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A SPECIFIC FEATURES OF SHALE COMPACTION IN THE AZERBAIJAN SECTOR OF THE SOUTH CASPIAN BASIN

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Summary. The South Caspian Basin (SCB) covering a small area experienced intensive subsidence in the lower Pliocene and was isolated from the world ocean. The structures of the Baku Archipelago have one of the world's most complex geological conditions for drilling, with rocks in the near well-bore area squeezed into the wellbore (the so-called well filling) when drilling through shales in the productive series, which account for as much as 90% of the Archipelago. Well filling leads to problems and accidents and triggers drilling mud blowouts and water/gas kicks, which often results in well abandonment.

The primary cause for well filling is abnormally high pore pressures in the cross-section of the structures, with gradients close to geostatic pressure gradients; such pressures are typical of thick shale strata. A study of shales found that shale porosity remained exceptionally high at great depths due to delays in shale compaction, the shortage of de-stressed zones and high rates of sediment subsidence.

Based on the core studies and measurements while drilling, various parameters were analyzed, including the density and porosity of shale samples taken in different years while drilling on the Baku Archipelago, in particular on the Umid structure. The compaction curve was plotted, and a potential zone of abnormally high pore pressures was delineated.

1. Introduction

It is known that the South Caspian Basin (SCB) covering a small area experienced intensive subsidence in the lower Pliocene and was isolated from the world ocean. As in all isolated basins, the basin's substantial subsidence was compensated by intensive sedimentation. Sediments were deposited from eroded mountain structures and land mass surrounding the basin, as well as quartz-rich terrigenous rocks from the Russian Platform inwashed by the Paleo-Volga. As a result, a productive series (PS) 6 to 7 km thick was formed over a relatively short period of time, approximately 4.2 million years. It should be noted that, according to research data, shales and sands account for 40 and 60% in the productive series in the Absheron Archipelago and the Absheron Ridge respectively, whereas PS in the Baku Archipelago consists of 80% shale.

The thick shale sequence was the reason for abnormally high reservoir and pore pressures (AHPP), which lead to numerous deep drilling problems.

Shale deposits and problems related to abnormally high pressures in the productive series of the South Caspian Basin have always been in the focus of geoscientists, especially those who advocate the hypothesis that hydrocarbons are of biogenic origin. Shales were brought into a sharper focus when the relationship between gas presence and shale volume had been established. Due to the above factors, the required analyses and predictions are difficult to make, which renders it more important and relevant to study the available data in depth, using state-of-the-art hardware, software, and mathematical tools and their best application practices.

2. Overview of the geology of the South Caspian Petroleum Basin and the nature of abnormally high pore pressures

The comparison of geological sections of PS for the Absheron Ridge, the Absheron Archipelago and the Baku Archipelago comprising the South Caspian Basin revealed that their lithofacies composition were markedly different. Whereas shales and sands account for 40 and 60% in the productive series in the Absheron Archipelago and the Absheron Ridge respectively, the productive series in the Baku Archipelago consists of 80% shale (Халилов, Балаев, 1981; Мехтиев, Юсифов, 1982).

Shale deposits in the productive series of the South Caspian Basin have always been in the focus of geoscientists, especially those who advocate the hypothesis that hydrocarbons are of biogenic origin. Shales were brought into a sharper focus when the relationship between gas presence and shale volume had been established. After many years of dedicated research, it was found that the thickness of the shale section and gas content increased in the direction of regional subsidence of PS deposits, i.e. from north to south and from west to east. At the same time, it was found that the quality of reservoirs containing commercial hydrocarbons deteriorated from north to south and improved from west to east (Александров, 1987).

Based on these findings, exploration areas were selected, which led to the discovery of major offshore gas condensate fields such as Bakhar, Khara Zirya deniz, Shakhdeniz, Umid, Absheron, etc.

On the one hand, the thick shale sequence was considered a positive factor for gas condensate exploration; on the other hand, it gave rise to abnormally high reservoir and pore pressures, which led to numerous problems during deep drilling (Мехтиев, Юсифов, 1982; Александров, 1987).

A study of shales in the top section of the productive series (Surakhany, Sabunchu and Balakhany Formations) of the Baku Archipelago, which consists of a shale sequence approx. 4,000 m thick with rare thin sand/siltstone layers, revealed that shales had abnormally high porosity at great depths (see the table below).

Most researchers rightly believe that abnormally high porosity of shales is a driving force behind abnormally high pore pressures, which in their turn are the result of a substantial delay in shale compaction.

It is known that in the process of diagenesis and catagenesis, sediments are compacted, their thickness reduces and their density increases under increasing pressure due to lower porosity. Experiments have proved that shale sediments have the highest compactibility.

