EARTH SCIENCES

GEOLOGY AND PROSPECTS OF HYDROCARBONS IN THE TRANSITION ZONE OF THE SHALLOW WATER OF THE APSHERON FIELD

Dr.Arzu Javadova
Geoscientist, MicroPro GmbH, Germany
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Abstract

The Apsheron field area is the most promising prospect of a Shallow water Transition zone of the Apsheron archipelago at all potential reservoir levels, for identification of the exploration potential of the area and the new business opportunities. The area covers with water depth between 10 to 20 meters. As a methodology used available seismic data, evaluation of reference well data and other geological factors in the Petrel program. Individual recoverable resource volumes per individual reservoir layers are calculated in the Monte Carlo program:

- The overall consolidated resource volumes for the Productive Series of the entire Bank-Apsheron area totalling 80.3 MMBBL.
- The overall consolidated resource volumes for the Mesozoic of the entire Bank Apsheron area totalling 21.4 MMBBL
- The consolidated resource volumes for the Gosha Dash area amount to 16.1 MMBBL This area is taken as undrilled. Gosha Dash structure is viewed as a target for potential field extension for the remaining exploration potential of Bank-Apsheron and West-Apsheron for the Mesozoic deposit which is identified on 2D seismic at approximately 2000 m depth. Therefore, this part of the structure is not identified as exploration, but as an appraisal & development target for future wells.

Keywords: South Caspian, offshore, oil and gas, seismic interpretation, geology, forecast

Introduction. In the study area underwater and above-water rocks, cones, banks and depressions characterize the relief of the Sea floor. The largest morphologic units are Gosha Dash, Apsheron bank North, East Apsheron and West Apsheron a group of underwater mud volcanoes. Fig 1

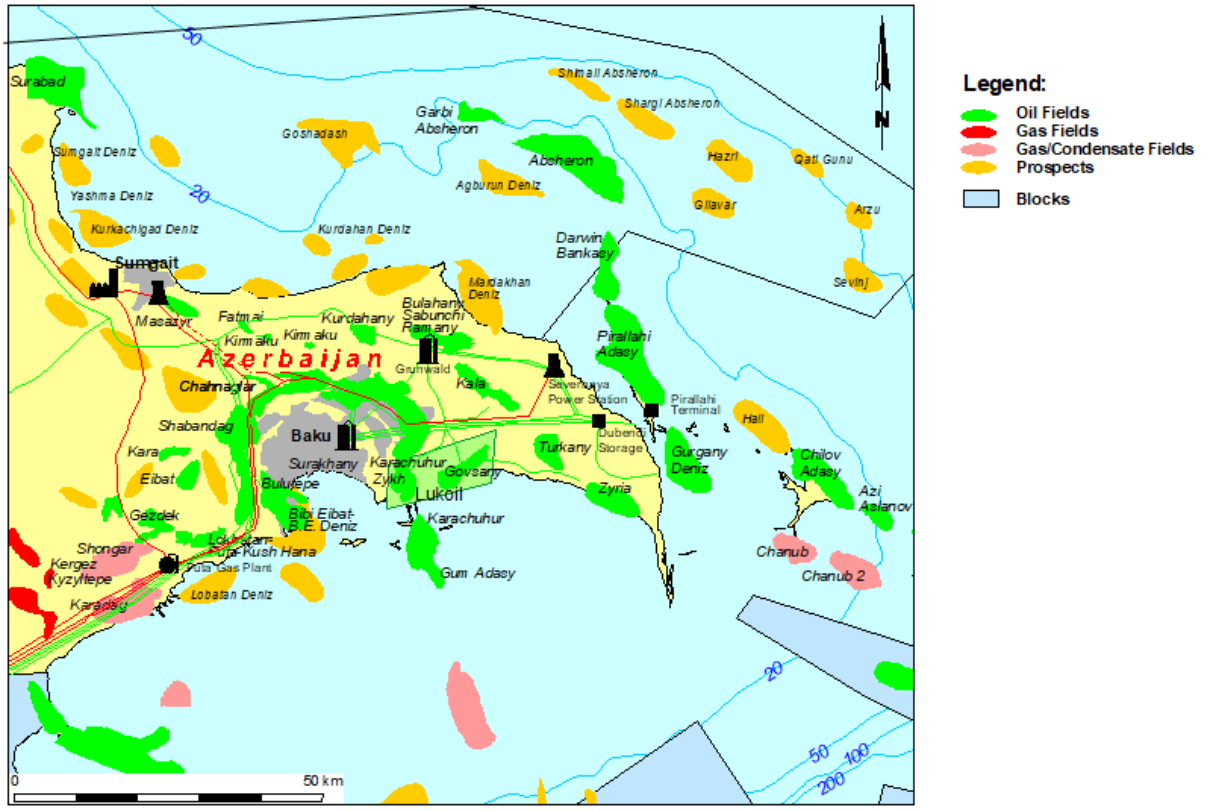

Figure 1 Apsheron Trend Shallow ater & Transition zone location map

In the north, Gosha Dash is formed by two ridges protruding above the Sea level separated by a strait. Water depth varies between 5 to 20 m. East from Gosha Dash is located Shurabad onshore/offshore field

The Apsheron bank is located at the 10 m isobaths. It is a 10 km long and 2,5 km wide structure. The maximum 20 m depth of the Sea above the bank is 2-3 m. The North Apsheron is located directly to the north of the Apsheron bank., as well as West Apsheron is located to the west of the Apsheron bank field accordingly East Apsheron is located to the east of Apsheron bank field

Gilavar , Khazri Arzu, Noukhany, Gatl Qunu, and Sevinj prospects are located as a single anticline zone to the east direction from Apsheron bank field. Kurkhachidag Sea, Sumgait Sea, Kurdakahni Sea and Mardakan Sea are located to the south and southwest of Apsheron bank field.

