Prospectivity of the Pacific and Caribbean Basins of Nicaragua.

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ABSTRACT

The Sandino Basin is a fore-arc basin which was developed over the subduction zone where the oceanic Cocos Tectonic Plate moves eastward and beneath the southwestern edge of the Continental Caribbean Plate. Geologically, Nicaragua rests on the southern part of the Chortis block, which originated at the western edge of the North American Plate prior to the Cenozoic. Subsequently, during the early Tertiary, it was jointed with the Caribbean Plate along a major strike-slip fault. Sandino Basin structure was established throughout the Cretaceous, spreading over some 30,000 square kilometers, 5,000 of which are onshore. Up to 10,000 meters of sediment have accumulated in its depocenter. The 3D seismic data was acquired in by Polarcus Asima in 2018 to confirme the prospective potential of Mango structure. There are several plays identified within the Sandino Basin spanning most of the age intervals. The most attractive play is the Oligo-Miocene carbonate play which carries the lowest exploration risk. This play was the focus of most exploration activity during the Equinor-ENIH partnership. A future exploration well within this play has the potential to de-risk several prospects and also elements of the other plays by proving a working petroleum system. The Eocene aged source rock interval is regarded as common to all plays with the ability to charge the different identified potential reservoir intervals. This provides a common dependency shared by all of the plays. Geochemical evidence from the Corvina-2 well confirms the presence of source rock potential in the basin and its distribution throughout the basin is extrapolated by seismic mapping. It is noted however that lack of other well penetrations in the offshore domain leaves uncertainty in the lateral distribution of source rock richness. Basin modelling indicates that the proven and probable source rock intervals within the Eocene section are mature over large parts of the basin depression, however there is wide variation from early- to over-maturity depending on the local conditions (i.e., burial depth).

The Miskito Basin is a pull apart basin, located in eastern Nicaragua. The Caribbean Margin of Nicaragua comprises a continental platform of 45,000 sq. Km with water depths averages less than 30 meters. The total area of this margin is more than 170,000 sq. Km.

Offshore Nicaragua in the Miskito Basin offers a frontier exploration area. Noble Energy, Inc. and partners conducted exploration studies from 2D seismic to 3D seismic to drilling from 2009-2013. A potential carbonate target was first identified on 2D seismic data. Once identified, extensive effort went into characterizing the carbonate as a drilling target and understanding both the petroleum system and reservoir potential utilizing 3D seismic. Seismic facies, gravity modeling, and acoustic properties were tied together with depositional models for two working hypotheses of reservoir conditions, depending on the age of sediments encountered. The two depositional models considered were a framework carbonate buildup and a carbonate shoal, with the shoal model favored based on the anticipated age of the buildup. Paraiso Sur #1 was drilled to test the carbonate build-up in late 2013. This was the first well in the offshore Caribbean of Nicaragua drilled in 30 years. Drilling results were very close to the prognosis for the reservoir in terms of depth (within 1%), thickness (>500m), porosity (average 19%), age (Eocene), and depositional environment (a carbonate shoal was encountered). Despite the excellent match of reservoir and depth structure to the prognosis, only residual oil was encountered. The primary failure mechanism appears to have been either migration or seal.
The Paraiso prospect is located offshore eastern Nicaragua, within the Caribbean Sea. Present day Nicaragua is an agglomeration of the Chortis and Siuna blocks and a triangular shaped region of attenuated continental crust known as the Nicaragua Rise. It is bounded by the Hess Escarpment to the south, Cayman Trough to the north and the Middle America Trench/Cocos Plate to the west.

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Outstanding Exploration Studies

Pacific Offshore (Sandino Basin):

Equinor Nicaragua B.V., acquired 2D, 2.5D and 3D seismic data between 2015 and 2018. Based on the seismic interpretation results ten key regional horizons have been identified and which can be mapped throughout the basin. Those regional horizons were a key input to the regional velocity model and the basin model. Horizons were tied as best as possible to the biostratigraphic control from the Corvina-2 well, although there is some uncertainty about the precise dating due to lack of abundant and confident data. See Figure 1.

