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Including stratigraphic hierarchy information in geostatistical simulation: a demonstration study on analogs of alluvial sediments

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When building a geostatistical model of the hydrofacies distribution in a volume block it is important to include all the relevant available information. Localised information about the observed hydrofacies (hard data) are routinely included in the simulation procedures. Non stationarities in the hydrofacies distribution can be handled by considering auxiliary (soft) data extracted, for example, from the results of geophysical surveys. This piece of information can be included as auxiliary data both in variogram based methods (i.e. co-Kriging) and in multiple-point statistics (MPS) methods. The latter methods allow to formalise some soft knowledge about the considered model of heterogeneity using a training image. However, including information related to the stratigraphic hierarchy in the training image is rarely straightforward.

In this work, a methodology to include the information about the stratigraphic hierarchy in the simulation process is formalised and implemented in a MPS framework. The methodology is applied and tested by reconstructing two model blocks of alluvial sediments with an approximate volume of few cubic meters. The external faces of the blocks, exposed in a quarry, were thoroughly mapped and their stratigraphic hierarchy was interpreted in a previous study. The bi-dimensional (2D) maps extracted from the faces, which are used as training images and as hard data, present a vertical trend and complex stratigraphic architectures. The training images and the conditioning data are classified according to the proposed stratigraphic hierarchy, and the hydrofacies codes are grouped to allow a sequence of interleaved binary MPS simulation. Every step of the simulation sequence corresponds to a group of hydrofacies defined in the stratigraphic hierarchy.

The blocks simulated with the proposed methodology are compared with blocks simulated with a standard MPS approach. The comparisons are performed on many realisations using connectivity indicators and transport simulations. The latter are performed with the Kolmogorov-Dmitriev method, which allows to investigate the transport behaviour at a spatial scale one order of magnitude bigger than the scale of the model blocks, using the transport properties statistics extracted from the results of particle tracking simulations on the model blocks. To allow a direct comparison with the observed facies maps, which are available in 2D only, all the aforementioned comparison are first performed in 2D and subsequently on the three-dimensional blocks.