West Apsheron discovery. The West Apsheron oil discovery is located 20 km offshore in the western sector of the Apsheron - Dan Ulduzu - Karabakh Trend in the Caspian Sea. Further towards the southeast (Azi Aslanova and Neft Dashlari fields) the depth of the Sea gradually increases from 30 to 100 m. Fig.2

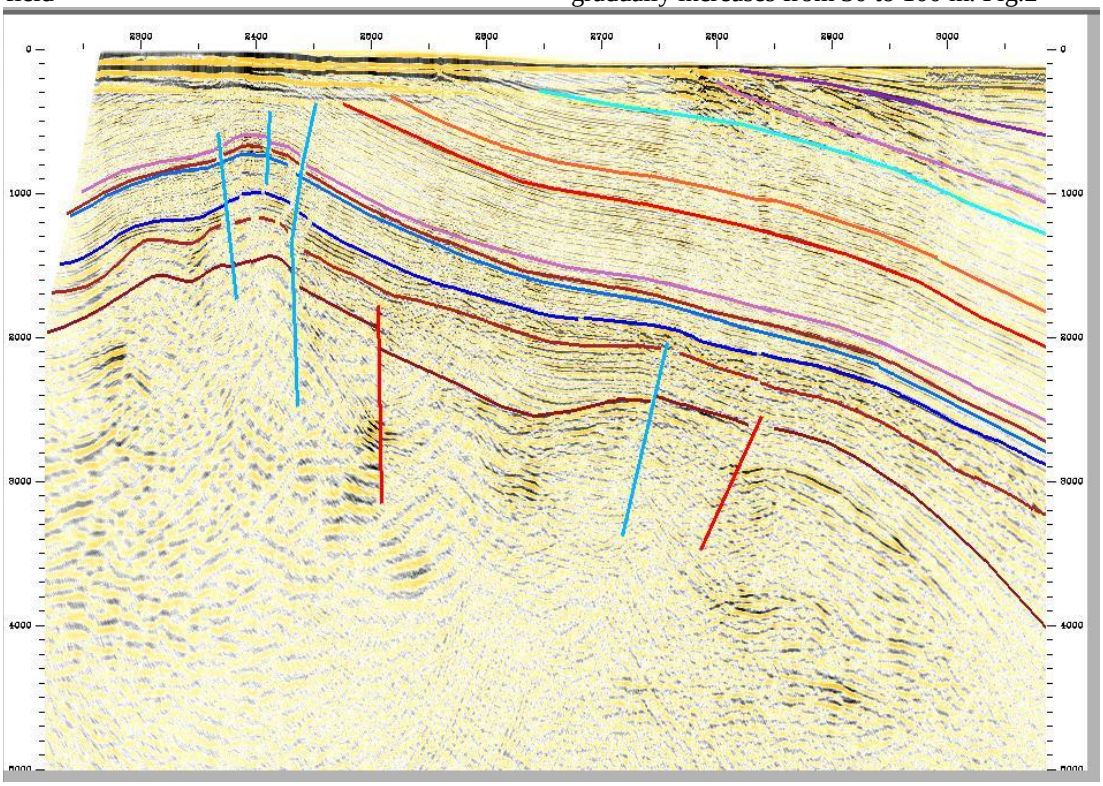

Figure 2 West Apsheron seismic section

The relief of the Sea floor is smooth; the ground is composed of grey sand and silt with shells. It is the structurally not-so-well-defined western culmination of a single large NW-SE trending anticline (30 km by 12 km) with two structural culminations, West Apsheron in the west and Apsheron in the east. The structural style of the anticline is typical of most fields in Azerbaijan: a major fault zone crosses the structure along its axis splitting it into two asymmetrical flanks. Several smaller dip faults divide it into several fault blocks In the West Apsheron field a small oil accumulation was discovered in 1986, when an oil flow was produced in well 85 from the Kirmaki (KS) Suite (901-908 m interval). In 1990 another minor oil pool was discovered in a clastic reservoir in the Lower Kirmaki (LK) Suite of the Productive Sequence. The field measures 11 x 2.5 km. Field stratigraphy comprises sediments from the Oligocene - Lower Miocene Maykop Suite to the Productive Sequence. The upper part of the Productive Sequence has been eroded from the crest and the Sequence unconformably overlies the Diatom Suite and the Pontian. The Supra Kirmaku Mudstone Suite outcrops at the crest of the anticline. The Productive Sequence is composed of alternating sands and mudstones with the latter predominating in a total thickness of 1,800-2,000 m.

The productive sand has a net thickness of 11 m, 24% porosity, an average permeability of 75 mD (max. 180 mD) and a water saturation of 20%. At West Apsheron, the initial oil in place is estimated at 17 mmbbl and 1.1 bcf of solution gas. Wood Mackenzie has classified reserves, which are unlikely to be recovered under the current development scenario, as technical reserves.

There is no foreign participation in West Apsheron field; it is operated by the Apsheronneft Oil & Gas Production unit of State Oil Company of Azerbaijan Republic (SOCAR). The West Apsheron field started producing oil in 1989 at a rate of 20 b/d. Production ceased five years later due to additional requirements of the platform and production facilities. The field is not developed

Table 1.

