

PS A New Look at the Stratigraphy and Depositional Setting of the Shallow Herrera Sands in Penal-Wilson-Barrackpore Field*

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Abstract

The Penal-Barrackpore Anticline lies within the onshore Southern Basin foredeep and is one of a series of en echelon anticlinal structures developed during Early-Middle Miocene oblique collision of the Caribbean plate with the northward subducting South American continental crust. The Herrera deposits of this area have been described as deep-water turbidites, but with few details of the palaeoenvironment in which they were deposited. Herrera deposits are believed to have been sourced from the ENE-trending Proto-Orinoco during the mid-Miocene and are calcareous to non-calcareous, very fine- to very coarse-grained deposits encased in deep-water clays and marls of the Ciperó Formation. Analysis of the full hole core from BP-344, showed the characteristic "salt and pepper" texture of white quartz grains, black chert, black limestone and other deposits. Bouma Ta – Te units were also identified in the core. Dark brown to black clays were observed above and below these sand beds, which were of varying thickness across the cored interval. Grain size varied from fine to very coarse grained, suggesting different flow regimes. The abundance of deep-water arenaceous and calcareous benthic foraminifera that were analyzed from cores of Fortin West 214, Barrackpore 344, Marac 1 and Morne Diablo 34 indicates a middle to lower bathyal palaeodepth for the Ciperó Formation. Using these data and analyzing SP & GR log signatures from the wells in the area, it is concluded that these sands were deposited on a slope fan - levee channel complex, as they showed blocky log signatures interpreted as predominantly channel sands in the Penal field, to primarily thinly bedded levee or splay deposits in the Barrackpore field to the east. The study area is characterized by mixed sand and mud filled channels and levees, mud slumps and slides that have localized sands. Previous deep-water depositional models were used to determine the setting where the sands were deposited. This new interpretation of the depositional environment and the further breakdown of its elements increases the prospectivity of the Penal Barrackpore Field. The proposed stratigraphic model is that of anastomosing channels and levees on multiple fans within the Southern Basin and off the flanks of the Penal-Barrackpore anticline. Some of these are stacked, while others are inter-fingering and adjacent to each another. This explains the rapid lateral changes in sand content between wells and creates opportunities to find new sands.

A NEW LOOK AT THE STRATIGRAPHY AND DEPOSITIONAL SETTING OF THE SHALLOW HERRERA SANDS IN PENAL-WILSON-BARRACKPORE FIELD

BY: LENNON BLACKMAN



Figure 1. Map showing location of Trinidad

The Penal-Barrackpore Anticline lies within the onshore Southern Basin foredeep and is one of a series of en echelon anticlinal structures that developed during Early-Middle Miocene oblique collision of the Caribbean Plate with the northward subducting South American Continental Crust (Kennan and Pindell, 2005). The Herrera deposits of this area have been described as Mid- Miocene deepwater turbidites, but with historically few detailed interpretations of the paleoenvironment in which these sediments were deposited.

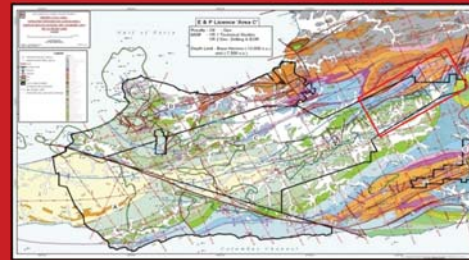


Figure 2. Location Map of Study Area

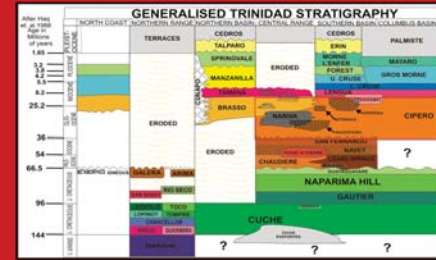


Figure 3: A generalized stratigraphic chart for Trinidad (Archie, 2006)

A literature review of the area has revealed a wealth of information of mainly structural analysis, which reveals the complex geology of the area. Little information is gleaned about a deeper understanding of the stratigraphy and spatial distribution of the Herrera sands within the area. This study was proposed to address this issue and essentially answer the burning questions about the lateral variations of sand content across the field. To do this, we took a different approach, based primarily on paleo-bathymetry and paleo-sub-environment.

