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IDENTIFICATION OF OIL FAMILIES IN HORIZONS XIII-XV OF UZEN AND KARAMANDYBAS FIELDS BY OIL FINGERPRINTING ANALYSIS

Seitkhaziyev Y.Sh.[1,2], DaumsharovA.A[1].

[1]*Atyrau Branch of LLP «KMG Engineering», Atyrau, Kazakhstan*
Building 10, pr. Elorda, md. Nursaya, Atyrau, Atyrau region,
Republic of Kazakhstan, 060097: esimhan89-89@mail.ru
[2]*«Oilgasscientificresearchproject» Institute, SOCAR, Baku, Azerbaijan*
88A, Zardabi avenue, Baku, AZ1012

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Summary. Geological exploration data indicates that effective application of available databases in combination with other methods enables to avoid drilling dry exploration wells. For instance, the integration of geochemical and geophysical data has been shown to enhance exploration outcomes by a factor of more than two when compared to the use of geophysical data in isolation. For this present study 201 oil samples were collected from wellheads of producing wells in Uzen and Karamandybas fields in 2023. The objectives of the study were (i) to assess reservoir continuity and compartmentalization studies by oil fingerprinting analysis of oils from horizons XIII-XV, (ii) to characterize source rocks of representative oil samples in terms of environmental condition and thermal maturity by biomarker analysis and (iii) to integrate the obtained outcomes to draw viable conclusion from geological point of view. Oil fingerprinting analysis showed three distinct groups in horizon XIII and four different groups in horizon XV. It should be noted that the oils from the first group (red) predominate in both horizons XIII and XV indicating good reservoir continuity between them. Biomarker analysis of representative oils showed that oils from upper horizons (XIII-XV) were generated from shaly lacustrine organic matters (OM), while those of lower horizons were from shaly marine OM(XXII-XXIV) and with depth increase the thermal maturity of oil samples rise.

Introduction

A review of global practice reveals that the effective application of available databases in conjunction with techniques can prevent from drilling dry holes. The combination of geochemical and geophysical data has been demonstrated to yield exploration results that are more than double those obtained from geophysical data alone (Ganz et al., 1999; Ganz, Hempton, 2005; Peters, Fowler, 2002; McCaffrey et al., 2012; Pim et al., 2018; Dekker et al., 2017; Stout et al., 2001; Chemodanov et al., 2023; Suleimanov, Abbasov, 2022; Suleimanov et al., 2023; Suleimanov et al., 2017; Suleimanov et al., 2022; Suleimanov et al., 2022a; Vishnyakov et al., 2019).

For instance, according to experts from Shell, oil fingerprinting from drilled well #21116-A10 (green) did not correspond to oils from neighbouring fields such as Eider (red), Tern (yellow), and Cormoran (blue) (Fig. 1). However, using the North Sea Oil fingerpinning Atlas, this oil appeared to be similar with that from Otter field, indicating the secondary hydrocarbon migration pathway from the northeast direction. According to this data, a well was drilled in the vaulted part along the fault direction and high amount of oil was found highlighting the significance of the geochemical atlas application. Shell experts claimed that successful well would not have been drilled without this information.

As can be observed, geochemistry yields favorable outcomes at the outset of geological exploration although the role of geophysics becomes increasingly significant with the increasing depth of drilled wells. Geochemical studies of oil are conducted on a variety of gas chromatography and chromato-mass spectrometer, enabling the detailed genetic characterization of oils (Sarsenbekov et al. 2018; Seitkhaziyev 2019, 2020, 2021, 2022).

Oil fingerprinting

For this present study, 201 oil samples were collected from wellheads of producing wells in Uzen and Karamandybas fields in 2023. The objectives of the

