Reservoir Prediction using the Forest and the Trees: Reducing Reservoir Risk and Uncertainty in Deepwater Gulf of Mexico Exploration by using a Wide Range and Scale of Predictive Tools

Cindy A. Yeilding, BP Exploration
Eric J. Ekstrand, BP Exploration
Christopher J. Travis, BP Exploration
J. Doug Boyd, BP Exploration
Roger Reagan, BP Exploration
Dennis M. Urban, BP Exploration
John D. Oldroyd, BP Exploration

In salt-bearing continental margins, including the northern Gulf of Mexico, a strong correlation commonly exists between the timing of salt movement and that of major regional deposition. Phases of vigorous deformation of the salt and its overburden (including both vertical and lateral movements, such as diapir rise, growth faulting, and growth folding) coincide with phases of rapid aggradation or progradation of clastic wedges. Inversely, phases of tectonic lull correspond to periods of slow sedimentation.

Reservoir prediction in exploration may be enhanced by following six axioms: (1) Acquire the right data; (2) Use all available data; (3) Work the problem at a variety of spatial and stratigraphic scales; (4) Apply multiple tools/methodologies and geologic disciplines;(5) Carry multiple models to quantify or qualify uncertainty; (6) Use new data to update/exclude models. Our analysis proceeds from regional to prospect-scale evaluation of reservoir potential, and we will use an example exploration well to illustrate the methods used, ranges of uncertainty and insights gained at each scale.

Regional-scale analyses provide the depositional and petroleum systems framework within which exploration is focused. Reservoir evaluation is based predominantly on a 2D seismic grid, calibrated using

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key well information, structural controls and biostratigraphy. Key products are a chronostratigraphic and sequence stratigraphic framework, a regional-scale understanding of the architecture and distribution of major depositional systems, and an associated regional reservoir risk pattern.

In the deepwater Gulf of Mexico, a range of risks on amount and type of reservoir facies present may be applied at a regional scale. The location of the major sediment input sites migrates with time, such that the ages of prospective reservoir intervals and their provenance is different in different regions. Well-developed sands are commonly found in a middle or lower slope setting directly down-dip of the major coeval shelf depocenter, which leads to a low "regional" risk for reservoir. Higher risk is associated with the lateral edges of the deposystem and the upper slope and shelf margin (often bypassed or characterized by complex reservoirs).

Reconstruction of the subregional structural and stratigraphic evolution of an area provides insight into the range of depositional processes and controls on reservoir geometry and distribution. Overall slope gradient, subsidence rate and local structures (faults, salt withdrawal)may generate accommodation space where sediment can aggrade or pond, even in a generally sand-poor setting such as the upper slope. Local bathymetric highs may lack reservoir but may restrict or impede flows and concentrate sand accumulation in adjacent areas.

Subregional analysis is typically built on a framework of 3-D seismic surveys and any available well data. Data includes detailed biostratigraphic analyses, seismic facies maps (geometries, textures and seismic attributes), log facies and lithology interpretations, and structural analysis of subsidence pattern, fault movement and salt migration. Key products are a detailed chronostratigraphic framework and a series of paleogeographic maps showing the nature and distribution of potential reservoir facies and their controls through time. The details provided by a robust subregional analysis allow us a better understanding of the details of potential reservoir systems, and allow us to corroborate or modify the risk associated with the regional framework.

On a prospect-scale, prediction is focused on reservoir thickness, extent, quality, and continuity. These parameters provide input to reserves ranges, well positioning, definition of stratigraphic trap edges, and the distribution of potential reserves within a trap. Detailed seismic and well log facies analysis are utilized to high-grade potential reservoir-prone intervals. Seismic attribute analysis tied to a rock properties database may be used to predict the range of possible lithologies for a target horizon. Delta-t/interval velocity, AI, and AVO techniques may be used to predict thickness and net/gross variations, across the prospect. Facies mapping and fault analysis are used to predict reservoir continuity. At the prospect scale, multiple reservoir models are described, risked and carried for each target interval, with risk and a range of reserves calculated for the "most likely" reservoir prediction.

In summary, the integration of a variety of methods, data types, and geologic disciplines across a range of scales yields more robust results for reservoir prediction than any one particular method of analysis. Different information and aspects of risk are derived from investigations at different scales, but sometimes the appropriate level of analysis is controlled by the availability and quality of data; for example, the regional picture may be the only tool available for reservoir prediction in some "wildcat areas". Well tests give us confidence that, using the approach described above, we can often predict the types of reservoir and general facies types within a deposystem.