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Middle Miocene to Recent structural evolution of the Oritupano-Leona area, Maturín sub-basin, Eastern Venezuela Basin

Luiraima Salazar (1,2) & Marino Ostos (3)

(1) Universidad Central de Venezuela
(2) Friedrich-Schiller Universität Jena, Germany
(3) LITHOS, Caracas, Venezuela

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INTRODUCTION

The Eastern Venezuelan Basin is located south of the Caribbean-South American plate boundary and is the second most important basin in Venezuela for oil potential. It contributes almost 40% of the present-day hydrocarbon production. The main purpose of the present work is to describe in detail the structural evolution of the Oritupano-Leona Field, located in the Tertiary succession of the Greater Oficina Trend. Structurally it is situated in the stable part of the foredeep platform zone (Parnaud et al., 1995) in the southern flank of the Maturín sub-basin of the Eastern Venezuelan Basin (Fig. 1)

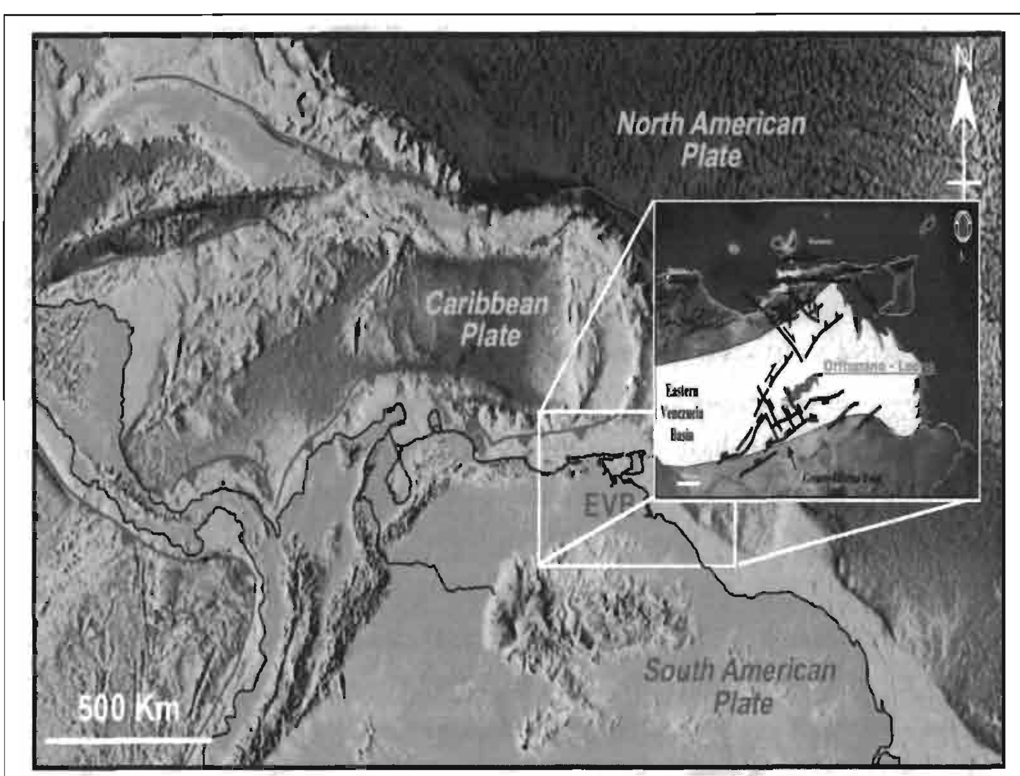

Figure 1. Oritupano-Leona location map. The study area is located on the southern flank of the Eastern Venezuela Basin, in the foredeep platform zone.

REGIONAL TECTONIC SETTING

The Eastern Venezuelan Basin formed as the result of the complex interaction between South American, North America and Caribbean lithospheric plates. Three major tectonic stages are commonly differentiated (Di Croce, 1995): (1) a Triassic to late Jurassic rift phase (break-up of Pangea), (2) a Late Jurassic-Oligocene passive margin phase, and (3) an early Miocene to present active margin phase.

