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MODERN STRUCTURAL AND TECTONIC MODEL OF THE CASPIAN REGION

The article analyzes the development and evolution of the structural and geodynamic systems of the sedimentary complex in the Caspian region, and the results of structural and tectonic modeling of individual tectonic zones in the region. Based on the modeling results, an important feature of the morphology and structure of the basement surface and sedimentary complex in the Caspian Sea is the tracked sea extension of many elements detected on land. The main features of the morphology and structure of the basement surface and sedimentary complex in the Caspian region are the presence of superdeep depressions of the earth's crust, with the basement depth up to 16 km or more in the North Caspian and up to 20–24 km in the South Caspian, as well as the distinct longitudinal (sublatitudinal) tectonic zonality of the region. Constructed as a result of the implemented reconstructions, the generalized geological and tectonic model of the uneven-aged basement surface comprises the sea and continental parts of the region under study.

Keywords: *Caspian region, structural and geodynamic systems, modeling, morphology, basement, sedimentary complex, geological and tectonic model*

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Introduction

The aim of this work is to analyze the development and evolution of the structural and geodynamic systems of the sedimentary complex in the Caspian region. The main feature of the morphology and structure of the basement surface in the Caspian region is the presence of superdeep depressions of the earth's crust with the basement depth up to 16 km or more in the North Caspian and up to 20–24 km in the South Caspian. Each of these depressions, in the deepest part, includes the graniteless areas of the earth crust; each of them is associated with the discovery of oil and gas, including large and unique hydrocarbon resources. Geologically, we understand the basement surface in sea regions as the partition of the plate complexes of an undisturbed or very weakly disturbed sedimentary cover and, to a different extent, disturbed and uneven-aged basement complexes, which may include layers of deformed primary platform section. The combination of superdeep depressions and high-stand areas of the eroded surface in the folded basement within the mountainous areas of the region, primarily in the Greater Caucasus, governs a gigantic vertical range of the generalized relief of the basement surface in the region, amounting to at least 25–30 km.

Research technique

The main research methods include: paleotectonic and paleogeographic reconstructions, construction of general structural maps, numerical spatial and temporal basin modeling. During the research of the Caspian region and adjacent territories, we used classical methods of reconstructing sedimentation conditions in the geological past, such as the analyses of thicknesses and facies, formation composition of sediments, breaks and disconformities, using a large amount of published and archived materials.

Modeling of tectonic development is the process of reconstructing history of changes in the tectonic processes of downwarding and rise in time and space, as well as reconstructing stages of initiation and kinematic activity of faults and their systems in the region. To make up such reconstructions of basin evolution and the evolution of discontinuous systems in the area under consideration, we collected and systematized all currently available regional and geological, geophysical, lithological and petrological, lithological and stratigraphic, geochemical and other data on their structure.

In accordance with the research technique developed by the authors using the numerical basin modeling tool, there are several modeling stages: the general analysis of the geological environment; formation of a digital structural and geological model of sedimentary basins and the analysis of the numerical modeling results.

For structural and tectonic reconstructions, the main sources were the data of geological and seismic surveys and analyses of geophysical fields, deep oil and gas prospecting and mapping drilling, regional geological sections built on their basis, data on the morphological features of the basement, analysis of geological maps and updated, as necessary, materials of production and thematic reports for individual zones and areas of the studied regions, as well as the numerous publications [1–9].

Research results and discussion

As a result of the reconstructions with regard to all conditions and circumstances, we have formed a general regional structural model of the uneven-aged basement surface, uniting the sea and continental parts of the region under study (**Fig. 1**).

High-gradient zones of the basement are also typical for the North Caspian subsidence area, but here the zones along its southern border are distinguished by the greatest contrast, where they fix the position of the suture upthrust–overthrust system along the southern edge of the East European platform.

According to the presented geological and tectonic model of the uneven-aged basement (**Fig. 2**), the northern part of the region, including the North Caspian up to latitude of about 45°30’, occupies the area of the pre-Riphean basement of the Peri-Caspian Depression, rejuvenated near the Donetsk-Astrakhan–South-Emba suture system of the Paleo-Tethys.

On the side of the Northern Ustyurt, this area is adjoined by the field of the pre-Middle Paleozoic basement expansion bounded in the west by the placement zone and the Karyn–Tokubay uplift zone formed above it at the depths of 6–8 km, and in the south by the Central Ustyurt rift-related system, in which the upper (near-surface) part of the basement is most likely represented by disturbed sedimentary and volcanogenic strata of the Late Paleozoic–Triassic. Westward of the North Ustyurt and southward of the North Caspian regions in a sublatitudinal direction, there is an expansion line at the level of the basement surface of folded pre-Upper Permian complexes corresponding to the uplift system of the Karpinsky range—Buzachi. The Carboniferous–Permian rock age of this line is confirmed by numerous data of deep exploratory drilling.

