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ABSTRACT

of the dissertation for the degree of Doctor of Science

BASIN ANALYSIS OF THE SOUTH CASPIAN BASED ON NEW GEOLOGICAL AND GEOPHYSICAL RESEARCH

Specialty:	2521.01 - Geology, prospecting and exploration oil and gas fields
Branch of science:	Earth Science
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GENERAL DESCRIPTION OF WORK

Relevance of the work and research status.

The Caspian region, in particular the South Caspian Basin (SCB) of Azerbaijan, is one of the main sources of oil and gas now and in the near future. The potential of the basin is being realized, thanks to such large-scale projects as the Baku-Tbilisi-Ceyhan pipeline, Azeri-Chirag-Guneshli, and Shah Deniz. However, the dynamic hydrocarbon system of the SCB is still poorly understood, and its study will bring great benefits in the future. The sediments located at great depths keep considerable secrets. The oil and gas potential of these sediments has been poorly studied. The SCB basin is completely unique in the history of its formation and evolution. It stands apart among the many sedimentary basins in the world. Studying the SCB and surrounding regions and comparing it with other basins of the world shows how important it is to find patterns in the filling of basins with sediments and to connect these factors with mountain building and erosion. To understand exceptions to the rules, it is necessary to clearly understand the rules and patterns themselves.

Over the past three decades, the national oil company (SOCAR), as well as many foreign oil companies operating in the South Caspian Basin (SCB), have collected and interpreted a huge amount of data. A regional database of high-quality 2D and 3D seismic data along with well data, collected from exploration drilling has been created. This made it possible to form a clearer holistic picture of the evolution of the basin. During this period, a great deal of experience has been accumulated; new approaches and technologies have been introduced into the practice of prospecting and exploration work. One of the approaches to basin study (basin analysis) is an integrated approach based on the following items: An integration of seismic, seismological and geological data; basin modeling; the synthesis and analysis of existing literature using systems thinking. The author, working for British Petroleum (BP) for over 20 years, led many regional studies, which were based on the processing and interpretation of the latest seismic data, as well as their correlation with available seismic, log and core data from the SCB. The author, jointly with various scientific institutes, conducted research of the SCB evolution. The author, jointly with team of geologists, for the first time calculated the absolute age of the PS series. The results of these works formed the basis of the author's scientific research over the past 10 years.

The synthesis of the theory of evolution for the SCB and for more than 1000 other sedimentary basins of the world made it possible to identify patterns associated with the formation of the sedimentary cover of the basins, the development of sedimentation and the determination of the type of basin and type of crust. In particular, a geodynamic model of the evolution of the basin, constructed on the basis of synthesis, allows us to explain some of the features of the SCB: the uneven filling of the basin, including differences in the river systems that filled the basin with sediments; changes in the supply of sedimentary material to the basin from these river systems during the accumulation of Productive Series (PS), as well as in the Upper Pliocene and Pleistocene. The establishing of the nature of the SCB anomaly in comparison with other sedimentary basins of the world is extremely important for understanding the science tasks of basin analysis. The special nature of the oil and gas content of the SCB is directly related to this anomaly.

Object and subject of research.

The object of study is the South Caspian Basin - a unique "laboratory" for understanding the processes of the world's sedimentary basins evolution. The subject of this study is the geological evolution of the SCB and its oil and gas potential.

Research goal and objectives.

Establishment of sedimentation patterns and development of the sedimentary cover of the SCB, based on methods of basin analysis and basin modeling, as well as comparison of the SCB with other sedimentary basins of the world, depending on their thickness, age, crust type and oil and gas content.

Oil and gas content and exploration risks forecasting in the SCB based on new geological and geophysical data and modern approaches and methods.

Objectives.

1. Study of the SCB and nearby basins sedimentary cover evolution based on data from regional seismic, isopach maps and basin

modeling, including one-way travel curves from wells, temperature data and the gravimagnetic modeling results.

2. Methodology and radiometric calculation of the absolute age of the Pliocene Productive Series of the SCB and the creation of an improved age model of the SCB.

3. Assessment of precipitation volume and sedimentation rates for the entire basin and regions.

4. Analysis of the evolution of the influx of sediments into the SCB through drainage systems, a study of the denudation rates of the sides of the basin in the Cenozoic era and a comparative analysis of the morphology of river systems flowing into the Caspian Sea. The estimation of erosion rates in the Cenozoic and explanation of the anomalous sedimentation of the SCB.

5. Comparison of the evolution of the sedimentary cover of the SCB and other sedimentary basins of the world. Clarification of differences between the basin types, as well as the volumes of the Earth's sedimentary cover, using the Pareto power distribution. Explanation of the importance of power laws in geological systems.

6. Study of the tectonic evolution of the SCB and surrounding regions in a view of plate theory starting from the formation of the basin in the Jurassic period to the present day.

Research methods and factual material.

This work is theoretical and methodological in nature. The work is based on a review and synthesis of modern geological and geophysical data, integration of modeling of the lithosphere and sedimentary cover of the SCB, as well as a quantitative assessment of the processes of filling the basin with sediments and their denudation on the sides of the basin.

A database that included about 1000 of the world's main sedimentation basins was also created, the sedimentation rates in each of these basins were studied and calculated on the basis of published data. This database was created by integrating the databases from the Earthbyte and CGG Tellus websites. The mapping of a large number of seismic horizons, including 20-second seismic sections was the basis of the factual material for the South Caspian basin. The author, jointly with a team of geologists and geophysicists from BP, carried out an interpretation using an extensive grid of 2D and 3D seismic data. The regional data for the Central Asia and Caucasus region (published maps and profiles) were also used in the work.

Another basis for analysis was data from the wells of the SCB and the Kura basin (including temperature measurements and stratigraphic picks).

Defensible assumptions.

1. Iterative dynamic model of the structure and sedimentation of the SCB and adjacent territories.
2. Observation of new patterns in crustal subsidence and sedimentation in the South Caspian Basin updated with results of better defined absolute age dating.
3. Results of comparative analysis and statistical parameters of sedimentary basins of the world, including their oil and gas potential.
4. Hydrocarbon potential of the SCB based on a comprehensive analysis and categorization of geological risks.

Scientific novelty.

1. It has been determined that the SCB is one of the unique basins in the world with an anomalous value of the average thickness of the sedimentary cover. The dependence of precipitation thickness on basin area for different types of basins has been derived.
2. For the first time, the rate of sedimentation was calculated based on the effective volume of sediment in the basin by using the average thickness of rocks in different areas of the basin. The mechanism of denudation of the sides of the SCB was studied and a relationship was established between the rate of denudation and the rate of sedimentation for each of the river systems that supplied the SCB with sediment.
3. It is shown that the observed nature of subsidence and sedimentation in the SCB is the result of the process of sedimentation load on the thinned oceanic-type crust with fading thermal subsidence.
4. It is substantiated that the SCB is one of the several basins that are genetically close to each other, formed along the back-arc boundary of the Neo-Tethys, such as the Greater Caucasus Basin (GCB), the Kura Basin (including the Yevlakh-Agjabedi depression (EAD)). A description of the evolution of these basins is given in a view of plate tectonics theory.

5. For the first time, the absolute age of the rocks of the Lower Pliocene Productive Series (PS) was measured in detail and it was shown that the PS was deposited from 4 million years to 2.7 million years, and not from 6 million years to 3.2 million years, as previously thought.

6. A correlation between the thickness of the consolidated crust and the thickness of the sedimentary cover of the SCB has been derived.

7. For about 1000 oil and gas basins of the world (OGB), the relationship between the volumes of sedimentary cover, the thickness of sediments and the volumes of hydrocarbon reserves in these basins were calculated.

8. Based on the Pareto power law, the ranges of resources in the hydrocarbon basins of the world and in the SCB were calculated.

9. Based on the exploration risk methodology proposed by the author, the degrees of geological risks for each of the 15 oil and gas province of the South Caspian basin are described.

Practical significance of the work.

The established patterns and characteristics of sedimentary basins make it possible to understand the relationships between various geological types of basins, including the SCB. Using similar patterns, the size and morphology of sedimentary basins can be revealed in the absence of seismic data that determines the size of the basin.

The constructed iterative models of the SCB subsidence and the updated absolute age of Pliocene deposits in the basin can be used to identify the characteristic features of the lithosphere and sedimentary cover. They can also be used to construct a more accurate three-dimensional model of heat flow in the center of the SCB, which provides a basis for understanding the processes of hydrocarbon generation and migration.

The results of the analysis of the tectonic structure of the basin and the irregularities of the sedimentary cover of the SCB can be used to predict the presence and extent of reservoirs in the basin where well data are limited.

Personal contribution of the applicant. All results that form the content of the dissertation were obtained by the author independently using Badleys diving modeling packages “FlexDecomp” and “Stretch”, Geosoft’s “GM-SYS” package for gravimetric modeling, Petrel XField package for gravimagnetic modeling and the company’s “Trinity” package Zetaware for mapping and basin modeling, as well as the “Spotfire” package for visualization.

The author, jointly with members of the BP exploration group, was directly involved in carrying out the scientific research in the offshore SCB, interpreting seismic data, constructing isopach (thickness) maps, paleogeographic maps and basin modeling, which served as the initial basis for this work. The author calculated and collected for the first time the large amount of data on the world's basins, collected the thickness maps of the Earth's sedimentary cover from various sources and synthesized and generalized all this data. All graphs demonstrating various dependencies used in the work were constructed by the author independently.

Approbation of work. There are 22 publications on the topic of the dissertation work, of which 12 articles in scientific journals and collections and 10 abstracts of reports at conferences and seminars. The research results were presented at 10 international conferences, symposia and seminars.

The name of the organization where the work was performed. The dissertation work was completed at the Institute of Oil and Gas of the Ministry of Science and Education of Azerbaijan.

Structure and scope of work. The dissertation consists of an introduction, ten chapters, a conclusion and a list of references. The total volume of the work is 349 pages of text and includes 5 tables, 135 figures and 308 references. The chapters reflect the main protected provisions. The work consists of an introduction (13605 characters), 10 chapters (1st chapter – 94030 characters, 2nd chapter – 27397 characters, 3rd chapter – 30674 characters, 4th chapter – 19531 characters, 5th chapter – 54573 characters, 6th chapter - 23443 characters, 7th chapter - 41386, 8th chapter - 21334 characters, 9th chapter - 26124 characters, 10th chapter - 83784 characters), and conclusions (7541 characters). Total number of symbols, excluding literature and illustrations is 443422.

Scientific results on the first protected position are reflected in the first, second, third and fourth chapters; the second protected position is reflected in the fifth, sixth and seventh chapters; for the third protected position are reflected in the eighth and ninth chapters; for the fourth protected position are reflected in the tenth chapter of the dissertation.

The author expresses deep gratitude to the scientific consultant, academician, vice-president of ANAS, doctor of geological and mineral sciences, prof. I.S.Guliev; Academician of ANAS, Doctor of Geology and Mineral. sciences; prof. P.Z.Mamedov (AGNA); Academician of ANAS, Director of the Institute of Oil and Gas, Doctor of Geology and Mineral sciences, prof. F.Z.Kadyrov; Academician of ANAS, Doctor of Geology and Mineral sciences A.A.Feizullaev; Academician of ANAS, Doctor of Geology and Mineral Sciences E.G.-M.Alieva; Dr. G.Riley (BP); candidate geologist-miner. sciences A.S.Javadova (SOCAR); Dr. R.Saxenhoffer (University of Leoben, Austria); Dr. D.Weber (University of Missouri, USA); Chris Van-Bak (University of Utrecht, Holland) for valuable advice, assistance and great attention during the work. The author expresses gratitude to the BP company for permission to publish the results of the research performed. The author also thanks Badleys, in particular Dr. A.Roberts, for the opportunity to use lithosphere modeling programs in carrying out this work.

Chapter I Review of the tectonic structure of the Caspian region.

A review of the evolution of the sedimentary cover of the SCB and border regions based on published works, including previous studies by the author, shows the unusual geotectonic nature of the SCB. According to refraction seismic data and telemetry (Fig. 1), a thin oceanic-type crust with a thickness of up to 5-6 km in the western part and more than 10 km in the eastern part (without the upper granite layer) lies under the thick sedimentary cover of the SCB at a depth of 25-27 km. On the territory of the Kura Lowland, the thickness of the consolidated crust is 25 km. The crust has a typical continental structure with the presence of a basalt and granite layer. All of the above is confirmed by numerous seismic, gravimetric and thermal data, as well as the results of the SCB subsidence modeling, performed by the author.

The results of the subsidence modeling work showed that with a basement depth of 24-25 km (Fig. 1 and Fig. 2), the total thickness of sediments in the South Caspian basin can be explained by the process of expansion of the passive continental margin of the proto-SCB and the formation of an oceanic basin during the Late Jurassic, followed by thermal subsidence over 145 million years, accompanied by sedimentation, loading and compaction.

Sedimentation in the center of the basin most likely began immediately after the formation of the back-arc basin of the SCB, which we attribute to the end of the Jurassic period (conditionally 145 million years ago).

