Sedimentology and Diagenesis of the Miocene-Pliocene Mona Reef Complex

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SUBSURFACE APPLICATIONS: Dolomitized and karstified carbonate reservoir in isolated platforms. Such as Malapaya field, Philippines; Luconia province, Malaysia; Banyu Urip Field, Indonesia

STATUS: Long-term project in progress

TIMING: Significant results to be reported – early results currently available to membership

FUNDING: None

Purpose
Isla de Mona (Figure 1) and Isla Monito are uplifted and faulted carbonate plateaus that expose sections of the only known Miocene-Pliocene reef complex in the Caribbean. The excellent 3D exposures on these two islands allow for detailed facies mapping and sampling of this unique reef complex. The upper units of the reef complex have been extensively karstified (Figure 2) and the lowermost units densely dolomitized (Figure 3). Dolomitization and karstification are early and appear to be controlled by sea-level oscillations (Gonzalez et al., 1997).

This study focuses on the generation of detailed facies maps of the reef complex, structure, and strontium isotope “dating” of exposure surfaces, limestone units, and dolomitized units. The goals are to produce a model of reef development linked to glacio-eustatic (global) or tectono-eustatic (local) oscillations. The model will serve as the foundation for diagenetic studies delineating mega-porosity (caves), macro- and micro-porosity distribution and evolution and dolomitization.

Project Description
The Isla de Mona plateau is composed of two Neogene lithostratigraphic units originally defined and named by Kaye (1959) and later redefined by Briggs and Seiders (1972) to the current units Lirio Limestone (Figure 2) and Isla de Mona Dolomite (Figure 3). Whereas Caribbean coral reef diversity and abundance increases in the late Miocene, no major shelf edge (i.e., barrier) system had been recognized prior to the 1990’s. The Mona Reef Complex in Isla de Mona is the first discovered and described Miocene-Pliocene (10 to 4 Ma) barrier reef complex in the Caribbean (Gonzalez et al., 1997). It is during the Miocene to Pliocene that the gradual (step-wise) closure of the Central American Seaway (CAS) occurred, and coupled with sea-level oscillations, controlled oceanic circulation from the Pacific to the Atlantic oceans (Burton et al., 1997). Furthermore, during the Miocene to Pliocene, this region was undergoing collision with the Bahamas platform resulting in clockwise rotation of Puerto Rico and the opening of the Mona Passage (Dolan et al., 1998). Thus, the Mona reef complex affords us a unique opportunity to gain understanding on the relative roles of global (glacio-eustatic), regional (closure of the CAS), and local (faulting) controls on reef development.
The reef complex exposed on Isla de Mona and Isla Monito bear many similarities in terms of facies and stratigraphic geometries to subsurface reef reservoir systems reported from the Philippines, Malaysia, Australia and Indonesia (Wilson and Bosence, 1997; Kusumastuti et al., 2002; Neuhaus et al., 2004; Vahrenkamp et al., 2004; Ehrenberg et al., 2006) (Figure 1).

Recent observations by our research team reveal that the Mona Reef Complex had two distinct phases of growth (Figure 4). A Miocene (Stage I) phase is characterized by a Stylolhorea reef framework, and is terminated by major exposure and development of an erosional surface (Stage II) in the late Miocene. Growth resumed in the Pliocene (Stage III) with a reef core dominated by Acropora cervicornis and Caulastrea portoricicensis. Laboratory work ($^{87}$Sr/$^{86}$Sr determinations, petrography) will help produce more accurate timing (ages) of deposition, faulting, calcitization, and dolomitization. As the reef complex has not been deeply buried, nor are there volcanic activity at this late stage of the arc, dolomitization must have been effected by marine or mixed freshwater - marine fluids.

Deliverables
• Conceptual model for evolution of barrier reef in a post-volcanic phase island arc collisional system.
• Predictive model for early karstification and dolomitization, porosity evolution and distribution.
• Rate estimate and rate law for massive dolomitization

References


**Figure 1.** (left) View of Isla de Mona from approximately 20,000 ft. North side of island is toward bottom of picture. (right, upper) A Subsurface Middle Miocene carbonate platform at Luconia Province, offshore Sarawak, Malaysia. This Miocene Platform is located in a regional fault-bounded structural high, first aggraded and then backstepped during a series of third-order sea-level fluctuations (Vahrenkamp et al., 2004). (right, lower) Bathymetry of the Mona Passage: Modified from UGS: New Bathymetric Map of Mona Passage, Northeastern Caribbean. Aids in Earthquake-and Tsunami-Hazard Mitigation (http://soundwaves.usgs.gov/2007/05/).
Figure 2. Karstified reef facies of the Isla de Mona Reef Complex (Lirio Limestone) along the cliffs on the southern side of the island.

Figure 3. Back reef to lagoon dolomitized facies (Isla de Mona Dolomite) exposed on cliffs of the southeastern tip of Isla de Mona (Pta. Este).
Figure 4. The evolution of the reef complex is divided in three stages that are attributed to episodes of relative fluctuations in sea level. The first stage comprises the deposition of a Miocene reef complex (Unit I) that is characterized by a Stylophora reef framework. The second stage represents a period of subaerial exposure that is associated with local tectonism. The third stage encompasses the deposition of the Pliocene reef complex (Unit II) that is characterized by an Acropora cervicornis and Caulastrea portoricensis reef framework. The platform was uplifted during the Late Pliocene to Early Pleistocene followed by the deposition of Pleistocene reef terraces.