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Geostatistical 3-D Facies Modeling of a Carbonate Reservoir Outcrop Analogue Based on a New Pluri-Gaussian Approach

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ABSTRACT

Realistic facies geometries and spatial relationships in carbonate reservoirs are difficult to represent in reservoir models with standard geostatistical tools conditioned to sparse well data. Here we present a new geostatistical method that builds on established two-point statistics tools to reproduce hitherto problematic aspects of facies architecture, and we test the method using a data-rich outcrop analogue. The outcrops of the Latemar platform (Italian Alps) provide a well-documented example of stratal architecture and facies distributions in a carbonate platform, comparable to many giant carbonate reservoirs within early dolomites such as the Khuff formation. Vertical transitions between facies in the platform interior are asymmetric and periodic, resulting in a series of vertically stacked, asymmetric cycles (shallowing-upward parasequences). We have developed a truncated pluri-gaussian approach constrained by transiograms, which are usually defined in the context of Markov chains, able to model the asymmetric facies transitions within a parasequence. The cyclic pattern of facies distributions, which reflects parasequence stacking, is also quantified by the transiogram through damped oscillations called hole-effects, and modelled using hole-effect covariance. Lateral facies variations in the platform interior occur over relatively large distances and lack apparent cyclicity. We model the contrasting vertical and lateral facies patterns by using a separable covariance model, which represents cyclicity and asymmetry in the vertical direction, and standard stationary variations in the lateral direction. The truncated gaussian method developed here is used to build a 3D model of the Latemar platform outcrop analogue from 1D vertical sections, and then compare the resulting model to 2D cross-sections. The approach is used here for three different facies categories, but can be extended to additional facies. To summarize, the modelling possibilities of truncated pluri-gaussian simulations have been extended to the representation of asymmetry, periodicity with three-dimensional anisotropy. It is expected that this method will help to generate reservoir models that are more representative of facies distributions in carbonate reservoirs, thus improving abilities to populate subsurface reservoir models at the inter-well to field scale.