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Paleotectonic development features and assessment of perspective of oil and gas possibility of Paleozoic sediments of the Pre-Caspian basin

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Abstract

The analysis of the history of the development and formation of the Pre-Caspian basin, the characteristics of the main stages of development from the Middle Devonian to the Lower Permian (Artinsky and Kungurian stages) are given. The main tectonic elements are identified, the analysis of which is used to assess the internal structure and prospects of oil and gas potential of the Paleozoic sediments. Separate analysis of sedimentation conditions and paleotectonic reconstructions along the northern, eastern, and southern pre-bead part of the Pre-Caspian basin was performed. Local structures and zones that are of exploratory interest in relation to the prospects of oil and gas potential are identified. Separately, an assessment and forecast of the conditions for the formation of the central regions of the deep Pre-Caspian basin are given.

Keywords: zone, Pre-Caspian basin, Paleozoic complex, oil and gas prospects, sediments, reservoir, paleo-depths, sedimentation

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INTRODUCTION

In the Paleozoic complex of the Pre-Caspian basin, the features of development and sedimentation conditions make it possible to distinguish pre-bead zones and the central submerged part, the deep-sea basin (**Fig. 1**). Pre-bead zones include the northern and western, eastern and southern zones (south and southeast). The northern and western airborne zones, in turn, have an external and internal part.

A characteristic feature is the development and wide distribution in the Paleozoic stratum of contrastively expressed accumulative forms that are well diagnosed by modern research methods and which are reflected in the interpretation of geological and seismic data (Azhgaliev & Taskinbaev, 2019). First of all, these are carbonate platforms and ledges of different ages in the onboard parts of the Pre-Caspian basin (Volozh & Parasyna, 2008; Kuznetsov, 2003). The relatively submerged inner part of the basin is characterized by sedimentary ledges, local elevations of carbonates — pinacles, large amplitude elevations of the developmental sedimentation style (Isenov, 2020).These forms form elongated along the sides and, generally, along the contour of the Pre-Caspian Paleozoic basin, elevated areas, which, in turn, are peculiar belts and new levels of sedimentation (Azhgaliev, Obryadchikov, Taskinbaev et al., 2018; Azhgaliev, Voronov, Obryadchikov, Taskinbaev et al., 2019).

An important feature in the development and formation of the Pre-Caspian basin at the Paleozoic stage of development is the migration of the sedimentation basin contours (Obryadchikov, 2018), i.e. a factor that contributed to the formation of inconsistent occurrence of strata, wedging and replacement zones, the formation of elevated forms of paleorelief in the process of fluctuations in water level and changes in the depths of the sedimentation basin. The sharp changes in the depths of the surface of the subsalt bed (OG P_1) are especially characteristic for the pre-bead zones in the southern, northern, and northwestern frames of the Pre-Caspian basin. In the southern part, three main areas of carbonate accumulation (the Karaton-Tengiz platform, the Astrakhan and South Emba uplifts) are clearly distinguished, which are contrastingly and hypsometrically high in the structural plan of the pre-bead part of the basin.

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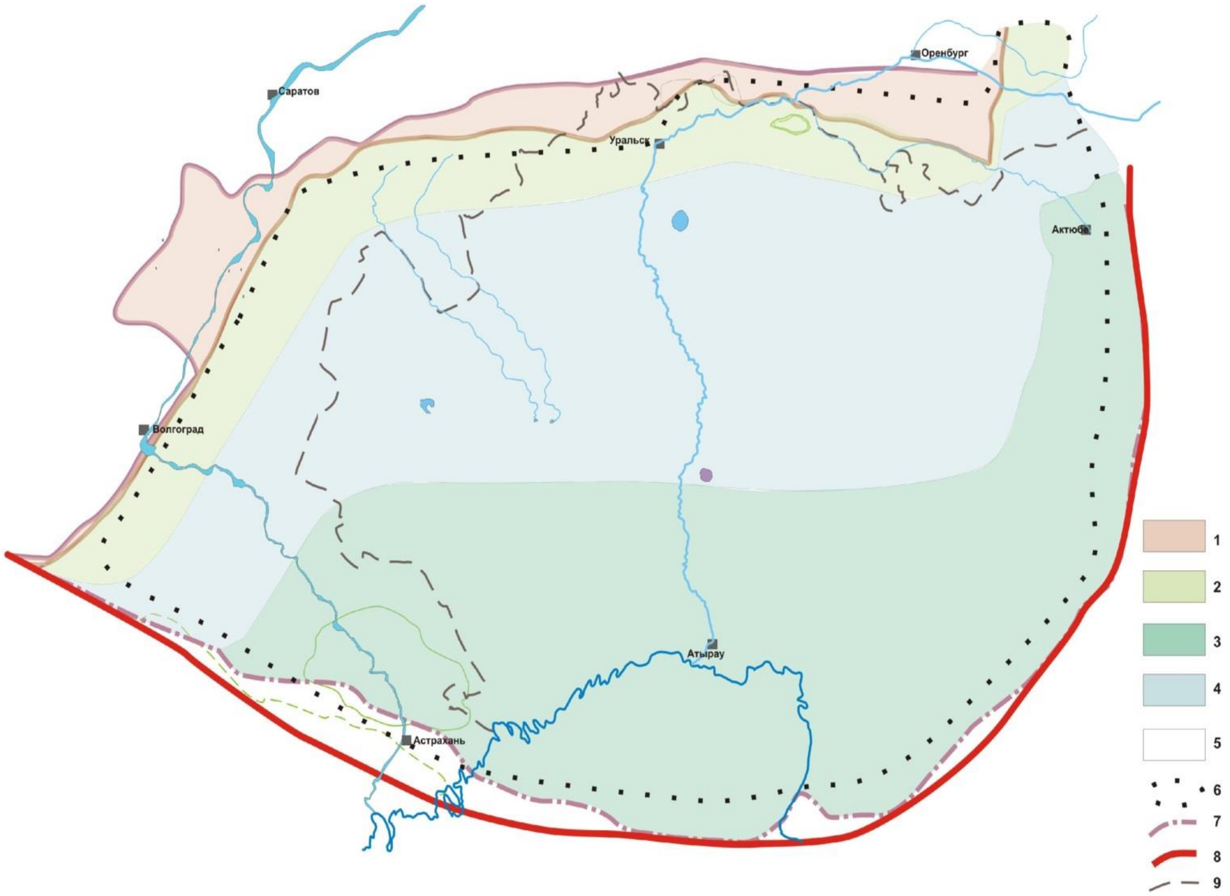

Fig. 1. Scheme of geotectonic zoning of the Pre-Caspian basin (according to O.S. Obryadchikov, 2018)
Legends: 1-2: pre-bead zones, western and northern: external (1) and internal (2); 3: Central Pre-Caspian basin; 4: eastern and southern pre-bead zone; 5: territories of the absence of Kungur salt due to carbonate or thick terrigenous deposits (P1 ar) of the lower Permian; 6: the territory of subsidence in the middle of the Bashkir century; 7: carbonate step (P1 ar); 8: faults; 9: state border of the Russian Federation and Kazakhstan

In the section of the onboard parts (practically along the entire perimeter of the Pre-Caspian basin), "alignment" strata are distinguished, which include shallow-water carbonates formed under known conditions and depths (60-80 m). These include limestones of the Upper Visean-Bashkir age, the analysis of which allows, as a first approximation, to estimate the paleo-depths and perform paleobatimetric analysis of the sea basin for various stages of development (Konovalenko, 2001; Kuznetsov, 2003).

MATERIALS AND METHODS

A high level of detail in the study of sedimentation conditions is provided with the use of new drilling and seismic data. The results of the study should be based on biostratigraphic definitions, data of analysis and integration of correlation-profile (hereinafter - CR), time and depth sections. The main factor in this case is the consideration of regional tectonic and lithological-facial features of development, the assessment of paleobatimetry and zonality of the sedimentation basin, data from petrophysical analysis and laboratory studies (Azhgaliev & Taskinbaev, 2019).

Taking into account the experience of previous years of study, as a rule, most researchers used analysis of the thickness of sedimentary complexes as the main methodological method for analyzing the development history of large and even small regions. But this categorically cannot be done without studying the ancient topography, basin depths and the degree of post-sedimentation differentiated compaction of sediments (Obryadchikov, 2006). This primarily refers to pools with a complex relief of the seabed. Therefore, the study of paleobatimetry of the conditions of ancient sedimentation is necessary to restore the history of the geological development of almost any sedimentary basin.

