POTENTIAL SOURCE ROCKS FOR LOS ANGELES OIL FIELD (UCAYALI BASIN, PERU)

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Introduction

Light oil (45° API) is being produced from the Cushabatay Formation in Los Angeles field, discovered in 2013 by CEPSA in the northwest of the Ucayali Basin (Perú). The field is a four-way dip closure with surface expression, uplifted during the Pliocene compressional event of the Andean orogeny. The Cushabatay reservoir is a 120 m-thick section composed of stacked fluvio-deltaic sandstone packages of Early Cretaceous age situated at ~1800 m below ground level, sitting unconformably on a pre-Cretaceous surface and overlain by the shallow marine shales of the Raya Formation in a gradational contact.

The source rock for Los Angeles oil is still far from clear. Multiple Paleozoic organic-rich marine shale intervals have been previously proposed as viable source rocks for the oil and gas reservoired in Cushabatay in other fields of the Ucayali Basin; e.g.: Agua Caliente, Aguaytia (Figure 1). However, hydrocarbons generated from Paleozoic intervals require a complex migration pathway to charge Cushabatay, the only hydrocarbon bearing reservoir in this part of the Basin, which systematically records oil shows when drilling its uppermost section. On the other hand, the Raya marine shales of Early Cretaceous age, which provide the top seal for the Cushabatay reservoir, should also be considered as a potential source rock, with a simple and direct lateral oil migration into the underlying Cushabatay.

Methodology

We have undertaken geochemical analyses to characterize the Los Angeles oil with the aim of identifying specific characteristics of the source rock and its depositional environment. Two oil samples from the Cushabatay reservoir, taken at different depths, have been analysed to determine bulk properties, SARA composition, fingerprint GC-FID profile, light hydrocarbons and biomarkers. These data have also been complemented with a petroleum system modelling by testing all the potential source rocks and varying the thermal history.

Results

Geochemical analyses-
Both oil samples have very similar features. They are light oils (45º API) with low sulphur and metal (Ni, V) content. Their GC-FID fingerprint reveals a decreasing trend in the n-paraffin profile and a high content of volatiles (~ 40%). No biodegradation is detected from the chromatogram profiles. The Pr/nC_{17} versus Ph/nC_{18} plot places the measured ratios in the region characteristic of mixed type II/III oil/gas prone kerogen. The SARA compositional analysis reveals that these oils are very rich in saturated compounds and no asphaltenes are present. Polar compounds (resins) only represent about 6-7% of the composition. The analysis of light hydrocarbons allowed to estimate a temperature of oil generation of ~130 ºC.

Moreover, the Halpern and Thompson parameters support that the oils are mature and not biodegraded.

Biomarkers were analysed by GC-MS in the SPE-separated saturated and aromatic fractions. Maturity-related parameters based on the isomerization of homohopanes (H_{32} homolog, R and S isomers) and C_{29} ααα steranes (R and S isomers at C-20) have reached their equilibrium values indicating that the generating source rock was mature. The vitrinite reflectance calculated using the MDR parameter give values of ~0.8% at the peak of the oil generation window. The source-related triangular plot of C_{27}-C_{28}-C_{29} steranes shows predominance of the C_{27} steranes suggesting that the organic matter is predominantly of marine origin. This was also supported by the presence of C_{30} steranes specific of marine algae. The gammacerane index was low (< 10%), and no biodegradation-specific 25-norhopane biomarker, nor angiosperms-specific oleanane biomarker were detected. Low DBT/P and high diasterane/sterane ratios suggest a shale lithology. The low DBT/P ratios together with Pr/Ph ratios in the range 1.7-1.8 suggest that marine shales are the likely source rocks.

Petroleum system modelling-
After testing different burial, erosion, and thermal history scenarios, calibrated with present day temperatures and vitrinite data, the petroleum system modelling suggests that the most likely source rocks for Los Angeles oil are either Raya or Ene Formations, whereas Ambo and Cabanillas must be practically discarded because of their high maturity levels.

Conclusions

The geochemical analyses in combination with the detailed biomarker data have provided consistent data supporting that Los Angeles oils were sourced from a kerogen type II/III marine shale and were expelled at a mature stage. The petroleum system modelling suggests that the most likely source rocks for Los Angeles oil are either the Raya or Ene Formations. An oil-to-source rock correlation and petroleum migration modelling should be attempted to finally discriminate which is the most solid candidate to source Los Angeles oil.

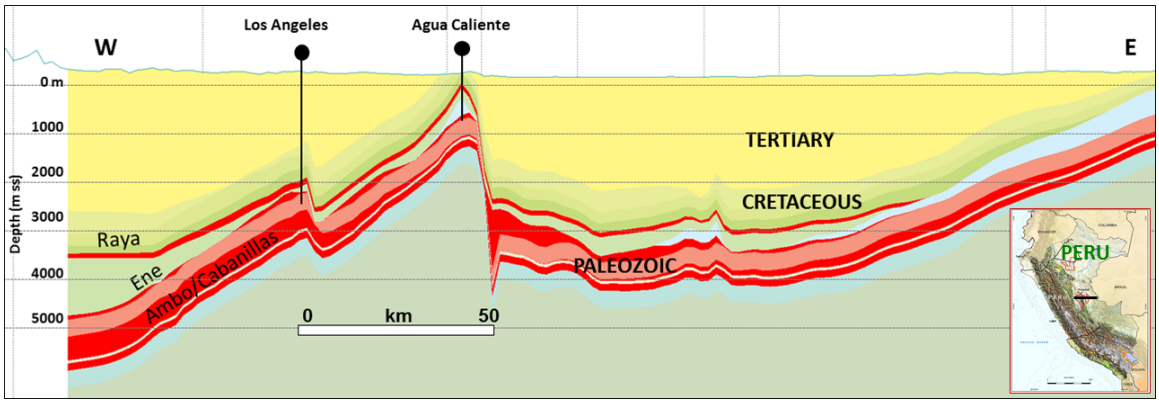

Figure 1. *Simplified regional cross section passing through Los Angeles and Agua Caliente oil fields. Potential source rocks for Los Angeles oil are indicated by red layers: Raya (Cretaceous), Ene (Late Permian), Ambo (Carboniferous) and Cabanillas (Late Devonian). Black line in the map shows the approximate location of the cross section.*