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Traces of paleogeodynamic processes in the zone junctions of the Middle and Lower Kura depressions

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The territory of Azerbaijan covers the southeastern part of the Greater Caucasus meganticlinorium, the northeastern parts of the mountain systems of the Lesser Caucasus and Talysh, i.e., basins of the Lower and Middle Kura, as well as the southwestern and western zones of the Middle and South Caspian depressions, respectively. The combination of these large structural elements determines the very complex tectonic structure of the territory of Azerbaijan, including the Middle and Lower Kura basins.

The article presents the results of a study conducted to study the paleotectonic processes that took place in the Cenozoic in the junction zone of the Middle and Lower Kura depressions, according to modern (2017—2018) seismic survey data using the common depth point method. The geological structure of the constituent parts of these depressions is considered, and paleotectonic processes are described that played an important role in their formation and led to the divergence of the geological sections of these depressions in the interval from the end of the Cretaceous to the end of the Lower Pliocene. When comparing the seismic wave pattern representing the geological sections of the Middle and Lower Kura depressions, it becomes clear that the compensation of the volumes of sedimentary material is carried out by Pliocene terrigenous deposits in the Lower Kura and Paleogene sediments in the Middle Kura depressions. At the same time, here, the hypsometry of the Miocene-Maikop interval of the section differs by 1300—1500 m.

The article presents the author's positions on the post-Cretaceous tectonic processes of the evolutionary development of the geological structure of these basins in the zone of their junction, where the Mingacheir-Saatli-Talysh transverse Mesozoic uplift (Saatly-Geokchay zone of Mesozoic uplifts) occupies an important place.

Key words: Mingachevir-Saatli-Talysh zone of Mesozoic uplifts, Lower Kura depression, Middle Kura depression, South Caspian depression, reflection seismic survey, paleoreconstruction.

Introduction. In 2017 and 2018, to clarify the geological structure of the Kura sedimentation basin, regional seismic surveys were carried out using the common deep point (CDP) method, including along a profile that runs mainly parallel to the Kura River. This profile starts from the western border of the oil and gas region between the Kura and Gabyrra (12 km from the left bank), east of the Tarsdallar field, crosses the Kura River and the Dalmammedli uplift in the Middle Kura basin and continues in the Lower Kura basin (0—20 km from the right bank) to the western coast of the Caspian Sea. At the same time, the profile crosses the well-known Muradkhanly and Saatly uplifts, which, in the author's opinion, are components of the Mingachevir-Saatli-Talysh Mesozoic uplift. The total length oftheprofileisabout400 km.

The interpretation of seismic data for this profile generally confirmed the area's tectonics. However, my attention was drawn to

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the seismic section of the zone of the Mingachevir-Saatli-Talysh Mesozoic uplift, i.e., to the mismatch of the stratigraphic ages of the layers from the Cretaceous to the top of the Pliocene.

In the Lower Kura depression, the hypsometry of the Miocene-Maikop interval of the sectionis1400—1800 m lower than in the Middle Kura depression. Interestingly, the results of seismic data interpretation indicate the formation of a geological section in this zone, accompanied by applicative tectonic regime. In other words, in the area of the ultra-deep well Saatly-1 (SG-1), the geological section of the Middle Kura depression in the interval from the Cretaceous to the top of the Pliocene is completely different from that in the Lower Kura depression (Fig. 1).

When comparing the wave pattern representing the geological sections of the Middle and Lower Kura depressions, it can be seen that the compensation of the volumes of sedimentary material is carried out by Pliocene terrigenous deposits in the Lower Kura depression, and by Paleogene in the Middle Kura depression.

The article presents the author's opinion on the paleotectonic events that led to such a divergence of geological sections along the line of the regional profile connecting the basins of the Middle and Lower Kura.

Materials and Methods. The material includes well logging (well logging data), vertical seismic profiling (VSP), and seismic survey work.

