APPROACHES TO THE GEOLOGICAL ASSESSMENT AND THE DEVELOPMENT OF THE KALIN FORMATION

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Abstract

Reliable forecast of reservoirs presence, their petrophysical properties and saturating fluids and optimal development approaches of poorly studied deep deposits with renewable HC resources is currently one of the major challenges of Exploration Geology. The article considers main approaches and solutions of the given paradigm on the example of Kalin formation within Shah Deniz field.

Keywords: Kalin formation, gas condensate field, sandiness, porosity, catagenesis, oil-producing deposits, source rocks, geothermal gradient, gas condensate factor, renewable HC resources, development

At the beginning of the twenty-first century, exploration for oil and gas in water area of the North (Kashagan), Middle (V.Filanovskogo, Khvalynskoe, etc.) and South Caspian (Shah Deniz) are highly successful and effective, multi increasing mineral hydrocarbon resource base of the region. Having realized the fund of large prospective structures at shallow depths, drilling rigs go to the greater depths. This trend is very indicative of the South Caspian region, where the pattern of hydrocarbons deposits formations can be traced: from the shallow onshore to greater depths in the central parts of the young Yuzhnokurinskaya depression. For example, the drilling of superdeep offshore wells led to the discovery of large gas condensate field Shah Deniz, 70 km South-East from the Baku and 25 km South-East from Bahar field (Figure 1). The sea depth in the area of the field varies from 50 to 600 meters.

Most remarkable features of the structure of the Shah Deniz field are:

- Mud volcanoes as a reflection of extremely high reservoir pressures in the lower section and particularly in the region of the source rock generation in the underlying strata (150 MPa at a depth of 7000 m),
- Thrust, complicating the western slope of a thrust folds, as a reflection of young Alpine folding
- Multi-layerd structure and an exceptional productive gas-bearing strata, as a reflection of

source rock staying in the area of hydrocarbon gases generation

Productive layers are uncovered in sandstones of Balakhany and Fasila formations. Kalin formation sandstones are deposited deeper and still not opened to the full thickness, lying directly on the source rock. The prospect of Kalin formation sandstones estimated higher than already identified condensate gas accumulations as being directly over the thick source rock. Hence the special attention of researchers to these deposits and a large number of papers on various aspects of the structure and formation properties [2, 3, 4, 5, 20, 21, 24, 25, 27, 30]. Below we consider fundamental questions in the context of predicting the presence of deposits of Kalin formation reservoirs, their petrophysical parameters and type of fluid on the Shah Deniz structure.

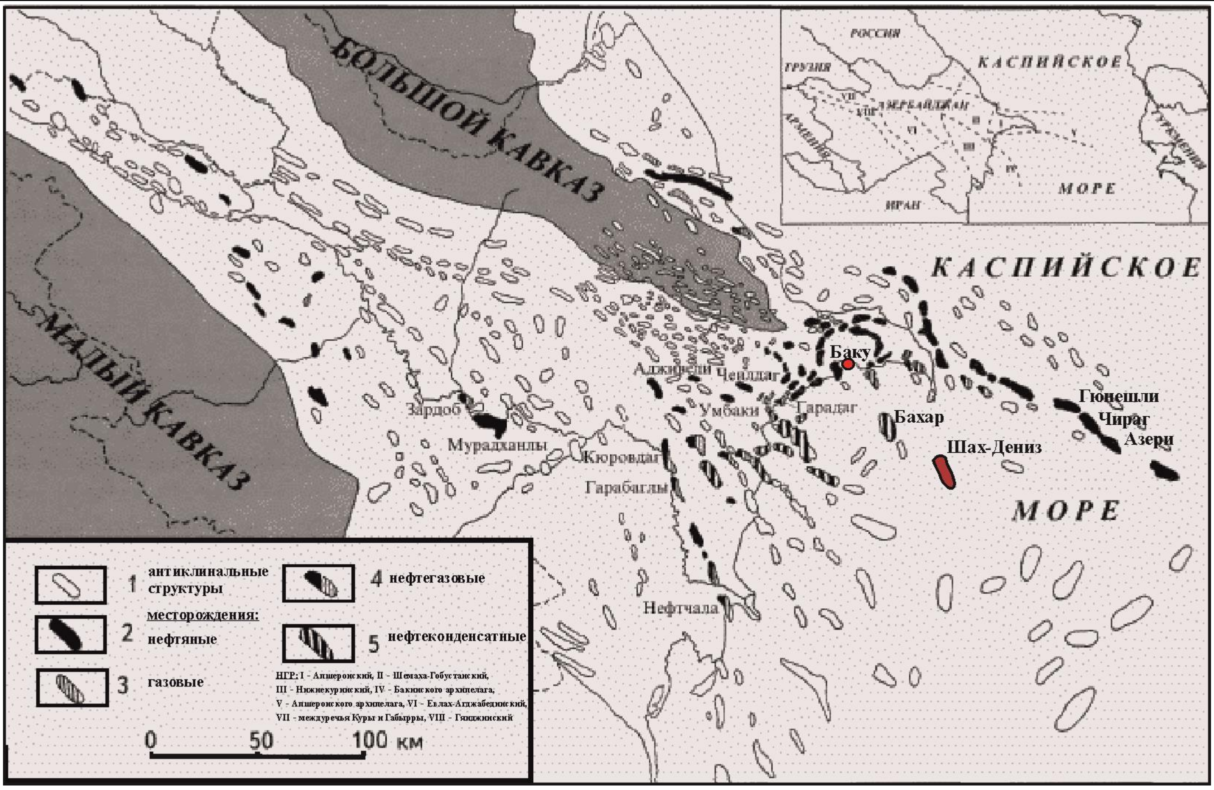

***Figure 1** – Shah-Deniz field location*

Only one well SDX-4 reached the top of Kalin formation at the depth of 7018 m (Figure 2). These deposits were studied in the southeastern part of the Apsheron Peninsula and belong to the regional oil and gas complex.

Kalin formation includes three subformations [2, 3, 4, 5, 20, 24, 25, 27, 30]:

- upper subformation (KaS_1)
- middle subformation (KaS_2)
- lower subformation (KaS_3)

Lower subformation (KaS_3) with the thickness 150-160 m is characterized by a predominance of clay over sandstone. Middle subformation (KaS_2) represented by almost uniform alternation of clay, sand and silt, thickness 40 – 50 m. Upper subformation (KaS_1) with the thickness 55 - 60 m characterized by sandy-silty rocks with thin clay layers.

In general, the section of Kalin formation is characterized by a larger number of positive anomalies on PS curve than the overlying section of Podkirmaky formation (Figure 3).

Uncovered section of KaS_3 by logging indications is described with high apparent resistivity and differentiated SP curve, because this subformation consists of great amount of clay layers and contains only a small admixture of silt material.

In regard to the mineralogy the correlational parameter is the content of anhydrite, celestite and marcasite: in KaS_1 it is missing, in KaS_2 either missing or its content is small, but in KaS_3 it occurs in the greatest numbers.

Microfossils of studied formation is a redeposited foraminifera, including Nonlor, Rotalid, Globigerina, Elplidium and partly Miliolidac, ostracods, shell carditis (rare) and the remains of fish (rare).

One of the main problems of searching of oil and gas in deep water under tight katagenesis and diagenesis is the question of preservation of reservoir rock properties under reservoir pressure and temperature when immersed to a depth of 5000-6000 m and more.

