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Characterization and reproduction of the aperture distribution patterns in a basaltic fracture plane by Multi-point Geostatistics algorithms

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Performing flow characterization and quantification inside fractured aquifers has been a great challenge faced by hydrogeologists, mainly due to technological limitations of well-established techniques to accurately measure the fracture geometry, like resin casting technique and profilometers. X-ray microtomography (micro-CT) is a non-intrusive option that ensures an interior detailing of solid objects through 3D images witch accuracy of a dozen microns. However, the size of the fractured basaltic rocks samples that can be analyzed is around 2 inches. The use of statistical methods can increase the representativeness of the data obtained by micro-CT, highlighting the application of the Multi-point Geostatistics methods (MPS). The MPS allows a characterization and reproduction of curvilinear heterogeneity patterns of a physical phenomenon, considering the spatial relation between finite points from a conceptual model called training image (TI). In this research, we evaluated the potentiality of multiple-point geostatistics technique to characterize and reproduce the random patterns of distribution of aperture values existing in a given fracture plane using a 3D micro-CT images of a basaltic sample as TI. This evaluation can help the accuracy and representativity of models that seek to simulate the flow in fractured media. Two MPS algorithms were used: The Direct Sampling-DS, a Pixel-Based method, adapted from Mariethoz (2009), and the Multi-Scale Cross Correlation-based Simulation-MS CCSIM, a Pattern-Based algorithm, based in the work of Tahmasebi, Sahimi, and Caers (2014). The TI used was obtained from a fractured plan of a basalt sample witch dimensions of 2.6 cm in length and 2.2 cm in diameter, taken from an outcrop area of the Guarani aquifer, in São Paulo, Brazil. The aperture values ranging from 0 to 500 μm. Initially, analyzes were made to identify the importance and the susceptibility of parameters/factors that govern the performance in both algorithms. The number of repetitions was 10 for each combination of values of the factors used. For the best configuration of these parameters, the DS results showed better spatial connectivity of the structures and channels existing in the fracture plane, through which the flow can occur, regarding the randomness of the aperture values and the distribution pattern found in the TI. The images reproduced by MS CCSIM, in contrast, tended to copy certain regions of TI to most of the combinations of parameters used. On the other hand, in terms of the computational effort required, the DS underperformed MS CCIM. Comparing their global statistics with those of the TI, both presented similar representativeness of the aperture values. A preference for the DS

algorithm is made and recommended for TI's with similar characteristics. However, for images with different features, sensitivity analysis should be performed. A second quality analysis of the reproductions obtained by DS was then performed, considering the use of conditional data taken from the TI, which were point conditionals and pixel groups. The DS showed a great ability to reconstruct the images from these conditional data, maintaining the randomness of the aperture values, the connectivity of both global and local structures, without a tendency to copy the TI.