Apparently, of the same or similar initial age is the line located to the south, which stretches across the Middle Caspian from west to east, from the subsided up to 3–7 km southern intervals of the Scythian Plate to the troughs and highs of the South Mangyshlak part of the Turanian Plate. However, in this zone, with the exception of the areas of the Middle Caspian and Karabogaz massifs, the original basement is likely to be altered to a different extent by later rift-related displacements and in some places (Central Mangyshlak) by subsequent Early Cimmerian fold movements. The northern boundary of this line is the fault bel assumed as the Meso-Tethys suture system, which, in fact, separates the Late Paleozoic–Early Mesozoic areas of compression and folding in the north from the areas of extension and rifting in the south. It should be noted that the completion of this process, with the formation of orogenic-folded zones in place of the paleorift, expressed in the basement surface, is typical only for the segment located in the Central Mangyshlak zone of the Turanian Plate. Accordingly, the Early Cimmerian age of this folding fits well the formation time of the Caucasian–South Caspian Early Alpine (“neotethis”) basin: during its expansion the rigid massifs in its northeastern framing should have been pushed to the north and northeast and “squeezed” the rift section that is in the displacement path of these massifs. Weaker structural consequences of this displacement, no longer in the form of folded ones, as in Gorny Mangyshlak, but in the form of block and arch dislocations of the surface in the pre-Mesozoic basement, are also noted north of the Central Mangyshlak zone, in the Buzachi region, in the zone of the supposed expansion of the pre-Mesozoic strata composing it.

The southern boundary of the considered line of the processed pre-Mesozoic basement is a belt of faults that form the Neotethis suture system, which limits the expansion area of the Alpine belt structures from the north.

The South Caspian subsidence area is limited by zones of high gradient basement surface, which corresponds to systems of faults or reverse thrusts, the total amplitudes of which can reach a few kilometers (from 2–4 to 8–12 km). The basement of the most South Caspian Basin, despite the geophysical evidence of expansion of the thinned, deeply altered earth crust here, the structure of which may lack the upper granite and metamorphic layer in some places, yet morphologically has features of a massive and block formation rather than a zonal and folded one, as evidenced by some new seismic data (**Fig. 3**). This suggests that the South Caspian massif split into separate blocks existed here in the pre-Mesozoic structure which in the pre-Alpine or Precambrian epoch could have been a part of a larger group of ancient massifs—the “Caspian microcontinent”.

The main tectonic elements of the Caspian region at the level of its basement include the segments of the East European and Scythian–Turanian platforms crossed by it, the Tersky–Caspian trough and the South Caspian depression.

To analyze the development and evolution of the structural and geodynamic systems in the regional sedimentary complex, we created structural and tectonic models of individual tectonic zones in the Caspian region. As follows from the modeling results, an important feature of the morphology and structure of the basement surface and sedimentary complex in the Caspian Sea is the traceable sea extension of many elements identified on land. The main tectonic feature of the sedimentary complex in the region under consideration is its distinct longitudinal (sublatitudinal) zoning which can be traced from the Black Sea to the Caspian Sea and is governed by the largest systems of longitudinal Paratethys faults—the Black Sea (or Karkinitsk)–North Azov and North Anatolian system [2, 10–14] within the boundaries by outlined the southern edge of the East European platform and by the northern edge of the Anatolian–Iranian belt of microplates and massifs. To implement a differentiated approach to modeling the study area by the nature of the structural and tectonic conditions, the age of the sediment complexes and their confinement to the tectonic structures and zones, we undertook 3D modeling of the Northern, Middle and Southern Caspian, as well as the Karpinsk–Mangyshlak, Easten Ciscaucasian tectonic zones and the Tersky–Caspian trough, the extensions of which are detected in the water area of the Caspian Sea. The examples of the numerical basin modeling are shown in **Figures 4** and **5**.

The North Caspian Basin is represented by the southeastern element of the East European Platform—the Caspian

Basin. It consists of the southern subsidence of the Astrakhan and Novobogatinsk–Shukat uplift systems, and the South Emba system of troughs with complex transverse zoning. The latter is considered as a pericratonic subsidence separated from the Caspian Basin by the indicated systems of uplifts.

The maximum subsidence of the basement in the system of troughs is 14–16 km in the area of the Provinskaya depression. The basement here is supposedly of the Archean–Proterozoic age. The deepest part of the depression might have a "basalt window" [5].