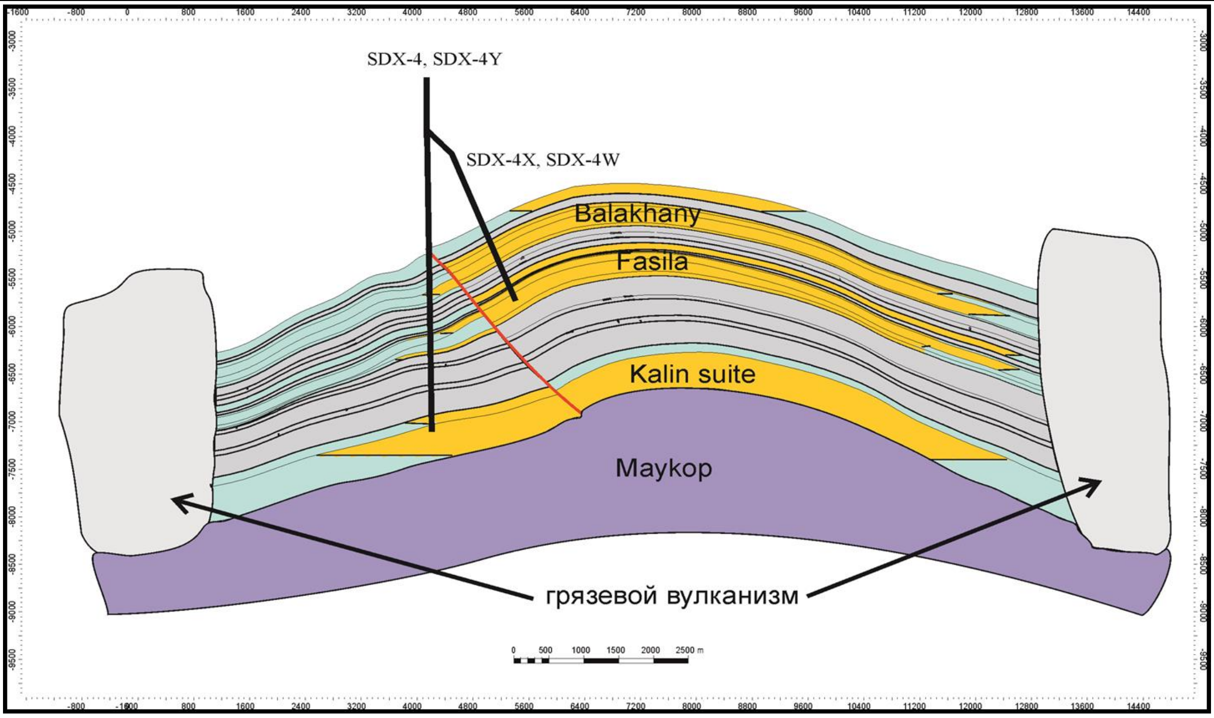

Figure 2 - Uncovered section of the well SDX-4Y

The expected depth of Kalin formation within Shah Deniz is 7,000 m or more, which suggests a significant deterioration of its properties and reducing the hydrocarbon potential. However there exists a several factors that in the aggregate retain the quality of reservoirs and hydrocarbons on the big depths of the South Caspian Sea:

- low geothermal gradient of Neogene sediments, equal to approximately 1,6 ºC/100 м, preserving hydrocarbons and limiting quartz cementation in sandstones;
- rapid sedimentation, creating a super-high pressure and thus preventing compression of pore space of reservoirs, resulting in a loss of porosity

In order to study and predict the parameters of Kalin formation within Shah Deniz field methodological approach was applied, which includes two basic principles:

- the principle of rational combination of different levels of information;
- the principle of a systematic approach to the study of geological space

The first principle involves the combination of a priori information in the form of a known quantitative geological patterns in the whole of South Caspian Basin (regional level) and within individual anticlinal zones (sub-regional level) with a detailed empirical information on the deposit-analog (local level) and indirect information on the project prediction [1].

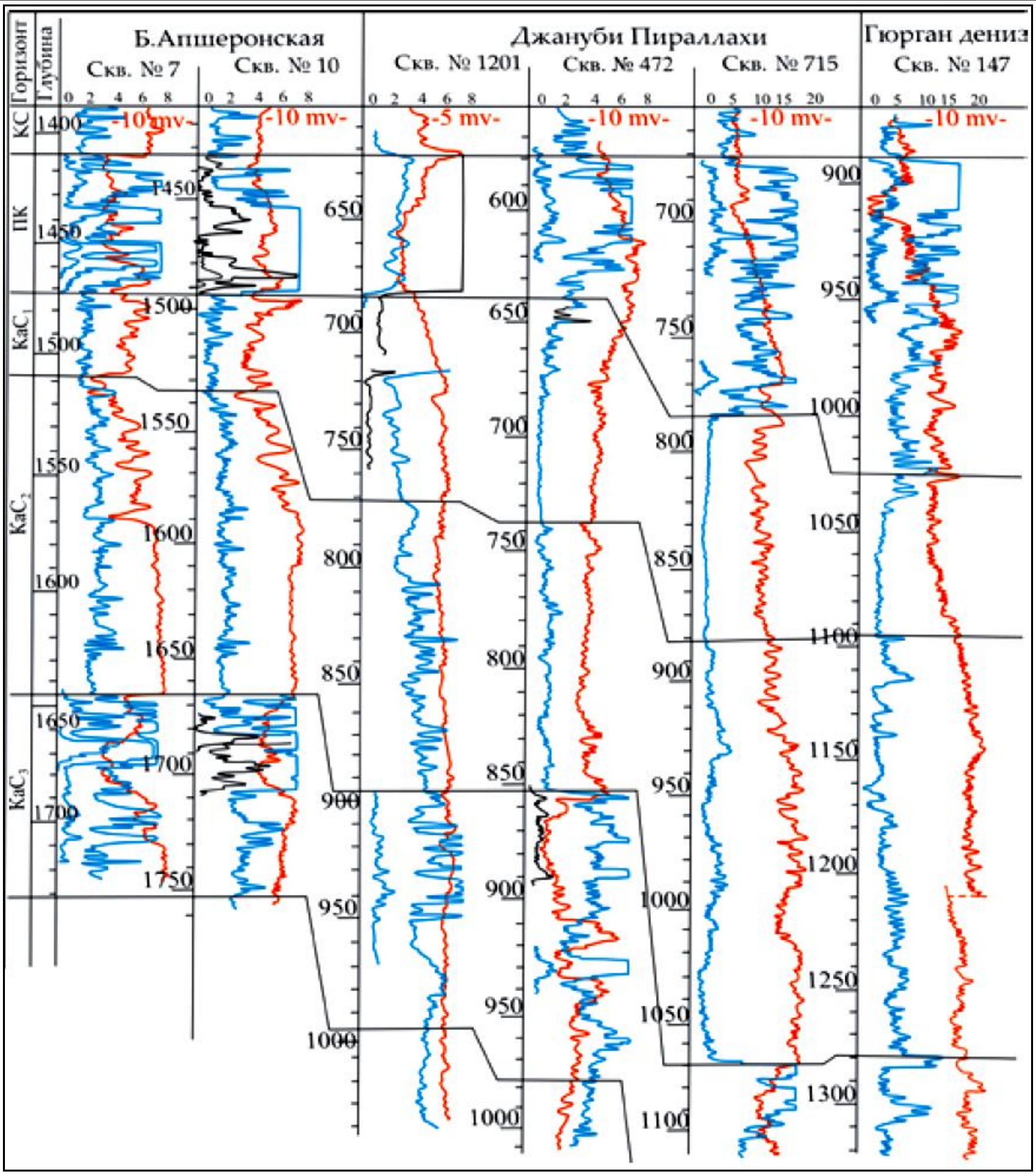

Figure 3 *- Comparison of the logs of the lower sections of productive formation of Apsheron archipelago: the red curve - PS, Blue - KS [18].*

