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GEOLOGY

# Tectonic Origin of the Apsheron Threshold in the Caspian Sea

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The Apsheron (Absheron[1]) Threshold is a seamount crowned by small islands and banks that separates the Middle Caspian (Derbent) and South Caspian basins of the Caspian Sea. It is traditionally considered as a link between orogenic structures of the Greater Caucasus and Kopetdag. As is shown below, the tectonic nature of this relatively heterogeneous structure is ambiguous. The purpose of this paper is to consider this problem.

The present-day Greater Caucasus developed within the following structures: (1) the southern margin of the Eurasian continent represented by the Scythian Platform with the Bokovoi (Lateral) Ridge on its southern wall; (2) the underthrusted northern margin of the Transcaucasian microplate (Vandam–Shemakha–Kobystan zone); (3) and the accretionary prism of the Alpine sedimentary complex accumulated in the Greater Caucasus marginal sea of the Neotethys (Speroz–Tufan and Zakataly–Kovdag zones of the Southern slope). The accretionary prism sandwiched between the first and second structures was detached from the basement and displaced to the south. It is bounded in the north and south by the Main Caucasian and Krasnaya Polyana–Zangin thrusts that represent the major tectonic fractures controlling the Greater Caucasus orogenic structure. Near the Caspian Sea in the West Caspian Anticaucasus Fault zone and eastern area, the thrusting amplitude of the northern microplate increases in parallel with its underthrusting by the Speroz–Tufan Uplift (main orogenic structure of the southeastern Caucasus) and tectonic juxtaposition of different-facies Cretaceous rock complexes of the Lateral Ridge (Khyzin zone) and Southern slope (Zakataly–Kovdag zone) along the Main Caucasian Fault.

[1] Given in parentheses is the transcription now accepted in Azerbaijan.

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The southern periphery of the epi-Hercynian Scythian–Turan Platform serves as the northern boundary of the region under consideration (Fig. 1). In the west, between Dagestan and Azerbaijan and in the adjacent Caspian Sea, this boundary extends along the Imamgulukend–Kachmaz Fault at the southern margin of the Samur–Yalama Seamount [4]. In the east (Turkmenistan), the boundary extends along the South Balkhan Fault at the southern margin of the Kubadag–Bol'shebalkhan Uplift [1]. The deep borehole recently drilled in the Samur–Yalama Uplift area recovered a thick Triassic sequence of volcanogenic–terrigenous sediments under Middle Jurassic strata. Another borehole drilled earlier in the Agzybirchala field penetrated slightly metamorphosed (probably, Permian–Triassic) rocks beneath the Middle Jurassic sequence at a depth of 4830 m. On the eastern side of the Caspian Sea, this boundary is very distinct and coincides with the Krasnovodsk (Turkmenbashi)–Bol'shebalkhan suture zone on its northern wall, where Upper Paleozoic–Triassic igneous rocks are exposed in the Krasnovodsk Peninsula.

The southern boundary of this uplifted margin of the Scythian–Turan Platform is marked by a band of Oligocene–Quaternary molasse troughs. Onshore in Azerbaijan, the boundary is represented by the Kusary (Gusary)–Divichi (Devechi) Trough filled with Pliocene–Quaternary molasse, which also smoothes down the southern margin of the Samur–Yalama Uplift. The offshore continuation of the Kuba segment of the trough hosts the North Apsheron Trough with a maximal depth of 5–7 km to the Mesozoic surface and 14–15 km to the pre-Jurassic basement surface [2, 3, 6]. The Kusary–Divichi is distinguished from the Terek–Caspian Trough located in the northern area of the Middle Caspian by the development of a relatively thick sequence of Lower Pliocene detrital deltaic sediments known as the Productive Sequence in Azerbaijan and the Redbed Sequence in Turkmenistan.