In the South Caspian Basin in general and the Baku Archipelago in particular, during PS sedimentogenesis, especially in the Surakhany, Sabunchu and Balakhany periods, the paleogeographic environment contributed to the accumulation of thick shale strata given the shortage of zones for fluid outflux, i.e. sand and siltstone. Under these conditions, pore water saturating the shales was under constantly increasing geostatic pressure equal to the product of the overburden column height and average overburden density. Fluids saturating the shales took the pressure, and further shale subsidence occurred with overburden and pore fluid pressure being approximately equal. Despite the subsidence to a depth of 5-6 km and increasing geostatic pressure even at great depths, the porosity of the shales remained high, given elastic compression of fluids (Халилов, Балаев, 1981). For example, the highest shale porosity of 37.5% was recorded in 5,113-5,118 m interval in Well 4 drilled in the Umid area, which, along with Khara-Zire deniz, has the highest shale thickness (see the table below).

The nature of abnormally high pore pressure is described in detail by N.Yu.Khalilov et al.; new data on shales acquired in recent years due to the increase in well depth and the discovery of new hydrocarbon deposits confirmed the relationship between high pore pressures and the exceptionally complex geology of the Baku Archipelago.

The genetic nature of abnormally high pore pressure is closely related to shale thickness and lithology variations. Even within the same South Caspian Basin, there are huge differences in absolute pore pressure values and gradients in two adjacent provinces, the Baku and Absheron Archipelagos. While the structures in the Baku Archipelago consist of 80% (and sometimes 90%) shales and have pore pressure gradients close to overburden gradients (Добрынин, Серебряков, 1978), the Absheron Archipelago has much less shale and a lot more sand reservoirs; shale porosity here is substantially lower, and pore pressure gradients are rarely higher than conditional hydrostatic pressure gradients.

Another reason why shale porosity remains high at great depths is a high rate of sediment subsidence (Халилов, Балаев, 1981; Александров, 1987) or SCB bottom sagging rate. It is assumed that the rate of sediment subsidence can be expressed as the quotient from the division of sediment thickness by the duration of epochs. Although recent studies have revised the age of the productive series downwards, we used the maximum sedimentation time of million years to calculate the subsidence rate for PS upper stratigraphic units, as recommended by famous scientist F.I.Samedov.

Table 1

The results of the analysis of shale rock samples taken from well sections of the Baku Archipelago

No.	Area	Well No.	Shale sampling interval, m	Porosity, %		Shale volume, %
				for the well	average	
1	Sangachaly deniz	4	2618-2622	12.5	12.6	70
2		28	3065-3069	11.8		
3		4	3084-3087	13.3		
4		4	3168-3171	13.5		
5		28	3185-3187	12.1		
6	Duvanny deniz	60	2564-2568	13.2	14.2	75
7		24	2826-2829	11.9		
8		48	3122-3125	13.5		
9		82	3795-3799	18.0		
10		82	3916-3920	14.0		
11	Khara-Zire adasy	92	3813-3819	13.0	14.9	75
12		75	4,003-4005	12.6		
13		74	4142-4144	14.1		
14		74	4738-4742	16.5		
15		75	4051-4055	13.1		
16	Umid	4	5113-5118	37.5	18.1	90
17		4	5455-5460	15.8		
18		6	5527-5532	9.5		
19		4	5979–5984	9.7		
20	Khara-Zire adasy	16	3009-3013	19.1	18.2	90
21		7	4108-4112	18.6		
22		7	5088-5091	17.0		
23		30	6025-6026	18.0		
24	Khamamdag deniz	7	4017-4021	13.6	18.7	90
25		13	4444-4449	22.4		
26		5	4585-4590	16.4		
27		13	4860-4864	22.3		
28	Sangi-Mugan	16	2806-2809	17.7	18.1	90
29		17	3770-3773	13.5		
30		8	3908-3911	13.5		
31		9	4392-4397	20.0		
32		8	4595-4600	16.0		

By our calculations, the subsidence rate for PS upper formations in the Umid and Khara-Zire deniz areas (more than 4,000 m thick) equals 0.2 m per 100 years, which is by an order of magnitude greater than the theoretical sagging rate in geosyncline zones calculated by famous scientist V.V.Belousov. We believe that such a high rate could not be only the result of the overburden sediment pressure. The subsidence rate was definitely affected by endogenous tectonic processes.

It is obvious that exceptionally high subsidence rates of shale sediments that form the top of the productive series, coupled with the lack of de-stressed zones, have led to a substantial delay in compaction and contributed to maintaining abnormally high shale porosity on the structures of the Baku Archipelago. The geologic cross-section for the Absheron Archipelago and the Absheron Ridge features alternating sand and shale; sediment subsidence rates are almost the same, but shale porosity is much lower and close to the values from curves by J. Weller and N.V. Vassoevich, which are typical of normal shale compaction. This is why there are no extreme AHPP shows in shales, and the conditions for deep drilling are moderate.