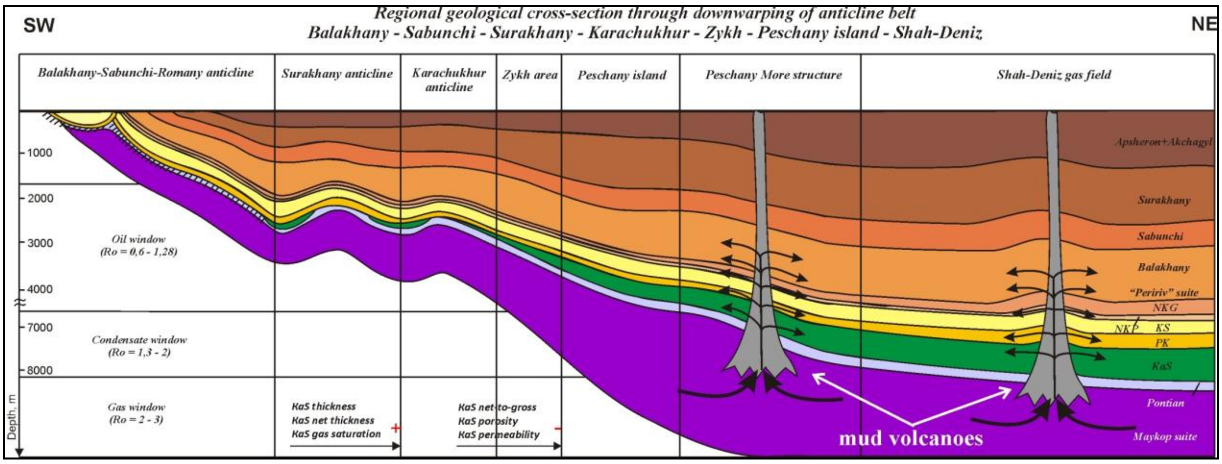

Figure 4 *– Regional geological cross-section through downwarping of anticline belt Balakhany – Sabunchi – Ramany – Surakhany – Karachukhur – Zykh - Peschany-More – Bakhar – Shah-Deniz (profile line is demonstrated on the Figure 5)*

Geological studies of regularities change the natural reservoir at the subregional level, i.e. within individual anticlinal belts, are highly informative in the South Caspian Basin, especially in the prediction of the parameters and the hydrocarbon potential of such structures as Kalin formation, exploration of which is to come.

Anticline belt Balakhany – Sabunchi – Ramany – Surakhany – Karachukhur – Zykh - Peschany-More – Bakhar – Shah-Deniz passes through a central part of the Apsheron Peninsula and is immersed in a Southeastern direction (Figure 4).

It is believed that all structures of the South Apsheron offshore zone (Peschany-more, Bahar Shah-Deniz) are close by geotectonic conditions of formation and petrological characteristics of the rocks. Probably there were identical processes and mechanisms of oil and gas formation.

Geochemical studies of clay and oil (condensate) samples from Bahar field suggest that based on the nature of steran biomarker distribution, hydrocarbons migrated from algal organic facies deposited in the marine environment [1].

It is supposed that the mixed migration of hydrocarbons from Oligocene - Lower Miocene source sediments (Maykop and diatomaceous formations) occurred, where there were favorable conditions for the conversion of buried organic matter in deep-seated horizons of the South Caspian Basin.

The presence of gas-condensate accumulations in the upper productive strata is due to selective tertiary vertical migration of the light components by numerous tectonic cracks.

It is obvious that with structural zone immersion to the Southeast and the growth of temperature and pressure parameters, the share of natural gas saturation reservoirs increases. This process is graphically represented in Figure 5, which clearly outlines petroleum, oil, gas and gas condensate fields. On the basis of these data, and data of Maykop formation maturity during the process of sedimentary basin dipping, areas of immature source rock have been identified (Ro = 0,4-0,6), oil (Ro = 0,6-1,28), condensate (Ro = 1,3-2) and gas window (Ro = 2-3).

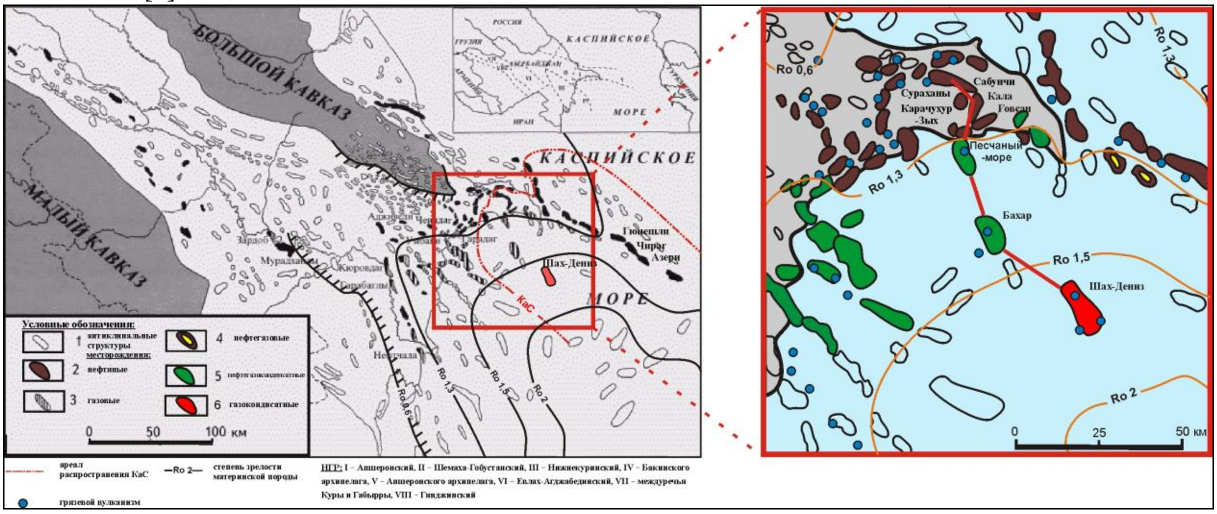

***Figure 5** – Map of Maykop source rock maturity*

Kalin formation within the study area was not deposited in the same way everywhere. Kalin formation sediments are placed in the southern part of the Kalin fold, Turkan area, on the eastern flank of Surahany-Karachuhur-Zykh fold, in the Bean-Hovsani syncline, in Baku trough in the north-east wing and south-south-east pericline Bibi-Heybat folds, on the Sabunshi-Ramani anticline, in the Peschany island and south crease of Artem island (Janubi Pirallahi), in the Gyurgyany offshore area, in the district of Zhiloy and Neftyanye Kamni (Figure 6).

