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MATURATION AND MIGRATION OF HYDROCARBONS IN THE CENTRAL REGION OF THE UCAYALI BASIN (PERÚ): INSIGHTS FROM 2D BASIN MODELING

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Introduction

The Ucayali Basin is located in the central region of Peru (Fig. 1). Ucayali is a Subandean basin and has been poorly explored until the present, remaining several untested structures.

Previous studies recognized several phases in the evolution of the Basin. A rift phase was developed during Ordovician to Devonian times followed by a sag phase during Late Paleozoic. A new rift stage possibly developed during Triassic passing later to a sag-foreland phase (Jurassic to Cretaceous). The present foreland configuration was developed during Tertiary times.

Three main source rock units are generally considered in Ucayali: Devonian (Cabanillas Group), the Early Carboniferous (Ambo Group) and the Early Permian (Ene Fm.). The Devonian source rock is speculative in the study area, and is present in half-grabens or grabens.

Several stratigraphic units are reservoir in the Ucayali Basin: Devonian sandstones of Cabanillas Group, the Early Carboniferous Ambo Group, the Late Carboniferous Green Sandstones, the Permian sandstones of Ene and Mainique Fms. and the Cretaceous Cushabatay, Chonta and Vivian Formations. The quality of these sandstone reservoirs is variable between fair to very good.

This study was performed in the framework of a general evaluation of the central part of the basin, with the main objective of understand different aspects of the petroleum systems evolution.

Modeled section

The 2D geochemical model was based on a section composed by several previously interpreted seismic lines, with the control of few wells. The seismic panel runs approximately from SW to NE. The total length of the section is 172 km, ranging from the foothills of the Shira Mountains in the SW to the climbing up ramp in the NE (Fig. 2). Only the main faults were considered in the models. Two source rocks were modeled: the Early Carboniferous (Ambo Group) and the Early Permian (Ene Fm.). The Devonian (Cabanillas Group) units were not recognized along the modeled section, therefore that source rock was not modeled.

Maturity information, especially vitrinite reflectance measurements are scarce in the study area, and present some degree of dispersion. The data are restricted to a few wells and outcrops.

Results

Considering the maturity information two end-member scenarios were calibrated and modeled. In one case (Model 1) the maturity profile present an offset between the base of the Cretaceous and the top of the Paleozoic. Based on the available information, the maturity of the top of the Paleozoic can be estimated in the order of 0.3 %Ro higher than the base of the Cretaceous. However, regarding the quality and dispersion of the available measurements an almost continuous profile (adjusting the entire maturity curve to the Paleozoic profile) was evaluated as an alternative scenario (Model 2). The calibration for the Model 1 was reached considering an eroded thickness related to the unconformity that separates the base of Cretaceous and the top of Paleozoic. Some wells encountered that section towards the north and west of the studied area.

In both models the source rocks of Ambo Group began the hydrocarbons generation during the Permian. The generation continued into the Tertiary. The current transformation ratio of the Ambo Group organic matter is over 90 % in the western part of the section, decreasing toward the east.

The source rock levels of the Ene Fm. began to generate hydrocarbons during the Cretaceous in the western part of the section, and continued until recent times. The current transformation ratio of this source rock varies from 50 % (Model 1) to 90 % (Model 2) in the western part of the section, being lower in the eastern part.

In the western half of the section, both models show that the source rocks of the Ambo G. are currently in the gas window. In the same area the Ene Fm. reached the early-peak oil window in the Model 1, and the late oil window in the Model 2.

In both models the sandstones of Ambo G. and the Green Sandstone reservoirs are easily charged with hydrocarbons generated by Ambo G., and the sandstones of Ene Fm. with hydrocarbons generated by source rock levels of Ene Fm. (Fig. 3). The charge of the Cretaceous reservoirs is more difficult, due to two main reasons. First, the volume of hydrocarbons generated by Ene Fm. is comparatively smaller due to the small thickness, and second, the charge from Ambo G. is less efficient and occurs mainly along faults.

The models show that the migration was active during Cretaceous and Tertiary. In Model 2 the generation and migration were more active processes during the Tertiary than in Model 1. There is a general trend of migration to the eastern part of the basin due to the regional dip, along carrier beds as the Green Sandstone and possibly the sandstone levels of Ene Fm. This migration pattern could have been interfered by N-S faults that were reactivated during Andean orogeny, resulting in either loss or entrapment of hydrocarbons, depending on the permeability of the faults. Andean deformation (Tertiary) is the most recent and potential cause of the destruction of traps and remigration. Hence, previously charged traps have a moderate to high risk of preservation.

Fig. 1 – Location of the Ucayali Basin and the modeled section.

