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Facial composition of the deposits of the productive strata based on qualitative interpretation of the log data

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As is known, most of the discovered oil and gas fields in Azerbaijan are associated with terrigenous deposits; thus, the successful discovery of new fields largely depends on determining the genesis of terrigenous formations.

Determining the genesis of reservoir deposits allows apetroleum geologist to more accurately predict the reservoir'sshape and change its main parameters in both lateral and vertical directions.This information also allows us to choose a rational drilling operationsystem in the field. Comprehension of the genesis of the productive stratum deposits is also important in developing oil and gas fields.

The research of the genesis of deposits of productive series is of great interest given the acceleration of exploration and evaluation of their oil and gas potential. In this regard, using the ««qualitative logging facies models» proposed by V.S. Muromtsev in the article, the sections of the wells of the Garbi Absheron, Shimali Absheron, Khazri, and Arzu structures of the North Absheron zone of the uplift PS suites «Fasila», «Upper Kirmaky Clayey» (UKC) and on the sedimentary rocks of the «Upper Kirmaky Sandy» (UKS) formation, a lithofacial analysis of sedimentary rocks was carried out, the genesis of sedimentary rocks was established, and an explanation of the results obtained was given.

Geophysical logging data of the borehole potential curve of intrinsic polarisation were used to build spatial models and 3D models. The constructed models allow us to attribute various shapes of the well potential curve (WP) to deposits of a defined facies composition.

In the research work, the total thickness of facies for the UKC and UKS suites was calculated, three-dimensional spatial models were built considering the variation in their thickness by structuresof the North Absheron zone of the uplift, and 3D models were built by the structures located on them.The facies composition of the sediments of the layers in the «Fasila», «UKC» and «UKS» formations was determined based on created models selected by their appearance and forms of display from WP diagrams of well sections in the Garbi Absheron, Shimali Absheron, Khazri, and Arzu structures.

These models are major for accurately calculating oil and gas reserves in the area, for drilling and designing new wells, and refining the operation scheme.

Key words: facies, alluvial riverbeds, alluvial river channels, coastal sea, genesis, spatial model.

Introduction. 90 % of the oil and gas condensate produced in our country is provided by sediments of the productive series of the early Pliocene of the South Caspian. In this regard, a more detailed study of these sediments is of great practical importance [Kerimova, Aliyev, 2022].

Major issues are determining the conditions for the accumulation of sediments in the early Pliocene and, especially, the targeted

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prospecting for hard-to-reach stratigraphic, lithological, paleogeomorphological, epigenetic, and other types of traps. Even information about the sedimentation process in the exploration of oil and gas fields associated with sand bodies, calculation of reserves, and stages of exploitation is of great importance.

Determining the genesis of reservoir deposits allows the petroleum geologist to more accurately predict the shape of the reservoir and the change in its main parameters in the lateral and vertical directions. These data also make it possible to choose a rational system of drilling operations in the field [Kerimova, 2019].

Information about the genesis of productive layer sediments is also important in developing oil and gas fields. Since most terrigenous reservoirs are heterogeneous in their genesis, the volume of oil extracted also varies.

As is known, most of the discovered oil and gas fields in Azerbaijan are associated with terrigenous deposits; the successful discovery of new fields largely depends on determining the genesis of terrigenous formations. Determining the conditions for the accumulation of terrigenous deposits makes it possible to predict the distribution patterns of sand bodies, judge the morphology of the layers formed by them, and map the porous and permeable zones [Kerimova, 2014].

To obtain the information that we have mentioned, it is necessary to use the materials of geophysical studies, primarily logging and seismic survey data.

Methods. The deposits of the productive layer of the South Caspian Basin are very thick (6—7 km) and rich in hydrocarbon reserves. They are composed of sands, sandstones, siltstones, and clays in various proportions [Mammadov, 2010]. Recently, due to geological and geophysical work on the Azerbaijani shelf of the South Caspian, up to 200 anticlinal structures rich in hyd-

