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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

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ГЕОЛОГИЯ ЖӘНЕ ТЕХНИКАЛЫҚ ҒЫЛЫМДАР СЕРИЯСЫ

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СЕРИЯ ГЕОЛОГИИ И ТЕХНИЧЕСКИХ НАУК

♦

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THEORETICAL FOUNDATIONS ON ESTIMATION OF OIL AND GAS POTENTIAL PERSPECTIVES OF PALEOSOIC SEDIMENTARY BASINS OF KAZAKHSTAN

Abstract. According to the results of the paleotectonicregime reconstruction from the position of plate tectonics, seven types of Paleozoic sedimentary basins are distinguished, which are significantly different in the sedimentation conditions, oil and gas generation potential and accumulation. These sedimentary basins are continental; passive continental margin`s basins, back-arc and inter-arc basins. A differentiated approach with accounting of geodynamic evolution in the identification of structural and formation complexes that correspond to the main stages in the basins development history and the reconstruction of the features of oil and gas formation and accumulation conditions at each stage with a change in the development regime allow us to identify the main areas of searching for new oil and gas accumulations in each basin.

Keywords: plate tectonics, geodynamic evolution, basin, spreading, subduction, rift, oil and gas generation.

Introduction. In Kazakhstan, fifteen petroleum-bearing and promising for the exploration of oil and gas sedimentary basins are known:

Most researchers distinguish basins of three types, located on an ancient platform, on young platforms and intermontane.

Known maps of the oil and gas bearing areas of the USSR, edited by A.Sh.Shardanov and L.N.Rozanov (1983), V.V. Semenovich, G.K. Dikenstein (1984), a map of the forecast of oil and gas potential of Kazakhstan, edited by O.A. Akchulakov (2000) and Daukeeva S., Uzhkenova B.S., Abdullina A.A. and others (2002). They were based on the doctrine of platforms and geosynclines and showed the stratigraphic range of the sedimentary cover, the main stages of their deflection, and the structural and morphological features of the structure (uplifts and deflections of different scales). The main factors, such as the formation (genesis) of the basins, their geodynamic conditions of evolution, which predetermined the conditions and the rate of sedimentation, the dynamics of the change in the climatic and thermal regime and their relation and relationship with framings of various nature were not taken into account. Without taking into account these factors, the forecast and assessment of the oil and gas potential of the basins in the current stage of development of geological thought and science in the geology of oil and gas are impossible. These shortcomings are largely taken into account and eliminated in the approach to the study and classification of basins and to oil and gas geological zoning from the standpoint of plate tectonics theory.

Proceeding from the position of plate tectonics, we reconstructed the paleotectonic regime for the development of a vast territory from the Kazakh massif in the east to Voronezh in the west and from the northern borders of Kazakhstan to the Kopetdag dislocation systems in the south. The obtained results indicate that the majority of Paleozoic sedimentary basins were formed as a result of the development of the Ural-Tien-Shan Paleozoic ocean between two lithospheric slabs of the East European and Kazakhstan.

Each pool is different. The degree of prospectivity of each of them depends on the volume and nature of sedimentary filling and the geodynamic development regime. These factors ultimately predetermine the possibilities of generation, accumulation and conservation of hydrocarbons. The lion's share of the explored reserves and the forecast resources of Kazakhstan's oil and gas are confined to the Paleozoic basins.

The pools underwent a complete cycle of geodynamic evolution. In the early divergent period of the cycle, in the situation of prevalence of continental divergences, sedimentation and, consequently, oil and gas formation processes occurred in rifts, sub-rhythmic zones of bending and on passive continental margins.

On the territory of Kazakhstan, basins are developed on the passive continental margin, not transformed by the subsequent collision of two plates that led to the formation of the Ural fold system, both the Eastern Caspian and the basins on the passive continental margin transformed by the collision of slabs like Torgai and Syrdarya, and in Perm, developed in geodynamic conditions of back-arc basins.

The average period of the geodynamic cycle is characterized by the collision of two plates with the predominance of horizontal displacements, the formation of the Ural fold system and the activation of volcanism on the marginal parts of the Kazakhstani approaching plate, as a result of which the Valerian-Beltau-Kuramin volcanic arc was formed. The final period of the geodynamic cycle is characterized by isostatic alignment, which occurs with different intensities on various structural elements of the Eurasian lithospheric plate formed after the closure of the Ural Ocean at the end of the Paleozoic, and this process was accompanied by the formation of new rift structures like the South Torgai and the outflow of trap basaltic volcanism in the early Triassic on the North Torgai trough.