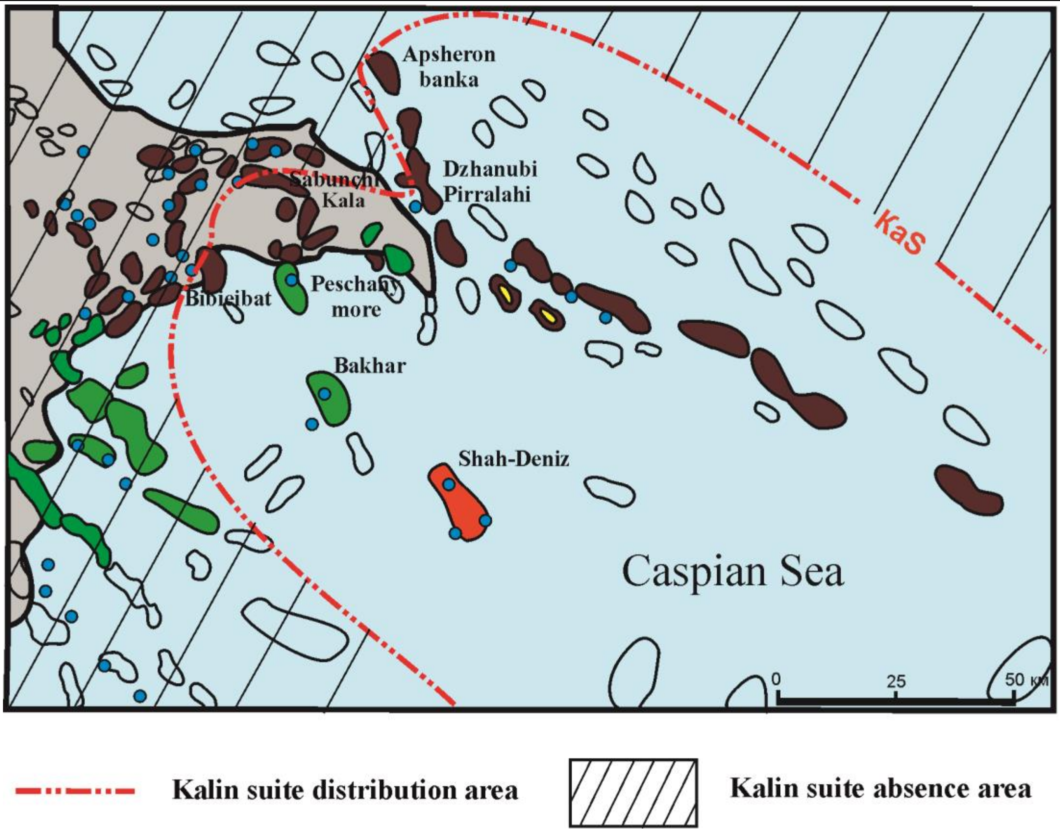

Figure 6 – Kalin formation distribution area within South Caspian area

A number of researchers note that the pool of clastic sediments of productive series during the Kalin formation formation occupied only the southern and southeastern part of the Apsheron Peninsula. The most northern Kalin formation distribution area is the Kalin saddle separating Surakhany lifting from Balakhany-Romaninskoe (Figure 5) [25]. To the north of this boundary around the Apsheron Peninsula there is no more Kalin formation sediments, but to the south and southeast the thickness of formation increases.

According to I.I.Potapov (1954) [14], the area of Kalin formation deposits absence corresponds to the location of the ancient regional uplift of Absheron geoanticline. According to the author, there existed a peninsula during the Kalin time dissected by bays and lagoons, similar to the current Absheron, but shifted to the north (Figure 6). This peninsula continued the ancient Caucasian land and extended to the current Artem island (Janubi Pirallahi) [25].

Thickness of Kalin formation is not constant. From the zone of pinching out the apparent thickness increases to the southeast and east direction. Available geological material shows that in a southern direction it is expected not sharp and significant formation thickness increasing, but the appearance under of the new, yet unknown formation of productive series [20, 25, 28, 30].

Conversely, a reduction of KaS in thickness according to I.I.Potapov is not associated with pinching out of individual packs of large thickness and is caused mainly by KaS3 pinching out bottom sediments and a slight reduction in thickness of KaS1.

It is worth noting that the change in the thickness of the lowest subformation (KaS3) is due to tectonic and geomorphic factors.

It is believed that the pool of Kalin time found within the Apsheron Peninsula more or less dissected topography, and clastic sediments filled firstly the most low-lying areas of paleorelief - valleys and hollows. Only after filling in depression sections, the overlap of more elevated areas has began [25]. Therefore, one of the characteristic features of productive series lithology is parallel stratification of individual horizons and packs. This feature of sediments is illustrated in the regional geological profile along the dipping anticlinal zone (Figure 4).

In addition to the KaS thickness changing within the area, large lithofacies changes are found out. To the pinching out zone, shaliness of formation increases. At the same time carbonatization of sandy layers decreases downwards and increases in argillaceous formations.

Table 1 summarizes the results of the Kalin formation studies within the Apsheron peninsula since the seventies of the last century (works of S.P.Maksimov, Sh.F.Mehtiev, S.T.Ovnatanov and A.A.Hanin) [22, 23, 25, 32]. On the basis of these data the forecast of main Kalin formation parameters was carried on, such as thickness, net to gross, porosity and permeability. Moreover temperature and pressure of the studied formation were calculated at depths greater than 7000 m based on identified gradients.

In order to forecast the general thickness of Kalin formation within Shah Deniz parameter dependence on the distance on the selected profile through fields was built, which uncovered this formation (Saubnchi - Kala - Surahany - Karachuhur-Zykh - Govsan - Peschany-More - Shah Deniz). It is proposed to use a logarithmic trend line because the sediment thickness increasing slower with the depth. Thus the predicted total thickness of Kalin formation is up to 375m (Figure 7).

Ali-Zadeh [2] estimated the possible thickness of KaS within Shah Deniz field as 400 m (based on the analysis of the Balakhany formations thickness change in the fields of anticlinal zone Kirmaku - Bahar), which confirms the result.

Likewise with the approach described above, sand content (33%), porosity (13%) and permeability (50 mD) of considered formation were analyzed. The results are summarized in Figure 7 and Table 2.

Based on the fact of the net to gross decline rate reducing with depth, while forecasting this parameter in the deepwater of the South Caspian a logarithmic trend line was also used. The result of a forecast is net to gross value equal to 33% within Shah Deniz field.

In order to evaluate the porosity on Shah-Deniz field the linear trend of parameter decreasing should be used, as rapid rate of porosity reduction is observed (Figure 7), which eventually gives a result of 13%.

According A.A.Ali-Zadeh [2], compaction gradients are significantly reduced with the depth of sediments immersion hence at the depth of 5000-6000 m and more remains relatively high porosity of clastic rocks.

Table 1

The summarized results of the Kalin formation studies within the Apsheron Peninsula (blank cells - the lack of data)

Field	Horizon	Fluid	Reservoir lithology	Depth or reservoir bottom, m	Total reservoir thickness, m	Net thickness, m	NTG	Total porosity, %		Connected porosity, %	Permeability, mD	Initial				Authors
												Pres, MPa	Tres, ^0C	GR, m^3/t	Oil/gas rate, t/d, ths.m^3/d	
Surakhany	KaS	O	S	2650	168	67,2	0,4			21		26,5	106	116,2	6	S.P. Maksimov
Karachukhyr	KaS	GO	S	2650	270					19	72	26,5	104		H 23,6	
Karachukhyr	KaS1				58	32	0,55									S.T. Ovnatanov
	KaS2				63	44	0,72									
	KaS3				156	66	0,42									
Zykh	KaS	O	S, AL	2700						22	184,3	27				S.P. Maksimov
Zykh	KaS1				65	33	0,51									S.T. Ovnatanov
	KaS2				55	39	0,71									
	KaS3				213	95	0,44									
Hoysany	KaS	O	S, AL	480-4140	250	100	0,4	KaS1 KaS2 KaS3	7,22-21,73 / 13,97 12,30-30,07 / 19,9 9,50-12,10 / 11,36	16	125,2	40,1-41,4	135	116		S.P. Maksimov S.T. Ovnatanov
Kala	KaS1, KaS2	GO	AL	2335-2375	24					20	162	23,5	67,9	150		S.P. Maksimov
Zurya	KaS	GO	AL	4800	250					17	137	48	90			
Peschany-More	KaS1	O	AL	3100-4100	300	105	0,35			18	92	35-41	98	158	49	
	KaS2	OGC	AL	3540						21		35,4	98			
Gurgany-More	KaS1, KaS2	O	S	2100-3100	400					17-30	250	21-31	55	200	6,4	
Sziloy island	KaS	GO	S	700-900	340					20	220	7,1-9	45	57		
Azy-Aslanov	KaS3, KaS4	O	AL	1340-1650	630					21,8				109	32	
Gryazevaya sopka	KaS1, KaS2, KaS3, KaS4	O	S, AL	630-1600	470					21	150	6,5-15,9	35-60	55	3-34,0	
Neftyanye Kamni	KaS1, KaS2, KaS3, KaS4	O	AL, S	730-1590	20-135					21-25	20-200	7,9-15,8	47-66	49-66	40	
	KaS2, KaS3	GO	AL, S	1250	59					23,5				35		

Table 2

The summarized results of the forecast of Kalin formation parameters at the Shah-Deniz