The table shows shale porosities obtained during the laboratory analyses of cores from wells drilled on the Baku Archipelago. As can be seen from the table and Figure 1, shale porosity does not decrease with depth, as it should in case of normal compaction. In fact, it is quite the opposite: porosity increases with the thickness of the shale section. Thus, the maximum values of average porosity (18.1 to 18.7%) were found in the areas where the PS section was shaled out most (90%) in the Khara-Zire deniz, Khamamdag-deniz and Umid areas. The data in the table confirm the known trend of shale porosity increasing in the direction of regional subsidence of PS deposits, i.e. from the northwest to the southeast, from Sangachaly deniz (12.6%) to Umid (18%). Another trend was also confirmed: shale porosity increases from north to south, from Sangachaly deniz (12.6%) to Sangi-Mugan (16.1%), as can be seen in Figure 2 showing porosity distribution. This data is shown in Figure 1, which demonstrates that PS shale porosities for the Baku Archipelago are on the right side of the shale compaction curves by J. Weller and N.V. Vassoevich. Actual porosity values exceed theoretical ones at relevant depths with normal shale compaction. It proves that there is a significant delay in compaction and that shale porosity remains abnormally high.

Notably, porosity in the thick shale sequence of the productive series in the Baku Archipelago does not decrease with depth; on the contrary, it reaches a maximum in the shales 200-300 m before the top of Horizon V (in the Garadag breakdown) and then decreases. Thus, there is a limited possibility for fluid release in Khara-Zire deniz, Umid and Sangi-Mugan, where the top section of the productive series contains shales 3000-4000 m thick, because there are no sand reservoirs in the top section that would receive the fluid released from the shales or their number is limited and they are very thin.

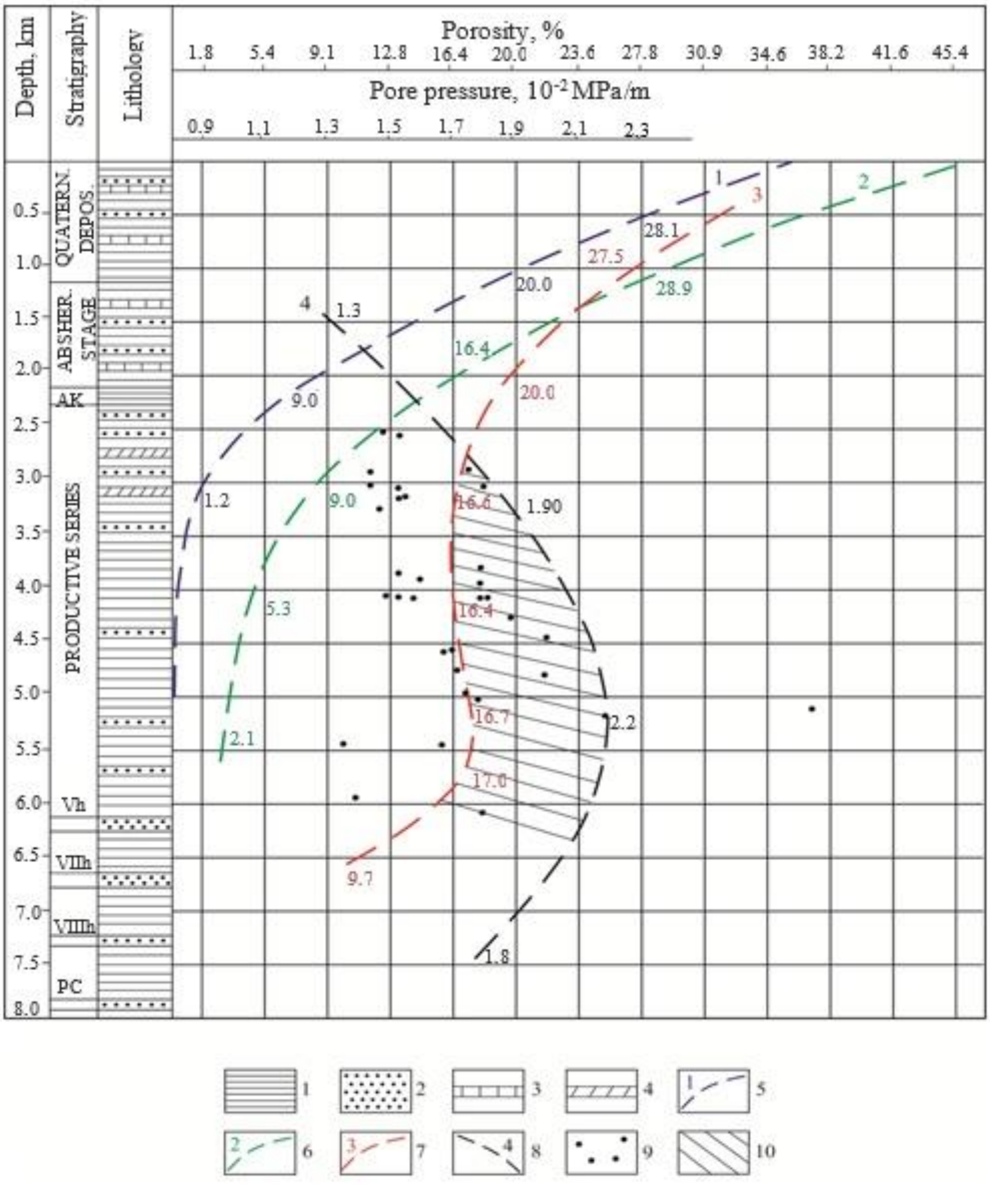

Fig. 1. Compaction vs. pore pressure curves:
1 – shale; 2 – sand, sandstone; 3 – limestone; 4 – evaporite; 5 – shale compaction curve by J. Weller; 6 – shale compaction curve by N.V. Vassoevich; 7 – actual shale compaction curve; 8 – AHPP gradients curve; 9 – shale porosity depths (from cores); 10 – zones of potential extreme AHPP shows