The oil and gas content of the basins is in a functional dependence on sedimentation, i.e. the greater the volume of precipitation, hence the volume of buried organic matter, the rate of their accumulation, the degree of warmth, the greater the probability of oil and gas formation processes. Since the nature and type of sedimentation, in turn, is predetermined by the geodynamic situation, the classification and assessment of the prospects for the oil and gas potential of the basins should be based on the results of the study of the paleogeodynamic evolution.

Taking into account the peculiarities of the geodynamic formation regime, it is necessary to distinguish seven types of Paleozoic basins in Kazakhstan. This is the basin of the passive continental margin of the Eastern Caspian, formed on the passive edge of the Ural Ocean in the Devonian and Carboniferous periods, the inland Central Central Caspian, the Tengiz and Shu-Sarysu basins within the Kazakhstan plate, the subripit South-Caspian, the marginal (southeastern) North Ustyurt, Torghaysky and Sirdarya, which developed in the Devonian and Early Carboniferous in the regime of the passive continental margins of the Kazakhstani plate, and in the late Carboniferous and Permian in the regime S arc basin.

In the Ural-Tien-Shan system, in addition to the main folded arc, as noted above, a volcanic arc that unites the Valerian and Beltau-Kuramin volcanic zones is clearly traced. Between the two arcs in the section of the Ural system turning to the Tien Shan, another type of intercurrent East-Aral basin was formed. This approach to the classification of basins based on the geodynamic conditions of their formation allows one to approach differently to each basin and each complex corresponding to the major stages of basin development in assessing the prospects of their oil and gas potential.

A schematic diagram of the formation of the above-mentioned Polozoo sedimentary basins is presented in the following sequence. The pre-Paleozoic (the first cycle of geodynamic evolution) and the Early Paleozoic (second cycle) history of the territory under consideration can be recovered in general terms, since the deposits of Riphean, Vendian, Cambrian, Ordovician and Silurian have been studied only in outcrops in the Urals and in the Kazakh, Ulytau and Karatau massifs and fragmentarily on Sultanuizdag and Northern Tien Shan. According to these data, it can be concluded that at the end of the Riphean and at the beginning of the Vendian, Eastern European and Kazakh lithospheric plates existed there. In addition to these surviving large slabs, there was the Ural-Tobolskmicroplate, broken off from the main plates by faults and rift zones.

Within the study part, the Eastern European continent consists of two parts. The north-western part of it is a continuation of the Archean-Karelian age of the oldest massifs of the Voronezh and the Volga-Urals. At present, within the Caspian syneclise, the surface of the ancient foundation is submerged to a depth of 18–20 km. The relatively young south-eastern part of the Riphean age formed approximately 1.7–1.0 billion years ago. The zone of articulation of these two uneven-aged parts of the southeast of the East European continent probably corresponds to the Astrakhan-Aktobe system of uplifts.