Researchers, with rare exceptions, conducting paleogeodynamic reconstructions of large territories, put them on a modern topographic basis (Shein, 2006), which seems to be incorrect. Another thing is when they demonstrate the position of cratons and oceans (Obryadchikov & Taskinbaev, 2007). Thus, they show their ideas about the interaction of large blocks and plates and the nature of the distribution of sedimentation basins, which is especially important in relation to the marginal parts of ancient platforms.

The restoration of paleobatimetry of the sedimentation basin allows us not only to more realistically study the conditions of sedimentation, but also to predict the development of various structures of sedimentation genesis, which can become non-anticlinal traps of hydrocarbons (hereinafter referred to as NAT), which have recently been associated with the genesis of practically all large oil and gas fields in the Paleozoic sediments of the Pre-Caspian basin (Azhgaliev, Karimov & Isaev, 2018; Azhgaliev & Taskinbaev, 2019).

The constructions based on the analysis of paleobatimetry of the sedimentation basin are carried out based on the characteristics and conditions of accumulation of various types of precipitation. So, the transfer of terrigenous sediments always occurs in the direction of lowering the relief, from high elevations to lower elevations. Shallow-water organogenic carbonates precipitate at depths of up to 40-60 m, and their development depends on the ratio of the rate of subsidence of the territory and sedimentation. If they coincide, then an organogenic structure or carbonate ledge is formed at this depth, in which the depth of the basin increases with an increase in clay content and a decrease in thickness. In the strip of carbonate ledge, reef-genic structures of the barrier type are formed. If the sedimentation rate is higher than the deflection intensity, a shift of the paleo-shallow waters towards the water area is noted, and with an increase in immersion this zone decreases and the carbonate ledge shifts upward in relation to the previous one in the uprising of the relief. In the era of carbonate sedimentation, isolated shallow areas (up to 40-60 m) in the waters of warm seas form (depending on their size and developmental characteristics) carbonate massifs, banks, atolls, pinacles.

It should be taken into account that when the sedimentation epochs change, the formed relief affects the features of sedimentation and the distribution of sediment thicknesses (Obryadchikov, 2006). Therefore, by following the direction of the paleo-russel, the change in the regional slopes and positions of the carbonate ledges and individual intra-basin organogenic structures in the plan, it is possible, along with the analysis of sediment thicknesses, to have an idea of the nature of the change in paleobatimetry of the sedimentation territory. This allows a more focused search for promising NAT. In the distribution of precipitation, the role of paleotrusion is important, and for reef structures, paleo-winds.

An analysis of the ratio of reflecting boundaries and the tracking of structural-formation complexes in different parts of the basin indicates the development of large inversion uplifts in the Paleozoic of the Pre-Caspian basin.

For some areas of the southern part of the basin, inversion according to seismic data is manifested in the inverse ratio of the depths of the basement and Paleozoic strata. So, the difference in the assessment of the structure model of the uplifts of the Karaton-Tengiz zone and the South Emba uplift on the one hand, the Astrakhan, Temir zone, etc., making up a series of raised basement blocks in a wide strip from Astrakhan to Aktyubinsk, on the other hand, is highlighted. In the first case, the Kashagan uplift, the Primorsky arch (Zhayylgan), Tengiz, Saztobe, Bekbulat are confined to the areas of deep basement (Obryadchikov 2018). On the contrary, the elevations of the Astrakhan, Temir, North Caspian, Novobogatinsky arch correspond to areas of elevated ledges. Given the more significant thickness of the Paleozoic section, in the first case, a high potential of the promising Upper Devonian-Tournaisian, Middle Devonian, and Dodevonian sequence should be predicted (Azhgaliev, Obryadchikov, Taskinbaev et al., 2018; Azhgaliev, Voronov, Obryadchikov, Taskinbaev et al., 2019). In the second case, with the proliferation of areas with a reduced section of these strata, wide possibilities are assumed for predicting promising NAT associated with zones of regional “cladding” of large Paleozoic structures. In both cases, there are very favorable geological and geophysical prerequisites for the prediction of NAT, including those associated with large sedimentary uplifts that can contain and maintain significant volumes of hydrocarbons.

According to the well data, there is a tendency to maintain the stratigraphic completeness of the section (Middle-Upper Devonian - Carbon - Lower Permian) in the direction from the onboard zones (K-3 Koblandy, UGS-3 Dolinskaya, Shr-1 Shirak, SG-2 Bikzhal) to relatively deep inland areas of the sedimentation basin (P-1 Embinskaya, P-3 Akatkol, G-1 Tasym Southeast) (Azhgaliev, Karimov & Isaev, 2018) (**Fig. 2**).

The complexity of identifying and substantiating the most important stages of the development and formation of a sedimentation basin is largely determined by the views on the nature of the structure and the conditions of occurrence of the marginal parts and adjacent areas of the East European Platform (hereinafter - EEP) and the Epigercin eastern and southern frames. The south-eastern border of the EEP is carried out at the eastern end of the Azov (Rostov) ledge and further along the section between the Caspian and the Scythian-Turan Plate (hereinafter - STP). Donbass, as part of the Dnieper-Donetsk aulacogen, was considered as a Hercynian orogenic structure until the last twenty years.

Volozh Yu.A., Parasyana V.S. (2008); Volozh Yu.A., Antipov M.P. Bykadorov V.A. et al. (2013); Kheraskova T.N., Parasyna V.S., Antipov M.P. et al. (2019) believe that the formation of the Donbass-Tuarkyr rift and the

