Sequence Stratigraphy and Quantitative Sea-level History of Miocene-Pliocene Carbonate Systems: A Global Perspective Based on Outcrop and Subsurface Data

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STATUS: Project at middle stage
TIMING: Four years
FUNDING: Seeking sponsors

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. The purpose of this study is to use the pinning point method to construct quantitative sea-level histories for Miocene-Pliocene carbonate-dominated systems in the Caribbean and Indo-Pacific to provide an objective and rock-based quantitative evaluation of magnitude, scale, and timing of sea-level fluctuations.

Project Description
Current evaluation of the eustatic control on carbonate systems largely relies on proxy curves, some of which do not separate data from interpretations or include high-frequency oscillations that may occur. The pinning point method (Goldstein & Franseen, 1995), developed in Miocene carbonates of southeastern Spain, is a rock-based approach for identifying ancient positions of sea level and construction of relative sea-level curves. An important element of the pinning point method is that it is scale-independent, distinguishes data from interpretations, and reflects confidence level of data, which, in turn, provides an objective and testable methodology for comparison to other areas.

Outcrop and subsurface data from the Caribbean (Dominican Republic and Puerto Rico) and selected areas in the Indo-Pacific 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 that is comparable to that developed in SE Spain. 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 to identify pinning points, and reconstruct pinning-point 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, paleotopography, 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 and Indo-Pacific systems being studied. Deliverables also include updated methodologies for reconstructing paleotopography, and constructing pinning point sea-level curves for application to outcrops and subsurface data throughout the geologic record.

**References**


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**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.