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Relationship between Textural and Mineralogical Properties of Crystalline Igneous Rocks Using Textural Quantification by Image Analysis

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Introduction

The mineralogical and textural characteristics of rock materials have an important influence on physico-mechanical properties. The effects of some textural characteristics like grain size (Brace, 1961), grain shape (Cox and Budhu, 2008), grain surface (Diepenbroek et al., 1992), grain size distribution (Gurkan Ozgurel and Vipulanandan, 2005), and grains interlocking (Hoek, 1965) on physico-mechanical behavior of rock materials has always been emphasized. On the other hand, it has been found that textural properties are originally controlled by the mineralogy and chemistry of rock materials (Locat et al., 1984). Knowing the textural, mineralogical and chemical properties of rock materials and understanding the governing relationships can help us predict the quantitative and qualitative behavior of rock materials. The aim of this study is to investigate the interrelationships among the various textural properties besides the relationship between the textural characteristics and the mineralogy and chemical composition.

Materials and methods

Fifteen crystalline igneous rock samples including a wide variety of rock types and grain size were collected from the granite quarries of NW Iran (Fig. 1) and the thin sections of the samples were prepared for quantification of the textural characteristic by image acquisition analysis under a polarized microscope. A total of 360 digital photomicrographs of each thin section were taken from the entire surface area of the thin section in three steps of natural light (PPL), polarizing light (XPL), and polarized light by a 45° rotation of the stage (Fig. 2). After preprocessing of distortion and skewness, the images were joined by Adobe Photoshop software to make the integrated mosaic image layers. The grain boundary tracing was carried out by drawing the grain outline through the interface of the adjacent grains via the three mosaic image layers on the background using the JMicroVision software (schematic diagram in Fig. 3). Simultaneously, identification and documentation of the mineral grains (crystals) were conducted by utilizing the optical properties of the minerals occurring in image layers. Overall, about 18,000 mineral grains were traced from the thin sections of fifteen samples. The accomplished graphic files after some of the file-format conversions were loaded by the ArcMap program to extract the main geometric textural properties like length, width, area, perimeter, circularity, and some related geometric concepts (Fig. 4) which were used to calculate advanced textural parameters such as roughness, rugosity, etc. Simultaneously, the mineralogy composition of the samples was obtained from the covered area of minerals in thin sections and used for classification of the samples according to the IUGS system (Fig. 5). In addition, textural mineral distribution map (TMDM) of the samples

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(Fig 6) were prepared and used to do petrographic textural studies of the samples.

Discussion

The results of correlations revealed that "size" is the most important textural parameter, which shows a notable relationship with mineralogy and chemical composition of the studied rock samples. Moreover, the result exhibited that the number frequency graphs of the grains (crystals) size distribution are asymmetric and non-normal that show negative (right) skewness. Consequently, arithmetic average cannot be an acceptable statistical mean to determine the average of the grain size due to the fine-grains tendency error, whereas textural and qualitative properties of rock are mainly controlled by the coarse and moderate grains content. Thus, the area-weighted mean diameter extracted from the cumulative distribution curves, (Fig 22) was suggested instead of the common arithmetic average to determine the mean grains size of the crystallized rock material. In addition, it was found that the elongation (aspect ratio) of the grains shows a good correlation with most of the shape-metric and grains-interrelation parameter. Thus, it should be considered as an efficient textural index to evaluate the grains interrelationships rather than the common texture coefficient (TC) index because of the simplicity and rapidity of its calculation.

Results and Conclusions

The statistical mean of the geometric textural parameters besides the total constituent grains were determined for the main minerals phases (quartz, plagioclase, alkali-feldspar) and mafic minerals (here all the other minerals). Therefore, correlation analyses were conducted among the various non-phasic and phasic textural variable as well as the chemical and mineralogical composition. The analysis was carried out through classification of textural parameters into three main groups of size-metric (diameter, area and perimeter), shape-metric (elongation, circularity, rectangularity, roundness, roughness, rugosity and compactness) and grain-interaction (size homogeneity, heterogeneity index, interlocking index and Texture Coefficient) parameters with respect to the nature of parameters' demands. Considering abundance of the evaluating textural variable, at first, the matrix correlations among the various textural, mineralogical and chemical variables were calculated and the significant correlations were interpreted via linear regression analyses and graphical illustrations.

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