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Research Article

Oil Geochemistry of the Middle Kura Basin, Azerbaijan

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Abstract Results are given of geochemical studies of oils and pyrolysis of core samples from fields of the Middle-Kura depression. The majority of the studied oils originated from organic matter deposited in a saline lacustrine environment with some terrestrial input. Slight differences in the steranes and hopane distributions together with a lack of β-carotane of the West Gyurzundag-1, Palantekian-2 oils were established. Based on biomarker data, rock pyrolysis and paleo- and recent temperature conditions the oils in the Middle Kura basin were generated from middle mature Tertiary (and probably also from Cretaceous) sediments.

Keywords Oil, Geochemistry, Biomarker, Source rocks, Organic matter, Origin, Maturity, Middle Kura Basin, Azerbaijan

1. Introduction

The object of this study is a part of the intermontane Kura depression, located between the Greater and Lesser Caucasus, and one of the largest structural elements in the Caucasus. Based on the geological structure the Kura depression is subdivided into three parts: Upper Kura, Middle Kura and Lower Kura depressions [1]. The whole Lower Kura depression and the major part of the Middle Kura depression are located within the Azerbaijan Republic; the residual part is located in Georgia (Fig. 1).

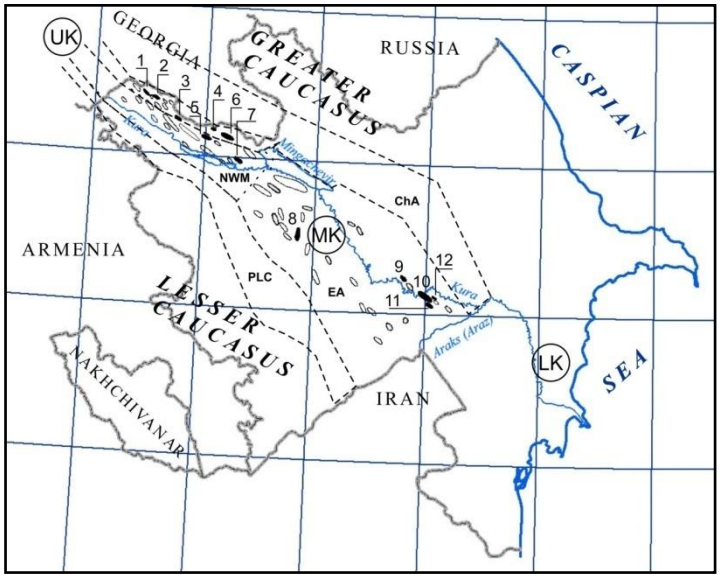

Figure 1: Locations of the studied areas and fields in Middle Kura basin

Depressions UK – Upper Kura; MK – Middle Kura; LK – Lower Kura*: Areas:* EA – Evlakh-Agjabedi depression; ChA – Chatma-Ajinour zone; PLC – PreLesser Caucasus zone; NWM – zone of North-West flank of the Middle Kura depression (Kura-Gabyrry interfluve). *Oil fields:* 1 – Udabno; 2 – Damirtepe-Udabno; 3 – Molladag; 4 – Agtepe; 5 – West Gurzundag; 6 – Boyuk Palanteken; 7 – Tarsdallar; 8 – Naftalan; 9-Zardab; 10 – Muradkhanly; 11 – Jafarli; 12 – Shaftakhal.