From late Paleocene to the present, transpressional deformation advanced diachronously along the northern border of South America, as the Caribbean plate migrated eastward with respect to South and North America (Pindell and Barret,1990; Lugo and Mann, 1995).

In western Venezuela transpression ocurred during the early-middle Eocene. Progressively younger transpression eventually affected eastern Venezuela and Trinidad, during late Oligocene-middle Miocene. Thrust sheets and associated foredeep basins overrode the former Cretaceous passive margin sequence as a result of the eastward migration of the Caribbean plate. Volcanism in the Lesser Antilles arc and the development of the "Lara Nappes" in western Venezuela took place in the Eocene (Pindel and Barret, 1990). The Oligocene is a tectonically quiet period and perhaps reflects a slowdown of the eastward Caribbean relative motion (Stephan et al., 1990).

REGIONAL STRATIGRAPHY

The Eastern Venezuela foreland basin lies mostly over crystalline basement that has been affected by three distinct phases of crustal evolution and the stratigraphy of basin is best described in five units from botton to top: A) Cristalline Precambriam Basement, it cosists mainly of meta-sedimentary and meta-igneous rocks. B) Paleozoic consists of 1827 m Cambrian Hato viejo and overling Cambrian Carrizal Formation. C) Jurassic: the jurasssic Espino graben has been described from the Machete-Zuata field (González de Juana., et al. 1980), that ist filled with red-beds and intercalated basalt flow (162 Ma). D) Passive Margin Sequence (Cretaceous to Oligocene): The Eastern Venezuelan Basin merges to the southeast into the Atlantic passive margin of South America. The sequence consists of Cretaceous to Oligocene marine clastic rocks although some carbonates may be present in the Cretaceous section. E) Neogene foredeep sequence: consists of 6100 m of sedimentary rocks, characterized by two overall transgressive-regressive cycles wedges (Di Croce, 1995).

ORITUPANO-LEONA STRUCTURAL FRAMEWORK

The tectonic-structural configuration has been recognized as dominantly extensional. The detailed 3D seismic interpration we report here permitted to distinguish three systems of normal faults and various types of folds, genetically related with the lateral and longitudinal propagation of these faults systems.

Fault System 1 is constituted by a set of faults trending NE-SW and dipping about 50° to the NW. It has been defined as Master Normal Fault System by Azálgara et al, 2001. This system corresponds to a regional lineament and throughout this system changes of thicknesses are observed, which gives it a syn-sedimentary character.

Fault System 2 is most prominent and extends through the entire area with a predominant E-W trend. Within this system there is a set of faults with the same trend but dipping toward the north and another set of faults which do not display thickness differences throughout the same units. These characteristics have allowed to subdivide this system into three subsystems: **Sub-system 1:** This subsystem is constituted by a fault set cutting the entire sedimentary section, including the basement. The faults trend E-W, dip towards the south and display evidence for syn-sedimentary motion. **Sub-system 2:** These are faults that are segmented in profused, but which when propagating laterally their ends connect and form a single fault. Different from sub-system 1, sub-system 2 does not present thickness differences, which indicates that it postdates the depositation of the sedimentary sequence. **Sub-system 3**

is characterized by slightly curved fault traces, E-W trend and northward dips. Also it displays differences of thicknesses, which reveals its synsedimentary character.

Fault System 3 has NW-SE trend and NE dip. This system affects the entire sedimentary sequence but not the basement and shows synsedimentary character.

The folds associated with these fault systems are longitudinal and consist of synclines in the footwall and anticlines of the hanging wall (reverse drag folds). Synclines in the hanging wall and anticlinals in the footwall (normal drag folds) can also be observed (Fig. 2). These folds in younger levels, they are attenuated demonstrating a change in the litological dominion, where one goes of a plastic to one fragile dominion. The most important traps in the Oritupano Leona area are generated by these longitudinal folds that in their majority are associate with the Fault System 2, which has relation with the extensional strain resulting from dextral strike-slip movements along the boundary of South America and Caribbean plates (Erlich and Barrett, 1992).

