Modeling of Turbidite Channel Reservoir Heterogeneity at Sub-Seismic Scale: Capture Key Features that are Important to Fluid Flows

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Abstract

Despite the fact that good quality seismic data are collected in deep-water turbidite channel reservoirs, it is still a challenge to represent the important geological features of turbidite channels in static reservoir models. A few critical features that have large impacts to fluid flow are well below the resolution limit of seismic data, such as the channel boundary layers and mud drapes, in addition to heterolithic bedding features seen on cores. A 3D static reservoir model that ignore the impact of these critical sub-seismic features would lead to wrong estimation of recoverable reserves and production profiles.

We present a multi-scale modeling working flow to address the sub-seismic scale heterogeneity in the turbidite channel reservoirs. First, major bounding surfaces digitized from seismic data are used to construct the framework of a turbidite channel reservoir. Based on geological interpretation and outcrop analog models, these digitized surfaces will be interpreted as boundaries of channel complex set, channel complex, or less frequently individual channels. Based on well data, channel boundary layers and mud drape distributions are then modelled for channel and channel complex. Infill deposits of individual channels are modelled subsequently based on the formation process of interpreted infill types. The result is a detailed stratigraphic grid that captures key boundary layers and facies distributions below the seismic resolution, but is also consistent with well data, seismic data and outcrop analog models.

The heterogeneity at the sedimentary bedding scale in turbidite reservoir is another sub-seismic scale we considered in our multi-scale modeling workflow. The impact of these small scale heterogeneity to fluid flow is represented by the directional permeability estimated from the sedimentary bedding models. Instead of assuming a constant Kv/Kh ratio (e.g., 0.1), we can estimate facies dependent Kx, Ky, and Kz for the stratigraphic grid modeled in the previous step. Application examples of the multi-scale modeling workflow demonstrate a significant improvement in the accuracy of 3D static reservoir modeling and reserve estimates for turbidite channel reservoirs.