Forecast of Kalin formation parameters within Shah-Deniz field	
Thickness, m	375
Net thickness, m	124
Net to gross, %	33
Porosity, %	13
Permeability, mD	50
Formation temperature, C (gradient 1,6 C/100 m)	115 (@ 7000 m)
Formation pressure, MPa (gradient 0,022 MPa/m)	150 (@ 7000 m)
CGR, г/м3	280
Gas saturation	0,67

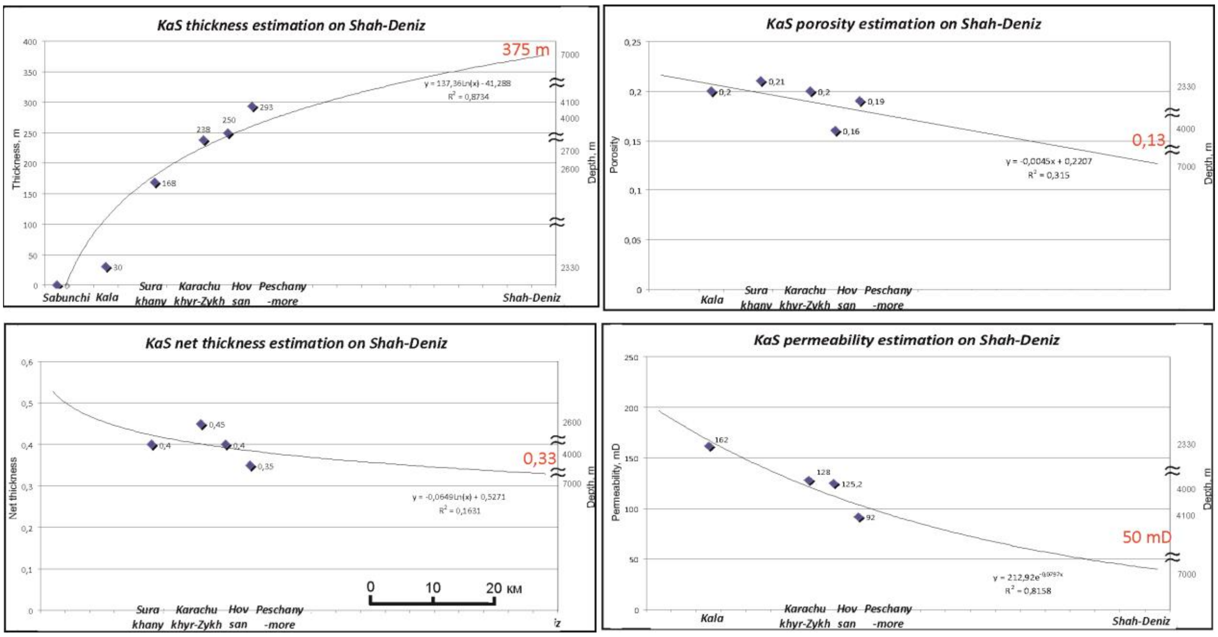

Figure 7 - *Forecast of Kalin formation parameters within Shah-Deniz field*

Quantitative estimation of rate compaction and the pore volume reduction of the individual rock types with depth in parts of the South Caspian Basin are given in Table 3. Extrapolation of obtained curves of the function R = f (H), built by AA Ali-Zadeh [2] as a result of statistical analysis, allows to evaluate the porosity of sand-silt rocks of Kalin formation at a depth of 7000 m in the range of 13-16%, which confirms our result (Figure 8).

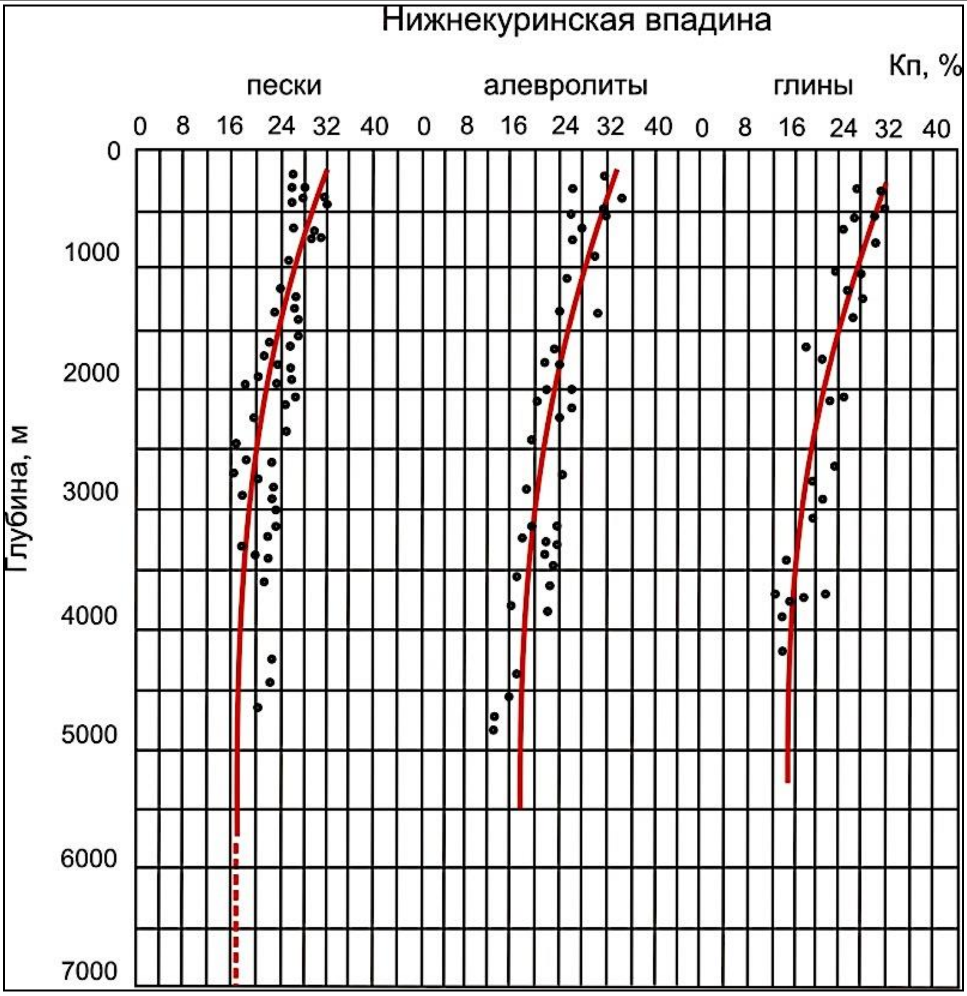

Figure 8 - The change of porosity of clastic rocks of productive series of Azerbaijan with the depth (after A.A.Ali-Zadeh [2])

The maximum value of the total porosity observed in sandy and silty rocks of subsuits KaS_1 and KaS_2. It is especially evident from Table 1, on the example of the opened Kalin formation on the Govsan field. It decreases in the subformation KaS_3 that seem to be associated with the sediments shaliness increasing up to the lower strata of Kalin formation.

Summarizing the above material, it is worth noting that at a depth of 7 km reservoirs of Kalin formation will have lower primary reservoir characteristics, however, these parameters provide satisfactory conditions for accumulation and extraction of hydrocarbons. Besides, at bigger depths it is possible to maintain different zones in reservoirs with high porosity and permeability. Abnormal pressure does not let rock to compact under increasing pressure of overburden thickness.

Study of peculiarities of pore pressures distribution in clays of productive strata, according to the well logging, shows the presence of areas with normal pressure gradients and areas with abnormally high values within the South Caspian Basin. The maximum values of parameter are observed on the structures of Baku Archipelago and Lower Kura depression. There the values of pore pressure gradients in the clays are on average 0,0180-0,0196 MPa/m, reaching Shah-Deniz field to 0.022 MPa/m (Figure 9).