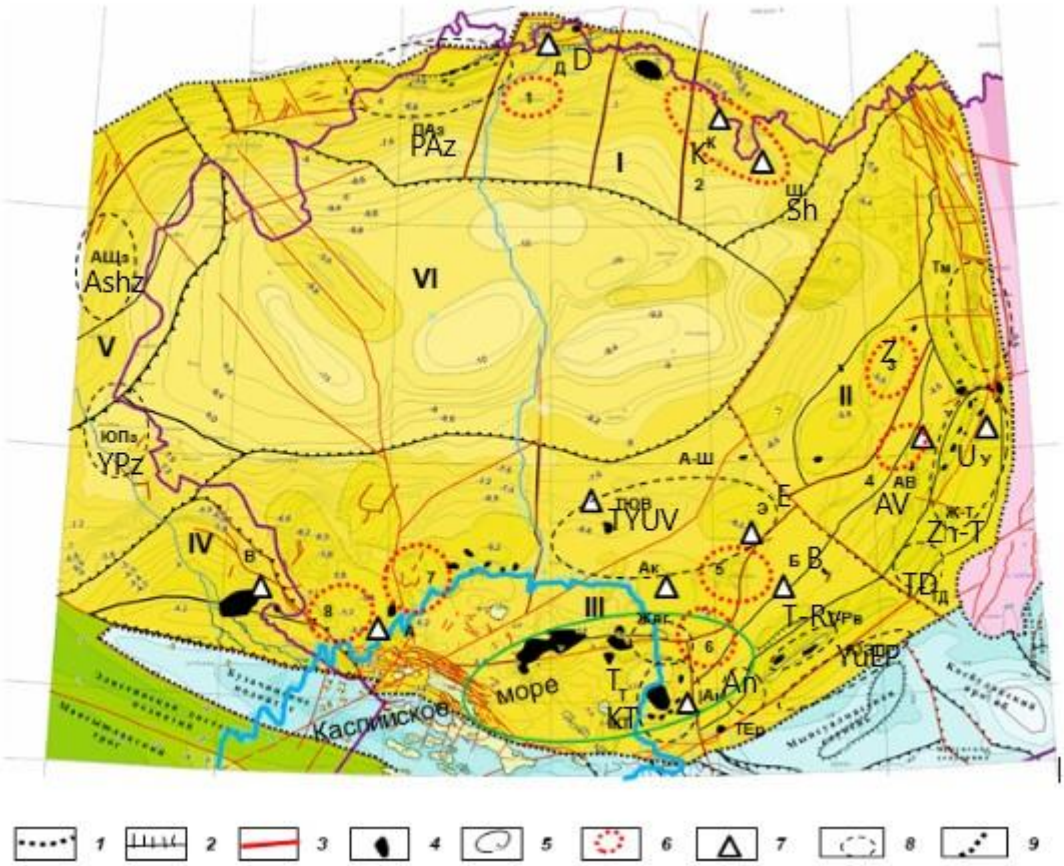

Fig. 2. Diagram of the Paleozoic complex of the Pre-Caspian basin (composed by Akchulakov, Azhgaliev, Taskinbaev et al., 2009-2013)
Legends: 1. Geoblocks: I - North, II - East, III - South, IV - Astrakhan, V - Northwest; 2. The contours of large structures of the upper order; 3. Regional faults; 4. HC deposits; 5. Isohypses along the roof of the Paleozoic sediments (OG P1), km; 6. Development zones of large Paleozoic uplifts (1 - Zhelaevskaya, 2 - Koblandy-Shirak, 3 - Koskol-Shubarkudukskaya, 4 - Akzharskaya, 5 - Munayly-Adayskaya, 6 - Kyzylkuduk-Matkenskaya, 7 - Zaburunye-Sazankurak-Oktyabrsky, 8 - Alga-Kobyakovskaya); 7. Ultra-deep wells: a) discovered Paleozoic horizons at elevated depths, 6.0 km and more (K - Koblandy K-3, D - Dolinskaya UGS-3, Sh - Shirak SR-1, AB - Akzhar Vostochny G-5, U - Urikhtau U-5, B - Bikzhal SG-2, E - Embinskaya P-1, Ak - Akatkol (Guryev arch) P-3, An - Ansagan G-2, TYuV - Tasym Southeast No. 1, A - Alga No. 1, B - Volodarskaya No. 2); 8. Large elevated zones; uplifts: Zhlg - Zhailganskoye, UES - South Emba; platforms: CT - Karaton-Tengiz, Tm - Temir, Zh-T - Zhanazhol-Tortkolskaya; TD - Tortkol-Diarsky site; zones: AShz - Atyrausko-Shukatskaya, PAz - Pogodaevsko-Astafyevskaya, YuPz - Yuzhno-Plodovitenskaya, AShz - Antipovsko-Shcherbakovskaya, Ter - Tasym-Elemes district, T-Rv - Tortai-Plain Val; 9. The border of the Pre-Caspian basin

separation of the STP from the EEP occurred in Kadom time. The breakaway block includes the southeastern part of the Pre-Caspian basin (East Caspian block) and the territory located to the south. V.S. Zhuravlev (1972), V.A. Benenson et al. (1978), Yu.A. Volozh et al. (2008; 2013) believe that the age of the consolidated foundation of the East Caspian block (hereinafter referred to as ECB) should be considered Baikal, and destructive processes occurred in addition to the Paleozoic and Mesozoic even in the Paleozoic and Mesozoic.

Along with the accumulated data from previous years, the analysis used the data from core studies of new wells, conducted a critical analysis of the results of seismic studies and case studies. The works were supplemented, in which sedimentation conditions were considered with an analysis of the distribution of thicknesses of the complexes, the most important factors of sediment accumulation were taken into account (paleo-slopes of the strata, the relative positions of the peaks of coeval reef structures, etc.). In order to analyze and restore the main periods of sedimentation, materials from regional and areal seismic surveys were used.

In the Pre-Caspian basin, the study of sedimentation conditions is possible only from the Eiffel stage. The materials on the Lower Paleozoic and Riphean-Vendian deposits are obviously not enough to build paleobatimetric plans of the epochs of terrigenous and carbonate sedimentation.

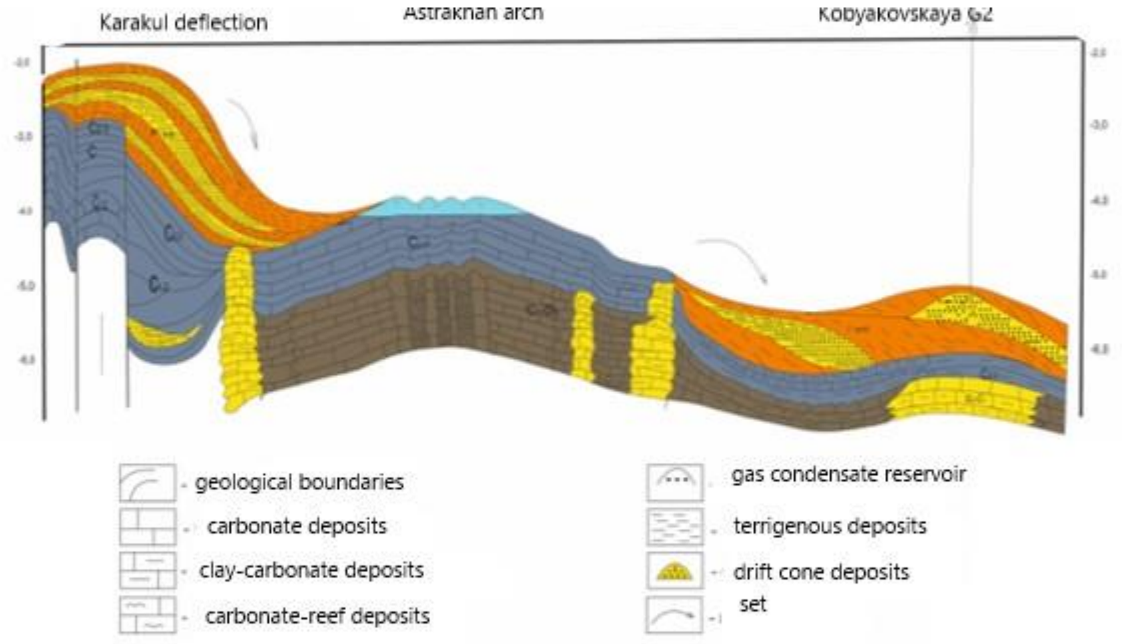

Fig. 3. Scheme of the formation of subsalt structures in the south of the Pre- Caspian basin along the Karakul trough - Kobyakovskoe uplift (according to the data of O.S. Obryadchikov, 1998; with additions of K.M. Taskinbaev, 2007)

In the Eiffel Age, conditions of carbonate sedimentation prevailed, and only occasionally in the pre-Biian and pre-Afoninian times was the accumulation of terrigenous deposits observed (Tikhomirov, 1995). Already since the Eiffel Age, (although this may have been earlier), the beginning of the dive towards the Pre-Caspian basin is presumably recorded in the western region. This is noted in the gradual change in the water regime: the transition from the freshwater regime to the regime of normal salinity (Tikhomirov, 1995).

By the beginning of the accumulation of the Middle Devonian predominantly terrigenous sediments, which lasted until the early Frans inclusively, the slope was towards the basin, as indicated by the directions of river systems and their extensions in the shelf area. The 50 m isobath was oriented in the meridional direction. Before the start of carbonate sedimentation in the Middle Franse, the change in relative shallow water to depths of more than 50-70 m passed along the eastern slope of the Kudinovskaya fold and, according to some data, drilling continued further south to the eastern borders of Donbass.

The Middle and Late Francs in the east of the EEP were marked by the inversion rises of individual basement blocks. Apparently, this was due to the collision of the Magnitogorsk island arc with the eastern edge of the EEP (Sonenshine & Matveenkov, 1984). The reaction to this was the uplift of individual blocks of the foundation of the ancient platform, which either came out from under sea level, undergoing erosion, or stopped at lower depths. The inverse rise of the Zadonsky, Antipovsko-Shcherbakovsky, South Plodovitensky blocks increased the area of relative shallow water in the direction from the eastern end of the Voronezh ledge. As a result, the Antipov-Shcherbakovsky block was withdrawn to a depth of 50 m and more. In its southern relatively elevated part, the formation of organogenic structures took place in the Late Fransian time.

On the border of the Sakmar and Artin centuries, the STP and the North Ustyurt plate shifted towards the Donbass (Obryadchikov & Taskinbaev, 2004; 2008; 2007). A folded zone was formed on the southern margin of the Caspian Basin, which served as a source of demolition of coarse clastic and carbonate material. By the beginning of the carbonate sedimentation, two areas of paleo-shallow water formed: the Astrakhan arch - as a fold of encircling above the ledge of the foundation and the Karakul-Smushkovskaya zone (hereinafter - KSZ) - a fold of the compensated type, due to the immersion of its southern part under the weight of heavy precipitation (**Figs. 3**, **4**).

Consequently, by the middle of the Bashkir century, the Astrakhan arch was a large carbonate bank, on the edges of which organogenic structures of the barrier type were probably developed. The past deflection lowered its peak below the level of shallow-water carbonate sedimentation and sedimentation did not occur on this underwater elevation until the end of the Sakmar century. Taking into account the regional slope towards the center of the Pre-Caspian region, the surface of the Lower Bashkir carbonates tilted in the northeast direction.