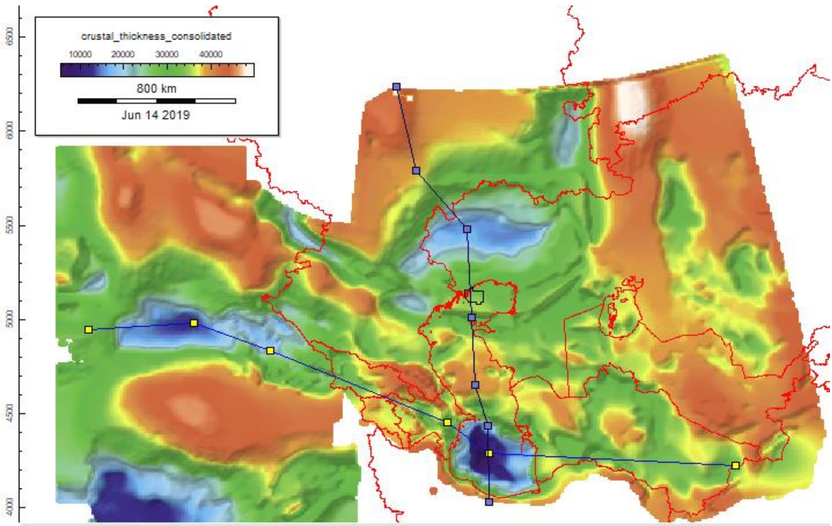

Figure. 1. Thickness of the consolidated crust throughout the Caspian region (in meters). The profile lines are shown in Figure 2.

The work also synthesizes the results of geotectonic modeling carried out previously for the Lower, Middle and Upper Kura basins, which are associated with the SCB. It is assumed that these basins are also the rifts of the continental margin of the back-arc basin or the fore-arc basins filled with volcanic sediments eroded from the Lesser Caucasus massifs. According to geophysical data, the consolidated crust of these basins is clearly continental in nature. A comparative analysis of the history of these basins is provided taking into account their geodynamic characteristics. Both the thickness of sediments and the thickness of the consolidated crust are compared throughout the Caspian region. It is shown that these basins generally have a thickness close to the average continental crust of 20-30 km and are characterized by a sedimentary cover thickness of no more than 15 km.

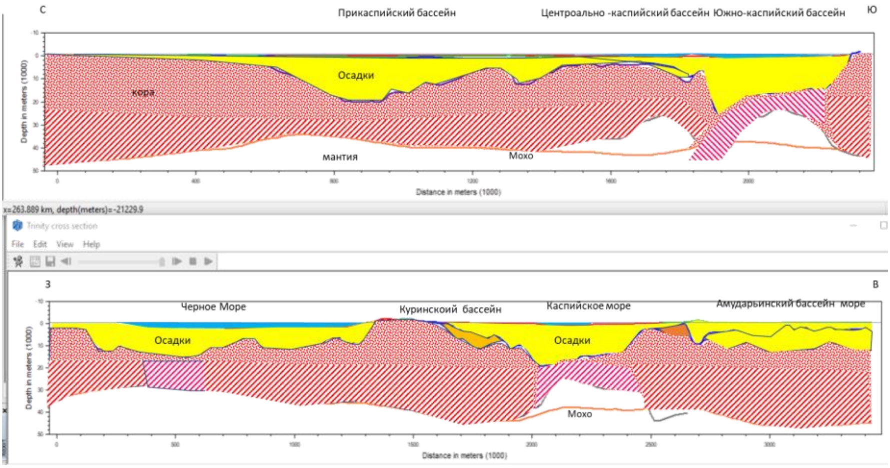

Figure. 2. Regional profiles north-south (A) and west-east (B). The red dashed lines indicate the granite and basalt layer of the consolidated crust. The sedimentary cover is highlighted in yellow.

At the site of the Greater Caucasus Range there also existed a back-arc basin in front of the passive margin (hereinafter called GCB), which opened around the Jurassic period simultaneously with the SCB. Up to 15 kilometers of sediments has accumulated in this back-arc basin. Now these sediments are exposed along the Caucasus ridge, and then eroded and redeposited in the SCB. Variscan (Paleozoic) metamorphic crust of this basin is exposed in the center of the ridge.

Further, in the first chapter, information is provided on the rocks of the Jurassic, Cretaceous, Paleocene and Eocene periods, as well as the maps integrating the onshore of Azerbaijan and the offshore of the SCB into a single basin based on the latest data. During this period (from the Cretaceous to the Miocene) in the SCB there was a gradual increase in the sedimentation rates as sediment input points approached the basin or became active in supplying coarse clastics. The Eocene and Oligocene-Miocene rock complexes are distinguished by a high content of organic matter material. At this time, the volume and rate of sedimentation increased sharply reaching maximum values of more than 10 km per million years (Fig. 3). This is possibly due to the rise of the Caucasus Mountains that began around the same period. The author, when describing the cyclicity of the Pliocene section of the SCB, based on his previous works, uses the terminology of sequence stratigraphy in relation to the SCB and shows that the Pliocene age Productive Series (PS) is a tract of a low sea level system in the terminology of sequence stratigraphy (lowstand systems tract). It is separated by an unconformity from the underlying tract of high sea level systems. We see that sedimentation in the SCB occurred unevenly in time and space, which in turn was associated with heterogeneities in the basement of the SCB and different levels of filling with sediments from four fluvial systems: the Volga, Kura, Amu Darya and Sefidrud. The heterogeneity of the basin fill described by the author is directly related to the entire subsequent evolution of the basin.

Chapter II. Modelling of depression and subsidence of the sedimentary cover of the south caspian basin

One of the main elements of basin analysis is the analysis of the sedimentary cover history using forward and inverse modeling. The paper presents the results of studies on the subsidence of the foundation and subsidence of the sedimentary cover of the SCB. The author adheres to the idea that the SCB opened between the Upper Jurassic and mid-Cretaceous periods, which does not contradict the modeling results presented in this work. To understand the evolution of subsidence in the South Caspian Basin, the author performed a combined structural and stratigraphic modeling of the basin along three regional sections crossing the SCB.

The paper describes the process of modeling the immersion of a pool, performed by the author in previous works and continued in this work. The modeling process carried out by the author in relation to the geological section of the South Caspian basin consisted of 4 stages: 1) Assessment of the main factors influencing the modeling result by constructing a simple angular model and varying parameters; 2) Flexure backstripping (decompaction and unloading) without modeling thermal settlement in the Flex Decomp program; 3) Direct modeling of the entire crust (and lithosphere) with thermal subsidence in the Stretch program; 4) Backstripping using new direct model constraints, also including a land profile. The author, in inverse modeling, applied the thickness of the thinned crust resulted from direct modeling, obtaining as a result the "residual" paleobathymetry of the SCB basin at the time of its formation. The gravimetric and magnetometric modeling confirm the basin subsidence modeling results.

The conceptual model created by the author and supported by observations and modeling shows that the SCB was revealed as a continental margin rift/back-arc rift. The direction of the maximum value of the beta factor (the ratio of the thickness of the stretched crust to the total thickness of the crust) reflects the geometry of the rift axis, orthogonal to which the opening and expansion of the basin occurred during the syn-rift Jurassic period, possibly forming a small oceanic window together with the Western Black Sea basin (Fig. 3). To the southeast of the rift axis was the continental margin of the "Godina massif," possibly bounded by deep transform faults and possibly genetically related to the Transcaucasian Massif (TCM). These possible deep faults had and currently continue to influence sedimentation.

Subsidence modeling supported the assumption that the pronounced south-to-north Mesozoic-Paleogene thickening in the South Caspian Basin results from a transition from thinned continental crust to oceanic crust. As a result, a large beta coefficient and subsidence are observed in the northern zone of the inferred oceanic crust. The maximum values of the beta factor are mapped along three simulated profiles in the sublatitudinal direction, south of the Absheron-Balkhan Ridge. A conceptual geodynamic model consistent with these observations shows that the South Caspian was exposed as a continental margin rift at the Neo-Tethys boundary. The direction of the maximum value of the expansion coefficient reflects the geometry of the rift trough, orthogonal to which the opening and expansion of the basin occurred during the syn-rift Jurassic period.

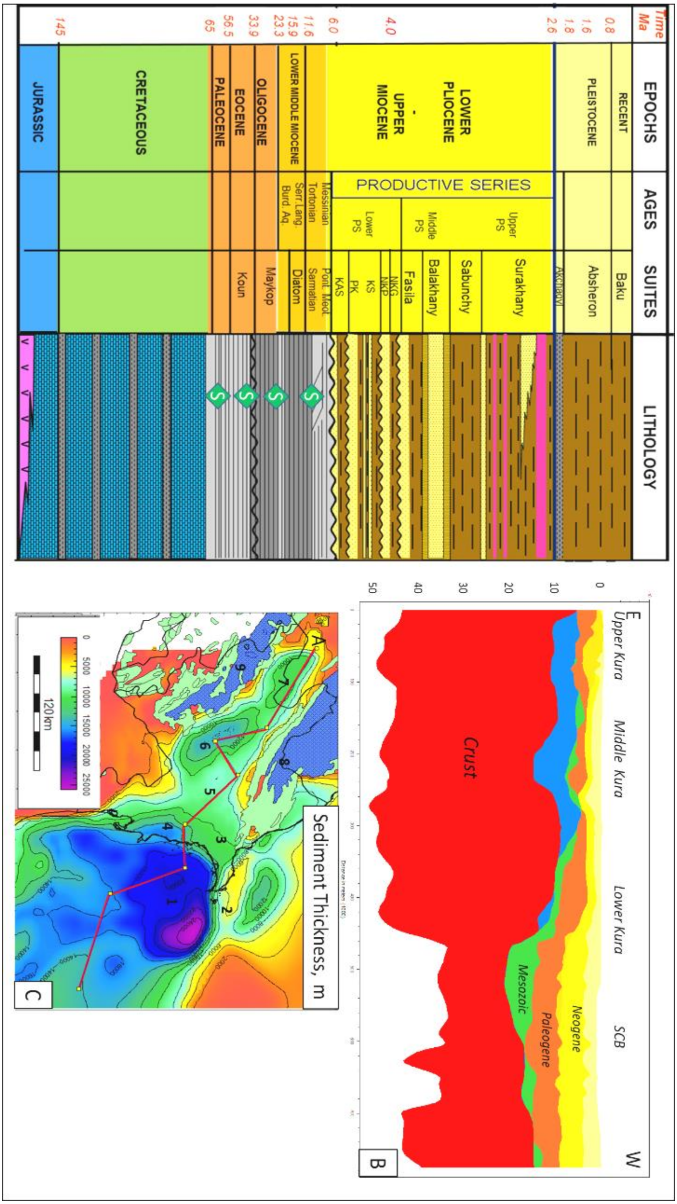

Figure. 3. Regional profiles north-south (A) and west-east (B). The red dashed lines indicate the granite and basalt layers of the consolidated crust. The sedimentary cover is highlighted in yellow.

Chapter III. Tectonic structure of the SCB and Kura basin of Azerbaijan based on temperature, gravimagnetic and seismic data.

The modern South Caspian and neighboring basins (Middle Kura, including the Yevlakh-Agjabadi depression, and the Vekhnekura basin) represent a completely unique basin of the globe, characterized by a large thickness of sediments, favorable tectonic and lithological-facial conditions, which determine high prospects for oil and gas potential. A generalization of numerous temperature measurements collected and interpreted in many works shows that the temperature distribution at equivalent depths in general reflects the main features of the tectonics of the South Caspian Basin (hereinafter SCB). For example, a decrease in temperatures is clearly visible from the sides of the depression to its center. The local temperature maxima at the tops of the PS horizon are observed at the edges of the Kura Depression, in the area of Aji-nour (80C), Amirarh (65-70C at a depth of 2400 m), while minima are found in the center of the basin (Duvanny-Deniz and Khara-Zyrya and, of course Shah Deniz, where temperatures do not exceed 50C at a depth of 2500 m).

Such a change is associated with geothermal gradients. We examined geothermal gradients extracted from a large number of temperature measurements at fields in Azerbaijan, both onshore and offshore. Temperature data from more than 150 wells with depths ranging from 100 to 6000 meters were used in the work to confirm the structure of the SCB basin. We traced a significant change in temperature gradients along the SCB boundary, which is associated with changes in both the thickness of the consolidated crust of the SCB and the thickness of sediments in the basin.

It is known that the thickness of the consolidated crust decreases significantly in the waters of the SCB. The thickness of the crust is 5-7 km. It is believed to be of oceanic nature. As shown in this work, the boundary between the oceanic and continental type crust passes on land, in the area of the Absheron Peninsula. In the center of the SCB, the thickness of sediments on the oceanic crust is 25 km (Fig. 1). In the Middle Kura basin, the thickness of sediments is 15 km, and the thickness of the consolidated crust reaches 30 km. These data were obtained both from published sources and from the results of a regional interpretation of the entire SCB carried out by the author. The regional profile, running from the western borders of Azerbaijan to the SCB center, demonstrates a change in the thickness of the sedimentary cover from west to east, as well as a sharp thinning of the crust east of the West Caspian Fault (WCF in Fig. 2).

The paper also indicates how these data can be compared across different geophysical fields. Let's start with heat flow and temperature measurements. There are a large number of publications on this topic. Figure 4 shows the change in temperatures with depth in various regions of Azerbaijan and the water area of the SCB. In areas of uplift or significant erosion, such as the Absheron Peninsula, the initial temperature values and their changes at the surface are problematic, so these values can be neglected to create a general regional picture of changes.

The temperature field varies from wells in the waters of the SCB with a depth of more than 6 km, temperatures exceeding 100°C and geothermal gradients of no more than 15°C/km (for example, Bulla-Deniz) to wells in the west of the Srednekurinskaya depression, with geothermal gradients exceeding 40° S/km. (Fig. 4). The highest values of geothermal gradients are observed in the west of Azerbaijan, especially in fields close to the Lesser Caucasus (for example, Dalimamedli, Gurzundag).

