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Eastern Gulf of Panama Exploration Potential

Introduction

Eastern Panamá is an example of an area largely condemned by explorationists based on a few wells drilled in a large, complex geologic province. When re-evaluated with a new play concept, however, the eastern Gulf of Panamá looks attractive. Exploration from 1919 to 1990 established the presence of surface oil seeps and potential source rocks. Several wells drilled on structural closures reported oil shows. However, good quality clastic reservoirs were not encountered, due to the volcanic nature of the terrains that were the provenance of the clastics. Re-interpretation of old seismic and well data from the Garachiné study area in the eastern Gulf indicates that there are potential reservoirs in what are interpreted to be carbonate banks and reefs of Mid Miocene age, never tested with the drill.

The Gulf of Panamá covers an area of about 25,000 km^2 on the Pacific side of the Isthmus of Panamá (Figure 1). The eastern Gulf and adjoining mainland are geologically distinct from the western part of the Gulf. The eastern Gulf contains a thick Cretaceous to Recent sedimentary section. The Miocene to Oligocene is the most prospective part of this section, but it is missing in the western Gulf, where Pliocene sediments rest directly on Eocene or older rocks.

Exploration History

The locations of significant wells drilled in eastern Panamá are shown in Figure 1. Sinclair and Gulf Oil acquired exploration concessions onshore eastern Panamá during the 1920's. One Sinclair well found gas shows and oil stains in a 110-foot Miocene sand. Gulf Oil drilled three shallow wells in the Sambu River valley, attracted by oil seeps in the lowlands near Punta Garachiné. Non-commercial oil and gas shows were found in two wells. The Garachiné-2 well still seeps oil today at about half a barrel a day. Onshore exploration continued intermittently by various local and international companies up until the early 1970's with several additional wells being drilled, but none with commercial success.

Interest shifted to the offshore in 1969 and continued until 1990. Companies including Mobil, Esso, Oceanic, Santa Fe, El Paso, Oxoco, and Idria Oil & Gas conducted exploration. Five offshore wells were drilled, all targeting anticlinal structures with clastic reservoirs as primary objectives. None found commercial hydrocarbons or adequate sandstone reservoirs. The wells encountered a section dominated by fine grained clastic rocks with minor limestones. Sandstones, where present, are mostly thin, with low porosity and permeability.

Geologic Development of the Eastern Gulf of Panamá

The sinuous shape of the Isthmus results from tectonic plate interactions since Oligocene time. NW-SE convergence between the South American Plate and eastern Panamá displaced the Isthmus northwestward relative to the original arc axis. This was accompanied by strike-slip faulting and transpressional folding with as much as 200 km of offset. The structural deformation of the Isthmus created an offshore deformed belt with greatest uplift in the Pearl Islands (Figure 2). The deformed belt has been structurally active since Mid Miocene time and divides the eastern Gulf into the Plaris and Sambu Basins.