The stratigraphic confinement of seismic horizons was determined by the standard method from GIS and VSP data, which consists of recalculating the depths of reference markers determined from logging into time using a vertical seismic hodograph. In this case, the correlation of reference seismic horizons also followed the standard method. As result of this work, the seismic horizons in the

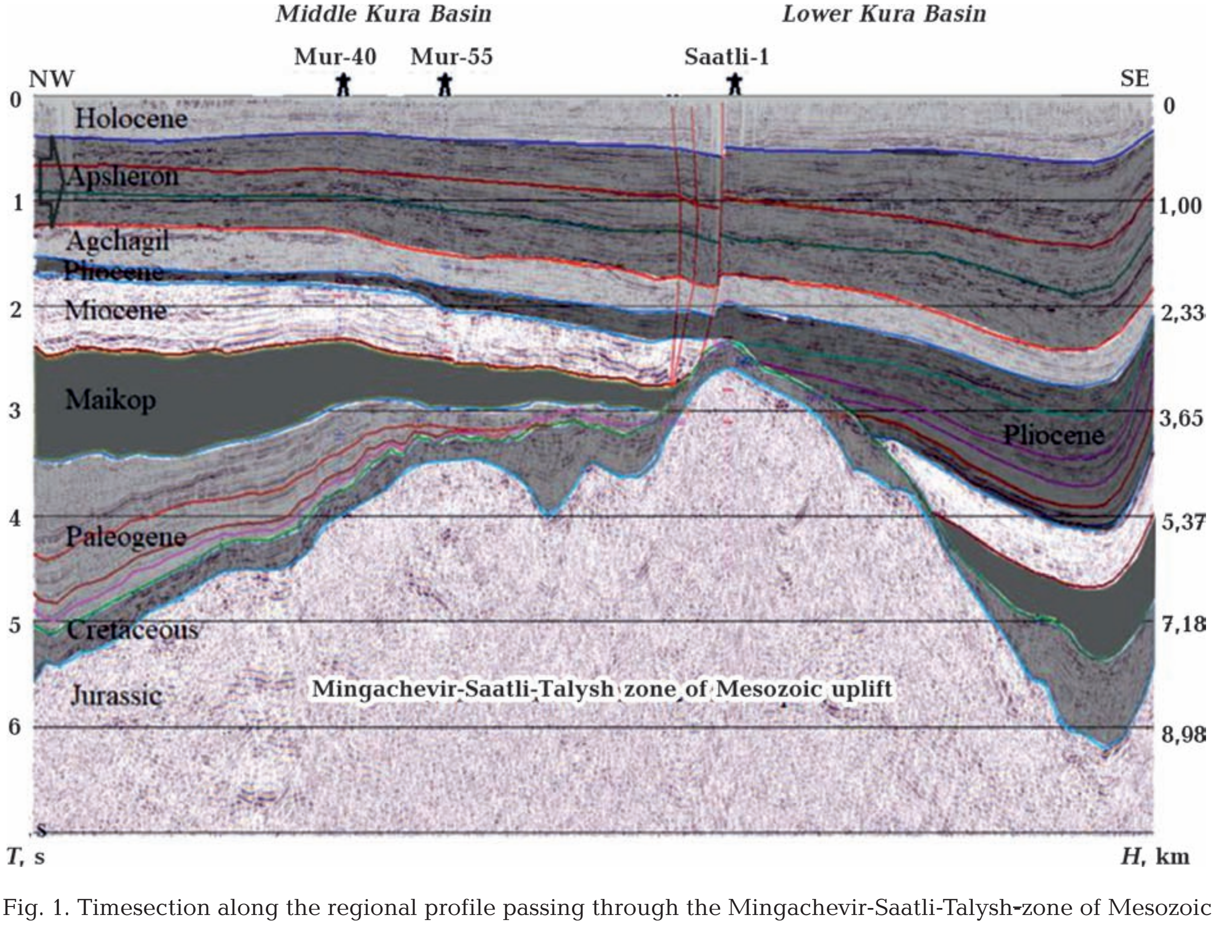

Fig. 1. Timesection along the regional profile passing through the Mingachevir-Saatli-Talysh-zone of Mesozoic uplifts and connecting the Lower and Middle Kura depressions.

Middle Kura basin are confined to the surfaces, respectively: Jurassic, Cretaceous, Paleocene, Eocene, Maikop (Oligocene—Miocene), Miocene, Pliocene (without division in to intermediate), Akchagyl, and Pleistocene deposits.

