A Novel Oil Opens Up a New Play Beneath the Gadiaga Gas Field, Senegal*

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Abstract

The Gadiaga Gas Field is located onshore Senegal to the northeast of the capital, Dakar. This field, operated by Fortesa International-Senegal, supplies the only production in Senegal. All wells encountered gas and minor condensate with production from Campanian to Lower Santonian sandstones. Interbedded claystones provide seal. Production is slowly declining and the field is regarded as mature. However, oil has been unexpectedly encountered in tests at Gadiaga and it had been commercially produced from the nearby Diam Niadio Field.

Introduction

The sandstones were deposited in intra-slope channels fed from a delta. This associated succession overrode and buried a Lower Cretaceous to Middle Jurassic carbonate bank that had formed along almost the entire length of North West Africa following the onset of drift in the early Jurassic. By the time the bank ceased growth in the Albian, it separated shallow water settings to the east from increasingly deepwater environments to the west. Loading instability developed along the ocean-facing margin in the Cretaceous cover section with the development of multiple listric fault-growth anticline pairs. Both the Gadiaga and the Diam Niadio Fields lie within this trend (Figure 1).

Discussion

In 2014, the Cairn Group discovered to the south of Dakar the giant SNE Oil Field, which is positioned on the then shelf. To the west and in depositional settings analogous to Gadiaga, they had success with their FAN-1 oil and gas discovery. From 2015 onwards, Kosmos Energy has found in a trend broadly west of Gadiaga some 50 TCF of gas. The origin of all this offshore oil and gas is considered the Albian to Turonian sources intersected further west in DSDP core holes 367 and 368. Historically it was assumed that the Gadiaga and Diam Niadio hydrocarbons originated by updip migration from the same source beds. This possibility was discarded after two light oils recovered from unexpected finds in Coniacian sands were geochemically analysed (Figure 2).

Results

The biomarkers revealed that these oils originated from a littoral marine or lacustrine source that is from an environment incompatible with mid-Cretaceous deepwater settings of the DSDP sources (Figure 3 and Figure 4). Subsequently it was found that the same biomarkers characterised all of Fortesa's oils and condensates, plus those from the Diam Niadio Field.

It had been previously suggested from seismic that a broad basin underlay the oldest Jurassic bank carbonates and it was speculated by others that this region might contain Lower Jurassic sources related to those known from Morocco and the American Atlantic coast. Mapping by FEC found that this basin runs the entire length of Senegal. Though it cannot be proved that this horizon is the source of the Gadiaga and Diam Niadio oils, this basin's rift-drift transition setting matches that indicated by these new biomarkers. The maturities obtained from the gas carbon isotopes appear consistent with the maturities obtained from the oils and condensates. The gasoline data for the oils and condensates reveal a history of evaporitic fractionation (Figure 5). The geothermal gradient for the wells indicates that the gases are derived, assuming vertical migration, from the same depth as the seismically defined, lower Jurassic section.

Conclusions

The lesson from Gadiaga is that it is never too late to cease being inquisitive about the workings of even mature fields. Pointers are readily overlooked if it assumed that nothing new remains to be found or learnt. The result in this case is a new deep source and multiple new play opportunities.