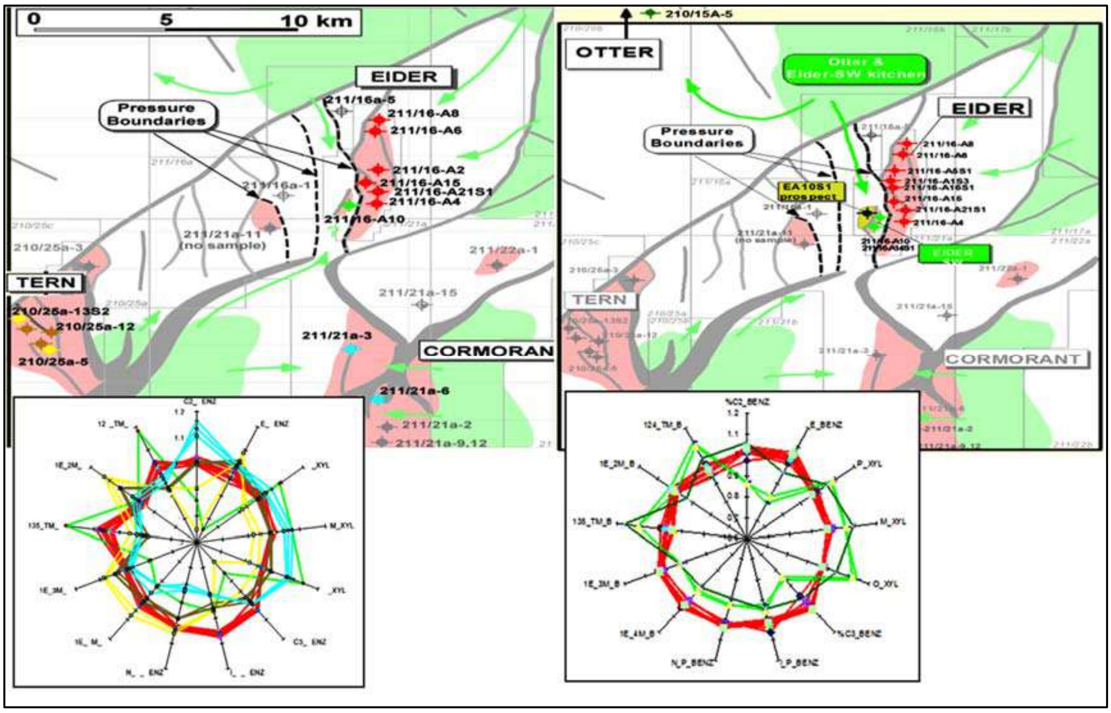

Fig. 1. The reproduction of oil migration direction and reservoir filling is based on the results of oil fingerprinting (Ganz et al., 1999).

study were: (i) to assess reservoir continuity and compartmentalization studies by oil fingerprinting analysis of oils from horizons XIII-XV, (ii) to characterize source rocks of representative oil samples in terms of environmental condition and thermal maturity by biomarker analysis and (iii) to integrate the obtained outcomes to draw viable conclusion from geological point of view.

As oil fingerprinting method, 12 aromatic peaks in oils from Low-thermal mass-multidimensional gas-chromatography (LTM-MD-GC) were employed to plot star-diagrams which exhibit similarities and differences between different oils derived from various pay zones: Identical star diagrams of oils attest to good reservoir continuity, whereas the opposite trend is true for reservoir compartmentalization.

Oil fingerprinting studies demonstrated the presence of 16 oil families within Uzen and Karamandybas fields. For convenience of comparison of oil compositions, samples were grouped according to their pay zones.

Oil fingerprinting of Horizon XIII

47 oil samples were used from this pay zone for this analysis, and the results demonstrated the identification of three distinct groups. This is clearly illustrated in the form of a Ward's dendrogram (Fig. 2) and on a structural map (Fig. 3) in the form of 'star' diagrams. The samples shown in red comprise the first group, while only two oil samples show the second group(orange). The samples in the north-west part of the field comprises the third group (blue).

Oil fingerprinting of Horizon XV

The results of the fingerprinting of 16 oil samples that penetrate this horizon indicate the presence of four distinct groups: (Fig. 4). In the structural map the oils of the first group are shown in red, while the only one sample(orange) comprises the second group. The samples in green and purple comprise the third and fourth groups correspondingly.

It should be noted that the oils from the first group predominate in both horizons XIII and XV indicating reservoir continuity between them.

