Roles of upwelling and restriction on the distribution and character of sediment on a low energy, Holocene carbonate ramp: Yucatan Peninsula, Mexico

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SUBSURFACE APPLICATION: Provide modern analogs for processes and dynamics of muddy organic matter-rich carbonate ramps.
STATUS: Multi-year project nearing completion
TIMING: Final results to be reported at KICC 2016
FUNDING: Full, including KICC, GSA, SEPM, AAPG

Purposes
Whereas isolated platforms and grain-dominated carbonate accumulations have been extensively studied (e.g., as in the Bahamas), Holocene mud-dominated, carbonate systems are not as well-understood. Yet, many ancient successions contain fine-grained carbonates deposited on low-energy ramp settings. To better understand the sedimentologic variability and accumulations of low-energy ramp systems, this project tests the hypothesis that sediment size, sorting and type and organic matter type and abundance varies among geomorphic elements on the Holocene ramp system on the western Yucatan shelf. Understanding how sediment and organic matter type and abundance vary in ramp carbonates is important for constructing actualistic depositional models for depositional heterogeneity within their ancient analogs, which can include prolific reservoirs. Beyond being one of the few extant carbonate ramps, components of this system may be a modern analogue for beach ridge coquina reservoirs of offshore Brazil (Carvalho et al., 2000; Jahnert et al., 2012), the lower Triassic of western Canada (Davies et al., 1997), the Cretaceous of Texas (Kerans and Loucks, 2000), and for fine-grained, nutrient-rich carbonate plays deposited in nearshore settings such as the Mississippi Lime and heterozoan carbonates (Westphal et al., 2011).

Project Description
The Yucatan shelf (Figure 1) represents the submerged part of the broad, generally northward plunging Yucatan Peninsula. The exposed part of the Peninsula includes a broad karst plain developed on Pleistocene and older carbonate strata; siliciclastics are absent across the area.

The focus for this soon-to-be-completed project has been on mapping and describing shoreface, lagoonal, and nearshore geomorphology and surface sediments, including grain size, type, and sorting, and the abundance and type of organic matter. The Yucatan shelf offers an opportunity to study a modern carbonate ramp with upwelling, and provide insight into the processes and potential heterogeneity in subsurface analogs deposited on ramp settings. The focus area on the Yucatan Peninsula has an abundance of fine-grained, organic-rich sediment, due to its occurrence on the lee of the peninsula, and the resultant lower energy conditions. The coquina beach ridges, which make up the barrier spits, prograde southward in a repetitive and predictable pattern, interpreted to result from northern winter cold fronts. The spits act as barriers to the offshore wave energy, creating...
a lower-energy, mud-rich lagoon with higher organic matter content (up to ~15% TOC) (Figure 1C, D), and a distinct molluscan assemblage. The effects of the upwelling in the area are interpreted to control the abundance of biosiliceous sediment (sponge spicules, diatoms; Figure 2) and the dominance of heterozoan carbonate producers.

This project focuses on several specific objectives: 1) Map the region using QuickBird remote sensing data, to provide a spatial context for all sampling; 2) Sediment characterization in each geomorphic environment to capture the range of variability by examining grain size, sorting and type, and characterize organic matter type and abundance through TOC measurement and gas chromatography and mass spectrometry analysis.

Deliverables
This project is part of a multi-year program (see Neal et al., this prospectus) to re-examine a classic ramp system that has not been systematically explored in more than 40 years. This phase (with final results presented in 2016) focuses on understanding the sedimentologic and geomorphic characteristics and processes in nearshore environments. The project will generate data and insights for conceptual models for heterogeneity in muddy carbonate ramp analogs.

References
Figure 1. A) Location of study area on the Yucatan peninsula. B) Isla Arena in comparison with larger scale beach ridges just north of Celestun. C) Percentage of mud (~63 μm) in part of the area. Note abundance of mud in the lagoon. D) Total organic carbon (TOC). Values are higher in the lagoon, with highest values (~15%) near the mangrove fringe.

Figure 2. SEM image from mud fraction of sediment. Note the ubiquitous biosiliceous particles (diatoms, sponge spicules) in addition to the nondescript carbonate particles.