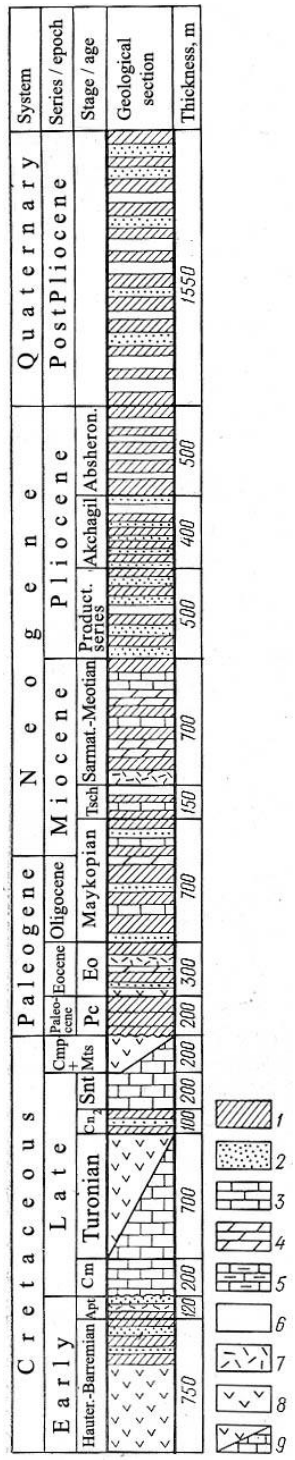

Figure 2: Generalized geological section of eastern part of Middle Kura basin (Evlakh-Agjabedi depression): 1 – clays; 2 – sands; 3 – limestones; 4 – marls; 5 – dolomites; 6 – sandstones; 7 – tuffs, tuff-sandstones, tuff-breccia, tuff-conglomerates; 8 – effusive rocks; 9 – replacement of effusive formations with carbonate sediments.

The Middle Kura depression, one of the prospective geological objects in Azerbaijan, differs significantly from the Lower Kura depression based on the evolution history, specific features of the geological structures and the number of hydrocarbons reserves together with the stratigraphic intervals of oil-gas content of the sedimentary section.

Two structural complexes are defined in the section of the Alpine sedimentary cover of the Middle Kura depression. These complexes involve Mesozoic-Eocene sediments covered by Oligocene-Anthropogene sediments that are composed of orogenic molasses complex (Fig. 2). The sedimentary cover (with a thickness of 12-14 km) lies on the Pre-Alpine metamorphosed basement, complicated by faults. The majority of these faults fade as sedimentary cover thins.

The geological section is composed of sedimentary, effusive and intrusive rocks, reefogenic massifs, zones of disconformities and sediments pinching out, etc. Over 100 structures have been found in the section of the Middle Kura depression; some having commercial oil-gas content. The oil-gas content covers the Late Cretaceous – Paleogene – Neogene stratigraphic interval.

Despite extensive geologic-geophysical studies and the great number of exploration wells, the success in finding new oil and gas deposits in the Middle Kura depression is very low. One possible reason is the limited study of the genetic aspects of hydrocarbon deposits forming here, based on the geochemical studies of oil compositions and their correlation.

Therefore, here are provided the results of modern geochemical studies of oils and pyrolysis of some core samples from the fields of the Middle Kura depression.

2. Results and Discussions

The oils analyzed come from three different tectonic regions of the Middle Kura basin: uplifts of the basin's northern flank (Kura-Gabyrry interfluve), the Lesser Caucasus foreland and the Evlakh-Agjabedi depression (see Fig. 1).

The Kura-Gabyrry interfluve area is considered to have good prospects with the main reservoirs being the clastic and carbonate sections of the Upper Cretaceous and Eocene. The samples in this study are all from sandstone reservoirs in the Eocene.

In the Lesser Caucasus foreland depression (also known as Gyanja region) only small accumulations of oil have been discovered in the Paleogene - Miocene sediments (Maykop Series) and this area is considered to have poor potential.

The Evlakh-Agjabedi depression is considered to have good prospects. The main field in this area is the Muradkhanly which has plays in the Upper Cretaceous, Eocene and Maykop.

The reservoir depths of the studied oils are generally between 3058 m and 5129 m, the one exception being the Naftalan Field where the reservoir is relatively shallow (500 m-600 m).

The studied oil fields, stratigraphic ages and depths of reservoirs are shown in Table 1.

