ISSN 2500-0632 (ON-LINE)
MINING SCIENCE AND TECHNOLOGY (RUSSIA)
GORNYE NAUKI I TEHNOLOGII
2020;5(2):72-81
MISIS National University of Science and Technology

ORIGINAL PAPERS / ОРИГИНАЛЬНЫЕ СТАТЬИ

DOI: 10.17073/2500-0632-2020-2-72-81

Oil and Gas Potential of Superimopsed Depressions in Azerbaijan

A. A. Feizullaev, S. S. Kocharli, S. V. Abbasova

Institute of Geology and Geophysics of National Academy of Sciences of Azerbaijan,
Baku, Republic of Azerbaijan

Abstract: The Republic of Azerbaijan has significant potential in the oil and gas industry, which is the basic for the country economy. Prospects for the development of oil and gas production technologies are largely determined by the effectiveness of geological and geophysical surveys and exploratory drilling. The features of the geology and oil and gas potential of the Azerbaijanian continental depression zones are considered for determining the targets for further exploration for hydrocarbons (HC). The analysis of such studies shows that the Srednekurinskaya depression (the Azerbaijani part) and the Guba-Divichinsky depression are superimposed with the corresponding features of the conditions for the formation and survival of hydrocarbon accumulations. Low oil and gas potential of the Miocene-anthropogenic strata of the discussed superimposed depressions is substantiated: this is due to low hydrocarbon potential of the rocks (especially the Lower Pliocene ones), as well as low temperatures insufficient for the conversion of organic matter to hydrocarbons. It is proposed to use poorly tectonized Jurassic and Cretaceous sediments, especially those overlaid by oil and gas generating Paleogene-Miocene strata (commercial accumulations of Muradkhanli type) as the HC exploration prospects.

Keywords: tectonics, superimposed depression, Meso-Cenozoic strata, unconformities, oil and gas potential, Azerbaijan, nondepositional hiatus, basin modeling, hydrocarbons.

For citation: Feizullaev A. A., Kocharli S. S., Abbasova S. V. Oil and Gas Potential of Superimopsed Depressions in Azerbaijan. *Gornye nauki i tekhnologii = Mining Science and Technology (Russia)*. 2020;5(2):72-81. (In Russ.) DOI: 10.17073/2500-0632-2020-2-72-81.

Наложенные прогибы Азербайджана в связи с их нефтегазоносностью

Фейзуллаев А. А., Кочарли Ш. С., Аббасова С. В.

Институт геологии и геофизики Национальной академии наук Азербайджана,
г. Баку, Республика Азербайджан

Аннотация: Республика Азербайджан обладает значительным потенциалом нефтегазовой отрасли экономики, которая является базовой для страны. Перспективы развития технологий добычи нефти и газа в значительной мере определяются эффективностью геолого-геофизических исследований и поисково-разведочного бурения рассматриваются особенности геологического строения и нефтегазоносности депрессионных зон суши Азербайджана с целью определения направления дальнейших поисков углеводородов (УВ). Проведенный анализ таких исследований показывает, что Среднекуринская впадина (азербайджанская часть) и Губа-Дивичинский прогиб имеют наложенный характер с соответствующими особенностями условий формирования и сохранения углеводородных скоплений. Обосновываются низкие перспективы нефтегазоносности миоцен-антропогенового комплекса отложений указанных наложенных прогибов, в связи с невысоким углеводородным потенциалом пород (особенно нижнеплиоценовых), а также низкими температурами, недостаточными для преобразования органического вещества в УВ. В качестве поисковых объектов предложено использовать слабо дислоцированные юрские и меловые отложения, особенно перекрытые нефтегазогенерирующими палеоген-миоценовыми комплексами (промышленные скопления типа Мурадханлы).

Ключевые слова: тектоника, наложенный прогиб, мезо-кайнозойские отложения, несогласия, нефтегазоносность, Азербайджан, перерыв в осадконакоплении, бассейновое моделирование, углеводороды.

Для цитирования: Фейзуллаев А. А., Кочарли Ш. С., Аббасова С. В. Наложенные прогибы Азербайджана в связи с их нефтегазоносностью. *Горные науки и технологии*. 2020;5(2):72-81. DOI: 10.17073/2500-0632-2020-2-72-81.

Introduction

The problems of assessing oil and gas potential depending on the nature of inheritance or superimposition of depressions are poorly studied, although there are some publications relative to this matter by the way [2, 3, 5, 10].

In this regard, notice that most of the oil and gas bearing depressions or oil and gas regions of Azerbaijan, such as the South Caspian basin, Apsheron region, southeastern Gobustan, Nizhnekurinsky and Yevlakh-Agjabedinsky depressions (up to Upper Miocene) are characterized by predominant inheritance of depression and sedimentation for the whole alpine orogenesis period.