Due to the right-hand shift of the STP south of the KSZ, high-amplitude orogenic structures arose that became the source of the transfer of large volumes of terrigenous material to the Artinsky paleobasin, which

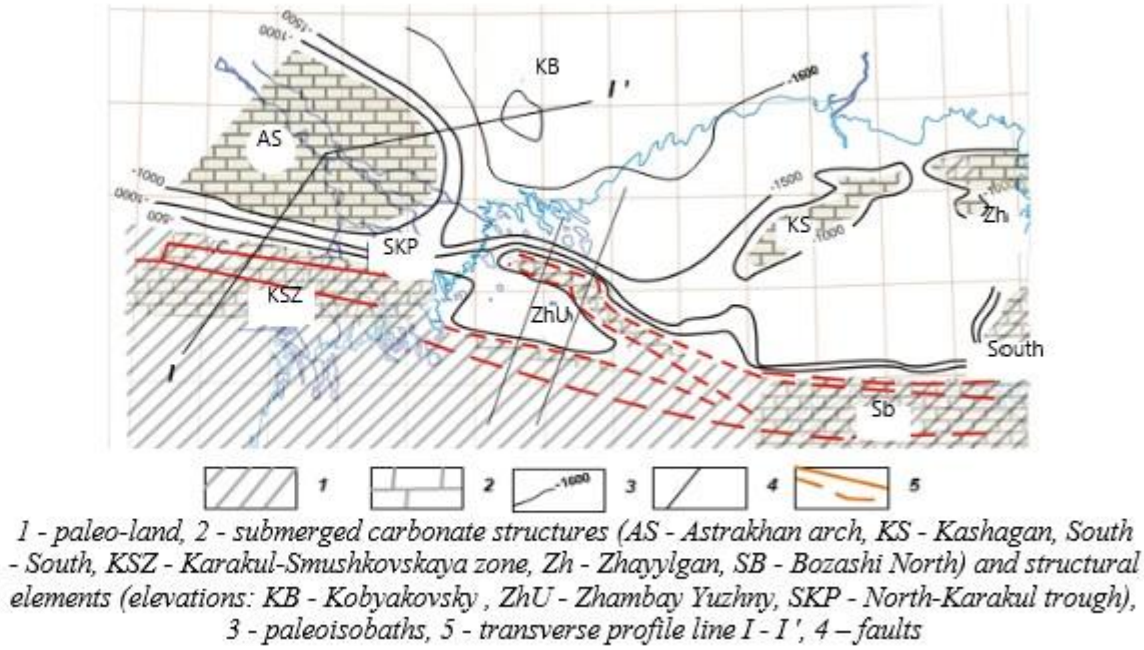

Fig. 4. Paleobatimetric diagram of the south of the Caspian basin in the pre-Martian time (compiled by O. Obryadchikov, 2018)

blocked the KSZ coal carbonates, the North Karakul trough, and the southern part of the Astrakhan arch (**Fig. 4**). A powerful flexure of the wedge-shaped structure was formed. The thickness of the Artin deposits in the south of the arch reached 1700 m, in the arched part within the Astrakhan uplift - about 100 m, decreasing to the edge of the carbonate megabank to 60 m. Then it sharply increases behind the carbonate ledge in the so-called "Volga Trough" to 500 m or more.

The connection of the Pre-Caspian basin with the Paleo-Tethys Ocean has ceased. An analysis of seismic and geological profiles and the thickness of redeposited clastic rocks indicates a high occurrence of pre-Artinian deposits and their deep erosion.

The Pre-Caspian basin at the beginning of the Artinian century was connected to the World Ocean only through the narrow Ural trough. Taking into account the total height of the Upper Devonian-Tournaisian, Visean-Lower Bashkir and Kashir-Artinsky carbonate ledges, minus the thickness of the terrigenous sediments of the Lower and Middle Carboniferous, partially compensating for the basin, we can estimate the depth of the Pre-Kungur basin near its western border of about 1 km.

The formation of the Karachaganak atoll-like carbonate massif is associated with an inversion uplift at the beginning of the Middle French time (Obryadchikov, 2006; Obryadchikov & Maksimov, 1984). The section of well D-1 Karachaganak, in which shallow-water carbonates of the Middle Frasnian age were discovered, testifies to this. The absence of the latter in the dr-6 and g-15 wells of Karachaganak is explained by the rise of the central part of the block at the end of the French century and the erosion of middle-upper fern carbonates. Above, an atoll-like carbonate massive structure was formed, with a height of more than 500 m. Upper Devonian-Tournaisian deposits were discovered in the UGS-3 well in the interval 6928-7006 m in the deep-water basin facies (Kuandykov, Matloshinsky, Sentgiorgi et al., 2011). Here we estimate the depths of the basin in the Devon at hundreds of meters with their subsequent increase. The change in the regional slope at the beginning of the late visa that we noted earlier, we now reflected in the changes in the paleo-depths of the basin. Of course, this affected mainly the position of the carbonate Upper Isaic-Lower Bashkir structure, which shifted relative to the Upper Devonian-Tournaisian and occupies only the western and central parts of the massif. Depths in the middle of the Bashkir century, the pre-Permian ascent, followed by a sharp dip immediately after it, were also taken into account. Thus, the Lower Permian deflection of the eastern part of the region was approximately twice as large as in the western regions.

Touching upon the peculiarities of the formation of the eastern and southern margins of the Pre-Caspian basin, we note that a significant area of its southern and eastern framing during the Upper Paleozoic was characterized by shallow-marine sedimentation conditions. In this regard, development and shallow-water sedimentation in the east of the Pre-Caspian Basin are somewhat detached. Under these conditions, the separation of reef structures in the deep waters of the basin is unacceptable if there is no evidence of the presence of a paleo-shallow-water area.

A. On the eastern side, the territory in question covers most of the Aktobe region. Here, the eastern border of the Pre-Caspian basin is drawn along the Izembet fault, beyond which is the Mugodzharsky orogenic massif. In the northeast, it is traced along the Aktobe folds (Zamaryonov, 2001). Historically, having broken away from the EEP at the end of the Proterozoic, the VPB foundation, shifting, became close to the Mugodzharsky microcontinent. The elevated shallow-water areas of the foundation relief — the Enbeksky ledge and individual inverted elevated blocks — are distinguished. As an example, for this, we note the area of the G-5 Akzhar Vostochny well.

In the Middle Devonian, shallow-water carbonate deposits accumulated, forming carbonate massifs of various sizes. The minimum marks of the paleorelief of the bottom of the pool were confined to them. At the beginning of the Late Devonian, the Mugodzhars rose and became a major supplier of clastic material to the Caspian basin. Under its weight, the eastern part of the VPB caved in. At this time, the formation of the basement of the Temir carbonate massif over the Enbek ledge continued, since coeval terrigenous deposits were deposited at its eastern edge at a relatively greater depth and did not interfere with shallow carbonate sedimentation at its top.

The growth of the Temir carbonate massif (**Fig. 2**) continued until the middle of the Bashkir century. As already mentioned above, at this time, the central regions of the Pre-Caspian Basin experienced immersion, and the top of the Temir Massif was below the level of shallow-water sedimentation.

By the beginning of the late visa, the removal of terrigenous material from Mugodzhar formed a vast area of paleo-shallow water, which is located between the latitudes of the Alibekmol structures in the north and Tuskum in the south, extending 60 km towards the central regions of the Pre-Caspian region and capturing the adjacent foamy part of Mugodzhar. At this place, a carbonate Zhanazhol-Tortkol platform with a thickness of KT-II arose, and along its periphery - chains of barrier reefs of the type Urikhtau, Kozhasai, Laktybai and others.

This conclusion is based on the fact that the accumulation of powerful shallow carbonate complexes is possible only in the absence of the introduction of terrigenous sandy-clay material. Among the clay clays underlying the KT-II strata, there are strata of sandstones and siltstones that could well form separate closed forms. Above KT-II, through the small interlayer of terrigenous rocks of Kashir-Podolsk age, a carbonate platform KT-I is located above, the age of which is from Podolsk-Balkovsky to Assel. On the Kozhasai-Laktybay site, the western edge of this carbonate platform is somewhat shifted eastward relative to the border along the thickness of KT-II.

Some researchers Zholtaev G.Zh., Abilhasimov, Kh.B. (1991) and Zamaryonov A.K. (2001). based on the interpretation of seismic information and deep drilling materials began to defend the point of view according to which the structures of Laktybai, Urikhtau and a number of other large objects were formed due to thrust from the east. However, this point of view for its full solvency is still quite vulnerable in some private areas. Thus, the time of thrust formation and the clear identification and position in the context of deep-sea analogues of the KT-I stratum are unclear, continuous tracking of the roof of subsalt deposits, etc. requires explanation. The formation of thrusts is associated with the pressure of the Mugodzharsky microcontinent. At the same time, questions remain about the time of formation of this violation and areas with products of destruction of the uplifted block. Especially if it is considered from the point of view of the analysis of the bathymetry of the basin.