Similar work was done for the Lower Kura depression. However, for this basin, seismic horizons were correlated corresponding to the surfaces: Jurassic, Cretaceous, Maikop (Oligocene—Miocene), Miocene, Lower Pliocene (with division in to intermediate), Akchagyl, and Pleistocene deposits. Here, the correlation of seismic horizons approximating the surfaces of the Balakhani, Sabunchu, and Surakhan formations of the productive strata was done according to the time section representing the Lower Pliocene interval.

For each basin, several reference seismic horizons were selected, according to the geostratigraphic scale, which were converted to a horizontal line, i.e., from the standard time section, paleosections were obtained (Fig. 2) for a certain geological time for paleotectonic analysis.

At the beginning, general evolutionary processes for the basins of the Middle and Lower Kura were analyzed. The work was performed on paleosections corresponding to the surface of the stratigraphic intervals: Paleogene, Maikop, Miocene (bottom of the Lower Pliocene), and upper Lower Pliocene (PT). Above the surface of the PT, the horizons were not considered since, in this interval, the geological sections of both basins are identical in age. They differ mostly in the thickness (see Fig. 1) and the dimensions of sedimentary material.

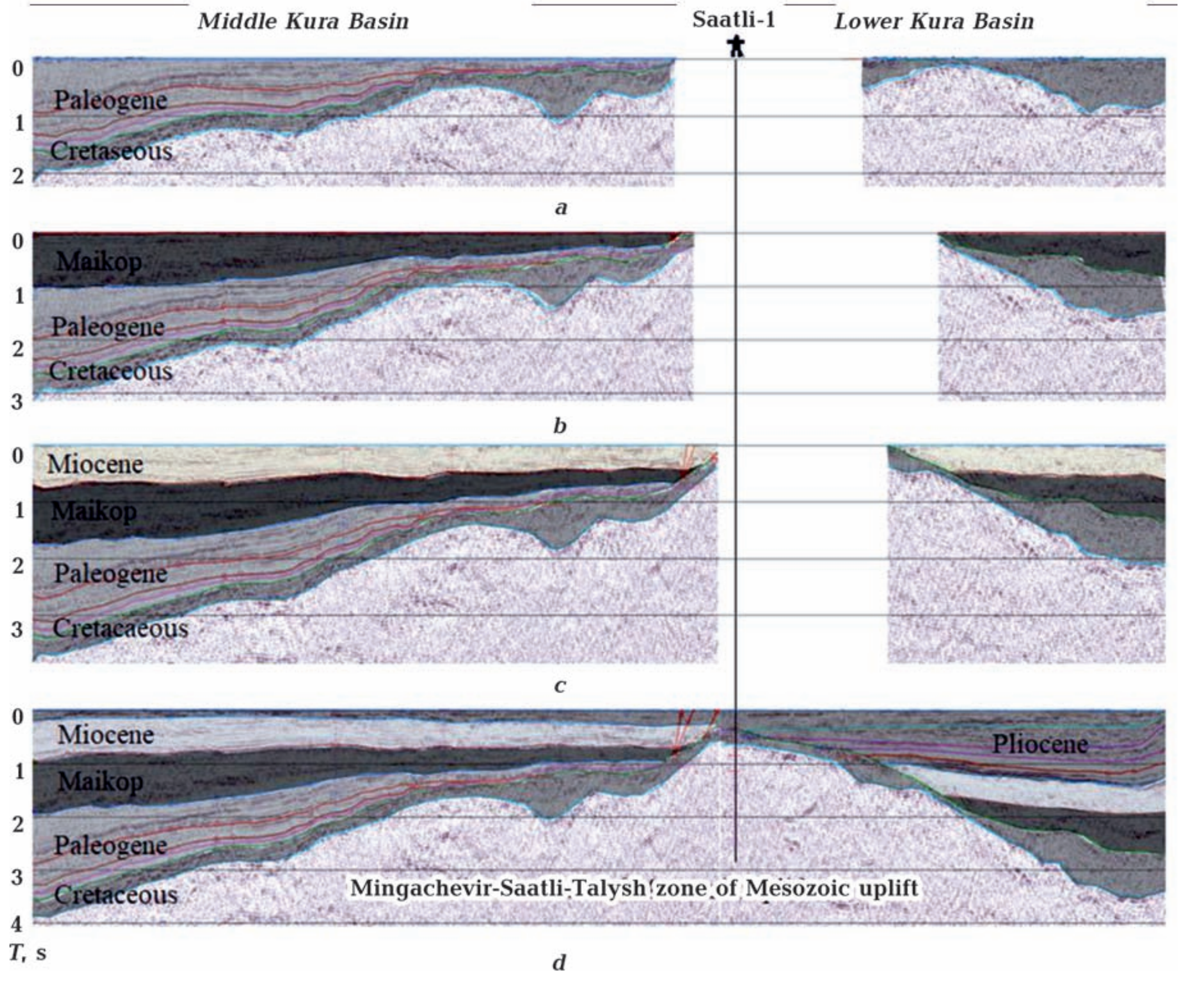

Fig. 2. Paleosections towards the end: *a* — Paleogene, *b* — Maikop, *c* — Miocene, *d* — Lower Pliocene.

Discussion of results. One of the main tasks of paleoreconstruction (paleoplanreconstruction) is the reconstruction of the paleorelief in relatively local area. For this purpose, regional reference horizons should be used. It is very important that the chosen benchmark has a regional distribution, is stratigraphically justified, and has a stable lithological characteristic.

At the end of the Cretaceous, i.e., at the beginning of the Paleogene, uplifts continued, much more intense, but not simultaneous for different parts of the Caucasus [Khain, Leontiev, 1950a, b]. In the western part of the Caucasus, uplifts appeared already in the Senon, and in the southeastern part, in the middle of the Paleocene. Assumedly, similar in versions also took place in the territory of the development of the Mingachevir-Saatli-Talysh Mesozoic uplift.