West Apsheron: well results (source: WoodMac)

Well Name	Operator	Spudded	TMD(m)	Result	Comment
Type		**Completed**	**WD(m)**		
West Apsheron 35	Government of Azerbaijan	01 Jan 1985	1,285	Oil	Tested oil at 511 b/d from Kirmaku formation (901-908 m)
Exploration					
West Apsheron 51	Government of Azerbaijan	01 Jan 1987	1,000	Oil	Tested oil at 157 b/d (617-630 m)
Exploration			15		
West Apsheron 52	Government of Azerbaijan	01 Jan 1987	1,000	Oil	Tested oil at 31 b/d (692-751 m)
Appraisal			15		

Volume estimation of this prospect we implemented together with Gosha Dash prospect evaluation.

Apsheron bank field. Gas seeps on the Sea floor along the fault trace sparked seismic surveys in the Apsheron area in 1947-51, 1952-54, 1958-59 and 1966-67. Shallow drilling was conducted on the Apsheron anticline in 1950-52. The first exploration well was drilled in 1951 to a total depth of 1,140 m and did not encounter any hydrocarbon shows. In 1964, two exploration wells (N2 and N4) were completed. Well, 4, located on the southwestern flank of the Apsheron field - tested 3.5-5.2 mmcfd of gas and 68-95 b/d of condensate from the Kala Suite (KaS) at a depth of 1,661-1,667 m. In 1965, well 11 was drilled on the northeastern flank of the field to a total depth of 803 m. The well-tested 204-238 b/d of oil from the Kirmaku Suite (KS). The oil accumulation was later confirmed by wells 21, 24 and 25. In May 2002, a new gas exploration well, number 23, was drilled to a depth of 2,005 m using the Khazar-4 jack-up drilling rig. The well tested an initial flow rate of 5.4 mmcfd. Between February and November 2004, SOCAR drilled two exploration wells to a depth of 800 m each using the semi-submersible rig Apsheron. In 2005, SOCAR drilled another exploration well and to build and install a stationary 12-slot drilling platform at the Apsheron Bank.

According to SOCAR source, the Apsheron field measures 15 km x 9 km at the top of the Kirmaku Suite (KS). The anticline is asymmetrical with a gently (25-30°) dipping southwestern limb and a steep (48-50°) northeastern dipping limb, trending WNW-ESE, cut by two longitudinal thrust and wrench faults as well as by normal transverse faults into several blocks. In the crestal part, the faulting was accompanied by diapiric clay intrusions related to the deep-Seated Miocene-Pliocene clayey sections. So far, oil and/or gas accumulations have only been found in the blocks situated in the NE limb. The trap mechanism is also related to lateral facies changes (shale-outs).

Field stratigraphy comprises sediments from the Oligocene-Lower Miocene Maykop Suite to the Productive Sequence. The upper part of the Productive Sequence has been eroded from the crest and the Sequence uncomfortably overlies the Diatom Suite and the Pontian. The Supra Kirmaku Mudstone Suite outcrops at the crest of the anticline. The Productive Sequence is composed of alternating sands and mudstones with the latter predominating in a total thickness of 1,800-2,000 m. In the Apsheron field, commercial hydrocarbon accumulations have been discovered in two reservoirs - oil in the Kirmaku Suite (KS) reservoir and gas in the Kala Suite (KaS). Oil specific gravity is 0.914 gr/cm^3 in average.

According to Woodmackenzie's source, the initial ABC_1 hydrocarbons in place at the Apsheron field are estimated at 37 mmbbl of oil and 25 bcf of gas (free and solution).

Commercial oil production from the Apsheron field began in 1971. Peak oil production was achieved in 1985 when the field produced over 380 b/d. Gas production from the Apsheron field peaked at 3.7 mmcfd in 1992. In the Apsheron field, a total of 21 development wells have been drilled, of which only five are active. The average oil well flow rate is 18 b/d of liquids, of which 14 b/d is oil (water cut is 25.9%). Two wells are understood to be producing free gas at this field.

Volume estimation for producing part of Apsheron bank is not implemented because the field is under the development of SOCAR.

Gosha Dash (old name Kamni Dva Brata) prospect. The uplift Gosha Dash is the marginal northwest structure within the studied area of the Caspian Sea. Gosha Dash has stratigraphic-lithological characteristics of the surface layers in this area related to independent uplift elongated north-west-south-eastwards and located in the continuation of the Tengin-Beshbarmak uplift. In 1950-1951 in the uplift Gosha Dash there was a weak local maximum demonstrating the approaching to the surface of the Mesozoic core.

The is in the north-western Apsheron archipelago, in 48-50 km to the north-west of Artiom island. The Sea bottom topography is dissected in the Stones area. An uplifted part is outlined in the central area where the Sea depth varies from 2 to 4 m. The stone outcrops in the Sea bottom form a range extending north-westward-south-eastward. It is 80 m long and 7-10 km wide. In some distance from the stone outcrops the Sea depth rapidly increases up to 30-35 m. At 20 m isobath, the shallow (uplifted) part is 6 km long and 2 km wide. The seismic survey in 1950-1951 identified far north-east and south-west limbs of an anticlinal high here. No reflections were obtained from the crests and an about 4

km wide blind zone remained in seismic profiles. An aerial survey in the Gosha Dash area gave no result either. In 1953 structure test drilling outlined the southwest limb of the uplift. Structure test drilling was performed in 1955 to find out the tectonic and stratigraphic relations of the Gosha Dash with the structure of the Apsheron and Tsurupa banks. The northwest pericline of the uplift was outlined and faulting in the south-west limb was identified. Further work outlined almost the entire structure. Yet the wells drilled on the northeastern uplift failed to provide data due to the very deep Sea and submarine currents. The Gosha Dash geology is built on the Productive series

