УДК 550.832 https://doi.org/10.24028/gj.v45i3.282420

Evolution of hydrocarbon deposits in the South Caspian Basin

V.M. Seidov, L.N. Khalilova, 2023

Azerbaijan State Oil and Industry University, Baku, Azerbaijan
Received 12 January 2023

Studies of the South Caspian Basin display that the Early Pliocene sediments define mainly the structural characteristic of the section in this area. The Productive Series consists of deposits accumulated during the Pliocene epoch. It is known that within the basin, the major commercial hydrocarbon accumulations are attributed to the Productive Series of the Early Pliocene and concentrated mainly in the Absheron oil and gas province, Baku archipelago and Low Kur oil and gas provinces. Studies of fluid generation are required for correct planning of geological exploration for oil and gas in these areas.

This research work aimed to study the fluid generation processes in the South Caspian Basin by use of 3D modeling.

The history of hydrocarbon formation was reconstructed. Fluid generation focuses were studied and the distribution areas of these focuses was clarified. The maturity of the Middle Jurassic and Low Cretaceous sediments and Maikop and Diatom deposits were assessed, the temperature regime of the Maikop and Diatom deposits were analyzed. We also evaluated the hydrocarbon fields' and mud volcanoes' relations to the focal areas of small-focused earthquakes.

In the South Caspian Basin, the Middle Jurassic, Low Cretaceous, Maykop, and Diatom focuses of fluid generation were outlined and their allocation and time-spatial evolution history were researched.

Evaluation of the maturity of Middle Jurassic and Low Cretaceous sediments, Maykop, and Diatom showed neither oil formed at the peak of oil-gas generation with maturity values R_o=0.8÷0.9 %, nor low-maturity gases of the transition zone even within the fluids of gas-condensate fields, while some oil fields had gases of abnormally high maturity of R_o=2.4÷3.09 %.

3D modeling of paleogeotemperatures in Maykop and Diatom suites found that a) both in the western and the eastern part of the South Caspian Basin the temperature in the bottom of Maykop increases by 20 °C in comparison to the top of the suite; b) in the west of the trough in the middle portion of Diatom at a depth of 8000 m and in the east of the trough at 9000 m, the temperature reaches 120 °C.

In the case of small-focused seismicity caused by fluid-generation processes, the latter at the phase conversions are accompanied by high energy output, decompaction, pressing-out of fluids and matters in pseudo-liquefied state into the permeable areas of the media, thus assisting the development of diapiric structures and mud volcanoes.

Key words: Productive Series, oil and gas generation, fluid generation source, trough, hydrocarbon generation, suite, accumulations.

Introduction. The most known commercial accumulations of oil and gas in Productive Series (PS) are concentrated mainly in three oil and gas provinces of Azerbaijan: Absheron oil-gas province, Baku archipelago oil-gas province and Low Kur oil-gas province

Citation: *Seidov, V.M., & Khalilova, L.N.* (2023). Evolution of hydrocarbon deposits in South Caspian Basin. *Geofizicheskiy Zhurnal*, *45*(3), 126—134. https://doi.org/10.24028/gj.v45i3.282420.

[Alizada et al., 2013; Kocharli, 2015; Seidov, Khalilova, 2019].

Absheron oil-gas province includes oil and gas bearing zones of Absheron Peninsula, North Absheron zone of uplifts, oil-gas zones of Absheron archipelago and Absheron threshold, South-Absheron territorial waters zone. Tectonically, the region is a periclinal trough of the Great Caucasus megaanticlinorium [Mamedov, 2008]. Rocks of Productive Series in this area are represented by «Absheron facies» with reservoirs characterized by high content of quartz sands with high filtration-volumetric properties. The suite named as Productive Series is the natural time-spatial system consisting of alternations of sand-aleurite and clay rocks distributed along the strike, repeated and diminished in upward direction in the section.

Tectonics of Baku archipelago region represents the marine extension of folded zones. A series of uplifts is identified between folded zones and a number of uplifts in the deep water area of the Caspian sea. The characteristic feature of tectonic setting of anticlinal belts here is the presence of large longitudinal fractures in the axial zones of the structure and most of them are traced along the entire extension of anticlinal belts. The sources of mud volcano activity are frequently attributed to longitudinal fractures. The clay presence in the section of Productive Series in Baku archipelago is higher than in Absheron oil-gas province [Huseynov, 2017; Yetirmishli et al., 2021].

