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Hierarchical Characterization of Submarine Channels for Compression Based Object Modeling

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ABSTRACT

Submarine channels can host large accumulations of hydrocarbons but are challenging from a reservoir modelling perspective as they are characterised by multiple scales of hierarchically nested depositional elements. For example, in confined systems a six-level hierarchical classification scheme ranging from channel complex sets to beds has been recognised. The objective of the current work is to establish a quantitative description of hierarchical channel deposits, and to apply this description to create more realistic reservoir flow simulation models of such deposits. The reservoir modelling is based on a novel hierarchical procedure developed for deep-water lobe deposits and adapted in the current work to submarine channel deposits: this procedure is the compression-based object modelling approach. The compression approach allows for independent input of net:gross and amalgamation ratios in object-based models. This is a significant advance on pre-existing object-based methods in which the amalgamation ratio is inevitably equal to the net:gross ratio, resulting in unnaturally well-connected geological models at relatively modest net:gross ratios. The models are conditioned to stacking and dimensional characteristics of channels measured in natural systems at different hierarchical levels. Stacking characteristics include the fractional volume of the container occupied by the smaller object, and the amalgamation ratio, which defines the extent to which the objects are interconnected. Dimensional characteristics principally refer to the size and shapes of the channel objects (thickness, width and length) in relation to the size and shape of the object in which they are contained. Preliminary results derive from outcrop observations compiled from published literature, and new analysis of 3D seismic data from the Taranaki Basin, offshore New Zealand. The outcrop studies provide data at the smaller scales, while the largest hierarchical levels are observed in the seismic data. Results suggest that channel objects at smaller, sub-seismic hierarchical levels are better connected than at larger levels. The results of the modelling are reservoir-scale but bed resolution three dimensional flow simulation models in which both the net sand facies and the hierarchical fine-grained non-net deposits are represented explicitly. Two-phase flow simulation modelling highlights the important heterogeneity levels governing reservoir sweep and drainage efficiency.