A partial decrease in shale porosity before horizon V can be attributed to a sand layer 20-30 m thick at the top of the horizon; the pore fluid from the overlying shales was released to the layer. Minimum porosity values are typical of shales in contact with thick reservoirs, e.g. between horizons V and VII (Figure 1). A delay in shale compaction in the top section of the productive series has led to consistently high porosity; the fluid saturating the shales took the overburden pressure (geostatic pressure), which resulted in abnormally high pore pressures in the shales, with maximums close to geostatic pressures. Abnormally high reservoir pressures develop in thick shale sequences in rare thin sand/siltstone layers as a result of fluids being released from shales; such pressures have a "cumulative" effect, and their gradients are also close to geostatic pressure gradients. Therefore, if we combine all the key factors contributing to abnormally high shale porosity, we can draw a flow diagram showing the sequence of AHPP development in the shale section.

3. Methods used to predict abnormally high pore pressures

Abnormally high pressure is inversely related to shale thickness, i.e. the greater the shale thickness, the higher the AHPP gradients and vice versa (Figure 1).

As can be seen from the compaction vs. pore pressure curves (Figure 1), changes in porosity in the geologic cross-section of the Baku Archipelago are complex. For example, in 500-2000 m interval consisting of Quaternary and partially Absheron deposits, where the section contains alternating sand and shale, high shale porosity is observed. This confirms that, due to low overburden pressure and temperature, the deposits are in the early catagenesis stage and have not yet transformed into rock. Based on the petrographic studies of N.Yu.Khalilov and E.S.Balayev (1981), shale porosity in this interval varies from 28.9 to 20.0%, which are close to theoretical shale porosity values of 29.5 to 11.0% for the corresponding depth interval determined by the compaction curves of J.Weller and N.V.Vassoevich. In this interval, pore fluid partially released from the shales creates reservoir pressure in the sands, which is higher than conditional hydrostatic pressure. The section shales out with depth, and sand/siltstone layers become very rare. Given an intensive subsidence of thick shale strata, a quick increase in geostatic pressure and the shortage of permeable formations for pore fluid outflux, the shales are poorly compacted and have consistently high porosity, whereas the pore pressure of the compacted fluid remains abnormally high. Curve 3 plotted from actual porosity data shows a substantial delay in pore fluid outflux from the shales under compaction. For example, actual shale porosity in 2000-3500 m interval is 20 to 16.7%, which is 2-3 times higher than the porosity based on theoretical curves 1 and 2 (12.8-5.5%) at corresponding depths. In 3,500-4,500 m depth interval actual porosity is already 4 to 5 times higher than the porosity based on compaction curves 1 and 2. At depths of 4,500-5,500 m where shale compaction ends according to the studies by J.Weller and N.V.Vassoevich, the shales of the Baku Archipelago still remain highly porous (Figure 1). The shales are compacted and the pore pressure decreases substantially only in the PS intervals with thick sand/siltstone horizons (horizons V, VII, VIII, PK, etc.) and adequate conditions for pore fluid outflux to permeable formations.

In 1978, works were carried out to predict pore pressure and determine shale porosity using the methodology of the All-Union Scientific Research Institute of Drilling Technology, when drilling deep wells in the Khara-Zire adasy and Khara-Zire deniz areas. A substantial delay in shale compaction vs. normal compaction values was observed in these areas.

Thus, the comparison of shale porosity for the Baku Archipelago with the theoretical shale compaction curves indicates that, despite the high geostatic pressure, the process of shale consolidation in 6-8 km depth intervals is not completed yet, and the main reason for that is the shortage and low thickness of permeable formations in the shales. As there are not enough zones for pore fluid release from the shales, the fluid under high geostatic pressure stays in shale pores and results in abnormally high pore pressures.

As noted above, such pressures lead to numerous problems during deep drilling on the Baku Archipelago. These problems are most often associated with well filling, which manifest as tight holes/hole restrictions and borehole collapses leading to drags and sticking of drilling tools and casing. In extreme cases, abnormally high pore pressures result in drilling tools being pushed out by the rock from the hole. In numerous cases, well filling provokes the occurrence of non-commercial water-bearing and gas-bearing formations, which leads to prolonged accidents, problems and often well abandonment. This translates into years-long delays in the discovery and development of new fields. It is therefore evident how important it is to be able to predict AHPP intervals prior to drilling.

To date, a variety of methods has been developed for predicting AHPP. Various schools have appeared in this field, with the most notable works by Khalilov and Balayev (1981), Buryakovsky et al. (1986), Shykhaliyev et al. (2010), Mkpese (2018).