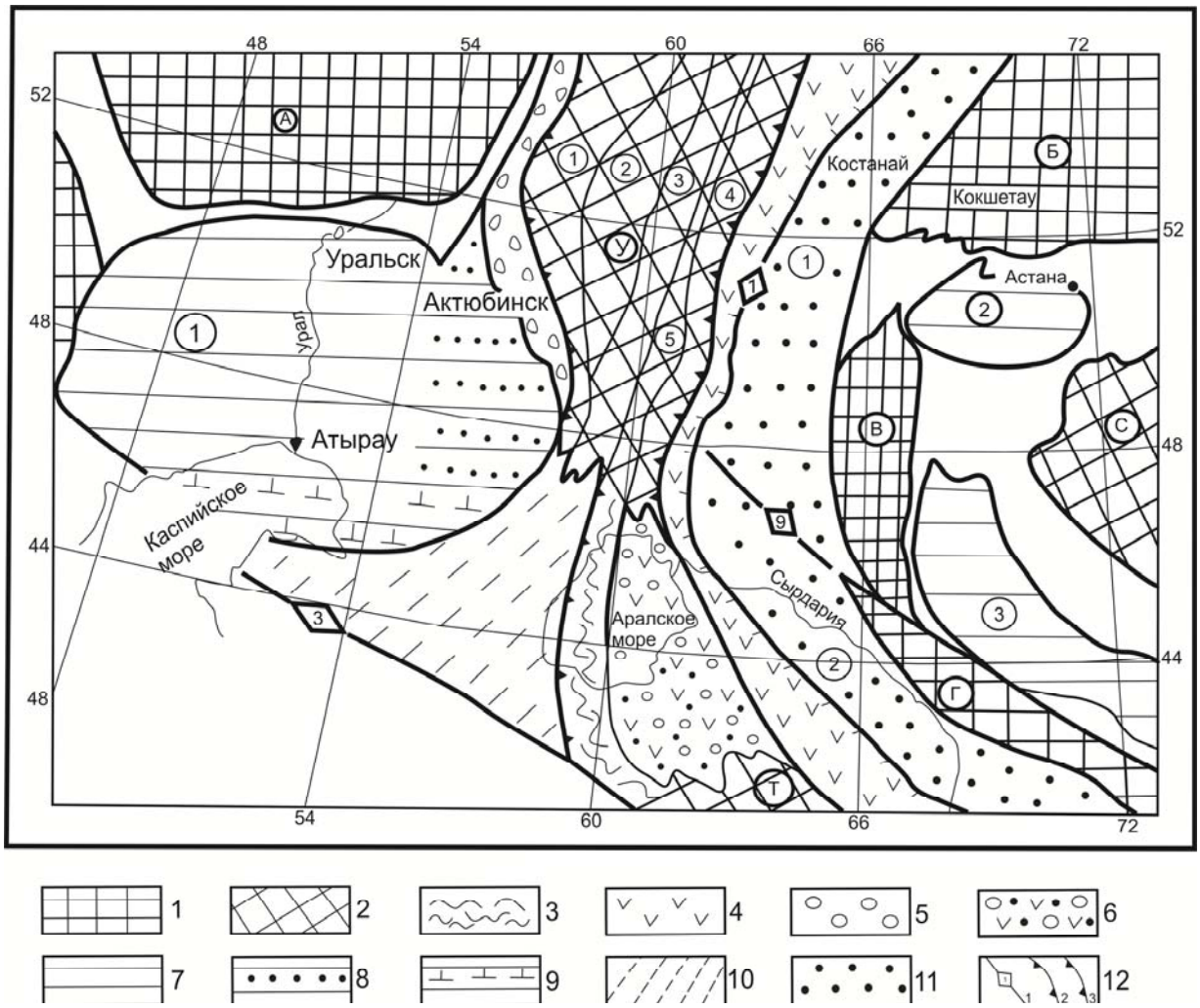

Figure 1 – Layout of Paleozoic sedimentary basins:
1 – Ancient Precambrian uplifts: A – Volga-Ural, B – Kokshetau, B – Ulytau and G – Karatau; 2 – fold systems: U – Ural: zones: 1 – Urals, 2 – Magnitogorsk, 3 – East Urals, 4 – Denisovskaya, 5 – Irgiz; T – Tien Shan and S – Selectin; 3 – Aralo-Kyzylkum folded arc; 4 – Valerian-Beltau-Kuraminskaya volcanic arc; sedimentary basins; 5 – pre-arctic Predural; 6 – intercurrent East Aral; 7 – inland: 1 – Central Caspian, 2 – Teniz, 3 – Shu-Sarysu; 8 – East-Caspian passive continental margin; 9 – the sub-arctic South-Caspian; 10 – the North-Ustyurt regional; 11 – back-arc: 1 – Torgay, 2 – Syrdarya; 12 – 1 – regional faults: 1 – Lebanon, 2 – Karatau, 3 – Mangyshlak; 2 – thrusts and 3 – ups.

The Kazakhstani component consisted of various ancient massifs: Kokshetau, Ulytau, Shuisky, Syrdarya and Precambrian blocks of the Northern Tien Shan.

The most ancient gneiss domes (the Serebryan complex of the Kokshetau Massif and the Ulytau Bekturgan Series) are more than 1900–1800 million years old, they constituted the most elevated part of the Kazakhstan continent, which was repeatedly crushed in the Riphean and Early Paleozoic. As proof of the existence of a single continental basis in this vast territory, the widespread distribution of pure quartz sandstones, converted into quartzites, having an age of 1100–900 my, can be cited. These quartzites form the Kokshetau suite on the Kokshetau massif, Ustobinskoye on Ulytau and the Uchkashoy suite on the Kirghiz ridge.