Tectonics of Low Kur oil-gas province represents the south-eastern extension of intermountain Kur trough subsiding into the water area of South Caspian. The borders of this province in the east and in the south-east are conditionally drawn along the coastal line of the Caspian sea. The characteristic feature of this province is its intensive subsiding and compensated sedimentation in Neogene-Quaternary. Lithology consists of irregular alternation of polymictic aleurolite and clay rocks.

A sufficient number of researches has been devoted to study of the Early Pliocene (Productive Series sediments), generation and accumulation of hydrocarbons in the South-Caspian basin. At present, the studies are continued by I.S. Guliyev, A.A. Feyzullayev, A.G. Gojayev, A.M. Salmanov, B.I. Magerramov, I.M. Mamedova, R.M. Huseynov, F.D. Hasanov and the others. In the paper of F.D. Hasanov based on analysis of PS section in Absheron Peninsula the causes of water presence in reservoir layers and mineralogical composition of rocks have been researched depending on clay minerals presence [Hasanov, 2013]. The research work also reflects facies analysis of Productive Series rocks.

R.M. Huseynov's paper researches lithological-mineralogical characteristics of Oligocene and Miocene in the western part of Absheron Peninsula [Huseynov, 2021]. According to the stratigraphic scale these sediments are related to the sediments of Maykop, Chokrak and Diatom. The research work indicates that reducing-alkaline environment existed during sedimentation in Maykop and Chokrak had developed the environment favorable for transformation of organic matter into hydrocarbons.

Analysis of geodynamic evolution stipulating development of complex-phased hydrocarbon systems of large oil and gas fields in the South Caspian Basin is fulfilled in the research work of A.D. Ismail-Zadeh [Ismail-Zadeh, 2013]. The paper considers geodynamics, time of generation of structural zones and peculiarities of large oil and gas fields generation.

The paper of A.A. Feyzullayev et al. is devoted to the study of fluid dynamics in underground gas storages, which are under long-term exploitation in the areas of Galmas and Garadagh of South-Caspian Basin [Feyzullayev et al., 2022]. According to the researches, the macro- and micro-inhomogeneity of geological units lead to the changes in geological structure of the reservoir and petrophysical characteristics of rocks and this, in its turn, is the major reason decreasing the efficiency of development of the deposit.

For correct planning of geological survey for oil and gas it is required primarily to study the processes of fluids generation in the South Caspian Basin.

This study in distinction to the above indicated researches is aimed at the researches on fluid generation processes in the South-Caspian Basin by use of 3D modeling of the basin.

Methods. To study and predict the characteristics of terrigenous natural reservoirs in promising structures of the South Caspian Basin a scientific-methodological approach was developed. This approach is based on the rule of rational combination of apriori data in the form of regional geological regularities with detailed empiric information about the field-analogue and indirect information about the promising geological structure.

Apriori information is based on the known and established by us qualitative and quantitative geological regularities in the whole South Caspian Basin and within separate anticlinal belts. The known approach was improved to some degree by our efforts. The data of recently conducted 3D seismic survey were used.

Empiric information on some fields, including the field-analogue, is based on analysis of core samples by use of methods of sedimentation petrology and petrophysics, including analysis of rock composition by rock samples, the rock structure by use of scanning electron microscope, researches on permeability, petrophysical properties of rocks, physical and chemical characteristics of oil, gas and water, testing and production data. In the study process we have used the state-of-the-art microscope.

The indirect information is based on the methods of borehole geophysics and the interpretation results of seismic survey data acquired from already known fields and promising structures. We have implemented processing of logging diagrams and 3D seismic survey data acquired for the last 5 years and we have used for this Petrel software.

Results of latest studies of sedimentary rocks in the South Caspian Basin based on the most modern laboratory methods of study of organic matter, oil and gas allow to reliably evaluate hydrocarbon reserves in PS. Evaluation of hydrocarbon reserves has been done by use of pyrolysis of core samples. Core samples were selected proceeding from their lithological characteristics. Laboratory studies of organic matter in clay rocks included optical study, pyrolysis, evaluation of total amount of organic hydrogen.

The level of oil maturity is the most important parameter, which together with other geological and geochemical parameters makes it possible to acquire sufficient information about the depth of oil and gas generation zone, stratigraphic attribution of source rocks, direction and conditions of hydrocarbon fluids migration and as a final step to evaluate the hydrocarbon reserves within the studied oil and gas basin.

