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Characterization of multifractal patterns in rock discontinuities.

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In this paper we describe an integrated methodology for the study and characterization of multifractal patterns in rock discontinuities. Rock mass discontinuities are generated through chaotic related processes and present geometric properties inherent of the underlying processes, such as repeatability and structural complexity. In the case of rough rock surfaces, complexity is studied in terms of fractal magnitudes, namely Fractal Dimension and Proportionality Constant. The variance of chaotic processes that affect a single surface may produce a multifractal pattern that need to be studied in order to gain knowledge about the mechanical and hydraulic behavior of the surface. In the recent years an extensive study has been carried out mainly using samples of small size and laboratory devices. Due to lack of suitable digitization devices, the research has not been extended in discontinuities of larger sizes. This paper describes the complete methodology developed for the recording, modeling, studying and the representation of multifractal patterns obtained from large size rock joint samples (in the order of $80m^2$).

The applied methodology is consisted of the digitization of large scale surfaces using a high performance geodetic laser scanner and the implementation of some known fractal techniques. The usage of the specific scanner gives the opportunity to scan a large area densely and accurately and thus model the geometric patterns that emerge or change over scale. Firstly, the acquired data were pre-processed so that the datum was corrected and several non-fractal components, such as adjacent vegetation and discrete rock parts, were removed from the digitization. The modeling of the discontinuities was performed using special developed software, throughout which the estimation of the Fractal Dimension and the Proportionality Constant is performed. The Fractal method used for this was the Semivariogram, adapted for usage with 3-dimension data.

The main analysis of multifractal properties was performed in two ways. In the first approach, using a regression algorithm, the correlation length at which the fractal magnitudes present a remarkable change is estimated. According to the second approach the fractal magnitudes are estimated over a shifting window of the sample surface. Fractal Dimension and Proportionality Constant changes are modeled with respect to location.

The valuation of the presented numerical results provides important conclusions regarding the multifractal character of rock joints. The existence of distinct multifractal characteristics was confirmed in all three surfaces. The developed methodology yielded the scale at which fractal pattern changes and thus multifractal components emerge. The estimation of the cross-over scale value consorted with visual observation of the surfaces.

The ability of describing patterns with disparate fractal characteristics inside the same surface is of great importance as it provides knowledge, not only of multifractal phenomena themselves, but of the chaotic processes responsible for their emerge too.