Table 1: Parameters of studied oil fields within the Middle Kura basin

Field, well	Tested depth interval (m)	Age of reservoir
	Kura-Gabyrry interfluves	
Demirtepe- Udabno, 7	4200	Eocene
West Gyurzundag, 1	4230-4450	Eocene
Palantekyan, 2	5112-5129	Eocene
Tarsdallyar, 1	–	Eocene
	Lesser Caucasus foreland depression	
Naftalan, 51	500-600	Oligocene- L.Miocene
	Evlakh-Agjabedi depression	
Zardob, 7	4093-4175	Eocene
Shaftakhal, 250	4200	Eocene-Oligocene

The correlation of oils shows that oils from the Kura-Gabyrry interfluve and the Evlakh-Agjabedi depression have similar geochemical characteristics, but the Naftalan oil from the Lesser Caucasus foreland is heavily biodegraded and its correlation with other oils is not possible (Fig. 3).

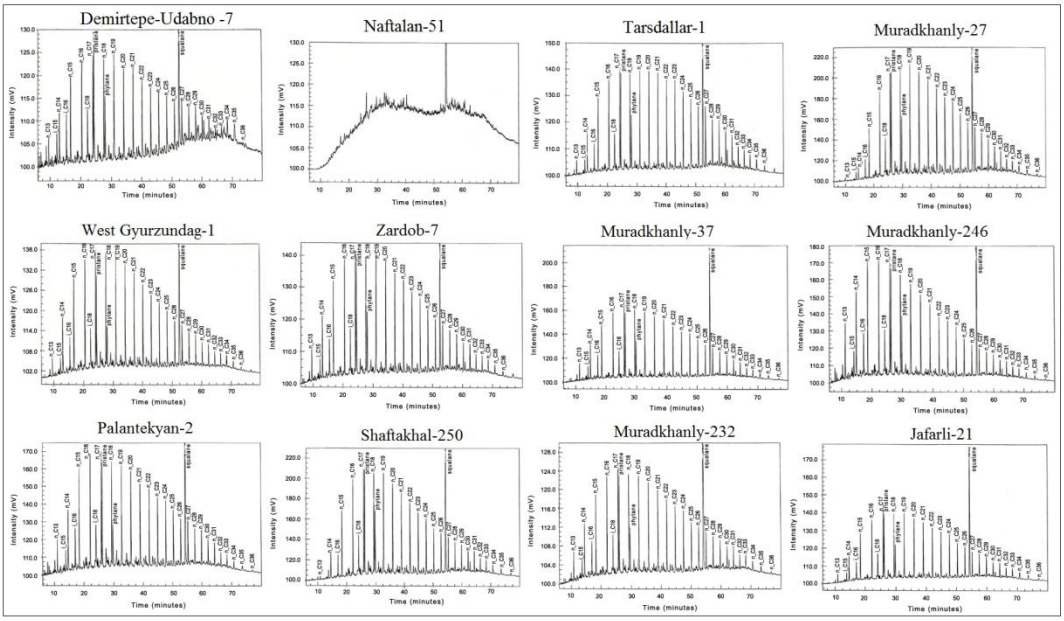

Figure 3: Alkane gas chromatograms of Middle Kura oils

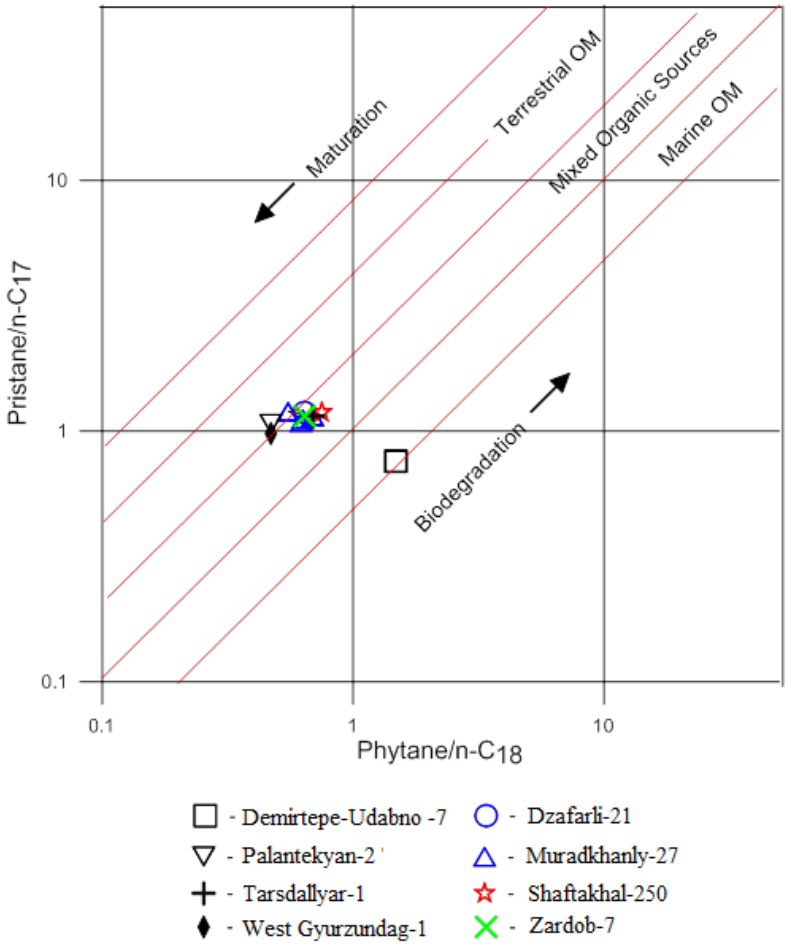

Figure 4: Cross-plot of Pr/n-C_{17} vs. Ph/n-C_{18} for oils of the Middle Kura depression

Whole oil and alkane gas chromatograms for all oils show distributions typical of oils sourced from marine sapropelic organic matter (OM) with some terrestrial input. For all oils normal alkane ratios such as CPI-1 and CPI-2 vary from 1.04 to 1.16, typical for immature kerogene and an oxic environment deposition for the source rocks. The ratio of isoprenoids to n-alkanes (Pr/n-C_{17} and Ph/n-C_{18}) is high also indicating that the oils were generated at a low level of thermal maturity and their relationship supports the premise of oil generation from terrestrial organic matter (Fig. 4). The pristane/phytane ratio (Pr/Ph) ranges from 1.58 to 2.46 indicating terrestrial organic source input [2].

The oils contain small quantities of oleanane indicating that the source sediments are Upper Cretaceous or Tertiary in age. The oils all contain small quantities of C_{30} diahopane (compound X) which is indicative of terrestrial source input. All the oils (except West Gyurzundag-1 and Palantekyan-2) contain β-carotane indicating a saline lacustrine depositional environment. The Ts/Tm ratio indicates possible differences in the source facies between the West Gyurzundag-1 and Palantekyan-2 oils. The distribution of C_{27}, C_{28} and C_{29} normal steranes (Fig. 5) and iso- and dia-steranes (Fig. 6) compounds shows a strong correlation between all the oils of the Middle Kura Depression but, again, these data may indicate subtle differences between the main family of oils and the West Gyurzandag-1 and Palantekian-2 oils.

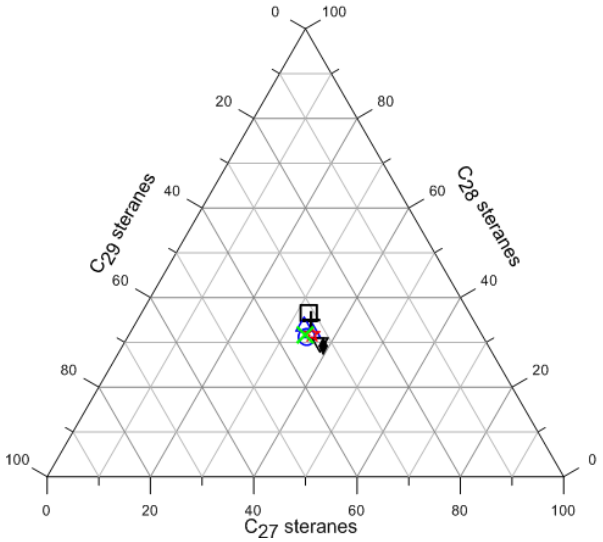

Figure 5: Correlation of the Middle Kura depression oils from distribution of C_{27}:C_{28}:C_{29} normal steranes (conventional signs see Figure 4)