To the north of the latitude of Tuskum, terrigenous material entered the Pre-Caspian basin from the end of the Assel to the Artinian centuries, inclusive. But to the south, carbonate sedimentation was noted, which is probably due to the leveling of the adjacent Mugodzhar territory and the practical absence of clay-sand rocks in the paleobasin, with the exception of a small paleo-channel section in the area of the Karate site. The presence of terrigenous Lower Permian rocks west of the Tortkol-Tobuskensky site can be explained by lateral transport from the northern territories.

Substantiated is the powerful removal cone of the Devonian-Lower Carboniferous complex on the Alibekmola-Laktybay traverse, as well as similar Lower Permian formations of high power, accumulating to the north. These forecasts allow us to highly assess the prospects of NAT in terrigenous subsalt deposits. The discovery of the large oil cluster Akzhar Vostochny proves the prospect of finding deposits in tar clay-carbonate sediments deposited in deep-water conditions behind carbonate ledges. Therefore, further work on the Akzhar Vostochny deposit necessitates the development of clear ideas about its geological model and the correct choice of directions for further work.

The structure of the southern and southeastern region differs from the conditions of the eastern region (side), taking into account sedimentation conditions. Here, on the Teresken-Diyar site, under the carbonate platform of the Late Visean-Sakmar age, layered terrigenous Devonian-Lower Carboniferous deposits occur. Their transportation to the basin, obviously, occurred from the southern end of Mugodzhar.

By the beginning of the late visa, the shallow-water zone spread east and south, expanding the area of the carbonate platform of the Late Visean-Sakmar age. In the Artinian century, sedimentation was carried out in a limited amount in the form of small inflows of sand and clay sediments from single erosive incisions. The depths of the basin near the Upper Visean-Sakmar carbonate

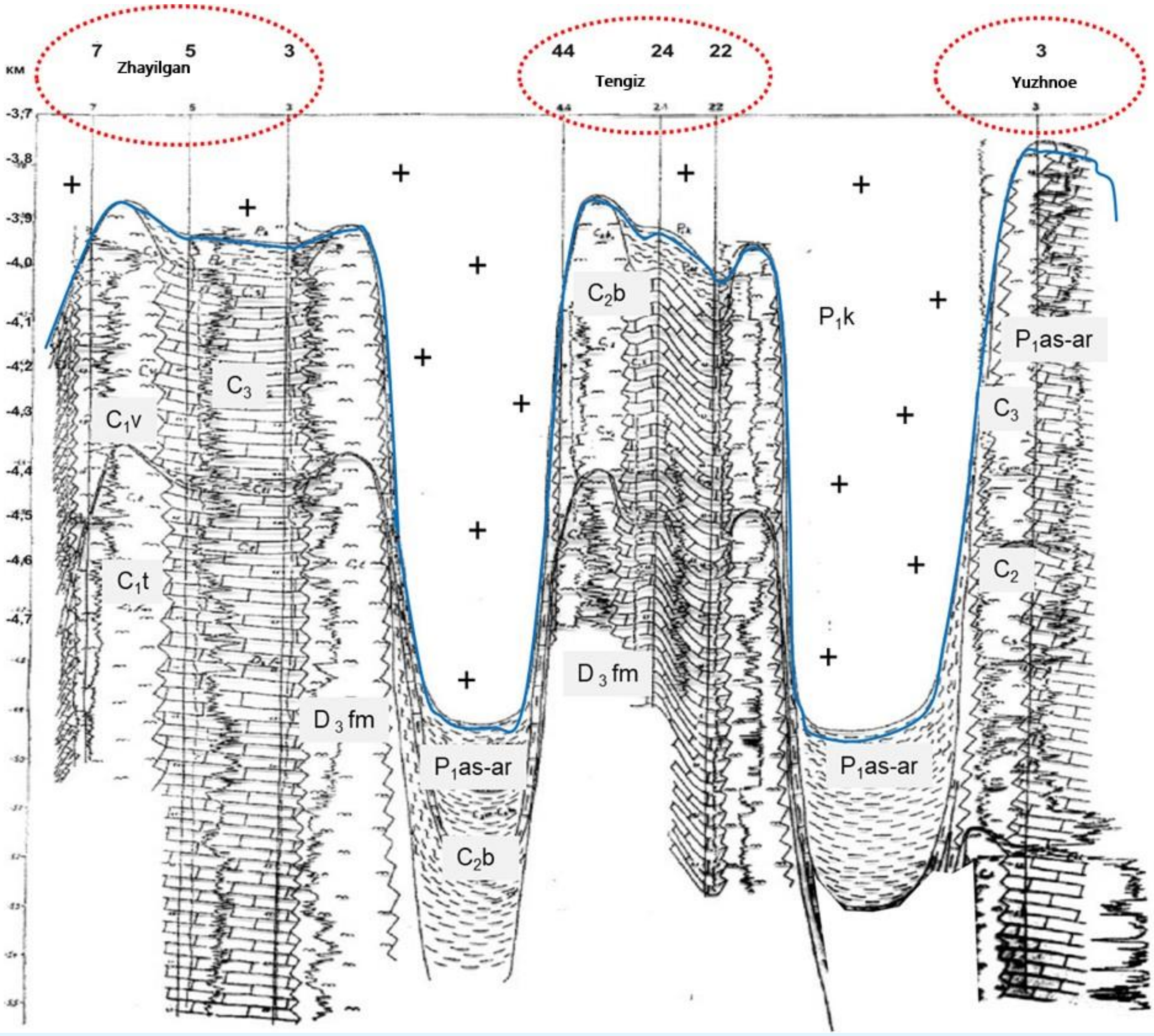

Fig. 5. Correlation profile section Zhayylgan - Tengiz – South (compiled by O.S. Obryadchikov, 2018)

ledge were more than 500 m, significantly increasing as they moved deeper into the basin.

In the east of the southern region is the South Emba Uplift, which is actually the southern continuation of the Zhanazhol-Tortkol carbonate platform. The location of the structures of the Minsualmass zone is associated with a right-sided shift of this territory (together with STP) in the pre-Martian time. Therefore, the Devonian, Carboniferous, and Assel-Sakmar basins of this region are considered in a broader version, since they spread south of the modern occurrence of their deposits. The western boundary of the shallow water zone of the Late Visean-Sakmara time included the Southern uplift and probably the territory of Bozashi. The accumulation of terrigenous deposits of the Devonian and Lower Carboniferous was due to the source of demolition in the east, where orogenic structures existed. Perhaps also, there was a supply of material from the south from the alleged and further elevated heights.

In the south of the pre-salt Caspian Sea, several unique hydrocarbon accumulations have been discovered. They are primarily associated with large and medium atoll-like carbonate structures - Tengiz, Kashagan, Korolevskoye, Kairan, Aktoty and Ansagan (**Fig. 5, 6**). With the exception of the Kairan cluster, they all formed and grew from the Devonian to the middle of the Bashkir century, after which their peaks were deeper than the shallow sedimentation level due to the general subsidence of the central regions of the basin. The growth of the carbonate masses mentioned above was interrupted during the Tula period. At this time, their peaks overlapped by the accumulation of tufargillites from above. But in a late visa - an early Bashkir, he continued.

