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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

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 use an example exploration well to illustrate the methods used, ranges of uncertainty, and insights gained at each scale.

Regional 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 key well information, structural controls, and biostratigraphy. Key products are a chronostratigraphic and sequence stratigraphic framework, a regional 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 the 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 are different in different regions. Well-developed sands are commonly found in a middle or lower slope setting directly down dip from the major coeval shelf depocenter, which leads to a low "regional" risk for the reservoir. Higher risk is associated with the lateral edges of the depositional system 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 reservoirs, but may restrict or impede flows and concentrate sand accumulation in adjacent areas.

Subregional analysis is typically built on a framework of 3D seismic surveys and any available well data. Data include detailed biostratigraphic analyses, seismic facies maps (geometries, textures, and seismic attributes), log facies and lithology interpretations, and structural analysis of subsidence patterns, 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 to better understand the details of potential reservoir systems and 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 analyses 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-to-gross variations across the prospect. Facies mapping and fault analysis are used to predict reservoir continuity. At the prospect scale, multiple ⇒

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Luncheon Meeting ——— *continued from page 15*

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 within a deposystem.

Biographical Sketch

Cindy A. Yeilding is team leader—frontiers, Gulf of Mexico exploration, BP Exploration. Her specialities and technical focus include stratigraphy and sedimentology of shelf margin clastic systems and analysis of stratal architecture/facies relationships from regional to production scale. Her experience includes 14 years in industry (with BP) as an operations, development, appraisal, and exploration geologist and R&D manager. She is also experienced in regional to 3D seismic scale salt-sediment interactions. In addition, she leads deepwater field workshops for BP. Her work has focused on the U.S. Gulf Coast, but she has worked exploration in Venezuela and subsurface imaging in Colombia.