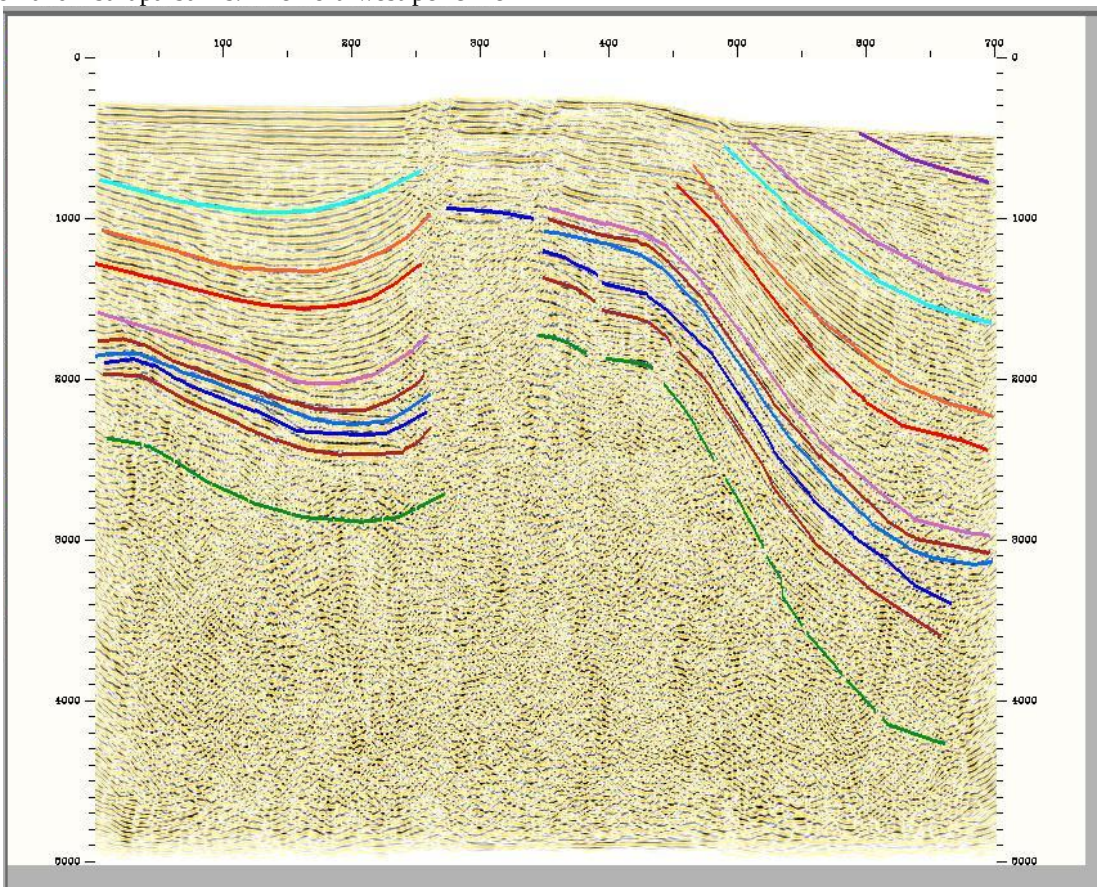

Figure 3. Gosha Dash seismic section

(PS), Akchagylian and Apsheronian deposits as well as the modern Caspian drifts. There are no modern drifts in the crest of the fold, but the further from the crest, the better they are developed and presented by fine- and mid-grained quartz sands. In the crestal position, the PS rocks are exposed to the Sea bottom. Their lithology is composed of poorly sorted and light-grey, coarse-grained sandstones, with black cherty pebblestone nodules. The light fraction is composed of predominantly quartz, feldspar and rock fragments. Seismic data shows that the Gosha Dash is located at the fork of two axes.Fig.3

One axis plunges south-eastward and the other trends east-south-eastward but does not join the fold axis of Apsheron bank as it shifts an echelon to the south of the bank. There is a small but sharp saddle between the periclinal closures of the Gosha Dash and Apsheron bank folds. A geological map shows the Gosha Dash uplift as a west-north-west-east-south-east trending brachyanticline. The Productive series (PS) top displays a 13x7 km fold. It is composed of the PS deposits (at the crest) and Akchagylian and Apsheronian stages (at the limbs). The PS crop outs are confined to the north-west pericline of the fold. They are sandstones in the middle part. This indicates that the PS is eroded up to the lower intervals. The fold is slightly asymmetric. The southwest limb is steeper than the northeast limb. The southwest limb dips at about 20-25°. The north-east limb dips at a maximum of 10-12°

The southwest limb is lowered and complicated by faulting near the northwest pericline of the Gosha Dash fold. The horizontal displacement of rocks near the northwest pericline is 1,5 km and 400 m in the southwest limb. High dip angles are due to this faulting: up to 65-70° in the northwest pericline and 28-30° in the southwest limb. The faulting is registered on the surface in the north-west pericline and it extends north-west-south-eastward, but it does not reach the Gosha Dash and turns south-south-eastward. Another transverse fault is registered in the southwest limb as it gets further to the east-south-eastward. This fault is also concurrent with the displacement of strata and high dip angles have been registered here (75-80°). The PS crops out to the southwest from the uplift to the shore along the coast, from Kilyazi Cape to Kechaldag. The PS deposits are fringed by the Akchagylian crop outs. On the other side, onshore structures in the coastline area are composed of older deposits – from the Pontian to Cretaceous. The Cretaceous crops out at the Sovetabad uplift crest. The periclines of the folds to the south of Tengin-Beshbarmak anticlinorium are built of the Pontian deposits. There are no these rocks in the Sea bottom

and this indicates that these folds flatten south-eastward, Seaward, to the known offshore folds - the Gosha Dash, Apsheron and Tsuryupa banks. A seismic survey is ongoing in the Gosha Dash area. As the PS is almost completely eroded in this structure, the Gosha Dash could be interesting as a Mesozoic oil and gas prospecting target. (Mammadov, 2004)