In these depressions, which were founded at least from the beginning of Jurassic period (the supposed surface of the crystalline basement), the thickness of the Meso-Cenozoic sediments is 10–25 km or more, and they are characterized mainly by the conformity of the structural plans of the composing sediments.

Meanwhile, in the territory of Azerbaijan, there are several oil and gas regions with clear imposition of structural plans.

It is necessary to make a reservation that the concept of "superimposed depressions" is used here in two meanings: stratigraphic and structural. The term "superimposition of folded zones of oil and gas regions" (which in fact has genetic nature similar to the depressions) is relatively rarer used.

In this paper, we consider two oil and gas regions: Kurinsky basin and Caspian-Guba region, although, according to many researchers, there are much more such depressions in Azerbaijan (this will be discussed later).

In this study, the features of geology and oil and gas potential of the Azerbaijanian continental depression zones are considered for assessing the prospects of discovering new commercially productive hydrocarbons.

Research Findings.

Superimposed depressions of the Kurinsky Basin

In the modern sense, the Kurinsky basin, as a large structural element separating the meganticlinories of the Greater Caucasus and Caucasus Minor, was formed in the post-Upper Miocene time. This was first indicated by V.E. Hain and A.N. Shardanov [9] as early as 1952. Later geological and geophysical studies [2, 5, 11] established that in the Mesozoic time (Jurassic-Cretaceous), the territory of the Kurinsky basin (the Azerbaijani part) was actually represented by the following independent structural units: Nizhnekurinsky (NKD) and Yevlakh-Agjabedinsky depressions, the Kura and Gabyrry interfluve (the southwestern side of Iorsky depression), Ajinoursky depression, and Mugan-Saatly-Geokchay-Mingechaursky uplift zone separating the depression areas (Fig. 1).

Paleotectonic restructuring, sometimes called inversion, began at the Upper Cretaceous – Paleogene boundary and ended in the Late Miocene, as mentioned above (Fig. 2).

Along with some common features, each of these tectonic zones has its own specifics of development and structure.

Among these depressions, only Yevlakh-Agjabedinsky depression has full independence (closureness) in the Azerbaijan territory, while Nizhnekurinsky depression is the southwestern gulf of the South Caspian Basin (SCB), and the Kura-Gabyrry interfluve is the southwestern side of the Iorsky depression.

The nature of these depressions within the present-day Kurinsky Basin was largely controlled by the nature of the Mugan-Saatly-Geokchay-Mingechaursky zone of uplifts, which in many respects coincides with the well-known Talysh-Vandamsky gravitational maximum.

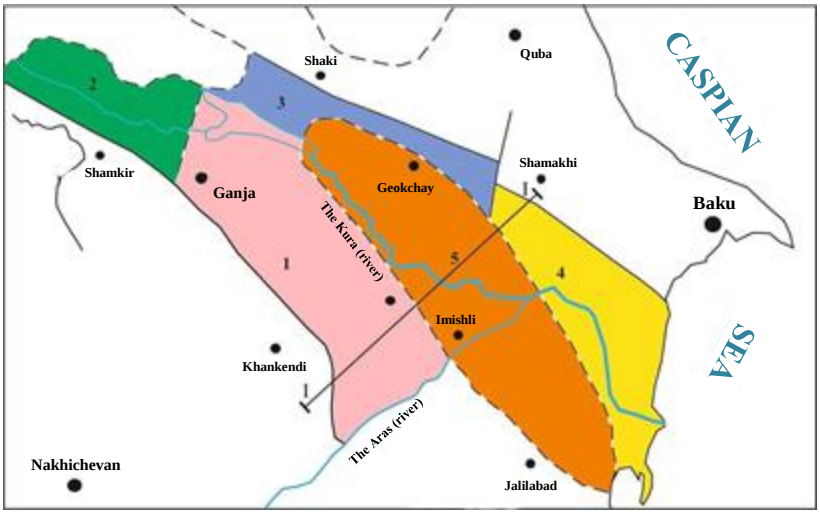

Fig. 1. Kurinsky basin. Mesozoic tectonic structure:
depressions: *1* – Yevlakh-Agjabedinsky; *2* – interfluve of the Kura and Gabyrry; *3* – Ajinoursky; *4* – Nizhnekurinsky; uplift zone: *5* – Talysh-Saatly-Mingechaurskaya; *I–I* – geological profile crossing the Kurinskaya depression (see Fig. 3)