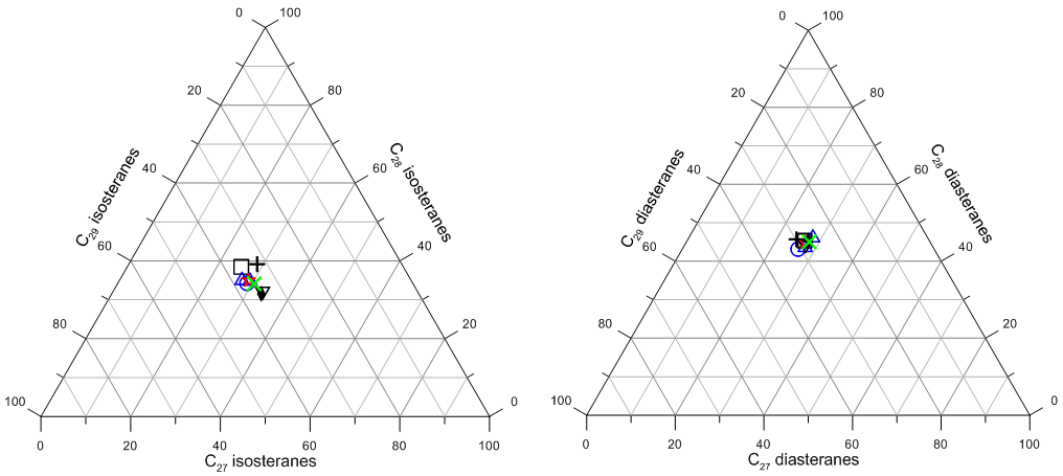

Figure 6: Correlation of the Middle Kura depression oils from distribution of C_{27}:C_{28}:C_{29} isosteranes (on the left) and diasteranes (conventional signs see Figure 4)

Slight difference of the West Gyurzandag-1, Palantekian-2 and Demirtepe- Udabno-7 oils appeared also in the distribution C_{29} steranes, isosteranes and diasteranes (Fig. 7).

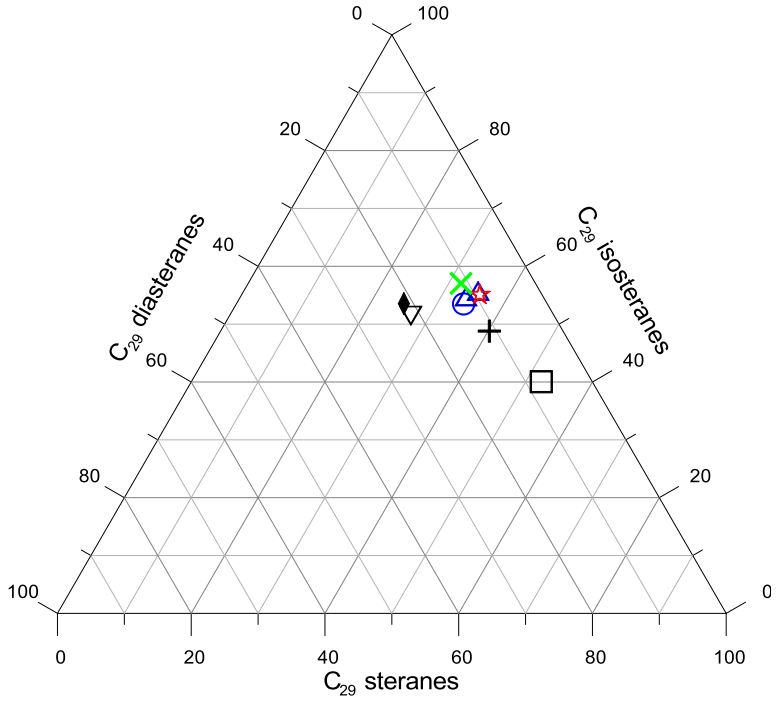

Figure 7: Correlation of the Middle Kura depression oils from distribution of C_{29} steranes, isosteranes and diasteranes (conventional signs see Figure 4)

