Structural Interpretation at the Vicinity of the Lama -Icotea Fault at the Cretaceous Section, Lagomar Field, Maracaibo Basin, Venezuela

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Abstract

In the frame of an Integrated Study of Cretaceous fractured reservoirs we investigate the link between the fracture systems at the Cretaceous section with the structural style of an associated major fault system.
As many other fault trends at the Maracaibo basin the Lama-Icotea fault system displays strike-slip classic features, as sub-vertical to high angle dip, restraining bends and oblique folding. Nevertheless, a thoroughly study of other important structural features is necessary to make an outstanding breakthrough in the definition of the fault damage zone and its fractures.
The analysis of maps of curvature attributes allows to identify shear zones alongside the Lama-Icotea Fault and to interpret fracture patterns at seismic scale.
These shear zones dominate the extent of the damage zone and consequently, the dimension of the fracture corridors alongside the Lama-Icotea fault. This also allows to map the boundary between the systematic fracture domain and the fracture swarm domain.
The study of the fracture damage zone indicate the presence of local Riedel Shears as a main control on the fracture pattern at seismic scale.
This study finally investigates the connection between the orientation of fractures at well scale and the pattern of faults at the shear zone at seismic scale.

Introduction

Maracaibo Basin, located in the northwest of Venezuela, is one of the most significant petroleum basins in the world. The Cretaceous reservoirs currently are shows how the most prolific in the area, with more than 6000 MMBLS original in situ hydrocarbon of oil light. Taking into account these numbers began in 2007 the "Cretaceous Lake Project", through this study we expected to get a static model of the Cretaceous reservoirs in the central area of Maracaibo Lake (figure 1). The aim of this work is to present some results of the seismic interpretation got in the construction of the 3D seismic model, since a point of view of determine the features of the faults systems that government the tectonics setting along Cretaceous section at Maracaibo Basin.

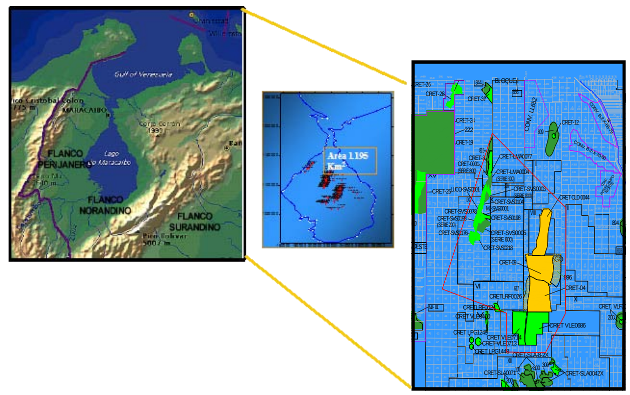

Figure 1: Study area of this project. It is situated in the central area of Maracaibo Lake.

The Lama-Icotea fault is one of the major structural features in the Maracaibo basin, it has a preferred north-south direction at southern of Maracaibo Lake and changes slightly to SW-NE at northern of Maracaibo Lake. This fault system displays strike-slip classic features, as sub-vertical to high angle dip, restraining bends and oblique folding. Several authors defined this fault as a high angle strike-slip fault (Escalona & Mann, 2003) with left-lateral displacement (Castillo & Mann, 2006).

We used the *Petrel* software for calculate several structural attributes that helped us during the interpretation and construction of 3D structural model. Among these attributes we have the maximum and minimum curvature. The results from this attribute were very powerful and improved our understanding about the tectonic and structural setting in the Cretaceous of Maracaibo Lake, specifically in the north central area, at the vicinity of the Lama-Icotea Fault.

Methodology and Results

Interpreted horizons and the main fault set were loaded in the interpretation package in order to build the structural model. After gridding the surfaces, some seismic and structural attributes were extracted to search for anomalies that can be associated to structural features.

A curvature is a structural attribute that allows to check the impact of the deformation associated to fault and tectonic mechanism.

Curvature operations

The curvature is calculated in the following manner: At each point on the surface or horizon interpretation the set of nearest neighbors are found. This is a 3x3 neighborhood.