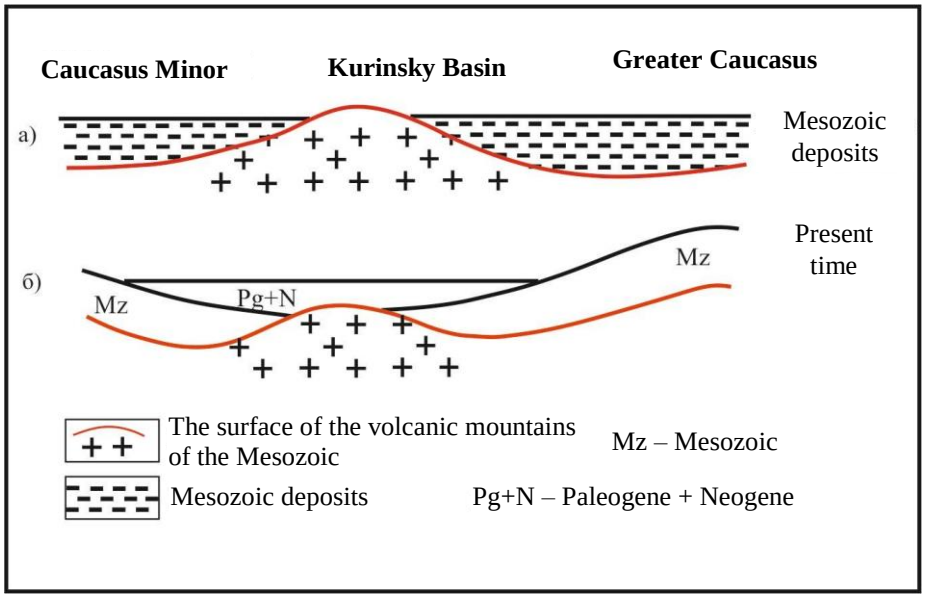

Fig. 2. Location of Caucasus Mountains:
a – in the Mesozoic; *b* – at the present time

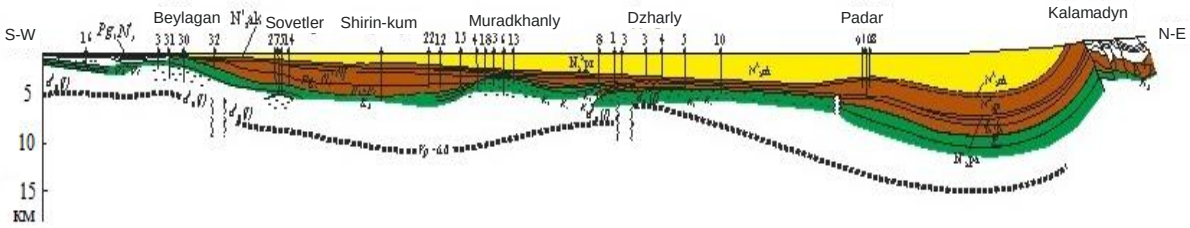

Fig. 3. Geological profile crossing the Kurinsky basin from southwest to northeast

The mentioned zone of uplifts, which apparently existed from Paleozoic time, underwent intensive erosion since the end of Upper Cretaceous up to the beginning of Upper Miocene, and sedimentation was completely absent here. The Nizhnekurinsky depression during this period developed together with the South Caspian Basin, having the inherited character of the Mesozoic-Cenozoic structural plans with the accumulation of molasses of great thickness (more than 15 km).

Since Upper Miocene, the whole territory of the central part of the Kurinsky Basin has undergone intense subsidence and sedimentation, and superimposed Srednekurinsky depression (SKD) has formed here, covering the Miocene-Pliocene-Anthropogenic sediments of about 5 km thick (Fig. 3).

Consequently, superimposition in the Kurinsky Depression took place only in its Srednekurinsky part, whereas the Nizhnekurinsky depression (NKD) has inherited downwarping nature.

The Adjinoursky region, especially its Alazan-Agrichay zone, is also considered by a number of researchers as a superimposed depression. If that's the case, then the whole Adjinoursky region should be classified as superimposed depression.

In a significant part of the SCD territory, the post-Upper Miocene sediments are almost not affected by folding, with the exception of the Chatma-Geokchay anticlinorium zone, partly the side part of the Yevlakh-Agjabedinsky depression, and the Adjinoursky region. In the NKD, as in the SCB, these formations have been intensively folded.

The question is: what is the nature of the oil and gas content of the Miocene-Pliocene-Quaternary sediments in the superimposed depressions of the Kurinsky Basin?

As is known, in the central part of SKD in the superimposed complex of the Upper Miocene-Pliocene-Quaternary sediments, steadily demonstrating near-horizontal occurrence, no signs of oil and gas content were observed. Commercial oil and gas potential or hydrocarbon manifestations have been identified in the underlying sediments of Upper Cretaceous-Paleogene (Muradkhanly, Jafarly, Sovelyar, Zardob fields) and Oligocene-Lower Miocene (Maykop series) (Gazanbulag, Ter-Ter, Naftalan fields).