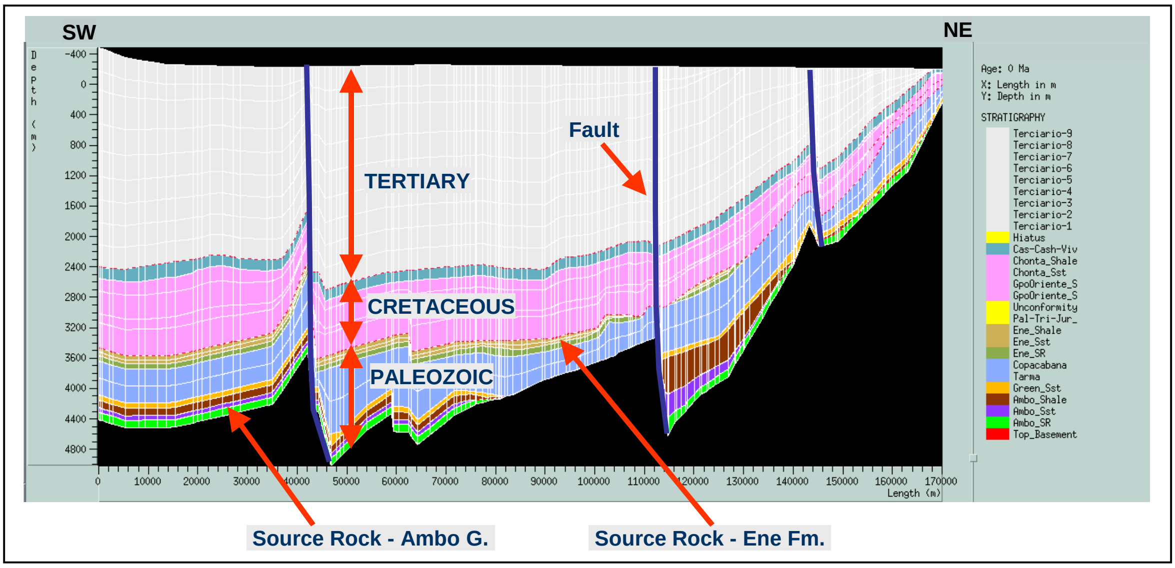

Fig. 2 – 2D Modeled section.

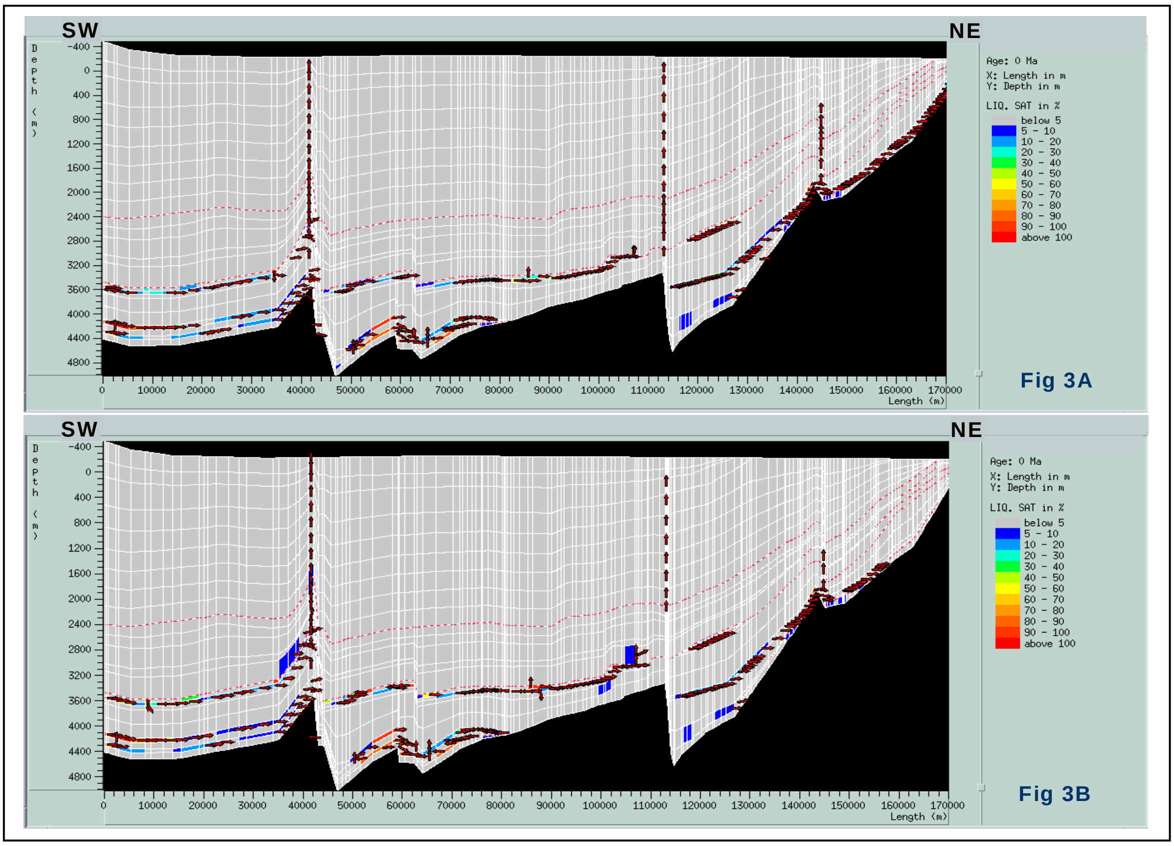

Fig. 3 – Recent migration and saturation: A) Model 1, B) Model 2. Models with open faults. Notice the migration along carrier beds and main faults. High saturations in sandstones of Ambo G., Green Sandstone and sandstones of Ene Fm.