Within the Astrakhan, North-Caspian and Biikzhal arch-like areas (massifs) included in the system of uplifts in the northern Caspian and its coast, the basement surface lies at the depths of 7–7.5 km. Separate arches within them have relative amplitudes of 1–1.5 km, less often up to 2 km.

The Middle Caspian depression is represented by the southeastern part of the Scythian–Turanian platform. The analysis of the data on the sea extension of the structural zones in the Karpinsky range indicates the necessity to separate the Caspian–Mangyshlak system of uplifts, its southernmost Kamyshan–Caspian zone, into an independent structural unit. This is governed by the following facts. As it enters the water area, the belt attributed to the Karpinsky range is divided into two branches in the direction of the Buzachi arch and in the direction of Gorny Mangyshlak, respectively. This separation occurs east of the series of costal placement faults. The northern and southern branches are separated by a system of troughs, the main of which are South Buzachi and Zyudev systems with the basement surface at the depth of up to 9–9.5 km. The Zyudev systems in the direction to the west narrows stepwise and passes into the Pridorozhny trough and further to the west into the Dzhanai one.

The modeled Karpinsk–Mangyshlak zone covers the Promyslovsk–Tsubuk and Caspian–Kamyshan buried swells separated by the Dzhanai–South Buzachi depression. The aquatorial part has the Rakushechnaya zone of uplifts on the extension of the Caspian–Kamyshan swell. The East Ciscaucasian tectonic zone consists of the East Manych trough, Prikumsk swell, Chernoles depression, Nogaysk–Tarumov interval, Khvalynsk interval, Western Caspian monocline and the Segendyk trough. Tracing of the sea extension of the Karpinsky range shows its sharp subsidence directly behind the coastline and, as noted above, its division into two branches—the northern and southern, between which there is a depression within the water area with the basement depth down to 9 km. The northern branch connects the ridge with the Buzachi arch, and the southern branch, through a series of transverse faults, connects it with the structural zones of Gorny Mangyshlak. At the same time, in the area where the fold zones of Central Mangyshlak emerge to the Kazakh coast, composed of Upper Paleozoic and Triassic sediments, their axes turn to the south, in the direction of the Tersky–Caspian trough, with the formation of a structural horsetail-like complex. The Tersky–Caspian trough is an inherited superimposed boundary structure that separates the platform and orogenic areas, and has different basement ages in the platform and priorogenic zones, respectively, from the Baikal and Paleozoic age to the Triassic–Jurassic. The maximum depths of the basement can reach 10–12 km. The Terek–Caspian trough adjacent to the Middle Caspian includes two depression formations in its outline—the western sublatitudinal Tersky trough located entirely on land and the eastern northwest-striking

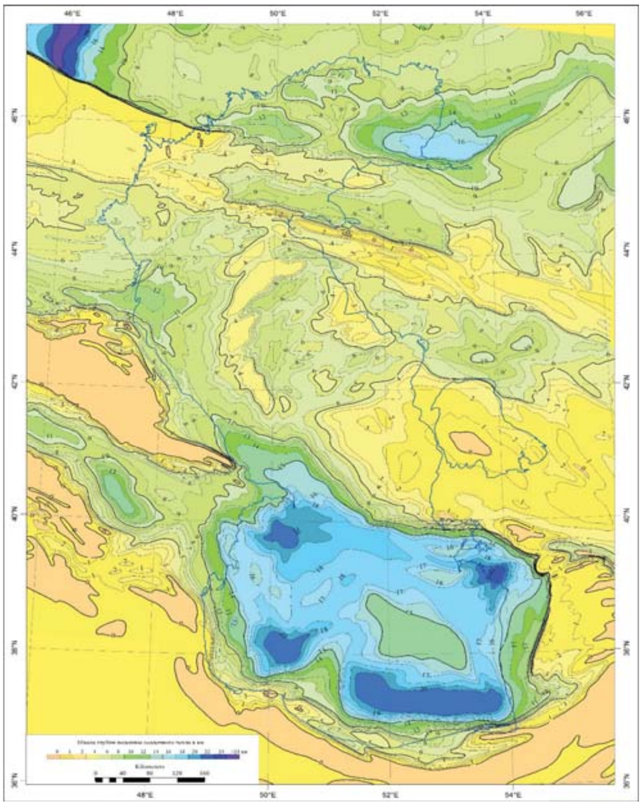

Fig. 1. General structural map of uneven-aged basement surface in the Caspian basin with adjacent water areas and territories

Sulak trough oriented in parallel to the folded structures of the Caspian part in the Eastern Caucasus. This trough is represented by the Agrakhan depression located both on land and in the sea. In the sea part of the trough, at the level of Jurassic and Cretaceous deposits, there is the Khazrinskaya barrier which bounds the Agrakhan depression from the south and the Achisu depression located to the south of the barrier. The western and southwestern parts of the Middle Caspian meet the sea extension of the Tersky–Caspian trough. Its structural limitations from the side of the platform are rather vague and represented by a series of sublatitudinal and submeridionally oriented benches pronounced in the basement surface, which probably correspond to flexural fault zones. The boundaries on the part of the Caucasian Orogen are more pronounced and, according to geological maps, are represented by systems of upthrusts, reverse thrusts and thrusts falling under the orogen and shown in the structural model by high-gradient zones of the basement relief.

