THE STRATIGRAPHY AND HYDROCARBON POTENTIAL OF THE LOWER KURA AREA

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Introduction

Azerbaijan has a more than 150 years history of oil production during which more than 15 Bn bbl of oil were proven. Until a few years ago, most exploration activities were confined to onshore areas. Recently however, the shallow water areas close to the mainland have become the main focus of activities. Despite the shift in focus, the onshore areas still offer a wide range of opportunities for future exploration and production.

Location

The Lower Kura Oil-Gas Bearing Region (OGB) is situated in the south-eastern part of the Lower Kura Valley. The depression is bounded by the Lengebiz and Alyat hills to the north, the northern border of the Talysh mountain chain to the south-west, and by the Caspian Sea to the south and south-east. The topography of this depression is characterised by the presence of several hills, but also by salinas at several locations.

Seismic work and exploration studies performed during recent years indicate that the Baku archipelago is highly prospective for discovering new oil and gas fields. One of the most prospective areas is the Kyurdashi block, located some 160 km south of Baku in a water depth of 70-75 meters. The study area is situated in the southern part of the Baku archipelago, in the delta of the Kura River, which drains large parts of the Caucasus Mountains. The Kyurdashi structure represents the offshore continuation of the Khilli-Neftechala anticlinal zone with two oil and gas fields producing from over 20 horizons within the Pliocene “Productive Series” (PS).

The studied sections within the depression consist of the PS, the Akchagyl, Apsheron and Pleistocene stratigraphic units. These rocks have been found in breccias of mud volcanoes at several locations in the Lower Kura depression. In addition, the PS crop out in Babazanan. According to a detailed study, the PS are represented by clayey and clayey-sandy facies on the western and the north-eastern part.

In the Lower Kura depression the upper portion of the PS is divided into separate horizons, in order to distinguish different stratigraphical units. The Neftechala stratigraphical scale is used in sections of the Kyurovdag-Neftechala structural zone, and also in Mishovdag and Kyursangya. In the eastern part of the Lower Kura depression the thickness of the PS is 2,800-3,500 m. Generally, the sections differ from the sections of the neighbouring Gobustan and Apsheron. It is very difficult to correlate these sections, but also to distinguish similar key horizons.

The PS are relatively well studied in Kyurovdag, Karabagli, Neftechala and other areas of the depression. Here the PS consist of grey, brown-grey and sandy clays, fine and medium-grained sands of different thickness. With the help of deep drilling the PS are studied within 2,600-3,000 m in the western and the south-western part of the depression – Kyurovdag, Karabagli and Neftechala. This section differs from the one in the eastern part of the depression. The studied part of the sections is divided into 20 sandy-clayey horizons inside of which there are clayey-aleuritic intervals.

From the north-west to the south-east well sorted sands and aleurites are observed. The sandy-clayey aleuritic horizons, distinguished in the sections, are corresponded to the Neftechala scheme. In comparison with the neighbouring Apsheron and Shemakha-Gobustan OGB the lower and the upper portions of the PS are eroded in the

Lower Kura depression. Here the total thickness of the PS is 3,500-3,600 m, and in Khamamdag structure it reaches up to 4,000 m. The deposits of the PS are the main target for oil and gas exploration in the Lower Kura OGB.

Lithostratigraphy

In Neftechala horizons I, II, III of the PS consist of alternations of sands, clays and sandstones with thickness of 350-450 m. Unlike the central and the northern parts, the clayiness increases (approximately 68%) in the south of the region. Here the specific resistance of clayey rocks is 0.7-0.8 ohm, and sometimes up to 1.4-2.0 ohm. All these three horizons are targets for field.

The percentage of net-to-gross decreases from the north to the south of the structure. As a result, no oil/gas discovery has been made in the south of the structure (blocks XIII, XIV).

Horizons IV, V, VI of the PS consist of clays, sands, clayey sands and sandstones, with thickness of up to 350-500 m. In all three horizons sands and sandy rocks account for 35-40%. Resistance of clayey rocks is approximately 1.4-1.6 ohm.

In the northern part of the depression horizon IV is oil-gas bearing yielding high amounts of hydrocarbons. This is in contrast to horizons V and VI. In the south of the region the rocks of horizon V are highly permeable and porous.

Horizons VII, VIII, IX, X, XII and XII of the PS are represented by sands, clays, sandstones, clayey sands and sandy clays, with total thickness of approximately 800 m. In these horizons the resistance of clayey sands is 0.8-1.2 ohm. Net-to-gross on average is 14%. These horizons are usually saturated with oil and gas in the entire region.

