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Correlation of equivalent quartz content, Slake durability index and Is_{50} with Cerchar abrasiveness index for different types of rock

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1. Introduction

Rock abrasiveness is defined as the abrasive effect of a rock on a metal surface. Abrasiveness influences the capacity of various types of soil to wear down excavation tools. The most important properties to consider for abrasiveness is the type of rock or soil, its mineral constituents, the grain size of the abrasive minerals, the strength and density of the soil, and the strength of bonds between rock particles.[1] For sedimentary rocks, grain size, hardness, texture, cement content, compressive and tensile strength, alteration and roundness affect abrasion of excavation tools.[1,2]

Bruland[3] investigated the effect of mineral constituents on rock abrasiveness by calculating their Vickers numbers. The equivalent quartz content is another method used to determine the hardness of rock; it is calculated as

$$EQC = \sum_{i=1}^{n} A_i R_i (\%) \tag{1}$$

The quartz content and other mineral contents are obtained by microscopic examination of the rock, and A_i is the abrasiveness index from the total sample and is multiplied by the Rosiwal (R_i) abrasivity index for the mineral where n is the total number of minerals.[4]

West showed that the abrasiveness of rocks is a function of the quartz and other abrasive mineral contents, average grain size, and grade and type of cement, with quartz content having the dominant effect.[5]

The Cerchar abrasiveness index (CAI) is a common method of predicting abrasiveness in excavation tools. This test was introduced by The Mining Research Institute of the French Coal Association[6] and is defined in French Standard AFNOR (NF904-430-1).[7] ASTM (D7625-10) also describes the testing method and production of the pin to calculate CAI.[8] The test uses a steel pin with a defined quality and geometry to scratch 10 mm of rough rock surface using a static load of 70 N and a speed of 1 mm/s.[9]

Many studies have investigated the factors affecting CAI. Some have focused on issues such as length of scratch, stress dependency, surface conditions of the sample rock, and speed of testing. Others have investigated the equipment used, particularly the metal pin, and on the effect of petrographic and geomechanical properties of the rock.[10–17,1] Deliormanli[18] studied the correlation between CAI and strength in marble rock using different methods and was able to propose correlations. Kohler et al.[19] assessed the performance of a tunnel boring machine, and Deliormanli[18] examined the effect of rock strength using multivariate regression analysis.

The present study investigated possible correlations between CAI and EQC (from thin-section petrographic analysis), point load index (I_{s50}), Slake durability index (I_{d2}) and percentage of water absorption (%S). Testing was carried out on 36 samples of igneous, sedimentary and metamorphic rock. The relationships between them were evaluated using univariate and multivariate regression.

2. Methodology

2.1. Sampling

Samples were taken from different geological formations in Iran and include metamorphic (eight samples), igneous (10 samples) and sedimentary (18 samples) rock.