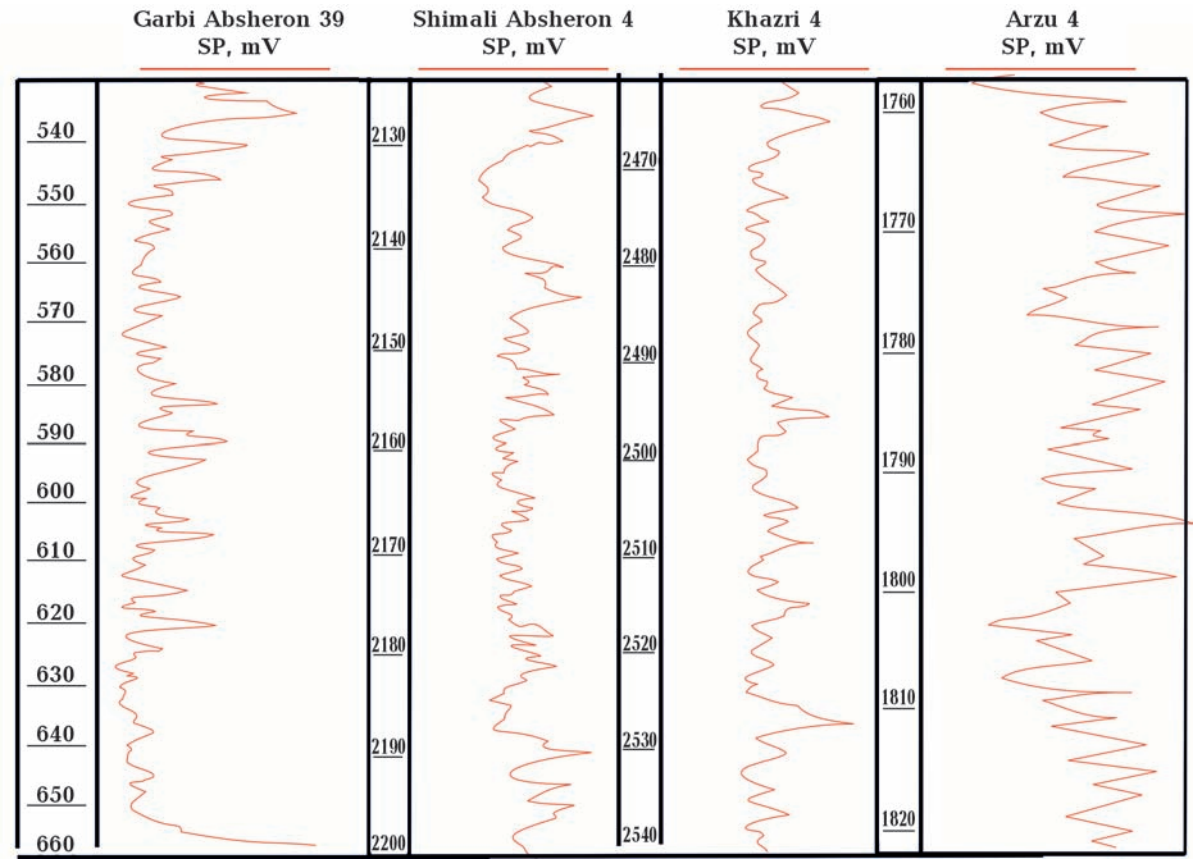

Fig. 1. SP data for the suites Fasila,«Upper Kirmaky Clayey» (UKC) and «Upper Kirmaky Sandy» (UPS) formations of the Garbi Absheron, Shimali Absheron, Khazri and Arzu structural well sections [Mammadov et al., 2015].

rocarbon resources have been discovered. As a result of the exploration work carried out on these structures, several large oil and gas fields were discovered, among which the Garbi Absheron, Shimali Absheron, and Khazri fields can be mentioned. According to calculations, the recoverable oil reserves of these fields alone amount to a 630 million ton [Mammadov, 2008].

The research on the genesis of deposits of the Productive Series (PS) is of great interest given the intensification of prospecting and exploration work in this area, including on the Arzu structure, and to assess their prospects for oil and gas. From this point of view, our studies using «qualitative logging facies models» proposed by V.S. Muromtsev, borehole sections of the GarbiApsheron, Shimali Absheron, Khazri and Arzu structures of the North Apsheron uplift zone, alsowas established suites of PS «Fasila», «Upper Kirmaky Clayey» (UKC) and lithofacies analysis of deposits on the «Upper Kirmaky Sandy» (UPS)