The most distinctive element of the Turanian plate within the water area, along the linear folded zones and troughs extended in its northern part, is the vast Middle Caspian massif, which occupies most of the Middle Caspian and is clearly traceable in the gravitational field. It is formed by two northern and southern segments which are separated by a series of sublatitudinal placement faults passing through the Kazakh Bay. The southern segment corresponds to the massive Karabogaz arch. The northern segment is an area of crushing and subsidence of the ancient basement, in which the largest

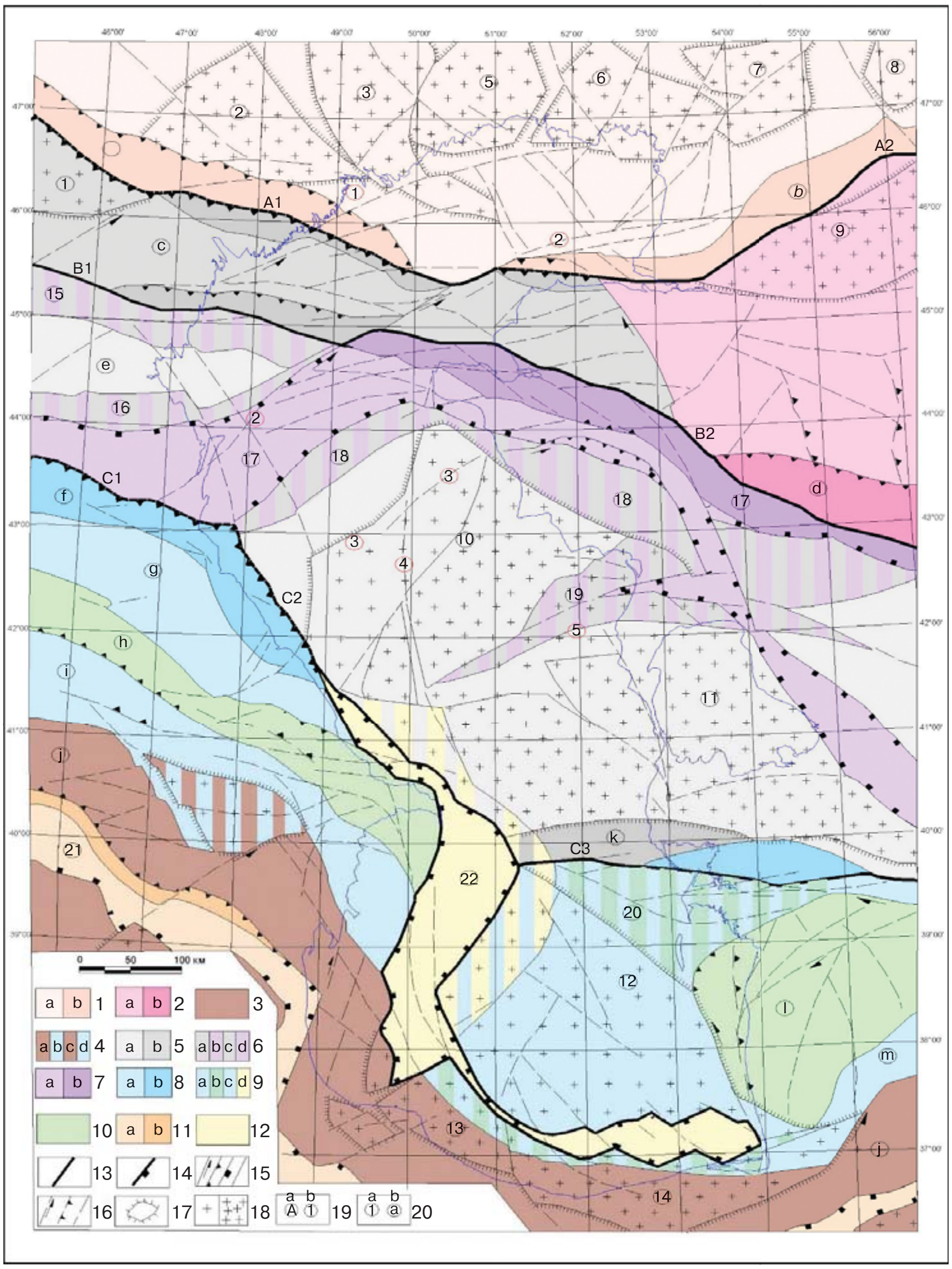

Fig. 2. Geological and tectonic model of uneven-aged basement surface in the Caspian Sea and adjacent territories:

