

BIOMARKER FINGERPRINTS FOR SOME REPRESENTATIVE OILS FROM THE NORTHEASTERN ORIENTE BASIN, ECUADOR: COMPOSITIONAL DIFFERENCES

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Introduction

The Oriente Basin in Ecuador is part of the foreland zone between the Andean Cordilleras to the west and the Guayana or Brazilian shield to the east. Most of Ecuador's oil reserves are located in the Oriente Basin, a part of the Marañon-Oriente-Putumayo foreland system which extends from Perú in the south to Colombia in the north. Oil and gas was generated by Upper Cretaceous shaly source rocks in the Napo Fm. Oil production comes from the Cretaceous T and U reservoirs within the Napo Fm, as well as the underlying Hollín Sands. The Napo Fm comprises a sequence of marine claystones, limestones and sandstones whose maximum thickness exceeds 700 m. The Napo Fm is informally divided into nine members from bottom to top (Baby et al., 2013): lower shales, T Sands, B limestones, middle shales, U Sands, A limestones, M2 and M1 (sandstones/limestones), as well as upper shales. Oil accumulations in the Oriente Basin can be attributable to a single petroleum system, though the location of source kitchen(s) is still debated. Thus, some authors proposed that hydrocarbons have migrated from mature kitchens located in the western basin or in southern Colombia. However, later data suggests that hydrocarbons might have been generated from Cretaceous source rocks located in the northwestern part of the Marañon Basin and the boundary between the Ecuadorian Oriente Basin and the Peruvian Santiago Basin (Baby et al., 2013).

Six samples of oil from the U sandstones were taken in various wells (Table 1) within the NE Oriente Basin for oil-oil correlation purposes. Saturates and aromatics were analyzed by gas chromatography-mass spectrometry on a GCMS-QP2010 Plus (Shimadzu). A capillary column DB-5ms (60 m × 0.25 mm i.d. × 0.10 µm film thickness, Agilent Technologies) was used. Carbon isotopic determination on SARA fractions was performed using a Thermo Finnigan 1112 elemental analyzer coupled to a Finnigan Mat Delta C mass spectrometer.

Results

The similar isotopic compositions of the samples (saturates and aromatics; see Table 1) might indicate that these oils were all derived from the same marine source rock. In addition, the samples showed relatively similar m/z 191 and 217 fragmentograms. The distribution pattern of regular steranes was $C_{27} \approx C_{28} > C_{29}$, as typically found in oil formed from marine sources of Cretaceous age or younger. Most oils showed pristane-to-phytane ratios (Pr/Ph) between 0.97 and 1.39 (Table 1), which agrees with the deposition of organic matter in a transitional marine environment under low-oxygen conditions, while the Pr/ n -C₁₇ and Ph/ n -C₁₈ ratios revealed that these samples lie into the zone that corresponds to oils generated from mature type II kerogen. Conversely, oils from Tiputini-1 and Ishpingo-1 showed Pr/Ph below unity, suggesting anoxic marine settings. Also, the latter two oils showed evidence of significant biodegradation. All the oils were characterized by C₂₆/C₂₅ below 1, as well as the

predominance of C₂₃-homolog with respect to C₂₄ (Table 1) and other counterparts, which is an indicator of organic matter of marine rather than lacustrine origin (Peters et al., 2005).

Table 1 Location and depth of sampled wells, bulk geochemical and molecular results

	VHR-1	Singue-1	Sansahuari-1	Cuyabeno-1	Tiputini-1	Ishpingo-1
Latitude	00°16'44"N	00°09'27"N	00°06'58"N	00°00'17"N	00°46'38"S	01°14'50"S
Longitude	76°21'11"W	76°17'03"W	76°17'33"W	76°15'31"W	75°34'30"W	75°36'58"O
Depth (m)	2539	2450	2520	2486	1627	1886
API gravity	31	24	24	26	17	16
Sulfur (wt%)	0.57	1.27	0.86	1.43	2.52	2.60
Pr/Ph	1.21	0.97	1.09	0.81	0.74	0.71
Pr/n-C ₁₇	0.77	0.99	0.95	0.88	1.09	1.13
Ph/n-C ₁₈	0.78	0.86	0.79	0.98	1.28	1.25
CPI	1.02	1.02	1.06	1.01	0.94	0.98
δ ¹³ C _{SAT} (‰)	-27.7	-27.9	-28.1	-27.5	-27.0	-27.2
δ ¹³ C _{ARO} (‰)	-26.0	-26.5	-26.4	-26.5	-26.8	-26.9
TT C ₂₄ /C ₂₃	0.59	0.56	0.63	0.49	0.38	0.39
TT C ₂₆ /C ₂₅	0.70	0.69	0.63	0.66	0.76	0.68
H C ₂₉ /C ₃₀	0.61	0.67	0.60	0.80	0.89	0.91
%20S	54	53	55	51	48	48
TA ratio	0.85	0.84	0.85	0.79	0.67	0.68

Tiputini-1 and Ishpingo-1 showed CPI values below 1, C₂₄/C₂₃ tricyclopolypropylene ratios below 0.4, similar relative abundances of 30-norhopane and hopane (Table 1), and presence of 29,30-bisnorhopane, indicating a carbonate source rock (Subroto et al., 1991). In contrast, higher proportions of diasteranes, CPI values above 1, absence of 29,30-bisnorhopane, a clear predominance of hopane over 30-norhopane, and C₂₄/C₂₃ tricyclopolypropylene ratios of around 0.6 (Table 1) would suggest that the other samples (except Cuyabeno-1) derived from siliciclastic source rocks (Peters et al., 2005). The major group of oils presented %20S ratios higher than 51% and TA ratios over 0.79, in contrast to Tiputini-1 and Ishpingo-1 showing %20S ratios equal to 48% and TA ratios below 0.7, which would be indicative of thermal maturity levels just after and before the peak oil window, respectively (Peters et al., 2005).

Conclusions

Results suggest that most oils can be grouped into at least two distinctive families. We conclude that two kitchen areas for hydrocarbon generation and expulsion from the same source rock (Napo-Chonta) have contributed to oil accumulations in the NE Oriente Basin. This has implied two oil charges (Baby et al., 2013): a latter during Late Miocene to Recent times (Tiputini-1 and Ishpingo-1 oils) and an earlier oil charge related to a less carbonate-rich subfacies in the Early Eocene. Cuyabeno-1 oil might represent a mixture of both oil charges.

References

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