High technology methods for researches on organic matter and oil at the level of molecular mineral resources (biomarkers) widely applied in organic geochemistry allows to perform oil-oil, oil-oil source rock correlation, define stratigraphic age of oil and most importantly define the level of maturity of oil, to say it more strictly the level of catagenetic transformation of kerogene. To reach the goal, the parameters of the level of isomerization of hopane, sterane, aromatization of sterane and relationship of aromatic steranes, steroids, etc. were applied.

The primary energy characteristic of the processes within the Earth depths is the density of thermal flow. It is defined by the amount of thermal energy passing through the unit of the square of the Earth's surface per time unit and it is expressed by the following formula: $\theta=\lambda \operatorname{grad} T$, where λ is thermal conductivity of the medium depending on lithological composition of rocks in geological section, as well as on the temperature, pressure and moisture content; $\operatorname{grad} T$ — geothermal gradient.

Application and discussion. The comprehensive understanding of time and spatial evolution of fluid generation sources, the level of realization of oil and gas generation potential of sedimentary units can be derived by results of 3D modeling in the northern part of South-Caspian Basin (Fig. 1, *a* — the present time). It can be seen from modeling that oil and gas generation in the Middle Jurassic sediments started at the end of Low Cretaceous 96 mln. years ago in the local sources

in the east of Absheron trough (Fig. 1, *f*). By the end of Upper Cretaceous 66.9 mln. years ago the locality of the source has widened slightly and in composition of generated fluids the amount of condensate and gaseous hydrocarbons was increasing (Fig. 1, *e*). The peak of hydrocarbons generation was reached in Oligocene with displacement of fluid generation sources into the western part of the trough and central portion of Absheron Pen-