The Assel-Sakmar reef-like superstructure in the west of the Primorsky (Zhyylgansky) atoll-like carbonate massif appeared due to the loss of a 30-meter-thick tuff-argillite sequence at the border of the Carboniferous and

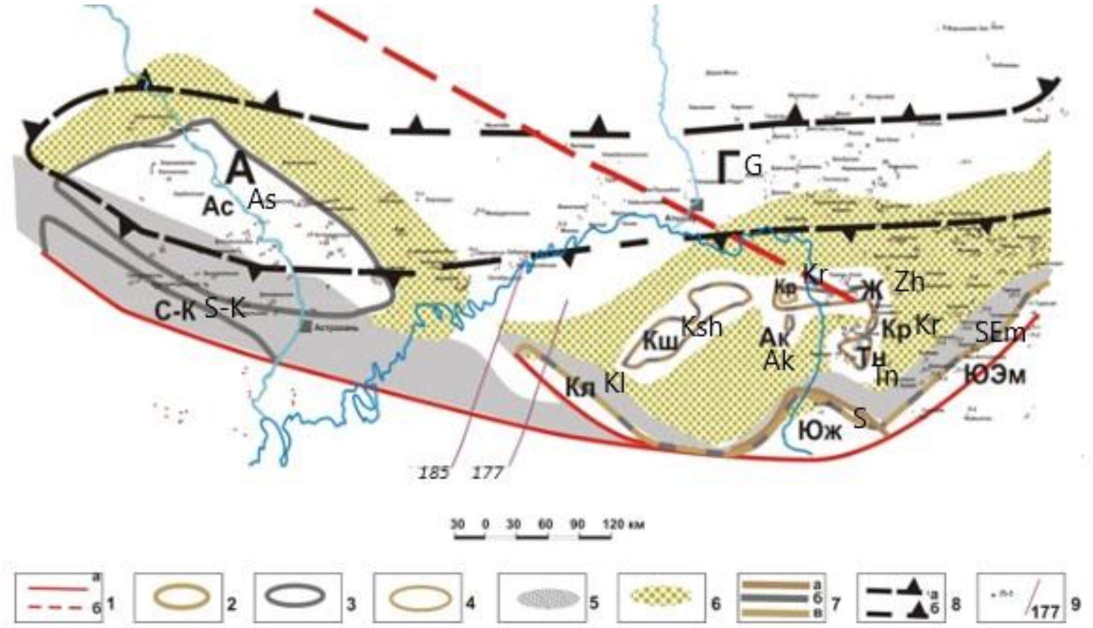

Fig. 6. The Paleozoic complex of the southern part of the Pre-Caspian basin.
Legends: 1 - faults: bead region and pre-bead region, b-Azgirsky; 2-4 - contours of carbonate massifs (2-Devonian-Tournaisian, 3-Lower Bashkir, 4-Assel-Sakmar); 5 - instrument cones of removal of artinsky terrigenous deposits; 6 - distribution area of oil-bearing clay-carbonate deposition deposits; 7 - age of the boundary of carbonate platforms: a-Devonian-Tournaisian, b-Lower Bashkir, c-Assel-Sakmara; 8 - the border of the Astrakhan-Aktobe zone of elevated bedding: a-confident, b-presumed; 9-wells and seismic-geological profiles.
Foundation ledges: A - Astrakhan, G - Guryevsky. Carbonate massifs and platforms: As - Astrakhan, Ksh - Kashagansky, F - Zhylgansky, Kr - Kairansky, Ak - Aktoty, Kr - Korolevskiy, T - Tengiz, SK - Smushkovsko-Karakulskaya, Kl - Kalamkas-sea, S - South, SEm - South Emba.

Permian periods, which formed a paleo-shallow-water section, which served as the basis for a reef structure up to 700 m high. mostly Tengiz deposit. All clusters are of massive type.

The first deep wells for subsalt deposits were drilled on Karatonskaya Square, which, as it turned out later, turned out to be the eastern part of a large Primorsky atoll-like carbonate structure.

The classic cross-hole arrangement confirmed the rise of carbonate coal deposits in the absence of rocks of the Moscow tier, Upper Carboniferous, as well as Assel and Sakmara age. Many researchers (some to date) explain this by erosion as a result of the inversion rise of blocks or the Pre-Caspian basin as a whole (Zhuravlev, 1972). When testing the wells, water inflows were obtained, which almost called into question the continuation of the search for saline oil. Then a profile of three wells was drilled on the Tengiz structure detected by the seismic survey, which led to the discovery of a unique oil cluster.

The Tengiz uplift is one of the most studied atoll-like carbonate massifs in the south of the Pre-Caspian basin (**Fig. 6**). The dimensions in the plan are about 500 km at an altitude of 1548 m. The structural plan of the surface of the Paleozoic complex has a triangular shape. Reef hills up to 80-100 m high stretch along the northern, eastern, and southern margins of the massif, forming a lagoon region in the central part. This is of fundamental importance, since it accordingly characterizes the distribution of precipitation types, as well as capacitive and filtration parameters.

The Upper Devonian-Lower Visean part of the carbonate massif has a similar structure. But due to the insignificant thickness of terrigenous sediments of the Tula age over reef hills, the hydrodynamic connection between the clusters in the Upper Devonian-Tournaisian and Upper Visean-Lower Bashkir complexes is apparently preserved. The conditional oil-water contact of the deposit was adopted at minus 5415 m, and the height of the massive deposit is minus 1548 m.

The absence of oil inflows in the first drilled wells in the Karatonsky area is due to the intersection of the Azgirsky fault massif, which was formed on the border of the Paleozoic and Mesozoic eras due to the split of the Turan plate and accompanied by this change in regional slopes in the south of the Pre-Caspian basin. As a result, a unique accumulation of oil (more than 10 billion tons) was destroyed and migrated up the section. At reef structures lying above the intersection marks of the Azgir fault, oil deposits were preserved under the Kungur saline cover (**Fig. 6**).

First, an industrial influx of oil was obtained at the Tazhigalinsky reef plant. In the G-13 well, at a bottom of 3819 m, an inflow of water-gas-oil mixture was obtained with an oil amount of 50-70 m3 / day. Oil and gas occurrences were noted in the wells of the Desert Square (G-5, 10). Then the Assel-Sakmara reef superstructure was opened in the west of the Primorsky massif, filled with oil and having a height of about 700 m.

Here, as in Tengiz, the idea of pre-Martian or Pre-Kungur erosion of coal deposits has no confirmation. Detailed seismic work clarified the structure of the Primorsky massif, identified early reef structures of the Early Bashkir age and mapped them, but, unfortunately, the intersection of the Primorsky massif with the Azgir fault has not yet been established. The importance of determining its location will probably make it possible to exclude some of the reef structures affected by it from promising sites and will facilitate the search for new deposits in suprasalt deposits. When developing a model of an oil deposit at the Kairan elevation, one should take into account the experience of working at a similar Karachaganak facility. Apparently, higher concentrations of oil will gravitate toward the eastern part of the reef building.

The discovery of the Kashagan carbonate massif was predicted back in 1984 (Obryadchikov & Maksimov, 1984). The Kashagan massif consists of two parts connected by a narrow strip. On the east side, it is complicated by reef superstructures curved in plan, which, as for the carbonate massifs described above, we connect with the directions of paleotrusion and paleo-winds that dominated the paleobasin.

In the marginal part of the Kashagan Vostochny structure, a raised (200–250 m) strip is distinguished — reef hills (Gabrielyants, Vishnevskaya, Pormeister& Aymagambetov, 2019). This zone represents the rim part of the reef. It should also be taken into account that the structure is somewhat inclined in a southwestern direction. The VOC of a massive deposit is defined at minus 4571 m, which is significantly lower compared to Korolevsky and Tengiz. Due to the low drilling depth of the reservoir, the construction of a geological and mathematical model (hereinafter - GMM) was carried out mainly on 3D and 4D seismic data. Critical remarks on the GMM of the Tengiz and Kairan clusters are also acceptable for Kashagan, whose geological resources are estimated at 4.8-6 billion tons.

Southwest of the Primorsky atoll-like carbonate massif, there is a small but similarly constructed Aktoty massif with dimensions of 6 km x 13 km and an altitude of more than 1000 m. The assumed GMM position is at minus 4582 m, which is determined by the depth of the isthmus separating it from the Primorsky massif. The open gas condensate reservoir is characterized by a high sulfur content in the condensate. The proportion of hydrogen sulfide and carbon dioxide in dry gas is 26 and 8.6%, respectively. The top of the massif is arranged in the same way as on the Tengiz uplift. A chain of reef hills is supposed to exist along the peripheral northern, eastern, and southern parts of the massif, and in the central part there is a lagoon opening to the west.

The Korolevskiy atoll-like carbonate massif is located between the Primorsky and Tengiz massifs and is characterized by a similar structure. Its top is formed by organogenic limestones of the Lower Bashkir, but their morphology requires significant refinement. The oil reservoir is characterized by abnormal seam pressure (ASP) (81.1 MPa), gas saturation of oil is 569 m3 / m3, the content of hydrogen sulfide in the gas exceeds 26%. The massive Korolevskiy Cluster and GMM deposits require significant improvement. The search for new organogenic massifs around Tengiz continued shortly after its discovery. To the west of it, the Ohai Rise as a reef massif was not confirmed.