In the Kura - Gabyrry interfluve, the presence of hydrocarbon accumulations was also established in the lower structural level – Eocene and the Upper Cretaceous in the Tarsdallar and Gyurzundag areas. In the superimposed Maikop-Upper Miocene-Pliocene complex, effective manifestations of oil and gas have not been established, with the exception of oil seepage in the Upper Miocene sediments in the Chatminsky anticlinorium zone.

In the NKD, which has an inherited origin in the Cenozoic and possibly Mesozoic complexes, oil and gas content was established mainly in the sequence of the Lower Pliocene (productive strata - PS), partially in the Upper Pliocene (Akchagyl Formation) and Quaternary (Apsheron Formation) sediments. The underlying sediments (Miocene-Oligocene) have been partially penetreted, and it is too early to talk about their prospects, although the preliminary findings are quite encouraging.

Thus, the superimposed depression in the Upper Miocene-Quaternary complex in SKD has relatively lower oil and gas potential, whereas in the NKD with the inherited nature of the structural plan, the whole mentioned complex has oil and gas content/or potential.

In this regard, oil and gas potential of the lower structural level of the SKD – from Middle Sarmatian to Upper Cretaceous – are of interest.

Three possible models of formation of HC accumulations, characteristic not only of the SKD, but also of other superimposed depressions, are considered. These models are shown in Fig. 4.

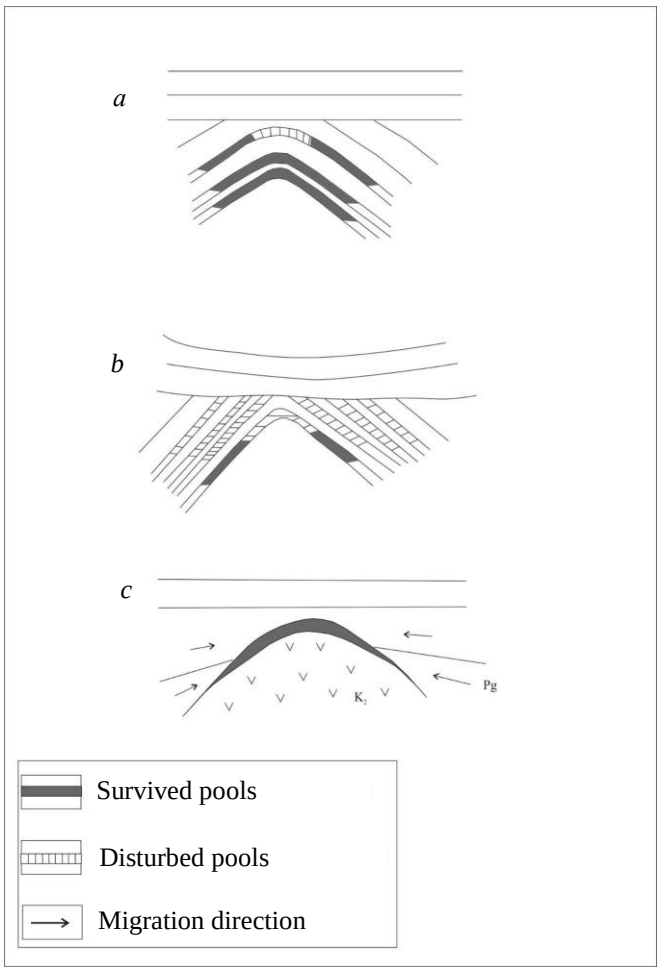

Fig. 4. Variants of oil-gas pool formation in superimposed depressions

Fig. 4, *a* presents the pattern of accumulation formation in underlying complexes, where reservoir beds are almost not affected by erosion and favorable conditions exist for the conservation of hydrocarbon accumulations.

Fig. 4, *b* shows the case of deep erosion degree of reservoir beds with possible disturbance of the accumulations and their preservation as a result of subsequent overlaying the underlying complex by young formations (Dzharly, Sor-Sor, Karadzhally fields, etc.

Finally, Fig. 4, *c* presents the model of Muradkhanly field, where the eroded protrusion of the Upper Cretaceous volcanic rocks is overlain by oil-and-gas-bearing Paleogen-Miocene sediments.

The exploration in the Dzharly-Karadzhally zone, located in the most elevated and highly eroded part of the Kurdamir Bridge, discovered no commercial accumulations of hydrocarbons. Even assuming oil and gas formation in the Mesozoic, however, long-lasting erosion in the Upper Cretaceous-Upper Miocene did not favor the formation and conservation of hydrocarbon accumulations (the model in Fig. 4, *b*).