The heat flux density in a basin depends on temperature gradients measured in wells and on thermal conductivity of rocks measured in wells, outcrops, the Caspian Sea floor, and mud volcanoes.

The research results also show the peculiarities of heat flow distribution in the South Caspian Sea and Azerbaijan. Within the deep-sea parts of this region, relatively low heat flow values from 20 to 50-60 mW/m^2 are observed, while increased heat flow values (from 50-100 to 480 mW/m^2) are confined to either the western and north-western periphery of the SCB, or to relatively narrow linear zones with anomalous geological conditions. For the Yevlakh-Agjabadi region, the heat flow density values are also small and range from 20 to 50 mW/m^2 (Fig. 5). Changes in heat flow are often associated with radiogenic heat generated in the mantle and crust.

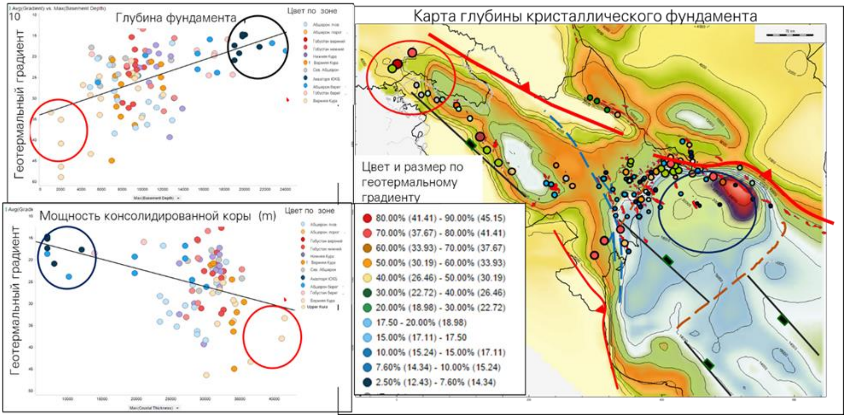

Figure. 4. Dependence of the geothermal gradient on the thickness of the crust and sedimentary cover. The graphs on the left side of the figure demonstrate the dependence of the geothermal gradient on the depth of the basement and the thickness of the consolidated crust

Geothermal gradients in the center of the SCB have very low values, amounting to only 12-13 OC/km, which corresponds to the greatest thickness of the sedimentary cover (more than 25 km) according to regional CDP profiles. It is necessary to note a certain dependence of the geothermal gradient on the thickness of sediments and on the depth of the foundation. Figure 4 shows these graphs and dependencies, as well as the depth of the foundation. The blue circle shows the minimum value of the geothermal gradient in the SCB water area, and the red circle shows the maximum value. They correspond to a basement depth of 20-35 kilometers (less than 10 km of sedimentary cover thickness) and 2-5 km (more than 40 km of sedimentary cover thickness), respectively.

The change in the thermal field over time is a function of thermal attenuation during basin formation and subsequent burial and sedimentation. A noticeable change occurred during the first 50 million years of the formation of the basin, after which no significant changes in the thermal field or sedimentation rate were observed until the beginning of the Oligocene. An increase in the rate of sedimentation in Maikop led to a decrease in temperature. A further decrease in the rate of sedimentation was accompanied by a corresponding increase in temperature. The onset of rapid sedimentation in the Pliocene was naturally accompanied by a sharp decrease in temperature. At a depth of 1 km, the temperature decreases by approximately 20C°, and at the basement-sediment boundary - by more than 50C°. The modern heat flow (HF) is 27 mW/m^2 on the surface, and about 60 mW/m^2 on the foundation (deep HF) (Fig. 5). The change in TP depending on the rate of sedimentation is clearly visible.

The study of the deep structure of the SCB and the Kura basin was also carried out using gravimagnetic modeling on several regional seismic geological profiles (Figures 5, 6, 7, 8, 9). Revealed that it is not possible to construct a single correlation dependence that allows calculating the depths of the crystalline basement due to the presence of volcanic bodies.

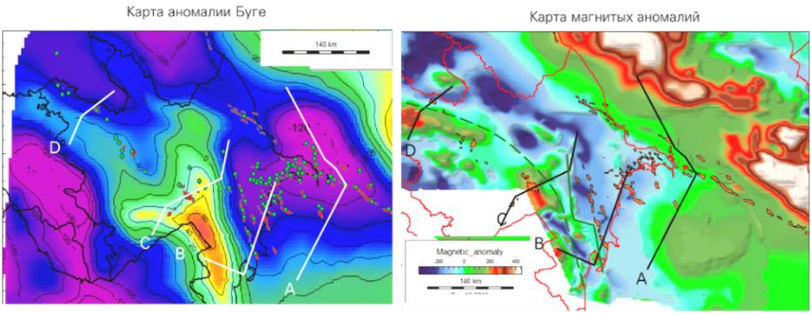

Figure 5. Map of the Bouguer anomaly and map of the magnetic anomaly from [7.8]

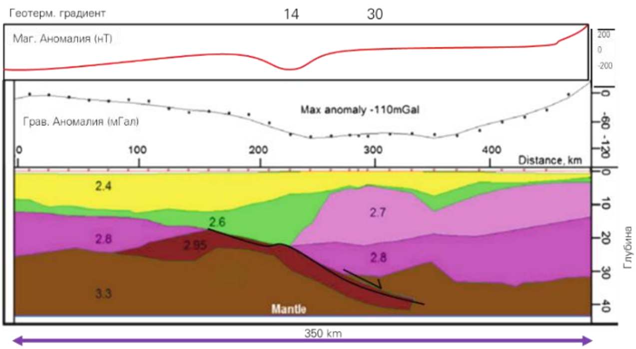

Figure. 6. Regional seismic geological profile A, constructed based on the results of gravimagnetic modeling

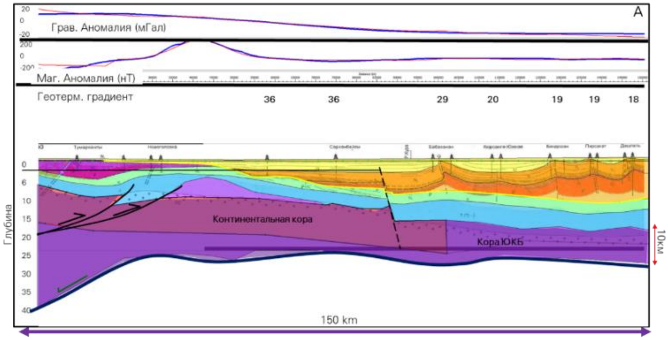

Figure. 7. Regional seismic geological profile B, constructed based on the results of gravimagnetic modeling

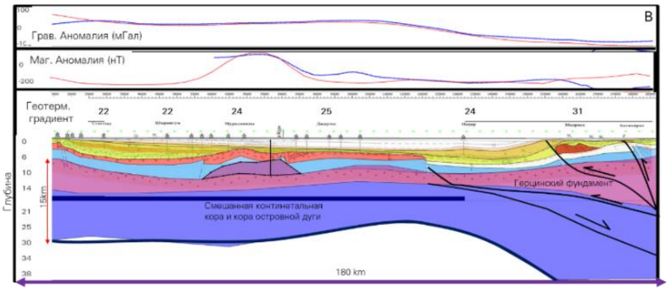

Figure. 8. Regional seismic geological profile C, constructed based on the results of gravimagnetic modeling

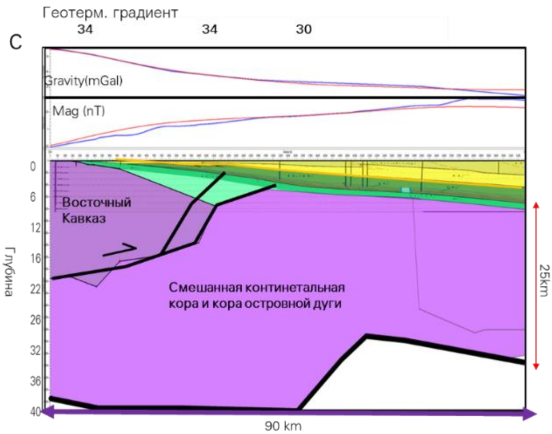

Figure. 9. Regional seismic geological profile D, constructed based on the results of gravimagnetic modeling

Profile A in Fig. 6 passes from the middle Caspian Sea through the Absheron threshold and the subducting oceanic crust of the SCB into the SCB basin itself. The significant negative Bouguer anomaly is associated with the subsidence of the relatively low-density crust of the SCB under the Absheron Ridge. The magnetic anomaly in the north of the profile is associated with the uplift of the basement north of the SCB.

Profile B (Fig. 7), running from Tumarkhanly and Novogolovka through Sarkhanbeyli, Babazanan, Kyurovdag and ending at Dashgil, crosses various tectonic blocks. In the western part, the profile crosses the region of the Saatli gravity anomaly, as well as the magnetic maximum. As the thickness of the sedimentary cover increases, the values of the Bouguer gravity anomaly decrease. On the same profile, the average values of the geothermal gradient between Sarkhanbeyli and Babazanan sharply decrease, which can also be seen on the map of geothermal gradients (Fig. 4). Here the main tectonic boundary lies identified by many seismological data - the West Caspian Fault. The fault separates the thinned crust of the SCB, possibly of an oceanic type, from the continental crust of a mixed type (volcanic arc).

Profile C (Fig. 8) passes within the Yevlakh-Agjabe-din depression from Sovetlyar through Muradkhanly and then goes out from it to the Kura lowland and upper Gobustan. In this profile, the Yevlakh-Agjabedi depression and the Saatli buried uplift are represented as a small positive Bouguer anomaly (30-10 mGal), which is replaced by a significant negative anomaly associated with the subsidence of the Kura depression under the Greater Caucasus. Profile modeling demonstrates 15 km of thinned continental and island-arc crust subducting beneath the Hercynian basement of the Greater Caucasus. In this case, the thickness of the crust increases to 40 km. The work[1] indicates that the thickness of the consolidated crust in the Yevlakh-Agjabedin depression is at least 25 km. However, it is difficult to explain geothermal gradients by such thickness and carry out the gravimagnetic modeling corresponding to such thickness. It seems to us that the crust is thinned, most likely due to initial rifting, which is confirmed by the DSS data. The magnetic anomaly on the Muradkhanlinsky uplift is associated

[1] Глумов, И. Региональная геология и нефтегазоносность Каспийского моря / И.Глумов, Я.Маловицкий, А.Новиков [и др.], - Москва: Недра, - 2004, - 343.

with volcanic intrusions of the island-arc order and a certain uplift of the basement at the edges of the supposed rift basin. According to gravimagnetic survey data, models of the volcanogenic structure of the northwestern side of the Yevlakh-Agdzhabedinsky trough are described in the work[2]. They, together with effusive rocks, influence the magnetic anomaly and its magnitude. The seismic geological profile D runs in the upper part of the basin through the region between the Kura and Gabyrra rivers into the Georgian part of the Upper Kura basin (Fig. 9). In this part of the profile, the thickness of the consolidated crust (according to gravimetric modeling) reaches 35 km under a thick layer of volcanogenic sediments and crust of the Eastern Caucasus. Under the sedimentary cover itself, in the interfluve, the thickness of the consolidated crust varies up to 25 km. Geothermal gradients in this area are high - from 34°C/km to 30°C/km, which in principle is a normal manifestation of radiogenic heat in the crust with a thickness of no more than 30-40 kilometers and a small sedimentary layer. Published data show that the thickness of the consolidated crust does not exceed 40 kilometers, which is consistent with our model. The regional seismic geological profile connecting the land and the sea of Azerbaijan is shown in Fig. 10.

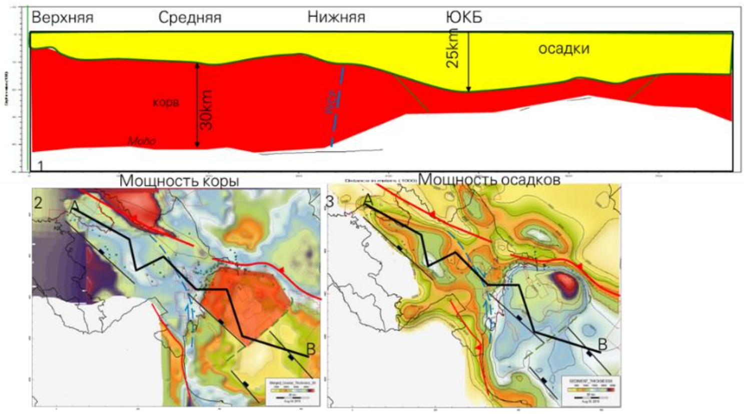

Figure. 10. Regional seismic geological profile D on maps of the sedimentary cover

[2] Гадиров, В.Г. Гравимагнитные исследования распределения погребенных вулканогенных пород в Среднекуринской депрессии в связи с их нефтегазоносностью // Геолог Азербайджана. - 2002. № 7, - с. 130-141.

Chapter IV. Synthesis of geodynamic evolution and sedimentation in the sedimentary cover of the SCB.

The Southern Caspian has a complex tectonic structure and is the center of complex deep geodynamic processes. Over millions of years, these processes changed it from a marginal deep-sea back-arc basin on the northern border of Tethys to a closed intermountain basin with lake and river sediments.