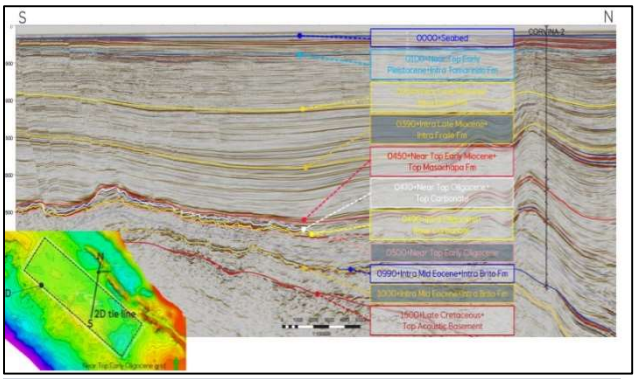

Figure 1: Well to seismic tie of the Corivina-2 well. The well is tied using a time-to-

The horizons were picked on prominent seismic reflector events whose characteristics change basin-wide. There is therefore increasing uncertainty with the horizon tie related to distance from the well control point, however Equinor assigned relatively good confidence to all horizons within the data uncertainty. Corvina-2 well drilled in 1974, gave evidences of an over pressured environment.

Plays and Prospects

There are several plays identified within the Sandino Basin spanning most of the age intervals.

The most attractive plays are:

- **Oligo-Miocene Carbonate Play**: Mango Prospect, Jocote Prospect, Café Prospect and Additional Oligo-Miocene Carbonate Leads.
- **Eocene Siliciclastic Play:** Papaya Clastic Prospect
- **Eocene Carbonate Play:** Eocene Carbonate Lead (Mango Eocene Lead), Papaya Carbonate Lead, Naranja Lead, Lemon Lead and Corinto High Lead. See Figure 2 and 3.

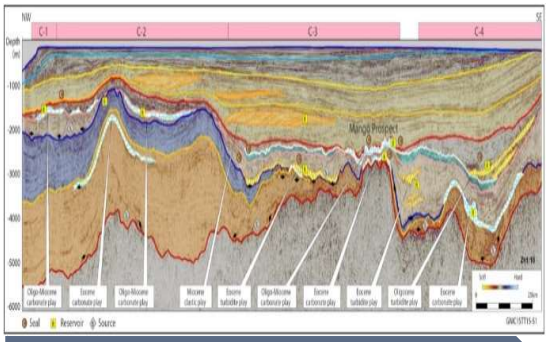

Figure 2: Play section. The section illustrates the main plays of the Sandino Basin. The significant structural complexity means that there are discreet areas in which some plays will be more prevalent.

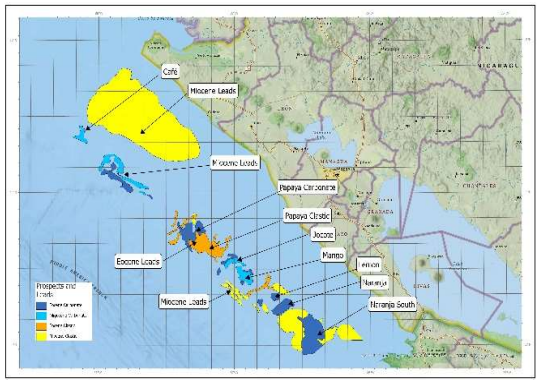

Figure 3: Prospects Map. The map illustrates the main prospects identified in different horizon of the Sandino Basin.

Caribbean Offshore (Miskito Basin)

Noble Energy Nicaragua Ltd. and their partners conducted exploration studies from 2D seismic to 3D seismic to drilling the first exploration well from 2009 to 2013. A potential carbonate target was first identified on 2D seismic data. Once identified, extensive effort went into characterizing the carbonate as a drilling target and understanding both the petroleum system and reservoir potential utilizing 3D seismic data. (Figure 5).

Historic wells were drilled based on structures identified utilizing 2D seismic data, and all the structures appear to be within an attached carbonate shelf environment. Many historic wells had hydrocarbon shows and some had limited production while running flow tests.

Reported oil gravity ranged from 21-28° API. However, no commercial hydrocarbon accumulations were encountered.

The 3D seismic data allowed to identify a carbonate build-up named Paraiso prospect and Noble decided to drill Paraiso Sur #1 well to test the carbonate build-up in late 2013.

Paraiso South #1 (PS-1) was the first well drilled offshore eastern Nicaragua since 1978, the first deepwater well (water depth 370m, 1214ft), and the first well in the area drilled utilizing 3D seismic data. The Paraiso reservoir was predicted to be an isolated carbonate buildup consisting of approximately 539m of Paleocene-Eocene carbonates deposited on a paleo-high of eroded Cretaceous volcanics. See Figure 4 and 5.