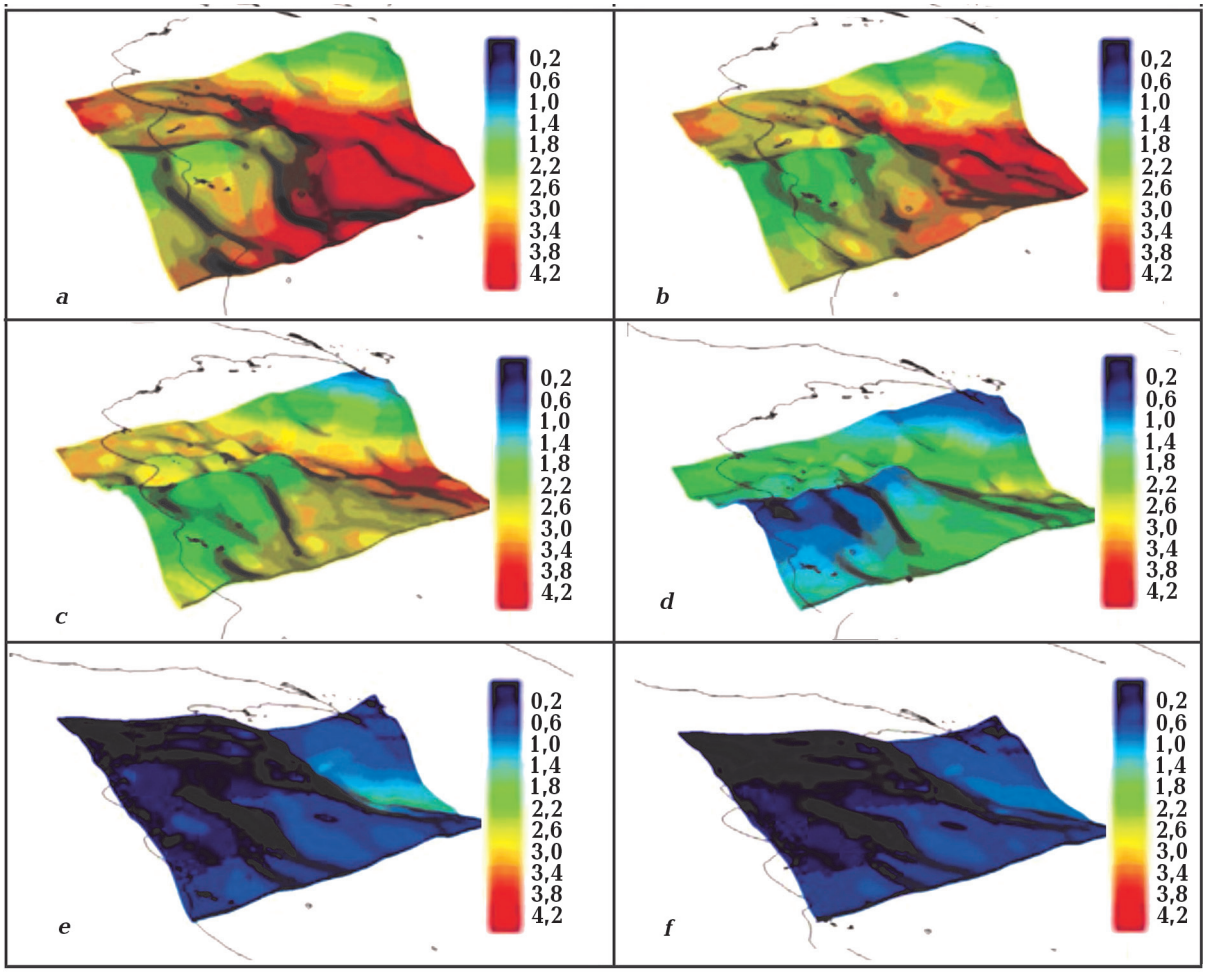

Fig. 1. Location of fluid generation sources and level of maturity of Middle Jurassic fluid generation suites: *a* — at the present; *b* — at the end of Low Pliocene; *c* — at the end of Miocene; *d* — by the end of Oligocene; *e* — by the end of Upper Cretaceous; *f* — by the end of Low Cretaceous.

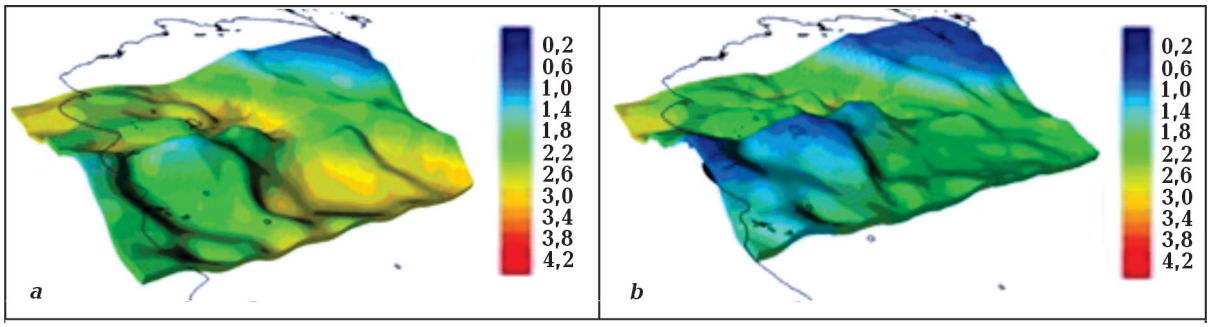

Fig. 2. Level of maturity of Low Cretaceous fluid generating suites: *a* — at present; *b* — by the end of Miocene.

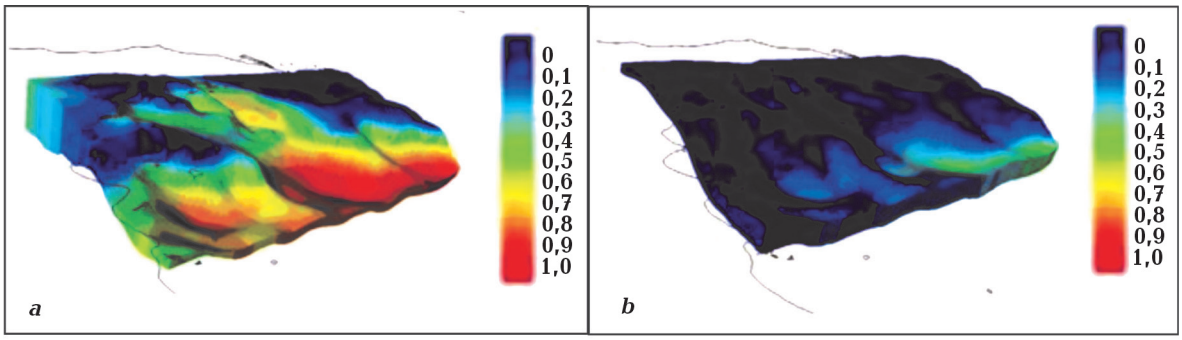

Fig. 3. 3D model of location of oil-gas generation sources and the level of transformation of hydrocarbons in Maykop (*a*) and Diatom (*b*) sediments.