The Kusary–Divichi Trough contacts in the south along the north-vergent Siazan Fault with the southeastern subsided segment of the Greater Caucasus (Fig. 2). The front of the latter fault is represented by a narrow uplift, which is often incorrectly defined as the Tengin–Besh-

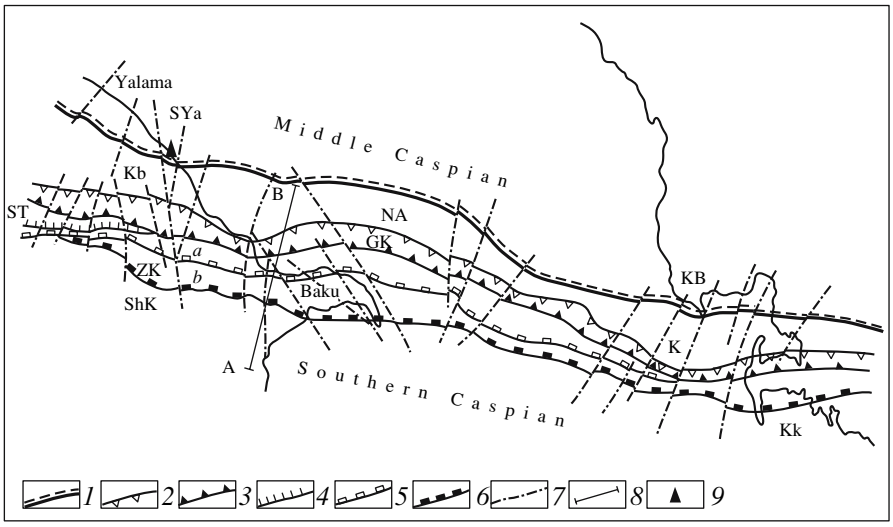


**Fig. 1.** Schematic tectonic structure of the Apsheron Threshold. Structures: (SYa) Samur–Yalama (Khachmaz) Uplift, (KB) Kubadag–Bol'shebalkhan Uplift, (Kb) Kuba Trough, (NA) North Apsheron Trough, (K) Kel'kor Trough, (KH) Khyzin zone, (GK) Gilyazi–Kubadag zone, (ST) Speroz–Tufan zone, (ZK) Zakataly–Kovdag zone: (a) Zakataly–Dibrar subzone, (b) Kovdag–Sumgait subzone, (ShK) Shemakha–Kobystyn zone, (Kk) Kyzylkum zone. Faults: (*1*–*6*) faults between structural zones and subzones: (*1*) Imamgulukend–Khachmaz–South Balkhan, (*2*) Siazan, (*3*) Main Caucasian (Germian, Apsheron–Balkhan), (*4*) Gamarvan, (*5*) Ilisu–Aladash, (*6*) Zangin, (*7*) transverse faults (proven and assumed). (*8*) profile; (*9*) Borehole Agzybirchala.

barmak Anticlinorium. The uplift is located at the eastern end of the Lateral Ridge of the Eastern Caucasus and crowned by outliers (klippes) of Upper Jurassic limestones that constituted the Middle Cretaceous south-vergent thrust and some elements of an olistostrome related to destruction of the thrust front [4]. The Beshbarmak Cliff rising above the Caspian coast represents an end member of this structure, while its offshore continuation hosts a chain of small rocky islands, e.g., Dva Brata (Gosha-Dash) Cliffs, and underwater banks (Apsheron and others) corresponding to anticlinal uplifts. According to seismic exploration data, Jurassic barrier reefs, which form the 10-km-long Apsheron Cordillera, are buried farther along the strike [6, 7]. It should be remembered that Upper Jurassic reefs are also recorded along the fault that borders the Scythian–Turan Plate in the south. The thickness of Cretaceous and Jurassic sediments decreases from the North Apsheron Trough toward the fault [6, 7].

The chain of uplifts borders the North Apsheron Trough in the south and is continued in Turkmenistan by the Kel'kor Trough (with the basement subsided down to 20–22 km), Interbalkan Trough, and Kopetdag Foredeep. The last two structures presumably connected with the North Apsheron Trough are bounded in the south by the South Turkmen Fault, a probable continuation of the Siazan Thrust in the Transcaspian region.

