Conceptual Geological Model about Hydrocarbon Flow Through Fractures in Siliciclastic Sequences of the Chicontepec Formation*

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Abstract

In heterogeneous reservoirs, it is important to evaluate the variation of the physical properties of the rocks to reduce uncertainty in petroleum system modeling. Natural fractures are one of the factors involved in reservoir evaluation affecting the distribution of the physical properties (porosity, effective permeability, water saturation) of lithostratigraphic units. Natural fractures in siliciclastic reservoirs (SR) can enhance or inhibit production and stimulation processes and therefore is substantial to use qualitative and quantitative criteria in order to discriminate the structural systems involved in the hydrocarbon flow.

This work summarizes the results of the static characterization of fracture systems in SR analogues of the Chicontepec Fm. The structural analysis was performed on several scales of observation: micro-structural analysis of oriented thin sections, quantitative and qualitative description of faults and fractures in outcrops and boreholes, structural lineaments in topographic relief, and seismic-structural interpretation. The structural characterization was performed on both the silicilastics sequences and the underlying cretaceous rocks, in order to establish a genetic relationship between fracture systems with regional structures related to the Mexican Fold-Thrust Belt (MFTB) and the foreland basin.

Two predominant structural systems were defined in seismic and regional scales of which the one with higher density is NE-SW system (35° to 60°), followed by the NW-SE system (315°-330°). Fracture families where identified at metric and centimeter scales compatible with the regional systems. Characterizing outcrop scale structures and boreholes was extended to classify them according to their internal morphology, mineral content, geometric features and hydrocarbon flow evidence. These qualitative attributes allowed us statistically discriminate families of fractures that are important in the history of oil flow in the analogue.

Finally, a conceptual model about the relative temporal evolution of the micro-fracture systems and hydrocarbon flow for the SR analogue is presented and which, by its self-similarity attribute, was correlated with the fault systems that were characterized at regional and seismic scales to identify the dominant system for migration and storage of oil.
References Cited

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1. Introduction

Natural fractures in siliciclastic reservoirs can enhance oil production and stimulate reservoirs, therefore in order to account for a qualitative and quantitative criterion in order to discriminate the structural systems involved in the hydrocarbon flow processes. This work is focused on the static characterization effective fractures in the Chicontepec Basin and the understanding of stress states in order to establish a good relationship between fracture systems with regional structures. Consequently structural analysis was implemented on several outcrops, core samples, and microstructural analysis of the existing fracture systems. Based on the evidences of cross-cutting relationships and the statistical discrimination of the qualitative attributes of the population of fractures, we propose a conceptual model of the hydrocarbon flow controlled by fracture mechanisms and, qualitatively, correlated with regional structures.

2. Objectives

- Relate regional and seismic scale fault systems with the bearing fracture systems.
- Define a model about relative temporal evolution of the micro-fractures systems and hydrocarbon flow for the SR domain.
- Define a model about relative temporal evolution of the micro-fractures systems and hydrocarbon flow for the SR domain at reservoir conditions.

3. Location map & regional stratigraphic column

- Palenque Formation
- Chicontepec Sandstone
- Divisores Limestone
- ARES 3675
- ARES 1470

4. Methods: Static Characterization

4.1 Outcrop Studies: 3D modelling and fracture characterization

- 5 fracture systems identified
- All fractures systems are filled with gilsonite
- At regional scale all vain systems are filled with gilsonite

4.2 Core Sample Studies

- Stratigraphic facies: grain facies (YAA.GE-062_SD1(3))
- Lamination/bedding (et. al, 2003)
- Fluid flow sequence: grain facies (Underwood et al., 2003)

5. Results:

5.1 Lineaments Extraction from DEM’s

- 675 lineaments identified (100 m)
- Linear kinematic attributes based on planar lineaments
- Multidirectional lineaments: 450°-150° azimuth families
- 145°-155° strike, domain of faults

5.2 Lineaments Extraction & Fault Patches from Scaled Data

- Strike slip over 4 meters
- 31 fault patches
- Random distribution of 25°-25° strike domain at reservoir conditions
- 150°-155°, domain of faults

5.3 Outcrop Studies: 3D modelling and fracture characterization

- Fracture systems identified
- Fracture systems 3-4 are filled with gilsonite
- At regional scale all vein systems are filled with gilsonite

6. Conceptual model of fracture evolution and fluid flow

- (d) Underwood, Chad A., M. Cooke, J.A. Simo, M. Muldoon, 2003, Stratigraphic controls on vertical fracture patterns in
- (c) Servicio Geológico Mexicano, 2016, Cartografía Geológica-Minera de la República Mexicana, http://sgm.gob.mx/
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- (a) Fitz-Díaz, E., P. Hudleston, G. Tolson, and B. van der Pluijm, 2014, Progressive episodic deformation In the Mexican

7. Acknowledgements

This work is an outcome from a research project sponsored by the Mexican Institute of Petroleum and the PEMEX E&P company, ”(1) Pervasive Hc impregnation & (2) Calcite precipitation”.

8. Literature Cited

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- [et. al, 2003]
- [Underwood et al., 2003]

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