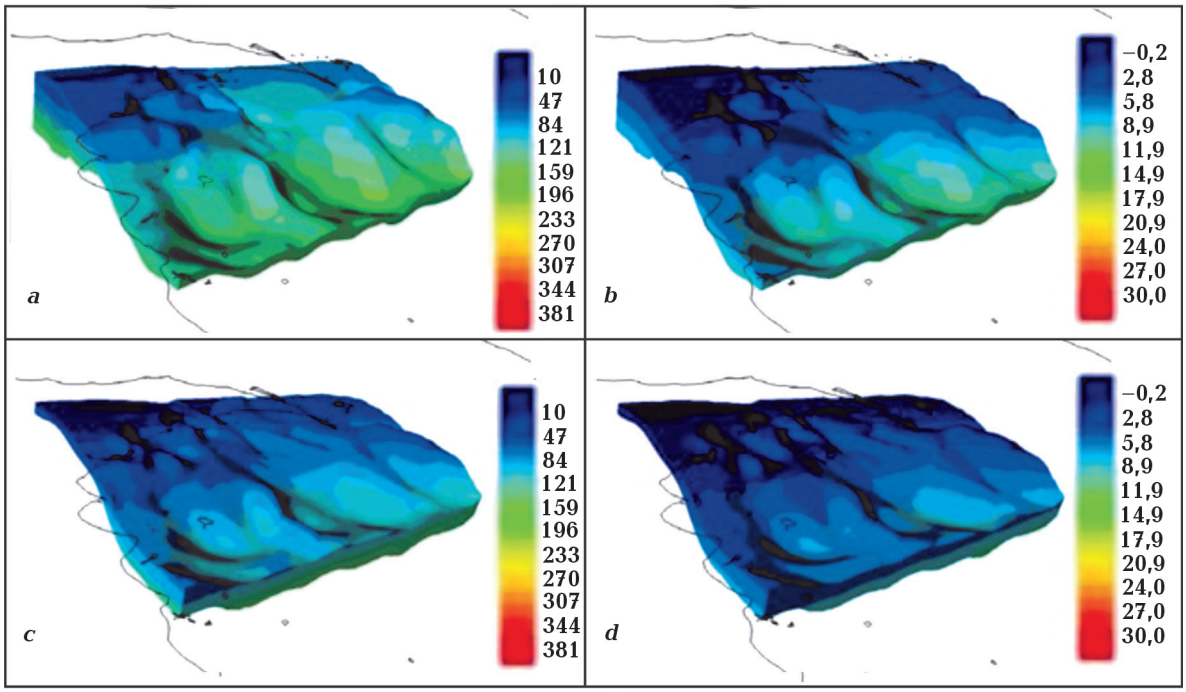

Fig. 4. 3D temperature and depth model of Maykop and Diatom. Temperatures: *a* — in Maykop, *b* — in Diatom, *c*, *d* — depth of burial (*c* — Maykop, *d* — Diatom).

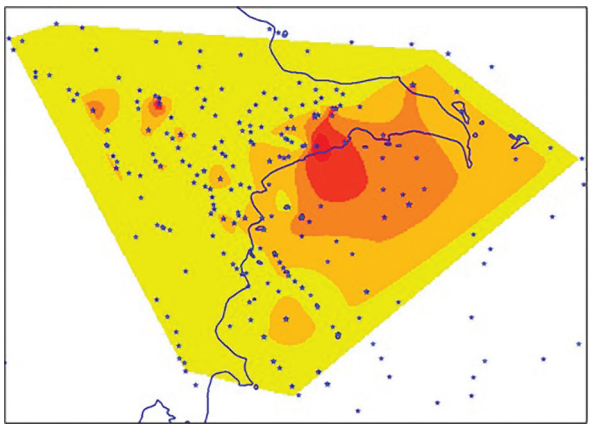

Fig. 5. Map of frequency of mud volcano eruptions (the weakening of gravity anomaly is observed from red towards the yellow). * — the sources of mud volcanoes.

insula (Fig. 1, *d*). By the end of Miocene, the Jurassic had practically entirely realized oil and gas generation potential and in fact as a whole it was in the zone of gas generation (Fig. 1, *c*). In the Low Pliocene time period the oil and gas generation potential of Jurassic sediments were entirely realized (Fig. 1, *b*).

Low Cretaceous (Valanginian) gas generating sedimentations are mostly of high maturity with values R_o=2.4÷2.6 %, in the troughs R_o is much higher — 2.9—3 %. The decrease of catagenesis of these sedimentations is clearly observed towards the north-east, where R_o drops to 1—1.4 % (see Fig. 2, *a*). Modeling displays that these sediments reached the

peak of gas generation by the end of Miocene (see Fig. 2, *b*).