1–12. Estimated or determined age of folded and metamorphic complexes emerging on the basement surface:

1—pre-Riphean age, *a*—in zones of relative stabilization, *b*—rejuvenated in zones of secondary collision folding; 2—pre-Middle Paleozoic age, *a*—in zones of relative stabilization, *b*—rejuvenated in zones of secondary collision folding; 3—Riphean–Paleozoic age (pre-Middle Devonian?); 4—Riphean-Paleozoic age, rejuvenated due to rift-related impact in Jurassic (?) Time; 5—pre-Upper Permian age, *a*—in zones of relative stabilization, *b*—rejuvenated in zones of secondary collision folding; 6—Upper Permian age, rejuvenated by Permian-Triassic rift-related processes; 7—Middle Triassic, rift-relate age, *a*—in zones of relative stabilization, *b*—in zones of inversion folding; 8—pre–Middle Jurassic age, *a*—in zones of relative stabilization, *b*—rejuvenated in zones of secondary collision folding; 9—Middle Jurassic age, rejuvenated in the zones of Jurassic-Cretaceous (*a*) and Cenozoic (*b*) rift-related processing; 10—pre-Upper Cretaceous age (pre-Eocene?); 11—pre-Pliocene, predominantly rift-related age, *a*—in zones of relative stabilization, *b*—in zones of inversion folding; 12—Pliocene-Quaternary zones of sliding (area of probable "graniteless" windows): *Tectonic boundaries and faults*: 13—main suture systems, 14—boundaries of the zone of Pliocene-Quaternary sliding; 15—boundaries of regional tectonic elements: placements, thrust and reverse faults, rift troughs and throws; 16—other violations: placements, thrust and reverse faults, rift troughs and throws; 17—boundaries of ancient massifs. *Other designations*: 18—Pre-Riphean and pre-Paleozoic massifs, *a*—relatively stable ones, *b*—reworked by later movements; 19—indices of faults; 20—indices of structural elements.

Different–age elements identified in the structure of the basement surface. *The main suture systems*: A—Paleotetis system (A1—Donetsk-Astrakhan zone, A2—South-Emba zone); B—Mesotetis system (B1—North-Manych zone; B2—North-Mangystau zone); C—Neotetis system (C1—North Caucasian zone, C2—West Caspian zone, C3—Turkmen zone. *Some principal fault zones*: 1—Coastal zone; 2—Agrakhan–Atyrau zone; 3—South Segendyk zone; 4—Middle Caspian zone; 5—North –Karabogaz or Kendyrlin zone. *Ancient (pre-Baikal and pre-Paleozoic) massifs*: 1—Buzginsk massif (West Kalmyk, Zavetnoe); 2—Astrakhan massif; 3—Akkolsk massif; 4—South Zhambay massif (North Caspian one); 5—Novobogatinsk massif; 6—Biikzhalsk massif; 7—Shukatsk massif; 8—Utebaysk massif; 9—Mynsualmas massif; 10—Middle Caspian massif; 11—Karabogaz massif; 12—South Caspian massif; 13—Safedrud massif; 14—Mazandaran massif. *Rift-related zones and associated zones of basement rifting*: 15—Manych zone; 16—Nogay zone; 17—Ciscaucasian-Mangyshlak zone; 18—South Mangyshlak zone; 19—Aksu-Kendyrlin zone (Kazakh Gulf); 20—Ogurchin zone; 21—Sevano-Akerin zone; 22—South Caspian zone of superimposed sliding. *Fold belts and zones*: *a*—Karakul–Smushkovsk zone; *b*—South-Emba zone; *c*—Karpinsk—(Chernozemelsk)—Buzachi zone; *d*—Central Ustyurt zone; *e*—Prikumsko-Tyulenevsk zone; *f*—North Caucasian foreland; *g*—the North Caucasus zone; *h*—the Main Ridgezone; *i*—Kurinsk zone; *j*—Lesser Caucasian-Elbursk zone; *k*—Kubadag-Bolshebalkhansk zone; *l*—Kopetdag zone; *m*—Gokchedag–Monzhuklinsk zone