Table 3

Rate of compaction (the numerator%) and reduction of the effective porosity (in the denominator%) of siliciclastic rocks from depth intervals in selected oil and gas regions of the South Caspian Basin (on A.A.Ali-Zadeh [2])

Depths, m	**Apsheron area**			**Baku Archipelago**			**Lower Kura depression**			**Pribalahanskaya zone of uplifts**			**Keymir-Chikish-lyarsky area**	
	sands	silts	clays	sands	silts	clays	sands	silts	clays	sands	silts	clays	sands	silts
0-1000	20,7	21,0	21,4	23,1	27,7	36,4	21,1	17,6	27,7	16,9	19,5	30,9	16,2	20,8
	6,2	6,5	6,5	6,0	7,2	6,0	7,0	6,0	9,5	6,0	7,0	10,2	6,0	7,5
1000-2000	11,0	12,9	12,9	15,4	17,0	22,6	9,7	11,8	11,8	13,9	13,9	23,0	13,5	16,2
	3,3	4,0	3,6	4,0	4,4	5,0	3,2	4,0	4,0	5,0	5,0	7,6	5,0	5,5
2000-3000	6,6	9,7	8,5	7,7	9,2	11,2	5,4	5,9	7,2	11,2	9,7	14,5	10,8	6
	2,0	3,0	2,4	2,0	2,4	2,5	1,8	2,0	2,5	4,0	3,5	4,8	4,0	2
3000-4000	1,7	8,4	3,6	3,9	5,8	6,8	2,8	4,7	2,9	6,9	6,9	9,7	6,7	6
	0,5	2,6	1,0	1,0	1,5	1,5	1,0	1,6	1,0	2,5	2,5	3,2	2,5	2
4000-5000	1,7	4,5	3,6	1,9	3,8	4,5	-	4,0	1,4	4,1	5,5	7,9	4,0	5
	0,5	1,4	1,0	0,5	1,0	1,0		1,4	0,5	1,5	2,0	2,6	1,5	2

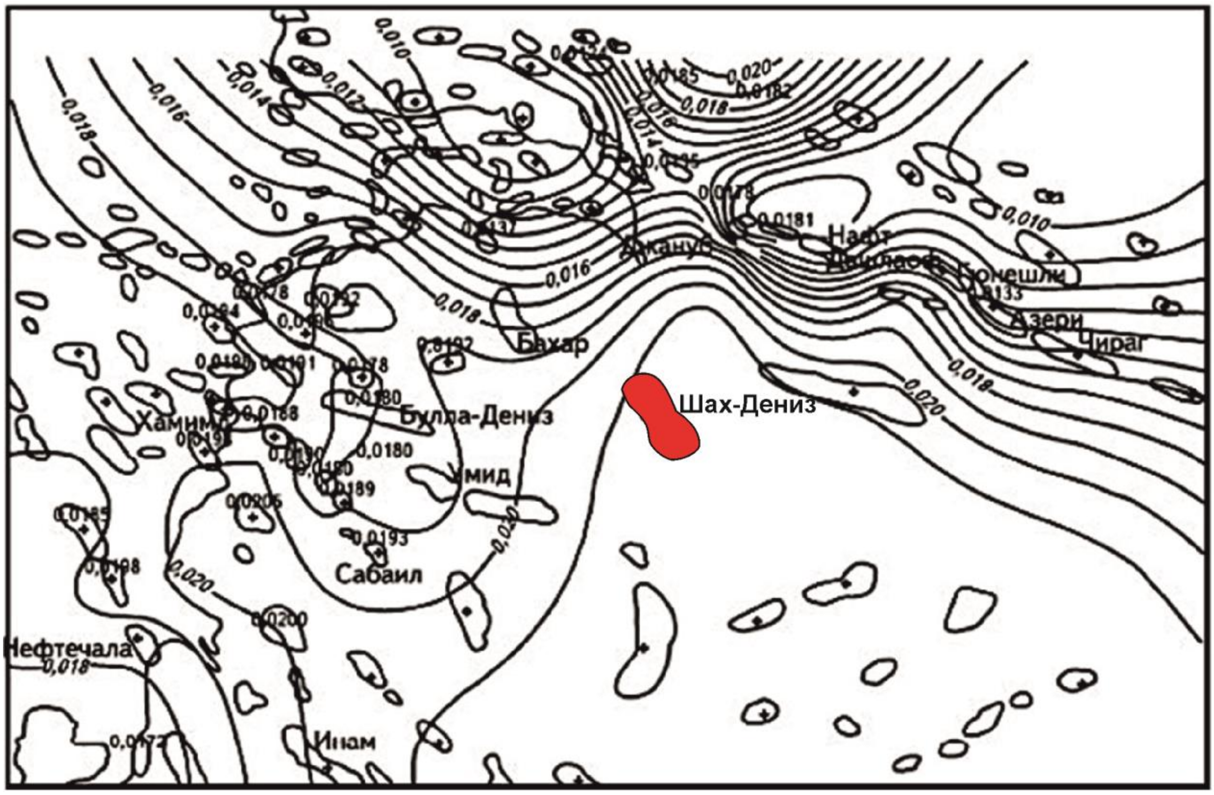

Figure 9 *- Map of distribution pore pressure gradients in clays of Periryva formation (by M.T.Abasovu, Yu.M.Kondrushkinu, R.Yu.Aliyarovu and L.G.Krutyh) [1]*

According to the analysis of the available well data (in particular, the results MDT), abnormal deposition ratio was calculated of Balakhany and Fasila formations in Shah-Deniz, reaching the value of 1.6.

For example, the initial reservoir pressure of Fasila D (SP4) reservoir, dissected on the southwest flank of the deposit at a depth of -6330 m was equal to 96.53 MPa.

Reservoir temperature gradient (1.6 C/100 m) and reservoir pressure (0.022 MPa / m) in Pliocene deposits were calculated based on the well data.

Graph of temperature versus depth (temperature gradient), built for all layers in general and described by the equation y = 97.104 x 3842, 9 (Figure 10).

The composition and physico-chemical properties of the reservoir gas in the productive deposits of Shah Deniz field have been studied by BPAmoco PLC based on the results of samples from deep wells № SDX-1y, SDX-2y, SDX-5y, SDX-4y, SDX-4w. Thus, the value of condensate-gas was obtained using laboratory data. On the basis of these data, we constructed the factor from depth dependence (Figure 11). At depths of 7000 m and more the value of the projected condensate-gas factor of Kalin formation within Shah-Deniz is expected equal to 280 g/m^3, which is consistent with the actual data on the overlying productive sediments of Balakhany and Fasila formations. Gas saturation coefficient taken as the average from uncovered deposits.

