Sequence Stratigraphy and Quantitative Sea-level History of Miocene Carbonate Systems: Puerto Rico & Dominican Republic

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SUBSURFACE APPLICATION: The Miocene outcrops in Puerto Rico are dominated by heterozoan carbonates and are an analog for Oligocene-Miocene heterozoan reservoirs in the Caribbean, such as the Perla giant gas field (offshore Venuzuela), and Miocene heterozoan reservoirs in the Indo-Pacific. Lessons from the outcrops can be applied to other heterozoan reservoir systems in the ancient.

STATUS: Part of ongoing research program. Final year for this specific project

TIMING: Summer 2015

FUNDING: Funded from various sources

Purpose

Quantitatively constraining sea-level history provides the basis for evaluating and quantifying other variables, such as rates of rises and falls, rates of carbonate production and accumulation, paleotopography, climate and paleoceanography, which can be used to better understand controls on carbonate sequence stratigraphy and model reservoir systems. This study constructs quantitative sea-level histories for Miocene carbonate-dominated systems in Puerto Rico and Dominican Republic and evaluates other controls on sequence development. Regional upwelling affected carbonate deposition in the Caribbean during the Middle-Late Miocene resulting in many of the systems being dominated by heterozoans, such as the studied system in Puerto Rico. Significant reservoirs occur in Miocene heterozoan carbonates in the Caribbean (e.g. Perla giant gas field). Our outcrop studies can aid in understanding controls on the systems and developing predictive models for subsurface reservoirs.

Project Description

Outcrop and subsurface data from the Caribbean (Dominican Republic and Puerto Rico) are currently being evaluated. The Cibao Valley, northern Dominican Republic, contains relatively undeformed Late Miocene-Pliocene carbonate and siliciclastic deposits (McNeill et al., 2008) that are equivalent in time (at least partially) to those exposed in SE Spain. Based on previous work (McNeill et al., 2008; Lutz et al., 2008), there is now a well-constrained chronostratigraphy in Cibao Valley deposits. Carbonate strata on the north and south coasts of Puerto Rico have a similar relatively stable tectonic setting (Meyerhoff et al., 1983; Monroe, 1980) and depositional history. New strontium isotope data (Ortega-Ariza, 2009) from Kuphus incrassatus tubes provide absolute age constraints to these rocks.

Methods of study include measuring stratigraphic sections, physically tracing strata and surfaces, documenting facies, sedimentary structures, and diagenetic features to determine environments of formation, especially those indicative of ancient sea-level positions (pinning points), collecting and assimilating structural data for paleotopographic reconstruction, and sampling of appropriate materials for strontium isotope data to supplement and refine chronostratigraphic data. All data will be integrated construct relative sea-level curve for each of the study areas. Each curve will be compared with the others to evaluate matches in timing and magnitudes of
rises and falls, which in turn, provides quantitative information on global, regional, and local contributions. Quantitatively constraining sea-level history provides the basis for evaluating and quantifying other controls, such as rates of rises and falls, rates of carbonate production and accumulation, paleoformography, climate, and paleoceanographic conditions (e.g., protected versus open marine indicators, heterozoan versus photozoan dominance due to climate or nutrient excess from runoff or upwelling, nature and amount of mixed siliciclastics; see Franseen et al., 1998, and Lipinski, 2009, for examples). The results will have an impact on refining sequence stratigraphy models, and provide quantitative data on various controls in that can be used as parameters in forward and inverse modeling, and petroleum reservoir modeling applications.

Deliverables
Deliverables for the project include maps, stratigraphic sections, cross sections, quantitative pinning point sea-level curves, absolute age data, quantitative data on the various controls for each of the Puerto Rico, Dominican Republic systems being studied.

References

**Figure 1.** A) Composite cross section of depositional sequences, modified from actual cross-section and outcrop sketch of La Molata locality, Las Negras area (Franseen et al., 1995). Numbered pinning point positions are illustrated; their relative elevations reflect differences in relative sea level elevation (Franseen et al., 2008). B) Interpretive relative sea-level curve with pinning points constructed for the depositional sequences from Cabo de Gata, SE Spain. Solid dots and numbers on the relative sea-level curve are the pinning points, known positions of relative sea level identified from outcrops and depicted on the cross section in A (Franseen et al., 2008).
Figure 2. Puerto Rico and Dominican Republic study areas. A and B) Location of North and South Tertiary sedimentary basins and general geology of Puerto Rico (modified from Meyerhoff and others, 1983 in Renken et al., 2002). C) Example photomosaic and interpretation of excellent quarry exposure of Ponce Limestone on southern coast of Puerto Rico. D) Location map for the Cibao Valley, northern Dominican Republic with generalized geology and major features (Ericson et al., 1998). E) Sea-level curves and age ranges of Cibao Basin Miocene-Pliocene strata based on magnetostratigraphy (McNeill et al., 2008). F) Rio Cana (red star on A) and Rio Gurabo (red circle on A) stratigraphic sections (Ericson et al., 1998). These rivers dissect the southern flank of the Cibao basin providing excellent exposures of the target units.