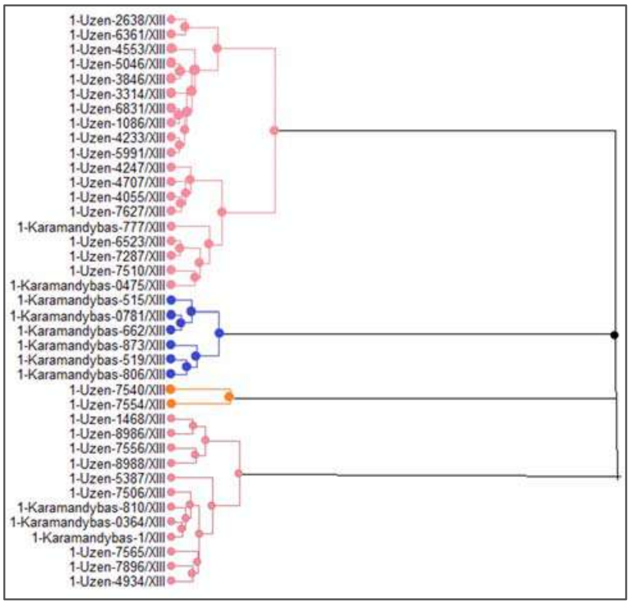

Fig. 2. Ward's dendrogramme on XIII horizon

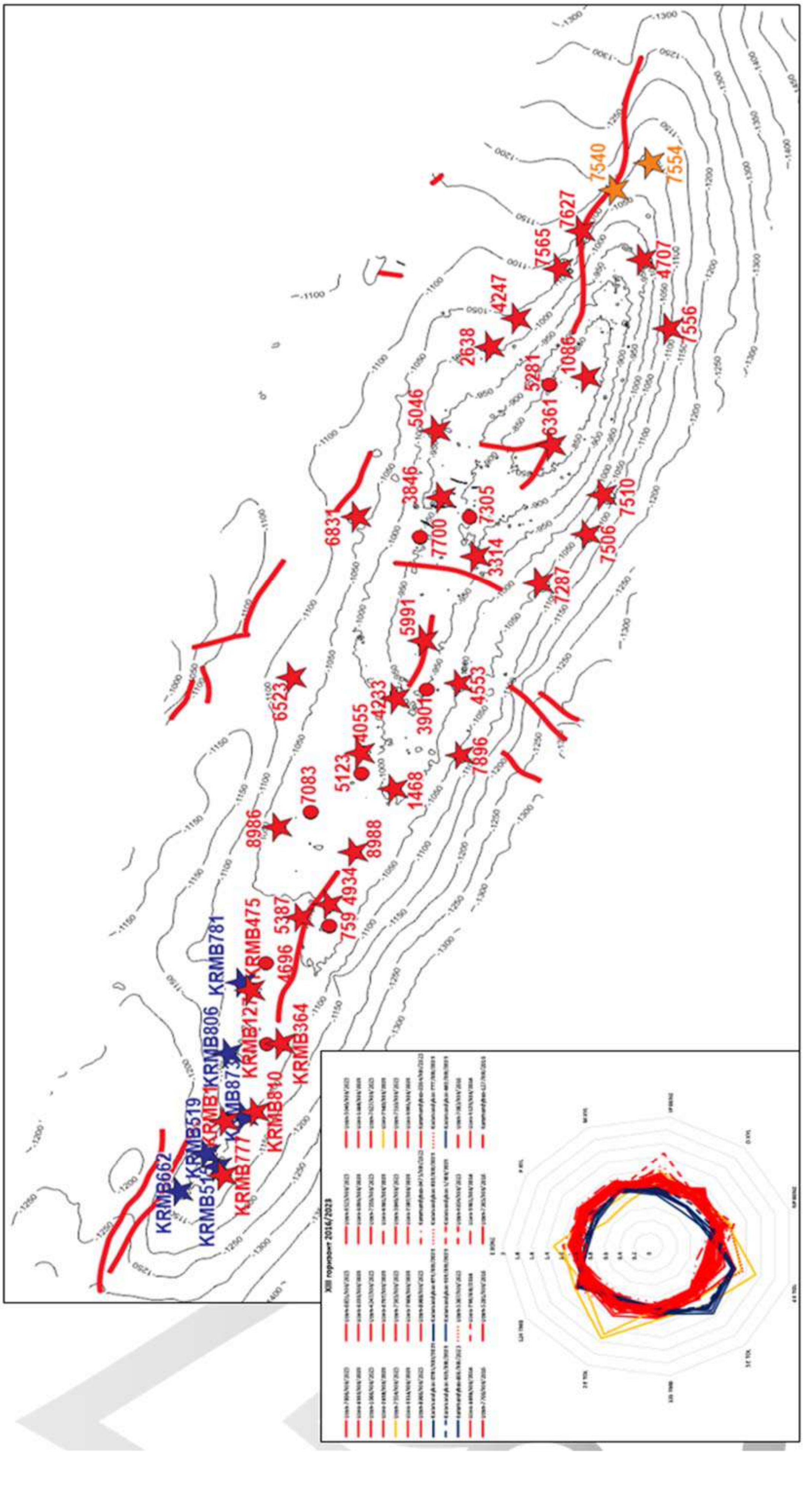

Fig. 3. Results of fingerprinting of oil from Uzen and Karamandybas fields (XIII horizon)