The work is carried out by studying the history of sediment accumulation in the basin. Based on temperature modeling, seismic geological profiles, geothermal gradients, gravimagnetic models and a number of other studies, the author provides a model of the evolution and formation of the SCB and adjacent geological basins, taking it as a basis and modifying previous works. The paleogeographic map of the location of the basins during the Upper Cretaceous period corresponds to the location of magmatic uplifts and magnetic anomalies. It is necessary to note several main parameters of the model:

1) The SCB was formed on the Neo-Tethys boundary as a back-arc basin of the continental margin of Eurasia together with the Greater Caucasus Basin (now located on the site of the Caucasus Mountains) in the Jurassic period (BCB and SCB), separated from it by the junction of island-arc uplifts.

2) The West Caspian Fault (WCF) is the tectonic boundary of the SCB plate throughout its evolution. Perhaps the fault marked the boundary of the SCB with Jurassic island-arc volcanic material, which was identified on the Saatli uplift. According to GPS data, modern vector movement occurs along the fault. According to DSS data, at this boundary there is a sharp thickening of the consolidated crust and a decrease in the thickness of the sedimentary cover, as indicated by temperature data.

3) The beginning of the Yevlakh-Agjabedi depression is the Upper Cretaceous inter-arc extension (rifting), coinciding in time with the formation of nearby back-arc basins, such as the East Black Sea basin and the Rioni basin in Georgia. The Yevlakh-Agjabedi depression is a typical example of a fore-arc basin. This is evidenced by the thick volcanic layers of Upper Cretaceous age at Muradkhanly and adjacent fields discovered during drilling.

4) The uplift of the Greater Caucasus as a result of the activity

of Alpine folding hid a significant part of the transition from the SCB to the BCB and the articulated arc, changing the burial regime to flexural and leaving an imprint on the location of sedimentary basins.

The development of the sedimentary cover of the SCB (in accordance with our existing ideas about sedimentation in the SCB and other basins and taking into account many previous studies) can be conditionally divided into several tectonostratigraphic stages, with their inherent characteristics, including oil and gas potential. A description of the development of the earth's crust at stages from the opening of the rift trough to the modern intermountain basin can be assembled into a single model of the basin's evolution.

The author made an attempt to create a model of the evolution of the basin, linking the formation of the basin and the uneven development of the basement with changes in the rates of sedimentation and subsidence of the basin, as well as with the supply of sediments. It should be noted that the supply of precipitation is directly related to mountain building and long-term climate changes.

The author identified 5 tectonostratigraphic stages of the evolution of the SCB according to the analysis of all factors influencing the sedimentation of the sedimentary cover (Fig. 11):

1) the formation of the basin during the Middle Jurassic period in parallel with other basins of the Neo-Tethys margin, most likely with the Greater Caucasus basin;

2) the divergent stage of thermal subsidence, which began in the Jurassic and continued in the Cretaceous, as evidenced by volcanism discovered on the margin of the basin in the ultra-deep Saatli well;

3) the passive stage of thermal attenuation of the basin margin, which lasted a significant period until the formation of the mountain ranges of the North Caucasus as a result of the incipient collision;

4) convergent stage of subduction and sedimentation growth;

5) stage of terrigenous avalanche sedimentation of the PT;

6) stage of avalanche sedimentation of the Pleistocene.

At the first stage, the Neo-Tethys subsided under the North Anatolian block and the formation of a back-arc basin in the SCB and, possibly of Greater Caucasus happened. It was also a deep-sea basin of the Eurasian margin bordered by the Tethys Ocean (Fig. 12).

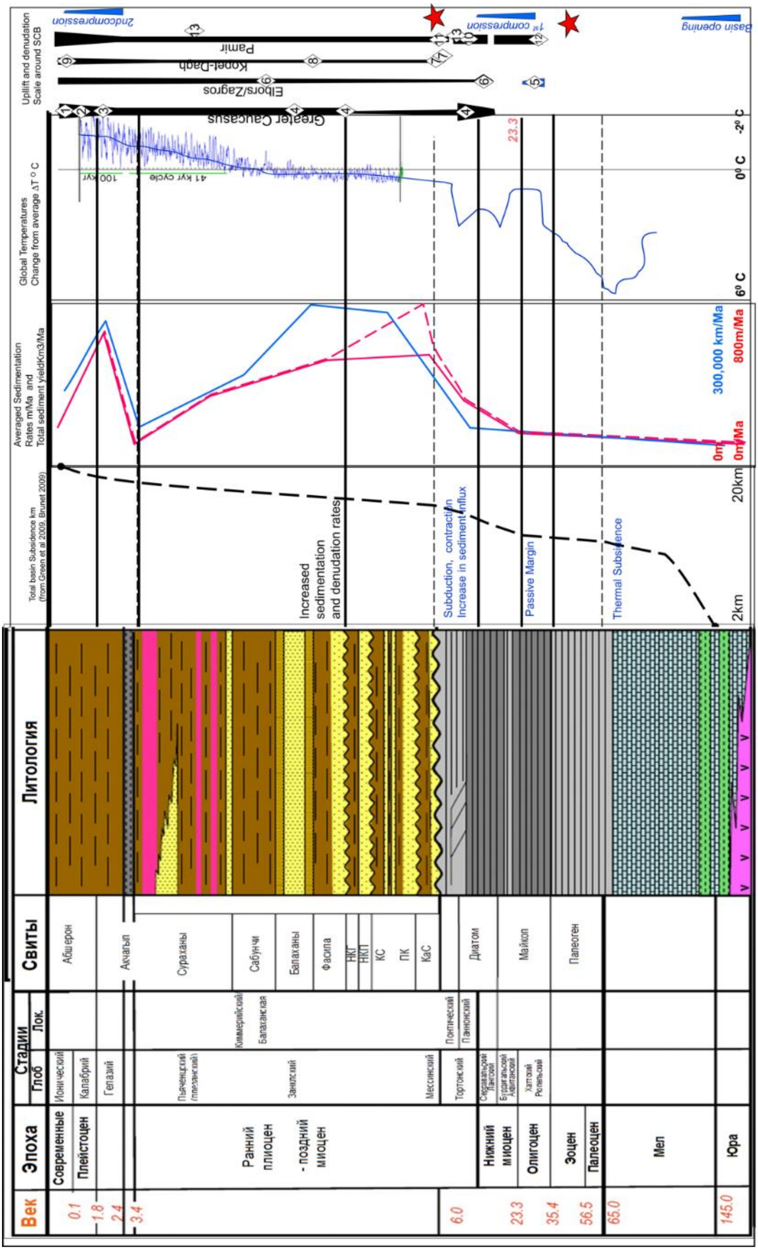

Figure. 11. Tectonostratigraphic stages of development of the SCB basin

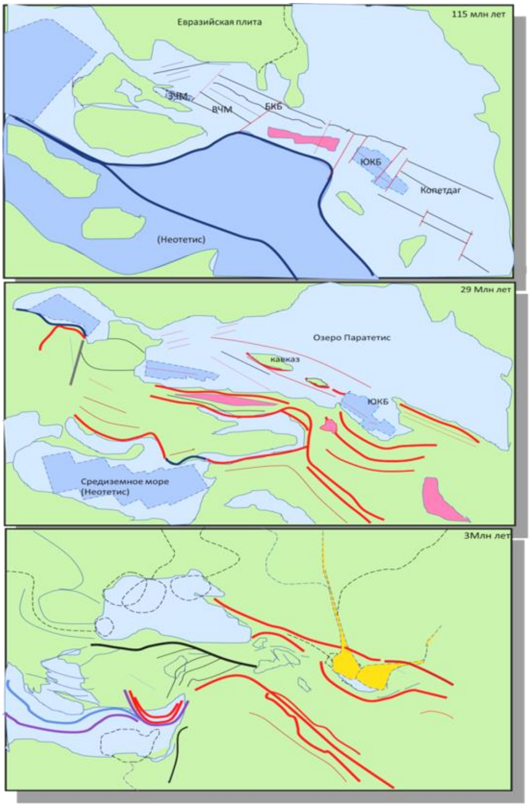

Figure 12. Regional paleogeography in the Aptian (115 million years ago), Maikop periods (29 million years ago) and Pliocene (3 million years ago)

The North Caucasus is an intercontinental tectonic system that was formed as a result of the Neogene inversion of the Paleozoic-Mesozoic back-arc basin due toconvergence of the Afro-Arabian and Eurasian lithospheric plates. The North Caucasus basin extended from the Black Sea to the southern part of the Middle Caspian Sea. To the east of the Middle Caspian there was also a basin filled with Jurassic marine sediments (proto-Kopet Dag). This Greater Caucasus Basin (hereinafter referred to as the Greater Caucasus Basin) was limited to the south by the Trans-Caucasian Massif (TCM), interpreted as the margin of the paleo-island arc margin. The southern edge of this margin was a volcanic belt, which included the volcanic Kurdamir-Saatli uplift. The

Shatsky rise in the Black Sea is an underwater continuation of the western part of the TCM. The eastern continuation of the TCM smoothly flows into the Kura Basin, now mostly covered with flysch sediments and submerged under the thrust faults of the Caucasus Mountains. Some part of this continuation reaches the Talysh Mountains. A thick layer of sediments, more than 10 kilometers of terrigenous and volcanic sediments of the Middle Eocene, are exposed in the Talysh Mountains of Azerbaijan. Here, the volcanic basalts pass to the east into turbidite flows directed to the southeast, to the southern part of the SCB. Actually, the same Eocene age can be given to the Yevlakh-Agjabedi Depression (EAD), located between the Talysh Mountains and the Saatli Uplift. Alternatively, the EAD could even have formed earlier, for example, during the Jurassic period. The EAD basin was, by its nature, possibly a back-arc island margin or a forearc basin.

The paleoceanic allochthon of the ophiolite belt was a single obduced element that developed in Mesozoic time. The oceanic crust is unconformably overlain by a volcanic-sedimentary suite of oceanic arc lava flows interspersed with deep-sea sediments of abyssal basins. Isotopic and geochemical data confirm the alkaline and, accordingly, arc-volcanic nature of the lavas. Several obductions of oceanic crust to the paleo-margins of the Mesozoic Tethys are recorded in 1) the Aptian-Cenomanian ophiolite complex of the Ipek Nappa; 2) Aptian-Cenomanian ophiolites; and 3) Coniacian-Santonian ophiolite olisostromes of the Sevan Mountains.

At the beginning of the Mesozoic, the oceanic basin separating the Arabian plate from the Anatolian-Iranian platform began to gradually narrow. According to the reconstructions of many researchers, at this time only the Iranian massif was separated from Gondwana, then it migrated to the North and at the end of the Triassic collided with the Eurasian continent (Cimmerean episode). The Tauride Anatolian massif separated from Gondwana later, somewhere at the end of the Jurassic period. The formation of Neo-Tethys occurred around this time in the middle or late Mesozoic. The northern displacement of the Tauride-Anatolian massif caused its gradual transition to the Pontic-Trans-Caucasus-Iranian active continental margin, while narrowing the Tethys and turning it into a back-arc margin basin and forming a suture belt between the Tauride-Anatolian and Iranian massifs. To the north of the suture belt, a series of basins are formed: Pannonian, East Black Sea, Western Black Sea, Greater Caucasus, Kurinsky, SCB and Kopetdag. During all this time the volcanism continued in the arc regions, and it especially intensified in the Eocene.

All tectonic zones of the Caucasus are located north of the ophiolite suture zone. During the Eocene period, rifting stopped in all back-arc basins, such as the SCB, BKB, and Kura basins, including the Yevlakh-Agjabedi depression. It is also necessary to note the gradual isolation of water bodies of back-arc basins, which led first to the formation of Paratethys (Fig. 12) - a practically isolated water area occupying the territory from Austria to the Caspian region, and in the Pliocene - to the complete isolation and drying of the Caspian Sea with the formation of the Caucasus Mountains and filling the SCB with PT sediments.

Chapter V. New data on the age and sources of sediment transport of the productive Pliocene strata, necessary for constructing the SCB evolution model.

Description of the main key moments of evolution and sedimentation in the SCB is impossible without new methods for determining the absolute age of the basin. Advances in the absolute dating of rocks using various radiometric methods have made it possible to use these methods to more accurately model the age of the basin. It was also possible to show how accurate is the measurement of the absolute age of a basin affects sedimentation.

The work provides a more accurate description of the absolute age of the rocks of the productive strata of the SCB. There are many methods for determining the duration of different geochronological units, the most basic of which are the so-called radiogeochronological methods (they are also called “radiological”). These methods make it possible to determine the absolute age of rocks with some errors. To establish the absolute age of rocks the various radioactive elements with long half-lives amounting to millions or even billions of years are used.

The most commonly used method is the uranium-lead (Pb/U). This method is based on the process of radioactive decay of uranium isotopes 235U, 238U, 232Th into lead isotopes. The uranium-lead method is the most reliable and is used to determine the age of ancient rocks of millions of years. Most often, for dating by the uranium-lead method, zircon crystals (ZrSiO4) are used, which is characterized by high strength, resistance to chemical influences and a high closing temperature - more than 950-1000°C.

The second method used in the work was the helium method (He-Sm/Th), based on the accumulation of helium during the decay of uranium and thorium in apatite minerals.

The third method used in this work to date Maikop and Miocene source rocks is the recently introduced rhenium-osmium (Re/Os) method, which is most suitable for dating clays with a high content of organic matter material.