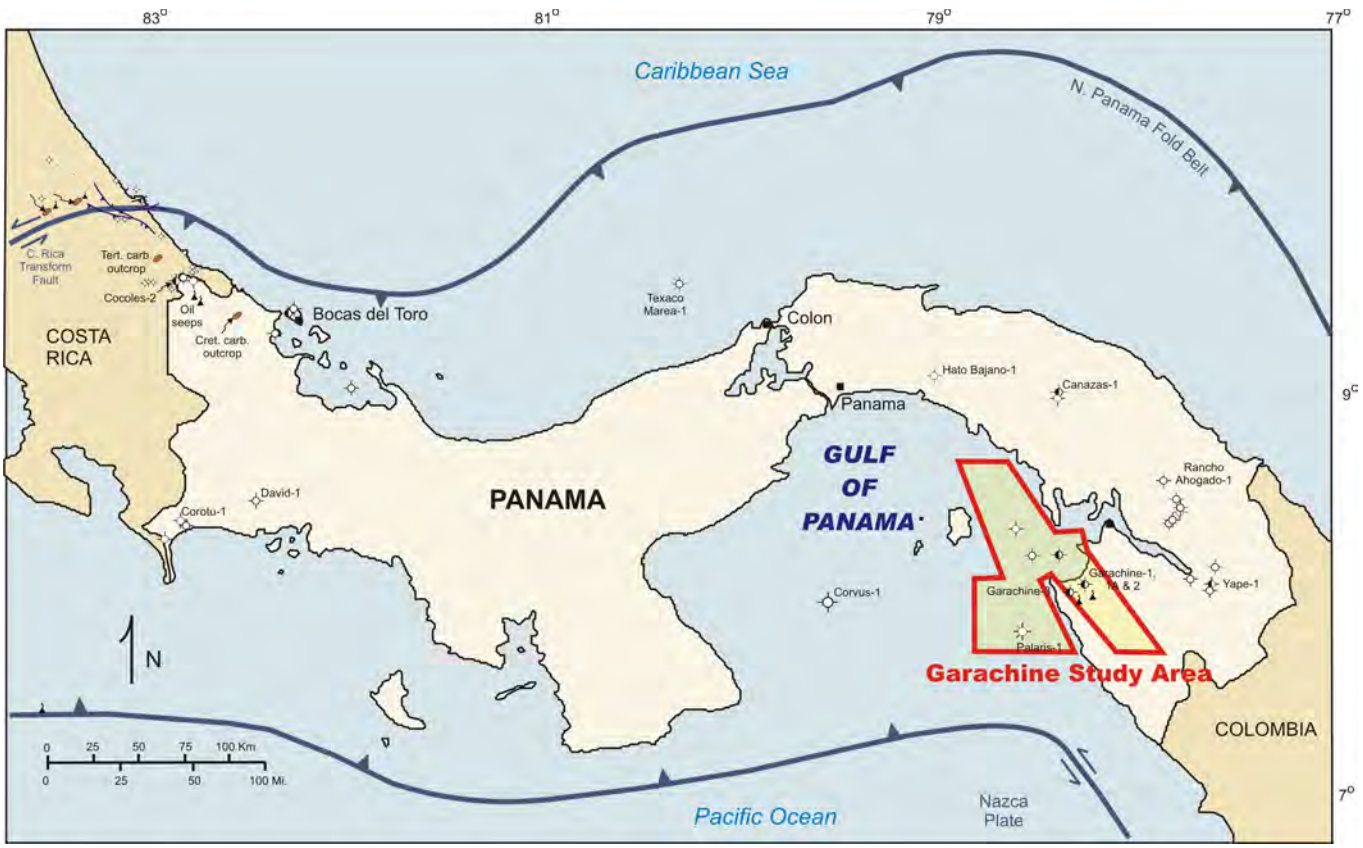

Figure 1. Location map of Panamá, the Garachiné study area shown in red

The Plaris Basin is in the southern part of the study area. It has as much as 3 seconds TWT (~12,000 ft) of sedimentary fill ranging from Eocene (?) to Recent, based on seismic ties to the Plaris-1 well. The basin was subjected to structural deformation beginning in late Mid Miocene time and continuing until the Pliocene.

The onshore Sambu Basin and its offshore extension developed as a pull-apart basin in the Miocene due to northwest striking, left lateral strike-slip displacement along the Sambu Fault Zone. Secondary faulting with an extensional component was prominent in the southern part of the basin, leading to as much as 3.8 seconds TWT (~18,000 ft) of sedimentary fill. This is still the deepest part of the basin.

Eastern Panamá Stratigraphy

Up to 20,000 ft of sedimentary section ranging in age from Eocene to Recent overlies Cretaceous basement in the deep onshore basins of the Darien Province of eastern Panamá. Several thousand feet of Eocene interbedded volcanic and sedimentary rocks overlie the Cretaceous. This is followed by more than 13,000 feet of organic shale, clastic sediments, and carbonates of Oligocene to Pliocene age. Volcaniclastic sediments and ash-flow tuffs occur throughout the section. Tertiary strata are involved in complex stratigraphic relationships involving facies changes, offlaps, onlaps, and unconformities. Much of the section was deposited in deep water. Stratigraphic nomenclature used in this report is shown in Figure 3. Clastic reservoirs in the Oligocene and younger section were the main objectives for petroleum exploration in the past. However, carbonate reservoirs may also be present which were essentially ignored previously.