Traditionally the Herrera sands are believed to have been sourced from the North (Central Range), but are now thought to be sourced primarily from the East-North East trending Proto-Orinoco during the Mid-Miocene (Pindell, 2005). The sands are calcareous to non-calcareous, very fine to very coarse grained deposits encased in deepwater clays and marls of the Cipero formation. Analysis of the full hole core from BP-344, showed the characteristic "salt and pepper" colour, which comes from white quartz grains, black chert, black limestone and other deposits. Bouma Ta – Te units were also identified in the core. Dark brown to black clays were observed above and below these sand beds which were of varying thickness across the cored interval. Grain size varied from fine to very coarse grained, suggesting different flow regimes.



Figure 4. Paleogeographic map for 12 Ma (Pindell, 2005)

Based on the abundance of deepwater arenaceous and calcareous benthic foraminifera that were analyzed from cores of Fortin West 214, Barrackpore 344, Marac 1 and Morne Diablo 34, a Middle to Lower Bathyal paleo depth for the Cipero Formation was put forward (Bolli, 1956). Using this data and analyzing SP & GR log signatures from the wells in the area, it was observed that there were lateral facies change within the paleo environment, as the logs showed blocky signatures interpreted as predominantly channel sands in the Penal field, to primarily thinly bedded levee or splay deposits in the Barrackpore field (the study area) to the East.

The study area is characterized by thinly bedded sand deposits over a relatively thick interval that averages 500 feet, with maximum thickness of 10 feet for individual sands. These were interpreted as sand-mud filled channels and levees, with occasional slumps and slides that contain localized sands. It was further interpreted that these sands were deposited on a slope fan - leveed channel complex setting. Several deepwater depositional models such as those from Richards and Bowman (1996), Chapin et al., (1994) and Cronin et al., (2011), were used to determine the sub-environment where the sands were deposited.

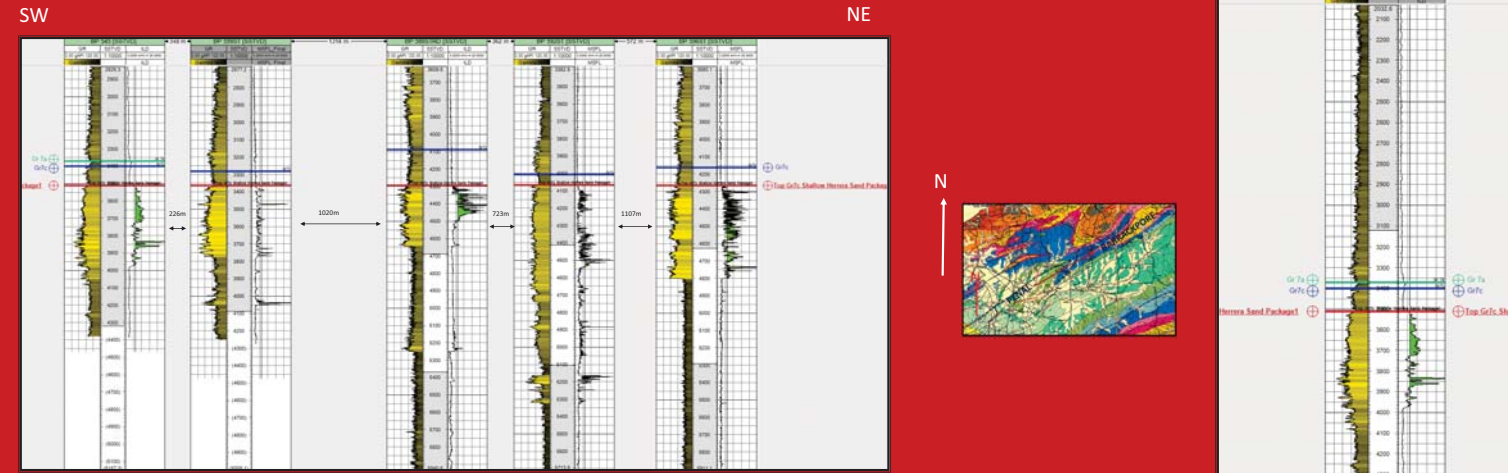


Figure 6. Correlation Panel showing lateral variation and thin bedded nature of Herrera Sands in Barrackpore

