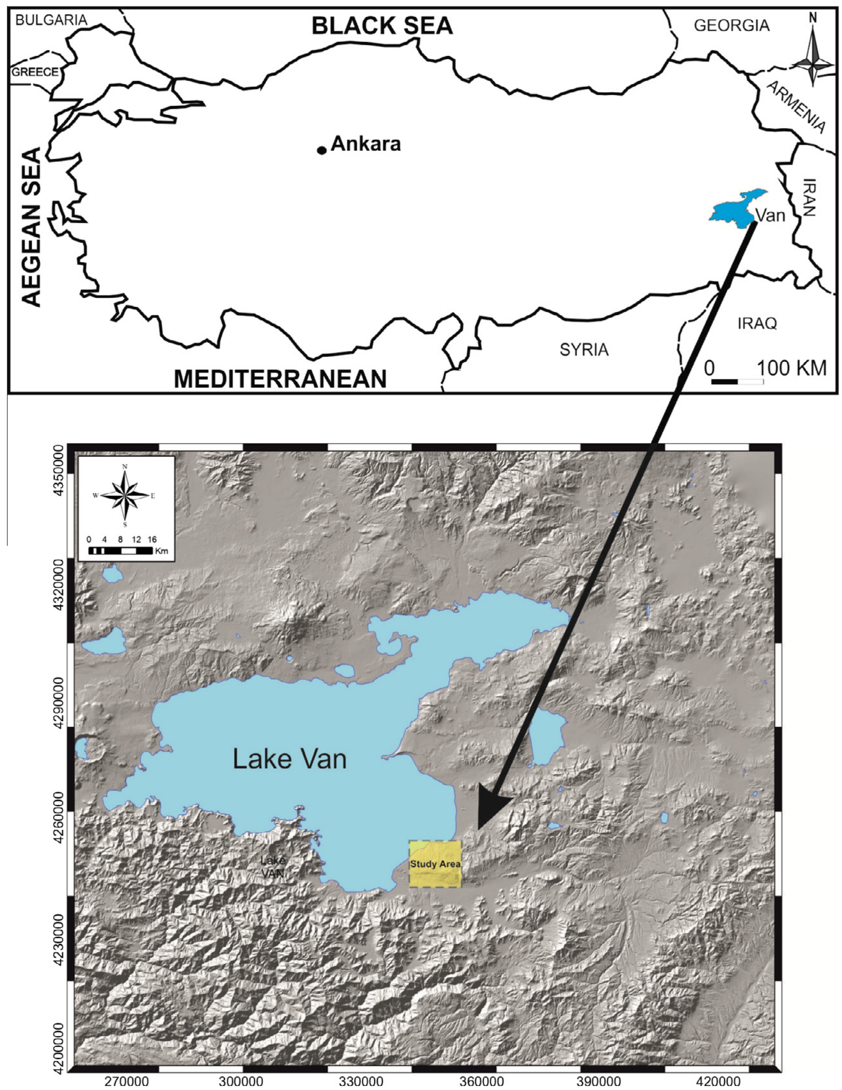

Fig. 1. The location map of the study area.

processes by using several accelerated weathering tests such as wet–dry, freeze–thaw and salt crystallization.

2. Material and method

This study is composed of different field and laboratory study stages. The travertine of Edremit (Van, Turkey) was selected as the study material. Firstly, general geology map was produced for the study area and its vicinity. Samples are collected from different locations of the study area to ensure the representation of the rock type. Shapeless and cylindrical travertine samples obtained from outcrops, quarries and drillings in the study area, are used to determine physico-mechanical properties using the test methods specified in ISRM (2007) standard. The mechanical properties of the travertine levels are obtained directly by testing the cylindrical samples under uniaxial compressive loads.

In the study area, strength map of different lithotypes of Edremit travertine is prepared according to the results of indirect uniaxial compressive strength values that are obtained from bedrock surfaces with Schmidt Hammer and point load tests. For this purpose, the indirect uniaxial compressive strength estimation is performed via the chart of Deere and Miller (1966) using the values of type L Schmidt hammer rebound and the density of the rock. Also, $Is_{(50)}$, the result of point load tests are multiplied with the coefficient of 22 in accordance with ISRM (2007) to estimate the UCS value of travertine samples. For each location, the minimum, maximum and average values are calculated and average values of Schmidt hammer rebound and point load test results are used to define the quality of travertine levels. The results of field observations along with the results of physico-mechanical tests are used to classify the travertine levels into three types weak, low and medium strength. Global Positioning System (GPS) has recorded the coordinates of the sample locations; and strength map of different lithotypes of Edremit travertine, using the results of indirect UCS tests and field observations, is created via Natural Neighbor Interpolation method, which is a common interpolation technique used in GIS based programme.

Accelerated weathering tests can lead to various changes according to the physical and mechanical properties of rocks (Topal and Doyuran, 1998; Benavente et al., 2004; Steiger, 2005; Yavuz and Topal, 2007; Akın, 2010; Akın and Özsan, 2011). Therefore, in the second part of the study, accelerated weathering tests are conducted on cubical travertine samples according to RILEM (1980), ASTM D5313 (1992), and TS EN 12371 (2002) standards in order to determine the possible use of travertines in construction industry. For this purpose, cube-shaped samples with