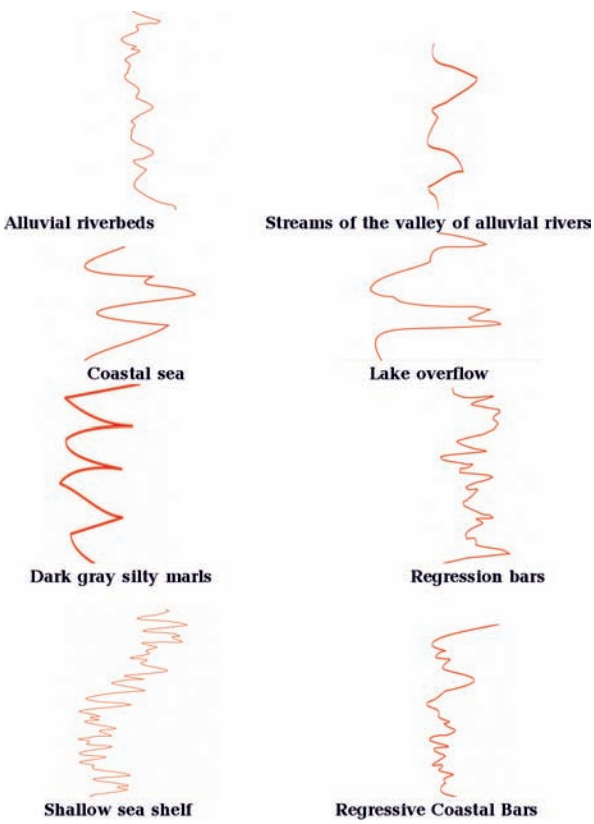

Fig. 2. Qualitative facies logging models compiled by V.S. Muromtseva.

formations and their genesis (Fig. 1).

For this purpose, first of all, based on the «quality of well-logging facies» model given by V.S. Muromsev, a lithofacies analysis of sedimentary rocks was carried out on rocks of formations PS suites «Fasila», «Upper Kirmaky Clayey» (UKC) and «Upper Kirmaky Sandy» (UPS) of the Garbi Absheron, Shimali Absheron, Khazri, and Arzu fields [Muromtsev, 1984].

These models make it possible to attribute different shapes of the spontaneous potential (SP) curve to deposits with a certain facies composition (Fig. 2) [Khalilova, Kerimova, 2022].

The facies composition of the deposits suites of the Fasila, UPS, and UKC formations of the section was modelled according to their appearance and manifestation forms from the SP-diagrams of the well sections into the named structures [Mammadov, 2007; Kerimova, Khalilova, 2020].

Results. The facies analysis of the deposits on the Garbi Absheron, Shimali Absheron, Khazri, and Arzu structures of the Fasila suite formation of PS is shown in Fig. 3.

For example, according to the appearance of the Garbi Absheron structure on the SP curve of the section of well 39, intervals corresponding to certain models were identified, and the following facies composition was predicted for the Fasila suite [Shilov, 2009; Lyons et al., 2018].

Thus, the SP curve in the depth interval of 658—625 m along the bottom of the Fasila Formation corresponds to the facies model of alluvial river valley runoff. This facies is replaced by an alluvial channel facies 12 m thick in the interval 622—610 m. Above it, a 10-meter facies of alluvial river runoff lies at 608—598 m. In the depth interval of 598—589 m, a 9-meter facies is observed, formed by coastal-sea currents. This facies is replaced by a temporary flow-type facies in the interval 590—560 m. In the depth interval 550—540 m above this facies, the facies composition of alluvial channels 10 m thick is again observed.

On the SP curve of the breakthrough layer of well 4 of the Shimali Absheron structure, the following facies are noted according to the forms of manifestation. In the depth inter-

