Surface-Based Modeling to Capture High-Resolution Facies Architecture and Its Impact on Hydrocarbon Volumes and Recovery

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Conventional reservoir modeling approaches are developed to account for uncertainty associated with sparse subsurface data, but are not equipped for detailed reconstruction of high-resolution geologic datasets. We present a surface-based modeling procedure that enables explicit representation of heterogeneity across a hierarchy of lengthscales. Numerous surfaces are used to construct complex facies-body geometries and distributions prior to generating a grid, allowing sampled and conceptual data to be fully incorporated within field-scale models. Our approach is driven by the improved efficiency that surfaces introduce to reservoir modeling through their geologically intuitive design, rapid construction and ease of manipulation. Cornerpoint gridding of the architecture defined by the surfaces reduces the number of cells required to represent complex geometries, thus preserving geologic detail and rendering upscaling unnecessary for fluid-flow simulations.

The application of surface-based modeling is demonstrated by reconstructing the detailed three-dimensional facies architecture of a wave-dominated shoreface-shelf parasequence from a rich outcrop dataset. The studied outcrop dataset describes reservoir architecture in a generic analog for many shallow-marine reservoirs. The process of model construction has demonstrated the role of (1) shoreface-shelf clinoforms, (2) paleogeographic changes in shoreline orientation, and (3) storm-event-bed amalgamation in controlling facies architecture. These subtle geometric features cannot be accurately represented using conventional stochastic reservoir modeling algorithms. In contrast, the surface-based modeling approach honors all data and captures subtle geometric facies relationships, thus allowing detailed and robust reservoir characterization. As a result, the surface-based model provides more accurate estimates of facies proportions and distributions, hydrocarbon volumes in place, fluid flow behaviors, and recovery.