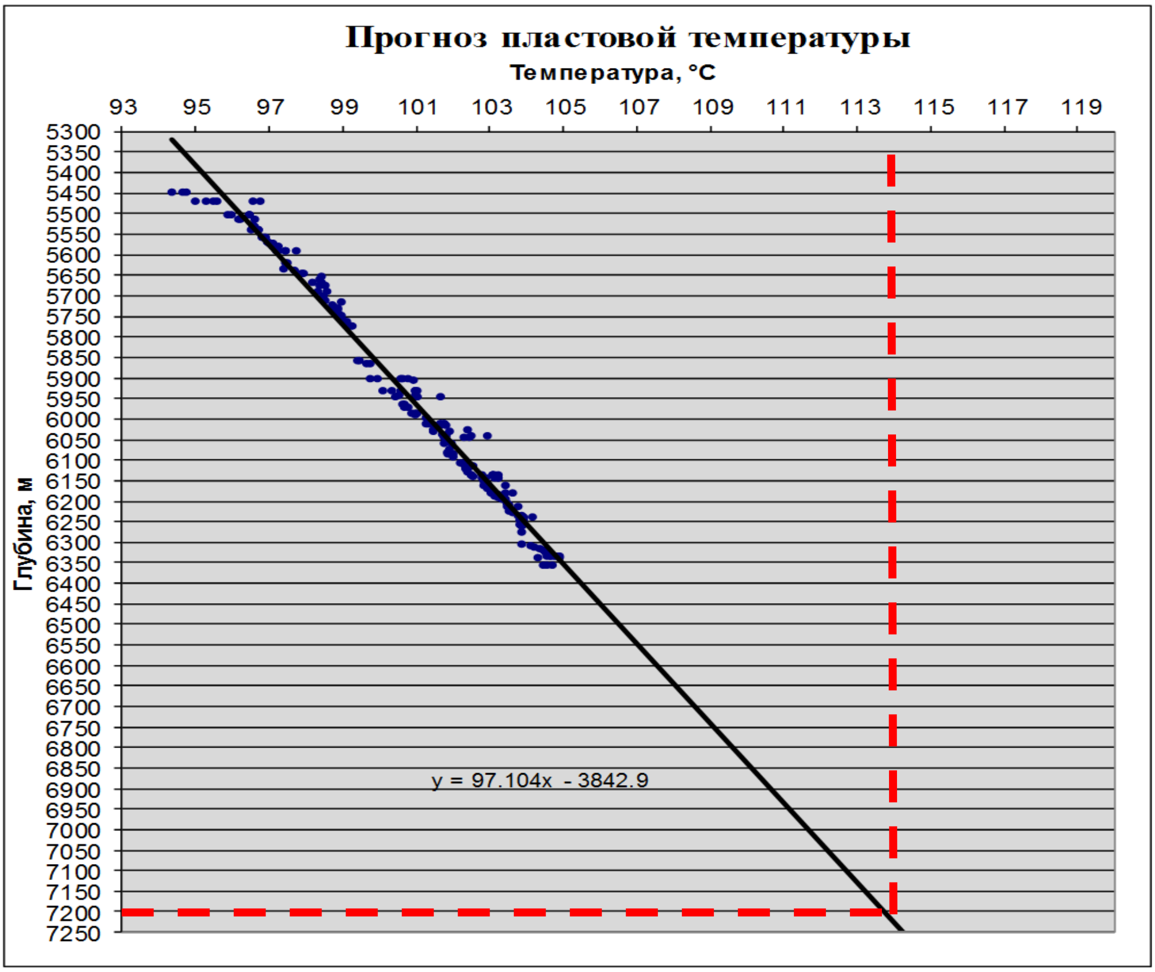

Figure 10 - Graph of temperature versus depth (temperature gradient) at Shah-Deniz

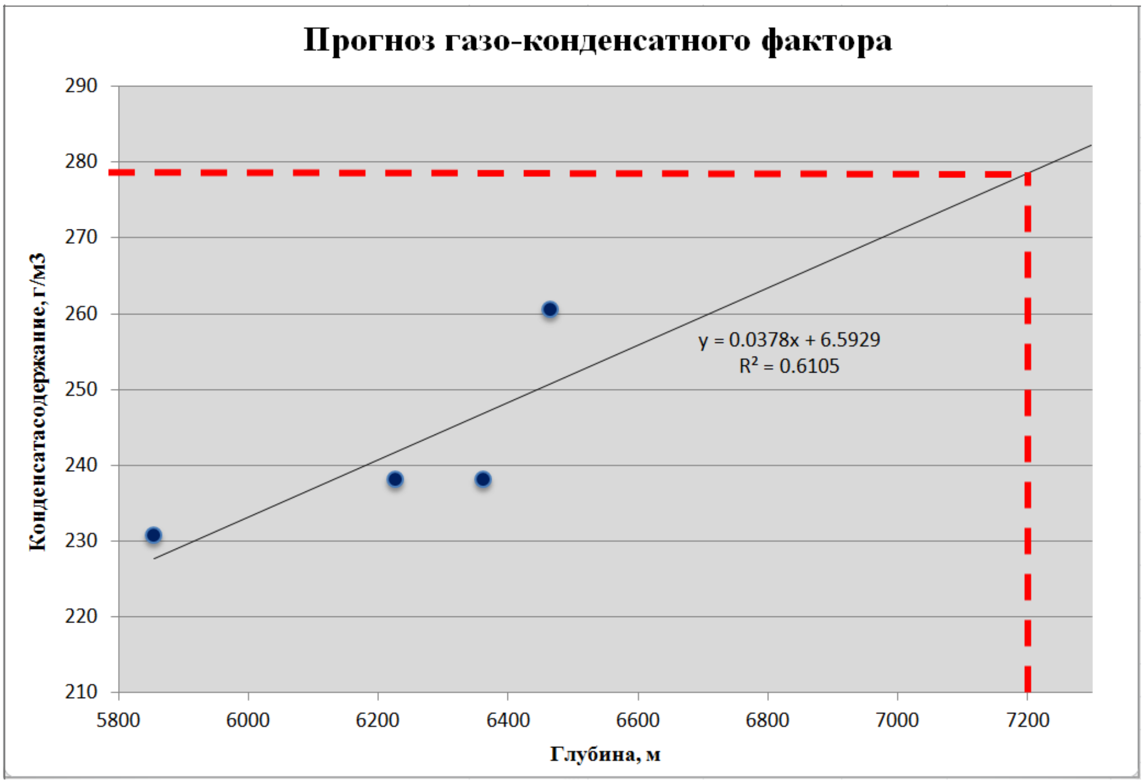

Figure 11 - A plot of gas-condensate factor versus the depth at Shah-Deniz

Approaches to the development of the Kalin formation at the Shah Deniz field

In the papers [7-19], the mechanism of HC generation and renewing, including for the Shah Deniz field [15-16], is shown in detail, and an approach is proposed to assess the Potential balance of renewable deposits [8, 9, 11, 15, 16, 17, 18, 19]. Thus, for the Shah Deniz field, according to a conservative estimate, at least one complete resumption of HC reserves to those already estimated is possible for the Shah Deniz field [15].

The Kalin formation lies directly above the oil and gas Maikop formation Source rocks, which is the main HC source for all fields of the South Caspian oil and gas basin, including the Shah Deniz field. HC enter the Kalin reservoirs not only through mud volcanoes (the main routes of HC migration at the Shah Deniz field) and faults, but also directly vertically over the entire area of contact of the Kalin and Maikop formations. This fact directly affects the choice of a development system for the Kalin formation.

The development of the Kalin formation at the Shah Deniz field should be carried out with the separate wells fund (at least 4 wells) with a horizontal completion (1-2 km) to increase the drained zone. Considering that the expected thickness of the Kalin formation within the Shah Deniz field can reach 120-150 m, horizontal wellbores must be carried out 1/3 of the total thickness from the bottom of the Kalin formation in order to maximize the inflow of HC from the Maikop formation.

At the stage of pilot operation, it is necessary to plan periodic stopovers in the first well (4 stops, starting from 4 weeks and sequentially up to 1 week) to obtain the dynamics of reservoir pressure recovery [15, 17] and calculate the most optimal flow rate of production wells, taking into account possible (permanent) Kalin formation HC renewal due to the receipt of new HC volumes from the Maikop oil and gas kitchen, what is related to the change of the general dynamic balance between the Kalin and Maikop formations due to the start of production from Kalin deposit.

This approach will make it possible to extend the production period and increase the volume of cumulative production from the Kalin formation by at least 1.5 times. The HC RF for such deposits can exceed 100% if we calculaty HC reserves by Volumetric method (this method does not take into account the influx of new HC volumes into the deposit). If we use the method of Potential balance [8, 9, 15, 17, 19], then the RF will tend to 100%, but not higher.

Conclusions:

The paper presents the materials justifying the existence of still uncovered high-promising deep-seated deposits of Kalin formation of deep zones within the South Caspian Basin on the example of the Shah-Deniz field.

The forecast of Kalin formation deposition area and its boundaries was carried out, identified key geological and petrophysical parameters in reservoirs (thickness, net to gross, porosity, permeability, reservoir temperature and pressure, CGR).

The proposed approach of reservoir properties and fluid type prediction allows reliable resource base estimation of Kalin formation, as makes it possible to narrow the range of uncertainty for input parameters.