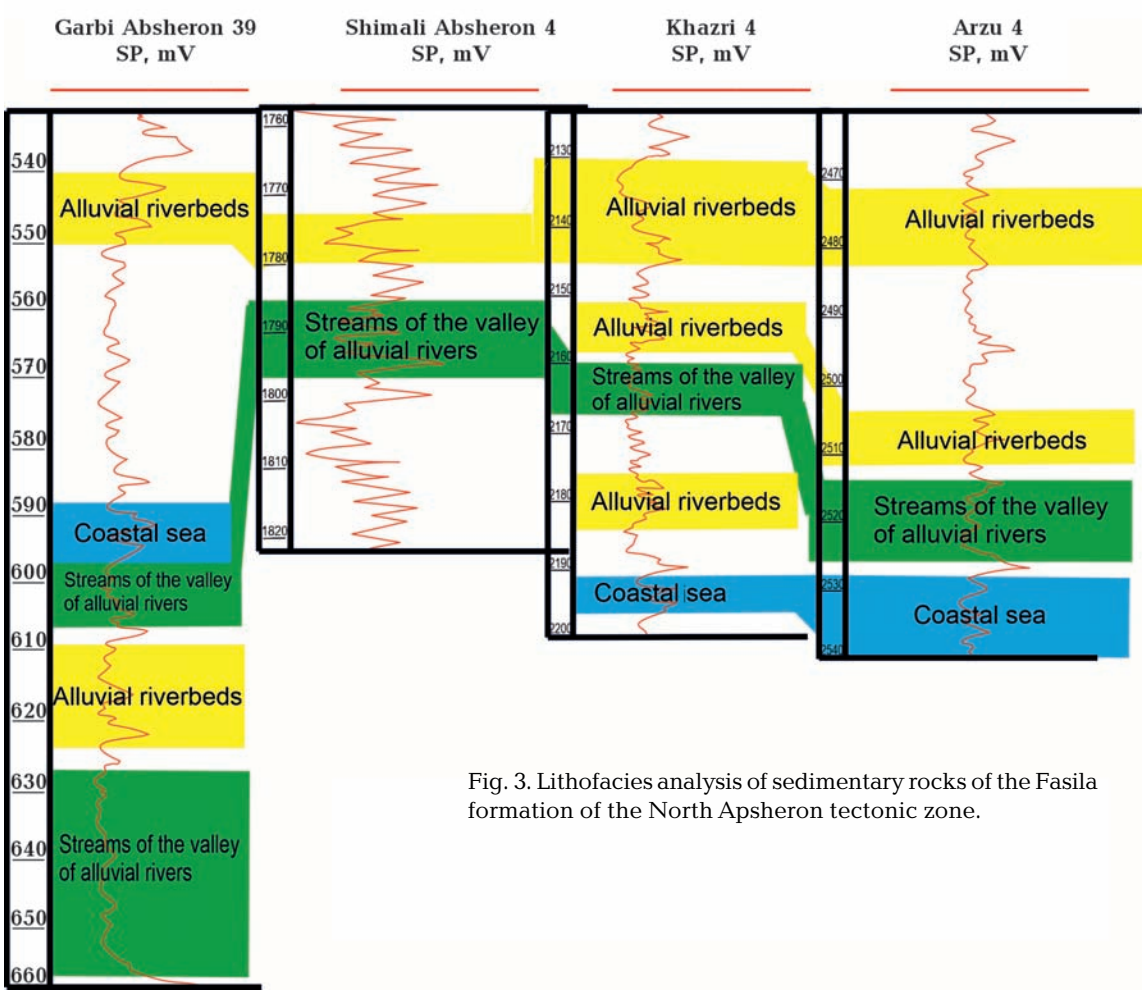

Fig. 3. Lithofacies analysis of sedimentary rocks of the Fasila formation of the North Apsheron tectonic zone.