Potential Miocene Carbonate Stratigraphic Traps & Reservoirs

Thin limestone beds are common throughout the Tertiary section. Eocene limestones containing reefal material are

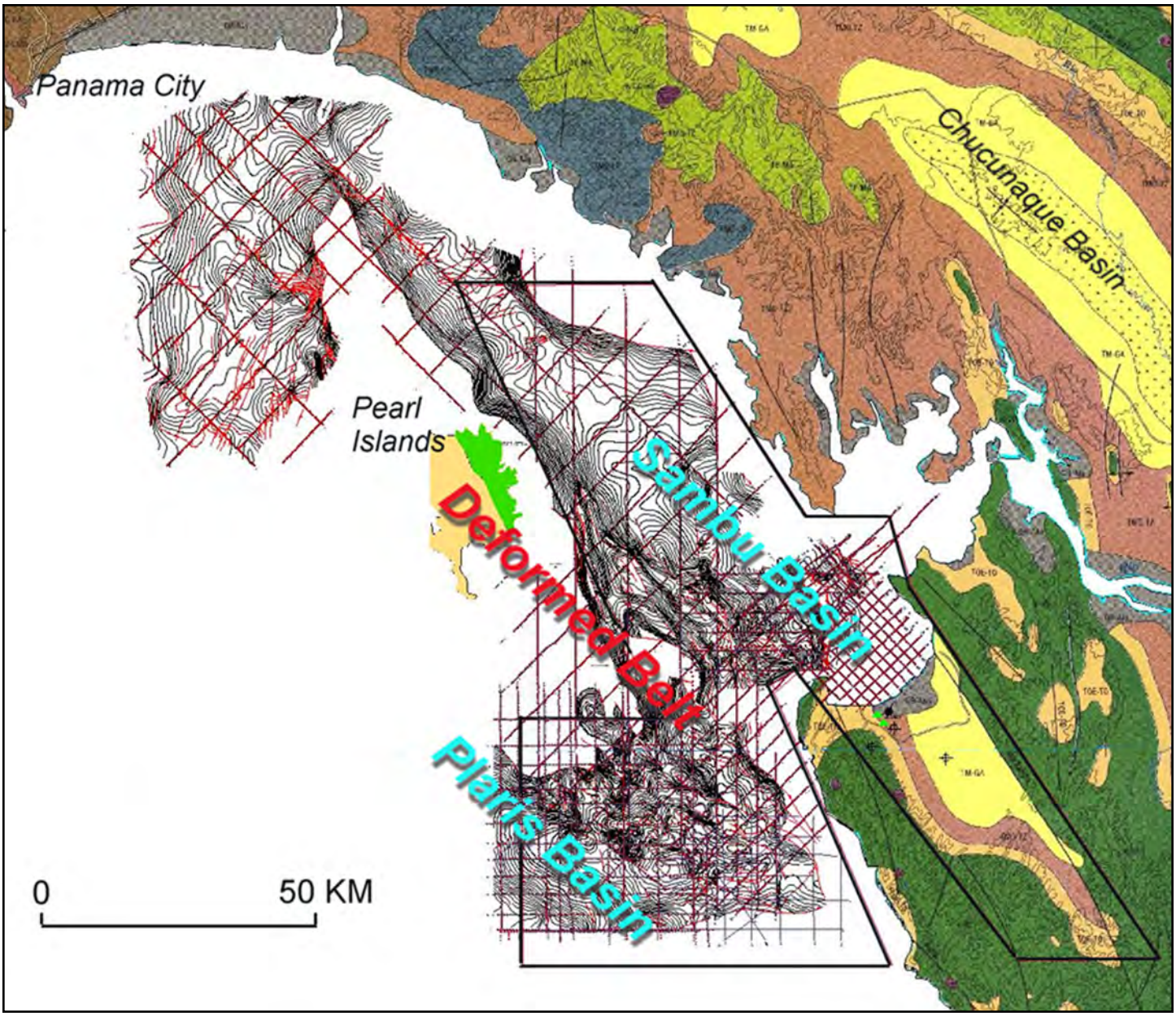

Figure 2. Base Mid Miocene time structure map superimposed on the geologic map of Panamá.