Horizons XIII, XIV, XV, XVI and XVII are represented lithologically by sands, clays, sandy clays, aleurites, aleurolites, and clayey sands, with total thickness of approximately 700 m, and net-to-gross of 20 to 30%. Electric resistance of clayey rocks is 1.2-1.6 ohm. Resistance of sands and sandstones is 2.2-2.6 ohm (sometimes 4.5 ohm) These horizons have commercial importance in the northern and southern parts of the depression.

Horizons XVIII, XIX and XX of the PS in those wells located on the northern part of the area, consist of high-resistance strata. Lithologically they are represented mainly by sandstones, sands and thin clays with total thickness of approximately 550 m.

According to the data obtained from deep drilling (log, core, cuttings) one can conclude that three horizons of the PS contain large oil reserves. From the above mentioned it can be concluded that in the Lower Kura depression the increase of clayiness is observed towards the south on the anticlinal folded zone of Kyurovdag-Neftechala.

Thus, we can say that in Babazanan, beginning with the period of horizon IV, the lithology of Apsheron and PS is represented by sands, sandstones and clays. But at the same time in Neftechala, these strata are marked by an increase in clay. South of the Neftechala structure a higher clay amount is observed in horizons IV of Apsheron and in horizon V of the PS. As a result of sea transgression the Upper Pliocene deposits cover this part of the area later during the Apsheron and Akchagyl period.

Sediments brought by the Paleo-Kura River towards the continental shelf formed wedge-shaped sandy features. They are linked with high prospectivity for oil-gas discoveries. They have clayey composition in the deeper parts, and towards the basin they frequently have strong oil-gas bearing potential in pinch-out features.

The sediments of the Akchagyl formation crop out on surface in the western and the north-western parts of the Lower Kura depression – on the arch of the Babazanan fold. In other parts of the depression the section of the

Akchagyl formation can be studied from well data. The thickness of the Akchagyl varies in all parts of the Lower Kura OGB. In the Khilli and Babazanan areas its thickness reaches 100-120 m.

Tectonic aspect

Based on the results of satellite image interpretation made at the Geology Institute, fault tectonics in the Lower Kura depression is represented by numerous faults of different orientation (sublatitudinal, anti-Caucasian and submeridional) and age (from old Pre-Mesozoic to young Cenozoic).

The highest density of faults can be observed in the north and north-west of the Lower Kura Depression. The oldest faults (Pre-Mesozoic and Mesozoic) are confined exclusively to this area and only there thrusts can be observed.

Anticlinal zones in this area are characterized by strong dislocation and numerous active mud volcanoes. All the anticlinal zones are complicated by regional longitudinal faults with branches of cross faults.

Lithologic-facial aspect

Lithologic-facial aspects of the PS are controlled by the role of different sources of the hinterland and by the tectonic regime of the sedimentation basin. The sources for the sediments in the Middle Pliocene were the Paleo-Volga, the Greater and the Lesser Caucasus, and the Talysh mountains. In the north of the Pliocene basin the Paleo-Volga and the Greater Caucasus were dominant features, whereas the central and in the southern part were influenced by the Greater and the Lesser Caucasus and the Talysh mountains.

The most favourable facies of the PS reservoirs is composed of well sorted quartz sands and sandstones with high porosity and is present within the Apsheron oil and gas region (the Apsheron peninsula and the Apsheron archipelago). South and south-westwards the amount of quartz becomes less. On the whole, the shelf of the South Caspian adjacent to the Lower Kura just like its onshore equivalent is characterised by a low amount of quartz (15-25 %). As can be observed on the schematic correlation of Kyzyl-Agach-Kurovdag, the amount of clay in the section increases towards the south-south-eastwards. In addition, the type of cement in the sandy-silty rocks in the upper part of the PS changes as well. Whereas in the Apsheron and Gobustan OGR, and in the north of the Baku archipelago clayey and calcic-clayey cement prevails, In the Lower Kura and in the south of the Baku archipelago calcic and clayey-calcic cement is dominant.

In conclusion, in the south of the studied region there was a strong impact of the Greater Caucasus and the Talysh mountains as source with the river Kura as the main water artery that transported the sediments to the west coast of the South Caspian.

Mineralogy

The study results of the mineralogical composition of recent sediments of the rivers in the Greater Caucasus, the Lesser Caucasus and in Talysh, and individually of the rivers Kura and Volga may prove the above mentioned facts (Table 1).