The Muradkhanly field is an exception in this case, since here the eroded surface of the Upper Cretaceous is overlain by oil and gas-forming Maykop-Eocene sediments with subsequent migration of hydrocarbons to the head part of the Mesozoic nose. In this regard, one of authors [6] based on paleogeological studies substantiated an exploratory criterion for discovering analogues of the Muradkhanly field – these are the areas of overlaying volcanics by oil and gas-forming Maykop-Eocene sediments.

The Khosrov-Agdash uplift zone and its southwestern plunge, up to Amirirkhsky area, comply with this condition.

Guba-Divichinsky superimposed depression (GDSD)

There are a lot of interesting, sometimes conflicting opinions about the nature of this unique depression, regarding both the history of geological evolution and the modern structure [1, 7, 8, 10]. Not considering the essence of these studies, we should note that this depression is a classic example of superposition of the Quaternary-Paleogene complex of sediments on the Mesozoic (Jurassic-Cretaceous) formations with a long nondepositional hiatus from Middle-Upper Jurassic to Paleogene-Miocene. There is also an opinion [2] that GDSD in the Mesozoic is not a typical synclinorium, most likely it is an uplift zone with the loss of a number of stratigraphic units of the Jurassic and Cretaceous from the sequence. Indeed, in the Jurassic – Cretaceous, this zone occupied higher hypsometric position than the zones of Tengi-Beshbarmasky anticlinorium and Khyzinsky synclinorium, where relatively complete sequence of these sediments is observed (Fig. 5).

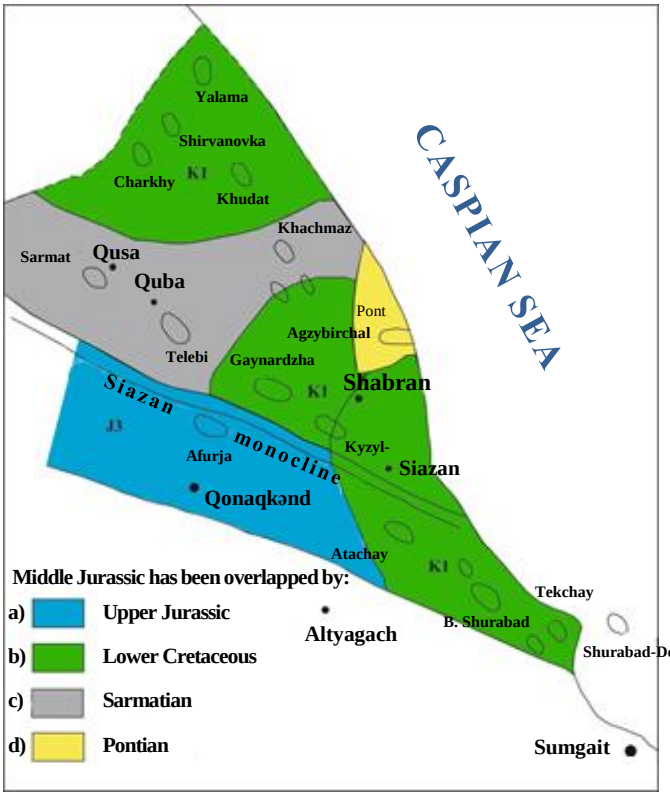

Fig. 5. The Caspian-Gubinsky region. Paleogeological map of Middle Jurassic sediment overlapping

The tectonics of the eroded surface of the Mesozoic sediments in the GDSD are far from calm: here, according to geological, geophysical, and exploratory drilling data, a number of anticlinal zones and separating them synclinal zones are distinguished. In particular, in the north-west of the region, local structures Gusar, Shirvanovka, Yalama, Yalama Nothern, Khudat, etc. were identified, and in the south-east, local structures Guba, Khachmas, Charkhi, Agzybirchala, etc. were identified. Between these zones, poorly expressed Zeykhur synclinal is located. In the south-west of the region, the Talabi-Gaynardzha-Gyzylburunsky anticlinal zone is linearly extended in par-

allel to the Siazansky monocline, and in the northeastern plunging part of the monocline, narrow synclinal strip is located.

The extents of erosion and exposure of the surface of the "underlying" (lower), i.e. the Mesozoic complex in the region are quite different. It should be noted that there are no Upper Jurassic formations throughout the region. In some areas, Middle Jurassic sediments through major unconformity are overlain by the Paleogene-Lower Miocene formations, in particular, by the Paleocene in the Khachmaz area, by the Pontian in the Agzybirchala area, and by the Lower Cretaceous in the Yalama area. The maximum extent of the break was observed in Gusar area, where borehole No. 1, at a depth of 2448 m left the Upper Miocene sediments and penetrated the Middle Jurassic interval of 220 m long (Fig. 6).