described from outcrops north of Panamá City and from the Azuero Peninsula. The Lower to Mid Miocene Clarita Limestone has been widely recognized in outcrops in the onshore basin northeast of the Garachiné area. Coral-reef facies of age-equivalent rocks (Emperador Limestone) are known from the Canal Zone. The offshore Bayano-1 well encountered 55 ft of Mid Miocene limestone described by Robertson Research as reefal carbonate, probably "deposited in a shallow, normal marine environment, possibly close to deeper water or slope environments. The limestone…has faunal elements which would possibly have developed patch reefs or been developed at the margins of a larger reef structure." The neutron density log shows porosities up to 30% in this section.

Re-interpretation of offshore seismic data indicates a probable Miocene shallow water carbonate platform, reefal buildups, and associated basinal facies (Figure 4). The best example of a potential pinnacle reef buildup is in the Plaris Basin (Figure 5). A high amplitude reflector outlines the mound-shaped feature. Its internal character is chaotic, but a fairly strong reflection occurs at the base. Ties with the Plaris-1 well indicate it to be Mid Miocene in

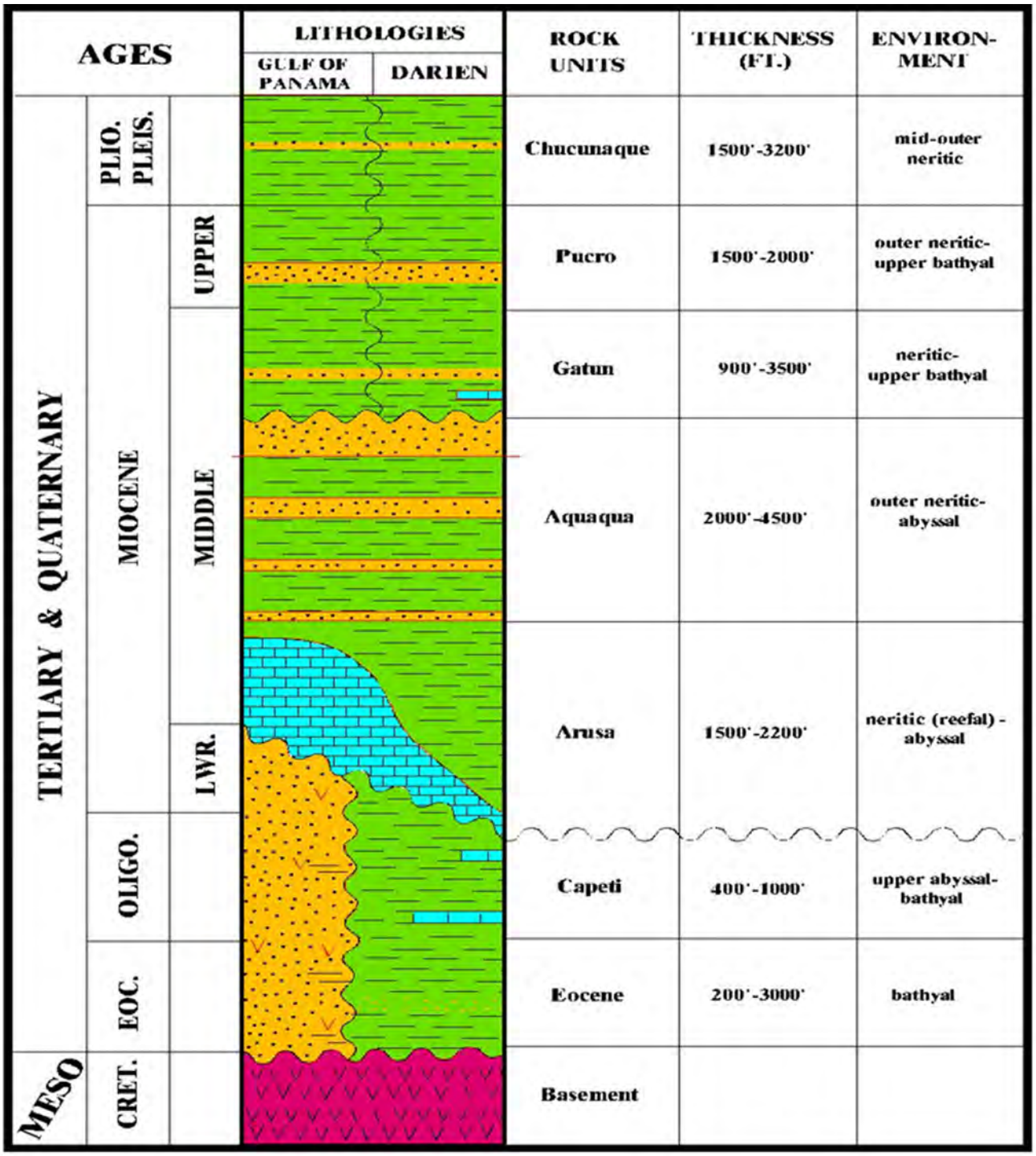

Figure 3. Generalized stratigraphic column for the eastern Gulf of Panamá.

age. Onlapping layers thin toward the mound, suggesting it was a paleohigh. A broad area of high amplitude reflectors surrounds the mound at its base, suggesting the presence of reef talus deposits. Ship-borne gravity and magnetic data give no indication that the anomaly may be related to submarine volcanism.

Other potential reefal anomalies are recognized in two parts of the offshore Sambu Basin at the same stratigraphic

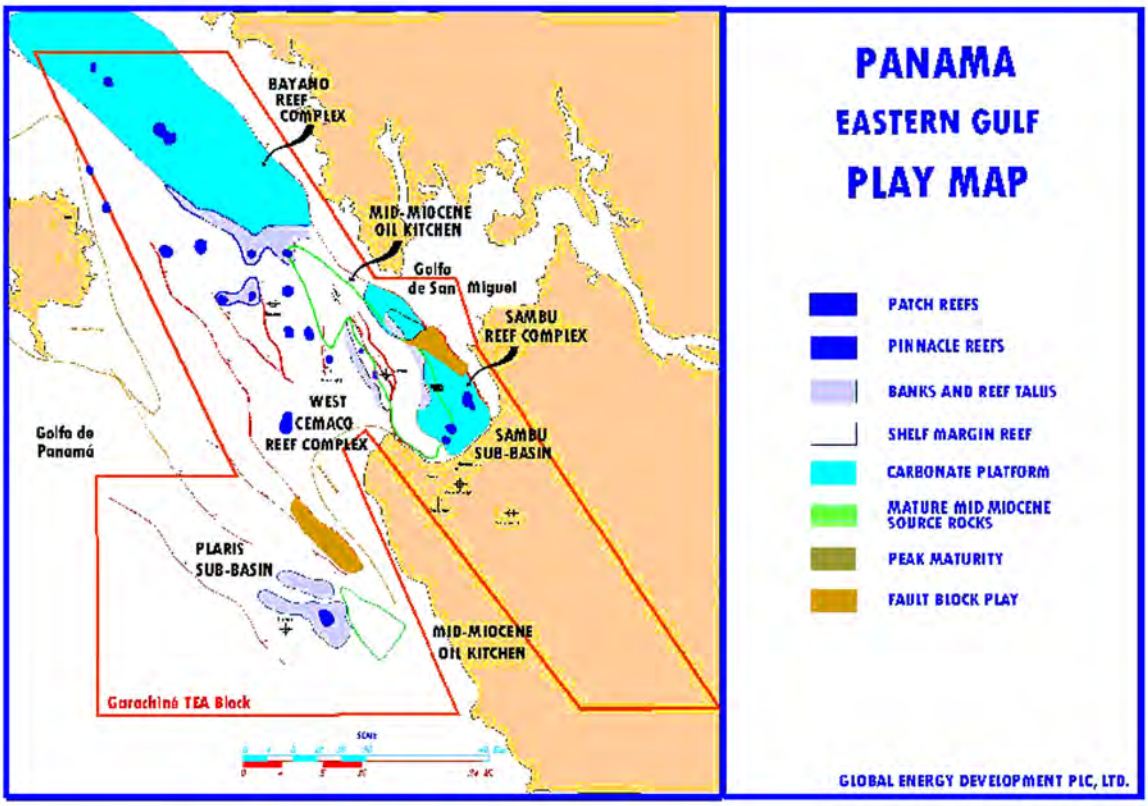

Figure 4. Play map of the eastern Gulf of Panamá showing the interpreted Miocene carbonate shelf with local buildups on its margin, and pinnacle reefs extending into the basin.