The fourth method, the results of which are used in the time model developed by the author, is the argon-argon method, which began to be used in the mid-1960s. Practical achievements are now associated precisely with the argon-argon method, which successfully makes it possible to date volcanic ash and is widely used in world practice.

The methods for calculating the age of the SCB on outcrops of the Gyrmakinskaya Valley were the uranium-lead dating method (U/Pb) on zircon detrital grains and helium dating (He-Sm/Th) on apatite grains. The apatite and zircon grains were found as a result of the geological material selection in Pliocene outcrops of productive strata in the Gyrmakinskaya and Yasamal valleys. As it is known, most of the clastic material in these outcrops was brought in the Pliocene by the Paleo-Volga, or from the Greater Caucasus. More than 1,300 apatite and zircon grains were found from more than 100 selected samples and analyzed by the author and a team of co-authors. Of these 1300 grains, most of them have a crystallization age assigned to their origin in the Proterozoic period on the East European Platform, and the provenance of sedimentary rocks from the East European Platform to the SCB has been confirmed. The rest of the rocks, according to these crystallization ages, have been sourcedfrom the Caucasus Range. The work established that the relative contribution of precipitation from the East European Platform did not exceed 60% at maximum values and 30% at minimum values.

In addition, about 100 zircon grains were discovered in which the crystallization age did not exceed 5 million years. Some apatite grains were of the same young age. The region where sediments were removed in the Precambrian East European Platform clearly could not have such a late age of crystallization. The late age of crystallization of these grains is most likely associated with emissions from the Lesser Caucasus and Talysh Mountains volcanoes, which were active at that time.

New data on the age of the Pliocene PT strata allowed us to create a more accurate time scale with some variations or scenarios (Fig. 13). All scenarios show that sedimentation rates during this period were significantly greater than previously predicted. The rate of deposition of the Pliocene PT ranged from 1.3 km per million years on the sides of the SCB to 3.9 km per million years in the center of the SCB basin.

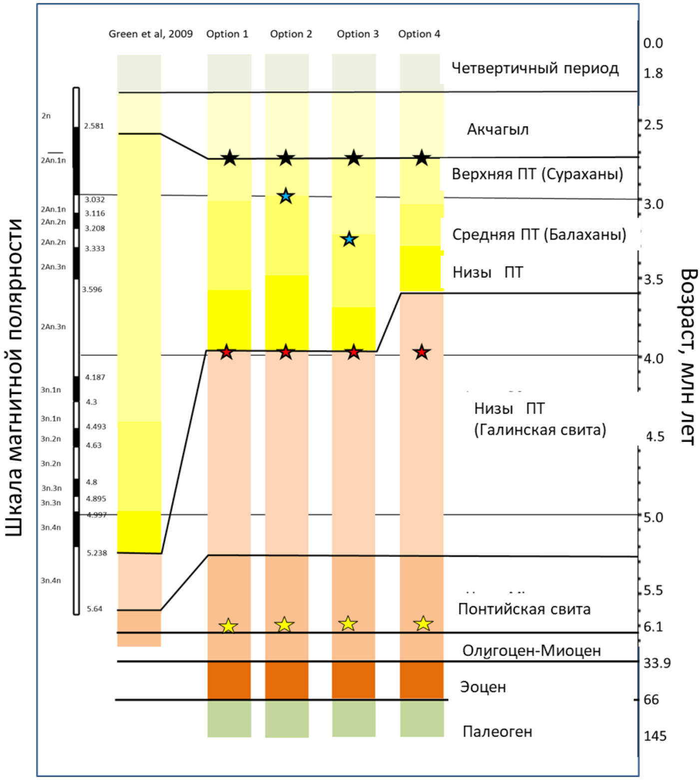

Figure. 13 Various scenarios for the age range of the SCB, studied in this work by absolute age calculation methods (black color - Ar/Ar-th, blue color - He-Sm/Th-th, red color - U/Pb-th, yellow color - Re/ OS methods)

Figure 13 shows four possible time ranges for Pliocene PT deposition in the SCB and compares them with the time range from the author's previous studies, which was used up until our latest thermochronological measurements. The four-time scales in Fig. 13 are given along with radiometric dates indicated by asterisks of different colors.

The paleomagnetostratigraphy of PT outcrops in the Gyrmakinskaya and Yasamal valleys was also studied. With its help, the end of the process of deposition of the Pliocene PT was determined. Using argon-argon 40Ar/39Ar analysis of ash at the top of the SCB, a date of 2.71 ± 0.02 Ma was obtained, which coincides with the results of studying the isotope stage (MIS) of G6.

Four scenarios for the Pliocene PT time range are given below:

1. In scenario 1, the result of uranium-lead U/Pb analysis of zircon grains is used, which clarifies the age of the Podgyrmakinsky PK formation no older than 4.0 million years ago.

2. Scenario 2 also uses the result of uranium-lead U/Pb analysis of zircon grains for the Podgyrmakinsky PK formation - up to 4.0 million years ago, while adding the result of the uranium-helium analysis of the Surakhan formation in the Yasamal valley, which dates the age of the Surakhan formation at 2.9 million years ago.

3. Scenario 3 also uses the result of uranium-lead U/Pb analysis of zircon grains for the Podgyrmakinsky formation PK - up to 4.0 million years ago but adds the result of uranium-helium analysis of the Surakhan formation in the Yasamal valley and gives it an age of 3.3 million years ago (the difference between scenarios 2 and 3 is due to inconsistencies in calculating the average age).

4. Scenario 4 includes the global magnetostratigraphic scale and compares the results of paleomagnetostratigraphic surveys on outcrops with the result of uranium-lead U/Pb analysis of zircon grains for the Podgyrmakinsky PC formation. A comprehensive analysis shows that the Podgyrmakinsky PC formation is younger than 4.0 million and begins with chron 2An.3n (3.596 million years ago).

Figure 13 shows different age range scenarios along with the magnetostratigraphic scale. Most of these scenarios significantly increase sedimentation rates in the PT compared to the author's previous studies.

Table 1 shows the temporal pattern, distribution of measured ages, and distribution of time intervals in the SCB, indicating methods for determining absolute ages. The magnetic scale and cyclicity are used to distribute ages that do not have absolute values.

Table 1

Distribution of measured ages and stratigraphic intervals in the SCB, indicating radiometric methods for determining absolute age

	Сейсмические поверхности интерпретированные в работе	Возраст, миллион лет	Средняя глубина в центре ЮКБ (без водного	Мощност	Временной интервал миллион ле	Скорсть осадконакопле ния км за млн лет	Место привязки к возрасту	Методы определения абсолютного возраста
Голоцен	Новокаспийская	0.00	0	250	0.15	1.67	Абшерон	Ar/Ar
Плейстоцен	Мангышлакская свита	0.15	250	250	0.15	1.67	Абшерон	Ar/Ar
	Хвалынская свита	0.30	500	250	0.15	1.67	Абшерон	Ar/Ar
	Хазарская свита	0.45	750	250	0.15	1.67		
	Бакинская свита	0.60	1000	250	0.15	1.67		
	Тюрканская свита	0.75	1250	250	0.15	1.67		
	Абшеронская свита (Верхняя)	0.90	1500	250	0.15	1.67		
	Абшеронская свита (Верхняя)	1.05	1750	250	0.15	1.67		
	Абшеронская свита (Средняя)	1.20	2000	250	0.15	1.67		
	Абшеронская свита (Средняя)	1.35	2250	250	0.15	1.67		
	Абшеронская свита (Средняя)	1.50	2500	250	0.15	1.67		
	Абшеронская свита (Нижняя)	1.65	2750	250	0.15	1.67		
	Акчагыльская свита (Нижняя)	1.80	3000	100	0.91	0.11	скважины	Ar/Ar
Плиоцен	**Кровля Продуктивной толщи**	**2.71**	**3250**	550	**0.08**	7.24	скважины	Ar/Ar
	Верха ангидритного горизонта	2.79	3800	1200	0.07	16.22		
	Средне сураханская свита	2.86	5000	500	0.07	6.76		
	Нижне сураханская свита	2.93	5500	500	0.07	6.76		
	Сабунчинская свита	3.01	6000	250	0.07	3.38		
	Балаханская свита	3.08	6250	200	0.07	2.70		
	Балаханы VIII	3.16	6450	100	0.07	1.35		
	Балаханы X	3.23	6550	200	0.07	2.70		
	Свита Перерыва	3.30	6750	200	0.07	2.70		
	НКГ	3.38	6950	100	0.07	1.35		
	НКП	3.45	7050	300	0.07	4.05		
	КС	3.53	7350	150	0.07	2.03		
	ПК	**3.60**	**7500**	**250**	**0.80**	**0.31**	Гырмакинская д	U/Pb
	Галинская свита	4.40	7750	300	0.98	0.31	Керн	U/Pb
Миоцен	Низы ПТ	5.38	8050	200	0.74	0.27	Локбатан	Ar/Ar
	Миоцен - Понтийский	6.12	8250	750	1.28	0.59	Локбатан	Ar/Ar
	Диатомовая свита (paper shale)	7.40	9000	500	9.80	0.05	Исламдаг	Re/Os
	Верхний Майкоп (Вебер С)	17.20	9500	250	12.90	0.02	Исламдаг	Re/Os
Олигоцен	(Соленовиан-Хадум)	30.10	9750	250	3.80	0.07	Исламдаг	Re/Os
Эоцен	(Средний Коун) - Перикешк	33.90	10000	1000	31.10	0.03	Перикешкюль	Re/Os
Палеоцен	Илхидагская Сумгаитская	56.00	11000	4000	89.00	0.04	Перикешкюль	
Мел	Меловой период	65	15000	3000	80.00	0.04		
Юра	Фундамент - Верхняя Юра	145	18000					

The modern task of geochronology is to calibrate absolute dates on a stratigraphic time scale with an accuracy of 1%. The author's research is close to a similar result, although in some methods the errors are still high. Over time, the geochronological methods are increasingly replacing biostratigraphic methods of age determination. It is necessary to fully study all intervals of the sedimentary layer of the SCB on land and in the basin's waters, paying special attention to the productive stratum of the Pliocene, Oligo-Miocene and Eocene rocks.

Chapter VI. Features of the properties of clays and sandstones of the productive stratum of the SCB.

When modeling subsidence and calculating sediment volume, an important parameter is the change in porosity with depth. For any basin analysis, knowledge of the lithological characteristics of sediment compaction is one of the most key modeling parameters.

When modeling, it is necessary to take into account the constant effect of sediment compaction with depth due to a decrease in porosity. The lithology of the PT SCB is mainly binary - the section consists of clays and sandstones. Figure 14 shows the distribution of porosity with depth across wells in the SCB along with compaction curves. These compaction curves, modified from the works of L. Buryakovsky, show a fairly good correlation with porosity values from log and core data for key wells in the SCB water area. Despite significant changes in clay content and sandstone types in the basin, the four curves accurately reflect the process of change in porosity with depth. The curves of changes in porosity with depth were used by the author both to reconstruct the section and to calculate the thickness of the rocks. The relationship of porosity ϕ to the immersion depth (D, in meters), the geological age of sediments (A in million years) and lithology (the ratio of clay thicknesses to the general ratio of terrigenous sediments R) was modified from the works[3]

Φ= ϕ0*exp [-0.014(13.3 logA-83.25logR+2.79)*10-3D,

where ϕ0 is the initial porosity of clay sediments (usually about 60%). The average static value of R=0.6 fits best with most Pliocene porosity curves (A=4 Ma) obtained from log data (Fig. 14). The rocks composing the basin are mainly represented by clays and mudstones, where the pelitic fraction of rocks with grain sizes less than 0.01 mm makes up almost 70% of the sediment mass, and sandy sediments make up no more than 1.5%. Despite significant anomalous pressures in clays, porosity still decreases with depth, changing from 20%-30% at a depth of 2 km to 3-15% at a depth of 12-15 km, leveling the effect

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[3] Buryakovksiy L. Petroleum Geology of the South Caspian Basin / Buryakovskiy L, Chilingar J, Aminzade F // 2001 Gulf Professional Publishing Copyright, Butterworth–Heinemann, -464 pgs 2001 ISBN 0-88415-342-8

of high pressure. These curves were used in a model to calculate sediment mass without taking into account porosity throughout the SCB basin, correcting for different regions and lithologies.

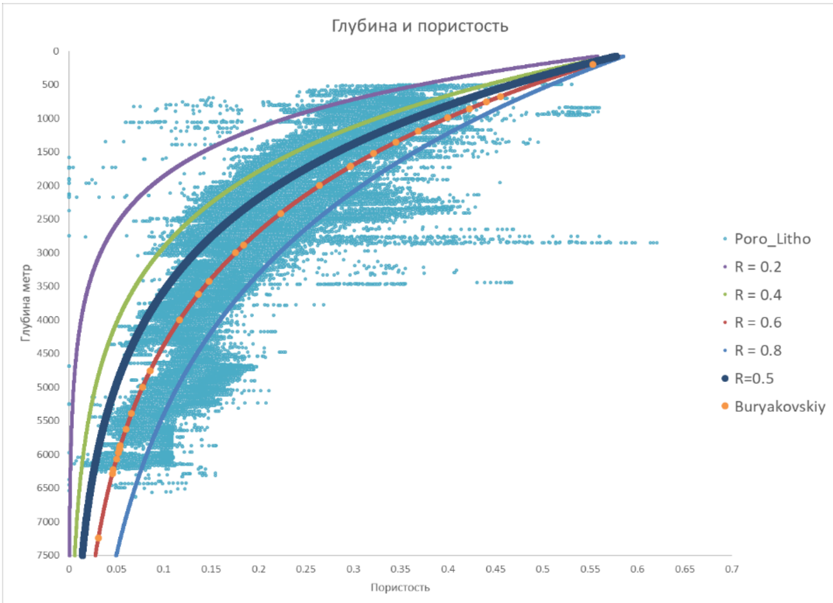

Figure. 14. Graph of changes in porosity and sediment compaction with depth across the basin. Log data is covered by compaction curves. The best correlation is at R=0.5.