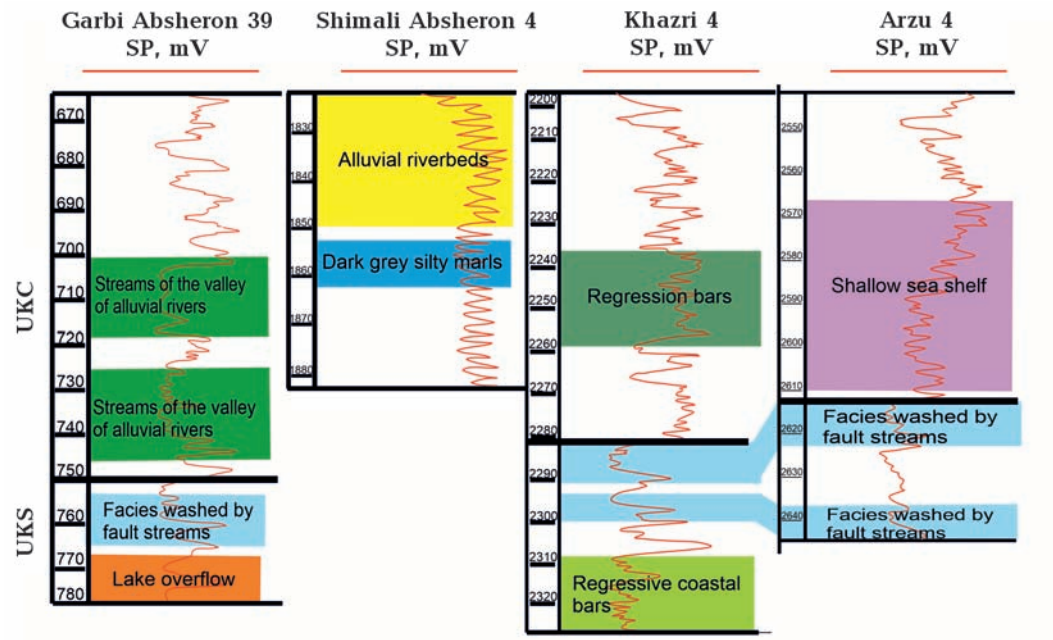

Fig. 4. Lithofacies analysis of sedimentary rocks of the «UKC» and «UKS» sequences of the North Apsheron tectonic zone.

Table. Lithofacies analysis of sedimentary rocks of the Fasila, UKC and UKS formations of PS on well sections of the structures of the North Absheron tectonic zone

Suites	Facies types	Garbi Absheron 39	Shimali Absheron 4	Khazri 4	Arzu 4
		Depth range, m	Depth range, m	Depth range, m	Depth range, m
«Fasila» Suite	Alluvial riverbeds	540—550, *h*=10 m 610—622, *h*=12 m	1773—1778, *h*=5m	2128—2145, *h*=17 m 2153—2157, *h*=4 m 2178—2185, *h*=7 m	2506—2510, *h*=4 m
	Streams of the valley of alluvial rivers	625—658, *h*=33 m 598—608, *h*=10 m	1787—1794, *h*=7m	2158—2165, *h*=7 m	2474—2482, *h*=8 m 2515—2527, *h*=12 m
	Coastal sea flow	589—598, *h*=9 m	—	2192—2196, *h*=4 m	2528—2540, *h*=12 m
UKC Suite	Streams of the valley of alluvial rivers	702—718, *h*=16 m 726—747, *h*=21 m	—	—	—
UKS Suite	Flushing streams of cracks	753—763, *h*=10 m 780—790, *h*=10 m	—	2281—2290, *h*=9 m 2293—2298, *h*=5 m	2612—2622, *h*=10 m 2638—2645, *h*=7 m

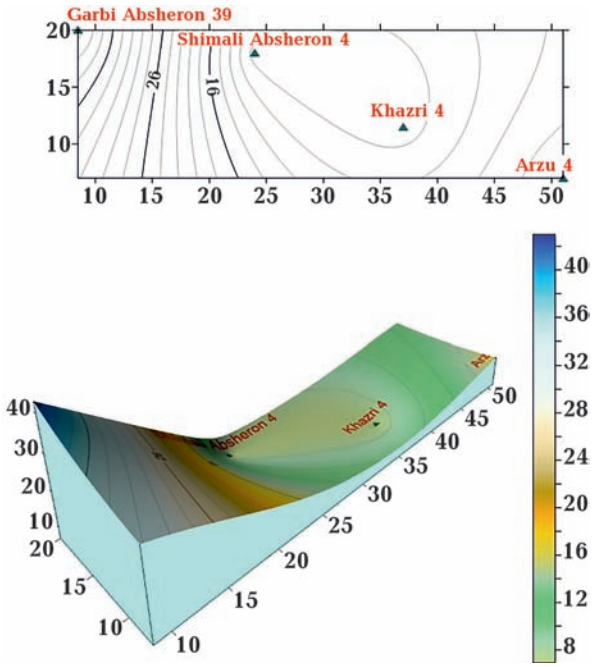

Fig. 5. 2D and 3D dimensional models of changes in the thickness of the facies of alluvial valley watercourses in the Fasila suitesediments of the PS of the North Absheron tectonic zone on the structures located on the research profile.