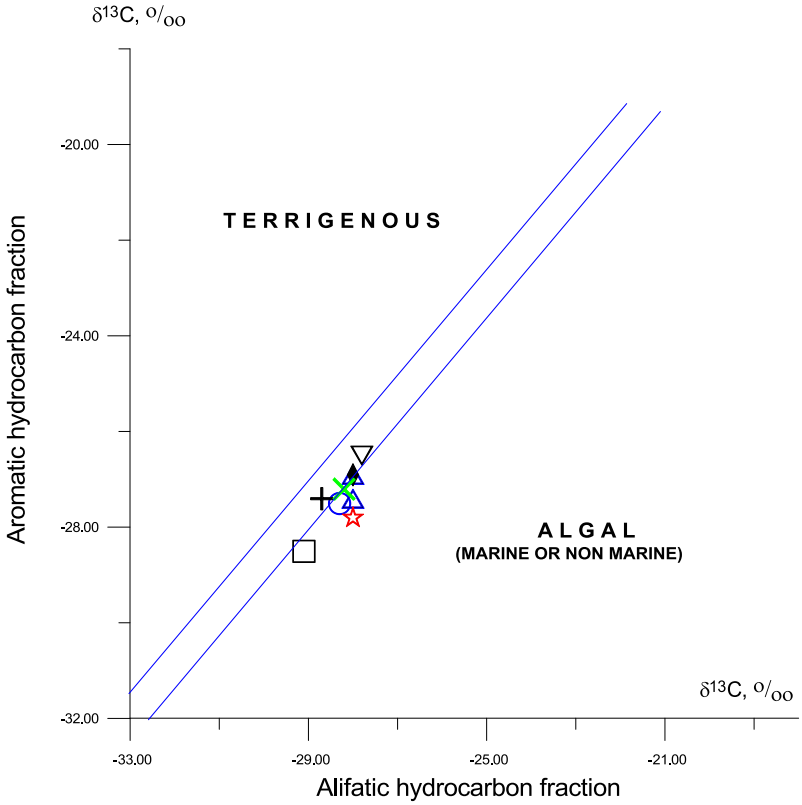

Figure 8: Distribution of carbon isotopes in the Middle Kura basin oils (conventional signs see Figure 4)

Generally, the more or less equal proportions of C_{27} and C_{28} compounds indicate a mixture of marine and terrestrial organic source inputs [3-5].

All oils are characterized by a relative abundance of hopane C_{30} over sterane C_{29} (hopane/sterane ratio varied from 1.43 to 3.67) that testifies to an association with bacterial degradation of higher plant-derived organic matter in an anoxic depositional environment. The lowest hopane/sterane ratio is typical for West Gyurzundag-1 and Palantekyan-2 oils.

The subtle differences between the steranes and hopane distributions and the lack of β-carotane suggests that the West Gyurzundag-1 and Palantekyan-2 oils were generated from a more marine source facies than the other oils.

The carbon isotope ratios show a strong correlation between all the oils of the Middle Kura Depression. Alkane carbon isotope values range from -27.8‰ to -29.1‰ and aromatic carbon isotope values range from -26.5‰ to -28.5‰. These values indicate a mixed marine and terrestrial organic source for the oils (Fig. 8). Based on $\delta^{13}C$ values of alkane and aromatic fractions all the studied oils correspond to oils formed in coastal-marine and delta conditions. This result is also supported by ratios of isoprenoides (Pr/Ph) and isoprenoides to normal alkanes. Accordingly the composition of initial organic matter had a mixed continental-marine character with predominance of sapropelic OM [6-8].

The physical properties show some differences between the oils from the Kura-Gabyrry interfluve and oils from the Evlakh-Agjabedi depression which are more than 150 km apart.

