GEOCHEMICAL STUDIES PROVE A PETROLEUM SYSTEM IN THE LOTIKIPI BASIN, KENYA, FEATURING A PROLIFIC LACUSTRINE SOURCE ROCK

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Introduction

Until Cepsa drilled Tarach-1 (2016) in Block 11A, Lotikipi Basin northwest (NW) Kenya, the presence of a proven Tertiary source rock was restricted to the Tullow operated Lokichar Basin blocks some 200 kms southeast (SE) of Cepsa´s block. The prolific lacustrine petroleum system of the Lokichar Basin has now yielded around 1 BBO recoverable resources.

Cepsa´s block is located at the junction of the N-S Tertiary East African Rift System and the NW-SE trending Cretaceous African Rift System. The existence of both, Tertiary and Cretaceous rift basins, should not be ruled out. The lack of stratigraphic control in the immediate area should not exclude the possibility of more than one rifting event. Outcrops of Plio-Pleistocene deposits, dominantly fluvio-lacustrine sediments, are present in the area; however, examples of older sedimentary sequences have not been identified in the block. Using neighbouring basin evolution as an analogue, the sedimentary fill was inferred to be a series of Miocene-age, stacked fluvial deltaic sandstones and lacustrine deposits, forming a sedimentary package of more than 3000 m thickness.

The Tarach-1 well was a frontier exploration wildcat. The well penetrated an intercalation of thick layers of volcanic rocks interbedded with shales and siltstones. The sequence drilled by the well is Late Oligocene to Middle Miocene based on biostratigraphy. The well did not encounter reservoir facies, however, it encountered two excellent organic-rich shale intervals.

In this study, we undertook the geochemical analysis of 81 cuttings sampled along the drilled sequence of Tarach-1. Rock-Eval pyrolysis, TOC measurements and petrographic studies were addressed for the evaluation of the kerogen type, the potential to generate hydrocarbons, the organic matter richness, and the thermal maturity of the rocks. GC-FID fingerprinting and biomarker analyses were only performed in the two selected zones of interest: the Lokhone shale D (1260-1320 m) and Lokhone shale E (1475-1505 m) intervals. Biostratigraphy, palynology, and isotube gas analyses have complemented these studies.

Results

Gas shows were recorded along the drilled sequence. Mud gas analyses revealed the presence of C1 to C5 gases, and measured $\delta^{13}C$ isotopic values for C1 indicated their thermogenic and oil-associated signature.

The GC-FID fingerprint profiles of samples from the Lokhone D interval showed abundant paraffins in the range nC_{23}-nC_{30} with the maximum in nC_{27}. Many lacustrine-sourced oils have been reported to be waxy with wax sourced by oil-prone algal biomass [1]. Biomarker analyses were carried out on the cuttings from the two identified zones of interest. Diverse biomarker ratios revealed that the two zones were composed of sedimentary shales deposited in a lacustrine setting, in agreement with the Rock-Eval data indicative of a prolific Type I source rock. This was strongly supported by the identification of botryoccoccane compounds biosynthesized by the race B fresh-brackish water lacustrine algae *B. Braunii*. Organic petrographic studies also corroborated these results by the observation of high abundance *B. Braunii* and *Pediastrum* colonial algae. These studies also revealed the presence of oil inclusions at the bottom of the Lokhone E interval. An anoxic environment was inferred from high pyrite sulphur levels and the preservation of botryococcane-derivatives.

Maturity-related biomarkers based on homohopane and sterane isomer ratios suggested that the rocks were immature to low mature. The Lokhone D interval seemed not to have entered the oil generation window. For these samples, the homohopane S and R isomer equilibrium had not been reached (figure 1, left) and a distinct pattern with most abundant less thermodynamically stable biologically synthesized ααα-R sterane isomers was clearly observed. The Lokhone E interval was comparatively more mature, with the relative proportion of homohopane S and R isomers closer to the equilibrium value (figure 1, right). These rocks are probably in the early oil generation window.

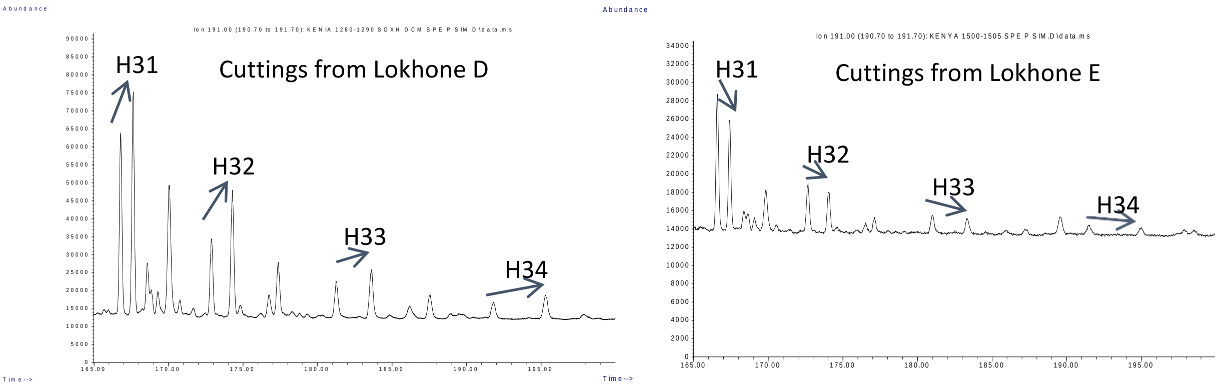

Figure 1 *Differences in thermal maturity between cuttings in the Lokhone D (left) and E (right) intervals. The different tendency in the R and S isomer intensities is highlighted with arrows.*

Conclusions

The geochemical data have confirmed the existence of a working petroleum system in the Lotikipi Basin. The stratigraphy encountered a sedimentary section interbedded with a dominant volcanic/volcaniclastic sequence, containing two excellent organic-rich shale intervals (Lokhone D and Lokhone E). The shales were deposited in a lacustrine environment under anoxic conditions. The lakes were developed at several levels and subjected to a number of strong volcanic episodes.

These units are immature to early oil mature at the well location. The Lokhone D shale interval is immature for oil generation, while the Lokhone E interval seems to be entering the oil generation window. 3D petroleum systems modelling calibrated with vitrinite reflectance, gas isotopes, and well temperatures have suggested that the oil kitchen may lie further to the southwest of the well location. Altogether, the analyses shown indicate the presence of a working petroleum system in the Lotikipi Basin with certain exploration potential.

References

[1] Farrimond, P., Green, A., Williams, L. *Petroleum geochemistry* 21 (2-3): 125-135 (2015).