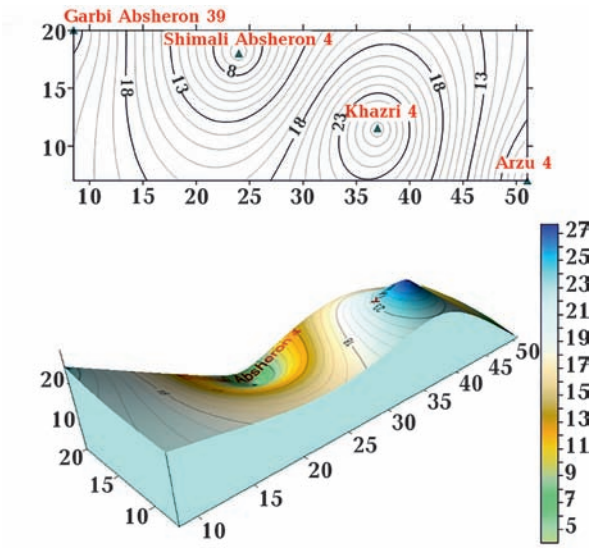

Fig. 6. 2D and 3D dimensional models of changes in the thickness of facies originating from the alluvial channels of the Fasila formation in the deposits of the PS of the North Absheron tectonic zone on the structures located on the research profile.

val of 1820—1805 m of the Fasila layer, washed-out alluvial sands are observed. This facies is replaced by the facies of the alluvial channel in the depth interval of 1788—1778 m. In the interval of 1778—1773 m of the intersection, an alluvial channel facies 5 m thick is observed.

According to the same rule, deposits of different facies composition were identified by the shape of the SP curve in the section of well 4 of the Khazri structure in the Fasila formation. In the depth interval of 2196—2192 m, facies of the coastal-sea current are observed. This facies is replaced by a 7-meter facies of coastal origin of the valley in the depth interval of 2165—2158 m. Alluvial channel facies are observed in the depth intervals of 2185—

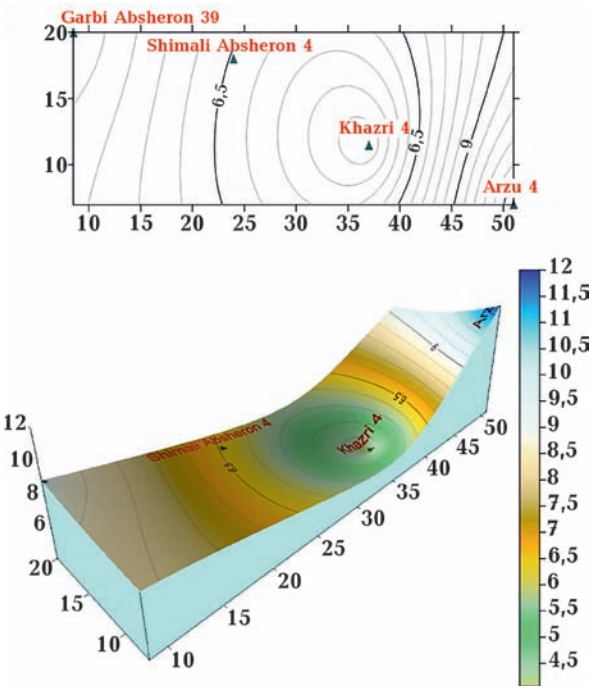

Fig. 7. 2D and 3D dimensional models of changes in the thickness of the facies of the coastal sea currents of the Fasila formation in the deposits of the PS of the North Absheron tectonic zone on the structures located on the research profile.

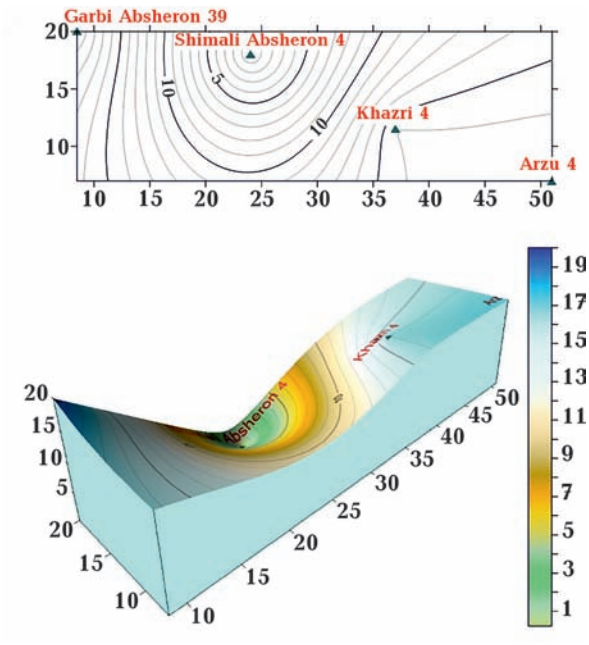

Fig. 8. 2D and 3D dimensional models of facies thickness variations resulting from the erosion of fault flows in the PS sediments of the UKS suite of the North Absheron tectonic zone on the structures located on the research profile.