According to seismic survey data (a breakin sedimentation and paleoreconstruction) and deep drilling, at the end of the Cretaceous, land, possibly shallow water, existed in the territories of the Kura and South Caspian depressions. Sea waters began to cover the territory of the Kura depression from the beginning of the Paleocene, when the Kura, Shamakhi-Gobustan, and Absheron troughs began to form [Klenova et al., 1962]. At that time, the northeastern part of the South Caspian Basin (the zone of Mesozoic protrusions) also began to be involved in subsidence. At the same time, there was the Saatly-Geokchay zone of uplifts, separating the Lower Kura and southeastern parts of the Shamakhi-Gobustan trough from the Middle Kura depression. As can be seen from Fig. 2, *a*, from the Cretaceous to the end of the Paleogene, the Paleogene terrigenous deposits accumulated in the Middle Kura depression against the background of successive subsidence of the bottom of the depression. During this period, the Lower Kura depression was not involved in the process of subsidence (see the left part of the figure).

Note that this paper does not consider the causes of subsidence of the basin bottom. However, I assume that the subsidence of the region under consideration was associated with processes occurring in the mantle and the lower crust, causing an imbalance in crust. This process is considered, for example, in the book [Leader, 1986].

The next stage in the development of the considered depressions against the background of the continuing uplift of the geoanticlines of the Lesser and Greater Caucasus created favorable conditions for the formation of the Maikop Sedimentary Basin. The Basin covered the entire territory during the Oligocene and partially the Miocene. Throughoutthe history of the accumulation of the Maikop deposits, the arched parts of the Mingachevir-Saatli-Talysh zone of the Mesozoic uplifts remained dry land (Fig. 2, *b*).

The Miocene stage of the evolutionary development of the basins followed the same pattern, i.e., as in the Maikop time (Fig. 2, *c*).

