Impact of Realistic Shale Properties on Exploration-Scale Vertical Migration Modeling

Dempster, Kelly[1], William R. Almon[1], William C. Dawson[1], Michael Hertle[2] (1) Chevron, Houston, TX (2) Maersk Oil & Gas A/S, Copenhagen, Denmark

Basin models incorporate information from other disciplines: structural and seismic interpretation for geometry, log analysis for lithologies, sequence stratigraphy for depositional framework, biostratigraphy for ages, and geochemistry for source rock properties, thermal calibration, and migration indicators.

Seal behavior has historically been treated differently: instead of using measured values as model inputs, results are often compared after the fact to observed seal properties. Default shales were designed to be excellent top seals and to hold large hydrocarbon columns. Early models for deep-water prospects in West Africa used shales mixed with silts in a high-resolution stratigraphic framework to predict hydrocarbon distribution. This empirical method was not satisfactory, because upward migration was not as great as observed in on-structure wells. Variability of results occurred due to differing modeler skills regarding parameter changes.

The lack of fit required Chevron to develop a methodology that incorporates measured shale/seal properties. Analyses of marine shales reveal six distinct seal lithologies, based on fabric and textural variations. Each type has a different compaction rate, described by porosity-depth and porosity-effective stress relationships, porosity versus permeability, and capillary entry pressure distributions. A regional database relates mudstone properties to stratigraphic position and depositional setting. Data relating interfacial tension to composition, temperature and pressure are also captured.

Subsequent simulations fit observation better and indicate that shale properties play an important role in controlling the distribution of hydrocarbons and composition. The use of basin-specific lithologic parameters, upscaled for stratigraphic variation, improves the assessment of migration, column heights, volumes, and pressure.