In the rivers of the Lesser Caucasus and in Talysh field-spar terrigenous material and fragments of effusive rocks prevail. In the sediments of the rivers of the Greater Caucasus the amount of effusives in the rocks fragments is not high. In addition, they are mainly clayey-shaly.

Rivers in these massifs differ also by the mineralogical composition of the heavy fraction. The sediments of the river Kura are composed of material from both the Greater and the Lesser Caucasus.

Comparison of the sediment composition of the recent Kura and Volga rivers reveals, that the river Kura contains sediments with the prevalence of the clayey fraction (<0.01 mm) (on average 42.2 %), whereas in the river Volga the sandy fraction (0.05-0.25 and >0.25 mm) amounts to 73.9% on average.

Geochemical aspect

As a result of geochemical studies of the PS and the underlying horizons, but especially recent research efforts utilising modern western technologies, it was determined that most of the oil in the PS are derivatives from underlying Miocene and Oligocene source rocks.

This conforms with results from basin simulation, which concludes that the “oil window” in the South Caspian depression owing is at a depth of 6-9 km. That is why when assessing the oil and gas potential of the PS in the different parts of the studied basin one should take into account two main facts: the character of change in space of the organic matter (OM) in the source rocks, and the level of dislocation of the overlapping deposits.

Studies of the Maykop series as one of the oil-generating source rocks in onshore outcrops in the south-eastern end of the Greater Caucasus and Talysh provide the opportunity to evaluate its facial variation from north to south.

According to these studies, in the north (the Sumgaitchay region) the main indexes - hydrogen index (HI) and generation potential (S_1+S_2) - come to 500-600 mgHC/gCorg. (mode 400-500), and 50-70 kg/t (mode 10-30), respectively, pointing to a type II kerogen, capable of mainly oil generation. In the south (Talysh) these indexes come to, 150 (mode 25-50) and 2 (mode 0.2-0.4), respectively, pointing to a type III in this region and to a mainly gas-prone Maykop. If suppose that the situation is similar within the western shelf of the South Caspian, there should be expected a prevalence of a gas phase in the reservoirs in the extreme southern and south-eastern parts of the Caspian.

As for the conditions of migration and preservation of hydrocarbon accumulations, the most favourable conditions for intensive sub-vertical migration obviously existed and still exists in the north-western part of the studied region. Large accumulations of HC should not be expected in those areas, where faults are developed up to the earth surface. In those structures where abundant surface oil-manifestations are available, there are either no commercial oil fields or they are small, such as in B. Kharami, Ayrantekyan, Solakhay, Shorbulag and Dashgil. Surface outcrops of the PS are characterised by the absence of the upper suites of the PS (Sangachaly-Duvanny, Garasu). Hydrocarbon discoveries in horizon VII are either small (Garasu) or are absent (Sangi-Mugan, Yanan-Tava).

Hydrocarbon potential

Total reserves of the Lower Kura Depression is estimated at 8 Bnoe, with 1.2 Bnbbl of recoverable oil and 5.1 Tcf of recoverable gas reserves. Considering that cumulative production from the existing 20 fields amounts to 560 MMbbl of oil and 2.7 Tcf of gas, there still exists a sizable volume of hydrocarbon to be developed. With a current production rate of only 10-12,000 b/d, considerable upside potential exists in this region.

Conclusions

In conclusion and according to all above mentioned aspects (tectonic, lithofacial, geochemical) the southern and the south-eastern parts of the Lower Kura depression together with the adjacent Baku archipelago are the least perspective areas for oil exploration. The northern limit of this zone passes just south of the Neftechala-Atashgyakh

area. However, this zone can be of interest for gas exploration. In contrast to other onshore areas of Azerbaijan, almost 98% of all hydrocarbon is contained in Pliocene Productive Series.

As for the near shore structures, they are undoubtedly perspective for the exploration of commercial oil deposits. However, the exploration for oil must be focused on the middle and lower horizons, developed on the flanks of structures, which dip to the deeper basin parts.

Table 1: Mineralogical composition of recent sediments of the rivers in the mountains of Azerbaijan

Source of removal	Light fraction				Heavy fraction
	quartz %	field spars %	Fragments of rocks		Mineralogical composition
			clayey-silty, %	effusive	
Greater Caucasus	13-35	12-30	35-60	2-12	ferrum oxides-magnetite-ilmenite-pyrataceous
Lesser Caucasus	13-18	21-23	8-12	50-63	pyroxene-magnetite-ilmenite hornblende
Talysh	13-15	16-25	6-13	20-51	pyroxene-ferum oxides-biotite
Kura	7-8	23-25	44-50	14-20	pyroxene-magnetite-ilmenite hornblende