With new developments in technology and engineering over the past few years, the quality of available data and decisions has noticeably improved, as evidenced by recent studies (Shykhaliyev et al., 2010; Mkpese, 2018). Results of the first pre-drill overpressure prediction in the South Caspian Basin (SCB) on the basis of seismic data are presented in the work by Shykhaliyev et al. (2010). The method is based on the REZAYR software package, which operates in Microsoft Windows. The analyzed time section fragment in SCB was initially converted to an impedance and then to a formation velocity sections. Three overpressure zones of different thicknesses and extents were established. The shallowest overpressure zone reaches depths of less than 1 km. The nature of this relatively thin zone can be associated with biochemical gas generation. The second overpressure zone covers the depth interval of 1.5-3.0 km and is most likely the result of non-equilibrium compaction (under compaction) because of high sedimentation rates. The third overpressure zone, the longest and thickest, is observed in the 6-9 km depth interval and is most likely associated with hydrocarbons generation. This deepest zone poses the greatest risk for drilling. The seismic method of direct overpressure prediction in SCB is in agreement with theoretical and experimental estimates and is therefore recommended for use in SCB (Халилов, Балаев, 1981; Мехтиев, Юсифов, 1982; Александров, 1987; Добрынин, Серебряков, 1978), including the express method, which was successfully used to predict potential problems during deep drilling in Khara-Zire adasy, Khara-Zire deniz, etc. Some authors suggest using methods based on the identification of abnormally high shale porosity. For example, Mkpese (2018) applied a porosity-based model to predict overpressured zones in an onshore environment of the Niger delta basin. Zones with hard overpressures greater than a magnitude of 0.7 psi/ft are generally within 10000 ft (3048 m) and below. Top of overpressures for studied wells ranges between 7000 and 10000 ft (2133-3048 m). Porosities in shale are of typical values ranging between 0.05 and 0.46. A robust concordance between PPP and MPP profiles for each of the wells validates the results here and confirms suitability of the model to the studied area.

As in earlier studies, zones of abnormally high pore pressures are identified using the normal compaction trend, which is a reflection of changes in geological, geophysical, petrophysical and operational properties like sonic velocity, resistivity and formation density values, and drilling parameters. Lithologically identical rocks with equal values of properties at different depths have the same effective stress. The normal compaction trend depends on the variation of rock properties with depth of burial at a normal hydrostatic pressure. Particularly, the physical properties of shale depend primarily on the degree of compaction. In nature, the density, resistivity and/or porosity of normally compacted rocks and burial depth have an exponential relationship (Mkpese, 2018). According to a complex of various features, by analyzing their measurements with depth, it is possible to identify homogeneous intervals, in which zones of abnormally high formation pressures are clearly distinguished (Efendiyev et al., 2019; Efendiyev et al., 2021). Plotting this relationship gives a very smooth curve called the normal compaction curve. Alternatively, the exponential dependencies are shown by straight lines if they were displayed on semi-logarithmic plots. Deviation from the smooth curve or the straight line would technically indicate an upper boundary called the top of geopressure zone (Буряковский и др., 1986; Shykhaliyev et al., 2010; Mkpese, 2018). Figure 2 shows, as an example, a curve of shale density variation in cuttings with depth taken while drilling a well at the Bulla-Deniz field, which clearly shows zones of normal compaction and abnormally high pore pressures.

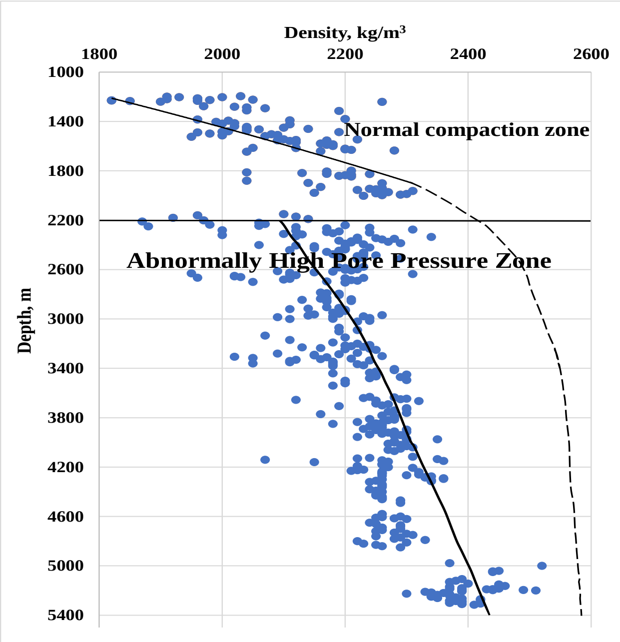

Fig. 2. Change in the density of clays with depth in the section of the well of the Bulla-Deniz field

Having analyzed earlier works, we propose the following approach for predicting AHPP. At the design estimates stage prior to drilling, shale porosity is studied based on the analyses of drill cuttings sampled from an adjacent well, and a prognostic shale porosity curve is plotted to describe the degree of shale consolidation (Figure 1). Then, a prognostic pore pressure curve is plotted for an adjacent well based on pressure measurements (if any) or mud weight. The area between these two curves plotted together on the same diagram should be considered as the area of extreme complications associated with abnormally high pore pressures, with maximum pore pressure gradients corresponding to maximum porosity. In general, AHPP development can be represented as a flow diagram shown in Figure 3. According to the diagram, abnormally high pore pressure depends on abnormally high shale porosity (2). In its turn, abnormally high shale porosity is due to a delay in shale compaction (3), which depends on three factors: lithological description of the section, a high sediment subsidence rate (5) and shale thickness (6).

