Grayburg Reservoir Characterization and Modeling: Integrating Outcrop (Brokeoff Mountains, NM) and Modern (Bahamas) Analogs

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STATUS: Project in progress
TIMING: Fieldwork underway
FUNDING: Occidental Permian, Ltd.

Purposes
This research project is largely funded via a recent multi-year contract between The University of Kansas and Occidental Permian, Ltd. Ultimately, a geocellular model for a Grayburg ooid reservoir will be delivered for simulation-based forecasting and history matching. This model will integrate outcrop analog data derived from tidal ooid sand ridges at Schooner Cays, Bahamas, and ooid-dominated Grayburg outcrops in the Brokeoff Mountains, New Mexico (Figures 1A and 1B). Facies probability cubes will be built for all three data sets to compare: (1) the internal architecture of individual bar and compound bars; (2) ooid bar dimensions; (3) depositional strike/dip orientation; (4) upscaling issues; (5) porosity/permeability trends; and (6) to establish a predictive framework (e.g., multi-point geostatistics) for populating Grayburg-equivalent ooid bodies within the final field model.

Understanding the spatial distribution of ooid grainstone bodies is critical for developing a robust model for the entire Grayburg section because they likely have a 1st-order impact on stratigraphic architecture and porosity/permeability evolution. A fundamental project hypothesis is that oolitic bar forms - characterized by different plan views - result from distinct processes (e.g., flow parallel vs. flow normal) and have distinct sedimentologic attributes.

Project Description
Modern Analog at Schooner Cays, Bahamas—The Schooner Cays data set includes approximately 100+ km of 2D seismic lines over the active ooid sand system (see Rush and Rankey, above). This part of the project is funded via an NSF grant to Gene Rankey. Remote sensing, interpreted seismic, and vibracore data will be integrated into a geocellular project that will provide a regional/field-scale constraint on sedimentologic parameters, ooid bar geometries, and lateral and vertical trends across the platform top. This laterally contiguous 3-D data set will facilitate geometrically consistent correlations of ooid bars across and between canyons within the Brokeoff Mountains.

Ancient Analog in Brokeoff Mountains, NM (Grayburg)—The Grayburg outcrops exposed in the Brokeoff Mountains provide an ideal analog for a number of producing Grayburg fields along the Delaware and Midland basins. In outcrop and in the subsurface, ooid grainstones are especially abundant in Grayburg HFS-2 (Barnaby and Ward 2007). The Brokeoff Mountains outcrops are situated some 15-miles landward of the terminal Grayburg margin, but are coincident with the underlying San Andres platform margin (Figure 1A). A LiDAR-constrained, 3D geocellular model (~1-sq. mile in area) will be built that focuses on the Grayburg HFS-2 ooid-dominated system (Figure 1C). Barnaby and Ward (2007)
describe multiple ooid grainstone units that are laterally continuous along depositional strike and dip for up to 1 km or more. They interpret the Grayburg HFS-2 as a tide-dominated system. Three-dimensional outcrops and well-exposed strata along West Dog Canyon (Figure 1C) will permit detailed bed tracing, stacking pattern analysis, and paleocurrent analysis. Petrographic analysis of rotary plugs will be used to determine porosity and permeability and to classify lithologies into petrophysically distinct rock fabrics for geocellular modeling purposes (Lucia, 1999). Exposures along West Dog Canyon, and Plowman Ridge will provide an extensive 3D data set and facilitate detailed analysis of Grayburg reservoir architecture. Additionally, a number of compound bars will be fine-scanned (cm-scale) using an engineering-grade LiDAR unit, to spatially constrain bar-internal heterogeneities. Long-term and unfunded objectives are to acquire cores and a high-frequency 3D seismic survey along Plowman Ridge (Figure 1D) using the Kansas Geological Survey coring rig and mini-vibe seismic vehicle.

Grayburg Reservoir Model—Occidental Permian, Ltd. requested that the petrophysical models of the reservoir remain confidential. However, they have agreed to release the final facies model. Occidental will provide The University of Kansas a project file that includes well headers, logs, routine and special core measurements, structural interpretation, and seismic attributes. Several thousand feet of Grayburg core will be described using Lucia (1999) methodology. Core descriptions will be imported into the geocellular-modeling package. Correlations (i.e., zonation) will be cycle-based and the layering (i.e., upscaling) scheme will reflect zone-internal porosity/permeability variability. The two data sets described above (Schooner Cays and Brokeoff Mountains) will be used as facies probability models for multi-point geocellular modeling of the Grayburg reservoir. Additionally, the upscaled facies, or rock fabric, logs will be modeled using sequential indicator simulation for comparison to the analog-conditioned model.

Deliverables
Grayburg ooid bar morphologies in the Brokeoff Mountains will be analyzed to ascertain if they represent flow-parallel tidal sand ridges, or flow-normal shoulder or parabolic bars. Additionally, fine-scale (>70-million cells) and simulation scale (>20-million cells) facies probability cubes for Schooner Cays and the Brokeoffs will be available to supporting companies. Considerable effort will be made to preserve stratigraphic architecture by capturing heterogeneities at a scale suitable for simulation studies. The models will contain capillary pressure specific rock fabrics. Porosity and permeability distributions can be assigned to each rock fabric and height-dependent water saturation functions can be added to build a hypothetical, but geologically realistic reservoir model. Project add-ons (e.g., coring and shallow seismic) and detailed porosity modeling could further leverage modeling efforts and provide an ideal training module.

References

Figure 1.—Location and setting of analog study areas. A) Brokeoff Mountains study area in relation to the terminal San Andres and Grayburg margins. B) Location of Schooner Cays, Bahamas along the north end of Exuma Sound. C) Orthophoto illustrating 3D nature of Grayburg outcrops in the Brokeoff Mountains and proposed LiDAR scans. D) Three-dimensional rendition of the Brokeoff Mountains showing relation of proposed cores and shallow high-resolution seismic survey to outcrops along Plowman Ridge.