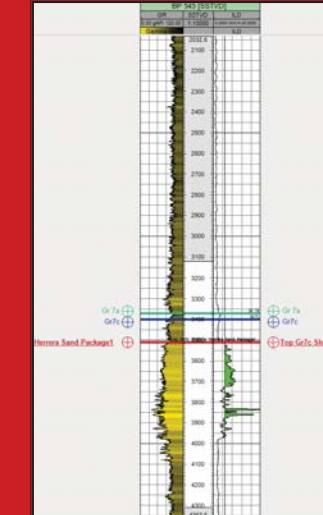


Figure 5. Type Log for the Area, showing Herrera Sands

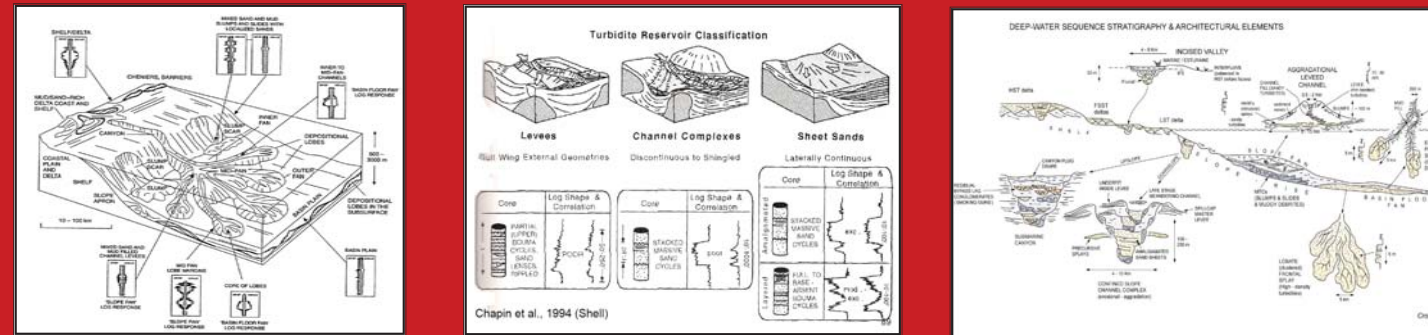


Figure 7. Log signatures from selected lobe and channel levee elements taken from (Cronin, 2014)

Analysis of the well log signatures for the Herrera wells towards the west in the Penal field shows a contrastingly different result from that found in the eastern Barrackpore area. The signature is more of a blocky type, and has been interpreted as belonging to an amalgamated deepwater channel complex, deposited on a slope fan. This further enhances the interpretation made. It is believed that the main channel complex is nearby, it can be found and will be a high quality reservoir to exploit. A lack of 3D seismic over the area makes this a difficult task, but very much worth further pursuit.

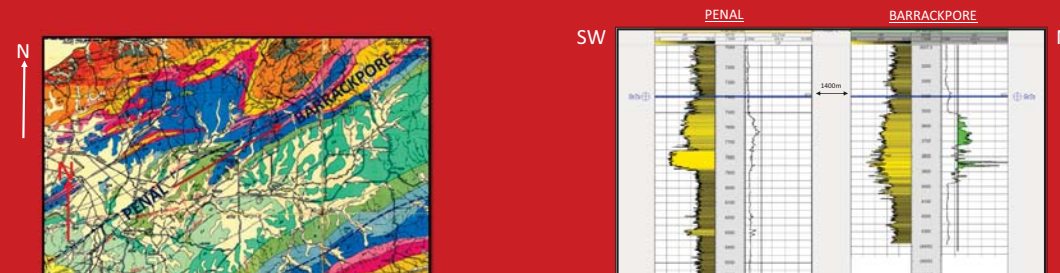


Figure 8. Comparison of typical well log signatures between wells in Penal (left) and wells in Barrackpore (right).