However, as can be seen from Fig. 2 and

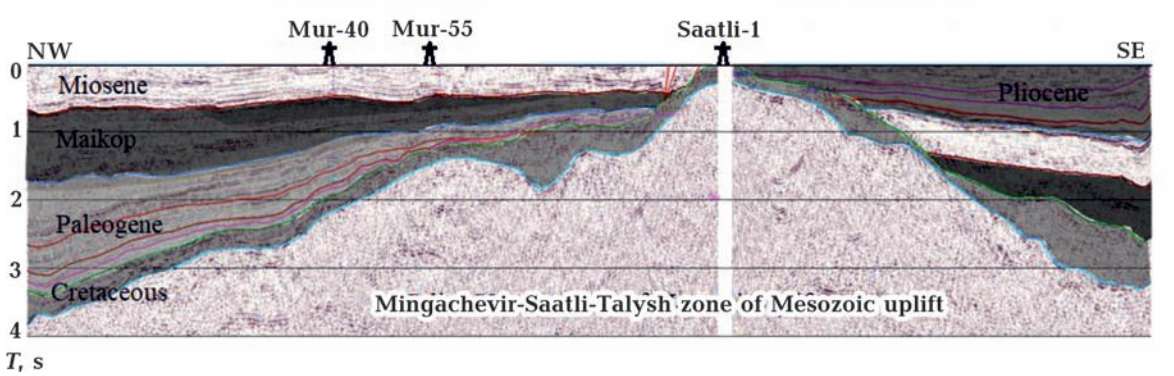

Fig. 3. Paleosection at the end of the Miocene in the Middle Kura and Sabunchu formations of the PT in the Lower Kura depression.

Fig. 3, after the formation of the Miocene interval of the basin sections, a tectonic inversion occurred in the region, which led to the fact that from the beginning of the Lower Pliocene to the end of the Sabunchu Formation of the Pliocene, in the considered region of the Middle Kura depression, dry land prevailed. At the same time, intensive accumulation of Lower Pliocene deposits took place in the Lower Kura depression. Only towards the end of the Pliocene Sabunchu Formation did the sea flood the basin of the Middle Kura. As a result, deposits of the Surakhan Formation accumulated in both basins.

Interestingly, these events coincides approximately with the time of the «Messinian salinity crisis» (end of the Miocene). As is known [Reynolds et al., 1998], the fallin the base level, approximately coinciding with the Messinian salinity crisis, led to the isolation of the Caspian Sea from the World ocean, hence its western part, i.e., Lower Kura trough. It is known that such a large-scale geological event integrated drainage systems into this sharply lowered base level, there by ensuring the delivery of large volumes of sediment and water from the Caucasus Mountains to the South Kura basin with the participation of the Paleo Kura and its numerous tributaries (mountain rivers).

My seismostratigraphic studies and reconstruction of the profile of the Kura basin at the end of the Miocene showed that the base level here was between 1400 and 1800 m, which is consistent with the above conclusion.

Although the timing of this event corresponds ot he Late Messinianeustatic sea level drop in the Mediterranean region [Haq et al., 1988], I believe that the base level here could also fall as a result of the subsidence of the bottom of the Lower Kura basin.

As the analysis of logging and seismic survey data showed, the sedimentation basin was formed with a gentle relief and in coastal zone sat shallow sea depths (up to 40 m). In such conditions, as rule, terrigenous reservoir rocks are common, forming bars, shafts, and ridges up to several meters high, parallel to the coast, beach formations. All this happens due to transgression and regression, ultimately leading to the coastline's movement. At the base of the transgressive sequence, basal horizons often occur, composed of clastic grains sorted by size. As is known [Bush, 1977; Leader, 1986], coastal facies are extremely favorable for the discovery of thick, relatively consistent terrigenous reservoirs with high capacitive-filtration properties. If they are limited by impermeable rocks, they become lithological natural reservoirs of oil and gas. In the described sedimentation environment, the Galmaz, Murovdag, Mishovdag, Garabagly, Kursangya and other deposits that are currently being exploited in the Lower Kura basin were created.

In the Middle Kura depression, Eocene and Maikop deposits are distinguished as oil source deposits [Alizade et al., 1975]. Here, the deposits are also located within the named areas. Therefore, we assume that the deposits here were formed due to the internal migration of hydrocarbons from the foci of formation to the reservoirs in the basal interlayers of these formations [Yusubov, Guliyev, 2022].

Clay rocks deposited during the Akchagyl period of sedimentation at high sea level formed a regional seal throughout the entire territory of the Lower Kura depression.