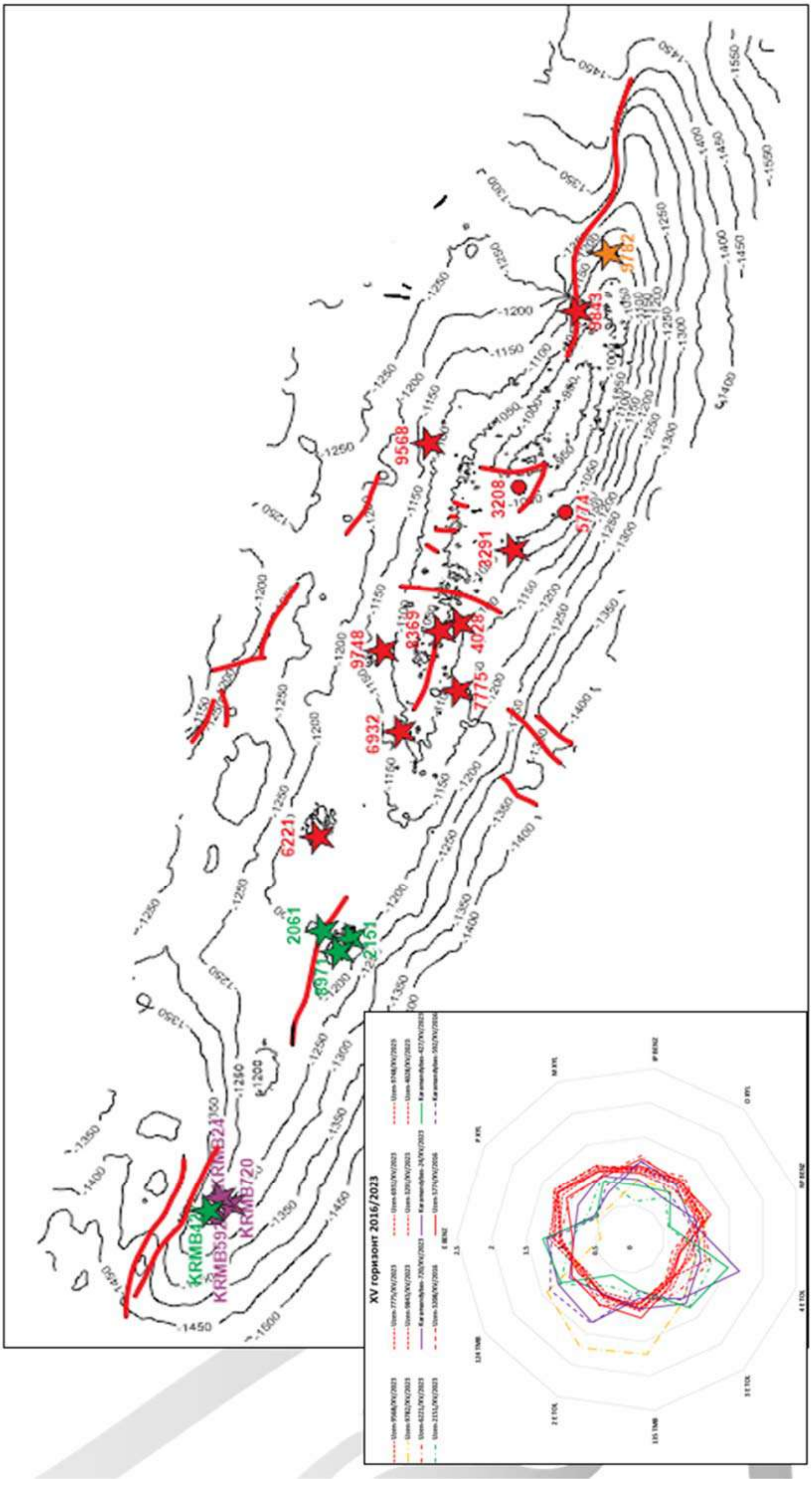

Fig. 4. Results of fingerprinting of oil from Uzen and Karamandybas fields (XV horizon)

Biomarker analysis of oil:
Environmental condition of OM

A plot of pristane to phytane ratios on the C_{29}sterane/C_{30} hopane ratio (Fig. 5) was used to differentiate organic matters deposited in marine, lacustrine, or deltaic environments. The plot demonstrates that the oils of Uzen field exhibit a higher contribution of marine OM with the depth increase. For instance, the oils from the 21st horizon (red triangles) exhibit a greater contribution of marine sapropelic OM in comparision with those of the upper horizons XIII (red circles) and XVI (red rhombuses), as evidenced by their elevated C_{29} sterane/C_{30} terpane ratios.

To differentiate OM deposited in marine and lacustrine environments, sterane ternary of oils was also employed (Fig. 6). Based on this analysis, analogous conclusions are drawn. This plot clearly demonstrates a regular transition in the composition of oil from lacustrine to marine source towards the lower horizons. It is noteworthy that the oil from well No. 7554 (orange circle) and well No. 9782 (orange square) differs from the other oils from horizons XIII and XV (red figures), indicating genetic difference.

Thermal maturity

As illustrated in Fig. 7, the graph of the dependence of sterane isomers C29αααα (S/S+R) on C29 αβββ(S+R)/αβββ(S+R)+ αααα(S+R), the oils of the upper horizons XIII and XV (red figures) exhibit the lowest thermal maturity, while the oils of the lower horizon XXII display the highest thermal maturity. It can be observed that there is a notable increase in thermal maturity with depth increase It is noteworthy that the oils from wells No. 7554 (orange circle) and No. 9782 (orange square) exhibit distinct characteristics that differentiate them from the other oils, thereby attesting to their genetic difference.

Fig. 8 also shows that the oils from the upper horizon (XIII) (red circles) exhibit relatively lower thermal maturity, whereas the oils from the lower horizon (XXII) (red triangles) display the highest thermal maturity. Similarly, the thermal maturity of the oils from the XIII, XIV, XVI and XXI horizons demonstrates a consistent increase with depth of occurrence. Furthermore, the oils from wells #7554 (orange circle) and #9782 (orange square) exhibit distinct characteristics that differentiate them from the other oils, thereby confirming their genetic divergence.