The obtained parameters give reason to satisfactory conditions for the formation of large accumulations of oil and gas structures, similar to Shah Deniz field in within young basins, mainly due to the low geothermal gradient and high sedimentation rates.

The development of the Kalinsky formation at the Shah Deniz field should be carried out by an independent well fund (at least 4 wells) with a horizontal termination (1-2 km) to increase the drained zone. Considering that the expected thickness of the Kalinsky formation within the Shah Deniz deposit can reach 120-150 m, horizontal shafts must be carried out 1/3 of the total thickness from the sole of the Kalinsky formation in order to maximize the inflow of hydrocarbons from the Maikop formation. This approach will make it possible to extend the period and increase the volume of hydrocarbon production from the Kalinsky formation by at least 1.5 times.

The development of the Kalin formation at the Shah Deniz field should be carried out with the separate wells fund (at least 4 wells) with a horizontal completion (1-2 km) to increase the drained zone. Considering that the expected thickness of the Kalin formation within the Shah Deniz field can reach 120-150 m, horizontal wellbores must be carried out 1/3 of the total thickness from the bottom of the Kalin formation in order to maximize the inflow of HC from the Maikop formation. At the stage of pilot operation, it is necessary to plan periodic stopovers in the first well (4 stops, starting from 4 weeks and sequentially up to 1 week) to obtain the dynamics of reservoir pressure recovery [15, 17] and calculate the most optimal flow rate of production wells. This approach will make it possible to extend the production period and increase the volume of cumulative production from the Kalin formation by at least 1.5 times.

References:

1. Абасов М.Т., Кондрушкин Ю.М., Алияров Р.Ю., Крутых Л.Г. «Методический подход к изучению и прогнозированию параметров природных резервуаров нефти и газа Южно-Каспийской впадины» // Геология нефти и газа, 2-2008

2. Али-Заде А.А. «Научная оценка перспектив нефтегазоносности Азербайджана и Южного Каспия»

3. Али-Заде А.А. «Геология нефтяных и газовых месторождений Азербайджана»

4. Али-Заде А.А. и др. «Геология нефтяных месторождений Азербайджана». М.:Недра, 1966.

5. Алиханов Э.Н. «Нефтяные и газовые месторождения Каспийского моря»

6. Ахмедов Т.Р. «Некоторые результаты наземной и скважинной сейсморазведки Говсанинского месторождения углеводородов» Журнал «Каротажник» 6(216)

7. Бочкарев А.В., Бочкарев В.А. Катагенез и прогноз нефтегазоносности недр. – М.: ОАО «ВНИИОЭНГ». – 2006. - 321 с.

8. Бочкарев В.А., Бочкарев А.В. Восполняемые запасы залежей углеводородов. – М.: ОАО «ВНИИОЭНГ». – 2017. – 276 с.

9. Бочкарев В.А. Концепция освоения сланцевых углеводородов – М.: ДПК Пресс, 2021. – 332 с. https://search.rads-doi.org/project/10029/index

10. Бочкарев В.А., Остроухов С.Б. Резервы восполнения сырьевой базы старых нефтегазодобывающих районов // Нефтепромысловое дело. – М.: ОАО «ВНИИОЭНГ», 2009. - № 9. – С.20-26.

11. Бочкарев В.А. Модель формирования коллекторской емкости и залежей нефти и газа в глинистых сланцах на юге США // Зоны концентрации углеводородов в нефтегазоносных бассейнах суши и акваторий. – СПб.: ВНИГРИ. – 2010. – С. 87-92.

12. Бочкарев В.А. Модель формирования коллекторской емкости и залежей нефти и газа в глинистых сланцах на юге США. // Зоны концентрации углеводородов в нефтегазоносных бассейнах суши и акваторий: сб. материлов Международной научно-практической конференции. Спб.: ВНИГРИ, 2010. - С. 87-92.

13. Бочкарев В.А., Остроухов С.Б. К вопросу разработки залежей с возобновляемыми ресурсами газоконденсата // Нефтепромысловое дело. – М.: ОАО «ВНИИОЭНГ», 2011. - № 10.– С.17-20.

14. Бочкарев В.А., Остроухов С.Б. Восполняемые и невосполняемые запасы как следствие многоэтапного формирования месторождений // Нефтепромысловое дело. – М.: ОАО «ВНИИОЭНГ», 2012. - № 7. – С.4-12.

15. Бочкарев В.А., Манапова К.Т. Восполняемые ресурсы месторождений над зонами генерации УВ Южно-Каспийского региона // Нефтепромысловое дело. – М.: ОАО «ВНИИОЭНГ», 2013. - №7. – С.8-18.

16. Бочкарев В.А., Манапова К.Т. Прогноз наличия и петрофизических параметров песчаников калинской свиты в разрезе месторождения Шах-Дениз // Геология, геофизика и разработка нефтяных и газовых месторождений. - М.: ОАО «ВНИИОЭНГ», 2013. - № 8. – С.4-14.

17. Бочкарев В.А., Манапова К.Т. Нефтегазоносные бассейны с восполняемыми залежами УВ: проблемы оценки и разработки месторождений // Нефтепромысловое дело. – М.: ОАО «ВНИИОЭНГ», 2015. - №12. – С.5-17.

18. Бочкарев В.А., Манапова К.Т. Концепция непрерывного формирования нефтегазоконденсатной залежи месторождения Карачаганак // Нефтепромысловое дело. – М.: ОАО «ВНИИОЭНГ», 2015. - №5. – С.10-20.

19. Bochkarev V. Principles and approaches of the geological and geophysical studies, development and production of HC shale. Danish Scientific Journal, 82, 2024. p. 9-20. https://zenodo.org/doi/10.5281/zenodo.10899563

20. Горин В.А. «Продуктивная толща Апшеронского полуострова» - Баку: Азнефтеиздат, 1939.

21. Джафаров Р.Р., Гаджиев С.С., Ибрагимов Ф.С. «О распространении Калинской свиты в пределах северо-западной части Апшеронского архипелага и перспективы ее нефтегазоносности» Азербайджанское нефтяное хозяйство 01.2011.

22. Максимов С.П. «Нефтяные и газовые месторождения СССР»: Справочник. В двух книгах / Книга вторая. Азиатская часть СССР. // М.: Недра, 1987.

23. Мамедов П.З. «О причинах быстрого прогибания земной коры в Южно-Каспийской впадине» // Азербайджанское нефтяное хозяйство. 2008. №1

24. Мехтиев Ш.Ф. «Вопросы происхождения нефти и формирования нефтяных залежей Азербайджана»

25. Овнатанов С.Т. «Геология и нефтегазоносность Фатьмаи-Зыхской антиклинальной зоны Апшеронского полуострова» - 1962.

26. Г. Райли, С. Грант, А. Джавадова, С.Дуппенбеккер, Дж. Илифф, К.Кенелли Статья «Газовый потенциал глубокозалегающих отложений со сверхвысокими давлениями в Южно-Каспийском бассейне: возможности и проблемы» 1-ая Международная Конференция, 2012 Баку

27. Потапов И.И. «Ритмичность отложений продуктивной толщи Апшеронского полуострова»- Изв. АН Азерб.ССР, 1947

28. Потапов И.И. «Апшеронская нефтегазоносная область» - Баку: Изд. АН Азерб.ССР, 1954.

29. Султанов А.Д. «Продуктивная толща западного борта Южно-Каспийской впадины» - 1963.

30. Тамразян Г.П. Тектоническое развитие Прикарадагского района Апшеронского полуострова и перспективы поисков новых нефтегазовых залежей.- Ученые зап. Азерб.Гос.Ун-та Серия геол.- географ., 1962.

31. «Труды третьего Всесоюзного совещания по литологии и минералогии осадочных пород»

32. Ханин А.А. «Породы-коллекторы нефти и газа нефнегазоносных провинций СССР» // М. «Недра», 1973