In 2012 SOCAR drilled exploration well N 1 in Gosha dash north-northeast flange of structure. In 2013 the same block of structure was drilled exploration well N 2. Both wells did not reach the planned well depth and were liquidated for technical reasons. **Volume estimation of this structure is implemented and attached.**

Stratigraphy. The geology of the north coast of the Apsheron peninsula is not studied very well. The main oil- and gas-bearing Suite is the Middle Pliocene Productive Series. Small oil accumulations occur as well in the Mesozoic deposits, which can be considered prospective due to oil fields onshore. The offshore area of the Apsheron peninsula is composed of deposits stratigraphically ranging from Jurassic to Quaternary (A.Alizadeh et al, 1972). The interval from Lower Cretaceous to Quaternary deposits was penetrated by wells.Fig.4

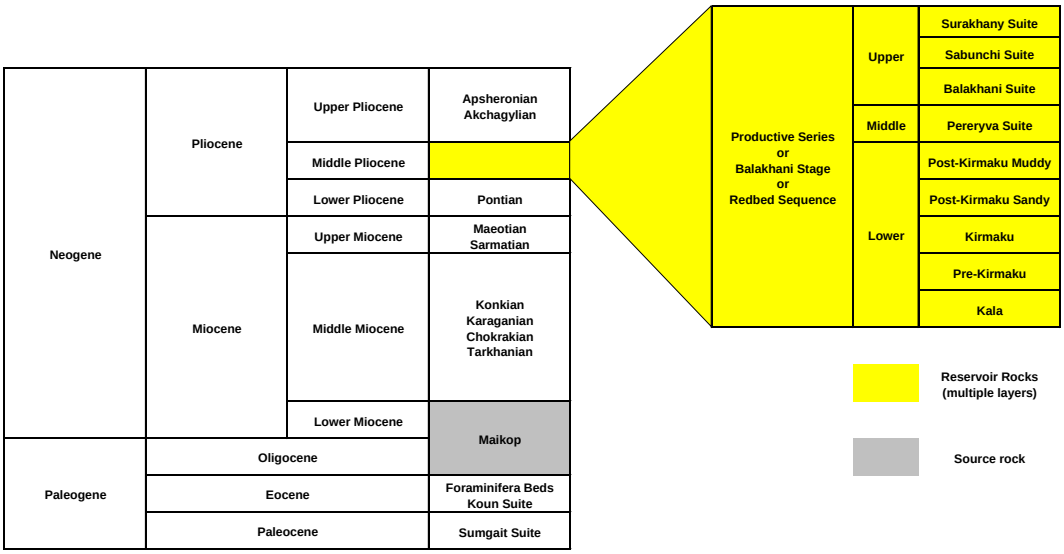

Figure 4. Generalised Stratigraphy of the Tertiary

General Tectonic Framework Tectonically the studied area is a part of the anticlinoria of the Apsheron archipelago. It occupies its northwest part. The Apsheron archipelago (the north-Apsheron Trend) is, on the whole, an independent complex-constructed structural element of the South-East Caucasus. It suffered the influence of two different tectonic factors in its evolution. One of them is the Mesozoic factor that resulted in the formation of large structures of a latitudinal strike and intensive down warping of the Caspian depression at the beginning of the Paleogene that determined sharp subsidence of the Cretaceous structural elements and their overlapping by the Tertiary deposits with the formation of structures of a meridional strike.

The uplifts in this zone have a very complicated structure. It is determined by the influence of deeply occurring (Mesozoic) layers on the formation of the Pliocene folding, i.e. by the combination of the fold-forming movements of a latitudinal (general Caucasian) and meridional (Caspian) trend.

The Greater Caucasus meganticlinorium stretches north-west-south-eastwards within the land and consists of the following structural units (from the south northwards): Altyagach-Kurkachidag anticlinoria, Dibraro- Yashminski synclinoria, Germiane uplift, Khizinski synclinoria, Tenginski-Beshbarmak anticlinoria, Kusar-Divichin synclinoria. Now there exists an opinion that in the general tectonic plan of the South-Eastern Caucasus the Apsheron Archipelago is a part of the Apsheron periclinal trough. The latter is a part of the Caucasian-Balkhan interpericlinal trough that was formed during the process of the subsidence of the bends of meganticlinoria in the Greater Caucasus and the Greater Balkhan. Tectonically the north-west part of the anticlinoria of the Apsheron archipelago is associated with the Tenginski-Beshbarmak anticlinoria. The tectonic position of the uplifts in the north-west part of the anticlinoria in the Apsheron archipelago, on the one hand, is determined by the folding of the axial zone in the southeastern Caucasus and, on the other hand, by the folding in the Apsheron region. Owing to this there arises a problem with the continuation of the folding southeastwards (Alixanov, 1978)

The studied area is located within the North-Apsheron Trend. It is worth attention from the point of view of the existence of favourable tectonic conditions which are necessary for the accumulation of commercial oil and gas deposits. Brachy-folds were determined in the Pliocene deposits (Gosha Dash, Apsheron bank, Agburun Deniz, Gilavar, Mardakyany - deinz, etc.), sometimes with structural complications of a terrace type. In the Apsheron bank together with oil and gas seepages associated with faults and supposed mud volcanoes, there were determined oil and gas deposits in the Kirmaki and the Kalin Suites of the Middle Pliocene.