The South Uplift developed as an organogenic carbonate massif, presumably from the Middle Devonian to the Sakmara century (**Fig. 6**). By the beginning of the Late Visean time, the paleo-shallow water zone extended from the Teresken-Diyar site to the Southern organogenic building. Atoll-like carbonate constructions of the Tengiz, Korolevskoye, Primorskoye, Kashagan, and Aktoty types were formed to the north in separate areas of the paleo-shallow waters from the Devonian time. Their growth continued until the middle of the Bashkir century, after which, due to the lowering of the central regions of the basin, their peaks were below the depth of shallow carbonate sedimentation and for a long period were paleotomic minus 60-100 m in Tula time due to the aerobic intake of powerful tuff argillite masses.

Many researchers do not explain the nature of the Tula mudstones that separate the Devonian-Tournaisian organogenic atoll-like structures and the Upper Visean-Lower Bashkir carbonates lying above them. At the same time, the hypothesis proposed by the authors of the deposition of tufous mudstone to the tops of organogenic massifs is not commented on.

So, in the middle of the Bashkir century, the territory of the Southern region regionally plunged, lowering the tops of the atoll-like massifs below the level of shallow carbonate sedimentation. The depth of the sea on the reef hills of the massifs is estimated to be about 60-80 m. The precipitation of tuff argillites also occurred in the Artinian age, covering all the peaks. In the Kairan section of the Primorsky (Zhylyoi) atoll-like massif, the deposition of tuff argillites supposedly occurred in the pre-Asselian time (**Fig. 7**). Their thickness was 30 m, which created a local area of paleo-shallow water and confirms the above-mentioned depth mark. Access to favorable elevations for shallow carbonate sedimentation led to the appearance of the Assel-Sakmarian atoll-like superstructure 350-400 m high.Therefore, by the end of the Artinian century, the basin depth at the foot of the atoll-like structures reached 1.5 km or more. The deposition of tuff argillites on the

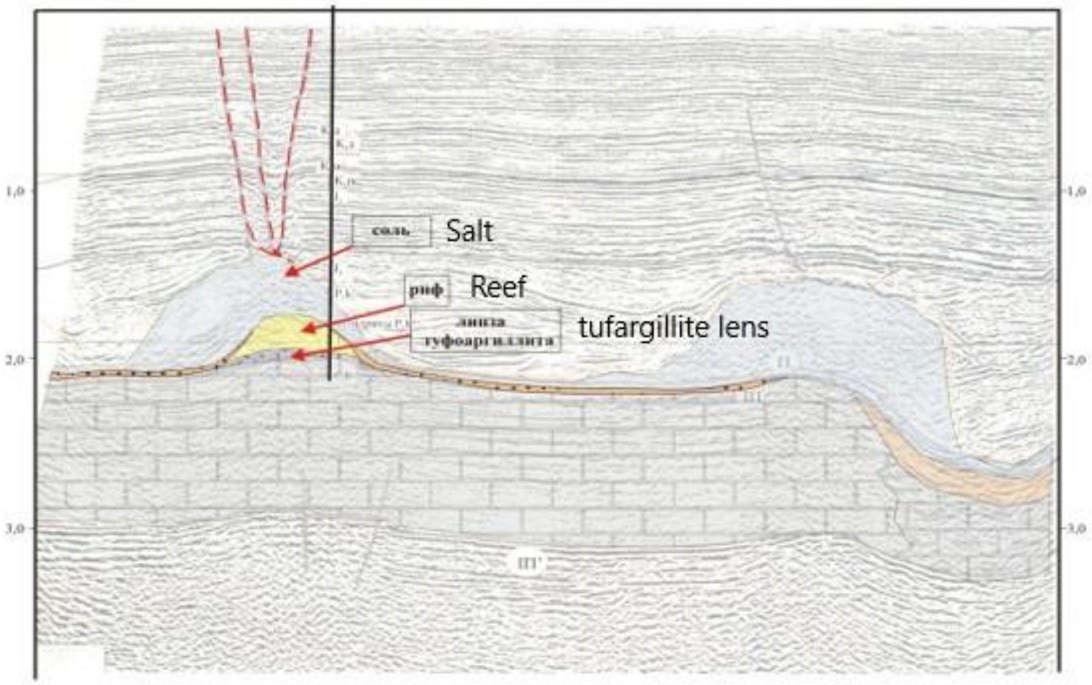

Fig. 7. Seismogeological section and trap model on the Kairan structure.

tops of atoll-like carbonate massifs contributed to the further growth of organogenic structures. Primorsky (Kairan site) massif - in pre-Assel time; The Tengiz, Kashagan, Royal, Aktoty, Primorsky (Karatonsko-Tazhigalinsky site) massifs - in Tula and Late Artinsky times; Karachaganak and the Astrakhan arch - in Tula time.

In the Kairan section in the west of the Primorsky (Zhyylgansky) massif, in the pre-Asselian time, the sea depth was 60-80 m (**Fig. 6, 7**). It was the loss of tuff argillites at this time that created the conditions for the growth of the Assel-Sakmarian reef structure.

Zholtaev G.Zh., Abilhasimov H.B., et al. (1991) distinguish in the terrigenous subsalt stratum, which, according to available faunistic definitions, belong to deposits of the Late Visean-Sakmara age, which closely coincide in terms of the cones of removal of clastic material into the basin from the side of the proposed uplift, located to the south. As is known, by analogy with this, it was initially assumed that the sections of wells drilled in the western region east of the carbonate ledges revealed carbon deposits. However, both of these ideas do not hold water. In both cases, faunistic sediments were redeposited: in the western region to the Late Bashkir, and in the southeast of the Pre-Caspian basin in the Artinsky time.

Until the Sakmar century, inclusive, through the territory of the Southern region, between the listed group of atoll-like massifs and the Astrakhan uplift, the Caspian Sea was connected with the Paleo-Tethys Ocean. Therefore, the depths in the territory of the modern Northern Caspian and, possibly, to the south exceeded 1000 m. Serious changes in the region occurred as a result of a right-hand shift of the enterprise standards (ES) and smaller elements adjacent to it. Their movement and rise led to crushing of the layers and the displacement of individual parts. As a result, during the Artinian century, a large amount of clastic material was carried into the basin. The depths of the pool have changed dramatically. For the Caspian Sea, its connection with the Paleo-Tethys ocean ceased and the southern side zone took shape. By the beginning of the Kungur century, the marginal part of the basin shifted north. In separate basins near the southern border of the basin, the depths were only a few hundred meters. The Kalamkas-Sea oblong block was torn off and moved from the Bozashi region.

B. Features of the formation of the central regions of the Pre-Caspian deep-sea basin.

Segregation in Precambrian and a 100-150 km displacement of the southeastern margin of the EEP led to the formation of a suboceanic crust between them. Subsequently, the VPB (the southern and eastern parts of the modern basin) and the suboceanic crust of central basin separating it from the EEP merged into a single craton.

Initially, in the 1950s and 1960s, it was assumed that the Pre-Caspian Basin in the Pre-Kungur Paleozoic developed and expanded eastward from the Lower Volga (Kazakov et al., 1958). In favor of this, it was believed that sections that were close in lithological composition were uncovered by wells at the Yuzhno-

Emba uplift and in the instrument areas of Volgograd, Saratov, and Orenburg. Basin itself, according to researchers, was established in the Kungur century, which was accompanied by the accumulation of large salts. In the 60-70s, it was established by geophysical methods that the foundation of the central regions of the Pre-Caspian region has a suboceanic type of consolidated crust. The southern and southeastern part of the region, according to seismic data, is characterized by a continental type of foundation. According to the ideas of the GIN RAS and Lower Volga Research Institute of Geology and Geophysics, the foundation is of Baikal age (Volozh & Parasyna, 2008; Yatskevich, Mamulina & Scheglov, 2003). By sections of wells drilled in different parts of the instrument zones and in the inner regions of the basin, a change in the sedimentation conditions of pre-Kungur deposits was proved: the transition of shallow formations in the onboard zone to accumulation in the central parts of their deep-sea analogues. A significant discovery was the discovery of large atoll-like carbonate massifs, which are associated with unique accumulations of hydrocarbons.

Researchers estimate the depths of the Paleozoic basin differently. According (Volozh & Parasyna, 2008; Yatskevich, Mamulina & Scheglov, 2003), a deep-water basin was formed in the Early or Middle Paleozoic time. It is assumed that the territory of the modern Astrakhan-Aktobe elevated bedding was dry land or shallow-water (Volozh & Parasyna, 2008). However, this is refuted by the limited distribution of carbonate massifs, their confinement both to areas of elevated basement (Astrakhan and Temirsky), and to its slopes and even dives (Kashagansky, Primorsky, Aktoty, Korolevsky and Tengiz). As noted above in the territory of the Eastern and Southern regions, the peripheral regions facing the adjacent orogenic structures were submerged in the Devonian and Early Carboniferous.