The large tectonic activity of the Kazakhstani continent was presumably predetermined by its position between the two oceans – the Doura and Paleo-Asiatic oceans. All the ancient massifs welded together by zones of Caledonian folding, called plastic (Akramkhodzhaev, Yuldashev, 1988) or suture (Abdulin, Shlygin, 1982), or from extremely fixed positions of geosynclinal zones, appeared at the beginning and during the development of the Ural-Tien Shan ocean in the form of a single Kazakhstan continent.

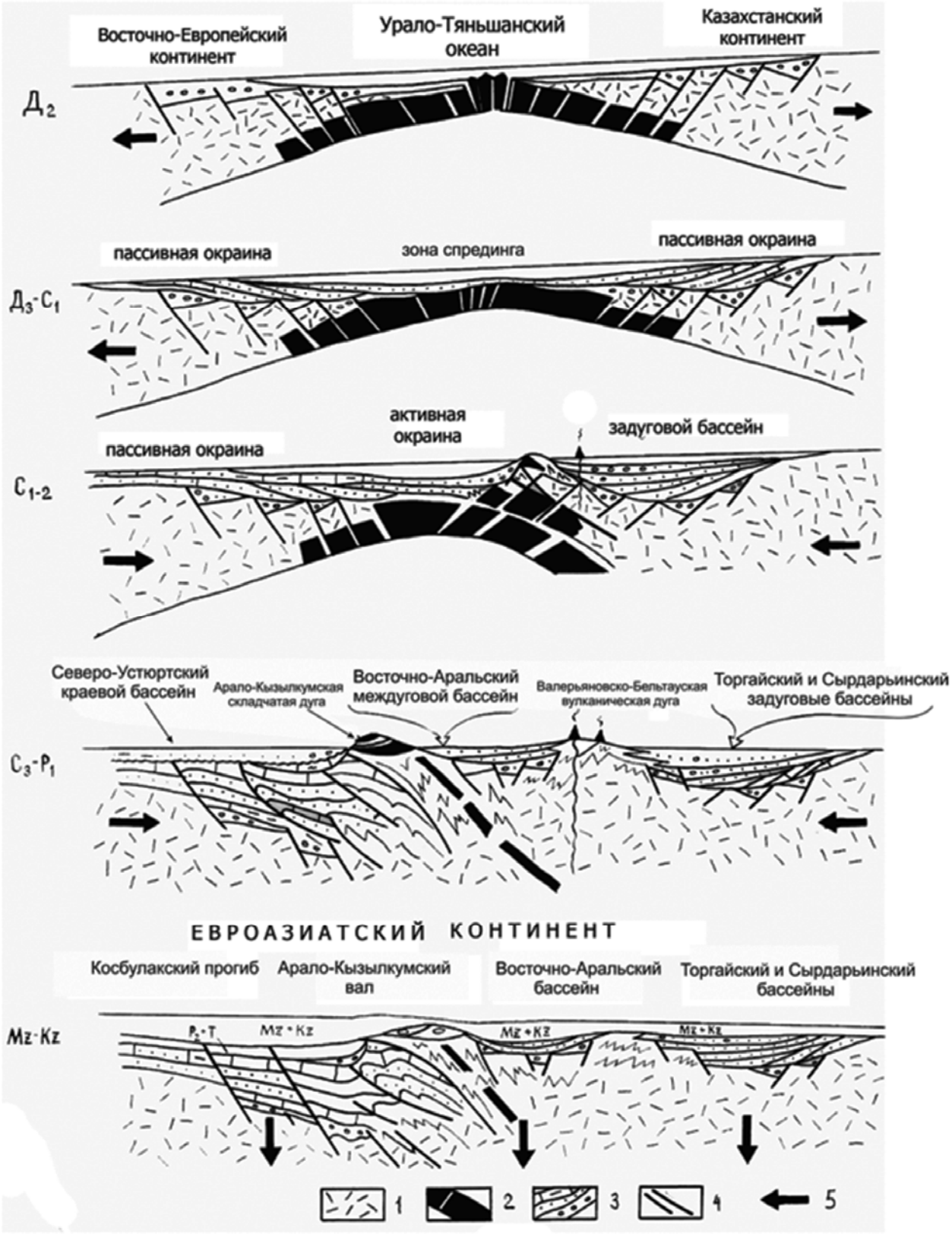

Figure 2 – Scheme of evolution of the Ural-Tien-Shan paleoocean:
1 – continental crust, 2 – oceanic pair, 3 – sedimentary cover, 4 – faults, 5 – direction of interleaving plates.