horizon (Figs. 6 & 7). These features appear to occur in distinctive facies belts: deep-water pinnacle reefs, shelf-edge banks, and shallow water patch reefs similar to carbonate assemblages in Southeast Asia. Four-way dip closures on the carbonate buildups are generally small (2-4 km^2) in area. Vertical relief ranges from 250 to 800 ft. Most of these features are large enough to potentially hold individual reserves of 20-40 MMBO. However, the four best leads are large enough to hold substantially larger reserves.

Structural Traps and Potential Clastic and Fractured Reservoirs

Purely structural leads with clastic reservoir objectives are considered secondary targets because of the historical lack of success of such wells in the region, but they cannot be completely discounted. In the Yape-1 well, onshore in the Chucunaque Basin, Miocene-age Aquaqua sands flowed 1,500 barrels of water a day on tests. Sands of this quality were not found in offshore wells, but not all of the wells penetrated this section. Only one of the offshore wells (Plaris-1) drilled through the Mid Miocene and into dated Lower Miocene section. At this distal location, the sand content is low. Exploration targets in the Sambu Basin, closer to former land areas, may have a better chance of encountering thick sands, perhaps in turbidite fans in former basin lows. There are numerous undrilled structures. There are also possible fractured carbonate reservoirs in faulted structures in the northern Plaris and Sambu Basins.

Source Rocks & Maturation

The best recognized potential source beds in the eastern Gulf of Panamá are in the Miocene. Oil seeps near Punta Garachiné (Figure 8) lie in a NW-SE trend and appear to come from the Mid Miocene Gatún Formation. It is 17.6º API gravity and biodegraded. Based on isotope ratios, the source was probably marine-derived organic matter, possibly

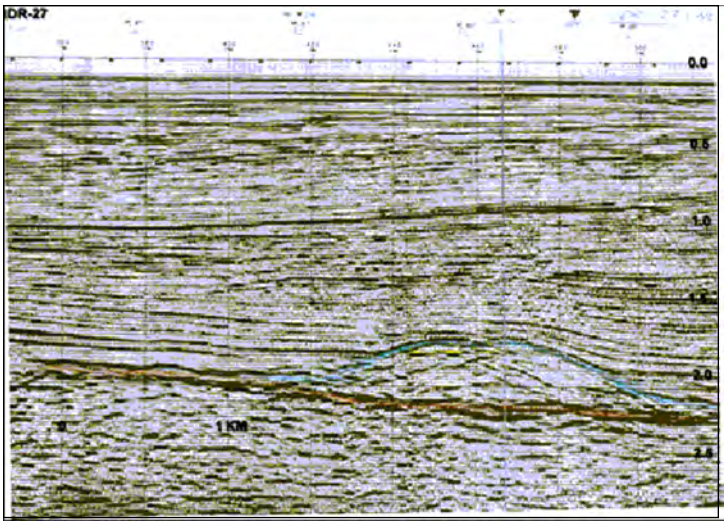

Figure 5. Part of N-S seismic line IDR-27 through an interpreted pinnacle reef in the Plaris Basin. Note a strong reflector underneath the feature, possible talus, onlap, compaction drape and downlap of overlying horizons.