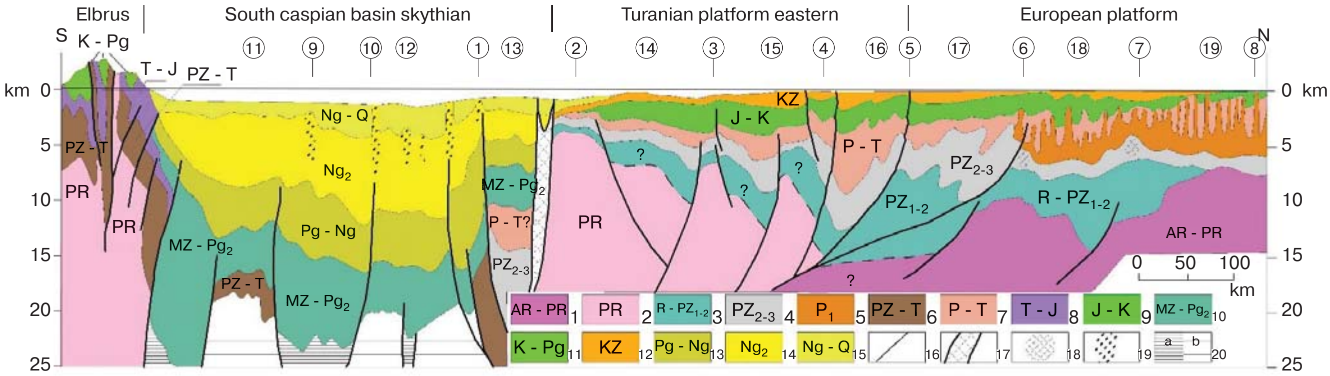

Fig. 3. Basic geologic section of the Caspian Sea along the submeridional section (composite line of seismic and geologic sections):

1—pre–Baikal crystalline basement; 2—Baikal crystalline and folded and metamorphic basement; 3–15—sedimentary and volcanogenic and sedimentary complexes, including transitional formations: 3—pre–Devonian basement; 4—subsalt, Middle–Upper Paleozoic basement– Pre–Caspian depression and synchronous complexes of the Scythian–Turanian platform; 5—salty Lower Permian basement; 6—Paleozoic–Triassic basement—Alpine belt; 7—suprasalt, Permian–Triassic sub–complex of the Caspian basin and the synchronous transition complex of the Scythian–Turanian platform; 8—Triassic–Jurassic complex of the Alpine belt; Mesozoic–Cenozoic complexes: 9—Jurassic–Cretaceous basement; 10—Mesozoic–Eocene basement; 11—Cretaceous–Eocene basement; 12—undivided Cenozoic undivided basement; 13—Paleogene–Neogene basement (including the Maikop series); 14—productive red–colored strata of the Middle Pliocene; 15—Pliocene–Quaternary deposits; 16—faults; 17—Turkmen suture; 18—bioherms; 19—shale diapirs and mud volcanoes; 20—complexes of the South Caspian depression base: a—zones of the newly formed suboceanic or subcontinental crust; b—zones of deep tectonic and magmatic alteration of the ancient Precambrian or Paleozoic basement.

Structural element indices (numbers in circles). Uplifts and uplift zones: 1—Apsheron–Pribalkhansk zone; 2—Karabogaz fold; 3—Samur–Peschanomyssk zone; 4—Caspian–Lagansk zone; 5—Promyslovsk–Buzachi zone (Kulalinsky shaft); 6—Astrakhan zone (South Zhambaysk); 7—Ural zone (Kashagan); 8—Novobogatinsk–Shukatsk zone; 9—Javadkhan–Natevan zone; 10—Abikha; troughs: 11—Elbursk trough; 12—South Apsheron trough; 13—North Apsheron trough; 14—Kazakh Gulf; 15—Segendyk trough; 16—Zyudevsk trough; 17—Ukatnensk trough; 18—South Emba trough (West Prorvinsk); 19—Burdynsk trough

of the preserved blocks form a line of highs stretching from the Yalama–Samur arch to the Peschanomys arch.

The South Caspian Basin is distinguished by the greatest depths of the basement, which, according to some estimates, can reach 22–24 km. At the same time, there are three depth maxima—South Apsheron, Ogurchinsky, or South Cheleken and Iranian, or Pre-Elbursky. The nature of the basement has been insufficiently studied; however, based on the analysis of the geophysical fields and geology of the continental framing, it is possible to suppose its extreme heterogeneity [12] governed by the combination of ancient massifs, Paleozoic and Cenozoic folded-block zones, and the areas of probable lack of granite layer of the earth's crust in its structure. Based on the comparison of the data on the morphology of the gravity field (in Bouguer corrections and free air) with the seismic tomography surveys of the region [9, 15–17], thermal regime of the subsoil, modern movements, with the morphology of the bottom and sections in the sedimentary cover, it is suggested that there is a very young deep fault (rift?) zone in the western and southern parts of the basin [3], which extends through the deepest depressions of the South Caspian to the north–northwest, along the western continental slope, past the Apsheron Peninsula and the western coast of the Middle Caspian, approximately to the latitude of the Kizlyar Bay. In the site between the cities of Derbent and Makhachkala, this zone can be hidden under young upthrust–overthrust structures of the Samur dislocation zone as a part of the North Caucasian foreland, which includes five subregional elements in the discussed model: Kabardin depression, Tersky–Sunzha fold zone, Osetin–Chechen zone of depressions, Dagestan fold zone and Kusaro–Divichin trough.