The results of the fingerprinting of oil samples from the Uzen field demonstrated the separation of distinct oil groups.

Conclusion

In this study oil fingerprinting and biomarker analysis were performed (i) to assess reservoir continuity and compartmentalization studies by oil fingerprinting analysis of oils from horizons XIII-XV, (ii) to characterize source rocks of representative oil samples in terms of environmental condition and thermal maturity by biomarker analysis and (iii) to integrate the obtained outcomes to draw viable conclusion from geological point of view.

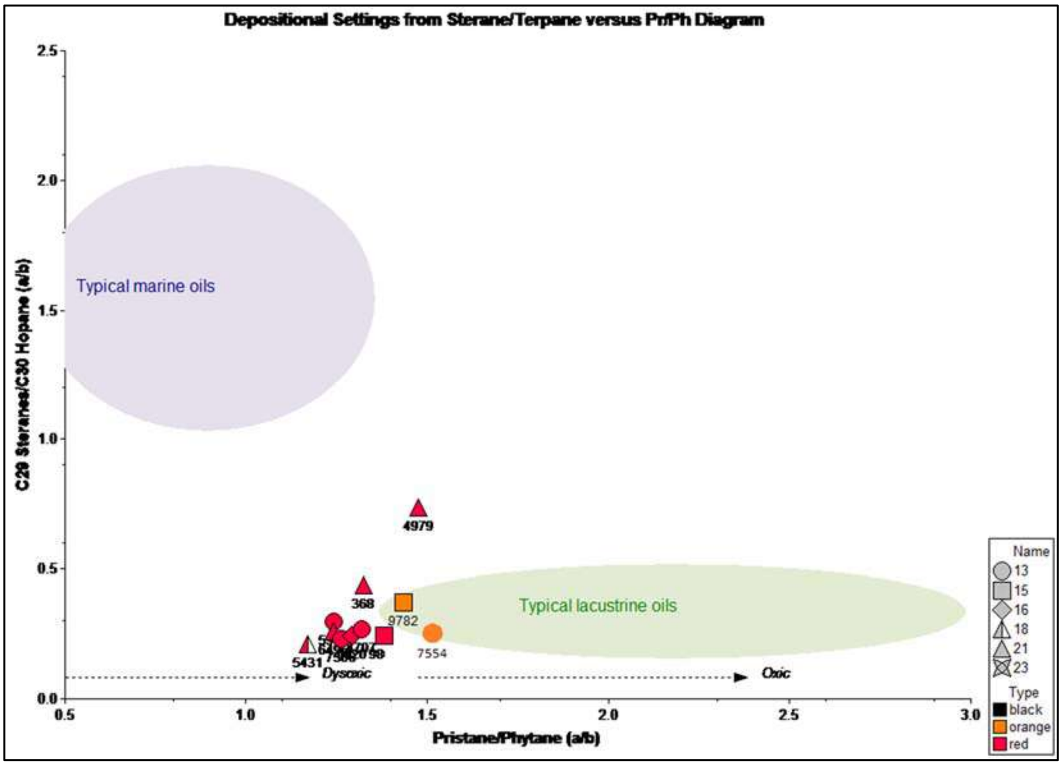

Fig. 5. Plot of C29 sterane/C30 terpane against Pr/Ph

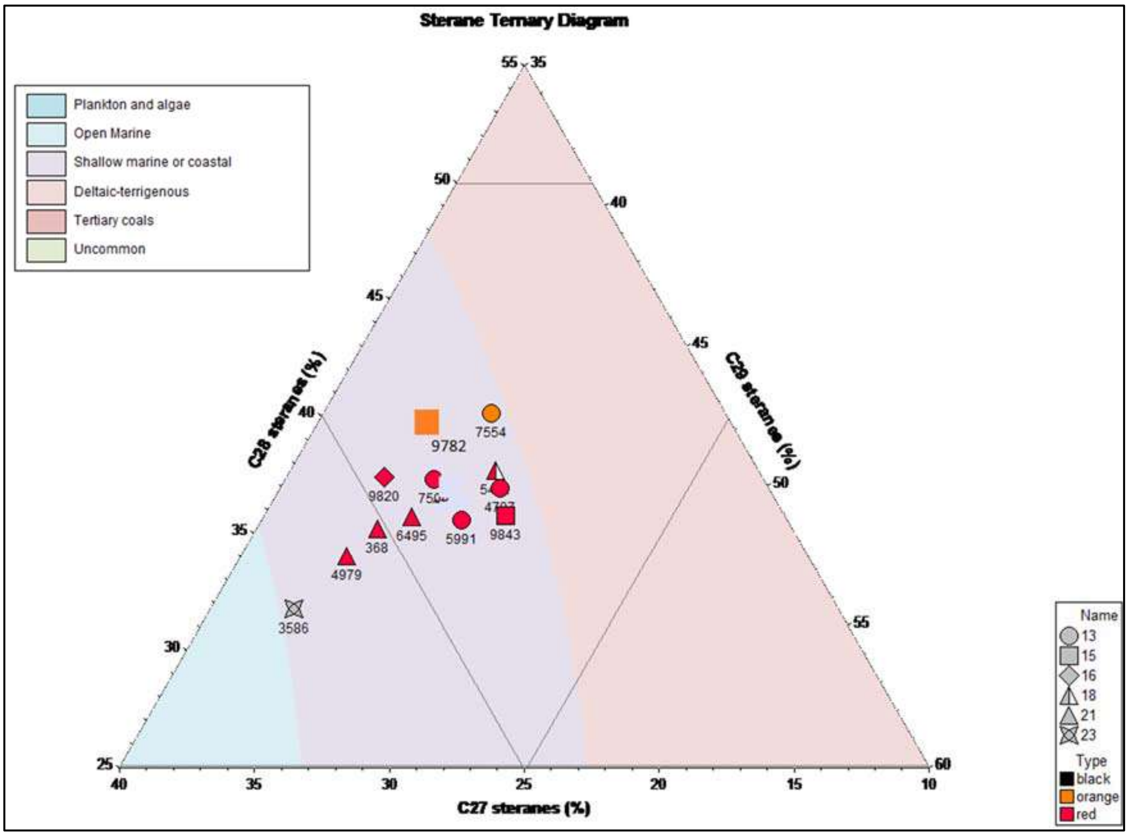

Fig. 6. Graph of pristan/phytane (Pr/Ph) to steraneC29/gopaneC30 dependence in oil samples

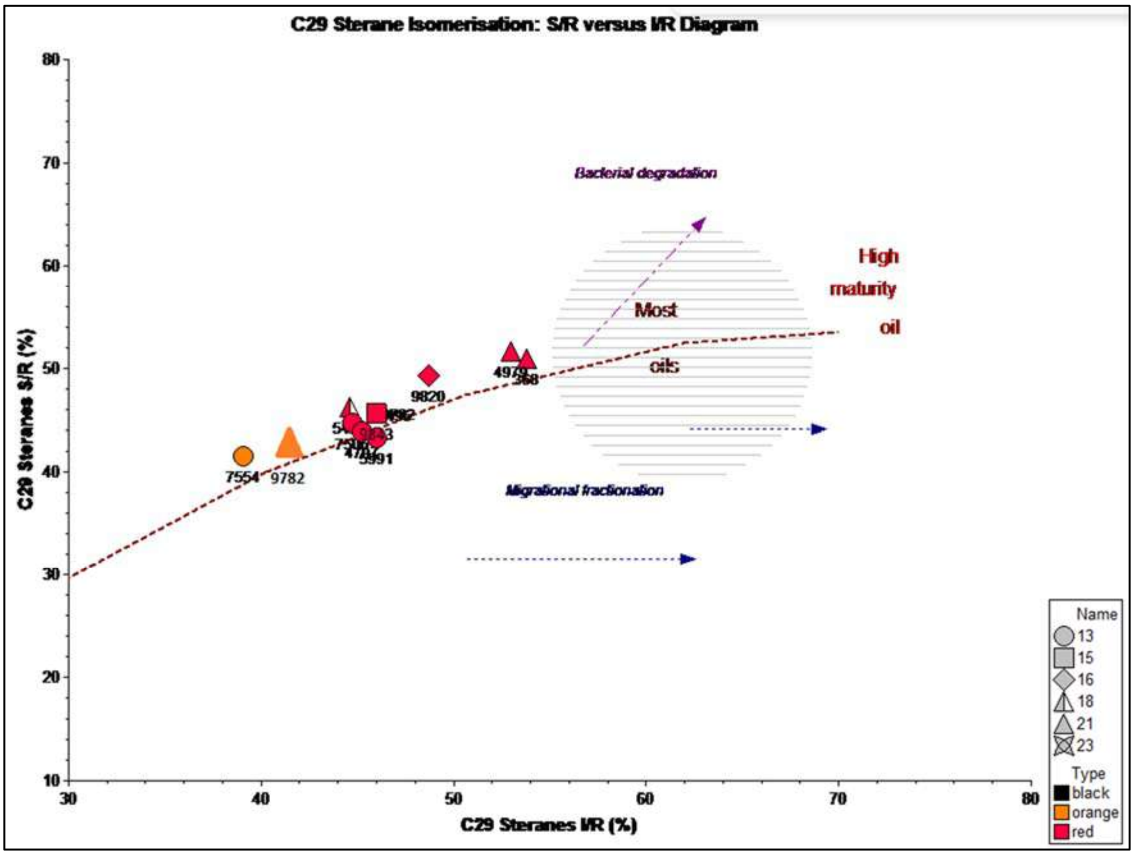

Fig. 7. Graph of dependence of sterane isomers C29αααα (S/S+R) on C29 αβββ(S+R)/αβββ(S+R)+ αααα(S+R) in Uzen oils

