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Quantitative Ranking of Geological Conceptual Models using Multi-Point Geostatistics

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Geological interpretation plays a crucial role in every phase of subsurface characterization from exploration to exploitation, e.g. of an oil reservoir or a mineral deposit. In general, the distribution of physical properties is controlled by the architecture of geological objects. Therefore, defining it becomes the initial step of geological modelling. However, insufficient data and the complexity of the earth processes create an ill-posed problem where many models are plausible. Consequently, several geologists will produce different geological models for the same location. This contribution proposes a way to objectivise the ranking of those conceptual models by comparing them with hard data.

Our proposal is based on Multi-point geostatistics (MPS) methods, which are capable to reproduce complex structures common in geology, such as meandering channels, erosional surfaces and salt bodies. MPS is typically used to produce simulations or scenarios of subsurface geology. In addition to spatial data, the methods need a training image, that might come from an expert opinion, a numerical physical simulation, or even from a modern analogue. Several competing models can be considered as alternative training images and the MPS method can be modified to be able to simultaneously sample from all of them. In this way it is possible to produce a complex arrangement of geological architecture, combining several conceptual models. By tracking the frequency with which every training image is visited we can rank the likelihood of each geological model. This can be done locally, for each voxel of the model, or integrated over a region. In this way, we can assess how likely that region patterns come from one particular training image, that is, from one particular conceptual model.

We demonstrate this method in a synthetic fluvial depositional environment where meandering channels transform into braided streams. A limited amount of hard data is extracted from the synthetic reference and three geological concepts are being imposed in the form of training images. These training images are of distinct patterns either braided, meandering or high sinuosity meandering with an oxbow lake structure. Both hard data and all training images become the input to the proposed MPS method and several realizations are being generated. The results indicate that the new method could be a useful tool in defining which geological concept dominates at a particular region and what are the corresponding frequencies for each training image on that region. In addition to that, the method also gives reasonable realizations that resemble the true setting.