Conclusions

The main feature of the morphology and structure of the basement surface in the Caspian region is the presence of superdeep depressions of the earth's crust with the basement depth—in the North (up to 16 km or more) and South (up to 20–24 km) Caspian, each of which is associated with the discovery of oil and gas accumulations, including large and unique hydrocarbon reserves. The South Caspian subsidence area is limited by the zones of high gradient basement surface, which corresponds to systems of faults or reverse thrusts, the total amplitudes of which can reach a few kilometers (from 2–4 to 8–12 km). The high-gradient zones of the basement are also typical of the North Caspian subsidence area, but here the zones along its southern border are distinguished by the greatest contrast, where they fix the position of the suture upthrust–overthrust system along the southern edge of the East European platform. As a result of the reconstructions, the integrated geological and tectonic model of the uneven-aged basement surface is constructed and unites the sea and continental parts of the region under study. Based on the modeling results, the important feature of the morphology and structure of the basement surface and sedimentary complex in the Caspian Sea is the traceability of the sea extension of many elements identified on land.

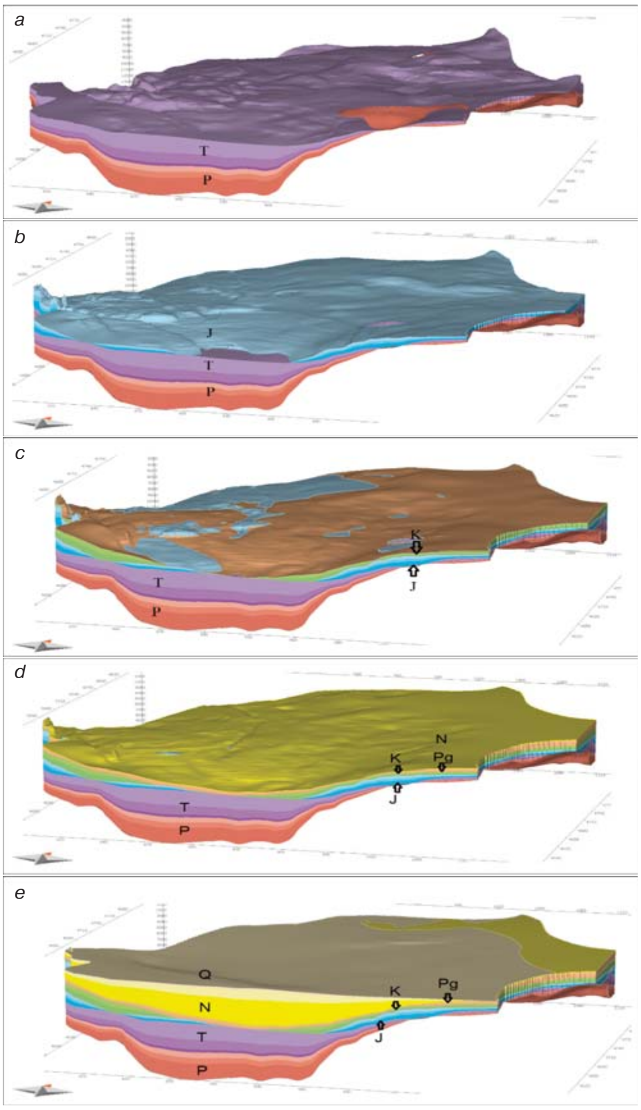

Fig. 4. 3D structural and tectonic models of the Middle Caspian depression:
a—at the end of the Triassic period; *b*—at the end of the Jurassic period; *c*—at the end of the Cretaceous period; *d*—at the end of the Paleocene; *e*—present time