Along with the Tengin–Beshbarmak zone, the Khyzin zone exposed on the Caspian coast in the southern area makes up the eastern continuation of the Lateral Ridge of the Eastern Caucasus [4]. The Khyzin zone is bordered in the south by the south-vergent Germian Thrust, which is considered as continuation of the Main Caucasian Thrust. In the paleotectonic structure, the Khyzin zone corresponded to the northern slope of the Greater Caucasus marginal sea of the Tethys in the Early–Middle Jurassic. In the pre-Callovian epoch, it was amalgamated by the southern margin of the Scythian Platform in response to compression. Beginning from the Late Jurassic, it represented a continental slope of this platform. The area located beyond this slope accumulated erosion products of the barrier reef since the terminal Jurassic. The tectonic nappe developed after the reef supplied detrital material from the late Aptian. These rocks constitute olistoliths and olistoplaques within olistostromes that occur throughout the entire Cretaceous sequence.

Rock beds in the zone form extended linear folds separated into brachyanticlines. The folds continue in the Kilyazi (Gilyazi)–Kubadag Uplift (offshore area north of the Apsheron Peninsula) that reaches the Cheleken Arch and borders in the south with the Apsheron–Balkan Fault, an offshore continuation of the Germian Thrust. Judging from the distribution of sediment thickness inferred from onshore structural–mapping drilling, the synsedimentary growth of these folds already commenced in the Valanginian. The Upper Paleocene sediments (Sumgait Formation) unconformably overlie older strata (Campanian included) on the arches of folds [4, 5]. A similar situation is inferred from seismic and drilling data at the onshore continuation of these folds [6, 7]. The main unconformity in this area is developed, however, at the base of the Oligocene–Miocene Maikop Group.

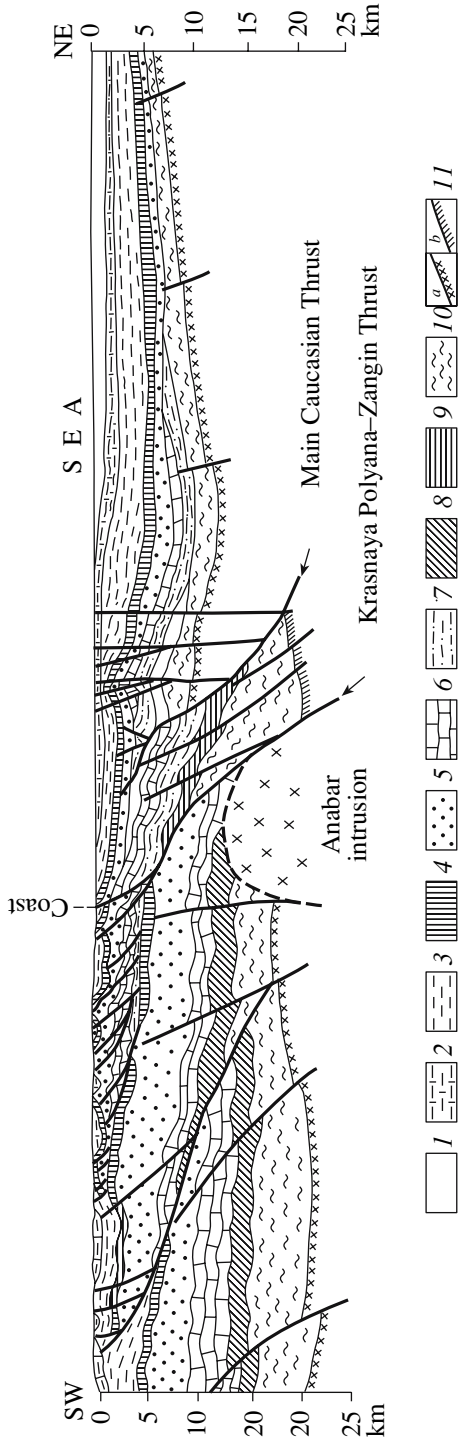


**Fig. 2.** Tectonic profile along the western Caspian Sea coast. Compiled by T.N. Kengerli. (*1*) Pleistocene–Holocene; (2) Eopleistocene (Apsheronian Stage) and Upper Pliocene (Akchagylian Stage); (*3*) Upper Miocene (Pontian Stage, only onshore) and Lower Pliocene (Productive Sequence); (*4*) Middle–Upper Miocene (Tarkhanian and Chokrakian horizons, Diatom Formation); (*5*) Paleocene–Lower Miocene; (*6*) Upper Cretaceous; (*7*) Lower Cretaceous; (*8*) Upper Jurassic–Lower Cretaceous; (*9*) Upper Jurassic; (*10*) Lower–Middle Jurassic; (*11*) surface of the pre-Jurassic basement: (*a*) proven by geophysical methods, (*b*) conditional.