2178 m, 2157—2153 m, and 2145—2128 m of the formation. The total thickness of this facies in the Fasila Formation is 28 m.

In the «Fasila» formation of well 4 of the Arzu structure, in the depth interval of 2540—2528 m, a 12-meter facies is observed, formed by coastal sea currents. Above this facies, there is an alluvial facies of channels with a thickness of 4 m in the depth interval of 2510—2506 m. In the depth intervals of 2482—2474 m and 2527—2515 m of the 20-m thick layer, facies of alluvial river flows are observed.

Let us consider the facies analysis using the «facies logging quality» models of the UKC formation in the Garbi Absheron, Shimali Absheron, Khazri, and Arzu structures. According to Fig. 4, as a result of the analysis of well sections for the UKC formation, the following was obtained:

In the Garbi Absheron structure, the following facies composition of the UKC formation is distinguished:

– facies of a coastal-marine fault current with a thickness of 3 m in the depth interval of 751—748 m;

– facies of shallow marine origin with a thickness of 6 m in the depth interval of 726—720 m;

– above itfacies of coastal-marine origin with a thickness of 2 m in the interval depths of 720—718 m;

– facies of alluvial river valleys with a total thickness of 37 m in the depth interval of 747—726 m and 718—702 m;

– coastal-marine transgressive littoral-bar facies are observed with a thikness 2 m in the depth interval 701—689 m.

According to the appearance of the SP curve of the section of well 4 of the Shimali Absheron structure, the following facies composition was distinguished for the UKC layer using a similar technique:

– temporary flow facies with a thickness of 17 m in the depth interval of 1879—1862 m;

– dark gray siltstone with a thickness of 10 m in the depth interval of 1861—1851 m is replaced by an alternation of marls;

– in the depth interval of 1850—1820 m, al-

luvial channel facies with a thickness of 30 m are observed.

In relation to the appearance of the SP curve of the section of well 4 of the Khazri structure, the following facies composition is distinguished:

– shallow-water-shelf facies 11 m thick in the depth interval 2281—2270 m;

– fault currents bar islands 11 m thick in the depth interval 2269—2258 m;

– in the depth interval of 2257—2237 m, the thickness of regressive bars is 20 m;

– the thickness of littoral transgressive bars is 7 m in the depth interval of 2237—2230 m;

– 20 m thick coastal-marine regression bars are observed in the depth interval of 2209—2229 m.

Consequently, according to the appearance of the QP curve of the section of well 4 of the Arzu structure, the following facies composition is distinguished:

– shallow shelf facies 45 m thick in the depth interval 2610—2565 m;

– shallow shelf open bay 8 m thick in the depth interval 2564—2556 m;

– in the depth interval of 2555—2541 m, the facies of the coastal-marine fault current is observed at a thickness of 14 m.

Similarly, the lithofacies composition of the UKS formation in the Garbi Absheron, Shimali Absheron, Khazri, and Arzu structures was analyzed according to the «logging facies quality» models (see Fig. 4).

According to the appearance of the SP curve on the UKS layer of the section of well 39 of the Garbi Absheron structure, the following facies composition was distinguished. In the depth interval of 780—766 m, in the depth interval of 765—753 m, the lacustrine facies 14 m thick is replaced by the continental valley facies 12 m thick.

Based on the appearance of the SP curve on the UKS formation of the Khazri structure, well 4, the following facies composition is distinguished (see Fig. 4). Regressive coastal swells 16 m thick in the depth interval 2325—2309 m, this facies 17 m thick in the depth interval 2308—2291 m is replaced by the main facies of fault currents. In the depth interval of 2290—2282 m, an 8-meter facies is observed, where fissure flows are predominantly washed.