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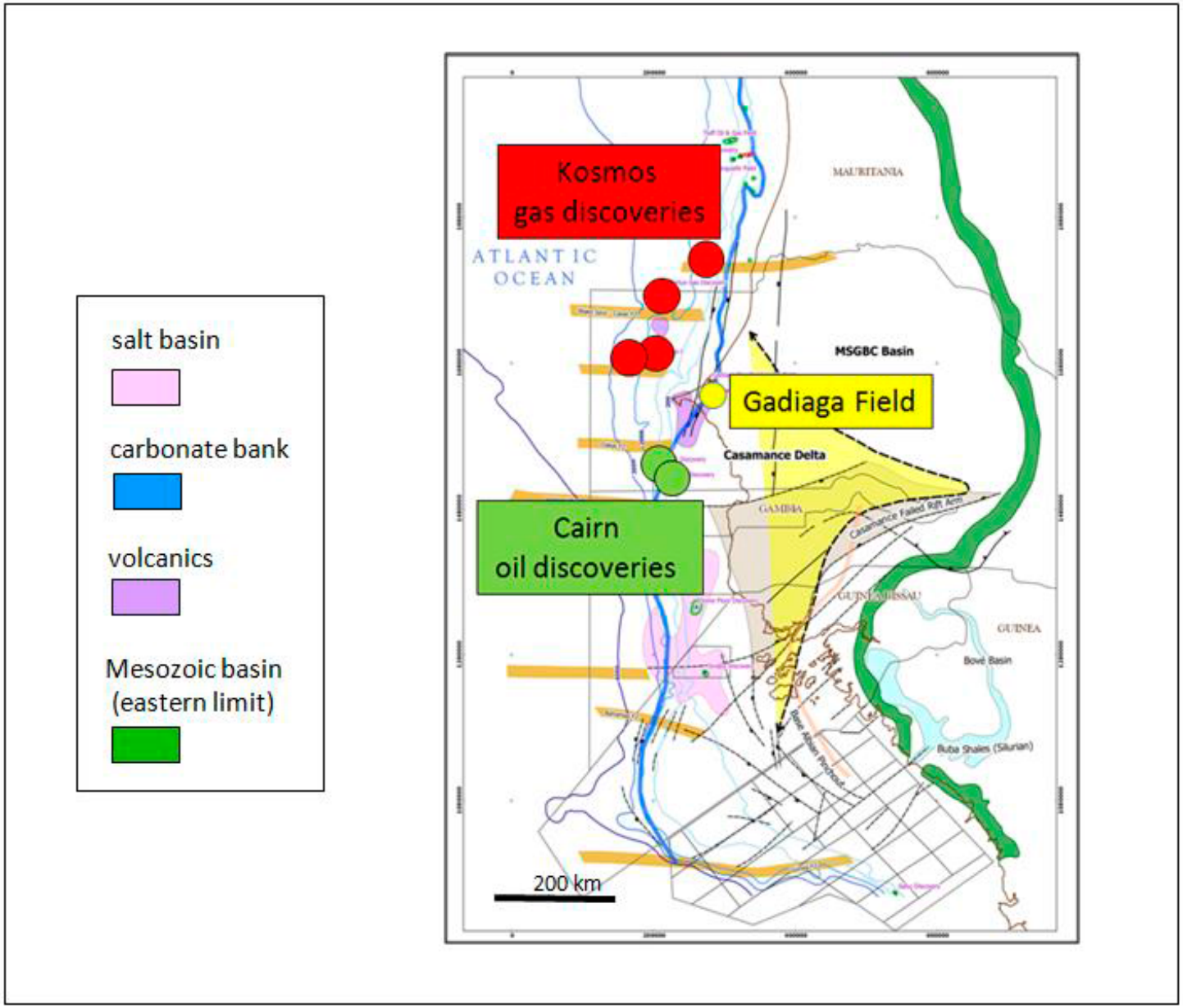

Figure 1. The geological setting of the Gadiaga Field.

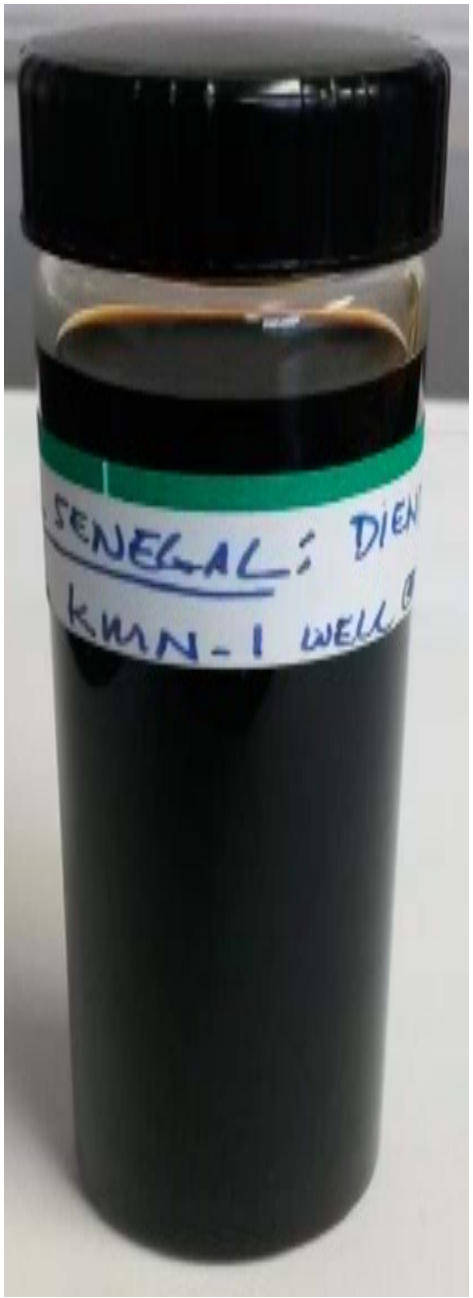

Figure 2. The KMN-1 oil. This was the first of the two Gadiaga oils to be analysed and the results provided the impetus for additional work.

