High-Resolution, Three-Dimensional Outcrop Modeling of a Fluvial-Dominated Deltaic Reservoir Analogue

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Deltaic deposits, such as those found in the Prudhoe Bay and Sahkalin Fields, contain significant hydrocarbon reserves and are a major focus of future exploration. However, the way in which their inherent geological heterogeneities impact on hydrocarbon recovery, and how this should best be captured in reservoir models, is still unclear.

We have used an extensive outcrop dataset to construct high-resolution, 3-D models of parasequence-set, parasequence, and facies architecture within the two lowermost parasequence-sets of the late Cretaceous Ferron Sandstone, exposed in Utah, USA. The dataset comprises measured sections, cliff-face photomontages, GPS-measured spatial data, laser-surveyed thicknesses and well-log data obtained over an area of circa 7 by 4 km, within which there is excellent 3-D data coverage.

To properly capture this rich, complex dataset requires the use of a new modeling methodology. We adopt a top-down, surface-based approach, in which each level of heterogeneity is represented using one or more surfaces. These surfaces may be deterministically interpolated between control points, or incorporate a stochastic element. The advantages of this approach over traditional grid-based stochastic techniques are that (i) any level of heterogeneity may be captured using additional surfaces; (ii) it is trivial to condition the surfaces to control data, however complex; (iii) surfaces are much less computationally expensive than large, 3-D grids, and (iv) the models can be efficiently gridded or meshed for flow simulation using adaptive techniques.

We can simulate fluid flow directly on the model without recourse to upscaling. It also allows us to resolve details of the sedimentology which could not be otherwise determined. Although we have developed the modeling methodology for rich outcrop datasets, it could be applied to sub-surface reservoirs.