Due to better exposure and opening of the Devonian, Carboniferous and Permian sediments by boreholes, it is possible to more reasonably determine the geodynamic position of each major tectonic element relative to the Ural paleoocean in the third development cycle (Figure 2), which resulted in the formation of the now known oil and gas bearing Paleozoic basins. In particular, the entire eastern margin of the East European plate was a passive western, in current coordinates, continental margin of the Ural paleoocean with a characteristic type of sedimentation and characteristic changes in the facies and thicknesses of precipitation. The Ural-Tobolskmicroplate was located east of the paleo-ocean spreading axis, i.e. closer to the Kazakh plate. Probably, in the second cycle of geodynamic evolution, the pre-Ural Early Paleozoic paleo-ocean extended to the territory of not only the present Ural fold system, but also to the east, encompassing the Denisovskaya, Valerianovskaya, Kostai (Borovskaya) and partially Ubagana zones to the western border of the Kokshetau Massif, representing the edge of the ancient Kazakhstan plates. In this early period of the ocean's development, the siliceous deposits of the Lower Paleozoic age probably originated in the central, deep, remote parts of the paleoocean from the shore. Separate fragments of the ocean floor are traced in Denisovo zone, ophiolitic associations Ordovik - Silurian (Venlok-udlov) age.

The first major clash of the East European, Uraltausk, Ural-Tobolsk and Kazakhstan plates, probably originated in the Late Silurian and Early Devonian, which was accompanied by thrusting the Ural-Tobolsk and Kazakhstan plates to the west and the closure of the eastern branch of the Early Paleozoic Douralskogopaleoocean, as evidenced in the general the thrusting nature of the Denisov zone to the east. Formed as a result of the closure of Early Paleozoic Pre-Ural ocean mining systems have been eroded and the landscape was peneplenizirovan during the Silurian and Early Devonian and, since the late Middle Devonian, forming a system of rifts, inherited submeridnonalnye stretch of the previous cycle of the geodynamic evolution, from which originates the spreading process in the Devonian, i.e. formation of the paleoocean Ural of the Atlantic type. In Mugodzhary and in the Berchogur trough, L.P. Zonenshayn, V.G. Korinevskiy, V.V. Matevenkov and V.E. Hainym (1985) described the pillow-lavas of mid-oceanic ridges of the Devonian age. Passive continental margins were formed in the west on the edge of the ancient Precambrian East European plate in the east on the edge of the Kazakhstani plate on the folded metamorphosed Caledonian base.

In passive continental margin of the East European plate resulted in the formation of precipitation, passive characteristic of the surrounding sea with predominance terrigenous- carbonate rocks huge thickness coal-Late-age.

In the east on the passive continental margin Kazakhstan plate stand Torgay and Sirdarya pools, sections that start with slightly dislocated continental redstone volcanic-clastic deposition medium Devonian corresponding step riftogenesis above which overlie marine terrigenous- carbonate formation Famennian-lower carbon formed under conditions of passive continental margin. The section is Paleozoic these pools of red terrigenousmolasse with volcanics of intermediate and acid composition and acidic composition of the Late Paleozoic back-arc corresponding to step geodynamic their development.

At the forefront of the approaching plate, island arcs of a complex structure with a distinctive set of facies were formed, including off-profile rock associations. At this stage, the island arcs, the Ural and Tien Shan (Sultanuizdag) folded systems, probably united, forming a uniformly shaped eastward structure.

To the east, in the rear of the palaeostrain arcs of the Urals-Sultanuizdag, the Torgai and Sirdaryo back-arc basins were formed.

At the end of the Early Carboniferous and the Middle Carboniferous, the Ural was most heavily thrust into the Eastern European plate, namely the terrigenous sediments of the Zilaire (in the Aktyubinskii Urals) and the Izembets (in the Primogodzharakh) series (D3-C1t), which were under the Sakma cover (€ -0-S), in turn, were pushed to the west, forming a modern picture of the ratio. In the folds that appeared under the Zilairian cover, medium-carbon deposits were mapped. Therefore, the time of this most intense overthrowing is assumed by us as late Carboniferous.

At the same time, along the Ural fold system, a pre-Predural basin was formed with dislocations typical of the final stage of the collision orogen, the formation of linear anticlinal folds complicated by upsets.