The shore located south of the Germian (Main Caucasian) Thrust is occupied by the Zakataly–Kovdag (Zagataly–Govdag) zone of the Eastern Caucasus. This zone consists of the northern Zakataly–Dibrar and southern Kovdag–Sumgait (Govdag–Sumgait) subzones separated by the Ilisu–Aladash Thrust. Like the previous zone, the Zakataly–Kovdag zone largely composed of Cretaceous and Lower Paleogene flysch experienced pre-Oligocene deformations. The Germian Thrust is unconformably overlain by Paleocene strata. The offshore continuation of this zone is marked by a double chain of brachyanticlinal uplifts extending in the same general Caucasian direction and representing an element of the southern Apsheron–Balkhash zone of the Apsheron Threshold [6].

This zone has the following specific features: (i) it lies at the continuation of central zones of the southeastern segment of the Greater Caucasus;(ii) the development of folds of this zone commenced simultaneously with sedimentation since the terminal Jurassic–initial Cretaceous; their arches began to rise above sea level at the Cretaceous–Paleogene boundary and were almost completely developed by the beginning of the Oligocene;(iii) owing to the hypsometrically elevated position of the relatively compact Mesozoic complex, they correspond to maximums in the gravity field; and (iv) the structural analysis shows that the northern band of anticlinal uplifts corresponding to the Zakataly–Dibrar subzone fades offshore (more exactly, it is truncated by the Apsheron–Balkhan Thrust) opposite to the western continuation of the Kubadag–Bol'shebalkhan marginal uplift of the Turan Plate; thus, the subzone does not reach the western termination of the Kopetdag fold system.

Relative to the northern Khyzin zone, the Zakataly–Kovdag zone is also distinguished by the abundance of mud volcanism in its southern wall, which corresponds to the Kovdag–Sumgait subzone and is displaced along the Zangin Thrust to the Shemakha–Kobystan (Shamakhy–Gobustan) zone. As is evident from microfossils enclosed in products of volcanic eruption, the mud volcanism is rooted in the Oligocene–Miocene clayey sequence buried under an overthrust. The amplitude of overthrusting increases along the strike of the zone from west toward the Apsheron Peninsula.

The Oligocene–Miocene sedimentary complex overlain by the overthrust (amplitude tens of kilometers or more) is largely composed of relatively deep-water clayey sediments in the Lagich (Lakhydzh) Trough. The trough originates west of Mt. Shemakha (Shamakhy) on the western wall of the Mesozoic Vandam Uplift of the Transcaucasian microplate and joins the spacious Shemakha–Kobystan Trough after subsidence of the uplift. Due to deep subsidence of its consolidated basement, the Lagich Trough corresponds to a significant gravity minimum.

The southern band of the Apsheron–Balkhan zone of the Apsheron Threshold extends from the eastern coast of the Apsheron Peninsula. The band represents an offshore continuation of the southern wall of the Zakataly–Kovdag zone (i.e., Kovdag–Sumgait subzone) that is thrust over the Shemakha–Kobystan Trough. This offshore continuation is represented by a brachyanticline echelon, which crosses the Caspian Sea and reaches the LAM Bank south of Cheleken on the Turkmen coast and adjoins the western subsided part of Kopetdag on the land. In its structure and development scenario, the zone is principally different from the Kilyazi–Kubadag zone and is separated from the Kubadag–Bol'shebalkhan suture uplift by the Cheleken Uplift and Kel'kor Trough. At the same time, this zone is located on the northern wall of probable continuation of the Lagich Trough in the Transcaspian–Kyzylkum Depression with the basement subsided down to 30 km [1]. The zone is characterized by the following peculiar features: (1) its structures are distinct in the Pliocene–Quaternary relief; they are not inherited from Mesozoic structures; consequently, they are inversion structures; (2) like on the western Caspian coast, all these structures are characterized by clay diapirism and mud volcanism; and (3) therefore, rocks of this zone are unconsolidated and marked in the gravity field by minimums rather than maximums.