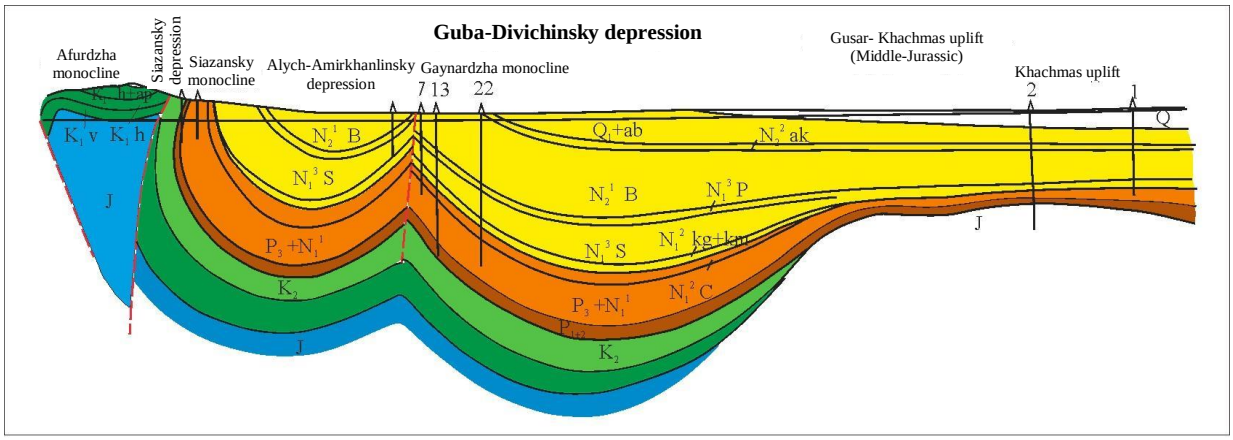

Fig. 6. Geological profile in the direction of Afurdzha-Khachmaz (according to A. A. Suleymanov et al. [8])

In Talabi area, located closer to the center of the Guba-Divichinsky Depression, borehole No. 12 discovered black mudstones of Middle Jurassic, underlying the Sarmatian sediments, proving superimposed nature of this depression as well. About the same sequence was intersected in borehole No. 15 in the same area.

Regarding tectonics of the superimposed Paleogene-Miocene-Pliocene-Quaternary part of the sequence in the region, one can say that according to the latest geological and geophysical data, almost all of them occur near-horizontally without any structural complications, being gently dipping to the northeast, towards the Caspian Sea, and therefore they do not have actual oil and gas prospects.

Regarding the oil and gas potential of the "underlying" complex in the region, it should be noted that in addition to the Siazansky monocline fields, oil and gas occurrences were identified in a number of areas in the region in the sequence of Jurassic and especially Cretaceous sediments. In particular, oil and gas occurrences were identified in the Yalama area in borehole No. 1 during drilling in the Turonian-Cognac sediments, and in borehole No. 9 (the Barremian), 28–30 m^3 of water with oil and gas-condensate were obtained. Oil and gas occurrences were also identified when drilling boreholes in the Khudat and Khachmas areas. Despite these positive facts, no commercial accumulations of oil and gas were identified here.

The reason for this situation, in the opinion of many researchers, lies in the insufficiency of geological and geophysical studies, especially deep drilling. Partially agreeing with this opinion, we note that one of the reasons could also be severe dislocation and greater exposure of the surface of the Jurassic and Cretaceous reservoirs, which contributed to the destruction of previously formed accumulations (the model in Fig. 4, b). Hydrocarbons formed in the lower structural level could be destroyed by the time of formation of

Miocene – Paleogene sediments [13]. In this regard, the observed oil and gas occurrences or hydrocarbon inflows in boreholes may be the surviving remnants of the former accumulations. In any case, only deep drilling exploration for such accumulation may enable estimation of their reserves and assessing profitability of their extraction.

Thus, in the GDSD, same to the SKD, oil and gas potential of the deeply eroded Jurassic-Cretaceous formations is assessed as low.

Conclusion

A comprehensive analysis of the findings of historical geological and geophysical studies, exploration drilling and determination of oil and gas potential of the Azerbaijanian continental depression zones was performed, and the following conclusions were made:

– the Srednekurinsky Depression (the Azerbaijani part) and the Guba-Divichinsky Depression have superimposed nature;

– low oil and gas potential of the Miocene-Quaternary complex of the discussed superimposed depressions has been substantiated: this is due to the low hydrocarbon potential of the rocks (especially the Lower Pliocene ones), as well as low temperatures insufficient for the conversion of organic matter to hydrocarbons. The latter is confirmed by the results of oil and gas generation modeling performed through the examples of the Khachmaz area (Fig. 7) and the Yalama area (Fig. 8);

– it is proposed to consider the poorly tectonized Jurassic and Cretaceous sediments as potential HC exploration targets.