Chapter VII. Calculation of precipitation volume and sedimentation rates of the SCB for river systems included in the basin.

Calculating the volume of precipitation in basins is an important part of basin analysis. The quantitative assessment of the main parameters of the sedimentary cover and the patterns in its evolution is very important for understanding all aspects of the development of basins, including their hydrocarbon systems.

The work calculated the volume of precipitation in the basin since its formation, as well as calculated the denudation of river systems in the geographic region surrounding the SCB. The volume of accumulated sediments in the SCB was calculated for 30 seismic intervals individually, and then recalculated for 8 grouped time intervals, taking into account decompaction and different time models given in chapter two. The precipitation volumes and sedimentation rates in the SCB are presented for eight time intervals (Fig. 15):

- 145-36 million years – Mesozoic and Paleogene, 0.04 km/million. years
- 36-6 million years – Oligocene and Miocene, 0.15 km/million. years
- 6-3.6 million years – lower part of the PT, 2.3-5 km/million. years
- 3.6-3.0 million years – middle part of the PT, 4.8 km/million. years
- 3.0-2.7 million years – upper part of the PT, 2.3 km/million. years
- 2.7-1.8 million years – Akchagyl formation, 0.03 km/million. years
- 1.8-0.9 million years – Absheron formation, 0.7 km/million. years
- 0.9-0 million years – Quaternary, 0.34 km/million. years

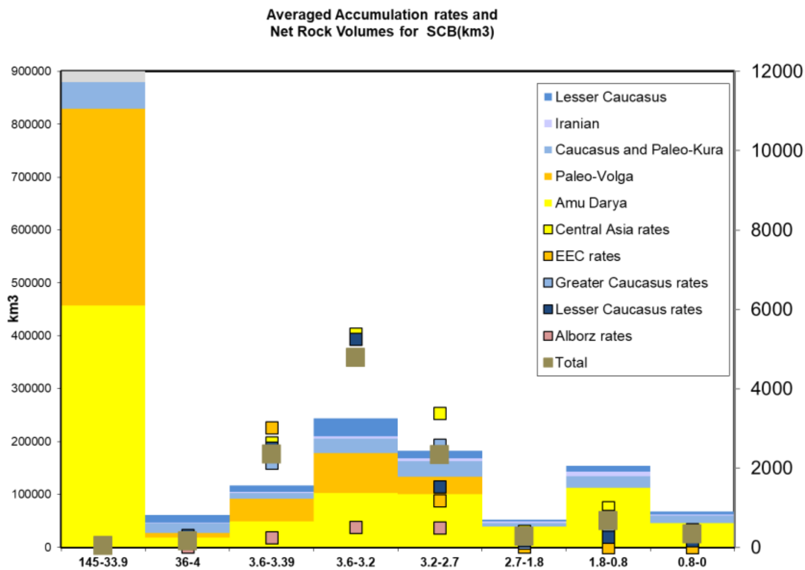

Figure. 15. Sedimentation rates in the SCB.

The author also divided the sedimentary cover of the SCB into regions of demolition using paleogeographic maps of the main stratigraphic units. An assessment of the volume of precipitation was carried out for each of the main river systems that supplied the SCB with precipitation. The distribution of changes in the effective volume of rocks in the SCB over time as a percentage of the total value indicates a gradual decrease in the influence of the Paleo-Volga and an increase in the influence of the Paleo-Amu Darya on the overall sedimentation in the SCB (Fig. 16). It was noted that the influx of sediments from the Amu Darya was always quite significant and completely dominated the volume of Pleistocene sediments.

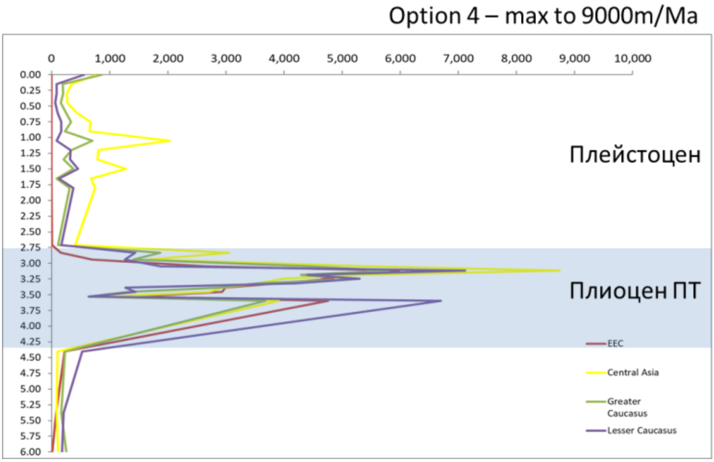

Figure 16. Instantaneous sedimentation rates in the SCB, measured in the model according to age scenario 4 (see Fig. 14)

The rate of effective sedimentation obtained as a result of the calculation is averaged and generalized, since the author uses the effective thickness of rocks averaged over intervals. During the analysis, the productive thickness of the PT is divided into 3 intervals, for which the velocities are averaged: lower interval, upper and middle. For shorter time intervals obtained from seismic mapping between wells, the rate of effective sedimentation increases significantly. The rate of avalanche sedimentation in the SCB could reach more than 9000 m/million years in a certain period of time in the Surakhani formation of the PT, brought by sediments of the Paleo-Amu Darya. These sedimentation rates are among the highest in the world for basins of this type (Fig. 16).

The work also notes that such an increase in the rate of sedimentation of PT is associated with global climate change over the past

2-4 million years and a widespread increase in sedimentation rates around the world and in the Eurasian basins, in particular. In addition, it is shown that a very large area of northern Eurasia, including Central Asia and even Western Siberia, was eroded into the SCB during the Pliocene period due to the fall of the Caspian Sea level and integration.

Chapter VIII. Comparative analysis of the world's basins.

Comparative analysis of basins is a series of comparisons of similarities and differences, considering the dynamics and nature of the basins. Comparing the world's basins according to various parameters makes it possible to create the patterns of their development, understand their structure and categorize their hydrocarbon potential.

The work compares the world's basins, including the SCB, and provides a description of the evolution of the Earth's sedimentary shell. The total contribution of sedimentary material to the structure of the crust does not exceed 8% of its total mass, but the sedimentary cover is extremely diverse. The sedimentary shell or "stratisphere" is one of the most important components of the Earth, with which the oceans, atmosphere, and biosphere are closely connected, which directly feeds and is nourished from the sedimentary shell. The sediments (a third of which are carbonate) occupy more than 64% of the Earth's area. In studying the volume of the Earth's sedimentary cover, much has been done by scientists such as A. Ronov, V. Khain, F. Kunen and others. These authors' data, together with the latest global rainfall data from different basins, were used to update the quantification of sediment volumes. The main source for constructing maps of sediment thickness, the thickness of the consolidated crust and lithosphere is the resource of Gabi Laske from the Institute of Geophysics and Planetary Physics UCSD[4], containing a map of precipitation thickness shown in Fig. 17, and the online resource Earthbyte (https://www.earthbyte.org/), which contains data on the power of individual basins around the world.

The total volume of sedimentary shell rocks, according to our

[4] Laske G.A. A global digital map of sediment thickness. University of California Sand Diego. Institute of Geophysics and Planetary Physics, USA, https: // igppweb.ucsed.edu/~gabi/sediment.html

measurements, is almost 10,000 million km3, which corresponds to about 11% of the planet's volume, and the average thickness of the stratosphere is 2.2 km, which coincides with the studies of A. Ronov and others.

The SCB, out of more than 1000 basins in the world, stands out for the largest maximum (26 km) and average (13 km) thickness of the sedimentary cover. Close to the SCB and equally anomalous in thickness are the Caspian basin, the Eastern Mediterranean, including the Nile delta, and the Black Sea basins. The basins containing the largest volumes of sediments include the Bengal fan, Gulf of Mexico, Arctic basins, and the Caspian basin. SCB is in 60th place in terms of precipitation volume. The anomaly of three Eurasian basins containing such thick sediments is explained both by their thinned crust and the large thickness of the lithosphere, and by their proximity to sources of sedimentation. For basins of passive margins, the work derives the relationship between the thickness of sediments and the lithosphere. It has been shown that about 20% of the world's basins contain approximately 80% of the total volume of sediment on the planet. The dependence curves of the thicknesses and volumes of the basins of the world indicate the exceptional importance of the SCB in relation to other sedimentary basins of the world and a certain dependence of the sediment thicknesses of the basins on the volume of sediments and on the thickness of the lithosphere.

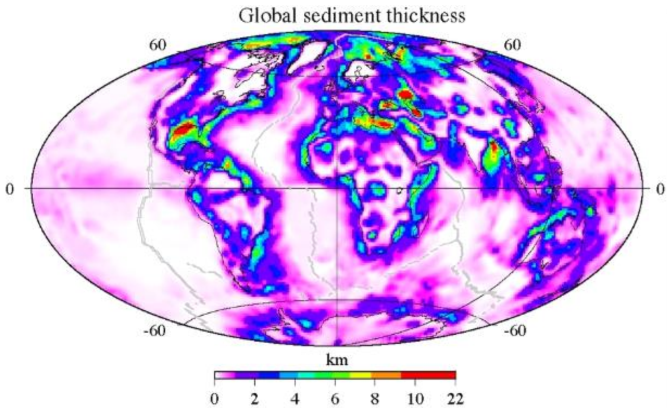

Figure. 17. Map of the thickness of the Earth's sedimentary shell, illustrating the main sedimentary basins of the world (source - Earthbyte: earthbyte.org/Resources)

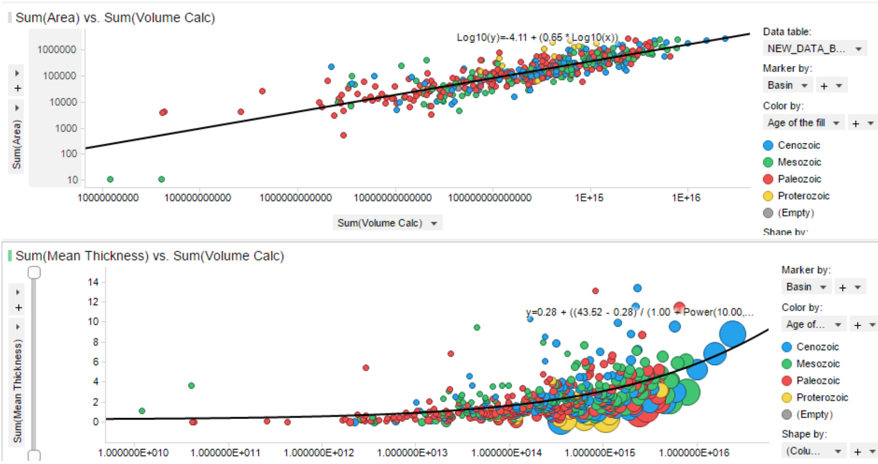

Figure. 18. Dependence of areas and thicknesses on the volumes of sedimentary basins of the Earth's sedimentary shell.

The dependencies clearly reflect the special position of the SCB basin as a basin with the thickest sedimentary cover in the world (Earthbyte). The author studied the capacity parameters of more than 1000 sedimentation basins in the world. A relationship was revealed between the sedimentary thickness of the basin, the area and volume of precipitation in these basins (Fig. 18). The sediments deposited on oceanic crust were excluded from measurements because they are not considered to be located in sedimentary basins. Most sedimentary basins are located on passive margins, active and rift margins, in cretonne depressions or aulacogens. Most precipitation is found in Eurasia (almost 50%), followed by North America, Africa, South America, Australia (Fig. 17). Most of the sediments found in the Phanerozoic were primarily clays and were distributed equally throughout the Paleozoic, Mesozoic, and Cretaceous. Passive margins and their basins contain more than 40% sediment. A clear relationship between the volumes and area of the pools is well described by two logarithmic functions shown below and in Fig. 18:

(1) Area (X) and Volume (X): Log10(y)= 4.11+(0.65*Log10 (x)) R2=0.75

(2) Average Power (Y) and Volume (X): Y=0.28+((43.54-0.28)/1.00-100.32*(18.55-Log10(x)))

The clear relationship is especially evident in passive margins, which contain more than 40% of the world's rock volumes, because in these basins there is a direct linear relationship between the thickness of sedimentary rocks in the basin and their geographic distribution. These basins have a relatively smooth transition zone between the basin margins and the depositional center and are generally not delimited by strong faults across which the thickness of the sedimentary layer sharply changes.

Chapter IX. Oil and gas potential of the world's basins according to some statistical parameters.

The paper discusses the oil and gas potential of the SCB and proposes a new methodology for assessing, classifying, and zoning the basin. A categorization of the oil and gas potential of the regions and time intervals of the SCB is proposed based on a comprehensive analysis of sedimentation, the volume of river systems and the depth of reservoirs. The work also provides a selection of regions that are most favorable for oil and gas accumulation, within which prospecting and exploration work should be concentrated in the future. A comparison is made between the basins of the world and the SCB in connection with their oil and gas potential. An analysis of the process of oil and gas formation in the SCB is made based on thermal stress maps on the surface of Oligo-Miocene oil and gas source rocks (Fig. 19).

