

# Bridging the missing-scales: New developments in small-scale heterogeneity modeling

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Reservoir heterogeneity exists at multiple scales, from pore structures, bedding structures, internal stratification, litho-facies, to fault blocks. Conventional reservoir modeling workflows do not consider multi-scale heterogeneity in an integrated manner, which results in unrealistic and inaccurate reservoir models. Applying such models in reservoir simulations increases the uncertainty in history matching and reserve predictions.

The original small-scale modeling approach was developed in order to model the heterogeneity at bedding structure scales (Wen et al., 1998), which bridge the scale gaps in core data and well log data. The near well-bore models (e.g., Figure 1) simulated from the process-oriented modeling method can be used to improve the estimation of petrophysical properties from well log data and core data. Case studies demonstrate that this geological modeling approach can be used to estimate facies-dependent permeability anisotropy, such as  $k_v/k_h$  in heterolithic reservoirs (Elfenbein et al., 2005; Nordhal et al., 2005, Ringrose et al., 2003; Ringrose et al., 2005; Ruvo et al., 2005).

Recent developments have extended the original process-oriented method to simulate larger scale geological models, such channel infill architectures, depositional lobes, and bar forms. The resulting models more realistically represent reservoir heterogeneity in terms of fluid flow properties. These new developments provide modeling methodology to bridge the scale gaps between well log data and seismic data. More realistic uncertainty estimates can be obtained from this type of modeling (Barton et al., 2003). Simulations of stratigraphic features at sub-seismic scales, i.e.  $< \sim 30$  m, (Figure 2) can also be applied to the interpretation of seismic attributes (Wen, 2004).

Another new development in the process-oriented modeling approach is the direct upscaling of reservoir properties (saturation, porosity and absolute and relative permeability) from both bedding structure models and sub-seismic stratigraphic models. This allows geologists and reservoir engineers to evaluate distribution of flow properties from all possible geological scenarios by considering multi-scale heterogeneity, thereby improving the prediction of reserve volumes and production profiles.

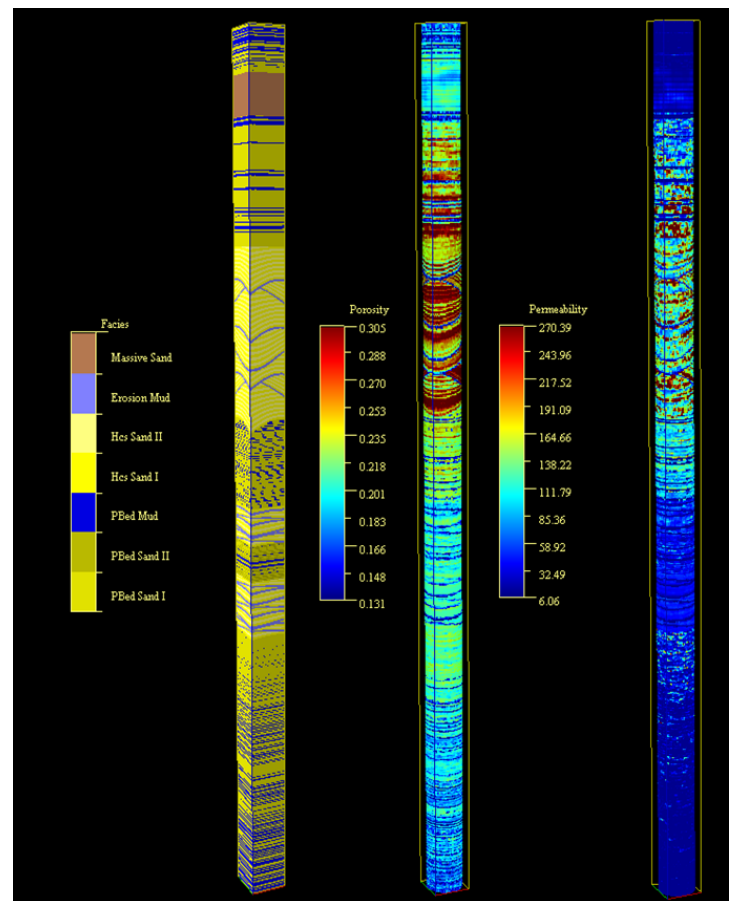


Figure 1. A near well bore model generated with bedding structure modeling software, SBED™. Such models have successfully been used to estimate  $k_v/k_h$  from very heterolithic reservoirs.