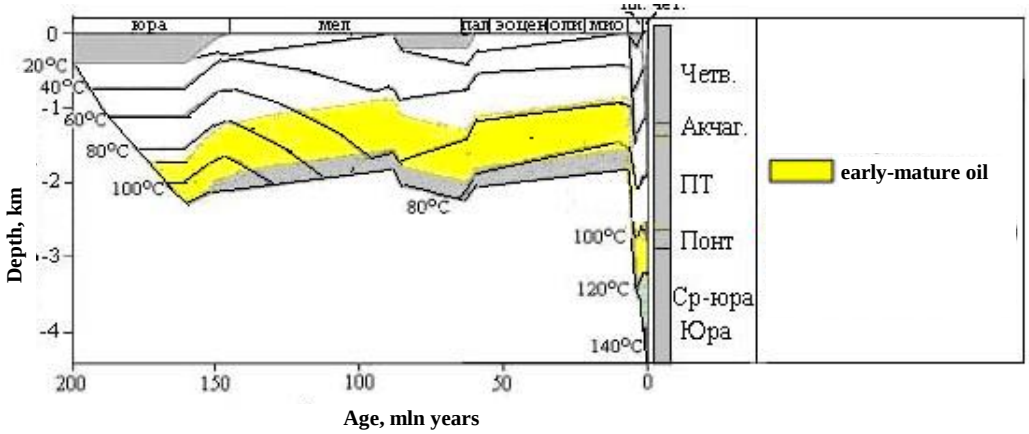

Fig. 7. Oil and gas formation model for Khachmaz area

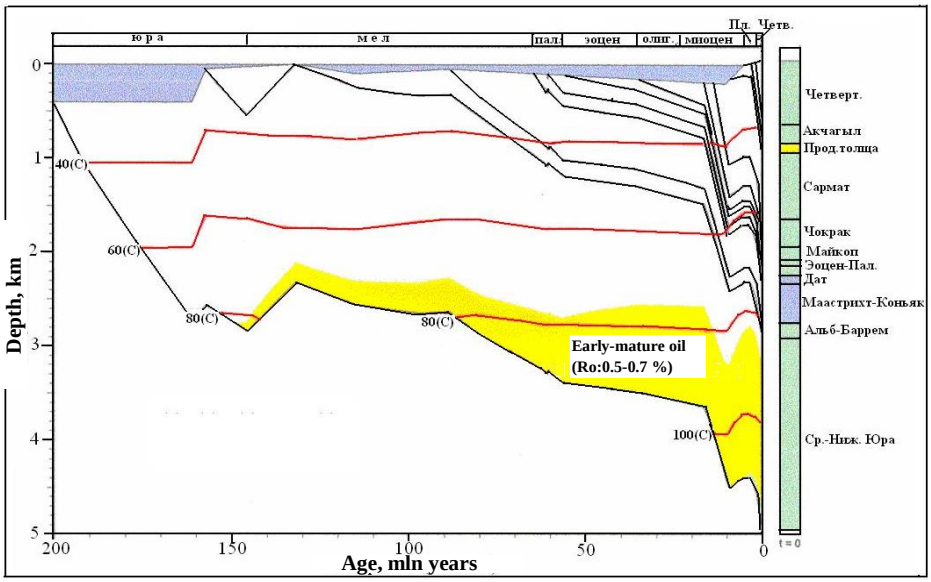

Fig. 8. Oil and gas formation model for the Yalama area

– the eroded volcanic, volcanic-sedimentary rocks of the Mesozoic, overlain by the oil and gas generating Paleogene-Miocene complexes (commercial accumulations of the Muradkhanly type) should also be considered as HC promising targets.

In the light of the research findings, for further exploration in the lower structural level, new, possibly unconventional geological and geophysical approaches and exploration methods should be developed.

References

1. Aliev A. *The internal depressions in Azerbaijan and assessment of their prospects for oil and gas*. Baku: Nafta Press Publ; 2003. 319 p. (In Russ.).

2. Alizade A. A., Akhmedov G. A., Akhmedov A. M., Aliev A. K., Zeynalov M. M. *Geology of oil and gas fields of Azerbaijan*. Moscow: Nedra Publ.; 1966. 392 p. (In Russ.).

3. Akhmedov G. A. *Geology and oil-and-gas potential of Gobustan*. Baku: Aznefteizdat Publ.; 1957. 299 p. (In Russ.).

4. Vassoevich N. B. About large overthrust sheets in the East Transcaucasia. *Zapiski Vserossijskogo mineralogičeskogo obŝestva*. 1940;69(2):395-416. (In Russ.).

