REDUCING THE UNCERTAINTY ON THE GENERATION AND EXPULSION HISTORIES OF THE UPPER MAGDALENA VALLEY AND PUTUMAYO BASINS, COLOMBIA.

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Abstract

Geochemical evaluation of rock samples from the Upper Magdalena Valley (UMV) and Putumayo Basins suggests that there is insufficient mature source rock volume to generate all the amounts of oil in place proven until today. Furthermore, geochemical modeling of the deepest parts of those basins using the thermal histories obtained by calibration of vitrinite reflectance data shows that many more oil accumulations are not likely to be found. Thermal models presented in this study, however, suggest that most maturity indicators measured on both basins are not representative of the real maturity reached by the source rocks. So a more realistic and optimistic scenario was obtained for those basins. This study identifies the most likely locations of the hydrocarbon pods in these basins, as well as the timing of oil generation and expulsion under this alternative thermal history.

One of the most prevalent approaches in studies of maturity history of the UMV and Putumayo Basins' source rocks has been measuring maturity indicators in the prolific Villeta Group and Caballos Formations (Cretaceous section), with only few measurements made within the Tertiary sections. This practice, common to both basins, is deemed here as a wrong approach that creates many uncertainties on the definition of the thermal and oil generation histories, and has led to incorrect interpretations and misconceptions of their generation and expulsion processes. Whenever maturity indicators measured on rocks from the Cretaceous section are used as inputs in thermal models, no match between the observed temperatures (BHT corrected) and the measured maturity indicators is obtained that fit the conceptual tectonic development of these basins (Copper et al, 1995). The calibration process suggests that the present temperatures are too high relative to the measured maturity indicators. Additionally, the thermal modeling results show that the deepest parts of those basins are at the beginning of the oil window, with only small amounts of oil discharged. This scenario is unlikely within the current conceptual models of these basins' evolution, and is inconsistent with the thermal calibration of the neighbouring Llanos, Middle Magdalena Valley and Eastern Cordillera basins.

In wells from the UMV and Putumayo basins, measured maturity indicators (% Ro and Tmax) from rocks sampled within the Tertiary sedimentary sequence show a good match with the BHT. A variable heat flow history of the rifting type was required to calibrate and optimize data from those wells (Figure 1). However the low number of wells that could be calibrated under this thermal history regime has undermined the importance of this calibration and has created controversy.

Several reasons can be considered to explain the disparity between thermal indicators and the thermal evolution of the source rocks. The following reasons may be argued:

- Most wells drilled in the UMV and Putumayo basin are located on structural highs, leaving the deepest part of the basin untested.
- The Villeta Group and the Caballos Formation are not adequate sedimentary sequences to measure vitrinite reflectance because of their low content of vitrinite in their maceral distributions.
- A suppression effect on the readings of vitrinite reflectance from the Cretaceous rocks has been identified. Apparently, the large amount of bitumen and the high hydrogen index present in the Villeta Group and the Caballos Formation suppress the normal increase of vitrinite reflectance with maturity at early stages of the oil window.

Although the oil accumulated in the UMV and Putumayo Basins may have been generated by the mature source rocks found in the Eastern and Central Cordilleras, thermal modeling results proposed in this study and by previous authors suggest that generation and expulsion of hydrocarbons occurred very early in the history of these basins, when most of the presently known oil traps did not exist.

Our thermal and maturity history interpretations of these two basins were based on geochemical modeling. Four pods of oil generation were identified in the UMV basin: one in the Girardot Sub-basin and three in the Neiva Sub-Basin (Figure 2). Pods in the Neiva Sub-Basin are larger than those proposed by previous works (Buitrago, 1994; Sarmiento and Rangel, 2004). It is here proposed that the generative pod that includes the Neiva syncline extends below the thrust sheets of the Central and Eastern Cordilleras, where oil generation and expulsion occurs today.

New results were also obtained in the Putumayo Basin, which challenge the current paradigm of lack of hydrocarbon generation and expulsion into the actual configuration of the basin (Goncalves et al 2002). Three independent generative pods were identified, with oil expulsion occurring during the last 10 Ma (Figure 3). One of these pods is located under the

central part of the Foothills; a second pod is located in the southern portion of the basin, and the third pod is part of the footwall of the thrust faults that form the Orito field.

Our results therefore (1) honour measured maturity and BHT values; (2) provide an alternative history of thermal evolution that is consistent with currently accepted models of basin evolution; and (3) imply an increased hydrocarbon potential due to the number and size of identified generation pods.

References:

Buitrago, J., 1994. Petroleum Systems of the Neiva Area, Upper Magdalena Valley, Colombia. Magoon & Dow, eds. The Petroleum System-from source to trap: AAPG Memoir 60. P. 483 – 498.

Copper, M. et al. 1995. Basin Development and tectonic history of the Llanos Basin, Eastern Cordillera and middle Magdalena Valley, Colombia. AAPG Bulletin, V. 79, P. 1421-1443.

Goncalves et al 2002 Petroleum generation and migration in the Putumayo basin, Colombia: insights from an organic geochemistry and basin modelling study in the foothills. Marine and Petroleum Geology Volume 19, Issue 6 , June 2002, Pages 711-725.

Sarmiento, L. and Rangel, A., 2004. Petroleum system of the Upper Magdalena Basin. Marine and Petroleum Geology, V. 21. P. 373-391.