Taking into account the tectonic position and the raised position of the Mesozoic surface (according to

the drilling data) and also the existence of structures in these deposits (geophysical data) the inflows of light oil and gas fountains out of the Mesozoic (Shurabad, Keshchai) as well as structural forms in the north-west of the Apsheron archipelago should be treated as targett for the Search of oil and gas in the Mesozoic deposits.

All the known and supposed new structural forms, probably, should contain oil and gas reserves. This supposition is based on the fact that they are located in the vicinity of the developed fields (Darvin, Pirallahi-north fold, Pirallahi-south fold etc.) and in the continuation of tectonic elements in the south-east of the greater Caucasus that are prospective from the point of view of the Search for oil and gas deposits in the Mesozoic deposits (Keshchai; Shurabad, etc.).

Deposits of the Productive series (PS) of the western side of the South Caspian Basin were formed after the processes of folding and before the formation of tectonic faults. The HC deposits were located in structural arches. At the late Pliocene-Quaternary period, as a result of tectonic fault formation, single arch (roof) deposits appeared to be separated into individual tectonic blocks.

Tectonic disturbances on the structures of the "Absheron trend" play both a negative and a positive role. In the first case, they contribute to the destruction of deposits (for example, on the Khala structure), and in the second, to their prevention (Chilov Island) under favourable geological conditions. The sediments underlying the PS are uncovered by wells to shallow depths. Given the deep erosion of PS deposits on the crests of uplifts, it is advisable to place wells here to study Mesozoic deposits. Geologic Evolution. (Babayev et al, 2006)

The geologic evolution of the north-western part of the Apsheron archipelago is governed by two factors: a) the constant uplift of the mountain chain of the Greater Caucasus and b) the intensive downwarping of the Caspian depression. This resulted in a shallow occurrence of the Mesozoic rocks along the crests of the uplifts together with the accumulation of a thick series of Middle Pliocene rocks in the areas of strong subsidence.

The thickness decreases of the Upper Cretaceous deposits or their complete pinch-out towards the arch (Agburun Deniz, Apsheron bank) demonstrates that in the frontier of the Lower and the Upper Cretaceous on the arches of the uplifts (Apsheron bank, Agburun Deniz) were underwater cordillera elevated above the Sea floor and it was the result of erosion.

Intensive down warping of the basin floor during the Eocene resulted in the accumulation of mainly clayey deposits of the Konian Suite that unconformable overlie the Cretaceous deposits (Apsheron bank, Agburun Deniz). The uplift process continued in the Oligocene and Maycopian period. This regime resulted in the appearance of certain uplifts within the Apsheron region. Intensive growth of the folding results in a considerable decrease of the Maycopian Suite thickness on the crests of the anticlines.

The Chockrak age is characterized by a regression of the Sea. This is indicated by the lack of the Chockrak horizon deposits in the arches and their existence on the slopes of most of the structures in the Apsheron archipelago.

Sedimentation mainly of the clayey formations of the Diatomic Suite started at the beginning of the Karagan stage period. It went on till the Meotian period inclusive. At the end of the Diatomic Suite, the dominating role was played by the tectonic movements of a meridional orientation determined by the down warping of the Caspian depression (the Meotian period).

By the beginning of the formation of the Productive Series deposits there occurred a regression of the Lower Pliocene Sea, as a result, the Kalin Suite (KaS) occurred in the Pontian deposits with angular unconformity. Moreover, the basin of the Kalin Sea was not large and covered the southeast pericline of the uplift Apsherons bank (wells N 3; 4; 5; 8; 10 and 14). Most of the northeast slope was land and it was composed of the Diatomic rocks. This is indicated by the lack of the KaS there and by the unconformable occurrence of the KS rocks in the Diatomic layers (wells N 11; 13; 16; 19 etc.) The decrease of the sedimentation basin of the KaS is also indicated by the lack of the appropriate formations in the section of well N1 in the uplift Gilavar where the Kirmaki Suite (KS) deposits directly occur in the underlying rocks (Maycopian). The KaS deposits up to 56 m thick were stripped in well 19 located in the far subsidence of the southeast pericline of the uplift Mardakyany - Deniz.

The beginning of the period of sedimentation of the Lower Kirmaki (LK) Suite is characterized by a widening of the basin margins that covered the near-arch part of the Agburun Deniz and also the southwest slopes and the east periclines of the Apsheron bank and the Agburun Deniz. The decrease of the LK Suite thickness and its pinching-out occurs northwards of the studied wells. Thus, the thickness of the LK Suite in well 15 is 24 m and in wells N23; 13; 2 and 17 there was a recorded absence of these deposits. By the beginning of the Kirmaki period, the sedimentation basin considerably widened and occupied the whole northwestern part of the Apsheron archipelago. When studying the map of equal thickness one can see that in the arches of the uplifts, there was recorded the minimum thickness of the KS and the maximum thickness was recorded in the subsidence of the structures.

The overlying deposits in the upper division of the PS in the arches of the uplifts are considerably washed out. They are only preserved in the far subsidence of the uplifts and in the adjacent synclines. The clayey nature of the Balakhany Suite deposits and the thickness of its deposits within the Apsheron archipelago show relatively calm geotectonic surroundings during the whole period of the Balakhany Suite. The increase of the clayiness of the deposits in the upper division of the PS in the ascending stratigraphic succession makes it possible to suppose that the fold-formation processes were decaying then.

The thickness and facies of the upper Pliocene deposits which are mainly composed of clayey rocks demonstrate their accumulation in the synclines and in the subsidence of the anticlines and that they are in complete conformity with the tectonic plan of the studied region. Thus, the sedimentation of the PS within the

archipelago just like in the whole Apsheron oil and gas region occurred in close relation with the processes of the fold evolution. A peculiar feature of the evolution of the Apsheron archipelago structures is a separate evolution of two groups of anticline structures that now contain oil deposits (Apsheron bank, etc.) and buried uplifts containing gas condensate accumulations (Janub, etc.). This peculiarity is determined by the formation of the flange framing of the Caspian depression and the regional dip of the layers from the flanges towards its central part.