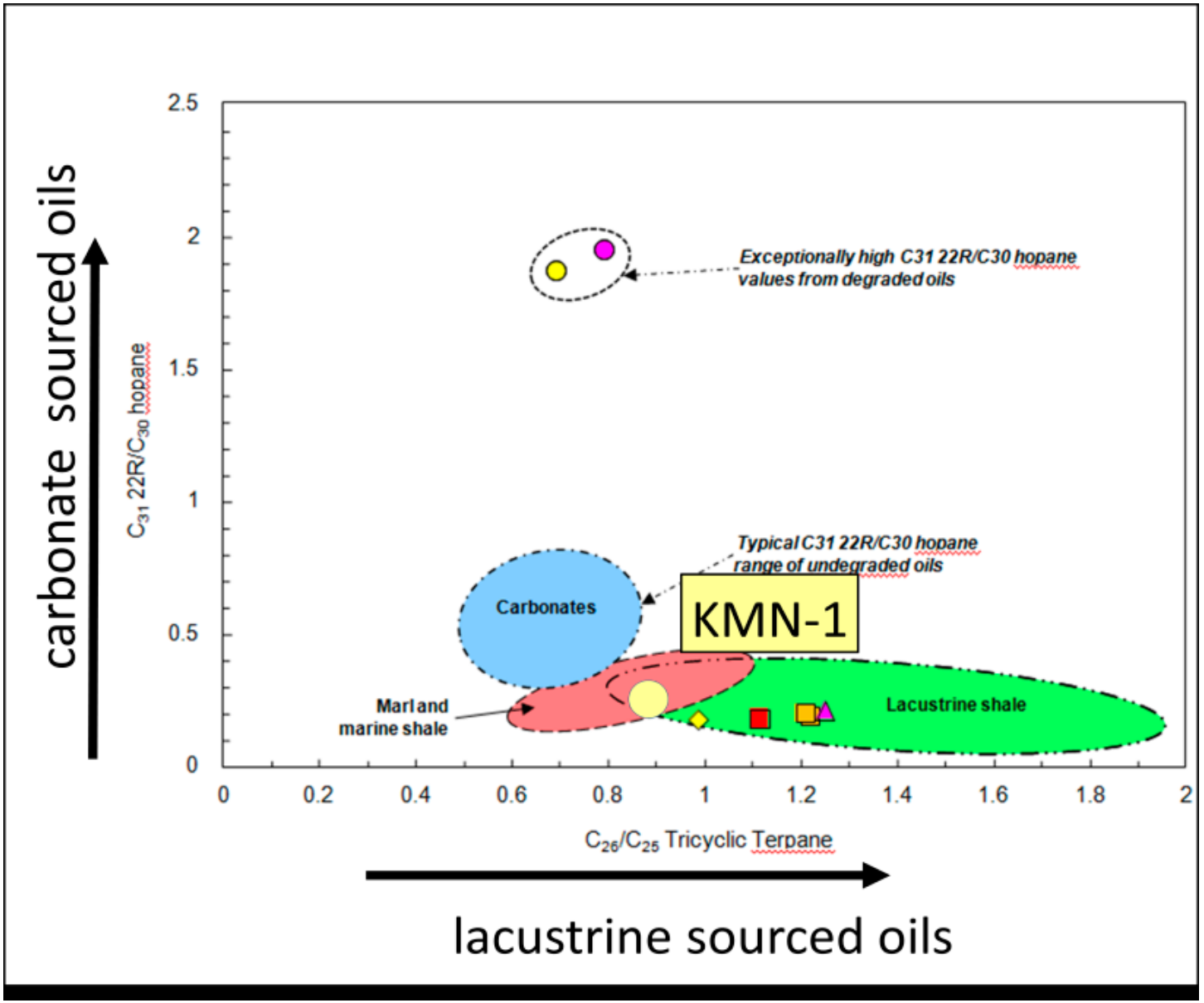

Figure 3. Terpane biomarker plot for the KMN-1 and other wells. The occurrence of the C30 tetracyclic polyprenoid (TPP) biomarker in nearby wells is consistent with the indicated high C26/C25 ratios. The low sterane/hopane ratios (mostly <1) for Gadiaga oils) are also consistent with a lacustrine source.