Throughout the profile, rocks of the Apsheron stage are developed. This interval of the section along the regional profile was deposited under the conditions of marine shallow water. The divergent nature of seismic reflections from this complex indicates its formation under conditions of a gradual inclination of the sedimentation surface and, at the same time, the variability in the rate of subsidence of the paleobasin. The fluctuation character of the amplitudes of the seismic record indicates the interbedding of sand and clay deposits. The sharp differentiation of the curves of the spontaneous polarization potential and the amplitudes of reflected waves in the time section indicates a frequent alternation of transgressive and regressive conditions of sedimentary material supply, which indicates a shallow-marine sedimentation regime. The Caucasus Mountains, rising, were eroded, supplying the foothills with rough material, where, leaving the gorges and mountain valleys, the rivers deposited powerful layers of pebbles in huge fan-shaped alluvial cones. A boulder-pebble path of the foothills was formed, which, far from the mountains, was replaced by finer detrital material: sands, small pebbles and clays in stagnant basins.

Conclusions. A study was carried out to identify the nature of ongoing paleotectonic processes that led to the divergence of geological sections in the junction zone of the Middle and Lower Kura depressions, according to modern (2017—2018) seismic surveys using CDP method. It has been established that the discrepancy between the geological sections of the Middle and Lower Kura depressions, in the interval from the end of the Cretaceous period to the end of the Lower Pliocene, is associated with a geotectonic process that occurred in connection with the late Messinian eustatic period, a drop in sea level in the Mediterranean region. At this time, the base level of erosion in the Lower Kura depression decreased by 1400—1800 m.

Although the time of occurrence of this event corresponds to the late Messinian eustatic sea level drop, we believe that the base level could also have fallen as a result of the bottom subsidence of the Lower Kura basin

My seismostratigraphic studies showed that when the level of erosion in the Lower Kura Basin decreased by 1400—1800 m, the hinge zone of the Mingachevir-Saatli-Talysh transverse Mesozoic uplift (Saatly-Geokchay zone of the Mesozoic uplifts) and its left flank, corresponding to the Middle Kura depression, remained above sea level until the end Surakhani (Lower Pliocene) suite.

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Сліди палеогеодинамічних процесів у зоні стику Середньокуринської та Нижньокурінської западин

Н.П. Юсубов, 2023

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Територія Азербайджану охоплює південно-східну частину мегантиклінорію Великого Кавказу, північно-східні частини гірських систем Малого Кавказу й Талишу, тобто басейни нижньої та середньої Кури, а також південно-західну та західну зони Середньо- та Південнокаспійської западин відповідно. Поєднання цих великих структурних елементів визначає дуже складну тектонічну будову території Азербайджану, зокрема басейнів Середньої та Нижньої Кури.

У статті наведено результати дослідження, виконаного з метою вивчення палеотектонічних процесів, що відбувалися в кайнозойській ері, у зоні зчленування Середньо- та Нижньокуринської западин, за сучасними (2017—2018) даними сейсморозвідки методом спільної глибинної точки. Розглянуто геологічну будову складових частин цих западин, описано палеотектонічні процеси, що відіграли важливу роль у їхньому формуванні та обумовили розходження геологічних розрізів названих западин в інтервалі з кінця крейдового періоду до кінця нижнього пліоцену. При зіставленні сейсмічної хвильової картини представлених геологічних розрізів Середньо- та Нижньокуринської западин стає зрозумілим, що обсяги осадового матеріалу компенсуються обсягами теригенних відкладів пліоцену в Нижньокуринській западині, і палеогенових осадів у Средньокуринскій западині. При цьому тут і гіпсометрія міоцен-майкопського інтервалу розрізу відрізняється на 1300—1500 м. У статті наведено авторські позиції на крейдяні тектонічні процеси еволюційного розвитку геологічної будови цих басейнів у зоні їх зчленування, де важливе місце належить Мінгачеір-Саатлі-Талиському поперечному мезозойському підняттю (Саатли-Геокчайська зона мезозойських піднять).

Ключові слова: Мінгачеір-Саатлі-Талиська зона мезозойських піднять, Нижньокуринська западина, Середньокуринська западина, Південнокаспійська западина, сейсморозвідка відбитими хвилями, палеореконструкція.