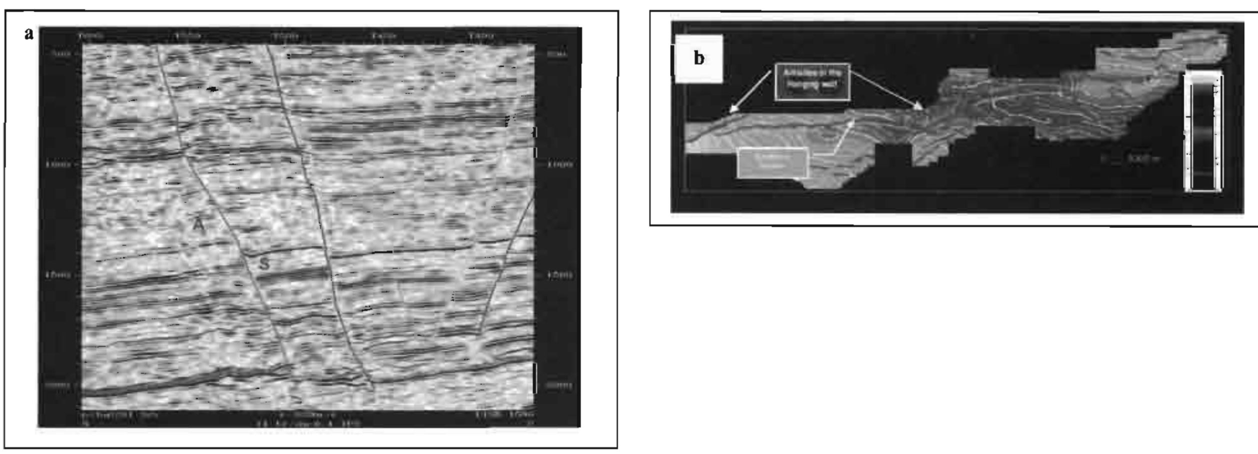

Figure 2. Example of folding in Oritupano-Leona field. a) Normal-drag folds. b) Horizon Ser 2 (13,5 m.y.). This map shows the longitudinal folds (normal drag folds) running parallel to Fault System 2. These folds are related with the most important traps in the study area.

TECTONIC EVOLUTION

In agreement with this the tectonic model of the area settled down, where three periods of tectonic evolution were interpreted:

1. Lower Miocene (17.3 Ma): The foredeep development began in NW-SE direction and the basin deepened towards the northwest.

2. Middle Miocene (15.35 Ma): The migration of the "foredeep" begins towards the northeast and the faults with NW-SE trends and NE dip were activated. At 14,8 Ma, two extension directions of exist, one NW and the other NE, and the Master Fault System (system 2, with E-W trend) originates. To the West, the formation of a structural high began, associated with the generation of a "peripheral bulge" which propagated diachronously towards the east. At 13,6 Ma the migration of the "peripheral bulge" continued and the Master Fault System (system 2) remained active whereas the faults with NW-SE trend and dip to the north were deactivated.

3. Upper-Pliocene to Miocene: During this stage the Master Fault System continued active and the NW-SE (Fault System 3) was reactivated. Antithetic faults of E-W trend and dip toward North were created in response to the sedimentary load to the south of the "peripheral bulge".

CONCLUSIONS

- Through the interpretation of the seismic horizons corresponding to the Middle Miocene to Present in the Oritupano – Leona area the detailed structural configuration was revealed.
- The structural style comprises two important elements: (1) Normal faults and (2) normal and reverse drag folds of extensive origin, genetically related to the development of the fault systems and parallel to their trends.
- The most important fault system in the study area is the W-E trending Fault System 2. This fault system seems to be in relation with extensional strain resulting from dextral strike-slip movements along the boundary of South America and Caribbean plates (Erlich and Barrett, 1992). Associated with this system are longitudinal folds that constitute the most important traps in the study area.
- The peripheral bulge developed as a direct result of flexure of the continental lithosphere and variations in thickness of lithosphere subjected to elastic deformation control the amount of flexure in the basin and the position of the peripheral bulge.
- We have derived a chronological sequence of the main structural events, allowing to reconstruct a detailed geological history of this zone and making an important contribution to the geology of the Eastern Venezuelan Basin.

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