Modeling shows that in the significant area in the Eastern part of the South-Absheron trough the Paleogene-Low Miocene sediments have utilized oil generation potential by 90 % and currently they are at the stage of gas generation (Fig. 3, *a*). In the western and northern parts of the trough the sediments are mainly at the stage of generation of mature oil and condensate. Within the limits of Absheron Peninsula and archipelago the considered sediments are of low and average maturity and utilized oil generation potential in the range from 20 to 50 %. In this part of the basin at least three sources of hydrocarbon fluids generation is observed in Maykop.

Diatom involvement in the oil window is limited and it is mostly at the initial stage of oil generation with a much less part being at the average stage of oil generation process (Fig. 3, *b*). The sources of oil generation in Diatom are projected to the sources of gas generation in Paleogene-Low Miocene.

It should be noted that in the areas of mud volcano presence also the sharp distinction in oil and gas maturity levels is observed [Huseynov, 2021]. There is neither oil formed at the peak of oil generation with maturity values R_o= 0.8...0.9 % nor low-maturity gas of the transition zone even in composition of fluids of gas condensate fields, contradicting the vertical zonation of hydrocarbon generation. It must be emphasized also that in some oil fields, for instance in Absheron bank, Neftchala, etc. the gas of abnormally high maturity with R_o from 2.4 to 3.09 % is identified. Earlier the gas with such maturity was identified in the Jurassic black-shale layers of the Southen slope of Caucasus.

In the north-western and northern flank areas of the basin in the Shamakha-Gobustan and Absheron zone the geothermal gradient is slightly higher (2—2.2 °C/100 m), and for this reason the sources of generation of dehydrated and metamorphogenic water fluids here have slightly lower hypsometry values relatively to the axial and deeply subsided parts of the basin [Mukhtarov, 2011; Feyzullayev et al., 2022]. For instance, according to 3D basin modeling (model has been designed by use of Petrel software applying data of temperature measurements in wells) the isotherms of 120 °C in Absheron Peninsula and adjacent water areas of Baku and Absheron archipelagoes are elongated to the depths of Maykop and Diatom (Fig. 4).

The South Caspian basin is characterized by quite diverse thermal mode of tectonic elements and the low temperature in Pliocene-Antopogene sediments. Analysis and generalization of multiple temperature measurements held in wells display that distribution of temperatures across the section in general reflect the main features of tectonics of the South Caspian Basin.

From the models displayed in the figures it can be seen that this temperature zone is attributed to the middle part of Diatom in the south water zone and corresponds to the depths at approximately 8000 m in the western part of South-Absheron trough and is subsiding down to 9000 m in the eastern part of the trough. Maykop in these sections is involved in the heating zone in relatively larger area. In the most subsided areas in the west of South-Absheron trough at the top of the suite at 9200 m depth the temperature reaches 145—150 °C, in the low part of the suite at 11000 m depths the temperature reaches 170 °C. In the east of the trough at the top of Maykop at 10500 m depth the temperature is about 160 °C, at the bottom at 12000 m depths the temperature is over 180 °C.

The level of relative fluid dynamics of various regions of the South Caspian Basin can be assessed by a frequency of mud volcano eruptions [Guliyev, 2015; Yusubov et al., 2020]. From the map of mud volcanoes eruption frequencies, it is clear that the area of the highest fluid activity is located within the central Absheron and adjacent southern water area (Fig. 5). It is important to underline that this area is located in the zone of negative gravity anomaly delineated by isoline of 110 mGal and including all oil and gas fields. The statistics of seismic data for the period of 1973—2009 displays that the earthquakes in the South Caspian region by the depth of the source can be divided into two groups: the

first group is with source depths down to 15 km (small focused) with extremely displayed frequency as 10 km and the second one is with source depth from 20 km to >70 km with clearly observed frequency as 34 km.

It is very important that absolutely all small focused earthquakes are located in the zone of gravity minimum and especially in the fluid active zone [Veliyev, 2021; Yusubov et al., 2020]. It has been indicated earlier that these depths correspond to the interval of intensive fluid generation in Paleogene-Low Miocene according to isotopic-geochemical data and basin modeling. This evidences that fluid dynamics (fluid generation) processes are one of the major mechanisms of small-focused seismicity. In this case, the energy and strength of fluid generating processes in the source is characterized by the strength of small-focused earthquake. Statistical analysis of such seismic events shows that for them the magnitudes with median values from 3.5 to 5.1 with maximum frequency M=4.5 are characteristic and this is quite high abnormal magnitude for earthquakes at such small depths. Therefore, if this seismicity is caused by fluid generation processes, then the latter at phase tansformations must be accompanied by release of a huge energy, dynamic effects, decompaction and pseudo-fluidization of the matter in the source, etc. In geological time scale this will assist to the press out the fluids and the matter in the pseudo-fluid state into the most permeable areas of the medium, generation of diapir structures and objects of various morphology with dominating pillar-shaped subvertical bodies of different sizes. The particular case of such objects are mud volcanoes and most probably the diapirs.