In proportion to the appearance of the QP curve in the Arzu structure, according to the appearance of the QP curve in the section of well 4 of the Arzu structure, the following facies composition is distinguished: the main sections of the fault with a thickness of 5 m flow into the depth interval 2645—2640 m, the thickness of this facies is 15 m in the depth interval 2639—2624 m, this is the facies of the coastal sea of regressive coastal bars, is replaced by fascia. In the depth interval of 2623—2613 m, a washed part of fracture flows with a thickness of 10 m is observed.

Based on the studies, the total thicknesses of the facies of the Fasila, UKC, and UKS formations were calculated (Table), and 3D models of changes in their thickness by structure were built.

The thicknesses of the facies of alluvial river channels, alluvial valley streams, and coastal marine streams in the Fasila formation were determined, and three-dimensional models of changes in their total thickness by structure were built (Fig. 5—8).

The UKC suite consists mainly of clay interlayers and a small number of fine-grained sandy-clay interlayers in the well sections and has a coastal-marine type in terms of facies composition.

As can be seen from the figure, the UKS formation consists mainly of sand and sandstone with a small amount of clay interlayers and belongs to the alluvial-deltaic type in terms of facies.

Conclusion. In a research work using a «qualitative» model of logging facies» in the database of mining and geophysical data of wells, sections of wells of the Garbi Absheron, Shimali Absheron, Khazri, and Arzu structures of the North Absheron zone of the PS suites «Fasila», «Upper Kirmaky Clayey», and «Upper Kirmaky Sandy», the genesis of sedimentary rocks was determined, and the results were announced.

In the article, the total thickness of facies for the UKC and UKS suites was calculated, three-dimensional spatial models were built considering the variation in their thickness by

structures, and 3D models were built by the structures located on them.

These models are important for accurate calculation of oil and gas reserves in the area, for drilling and designing new wells, as well as for refining the operation scheme.

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Фаціальний склад відкладень продуктивної товщі на основі якісної інтерпретації даних геофізичних досліджень свердловин

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Як відомо, більшість виявлених нафтогазоносних родовищ в Азербайджані пов'язані з теригенними відкладами, отже, успішне відкриття нових родовищ більшою мірою залежить від визначення генези теригенних утворень.

Встановлення генези відкладів продуктивного пласта дає можливість геологу-нафтовику з більшою точністю прогнозувати форму колектору та зміну його основних параметрів як за латераллю, так і за вертикаллю, а також обрати раціональну систему бурових робіт на родовищі. Розуміння генези покладів продуктивної товщі (ПТ) має велике значення й при розробці родовищ нафти та газу.

Вивчення генези відкладів продуктивних пластів становить великий інтерес у зв'язку з прискоренням розвідки та оцінюванням їхньої їх нафтогазоносності. Тому за якісними фаціальними моделями каротажу, запропонованими В.С. Муромцевим, у статті за розрізами свердловин структур Західноабшеронської, Північноабшеронської, Хазрі та Арзу в Північноабшеронській світа «Перерив» (СП), «Надкірмакинська глиниста» (НКГ) і «Надкірмакинська» піщана (НКП) проведено пошаровий літофаціальний аналіз осадових порід, встановлено генезис осадових порід і описано отримані результати.

Для побудови просторових моделей і трьох моделей використано геофізичні дані каротажу кривої потенціала власної поляризації свердловин. Згідно з побудованими моделями, різні форми кривої потенціала свердловини (ПС) характеризують відклади певного фаціального складу.

Під час дослідницької роботи розраховано загальну потужність фацій шарів у світах НКГ і НКП, побудовано тривимірні просторові моделі з урахуванням варіації потужності цих шарів у структурах Північноабшеронської зони піднять, а також 3D моделі. Фаціальний склад відкладів шарів у світах «Перерив», «НКГ» і «НКП» визначено на підставі побудованих моделей, обраних за їхнім зовнішнім виглядом та формами прояву з ПС-діаграм розрізів свердловин у структурах Західноабшеронської, Північноабшеронської, Хазри та Арзу .

Ці моделі важливі для точного підрахунку запасів нафти і газу на території, буріння та проєктування нових свердловин, а також у разі уточнення схеми експлуатації.

Ключові слова: фації, алювіальні русла, алювіальні русла річок, прибережне море, генезис, просторова модель.