The API gravities of oils from the Kura-Gabyrry interfluve are low (25.7°-26.1°) and those of the oils from the Evlakh-Agjabedi depression are generally higher (24.0°-31.5°, average 28.6°). The nickel content in oils from the Evlakh-Agjabedi depression is moderately high (21-41 ppm) but from the Kura-Gabyrry interfluve is low to moderate (4-10 ppm). These variations in API gravity and metal content may be due to post-generation processes rather than differences in source facies. The sulphur content of the oils from both regions is generally low to moderate (0.39%-0.91%) except for the Demirtepe-Udabno-7 oil which has relatively high sulphur content (2.2%). Note that this oil appears to have been generated at a lower level of maturity than the other oils as seen by the abundance of biomarkers on the alkane gas chromatogram and several biomarker maturity parameters. This high sulphur oil is isotopically the lightest oil among all oils of the study area.

The oils from the Middle Kura Depression may be classed as a single family of oils sourced from Tertiary sediments with mixed marine and terrestrial organic matter. Within this family there are some variations of source facies with the majority of the oils having a saline lacustrine environment of deposition but the West Gyurzundag-1 and Palantekyan-2 oils having a more marine influence on the source facies. The Demirtepe-Udabno-7 oil may also have been sourced from slightly different facies from the main oil family.

No biomarker data are available from possible source sediments in this area and therefore no correlations can be made between the oils and source rocks. There are only some estimates of hydrocarbon potential of Paleogene rocks from fields of the Kura-Gabyrry interfluve area, based on the content of total organic carbon and hydrocarbons ((S_1+S_2) pyrolysis parameter) (Table 2).

Table 2: Geochemical parameters of Paleogene rocks from fields of Kura-Gabyrry interfluve area

Field, well	Age	Depth interval, m	Ro, %	TOC, %	S_1+ S_2, mg HC/g rock
Tarsdallyar, 12	Maykop	3654-3664	0.4	1.3	3.1
Tarsdallyar, 12	Maykop	3872-3882	0.5	1.3	4.3
Tarsdallyar, 27	U.Eocene	2934-2944	0.4	1.0	2.0
Tarsdallyar, 27	M.Eocene	3061-3071	0.5	0.1	0.2
Agtepe, 2	Maykop	3165-3175	0.4	1.9	4.2
Molladag, 1	Maykop	3100-3105	0.45	1.2	1.9
Molladag, 1	U.Eocene	3472-3476	0.5	1.6	4.6
B.Palantekyan, 3	Maykop	3650-3657	0.45	1.1	1.9
B.Palantekyan, 3	U.Eocene	4700-4710	0.82	2.1	9.3

The Oligocene-low Miocene deposits (Maykop Series) are a well-known regional source rocks [9]. Data

provided in Table 2 confirm the high petroleum potential of the Mykopian rocks in the Kura-Gabyrry interfluve area. However, the immature level of Maykopian OM casts doubt on the possibility of the realization of its potential. Biomarker maturity ratios show that all oils were generated at similar levels of maturity in the main oil window (R_{eq} 0.65-0.80 %). These data, together with data on the maturity of the OM of Eocene rocks (see Table 2), recent temperature in Eocene formations (around 121°C) as well as the industrial oil content in middle-upper Eocene rocks, allow one to attribute the source rocks in the Kura-Gabyrry interfluve area. These rocks are represented predominantly in clay lithofacies with thin layers (reaching in rare cases 1.0-1.5 m) of dense sandstones.

In the Evlakh-Agjabedi area recent temperatures in the Maykopian formation are about 112-116°C, favorable for mature oil generation. However, pyrolitic studies of rocks of the Maykopian series show that these sediments are characterized by low maturity (Tmax values), in rare cases reaching R_{eq} 0.65 %. This result is not in agreement with oil maturities from the Cretaceous, Eocene and Oligocene-Miocene reservoirs. Oils from these reservoirs are characterized by greater maturity corresponding to vitrinite reflectance equivalent Req=0.70-0.73% (calculated by the degree of sterane isomerization and isosterane/normal sterane ratio) [10]. Thus the oil-gas generation focuses on the Evlakh-Agjabedi depression, as well as Kura-Gabyrry interfluve, mainly corresponding to Eocene sediments.