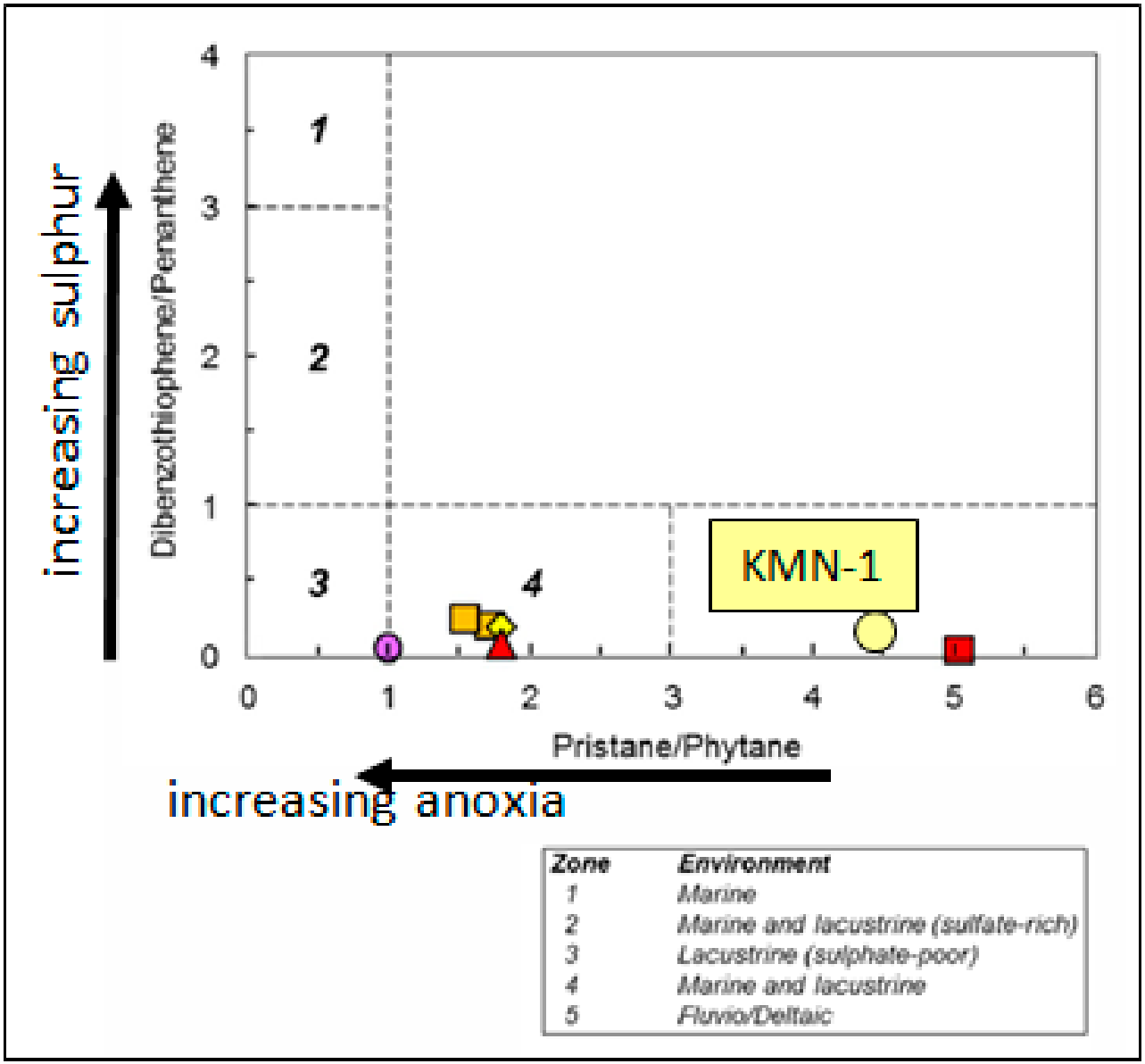

Figure 4. DBP/Phen vs. Pr-Ph plot. The source was associated with anoxia and had limited marine connections. Such settings are incompatible with the palaeogeography of the established, mid-Cretaceous, marine sources.