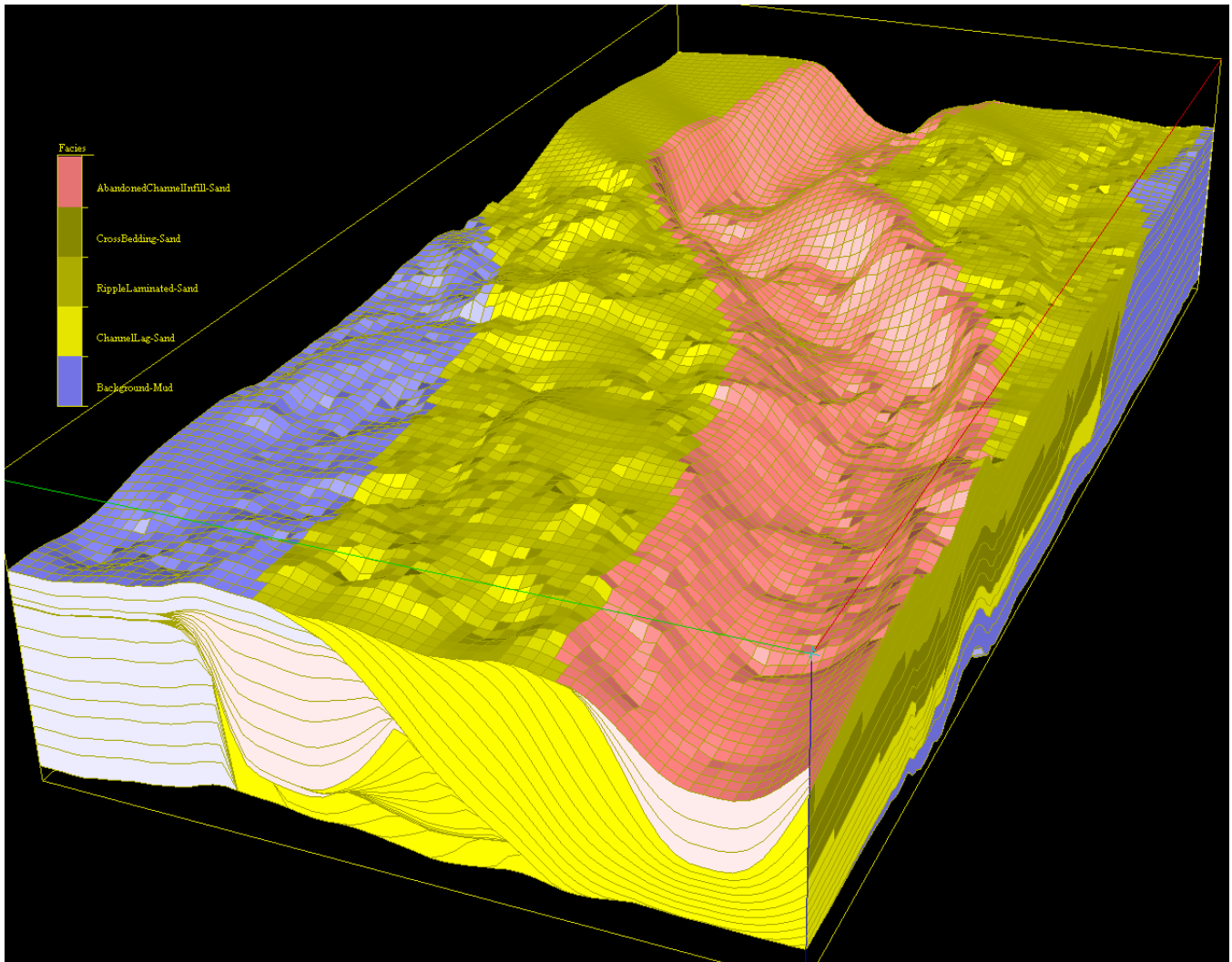


Figure 2. A reservoir-scale geological model that includes sub-seismic-scale stratigraphic surfaces generated with SBED Studio™. Channel infills are not represented by objects, but by stratigraphic layering, thus making it possible to represent important flow barriers, such as shape drapes.

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