Because of the absence of oil biomarker and pyrolysis data for Mesozoic deposits in Middle Kura depression, it is impossible to estimate the generative potential. In this connection note that one has commercial oil flows from Late Cretaceous sediments during the drilling of some exploration wells. Thus, in the Sovetlyar field (well #9) the fountain oil flow (with a yield of 500 tons/day) was obtained from the contact of the Paleocene and Late Cretaceous sediments. In the Sovetlyar field, in well #1 from the similar contact zone 150 m^3/day of fluids have been obtained of which 20 tons were oil. In the same field (in well #2) the fluid fountain with a yield 4000 m^3/day was obtained from the Late Cretaceous with 18 tons oil and 2 thousand m^3 gas. Oil inflow (with a yield of 160 tons/day) has been obtained in the Tarsdallar field in well #4 [11]. These data provide the reason to indicate the favorable source rock potential of Cretaceous sediments too (most probably Low Cretaceous).

Conclusion

Biomarker data, results of rock pyrolysis, paleo- and recent temperature conditions show that the oils in the Middle Kura basin were generated from middle mature Tertiary (and probably from Cretaceous) sediments which were deposited in a saline lacustrine environment with input of terrestrial organic matter.

References

[1]. Geology of Azerbaijan, 2005.Volume IV. Tectonics. Baku. Nafta-Press, 506 p. (in Russian).

[2]. Peters K.E., Moldowan J.M., Shoell M. and Hempkins W.B., 1986. Petroleum isotopic and biomarker composition related to source rock organic matter and depositional environment. *Org. Geochemistry*, **10**, 17-27.

[3]. Peters K.E. and Moldowan J.M., 1993. The Biomarker Guide: interpreting molecular fossils in petroleum and ancient sediments. Prentice-Hall, New Jersey, 363 p.

[4]. Mackenzie A.S., 1984. Application of biological markers in petroleum geochemistry. *Advances in Petroleum Geochemistry*, **1**, 115-214.

[5]. Requejo A.G., 1992. Quantitative analysis of triterpane and sterane biomarkers: Methodology and applications in molecular maturity studies. In: Biological Markers in Sediments and Petroleum (J. M. Moldovan, P. Albrecht and R. P. Philp, eds.). Prentice-Hall, Englewood Cliffs, NJ, 222-240.

[6]. Sofer Z. 1984. Stable carbon isotope composition of crude oils: Application to source depositional environments and petroleum alteration. *The American Association of Petroleum Geologists Bulletin*, **68(1)**, 31-49.

[7]. Chung H.U., Rooney M.A., Toon M.B. and Claypool G.E., 1992. Carbon isotope composition of marine oils. *The American Association of Petroleum Geologists Bulletin*, **76(7)**, 1000-1007.

[8]. Collister J.W. and Wavrek D.A., 1996. $\delta^{13}C$ composition of saturate and aromatic fractions of lacustrine oils and bitumens: evidence for water column stratification. *Org. Geochemistry*, **24(8/9),** 913-920.

[9]. Guliyev I.S., Feyzullayev A.A., Huseynov D.A., 2008. Organic matter and hydrocarbon fluids geochemistry. In "Geology of Azerbaijan". Volume VII. Oil and Gas. Baku. Nafta-Press, 672 p. (in Russian).

[10]. Guliyev I.S., Feyzullayev A.A., Huseynov D.A. 2000. Oil maturity from different age reservoirs in South Caspian basin. *Oil and Gas Geology*, **3**, 41-50 (in Russian).

[11]. Rakhmanov R.R., 2007. Regularities of formation and distribution of the petroleum pools in Mesozoy-Cainozoic deposits of Evlakh-Agjabedi trough. Baku, Taknur, 190 p. (in Russian).