5. Mamedov A. V. *History of geological development and paleogeography of the Srednekurinsky depression in relation to oil-and-gas*. Baku: Elm Publ.; 1977. 221 p. (In Russ.).

6. Kocharli Sh. S. *Problematic issues of oil and gas geology of Azerbaijan*. Baku: Ganun Publ; 2015. 280 p. (In Russ.).

7. Salaev S. G. *Oligocene-Miocene sediments of the South-East Caucasus and their oil-and-gas potential*. Baku: Azerbaijan Academy of Sciences Publ.; 1961. 253 p. (In Russ.).

8. Suleymanov A. M., Zeynalov R. L., Maharramov B. I. Paleotectonic and paleogeographic reasons of oil-and-gas prospects of Mesozoic sediments of the Caspian-Guba NQR. *Azerbajdžanskoe neftânoe hozâjstvo*. 2010;3:3–8. (In Azerb.).

9. Khain V. E., Shardanov A. N. *Geological history and structure of the Kurinsky basin*. Baku: Azerbaijan Academy of Sciences Publ.; 1952. 348 p. (In Russ.).

10. Shardanov A. N. About the phenomena of overthrust sheet formation in the South-East Caucasus. In: *Proceedings of Azerbaijan Academy of Sciences*. 1953;9(8):439–444 (In Russ.).

11. Shikhalibeyli E. Sh. *Geological structure and history of tectonic development of the eastern Caucasus Minor*. Baku: Azerbaijan Academy of Sciences Publ.; 1966. 110 p. (In Russ.).

12. Shurygin A. M. *Conditions for the formation of structures in the South-East Caucasus*. Moscow: USSR Academy of Sciences Publ.; 1962. 139 p. (In Russ.).

13. Feizullaev A., Ibragimov B., Godzhaev A., Dzhabbarova N. Modeling of oil and gas formation in sedimentary strata of the Caspian-Gubinsky region. *Izvestiya NAN Azerbaijana. Nauki*. 2005;(1):16–20 (In Russ.).

Библиографический список

1. Алиев А. *Внутренние впадины Азербайджана и оценка их перспектив нефтегазоносности*. Баку: Нафта пресс; 2003. 319 с.

2. Ализаде А. А., Ахмедов Г. А., Ахмедов А. *М., Алиев А. К., Зейналов М. М. Геология нефтяных и газовых месторождений Азербайджана*. М.: Недра; 1966. 392 с.

3. Ахмедов Г. А. *Геология и нефтегазоносность Гобустана*. Баку: Азнефтеиздат; 1957. 299 с.

4. Вассоевич Н. Б. О крупных тектонических покровах в Восточном Закавказье. *Записки Всероссийского минералогического общества*. 1940;69(2):395-416.

5. Мамедов А. В. *История геологического развития и палеогеография Среднекуринской впадины в связи с нефтегазоносностью*. Баку: Элм; 1977. 212 с.

6. Кочарли Ш. С. *Проблемные вопросы нефтегазовой геологии Азербайджан*а. Баку: Ганун; 2015. 280 с.

7. Салаев С. Г. *Олигоцен-миоценовые отложения Юго-Восточного Кавказа и их нефтегазоносность*. Баку: Изд. АН Азерб. ССР, 1961. 253 с.

8. Süleymanov Ə. M., Zeynalov R. L., Məhərrəmov B. İ. Xəzəryanı-Quba NQR-in mezozoy çöküntülərinin neft-qazlılıq perspektivliyinin paleotektonik və paleocoğrafi əsasları. *Азерб. Нефт. хозяйство*. 2010;(3):3–8.

9. Хаин В. Е., Шарданов А. Н. *Геологическая история и строение Куринской впадины*. Баку: Изд. АН Азерб. ССР; 1952. 348 с.

10. Шарданов А. Н. К вопросу о явлениях покровной тектоники на Юго-Восточном Кавказе. *Докл. АН Азерб. ССР*. 1953;9(8):439–444.

11. Шихалибейли Э. Ш. *Геологическое строение и история тектонического развития восточной части Малого Кавказа*. Баку: Изд. АН Азерб. ССР; 1966. 110 с.

12. Шурыгин А. М. *Условия формирования структур Юго-Восточного Кавказа*. М.: Изд. АН СССР; 1962. 139 с.

13. Фейзуллаев А., Ибрагимов Б., Годжаев А., Джаббарова Н. Моделирование генерации нефти и газа в осадочной толще Прикаспийско-Губинского района. *Известия НАН Азерб. Науки о Земле*. 2005;(1):16–20.