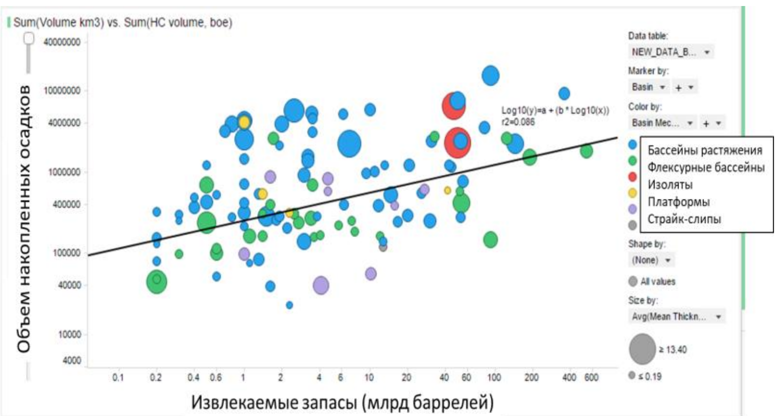

Figure. 19. Dependence of recoverable reserves on sediment volume

Table 2

Volume of oil and gas reserves in 500 major sedimentary basins of the world according to USGS

Количество бассейнов	Запасы млрд баррель	% бассейнов	% запасов от общего
10	1744	2%	56%
20	2213	4%	71%
25	2360	5%	75%
30	2462	6%	79%
35	2541	7%	81%
50	2716	10%	87%
100	2960	20%	95%
200	3095	40%	99%
500	3131	100%	100%

The work derives the relationship between the volume of sediment in the basins and the recoverable reserves of the basin. Recoverable reserves of the world's basins are obtained from USGS data[5] (Figure 20). These data show that a logarithmic relationship between precipitation and oil and gas recoverable reserves in all types of basins around the world can be fairly easily derived. This will make it possible to apply a similar dependence to other, yet unexplored basins of the world, if they have oil and gas systems.

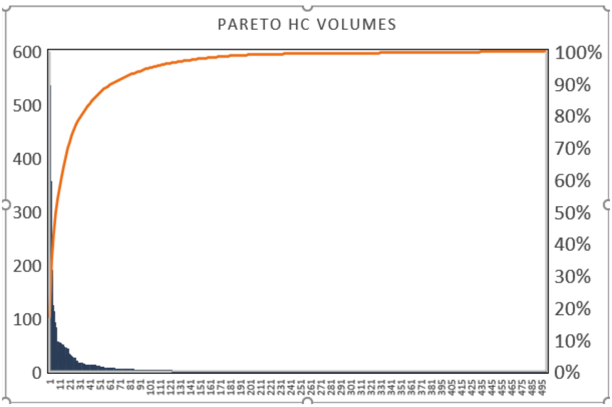

Figure. 20. Pareto distribution over 500 basic oil and gas basins of the world according to USGS data

[5] Klett, T.R., Ahlbrandt, T.S., Schmoker, J.W. and Dolton, G.L., Ranking of the world's oil and gas provinces by known petroleum volumes. U.S. Geological Survey Open File Report, - 1997. - p. 97-463.

It is also noted that reserves in the world's basins are measured according to the Pareto power law or the 80/20 rule (Fig. 20). Thus, 5% (25 basins) of all hydrocarbon-containing basins in the world account for 75% of hydrocarbon reserves, and the remaining 475 basins account for 25% of these reserves. SCB is included in the top 5% of leading basins and ranks 15th.

Chapter X Oil and gas potential of the SCB and promising directions for prospecting and exploration in the basin.

The South Caspian Basin (SCB) has been an oil province of global importance since the 19th century. The offshore exploration has led to the discovery of such giant gas condensate fields as Shah Deniz and Absheron, which confirms the presence of the giant oil and gas system.

The SCB and its neighboring basins (Middle Kura, Yevlakh-Agjabedi Depression, Verkhne-Kura) represent a completely unique basin, characterized by a large thickness of sediments, favorable tectonic and lithological-facial conditions, which determine high oil and gas potential. The oil and gas bearing systems of the Southern Caspian are unusual due to their rapid sedimentation, since rapid and uneven filling determines the dynamism of the SCS system and the generation of hydrocarbons.

The oil and gas source rocks of the SCB are beyond the possibility of drilling due to the significant depth of their occurrence. Oil and gas source rocks of the Maikop and diatomaceous formations are exposed at the edge of the basin or contained in emissions of mud volcanoes, from where information is taken for basin modeling. In the waters of the SCB, the geochemical data from fluids in deposits provides the most valuable information about the properties of source rocks beneath deposits that are tens of kilometers away from analogues fields. This is especially important in light of recent studies that have revealed a significant degree of geographic variability and quality of these source rocks[6]. In the work, the author discusses the geological

[6] Johnson, C.L., Hudson, S.M., Rowe, H.D. and Efendiyeva, M. A., Geochemical constraints on the Palaeocene-Miocene evolution of eastern Azerbaijan, with implications for the South Caspian Basin and eastern Paratethys. Basin Research, - vol. 22 (5), - 2010. - p. 733-750.

age of the Maikop deposits in the basin and notes that the beginning of the formation of the Paratethys basin coincides with the Eocene-Miocene boundary, where normal marine conditions with clays saturated with calcium were replaced by fresher stratified waters. Maikop and diatom layers are very plastic and have been subjected to significant pressure over the past 5 million years at depths exceeding 10 km, thereby preventing the normal displacement of fluids, and creating significant overpressure.

The stratigraphy of source rocks in the deep-water and submerged parts of the South Caspian Basin is unclear. Previous stratigraphic studies on the margins of the Kura Basin are described. According to paleogeographic maps, it is believed that the central part of the South Caspian basin consists of thicker layers deposited under anoxic conditions, while the layers of the Maikop Formation, located closer to the Greater Caucasus, contain a large admixture of clastic sediments from the source sediments. The work includes Re-Os geochronological data obtained from analyzes of samples of Maikop sediments. Re-Os geochronology is a relatively new method, first used to obtain the absolute age of source rocks.

A team of authors, among whom was the author of this work, conducted research on the deepest part of the Absheron oil and gas zone of the SCB, where the Shah Deniz field is located. Diamondoids, the most thermally stable group of hydrocarbons, were found in high concentrations (up to 160 ppm 3- + 4-methyldiamantanes) in condensate from the giant Shah Deniz field. Both the isotopic composition of the gas (δ13C1 - δ13C3) and the concentrations of diamondoids indicate the source rock presence with a high level of thermal maturity (1.5-2.0 Ro equivalent), which is due to the very low geothermal gradients of the South Caspian basin (16-17° C/km on Shah Deniz) and rapid subsidence of the basin.

As a result of modeling and analysis of the results, it was concluded that the source rocks should be buried at depths exceeding 13 km in the Shah Deniz drainage area (Fig. 21). Of the rich oil and gas producing basins in the world, only in the deepwater Gulf of Mexico are source rocks efficient and actively generating hydrocarbons at such depths. We estimate that as a result of thermal cracking, approximately

5.5 billion barrels of oil (1 billion cu. tons) were converted into 12 trillion cubic feet of gas in the Shah Deniz region (3 billion cu. tons).

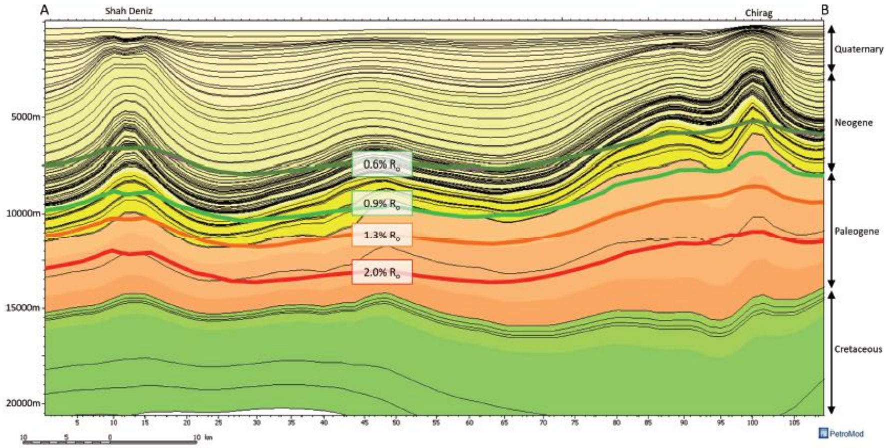

Figure. 21. Regional profile through a 3D model (Petromod package), depicting the stratigraphic breakdown and thermal maturity contours (EASY%Ro).

This indicates that source rocks in this area likely become oil- and gas-producing in marine facies rather than on land. Inverse modeling of volumes show that a significant part of the gas was formed by cracking oil into gas at great depths. The geographic distribution of source rocks of this model into the shallow-water transition zone near the Absheron Peninsula and further into the deep-water basin indicates that there is still significant potential for geological exploration for oil and gas.

Figure. 21. Regional profile through a 3D model (Petromod package), depicting the stratigraphic breakdown and thermal maturity contours (EASY%Ro).

To explain hydrocarbon maturity based on basin fluid analyses, the source rocks in the Shah Deniz field must be at depths greater than 13 kilometers.

Zoning of the SCB and nearby regions according to general geological parameters allows us to identify 15 main oil and gas bearing regions (Fig. 22), in each of which 4 stratigraphic intervals (mega-sequences) are distinguished, which contain the main reservoir systems

- Mesozoic, Paleogene, Pliocene and Pleistocene. The overwhelming volume of hydrocarbons was accumulated in the Pliocene system within the productive strata of the SCB.

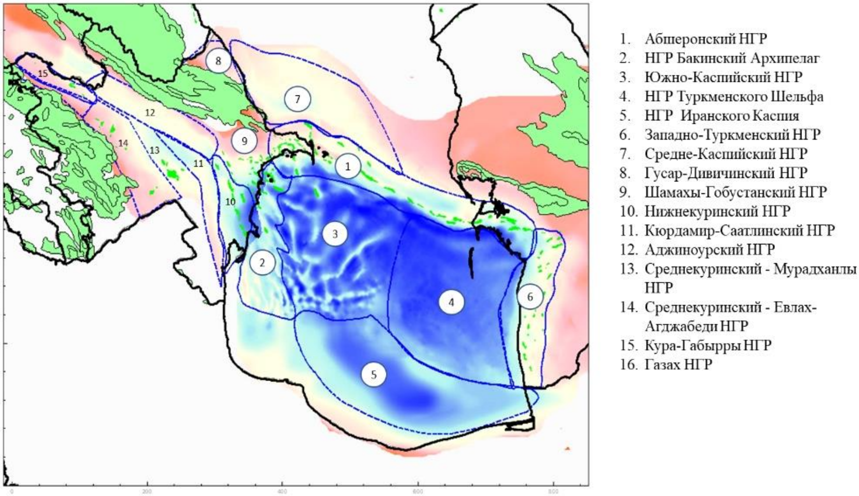

Figure. 22. Map of oil and gas regions (OGR) of the SCB xcluding possible GGRs of the Greater and Lesser Caucasus and Talysh)

The following areas (or NGR) are identified in the waters of the SCB:

1) Absheron GGR (zone of the Absheron archipelago),

2) GGR zone of the Baku Archipelago (Lower Kura Depression),

3) zone of the central part of the waters of the SCB (South Caspian GGR),

4) Turkmen GGR shelf,

5) zone of the Pre-Elburs trough of the SCB (Iranian sector),

6) Western Turkmen oil and gas reserve,

7) Middle Caspian oil and gas region,

8) Gusar-Devechinsky oil and gas reserve,

9) Shamakha-Gobustan oil and gas reserve,

10) Nizhne-Kura oil and gas reserve,

11) Kurdamir-Saatli oil and gas region,

12) Adzhinoursky possible oil and gas region,

13) Middle Kura oil and gas region - zone, including the Yevlakh-Agjabedin depression and the foothills of the Lesser Caucasus,

14) Middle Kura oil and gas region (Yevlakh-Agjabedin depression),

15) Upper Kurinsky or Kura-Gabyrra possible oil and gas region and

16) Possible Gazakh oil and gas region.

The author proposes a new method for comparative analysis of oil and gas potential assessment, which is based on determining the relationship between the geodynamic type of the basin (oceanic or continental), the type and source of sediments (I), the thickness of sediments in meters (M), and the rate of sedimentation in m/million. years (S.O), the density of potential resources (P). Most of the counting parameters are taken from previous chapters of this work. Sediment sources are discussed in Chapter 5, sediment thickness and volume - in Chapter 3. The density of hydrocarbon resources is determined on the basis of reference values of proven reserves in a number of fields.

It is noted that the hydrocarbon potential of the SCB sedimentary section in each of the 4 reservoir systems and in each of the oil and gas zones is distributed unevenly (Table 3). The greatest potential is confined to the Pliocene section of the Pre-Elburs trough, the central part of the SCB, the Turkmen shelf and the northwestern part of the SCB water area. These sections are characterized by a large thickness of sediments, high rates of sedimentation in the Tertiary period and the ubiquitous presence of both source rocks of the Maikop formation and reservoir rocks of the PT formations deposited by the Paleo-Volga. According to forecasts from the works[7], the resource density in the northwestern part of the SCB reaches more than 750 thousand tons per km, which is close to our forecasts. Less promising areas of the section are the southwestern part of the SCB, where sediments of the Kura facies with low-quality reservoirs dominate. Some terrestrial areas of Azerbaijan, devoid of thick sedimentary cover, are unpromising.