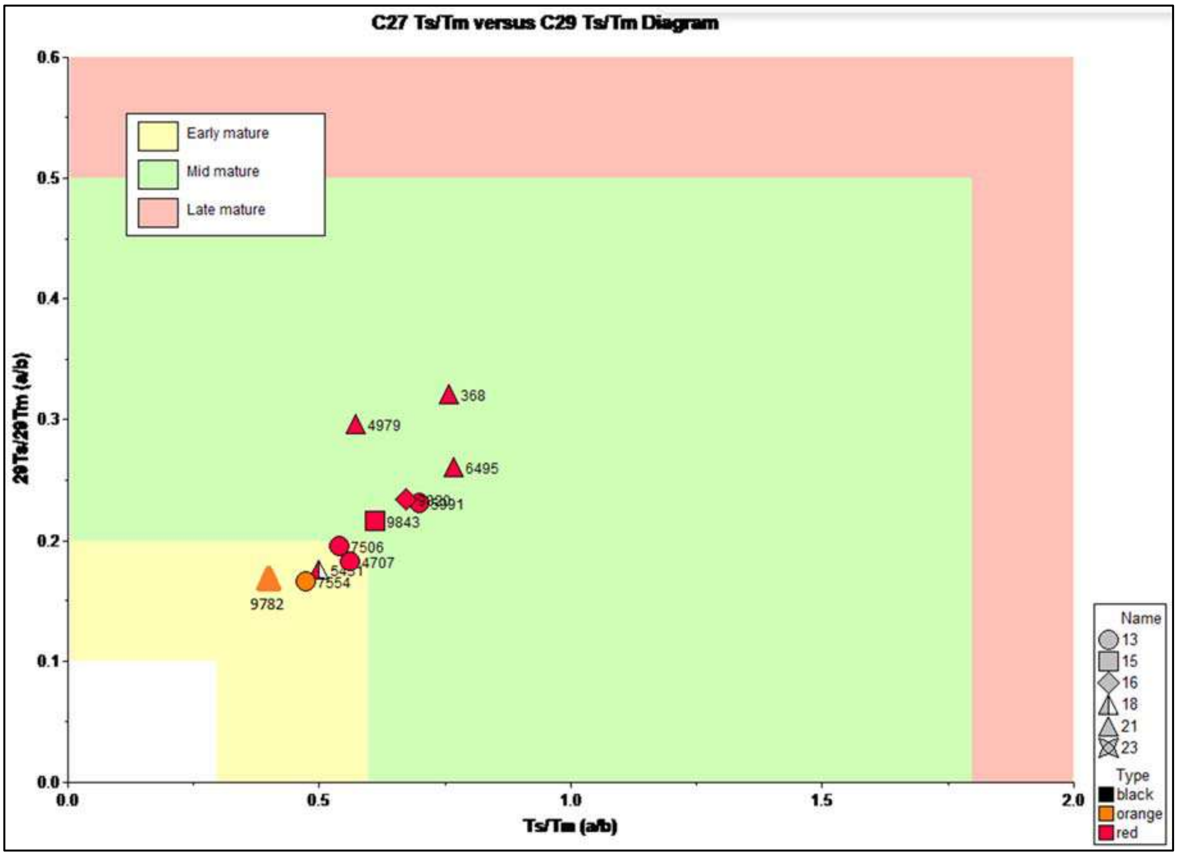

Fig. 8. Graph of dependence of terpanes C27Ts/Tm on C29Ts/Tm in oils from the Uzen field

Oil fingerprinting analysis demonstrated three distinct groups in horizon XIII and four different groups in horizon XV. It is worthy to note that the oils from the first group (red) predominate in both horizons XIII and XV indicating good reservoir continuity between them. According to biomarker analysis of representative oils, oils from upper horizons (XIII-XV) were generated from shaly lacustrine OM, while those of lower horizons (XXII-XXVI) were from shaly marine OM and with depth increase the thermal maturity of oil samples rise.

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ТИПЫ НЕФТЕЙ, ВЫДЕЛЕННЫЕ В РЕЗУЛЬТАТЕ ГЕОХИМИЧЕСКИХ АНАЛИЗОВ НА МЕСТОРОЖДЕНИЯХ УЗЕНЬ И КАРАМАНДЫБАС

Сейтхазиев Е.Ш.[1,2], Даумшаров А.А.[1]

[1]Атырауский филиал ТОО «КМГ Инжиниринг», Атырау, Казахстан
060097 Атырауская область, Атырау, мкр. Нурсая, пр. Элорда, Здание 10: esimhan89-89@mail.ru
[2]НИПИ "Нефтегаз", SOCAR, Азербайджан
Просп. Зардаби, 88А, Баку, AZ1012