Results. 1) The sources of fluid generation were identified; 2) Stratigraphic intervals of hydrocarbon generation were identified; 3) The sharp distinction is observed in maturity of oil and gas in mud volcanoes; 4) Geothermal gradients within Shamakha-Gobustan and Absheron zones are slightly higher than in other areas; 5) The South Caspian basin is characterised by quite diverse thermal modes of tectonic elements and the low temperature in Pliocene-Antopogene sediments.

Conclusions. Four sources of fluid generation with areas of allocation and time-spatial evolution history have been outlined in the South Caspian Basin and these are Middle Jurassic, Low Cretaceous, Maykop and Diatom.

In the South Caspian Basin there are no oils, which are forming at the peak of oil-gas-generation with maturity values R_o=0.8÷0.9 %, as well as the low maturity gases of transition zone, even within the fluids of gas condensate fields, while in some oil fields the gas of abnormally high maturity with R_o from 2,4 to 3,09 % has been identified.

3D modeling of paleotemperatures in Maykop and Diatom suite evidences the following:

- in the western part of South-Caspian trough in the top of Maykop at 9200 m depth the temperature reaches 140—150 °C, in the bottom of the suite at 11000 m depth the temperature reaches 170 °C.
- in the eastern part of the trough at the top of Maykop at 10500 m depth the temperature is about 160 °C, at the bottom at 12000 m depth it is over 180 °C;
- in the western part of the trough in the middle of Diatom at 8000 m depth and in the eastern part of the trough at 9000 m depth the temperature reaches 120 °C.

Predominantly, all small-focused earthquakes, which were within the limits of gravity minimum, and in particular within fluid activity areas on the basis of isotopic-geochemical data and basin modeling correspond to the intervals of intensive fluid generation in the Paleogene-Low Miocene deposits. The intensive fluid generation processes play the role in the forming of diapir structures and mud volcanoes and by this, they trigger seismicity.

References

Alizada, A., Aliyeva, E., Huseynov, D., & Guliyev, I. (2013). The Elemental Stratigraphy of the South Caspian Lower Pliocene Productive Series. *First International Congress on Stratigraphy. At the Cutting Edge of Stratigraphy* (pp. 827—831). Springer.

Feyzullayev, A.A., Gojayev, A.G., & Mamedova, I.M. (2022). Features of fluid dynamics in long-term heterogeneous gas reservoirs. *Mining science and technology, 7*(1), 18—29. https://doi.org/10.17073/2500-0632-2022-1-18-29 (in Russian).

Guliyev, I.S., & Guseinov, D.A. (2015). Relics of mud volcanoes in the sedimentary cover of the South Caspian Basin. *Lithology and minerals,* (4), 350—361. https://doi.org/10.7868/S0024497X15040035 (in Russian).

Hasanov, F.D. (2013). Lithological-mineralogical characteristics of the Lower Pliocene deposits of the South Caspian depression. *Bulletin of Baku State University,* (4), 129—141.

Huseynov, R.M. (2021). Conditions for the Formation and Accumulation of Hydrocarbons in Oligocene-Miocene Sediments of Western Absheron. *SOCAR Proceedings,* (3), 022—030. https://dx.doi.org/10.5510/OGP20210300525 (in Russian).

Huseynov, D.A. (2017). Multiple deep stratigraphic sources of the hydrocarbon fluids in the South-Caspian basin. *Proceedings of 79th EAGE Conference Exhibition.* Paris. Franca. 34 p.

Ismail-Zadeh, A.D. (2013). Geodynamic analysis of petrolium in the South Caspian Basin (Azerbaijan sector). *History and pedagogy of natural sciences,* (3), 29—35 (in Russian).

Kocharli, Sh.S. (2015). Problematic issues of oil and gas geology of Azerbaijan. Baku, 227 p. (in Russian).