4. Conclusion

1. The structures of the Baku Archipelago are known to have some of the most complex geological and operating conditions for drilling, with the so-called well filling that leads to various problems during deep drilling.
2. Difficult drilling conditions are mostly due to abnormally high pore pressures that developed during intensive subsidence of thick shale strata, given the shortage of zones for pore fluid release from shales; these pressures cause a substantial delay in shale compaction as compared to compaction in alternating sand and shale sections.
3. Because of the delay in compaction, shale porosity remains abnormally high and the pore fluid in shales is compacted under pressure increasing to overburden gradients.
4. The actual shale compaction curve plotted together with the AHPP gradient curve will make it possible to identify the intervals where problems may be expected during drilling through shale on the Baku Archipelago.

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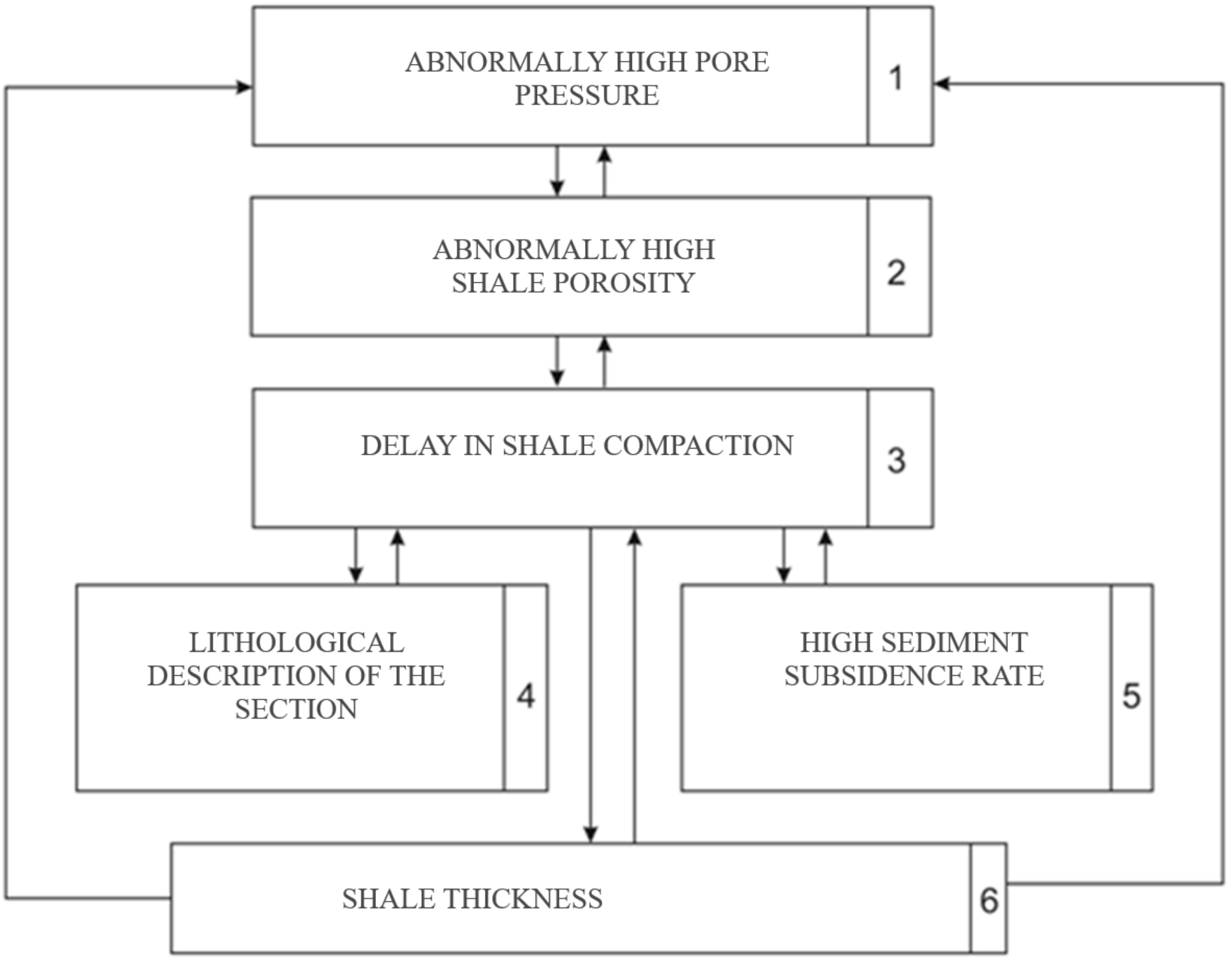

Fig. 3. Block diagram of the formation of abnormally high pore pressures

REFERENCES

Aleksandrov B.L. Abnormally high reservoir pressures in oil and gas basins. Nedra. Moscow, 1987, 216 p. (in Russian).