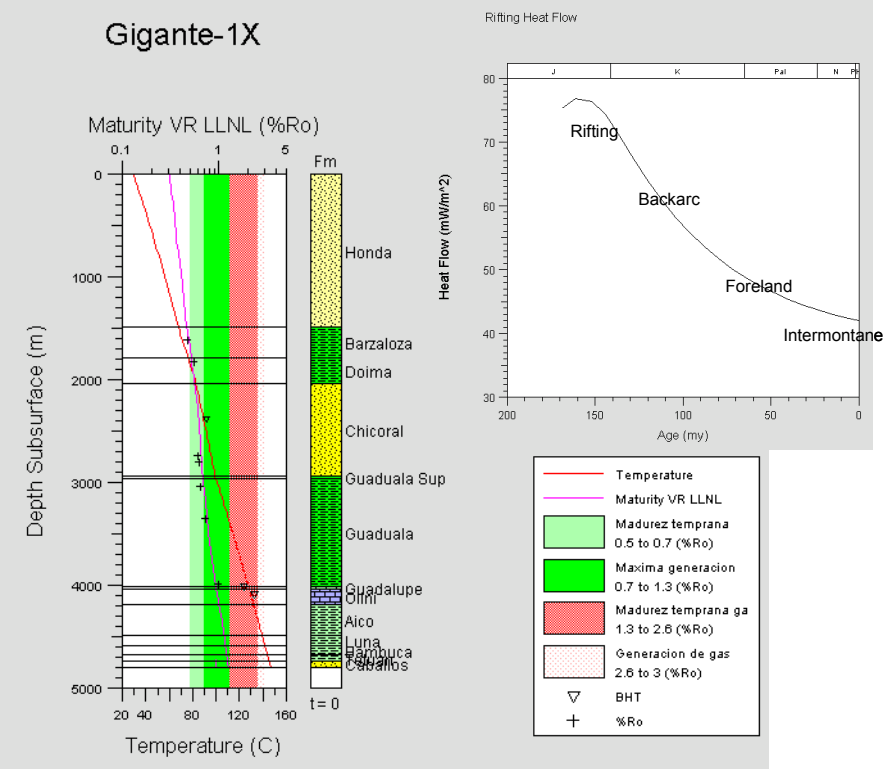

Figure 1. Thermal calibration and modeled heat flow history of one well drilled in the UMV basin.

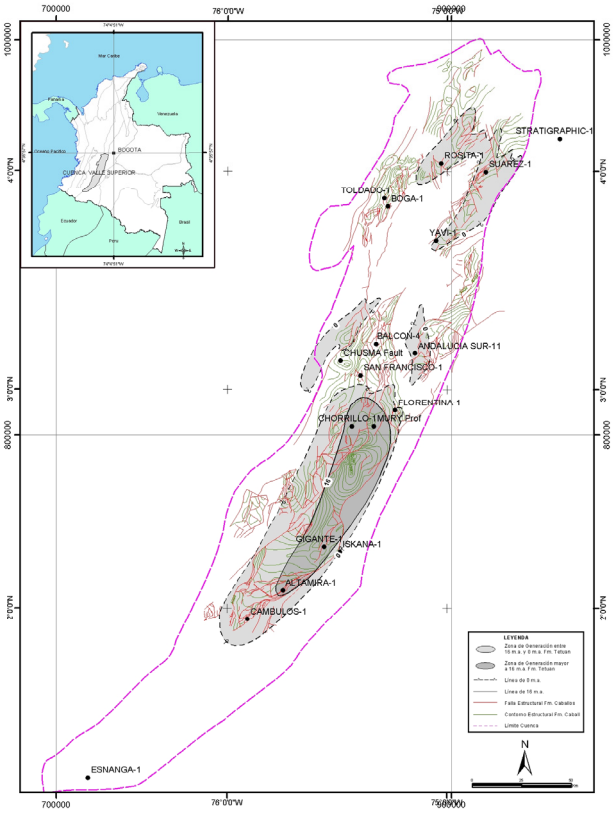

Figure 2. Map of identified generation pods in the UMV with their time of entry into oil

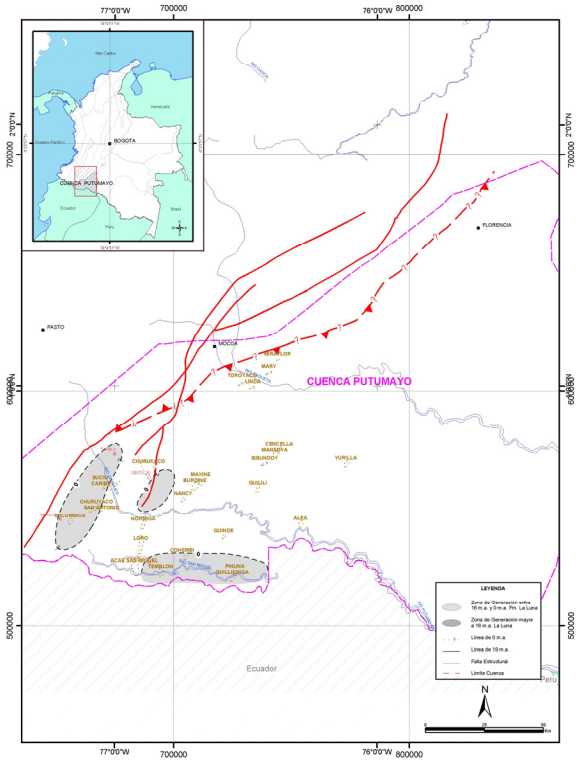

Figure 3. Map of identified generation pods in the Putumayo with their time of entry into oil expulsion.