The paper presents the maps of thermal stress (according to the intervals mapped in the SCB), compiled from available temperature data based on which the author calculated the hydrocarbon potential of the entire SCB and the volume of hydrocarbons produced (Fig. 23).

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[7] Guliyev, I.S. Hydrocarbons potential of the Caspian region (expert review). / I.S.Guliyev, L.E.Levin, D.L.Fedorov, - Baku: Nafta-Press, - 2003. - 120. p.

These maps are the result of a synthesis of works on the study of the hydrocarbon prospects of the SCB, which were carried out by the author over many years.

The methodology for assessing risks using a point system assigns the following values: more than 100 – for oil and gas exploration with low risks and large volumes of hydrocarbons; values from 10 to 100 – for NGR with average risks; values less than 10 are for NGR with high risks and low potential (Table 3).

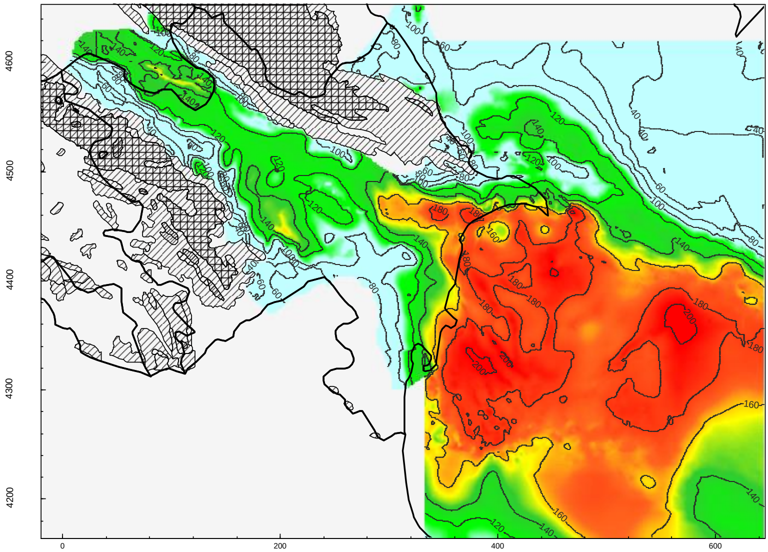

Figure 23. Map of thermal stress for the SCB and adjacent basins

Table 3. Risk assessment table for each NGR in the SCB.

		Мощность					Риски					Запасы			Оценка
НГР	Площадь км	Общая	Мезозой	Палеоген	Плиоцен	Плейстоцен	Мат. Породы	Миграция	Ловушки	Покрышки	Коллектора	Миллиард barrel у.е	Миллиард тон у.е	Изученность	Балл
Иранский сектор ЮКБ	31.0	13.4	3.6	3	3.4	3.4	1	1	1	1	1.0	22	3	1.0	631
Глубоководный ЮКБ	29.9	17.1	3.9	5.1	5.3	2.8	1	1	1	1	1.0	8	1	1.0	594
Абшеронский Архипелаг	20.0	11.8	4	2.4	3.6	1.8	1	1	1	0.95	1.0	27	4	0.5	382
Бакинский Архипелаг	15.0	15.7	3.9	5.3	4.4	2.1	1	1	1	1	0.9	20	3	0.5	306
Туркменский Шельф	34.0	12.7	1.8	2.9	4.5	3.5	1	0.7	0.7	0.9	1.0	0	0	1.0	190
Западно-Туркменский НГР	12.4	9.1	2	0.9	2.8	3.4	1	1	1	0.9	1.0	7	1	0.7	142
Северно Абшеронский НГР	18.8	7.1	2.6	1	2.2	1.3	1	1	0.9	0.9	1.0	0	0	1.0	109
Нижнекуринский НГР	12.1	9.5	4.9	1.4	2.7	0.5	1	1	1	1	0.5	1	0	0.4	33
Среднекуринский НГР YAD	8.7	8.8	5.3	1.1	1.4	1.0	1	1	1	1	0.3	0	0	0.9	18
Гобустанский НГР	2.9	12.1	6.4	2.6	2.6	0.5	1	1	1	1	0.5	0	0	0.4	12
Среднекуринский НГР Mur	5.2	10.1	5.4	0.7	1.6	2.4	1	1	1	1	0.25	0	0	0.8	11
Гусар-Дивичи НГР	3.1	8.9	6.7	0.7	0.1	1.4	1	0.9	1	1	0.4	0	0	0.8	10
Кура-Габырры	9.2	6.9	4.3	0.7	1.1	0.8	0.9	1	1	0.6	0.25	0	0	0.8	7
Аджиноурский ВНГР	7.7	8.6	3.7	1	2.3	1.6	0.9	0.7	1	0.6	0.25	0	0	0.8	5
Кюрдамир-Саатлинский НГР	5.1	9.1	4.8	0.4	1.3	2.6	0.9	1	1	0.9	0.25	0	0	0.5	5
Газахский ВНГР	2.4	4.6	3	0.5	0.4	0.7	0.5	0.7	1	1	0.25	0	0	0.8	1

Conclusions and recommendations

This work reveals a connection between the evolution of the sedimentary cover of the SCB and the patterns of sedimentary filling in other basins of the world. The peculiarities of the sedimentary fill and sedimentation rates of the SCB in comparison with other sedimentary basins have been determined. Based on the latest modeling algorithms, a large amount of modern factual material and a synthesis of previous works, an integrated approach to understanding the process of evolution of the basin is proposed. This approach, called basin analysis, makes it possible to more accurately assess the prospects of various parts of the basin and its place in the hierarchy of basins in the world.

First defended position. An iterative model of the structure and sedimentation of the SCB and adjacent territories is proposed. The modeling results show that the observed nature of subsidence and sedimentation in the basin can be explained by the process of sedimentation load on the thinned oceanic crust with fading thermal subsidence. The modeling confirms the rifting as a possible cause of the formation of the SCB and the presence of oceanic crust, and also delineates the boundaries of a potential rift axis.

Modeling demonstrates that the initial geometry of the basin determines the unevenness of the subsequent filling of the basin with sediments. This geometry, inherited at the time of deposition, is determined by the type, thickness of crust, beta value and volume of sediments filling the basin after rifting.

The SCB evolution model includes a synthesis of the results of the lithosphere subsidence modeling, the initial geometry of the basin at the time of its formation, the volume and denudation of sediments along river systems. The climatic fluctuations played a major role in the supply of precipitation to the SCB, causing changes in water flow and the supply of sediment to the basin from various river systems flowing into the SCB. The drainage of these hydraulic systems depended on the denudation rate of basins and mountain ranges.

As a result of the evolution of the lithosphere and sedimentary cover, a unique oil and gas basin was formed, the development of the sedimentary layer in which can be divided into 5 main stages:

1) rifting (Mesozoic, duration 150-65 million years);

2) thermal subsidence of the passive margin (duration 65-34 million years);

3) subduction and deposition of source rocks (Oligocene - Miocene, duration 34-6 million years);

4) avalanche terrigenous sedimentation and deposition of PT reservoirs (duration 6-2.5 million years);

5) compression, formation of folds and migration of hydrocarbons into traps (Upper Pliocene and Pleistocene, duration 2.5 million years - 0).

Second defended position. A quantitative assessment of the volume of sediments, their thickness, age and sedimentation rates of the SCB was carried out. The work calculates the volume of sediments that filled the SCB during its evolution. The bulk of sediments accumulated in the basin from the Oligocene to the present day, and the average sedimentation rates during this period ranged from 500 to 600 m/million. years. The rate of sedimentation reaches its maximum in the PT. The volume of precipitation accumulated in the SCB over the entire existence of the basin is more than 775,000 km3. The figures show that the SCB is the second basin after the Bay of Bengal in terms of sediment volume during the Pliocene and the first in sedimentation rate.

In order to more accurately calculate the change in sedimentation rates in the basin, the absolute age of the rocks of the Pliocene productive strata (PT) was measured in detail using various geochronological methods and it was shown that the PT was deposited from 4 million years to 2.7 million years, and not from 6 million years up to 3.2 million years, as previously thought. Four time scale scenarios show several variations in sedimentation rates, the most radical of which exceeds 9 km per 1 million years.

For the first time in the SCB, precipitation volumes were calculated for river systems separately. The sediments from two river basins, the Paleo-Volga and Paleo-Amu Darya, played the greatest role in filling the SCB. They filled the pool unevenly in time and space. In the lower part of the PT, sediments of the Paleo-Volga prevailed, and in the upper part and in the Pleistocene, the sediments of the Paleo-Amu Darya prevailed, which created a powerful progradational delta in the SCB. Paleo-Volga sediments migrated north and their input decreased sharply in the Pleistocene. In the Pliocene and Pleistocene, sediments from the Paleo-Amu Darya and sediments from the Caucasus Mountains prevailed. Sediment brought from the mountain systems of Iran played a lesser role.

The volume of sediments deposited in the South Caspian Basin during the PT and Upper Pliocene also suggests denudation on a large scale and in a very short time, compared with global counterparts. The denudation coefficient increases with time and reaches a maximum in the upper part of the PT and in the Absheron time, when more than 300,000 km3 of sediments were introduced into the basin over 1 million years. The rate of denudation of the springs feeding the Caspian Sea is comparable to the rate of denudation of the rivers eroding the Himalayan mountains.

Drainage (sediment removal) of rivers during sea level drops increases significantly due to an increase in the gradient on the sides of the basin. The author clarifies question of Aral Sea drainage with such drop of the sea level. The drop of the Caspian Sea level to the level of Aral sea will involve the integration of the whole Middle Azia drainage into the SCB drainage by Paleo-Uzboy.

Third defended position. A comparative analysis of the statistical parameters of sedimentary basins of the world, including oil and gas content, was carried out. The work shows that the volume of precipitation in the world's sedimentary basins varies according to the Pareto power law (the so-called 80/20 rule), since 80% of the total volume of sediment is contained in the largest (20%) basins in the world. A similar relationship between basin size and volume is clearly observed in passive margin basins and extension basins (rifts and vertical subsidence). The passive margin basins are generally more widespread around the world, containing up to 40% of the world's total sediment thickness. The passive margins are characterized by an average thickness of 4 km, foreland basins - 3 km, and intercratonic basins - less than 2 km. The South Caspian basin, together with other rapidly sinking and limited in area basins of the world, is definitely anomalous. This anomaly is explained by a combination of the rift nature of the basin, the influence of the flexure effect, which reduced its territory, and rapid sedimentation in the Pliocene.

Fourth protected position. The oil and gas potential of the SCB is revealed on the basis of a comprehensive analysis and categorization of geological risks. Several main topics covered in the work can significantly change the understanding of the prospects for oil and gas bearing systems of the SCB.

Previously, it was believed that the highest quality source rocks of the SCB are divided into 3 main stratigraphic units (Lower Maikop, Middle Maikop and diatomaceous rocks of the Upper Miocene). Recent information about the Eocene clays of the Koun Formation shows that they have a high organic content material (up to 24% Corg) and are still poorly studied with.

Due to the low geothermal gradients in the SCB and the relatively high temperatures required for rapid burial and hydrocarbon generation, the source rocks must be buried to depths greater than 13 km. In the absence of evidence of a functioning Mesozoic hydrocarbon system on land, such generation depths may indicate increased thicknesses of Paleogene rocks, particularly Eocene source rocks (equivalent to the Koun Formation). The depth of generation and the high content of organic matter material in Eocene outcrops indicate the key role of the Eocene in the generation of giant volumes of hydrocarbons in the SCB. Although the interpretation of seismic profiles cannot accurately indicate the age of thickened rocks in the center of the basin, the Mesozoic nature of these intervals seems less likely to us, since there is no evidence of Mesozoic petroleum systems in biomarkers of wells in the SCB water area.

Compared to the Eocene, the Maikop rocks of the Oligocene and Lower Miocene contain much less organic material (5% TOC), but can also take part in the generation of hydrocarbons. Upper Miocene diatomaceous clays contain up to 22% Corg, but often do not reach maturity in the center of the basin and onshore Azerbaijan.

The assessment of oil and gas potential prospects proposed by the author makes it possible to rank the prospects of hydrocarbon potential by oil and gas zones for each of the oil and gas zones based on comparative analysis, using a point system based on various play elements. The risks for each of these play elements are assessed independently and then combined. The method shows that the greatest hydrocarbon potential is observed in the central part of the SCB and in the waters of the Baku archipelago, which is associated with the large thickness of sediments, high rates of sedimentation in the Tertiary period and the widespread presence of both Eocene source rocks and the Maikop Formation, and PT reservoir rocks deposited by Paleo -Volga. Less promising zones of the section are the southwestern part of the SCB and the onshore of Azerbaijan. The prospects of the Iranian part of the SCB and the Turkmen depression south of the Absheron threshold remain little studied, but the exploration work carried out in these regions deserves the closest attention.

The oil and gas bearing systems of the Southern Caspian are unique due to sedimentation, since intensive and uneven filling with sediments caused instability of the SCB system. The hydrocarbon potential of the sedimentary section of the SCB at each stage is distributed unevenly, which is associated with the unevenness of sedimentation and the type of subsidence of different parts of the basin.

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