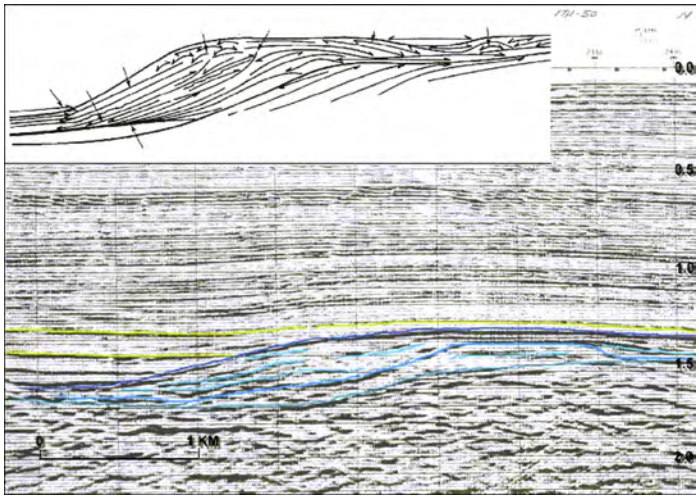

Figure 6. Part of N-S seismic line ITH-50 through interpreted rimmed carbonate shelf edge of the Bayano carbonate complex. The inset shows an idealized representation of common large-scale stratal patterns across carbonate platforms.

lime mud of a back-reef, shallow lagoon. The source beds are moderately mature to mature.

In the offshore Plaris-1 well the Mid Miocene section is relatively immature, but has fair gas to very good oil source character. Some of the shales contain up to 5.9% TOC, and are composed dominantly of amorphous-type kerogen with secondary herbaceous material. In the offshore Cemaco-1 well, source rock quality is good over a 3,000 ft Miocene section, due to a combination of thin bituminous shales with gas potential and thick mudstones with oil potential. The upper part of the well encountered live oil shows. They appear to have originated from a thermally mature source, near the peak of oil generation. Oil from near the bottom of the well appears to have been sourced by *in situ*

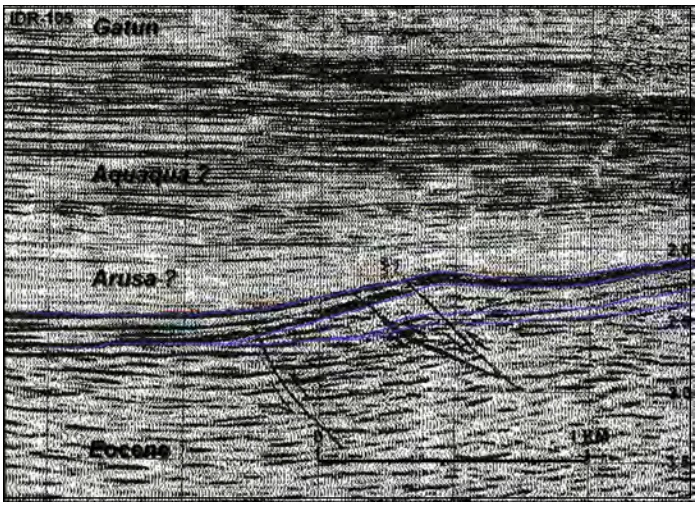

Figure 7. Interpreted rimmed carbonate shelf margin in the Sambu Bay area on Line IDR-105.

Figure 8. Oil seep at the Garachiné-2 well location, drilled in 1926 in the onshore Sambu basin.

Mid Miocene mudstones, which are at an early-generation thermal stage (Ro = 0.4-0.5%, spore color 5.0-6.0). TOC values in the lower part of the well are in excess of 2%. Kerogen type is sapropelic in the mudstones, with hydrogen indices in places above 200, indicating good oil source potential for the overall section.

Results from maturation modeling of wells and the potential "kitchen" areas for the Miocene and older section indicate that more than enough hydrocarbons were probably generated and expelled to charge the potential traps identified in the region. There is no direct evidence of source potential in the pre-Miocene section in the eastern Gulf, but regionally, organic-rich rocks of Cretaceous and Oligocene age are recognized.

Logistics and Market Considerations

This is mainly an offshore play. Water depths range up to about 300 ft, but are generally less than 150 ft. The region is sheltered from large storms off the Pacific or Caribbean. The entry for the Panamá Canal lies at the north-central edge of the Gulf. The logical market for any oil that might be produced in the Gulf of Panamá is the U.S. Gulf Coast, with transport through the Canal or through the Trans-Panamá pipeline. Any gas produced would probably find ready consumers in the growing Central American electricity-generation market.

Acknowledgements

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