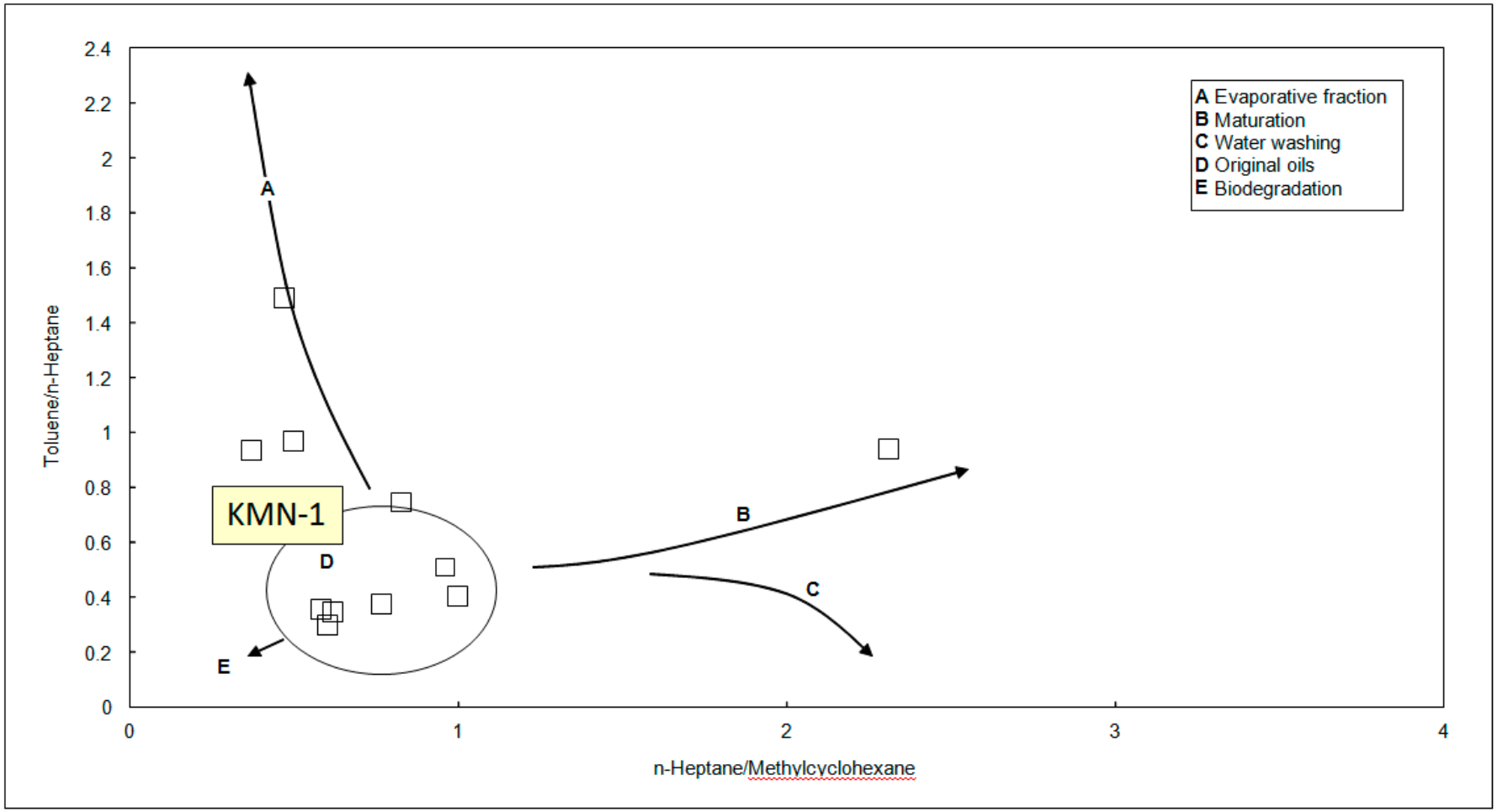

Figure 5. Gasoline plot. The condensates are the result of the evaporative fractionation related to the inversion associated with the Eocene aged, Dakar Dome magmatism, plus earlier tectonics.