Analysis of the history of the geological evolution of the northwest of the Apsheron archipelago allows making the following conclusions:

1. The geotectonic evolution of the area is determined by the rising of the Greater Caucasus and the down-warping of the mountain structures in different geological periods caused the absence of the appropriate deposits in the arches of the uplifts whereas the down-warping of the Caspian depression resulted in the accumulation of these deposits in the subsidence of the structures and in the synclines that separated them.

2. The formation and evolution of the structures coincided with the active manifestation of the Alpine folded system. The growth of positive structures occurred in the background of a general subsidence of the basin together with the sedimentation, i.e. it was of a condemnation character.

3. The history of geological evolution in the upper Cretaceous epoch allows us to suppose the existence of a complete section of the Cretaceous deposits in the subsided areas of the structures Apsheron bank, Agburun Deniz ,Gosha Dash, etc.

4. Anticline folds (structural complication) are located to the north and to the northwest of the uplift Apsheron bank. Before the sedimentation of the Middle Pliocene deposits, they developed independently. During the sedimentation of the PS, their growth sharply logged from that in the b. Apsheron bank. As a result of the folds “opened” and in the recent middle Pliocene structural plan they are a structural terrace and a low amplitude (up to 50 m) anticline structure.

5. Regional dislocations that complicate the arches of the structures of Gosha Dash, Agburun Deniz and Apsheron bank have been developed for a long time. They formed before the sedimentation of the Middle Pliocene and significantly influenced the sedimentation.

6. From the Upper Cretaceous till the Middle Pliocene the arch of the uplift b occupied the highest hypsometrical position. Agburun Deniz. Since the late Middle Pliocene, it has been occupied by the uplifted Apsheron Bank.

7. The washout of the upper Pliocene and the Anthropogenic deposits in the elevated areas of the structures Mardakyany - Deniz, Gosha Dash, Apsheron bank and Agburun Deniz does not allow reconstructing the character of their evolution during the post-Pliocene epoch. At the same time, the sections of the Akchagyl and the Apsheron stages in the subsided areas of these uplifts is mainly represented in the deep-water facies where one can observe the lack of the rudaceous differences. A constant lithofacial composition like that allows to make a supposition that in the basin of the upper Pliocene there was recorded a lack of big islands. Hence, the washout of the Upper Pliocene deposits in the near-arch areas of the above-mentioned structures occurred after the Baku tectogenesis which determined a sharp rise of the uplifts and a complete formation of the recent structural plan.

8. As it is known, hydrodynamic conditions in the Sea existing within the studied area result in the wash-out in the Gosha dash, Apsheron bank and Agburun Deniz. Despite this, isobaths of the smallest depths contour the near-arch areas of the brachyanticlines. We think that this demonstrates the continuation of weak ascending movements nowadays as well.

Reservoirs and Source Rocks. Mature source rocks are proven by the many discoveries of oil and gas in the South Caspian Basin. The balance of expert opinion favours the Maykop Suite of the Oligocene-Lower Miocene as the primary source rock for the oil and gas discovered in the Productive Sequence. The intraformational shales of the Productive Sequence are also considered to have significant source potential. In global terms, the South Caspian is a very young basin and is relatively cool. As a consequence, the Oligo-Miocene source rocks continue to generate oil at burial depths over 6 km. Only in the deeper parts of the basin are the source rocks sufficiently deeply buried to generate significant volumes of gas. The relative proportions of oil and gas generated in the deeper parts of the South Caspian Basin remain highly uncertain but the discovery of gas in Shah Deniz has led many industry experts to predict the same for many of the prospects in the deeper water basin.

In the Apsheron shallow & transition Block uplifts are highly raised and deeply washed out, therefore oil contained here are only suites of the lower section (KaS, LK, KS, LKS, and LKC) of PS (L.Neogene). Fig.5

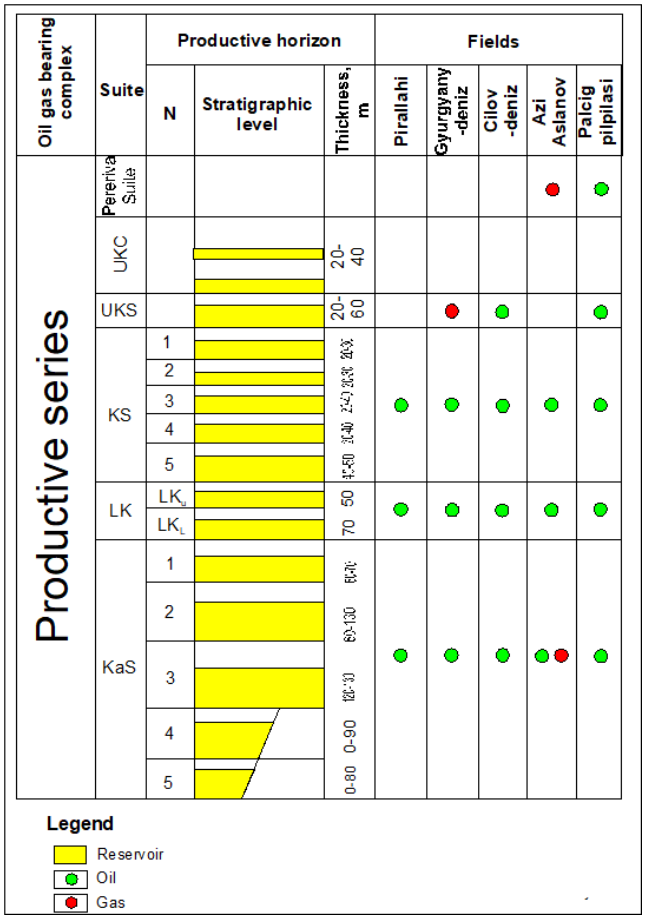

Figure 5. Shallow water transition zone of Apsheron Trend. Main oil and gas contained fields