Thus, we can conclude that central structures of the Greater Caucasus do not reach the eastern Caspian coast. They are truncated by the southern edge of the Eurasian continent, except for fragments of the Kovdag–Sumgait allochthon buried under Pliocene–Quaternary sediments.

As is known [8], the Apsheron Threshold is characterized by present-day pseudosubduction of the South Caspian microplate under the southern margin of the Eurasian lithospheric plate represented here by the Scythian and Turan platforms. The northern and southern zones of the Apsheron Threshold occupy different positions relative to this pseudosubduction zone. As was mentioned, the northern zone is confined to the hanging wall that belongs to the Eurasian Platform, while its southern counterpart is an element of the southern underthrusted footwall that belongs to the South Caspian microplate and hosts the allochthonous Cretaceous–Miocene complex of the central Greater Caucasus. The Lagich Trough probably represented, at least initially, a deep-water basin between these two plates.

All these features combined with the position in the general structure of the region suggest that the southern zone of the Apsheron Threshold is similar to the Mediterranean Ridge in the eastern Mediterranean Sea. The Mediterranean Ridge (up to 300 km wide and 1500 km long), which has been studied thoroughly in marine international expeditions with the participation of Russian scientists M.K. Ivanov and A.F. Limonov [9], extends along the northern margin of the African lithospheric plate. The ridge is parallel to the Hellenic deep trench that marks at the Mediterranean Sea floor the zone of the African lithospheric plate subduction under

the Eurasian Plate. The trench fringes in the south the marginal element of the Eurasian Plate: the outer neovolcanic Hellenic island arc with Crete Island in its central part.

The internal structure of the Mediterranean Ridge is highly complicated owing to the abundance of diapirism and mud volcanism. This is attributed to dragging and piling of the upper sedimentary cover of the African Plate along the plastic sequence of Messinian (uppermost Miocene) evaporites in the course of its thrusting under the Eurasian Plate.

We assume a certain analogy between the Mediterranean Ridge (its structure and formation settings) and the southern part of the Apsheron–Balkhan zone of the Apsheron Threshold. The Maikop Series and probably lithologically similar Eocene sediments in some places (the middle Koun Formation is lithologically identical to the Maikop facies) could play the role of Messinian evaporites in this case. The Lagich Trough is a homologue of the Hellenic Trench, while the northern Kilyazi–Kubadag zone of the Apsheron Threshold is similar to the Hellenic island arc. We believe that these analogies (although conditional) provide insight into the tectonic nature of the Apsheron Threshold of the Caspian Sea.

## CONCLUSIONS

Two sharply different (in tectonics, age, and formation settings) zones are defined in the Apsheron Threshold. The northern Kilyazi–Kubadag zone represented by folds of the Apsheron Archipelago is a continuation of folds of the Lateral Ridge of the Greater Caucasus. The zone started to form intensely in the Paleogene, particularly prior to the Oligocene. It is bounded in the north by the North Apsheron Oligocene–Quaternary molasse trough, which separates the northern zone from the buried Samur–Yalama inlier of the young Scythian Platform. In the east, this zone continues in the Transcaspian region and corresponds to the Cheleken group of brachyanticlines. In the north, it is separated from the Kubadag–Bol'shebalkhan zone by the Kel'kor molasse trough that underlies the North Apsheron Trough in the echelon manner.

The southern zone of uplifts of the Apsheron Threshold originates near the northeastern coast of Apsheron Peninsula, crosses the entire Caspian Sea, and continues onshore in Turkmenistan as the Balkhan zone of uplifts. Folds of the southern zone lack signs of inheritance from the pre-Oligocene structure and most likely represent inversion structures. They are characterized by intense clay diapirism and mud volcanism.

The Apsheron Threshold is a modern (probably terminal Miocene) zone of subduction of the South Caspian microplate under the Eurasian lithospheric plate. The northern zone is presumably confined to the hanging wall of the pseudosubduction zone and, consequently, assigned to the Eurasian Plate, while the southern zone is confined to the hanging wall of the pseudosubduction zone and, correspondingly, assigned to the South Caspian microplate.

There is a certain similarity between the Apsheron pseudosubduction zone and the Hellenic subduction zone in the eastern Mediterranean Sea, in particular, between the southern zone of the Apsheron Threshold and Mediterranean Ridge.

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