By the middle of the Bashkir century, the depths of the Pre- Caspian basin increased to 1000 m and more. During breaks of carbonate sedimentation from the EEP, detrital material was removed. The material entered through the incisions of river valleys passing along the basins of the ancient paleorelief, forming outflow cones behind the previous carbonate ledges. The latter partly changed paleobatimetry in the instrument zone, which was subsequently reflected in the planned shift in the position of the carbonate ledge relative to the overlying stratum.

Let us consider how the sea depths varied from instrumented areas to the central basin throughout the entire Paleozoic. Starting from the Devonian period, and most likely from the Proterozoic, most of the Pre-Caspian basin developed as a basin, which at the beginning of the Paleozoic and at least the Devonian was only partially filled with sediments. Starting from the Eiffel Age, it can be confidently stated that the basin depths exceeded 100 m. Later on, they mainly increased even during the periods of terrigenous sedimentation. Some areas experienced inversion shifts, which locally or zonally expanded the areas of pale shallow water and, accordingly, increased the zones of shallow carbonate sedimentation.

The depths of the Pre-Caspian basin by the beginning of the Kungur century in the central regions reached 1,500 m, possibly exceeding them. Consequently, a thick saline stratum began to accumulate in deep-water rather than shallow-water conditions, according to Yu.A. Volozh (Volozh & Parasyna, 2008).

RESULTS AND DISCUSSION

The high efficiency of applying new teaching methods and “approaches” in assessing the paleotectonic development of the Pre-Caspian basin is confirmed by the following examples.

In the east of the Pre-Caspian region, taking into account the relationship between the development of the basin and the migration of carbonate ledges, the influence of faults with the volume of filling strata, and breaks in sedimentation made it possible to substantiate the contours of the Zhanazhol-Tortkol and Temir carbonate platforms. They, in turn, fully determine almost all favorable zones for oil and gas accumulation and control the productivity of the carbonate strata KT-I and KT-II.

On the southern, southeastern and northern rim of the basin, an analysis of all available basin data makes it possible to diagnose areas of carbonate, carbonate-terrigenous and mainly terrigenous sedimentation. Along the side, trends of structural forms are characteristic, marking large protrusions associated with the development of peculiar sedimentation zones (levels). As a result, the forecast of a more submerged sedimentation belt and the formation of large elevations Kuznetsovsky, Kuznetsovsky Vostochny, Fedorovsky, Karachaganak and Berezovsky is justified in the north. At the same time, the forecast of the area of carbonate-terrigenous and terrigenous sedimentation in the latitudinal strip of large elevations of Koblandy-Tamdy-Shirak is substantiated on the northeastern frame.

Special attention should be paid to the Upper Devonian-Lower Carboniferous deposits, the development and distribution of which is well connected with the main conclusions of the performed paleobatimetric analysis of the sedimentation basin. The characteristic development of the main tectonic elements of the southern and eastern parts of the Pre-Caspian basin is noted (Astrakhan arch, Atyrau-Shukat system of ledges, South Emba uplift, Karaton-Tengiz and Temir-Zhanazhol uplifts). The differentiation of these regions depending on the elevated and, relatively, lowered occurrence of the basement surface determines the high prospects and prognosis of large-sized non-anticlinal trap in the Devonian and Lower Carboniferous deposits (Soloviev, Nemtsov, Obryadchikov et al., 1989). The structural features of large elements and megastructures in these areas make it possible to predict, respectively, large-sized traps. Examples are the proven presence and oil and gas potential of non-anticlinal trap on the Tasym uplift of the South-East (Atyrau-Shukat system of basement ledges) and the Tasym-Elemessky area (southwestern pericline of the South-Yumbinskaya uplift) in the Carboniferous deposits, representing the area surrounding the large ledge of the basement (Soloviev, Nemtsov, Obryadchikov et al., 1989).

According to the results of paleobatimetric analysis, the formation of the modern structure of this site and traps as a result of the subsidence of the territory under the weight of accumulated sediments (the principle of "isostasy"), the formation of a subsalt stratum in the north and south, extended elongated deflections are justified by the example of the Tortai - Plain - Molodezhnaya structural line.

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Given these factors, a significant increase in the forecasting efficiency of large hydrocarbon accumulations is expected due to a comprehensive study and forecast in the Paleozoic stratum of the non-anticlinal trap. At the same time, the possibilities for further clarification of some important issues of a regional and applied nature, which are as follows, are significantly increased.

Evaluation of the characteristics and the selection in the conceptual plan of oil and gas source formations, clarification of their relationship with open hydrocarbon deposits allows us to justify the prerequisites for the genetic classification of structures associated with non-anticlinal trap. The classification of traps on a genetic basis, in practice, reflects the conditions and characteristics of sedimentation.

Taking into account the analysis of the conditions of sedimentation and a separate examination of areas with a lowered and raised bedding of the basement roof in the contour of the strip of latitudinally elongated projections of the basement in the southern part of the Pre-Caspian Basin, the views on the model of the structure of large uplifts in the Paleozoic stratum are substantially refined.

An analysis and refinement of the regularities of OG P_3 tracking allows one to evaluate the nature and more complete composition of the section, structural features of the Pre-Devonian, Lower-Middle Devonian and Upper Devonian-Tournaisian sequence. The identification of the relationships between the patterns in changes in the thicknesses of these complexes between different regions makes it possible to preliminarily evaluate the propagation zones of large non-anticlinal traps.

CONCLUSION

The above material and the features of the paleotectonic development of the Pre-Caspian basin in the Paleozoic make it possible to formulate the following main conclusions.

1. The following important regional factors (events), which determined the main structural features of the Paleozoic stratum and influenced the change in sedimentation conditions, are substantiated.

- Immersion of the central regions and instrumentation zones of the basin in the middle of the Bashkir century with the location of the peaks of atoll-like massifs below the level of shallow-water carbonate sedimentation, and therefore, sediments did not accumulate on these massifs for a long time.
- The right-hand shift of the STP at the turn of the Sakmar and Artinsky centuries, which led to the isolation of the Pre-Caspian basin from the south and overlapping in several places of the Ural marginal trough and in the future - the creation of conditions for evaporite sedimentation.
- The activity of powerful cones for the removal of coastal shallow water in the lower Permian in the east and southeast of the Pre-Caspian basin and, possibly, in the Devonian-Lower Carboniferous sediments under conditions of a relatively deepwater part of the sedimentation basin.
- Geodynamics and changes in paleobatimetry of large tectonic elements (the basement basement as part of the ancient Russian plate, the Mugodzharsky microcontinent, etc.), which had a significant impact on the formation of the eastern side of the Pre-Caspian basin and favorable conditions for the development of the Temir and Zhanazhol-Tortkol carbonate platforms
- Inversion processes of large basement blocks in the Middle - Upper Devonian, which resulted in the formation of shallow-water carbonate sedimentation zones mainly in the southern part of the Pre-Caspian basin.

2. Clarification of the features of the paleotectonic development of the Paleozoic stratum based on the study of paleobatimetry of the marine basin show high efficiency in an objective assessment of the situation and conditions of sedimentation. In general, a comprehensive analysis taking into account the paleo-depths defines an almost new approach in the reconstruction of the marine sedimentation environment for the specific conditions of the Pre-Caspian basin.

3. Assessment of the prospects and forecast of oil and gas structures based on this approach takes on a more detailed and objective character. The possibilities of paleotectonic analysis should be expanded in assessing the conditions of sedimentation and determining promising oil and gas regions and large elevations by using data from analysis of potential fields.

4. The results obtained more fully characterize the specific conditions and features of sedimentation in the Paleozoic complex of the Pre-Caspian basin. Because research methods include common data processing and analysis procedures (primary and borehole data, results of paleotectonic analysis, time and depth seismic sections). As can be seen from experience, in the majority of all the noted “tools” of basin analysis allow reconstruction of sedimentation conditions at a fairly high level and justify regional structural features in connection with the manifestations of fault tectonics and movements of basement blocks.

5. Based on the analysis and synthesis of data on the Pre-Caspian basin, the range of possibilities for prospecting geology and exploration production as a whole is expanding due to the forecast and study of nonantical trap. The proposed methods and approaches in studying the features of paleotectonic development and sedimentation conditions allow expanding the direction of research on the forecast of new large promising search objects. Without a doubt, this direction of comprehensive research requires its continuation and further development.

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