Using a stratigraphic approach we have increased the prospectivity of the Penal Barrackpore Field. The proposed stratigraphic model is that of anastomosing channels and levees on multiple fans within the Southern Basin, as seen as these found on the flanks of the Penal-Barrackpore anticline. Some of these are stacked while others are inter-fingering and adjacent to each other. This explains the rapid lateral changes in sand content between wells and creates opportunities to find new sands that have not been produced. Previously, we encountered these various sands in numerous wells, but did not pursue these sands in a systematic way because we did not know what they were and how they were trending. Drilling mostly based on structure in the past led to numerous dry holes, but with a combination of structural and detailed stratigraphic interpretations this has changed.

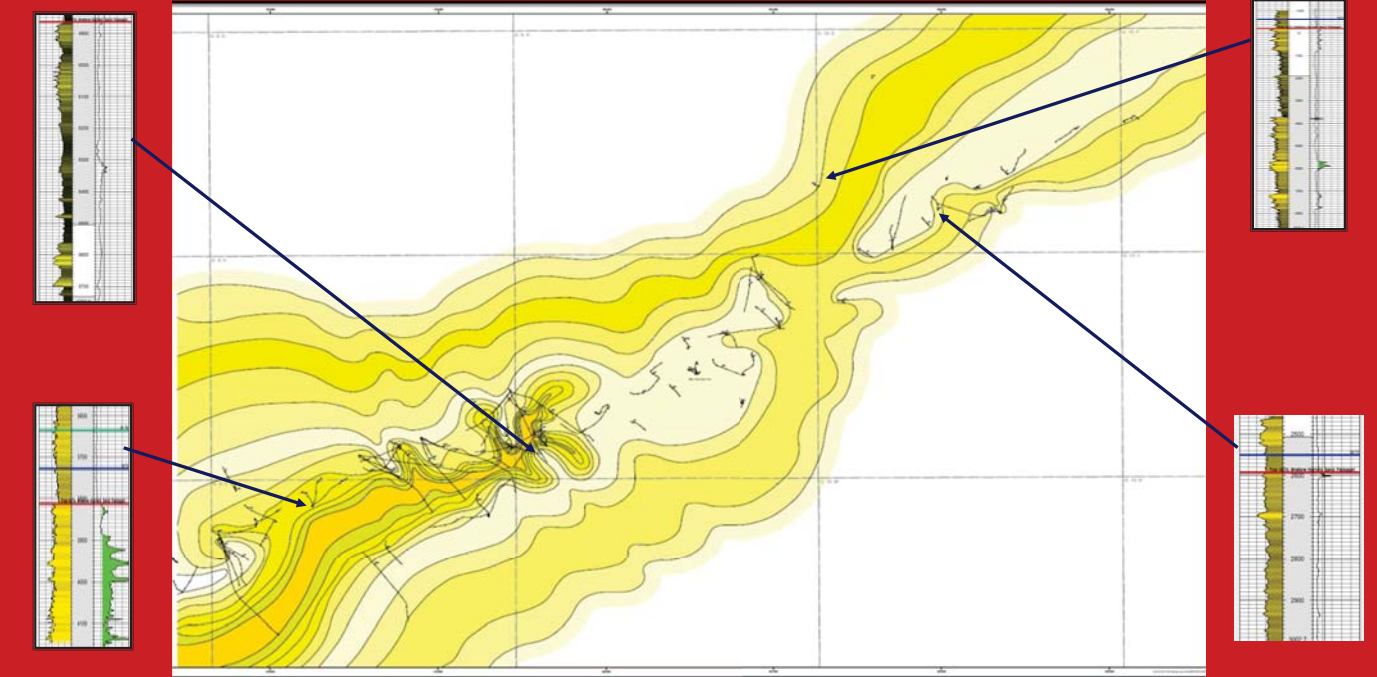


Figure 9. Interval Sand map on Top of Gr7c Herrera Sand showing lateral variations in sand thickness

The Herrera Sands in this area are found to have a very high net to gross ratio, are an excellent reservoir and still has potential for development. The sands were found to have intergranular porosity, ranging from 12 to 40% and permeabilities ranging from 0.5 to 135 md. A deeper understanding of the Herrera sands was obtained using these depositional models for analysis of the well log signatures and analogues to tell a more precise story for deposition of the reservoir. It can be seen that across the field the character of the sands change and this is due to the different locations the sands were deposited in within the deepwater environment. This knowledge can be used to model reservoir and production forecasts and aid in deriving better techniques for field development going forward.

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