Buryakovsky L.A., Dzhevanshir R.D., Aliyarov R.Yu. Geophysical methods of study of geofluidal pressures. Elm. Baku, 1986, 148 p. (in Russian).

Dobrynin V.M., Serebryakov V.A. Methods of prediction of abnormally high reservoir pressures. Nedra. Moscow, 1978, 232 p. (in Russian).

Efendiyev G., Isayev R., Piriverdiyev I. Decision-making while drilling wells based on the results of modeling the characteristics of rocks using probabilistic-statistical methods and fuzzy logic. ISAIC 2020, Journal of Physics: Conference Series, Vol. 1828, 2021, https://iopscience.iop.org/article/10.1088/1742-6596/1828/1/012016/pdf

Efendiyev G.M., Mammadov P.Z., Piriverdiyev I.A. Modeling and evaluation of rock properties based on integrated logging while drilling with the use of statistical methods and fuzzy logic. 10th International Conference on theory and application of soft computing, computing with words and perceptions – ICSCCW-2019. Advances in intelligent systems and computing book series (AISC), Vol. 1095, 2019, pp. 503-511.

Khalilov N.Yu., Balayev E.S. The effect of abnormally high reservoir pressures on reservoir and shale parameters in the Baku Archipelago areas. Gas Industry, Express Information, Series: Development of Oil and Gas Resources for Offshore Fields, Vol. 6, 1981, pp. 512 (in Russian).

Mekhtiyev P.G., Yusifov M.G. Specific features of distribution of abnormally high pore pressures in the Baku Archipelago areas. Oil and Gas Geology, No. 8, 1982, pp. 51-53 (in Russian).

Mkpese U.U. Estimation of overpressures from porosity based method: a theoretical approach applied to the central/coastal swamp depo-belts of the Niger delta basin. International Journal of Advanced Geosciences, Vol. 6, No. 1, 2018, pp. 14-26.

Shykhaliyev Yu.A., Feyzullayev A.A., Lerche I. Pre-drill overpressure prediction in the South Caspian Basin using seismic data. Energy Exploration & Exploitation, Vol. 28, No. 5, 2010, pp. 397-410.

ЛИТЕРАТУРА

Efendiyev G., Isayev R., Piriverdiyev I. Decision-making while drilling wells based on the results of modeling the characteristics of rocks using probabilistic-statistical methods and fuzzy logic. ISAIC 2020, Journal of Physics: Conference Series, Vol. 1828, 2021, https://iopscience.iop.org/article/10.1088/1742-6596/1828/1/012016/pdf

Efendiyev G.M., Mammadov P.Z., Piriverdiyev I.A. Modeling and evaluation of rock properties based on integrated logging while drilling with the use of statistical methods and fuzzy logic. 10th International Conference on theory and application of soft computing, computing with words and perceptions – ICSCCW-2019. Advances in intelligent systems and computing book series (AISC), Vol. 1095, 2019, pp. 503-511.

Mkpese U.U. Estimation of overpressures from porosity based method: a theoretical approach applied to the central/coastal swamp depo-belts of the Niger delta basin. International Journal of Advanced Geosciences, Vol. 6, No. 1, 2018, pp. 14-26.

Shykhaliyev Yu.A., Feyzullayev A.A., Lerche I. Pre-drill overpressure prediction in the South Caspian Basin using seismic data. Energy Exploration & Exploitation, Vol. 28, No. 5, 2010, pp. 397-410.

Александров Б.Л. Аномально-высокие пластовые давления в нефтегазоносных бассейнах. Недра. Москва, 1987, 216 с.

Буряковский Л.А., Джеваншир Р.Д., Алияров Р.Ю. Геофизические методы изучения геофлюидальных давлений. Элм. Баку, 1986, 148 с.

Добрынин В.М., Серебряков В.А. Методы прогнозирования аномально высоких пластовых давлений. Недра. Москва, 1978, 232 с.

Мехтиев П.Г., Юсифов М.Г. Некоторые особенности распределения аномально высоких поровых давлений на площадях Бакинского архипелага. Геология нефти и газа, No. 8, 1982, с. 51-53.

Халилов Н.Ю., Балаев Э.С. Влияние АВПД на параметры коллекторов и глин на площадях Бакинского архипелага. Газовая промышленность, экспресс-информация, серия: Освоение ресурсов нефти и газа морских месторождений, Т. 6, 1981, с. 5-12.