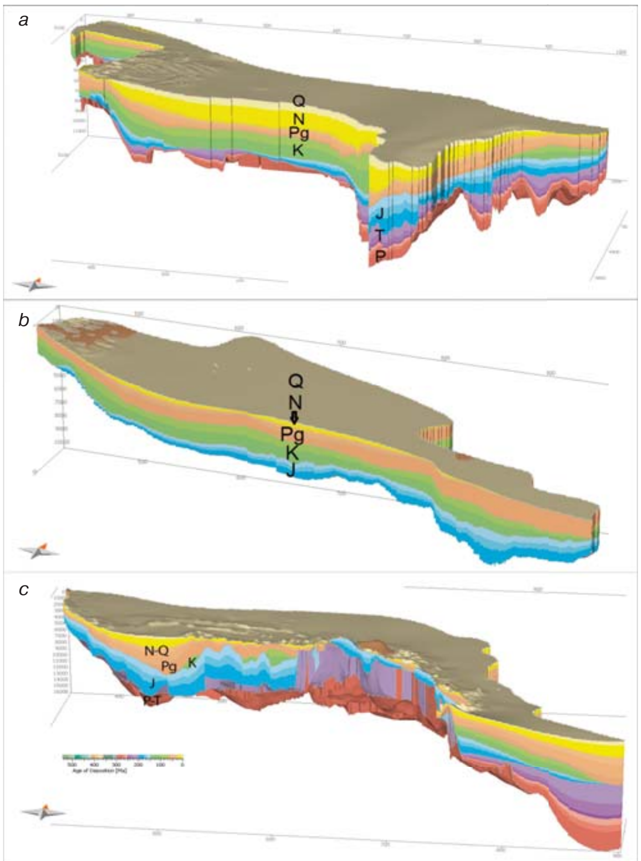

Fig. 5. 3D structural and tectonic models:
a—East-Ciscaucasian oil- and gas-bearing area; *b*—Karpinsk-Mangyshlak oil- and gas-bearing area; *c*—Tersky–Caspian trough

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THE STRUCTURE AND ROLE OF FAULTING AND FRACTURING SYSTEM IN SPATIAL OIL SATURATION OF ROCKS AND IN OCCURRENCE OF OIL RESERVOIRS WITHIN CHEZHEN SAG OF JIYANG DEPRESSION IN THE BOHAI BAY BASIN IN EAST CHINA

The article reports the integrated analysis of the history, geodynamics, modern faulting system, internal structure and spatial occurrence of Paleozoic and Paleogene (Eocene) accumulations of oil in the promising Chezhen block of the Chezhen sag of the Jiyang depression in the Bohai Bay Basin in East China. After review of the new geological, geophysical and field studies, the authors find out that in this structurally complex system of faults and fractures of different age, orientation and types, the present-day spatial occurrence of oil reservoirs is governed by the neofaults which blanket the whole geological section, including the Paleozoic period.

The studies (analysis of polished sections) into internal structure (micro fracturing) and oil saturation of rocks produce some new data of interest for the theory and practice. The studies of samples from the reservoir and non-reservoir rocks in exploration drilling in the Shahejie pay horizon show that oil saturation is connected with the presence of the younger age system of micro fractures (permeable) of horizontal and vertical (faults) orientation.

The further exploration in the promising Chezhen block of the Shenli oil field is recommended to continue in the zones of the Cenozoic faults as any rocks (irrespective of their lithology, including low-porosity rocks) can be saturated with oil in these zones which contain the best-type reservoirs (fractured) and feature active fluid neodynamics.

Keywords: *Bohai Bay Oil Basin, Shenli oil field, Chezhen sag, faulting system, drillhole, rocks, polished section analysis, micro fractures, oil reservoir*
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Introduction

The Chezhen hydrogen block of the Shenli field, which is China's second largest oil and gas reservoir [1], spatially coincides with the Chezhen sag (2nd order structure) of the Jiyang depression (1st order structure) in the Bohai Bay Basin (**Fig. 1**). Tectonically, this is one of the largest rift basins (its length is around 2600 km and the width is around 1200 km [2, 3]) within the East China Cenozoic Rift Zone in the northeast of the ancient North China.

The relevance of this research topic is defined by the need to support geological exploration in the Chezhen sag which possesses a high oil and gas potential but is yet underexplored [4, 5]. Oil occurs in the complicated geological conditions in the Chezhen sag: there are many productive strata with numerous and diverse faults, and ore reservoirs spatially gravitate to the systems of faults [1, 6–14].

This research aims to reveal tectonic conditions of such spatial selectivity of oil occurrences within the Chezhen sag boundaries.

According to [1, 10, 11, 15–20], geological history of the East China Rift Zone territory underwent a number of tectonic reconstructions under the influence of large-scale and differently directed horizontal tectonic movements (Fuping, Taishan, Caledonian, Hercynian, Indosinian, Yanshan, Himalayan). After multiple changes in geodynamic conditions, the modern geology of this territory, including the Bohai Rift, is complex (structures induced by compression, shearing and tension)