By the end of the Paleozoic, the collision of lithospheric plates had not yet been completed and the sedimentary basins of the Paleozoic also continued to form in accordance with changing geodynamic conditions. This is on the East European plate the Central Caspian near-continental basin, the South Caspian pre-Caspian basin and the Eastern Caspian basin of the passive continental margin.

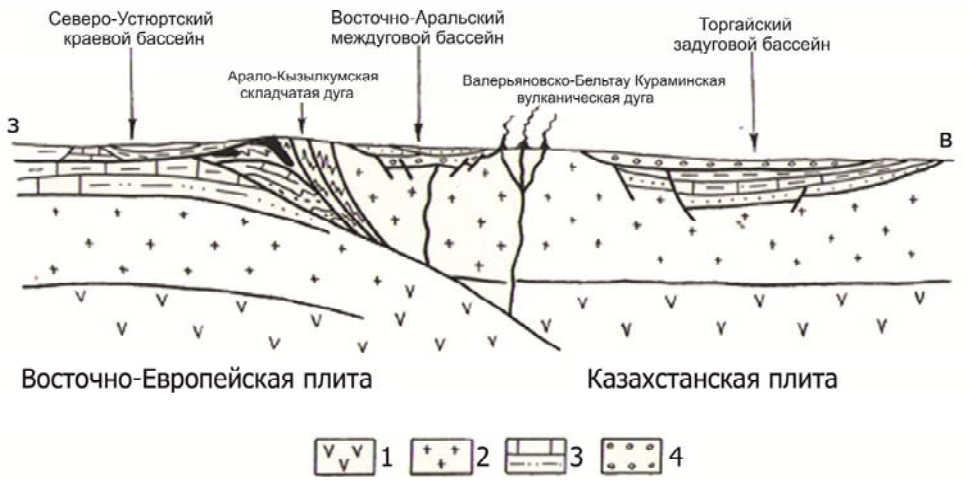

Figure 3 – Location of Paleozoic sedimentary basins:
1 – basalt layer, 2 – granite layer, 3 – sediments of the Devonian-Carboniferous age accumulated in the conditions of the passive continental margin, 3 – sediments of the Devonian-Kamennougol age accumulated in the passive continental margin, 4 – sediments of the Carboniferous-Permian age formed in the stages of the collision of the East European and Kazakhstani lithospheric plates in the marginal, intercurrent and back-arc basins.

North Ustyurt during the Early Paleozoic and Early Devonian was part of the East European plate in the southeast. In the middle and late Devonian during the formation of the South Emba rift, in the continuation of the Mugodjarian branch of the Ural ocean to the south, it was separated from the East European plate, forming the marginal type of the basin. The South Emba rift was filled with the coarse-grained strata of the Graywacke series of the Upper Devonian-Tourney age with well-studied wells at the Mynsulmas section and parametric and exploratory wells in some areas like Toreisai, Janasu, Diar, Teresken, etc. The position of the North Ustyurt basin between the South Emba inversion uplift and The Aral-Kyzylkum folded arc caused a great intensity of tectonic processes on its territory, the formation of large blocks with various conditions of sedimentation opleniya and different degrees of completeness Paleozoic section. The well-known oil and gas fields on the Alambek shaft, confined to the Carboniferous sediments, and the Paleozoic section in the Eligazhi area in the south, indicate the possible development and conservation of carbonate-terrigenous Middle-Upper Paleozoic formations throughout the whole of North Ustyurt, especially in its proving zones.

Three categories of sedimentary basins are distinguished on the approaching Kazakhstani plate, which differ significantly from one another according to the conditions of development, and therefore also according to the conditions of sedimentation, the degree of dislocation of rocks and the manifestation of magmatism. The Tenis and Shu-Sarysuyskian basins are classified into the category of inland-continental sedimentary basins, carried out by Devonian, Carboniferous and Permian carbonate-terrigenous sediments, poorly dislocated and sometimes broken by magmatic rocks near regional faults.

On the western, in modern coordinates, the passive outskirts of the Kazakhstani continent, the back-arc basins Torgay and Syrdarya were formed, separated by a northwestern continuation of the Karatau anticlinorium. These back-arc basins subsequently underwent a tension directed parallel to the edge of the approaching plate, resulting in the formation of three systems of grabens-Carboniferous, Permian-Triassic and Jurassic formation times; they are stretched for a distance of 6000 km with a width of 100-150 km and form a single East Ural rift system.