Резюме. Мировая практика показывает, что при геологоразведочных работах эффективное применение имеющейся базы данных в сочетании с другими методами позволяет избежать бурения сухих поисково-разведочных скважин. Например, сопоставление геохимических и геофизических данных увеличивает результаты разведки более чем в два раза, по сравнению с использованием только геофизических данных. В данной работе рассматривались образцы нефтей в количестве 201 единиц, которые были отобраны с устьев скважин месторождений Узень и Карамандыбас в 2023 г. Целью исследования являлось определение генетического происхождения нефтей и их сопоставление с анализированными пробами нефти (2016 г.) в имеющейся базе данных. Представлены результаты геохимических исследований указанных образцов нефти основных продуктивных горизонтов (XIII, XV) месторождений Узень и Карамандыбас. Для корреляции нефтей продуктивных пластов использовались соотношения 12 ароматических пиков на хроматограммах LTM, по которым строились так называемые звездные диаграммы, наглядно иллюстрирующие сходство и различие флюидов. Многомерная газовая хроматография компонентов с низкой термальной массой (Low Thermal Mass Gas Chromatography-далее LTM) позволяет произвести качественную оценку «отпечатков» каждого индивидуального пласта, горизонта или объекта разработки. Все исследованные пробы были пригодны для фингерпринтинга. Как эмпирически, так и практически установлено, что в едином хорошо сообщающемся резервуаре звездные диаграммы нефтей идентичны, в то время как для нефтей из разобщенных резервуаров они существенно различаются. В целом все исследуемые нефти месторождений Узень и Кармандыбас по результатам «фингерпринтинга» были разделены на 16 групп. Также для удобства интерпретации все образцы нефти были сгруппированы по принадлежности к горизонтам (XIII-XXIV).

Ключевые слова: *фингерпринтинг нефти, дендрограмма Варда, тригонограмма стеранов*

UZEN VƏ KARAMANDIBAS SAHƏLƏRİNDƏ APARILMIŞ GEOKİMYƏVİ TƏHLİLLƏR NƏTİCƏSİNDƏ MÜƏYYƏNLƏŞDİRİLMİŞ NEFT TİPLƏRİ

Seytxaziev E.Ş.[1,2], Daumşarov A.A.[1]
[1]Atırau filialı, «KMG Engineering» MMC, Atırau, Qazaxıstan
[2]NQETLİ "Neft və Qaz", SOCAR, Azərbaycan

Xülasə. Dünyada təcrübəsi göstərir ki, geoloji-axtarış işlərində mövcud məlumat bazasınından effektiv istifadə və digər metodlarla birləşdirilmə quru axtarış-kəşfiyyat buruq qazılmasından imtina etməyə imkan verir. Məsələn, geokimyəvi və geofiziki məlumatların müqayisəsi, yalnız geofiziki məlumatlardan istifadə etməklə müqayisədə kəşfiyyat nəticələrini iki dəfə artırır. Bu işdə 2023-cü ildə Uzen və Karamandıbas sahələrindəki quyulardan götürülmüş 201 nümunə neftin tədqiqi aparılmışdır. Araşdırmanın məqsədi neftlərin genetik mənşəyini müəyyənləşdirmək və onları 2016-cı il tarixli mövcud məlumat bazasında olan neft nümunələri ilə müqayisə etmək idi. Uzen və Karamandıbas sahələrinin əsas istehsal qatları (XIII, XV) üzrə göstərilən neft nümunələrinin geokimyəvi tədqiqatlarının nəticələri təqdim olunmuşdur. İstehsal qatları neftlərini korrelyasiya etmək üçün LTM xromatoqramlarında 12 aromatik maksimumun nisbətləri əsasında, neftlərin oxşarlığını və fərqlərini vizual şəkildə göstərən "ulduz diaqramları" qurulmuşdur. Aşağı İstilik Kütləsi Qaz Xromatoqrafiyası (Low Thermal Mass Gas Chromatography - LTM) hər bir fərdi qatın, horizontun və ya inkişaf obyektinin "izi"nin keyfiyyətli qiymətləndirilməsinə imkan verir. Araşdırılmış bütün nümunələr “fingerprinting” üçün uyğun olmuşdur. Empirik və praktik olaraq müəyyən edilmişdir ki, bir-biri ilə yaxşı əlaqələndirilmiş bir yataqda ulduz diaqramları eynidir, halbuki ayrılmış yataqlardan alınan neftlər əhəmiyyətli dərəcədə fərqlənir. Ümumilikdə, Uzen və Karamandıbas sahələrinin araşdırılmış bütün neftləri iz (fingerprinting) nəticələrinə görə 16 qrupa ayrılmışdır. Həmçinin, interpretasiyanı asanlaşdırmaq üçün bütün neft nümunələri XIII-XXIV qatlarına aid olanlara görə qruplaşdırılmışdır.

Açar sözlər: *fingerprinting, Varda dendroqramı, steranların triqonometriyası*