ХАРАКТЕРНЫЕ ОСОБЕННОСТИ УПЛОТНЕНИЯ ГЛИН НА ПЛОЩАДЯХ АЗЕРБАЙДЖАНСКОГО СЕКТОРА ЮЖНО-КАСПИЙСКОГО БАССЕЙНА

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Резюме. Известно, что небольшой по площади Южно-Каспийский бассейн (ЮКБ), испытывающий интенсивное погружение в нижнем плиоцене, развивался в отрыве от Мирового океана. Сопоставление геологических разрезов продуктивной толщи Абшеронского порога, Абшеронского и Бакинского архипелагов, являющихся частями ЮКБ, выявило значительное различие литолого-фациального состава пород. Геологические условия бурения скважин на структурах Бакинского архипелага, являются одними из самых сложных в мире. Выражаются они в сильных породопроявлениях, при бурении глинистых пород ПТ, которые в разрезе структур архипелага составляют до 90%. Породопроявления приводят к осложнениям, авариям, провоцируют выбросы бурового раствора и водогазо-проявления, что часто приводит к ликвидации скважин. Высокая аварийность затягивает на долгие годы ввод в эксплуатацию перспективных залежей и месторождений углеводородов.

Основной причиной породопроявлений является присутствие в разрезе структур аномально высоких поровых давлений, характерных для мощных глинистых толщ, градиенты которых приближаются к градиентам геостатического давления. Изучение глинистых пород выявило сохранение на больших глубинах исключительно высоких значений пористости глин, связанных с отставанием уплотнения глин, дефицитом зон разгрузки и высокой скоростью погружения осадков.

По результатам исследований керна и геолого-технологических исследований в процессе бурения выполнен анализ различных характеристик, в том числе плотности, пористости глин, отобранных в разные годы при бурении скважин на структурах Бакинского архипелага, в том числе на структуре Умид, построена кривая уплотнения и выделена зона возможных проявлений аномально высоких поровых давлений.

Ключевые слова: *Южно-Каспийский бассейн, Бакинский архипелаг, продуктивная толща, глинистые отложения, аномально высокая пористость глин, аномально высокое поровое давление, уплотнение глин, осложнения в процессе бурения скважин*

CƏNUBİ XƏZƏR HÖVZƏSİ AZƏRBAYCAN SEKTORU SAHƏLƏRİNDƏ GİLLƏRİN SIXILMASININ XARAKTERİK XÜSUSİYYƏTLƏRİ

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Xülasə. Bakı arxipelaqı strukturları quyuların qazılması baxımından geoloji şəraitə görə dünyada ən mürəkkəb strukturlardan biri hesab olunur. Bu çətinliklər Məhsuldar qatın 90%-ni təşkil edən gilli suxurları qazarkən güclü suxur axınının baş verməsi ilə ifadə olunur. Güclü suxur axını quyularda mürəkkəbləşmələrə, qəzalara, quyudan buruq məhlulunun sıçramasına, su-neft-qaz təzahürlərinə səbəb olur ki, bu da quyuların tez-tez ləğv olmasına gətirib çıxarır. Qəzalar isə perspektivli yataqların və karbohidrogen ehtiyatlarının istismara verilməsini uzun illər ləngidir.

Quyudan süxur axınının əmələ gəlməsinin əsas səbəbi, qalın gil təbəqələri üçün xarakterik olan, qradiyentləri geostatik təzyiq qradiyentlərinə yaxınlaşan anomal yüksək məsamə təzyiqinin kəsilişdə olmasıdır. Gil süxurlarının öyrənilməsi nəticəsində yüksək dərinlikdə onların məsaməliyinin böyük qiymətlərə malik olduğu göstərilmişdir, bu da onların sıxılma prosesində "ləngimə" baş verdiyi, boşalma zonasında çatışmazlıqların mövcudluğu ilə izah oluna bilər. Süxur nümunələri üzərində aparılmış tədqiqatlar və qazma zamanı aparılan geoloji-texnoloji tədqiqatlarin nəticələrinin təhlili aparılmış, müxtəlif vaxtlarda Bakı arxipelaqında qazılmış quyulardan çıxan gil şlamının sıxlığının dərinlik üzrə dəyişməsi araşdırılmışdır.

Qazma vaxtı quyulardan götürülmüş gil nümunələrinin tədqiqi göstərdi ki, böyük dərinliklərdə gilin sıxılmasının gecikməsi, kəsilişdə boşalma çatışmazlığı və çöküntülərin böyük dərinliklərə enməsi səbəbindən gillərdə yüksək məsaməliliyin qorunub saxlanmasına səbəb olmasıdır. Qazma zamanı aparılan geoloji-texnoloji tədqiqatların nəticələrinə əsasən, müxtəlif xarakteristikaların təhlili Bakı arxipelaqının strukturlarında, o cümlədən Ümid strukturunda quyuların müxtəlif illərdə qazılması zamanı götürülmüş gil nümunələrinin sıxlığının təhlili aparılmış, əyrilər qurulmuş və anamal yüksək məsamə təzyiqinin mümkün təzahürləri zonası müəyyən edilmişdir. Anomal yüksək məsamə təzyiqinin formalaşması zamanı baş verən proseslərin ardıcıllığı müvafiq sxem şəklində verilmişdir.

Açar sözlər: *Cənub-Xəzər hövzəsi, Bakı arxipelaqı, məhsuldar qat, gil çöküntüləri, gillərin anomal yüksək məsaməliliyi, anomal yüksək məsamə təzyiqi, gilin sıxılması, quyuların qazılması zamanı mürəkkəbləşmələr*