Between the volcanic and island arcs, the inter-arc East-Aral basin was formed, saturated with respect to other types of basins by magmatic rocks of the Upper Paleozoic and Lower Mesozoic ages.

As a result of the collision of two continents - the East European and the Kazakh - the Ural-Tien-Shan folded system was formed, i.e. By the end of the Paleozoic, the Eastern European and Kazakh lithospheric plates were welded together and a new Eurasian lithospheric plate was formed. The Kazakhstani plate, which was pulled to the west, occupied a hypsometrically elevated position and served as an arena for denudation during the late Permian and Early Triassic. The terrigenous sediments carried from it filled the deflected and deflected sections of the East European-Turanian plate, the Caspian syneclise and the

North Ustyurt trough zone, forming a powerful red-colored thickness of the upper Permian and lower Triassic.

The subsequent history of the development of the region was strongly influenced by the Mesotetisocean, with the formation of which the southern part of the region experienced stretching in the Late Paleozoic and Triassic. As a consequence of this, numerous rift zones were formed, such as the Bozashinskaya at the end of the Paleozoic and Mangistau in the Permian and Early Triassic.

In the Jurassic, the entire southern part of the Eurasian plate-the territory of the Caspian and Northern Ustyurt-has experienced a significant subsidence, forming intracontinental and super-rhythmical sedimentary basins that connected with Mesotetis through the Ciscaucasian-Mangistau and Amudara straits. During the Cretaceous and Paleogene periods along the northern periphery of the Mesotetis, the marine basin expanded, and in the Neogene, due to the collision of the Eurasian plate with the African-Arabian, the Caucasian and Kopetdag folding systems were formed.

Sedimentary basins of Kazakhstan are polycyclic formations and differ in tectonic position, geodynamic conditions of evolution, formation time, conditions of sedimentation and ontogeny.

A differentiated approach, taking into account geodynamic evolution to the isolation of structural and formation complexes that correspond to the main stages in the history of basin formation, and the reconstruction of the features of oil and gas formation and oil and gas accumulation at each stage and during the transition from one stage to another, make it possible to more accurately distinguish the priority directions for the search for new oil and gas accumulations in each pool.

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ҚАЗАҚСТАННЫҢ ПАЛЕОЗОЙЛЫҚ ШӨГІНДІ БАССЕЙНДЕРДІҢ МҰНАЙГАЗДЫЛЫҒЫН БАҒАЛАУДЫҢ ТЕОРИЯЛЫҚ НЕГІЗДЕРІ

Аннотация. Тақталар тектоника теориясына сүйене отырып жасаған ғылыми зерттеулердің нәтижесінде Қазақстанда жеті түрлі шөгінді палеозойлық бассейндердің барлығын көрсеткен. Олардың шөгінділердің түрі және қалыңдығы, мұнай мен газдылығы және геодинамикалық даму ерекшеліктері суреттелген. Болашақта әр бассейннің геодинамикалық ерекшеліктерін еске ала отырып мұнай мен газ кен орындарын іздейтін бағыттарды белгілеу керек.

Түйін сөздер: тақталар тектоникасы, геодинамикалық даму ережесі, бассейн, спрединг, рифт, мұнай мен газ кен орындары.

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ТЕОРЕТИЧЕСКИЕ ОСНОВЫ ОЦЕНКИ ПЕРСПЕКТИВ НЕФТЕГАЗОНОСНОСТИ ПАЛЕОЗОЙСКИХ ОСАДОЧНЫХ БАССЕЙНОВ КАЗАХСТАНА

Аннотация. По результатам реконструкции палеотектонического режима развития с позиции тектоники плит выделено семь типов палеозойских осадочных бассейнов существенно отличающихся условиями осад-конакопления, возможностями нефтегазообразования и нефтегазонакопления. Выделены осадочные бассей-ны внутриконтинентальные, на пассивной континентальной окраине, надрифтовыезадуговые и междуговые. Дифференцированный подход сучетам геодинамической эволюции к выделению структурно-формационных комплексов, отвечающих основным этапам в истории формирования бассейнов и реконструкции особенностей условий нефтегазообразования и нефтегазонакопления на каждом этапе и при смене режима развития, позволяют более обоснованно выделить приоритетные направления поисков новых скоплений нефти и газа в каждом бассейне.

Ключевые слова: тектоника плит, геодинамическая эволюция,бассейн, спрединг, субдуция, рифт, нефтегазообразование.

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