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Reservoir Modeling Using Multiple-Point Statistics

Two approaches are traditionally used to build numerical models for facies distributions within a reservoir. Pixel-based techniques aim at generating simulated realizations that honor the well data values, and reproduce a given variogram which models two-point spatial correlation. However, because the variogram cannot look at spatial continuity between more than two locations at a time, pixel-based algorithms give poor representations of the actual facies geometries. In contrast, object-based techniques allow reproducing crisp geometries, but the conditioning on well data requires iterative ``trial-and-error'' corrections, which can be time-consuming, particularly when the data are dense with regard to the average object size.This paper presents a new approach that combines the easy conditioning of pixel-based algorithms with the ability to reproduce ``shapes'' of object-based techniques, without being too time and memory demanding. In this new approach, the complex geological structures expected to be present in the reservoir are characterized by multiple-point statistics, which express joint variability at many more than two locations at a time. Such multiple-point statistics cannot be inferred from typically sparse well data but could be read from training images depicting the expected subsurface heterogeneities. A training image need not carry any locally accurate information on the reservoir; it need only reflect a prior stationary geological/structural concept. Thus training images can be generated by object-based algorithms freed of the constraint of data conditioning. The multiple-point statistics inferred from the training image(s) are then exported to the reservoir model, where they are anchored to the well data using a pixel-based sequential simulation algorithm.

This algorithm is tested for the simulation of a turbidite system where flow is controlled by meandering channels with cross-bedding. The training image reflecting the channel patterns is an unconditional realization generated by an object-based algorithm. The final simulated numerical models reproduce these channel patterns, and honor exactly all well data values at their locations.