Mamedov, P.Z. (2008). On the reasons for the rapid subsidence of the Earth's crust in the South Caucasus. *Azerbaydzhanskoye neftyanoye khozyaystvo,* (1), 8—20 (in Russian).

Mukhtarov, A.Sh. (2011). The structure of the thermal field of the sedimentary complex of the South Caspian basin. *Extended abstract of Doctor's thesis.* Baku. 43 p. (in Russian).

Seidov, V.M., & Khalilova, L.N. (2019).Examples of reconstruction of productive strata depositional environment in Azerbaijan on the base of well logging data. *Oil industry*, (1147), 62—66. https://doi.org/10.24887/0028-2448-2019-5-62-66 (in Russian).

Veliyev, G.O. (2021).The role of geodynamic stress in the formation of oil and gas structures in the Caspian Sea (on the example of the Shah Deniz, Umid, Babek, Bulla Deniz fields). *Geotectonics and Geodynamics. Geology and Geophysics of Russian South, 11*(2), 36—50. https://doi.org/10.46698/VNC.2021.68.77.003 (in Russian).

Yusubov, N.P., Guliev, I.S., & Guseinova, Sh.M. (2020). Paleo-environments of sedimentation, mud volcanism and hydrocarbons migration in the South-Caspian basin. *Geofizicheskiy Zhurnal, 42*(3), 195—205. https://doi.org/10.24028/gzh.0203-3100.v42i3.2020.204710 (in Russian).

Yetirmishli, G.J., Ismayilova, S.S., & Kazimova, S.E. (2021). Seismicity of the territory of Azerbaijan in 2019. *Seismoprognosis observations in the territory of Azerbaijan, 19*(1), 3—18.

Формування покладів вуглеводнів Південнокаспійської западини

В.М. Сеїдов, Л.М. Халілова, 2023

Азербайджанський Державний Університет нафти та промисловості, Баку, Азербайджан

Дослідження Південнокаспійської западини (ПКЗ) показують, що відклади раннього пліоцену переважно визначають структурну характеристику осадового розрізу. Продуктивна товща складається з відкладів, нагромаджених у пліоцені. Як відомо, у межах западини основні промислові скупчення вуглеводнів пов'язані з продуктивною товщею раннього пліоцену та зосереджені головно в Абшеронському нафтогазоносному районі (НГР), НГР Бакинського архіпелагу та Нижньокуринському НГР. Вивчення процесів флюїдогенерації в межах ПКЗ необхідно для правильного вибору напрямів геологорозвідувальних робіт на нафту і газ у цих районах.

Мета цієї роботи — вивчення процесів флюїдогенерації в ПКЗ на підставі тривимірного басейнового моделювання.

Відновлено історію формування вуглеводнів. Вивчено осередки флюїдогенерації, уточнено ареали поширення цих осередків. Оцінено зрілість середньоюрських та нижньокрейдяних комплексів, майкопських та діатомових відкладів, проаналізовано температурний режим майкопських і діатомових відкладів, а також зв'язок нафтогазових родовищ і фокус.

У межах западини було виділено середньоюрський, нижньокрейдяний, майкопський та діатомовий осередки флюїдогенерації з власними ареалами поширення та історією еволюції у просторі та часі. Оцінювання зрілості середньоюрських і нижньокрейдяних комплексів порід, майкопських і діатомових відкладів показало, що в западині відсутні нафти, які формуються на піку нафтогазогенерації зі значеннями зрілості R_o=0,8…0,9 %, а також низькозрілі гази перехідної зони, навіть у складі флюїдів газоконденсатних родовищ, тоді як у ряді нафтових родовищах виявлено гази аномально високої зрілості з R_o від 2,4 до 3,09 %.

Тривимірне моделювання палеогеотемператур у майкопських та діатомових комплексах показало: а) у західній та східний частинах Південнокаспійського прогину температура у підошві майкопа підвищується на 20 °С порівняно з температурою в покрівлі світи; б) на заході прогину в середній частині діатомового комплексу температура досягає 120 °С на глибині 8000 м, на сході прогину — на глибині 9000 м.

У разі, якщо дрібнофокусна сейсмічність викликана флюїдогенераційними процесами, останні при фазових перетвореннях супроводжуються викидом великої енергії, розущільненням, видавлюванням флюїдів і речовини у псевдозрідженому стані в проникні ділянки вмісного середовища, що сприяє формуванню діапірових структур і гряд.

Ключові слова: продуктивна товща, нафтогазогенерація, вогнище флюїдогенераці, прогин, вуглеводнеутворення, комплекс, скупчення.