A general quadratic surface is fitted to the neighborhood of the point allowing for easy computation of first and second derivatives in any direction. The curvature in any orientation is 1/r where r is the radius of the best fitting circle to the surface in that orientation. These circles are known as osculating circles. If for a particular orientation the surface is extremely curved, the osculating circle will have a small radius and so the resulting curvature value will be high and if the surface is only slightly curved then the curvature value will be low.

$$\text{Min curvature} = 1/r_{max},$$

where r_{max} is the maximum radius of the osculating circle over all possible directions.

$$\text{Max curvature: } 1/r_{min},$$

where r_{min} is the minimum radius of the osculating circle over all possible directions.

Mean curvature: (Max curvature+Min curvature)/2

In order to test the match between the seismic attributes with well data, after calculating the maximum and minimum curvature in some horizons at level of Cogollo Group (Early to mid Cretaceous, Maracaibo Lake), we compare the results with the well data of fractures from image logs and cores of some key wells situated into the study area.

Results

We obtained two maps of seismic attributes (maximum and minimum curvature) for each main seismic reflector that we identified in Cogollo Group (four reflectors shallower to deeper: Socuy –La Luna, Maraca – Lisure, Apon and Rio Negro). The analysis of maps of curvature attributes allows to identify shear zones alongside the Lama-Icotea Fault and to interpret fracture patterns at seismic scale.

These shear zones dominate the extent of the damage zone and consequently, the dimension of the fracture corridors alongside the Lama-Icotea fault. This also allows to map the boundary between the systematic fracture domain and the fracture swarm domain.

Figure 2, show that these attributes allow identify the orientation of the main fault (Lama-Icotea), the damage zone, and the trends of its derivate faults, which ones there are in NW – SE direction.

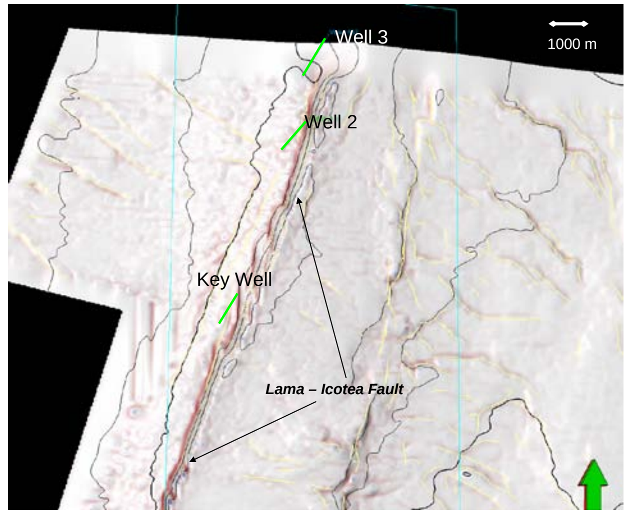

Figure 2: Minimum Curvature map (at level of Apon Formation) at northern of study area. Solid green lines represent three wells situated into the study area. Red trends shows are associated with the orientation of the mains faults systems (see Lama – Icotea Fault), and yellow lines are the fault polygons got from 3D seismic interpretation.

As well as from figure 2 we can see the structural setting and faults orientation at northern of study area, figure 3 displays the same map with more detail around the wells and the damage zone.

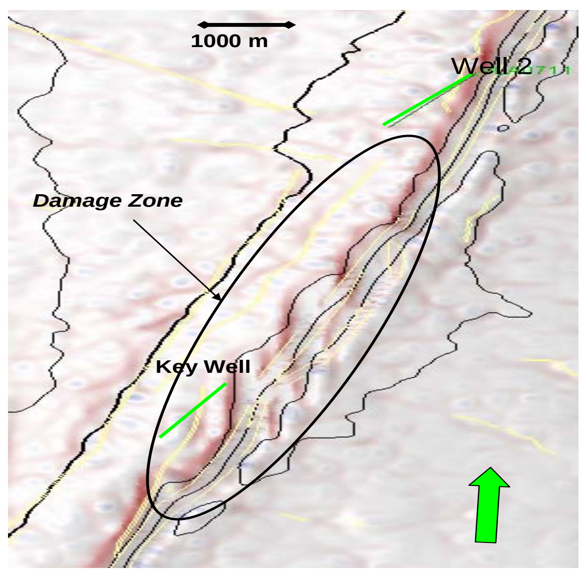

Figure 3: Minimum curvature map at Apon Formation, at northern of study area showing a damage zone (red lines inside black oval) along a sector the Lama –Icotea fault