The Paraiso carbonate buildup is approximately 8 km wide and 35 km long and trends NNE with the windward side to the east and the leeward side to the west (Figure 5). Paraiso is generally triangular in cross section being widest at its base and narrowing upward. The buildup is subdivided into a deeper Stage 1 and a shallower Stage 2 separated by an unconformity.

The seal was predicted to be a mix of shale and marl of lower mid-Eocene age (Punta Gorda formation) with a thickness that could range from a few 10s of meters to a couple hundred meters. Faulting across the top of the feature is consistent with differential compaction, and stress analysis suggested that the faults should be closed present day.

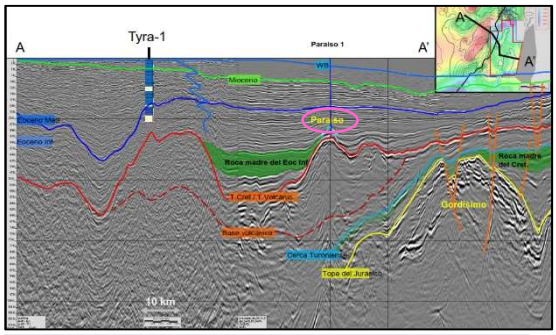

Figure 4: Seismic section illustrating the relationship between the predicted Paleocene to early Eocene Paraiso reservoir, early Eocene source rock, early to middle Eocene seal and migration pathway. Gordisimo is a large untested anticline lead.

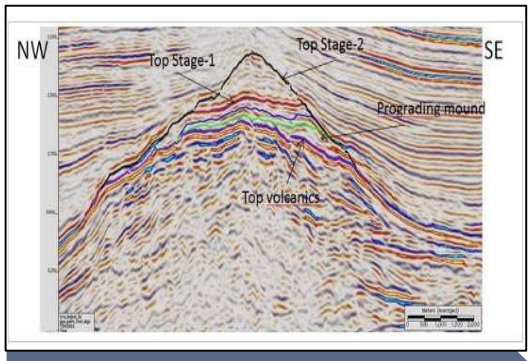

Figure 5: Prograding Mound and Erosion at Paraiso Structure.

PS-1 Drilling results and post-well analyses

Source: The trace of hydrocarbons in the reservoir were generated from a proximal, Eocene marine carbonate deposited in an anoxic environment. The seal interval penetrated at the well had little to no hydrocarbon source potential. However, away from the Paraiso

Reservoir: Approximately 553 m of carbonate reservoir was encountered in PS1, in descending order include Stage 2 (265 m), Stage1 (271 m), and Stage1 to TD (17m).

Stage 2 consist of Late to Middle Eocene age and Paleocene carbonates and is interpreted to be a stable carbonate platform, possibly deposited in more open marine conditions (based on planktonic forams, because nannos are just about barren in the reservoir section).

The reservoir is unconformably overlain by a seal of Oligocene (Chattian) age muddy carbonate with some siliciclastic deposits in a middle Bathyal setting. The Oligocene (Rupelian) section is missing, representing about 5.8 million years of missing section, and occurs at a major seismic event. The seal interval is predicted to have increasing hydrocarbon source potential along the flanks of the structure and into the basin to the northwest.

Lithology indicates competent top seal with all samples of the seal classified as Sneider Seal Type A (may hold ≥ 300 - < 1500m oil column). Calculations of potential seal capacity indicate the average oil column that could be held is 1034 m (range 810-1216 m); and the average gas column that could be held is 493 m (range 386-579 m). Faulting may have breached the top seal. Lateral seal integrity is not known based on available information.

RSWS result indicate a potential hydrocarbon column between 2620 to 2645 meter of depth, this implicates 25 meters of paleo column. Porosity average was 19% and ºAPI value was 35. Mineralogic XRD analysis (Corelab) results indicated a low dolomite presence with calcite predominance.

Potential seal capacity indicates the average oil column that could be held is 1034 meter (range 810-1216 m) and the average gas column is 493 m (range 386-579 m).

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Seismic carbonate reservoir prediction and drilling results, offshore Nicaragua, Caribbean Sea, Robb Bunge, Yusri Yusri , Scott L. Miller, Elmer Ferro, John Bova, Noble Energy 2016.