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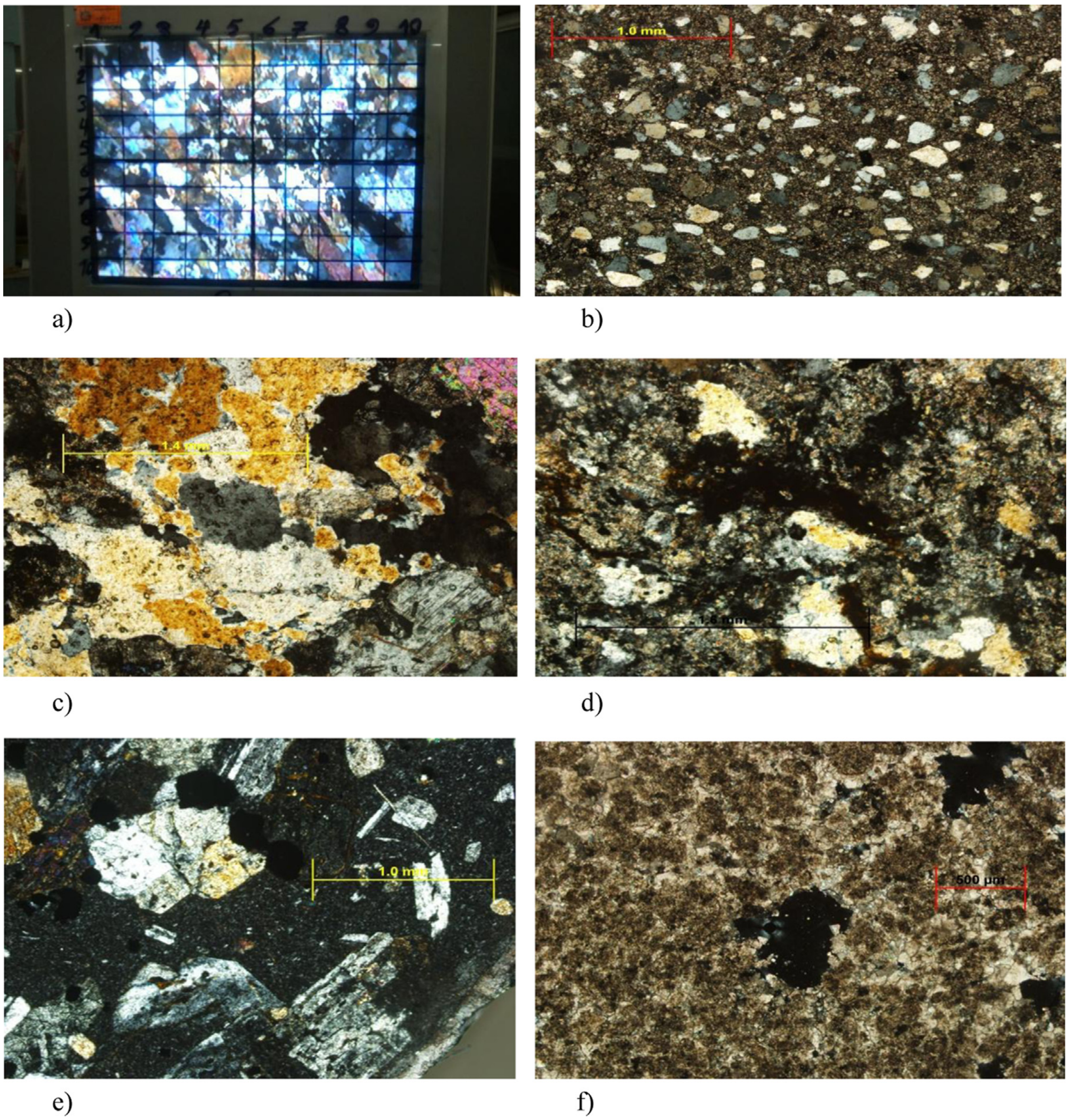

Fig. 1. (a) Gridding the picture of the thin section into 100 identical squares, (b) petrographic analyses: Quartz arenite, (c) Sericite schist, (d) Sericite schist, (e) Andesite, (f) Crystalline limestone.

2.2. Laboratory testing

2.2.1. Petrographic analysis

Petrographic analysis was conducted using the Rosiwal and modal methods using an optical microscope and a mechanical stage as explained in Refs. 20 and 21. Fig. 1 shows that the stages of petrographic analysis differ from the modal methods in that they produce error that decreases the accuracy of measurement. These included errors in measurement of the area of each thin section, overlap of minerals at the sides of an area, and overlap of an image with an adjacent image under the microscope.

Since determining the percentage of error in the modal methods is a lengthy process, a method of analysis was adopted by which the field of view of the microscope is transmitted to a monitor using a camera to allow consideration of similar areas for each thin section. To prevent overlap of the first field of view with the next one, the pictures on the monitor were marked and scaled so as to distinguish between them. A regular grid dividing the total field of view into 100 equal portions was placed on the monitor and the results of the two methods were collected and their averages calculated.

Based on microscopic studies calculated EQC for each samples. The results are shown in Table 1.

2.2.2. CAI

Cerchar tests are done with steel pins of Rockwell hardness HRC-55 and tension strength 2000 MPa. Cerchar tests are done on smooth surface. The CAI was calculated according to ASTM (D7625-10)[8] and the results are shown in Table 1 for different types of rock. ASTM (D-7625-10) categorizes the rock abrasiveness of samples of igneous rocks as very abrasive or extremely abrasive, according to the quartz and glass content of the sample. An increase in granular or porphyrique the grain texture and whether or not the quartz texture contains phenocryst will determine the abrasivity of the rock. Metamorphic rocks fell into the medium to extremely abrasive categories because of differences in temperature and stress. All the limestone samples were categorized as abrasive because of their similar petrography. Siliclastic rock

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