The study of the fracture damage zone indicates the presence of local Riedel Shears as a main control on the fracture pattern at seismic scale.

Riedel structures are networks of shear bands (figure 4), commonly developed in zones of simple shear during the early stages of faulting (Katz, Y., *et. al.*, 2004)

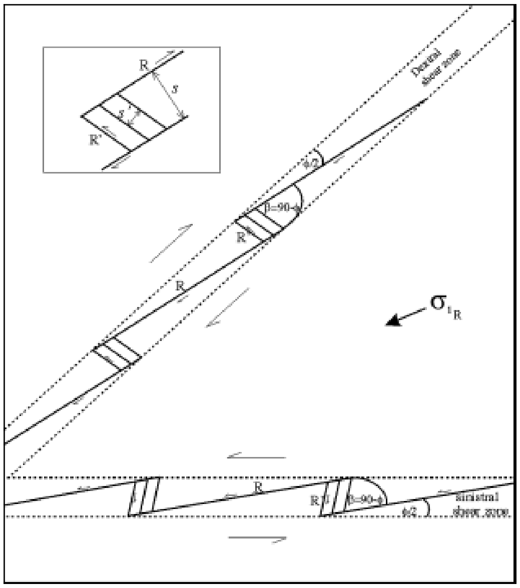

Figure 4: Basic Riedel shear structures forming sinistral and dextral conjugate shear-zones. R and R´ are synthetics and antithetic shear bands, β is the angle between R and R´ and Φ is the angle of internal friction. Σ_{tR} denotes the remote maximum compressive principal stress.

The correlation between the orientation of fractures at well scale and the pattern of faults at the shear zone at seismic scale, can be seen in figure 5. We took images logs, core data and dip-meters from some wells situated into the study area. As a first view, there is a good match between the well data and 3D seismic interpretation observed the same orientation and dip of fractures at well scale and faults at seismic scale.

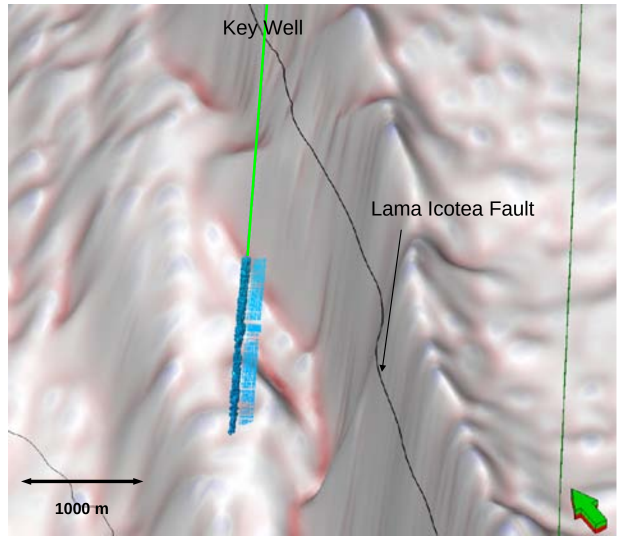

Figure 5: Fractures orientations (light blue circles) in the Key Well (light green line) associated with the 3D seismic interpretation from Curvature Attribute. Horizontal axis of Lama-Icotea fault is represented by the black line.

Conclusions

This method has served for location of deformation points caused by the main fault and has enabled us to visualize the behavior of the faults to better understand of structural model. This study investigates the connection between the orientation of fractures at well scale and the pattern of faults at the shear zone at seismic scale, although as a first view there is a good match between both, should be make and deeper analysis of all available information

References

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