KaS is lithologically variable by area and section. LK Suite contains oil in sandstone benches in the lower and upper parts of the section. KS is one of the main oil and gas-containing objects in Chilov-Deniz, A. Aslanov fields. Gyurgyan-Deniz field has deposits only in the lower KS. On Pirallakhi only four objects are oil and gas bearing- KS_2-KS_5. The commercial oil and gas content of the UKC Suite is determined only on separate blocks of A. Aslanov and Palchyg Pilpilyasi fields. The rhythmic sequence of reservoirs and intra-formational clayey Seals created favourable HC conditions for saturation of most of the section as well as pre-determined a possibility for preservation of gas-condensate and oil deposits even in tectonically dislocated and deeply washed-out structures.

There are two Santonian-Campanian gas-bearing sandstone reservoirs tested so far (August 2000), in the Shurabad structure: the upper interval is between 132 m and 135 m (tested in the Shuraabad 54 well in 1937) and the lower interval is between 180 m and 183 m (tested in the Shuraabad 8 well in 1936). The Oligocene-Lower Miocene bituminous shale and marls of the Maykop Group type as well as some clays and carbonates of the Middle Miocene Chokrak and Karagan formations are considered to be one of the main source rocks in this area. In general, these bituminous shale and clays, which are deposited in a strongly reducing environment, have a high organic carbon content (0.5 to 5%) and are of sapropelic type. The average organic carbon content of these Miocene source rocks is 1.55%. Granular reservoirs of the M.Jurassic and fractured-granular ones of Valanginian and Hauterivian stages of the L.Cretaceous, and granular reservoirs of Maykop (U.Miocene). Seal- carbonate and non-carbonate clays (Cenozoic-Mesozoic deposits). Traps are fault-blocked and stratigraphic traps.

Well and Seismic database. For estimation of reserves, well-log analysis of the following wells:

West Apsheron – 3 wells (18; 46; 47); Apsheron Bank – 11 wells (7; 8; 9; 10;!4; 15; 16; 18; 19; 41;50); West Apsheron correlation1- 3 wells (6; 15; 17); Apsheron Bank – correlation – 3 wells (18; 11; 7); Kalin Zaliv – 2 wells (13; 14); North Apsheron – 4 wells (1; 2; 3; 5); Mardakyan – 2 wells (13; 16); Noukhany 1 well (1); Gilavar – 2 wells (1; 2); Khazri - 2 wells (3; 4); Arzu –1 well (1); Kurkachidag- 1 well (1); Yashma Sea-1 well (1); TOTAL: 36 well logs.

Interpretation of Regional Seismic Grid width 10 km, locally increased to 5 km line spacing, oriented in NW-SE and SW-NE direction. Area depth closure of the Gosha Dash –West Apsheron prospect (For volume estimation selected two target horizons PK of Lower Productive series and Mezozoic deposits).Fig.6

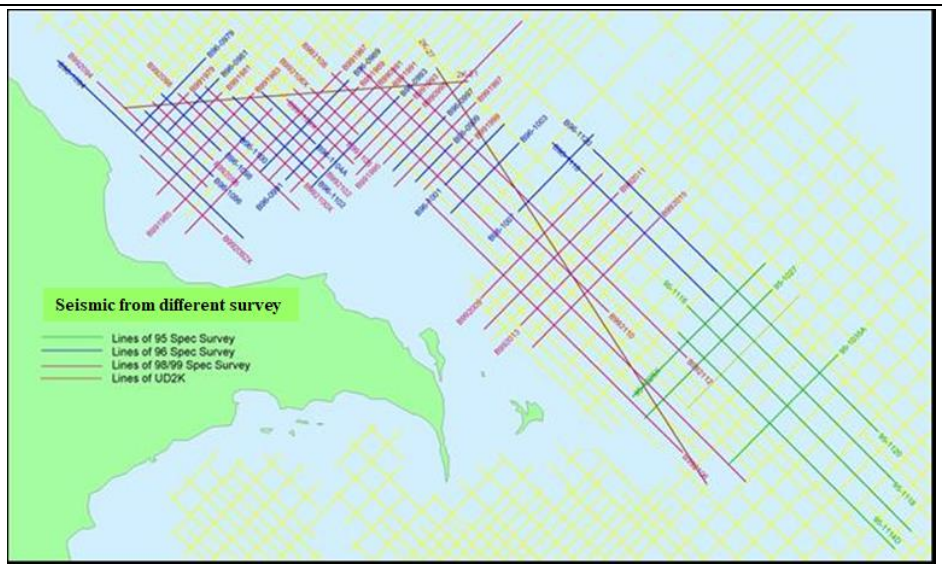

Figure 6. Location of used Seismic lines

A structure at the Mesozoic interval is identified on 2D seismic data. This structure is of a potential exploration nature, but very risky due to expected severe internal compartmentalization, and very limited knowledge of the charge mechanism for the Mesozoic, reservoir properties. The entire Mesozoic below the Bank-Apsheron area is undrilled to date. Only one well-penetrated Mesozoic at the edge of this structure in a very down-dip position. For the estimation of reserves, we used the famous Monte Carlo method.

Resource volume estimation.

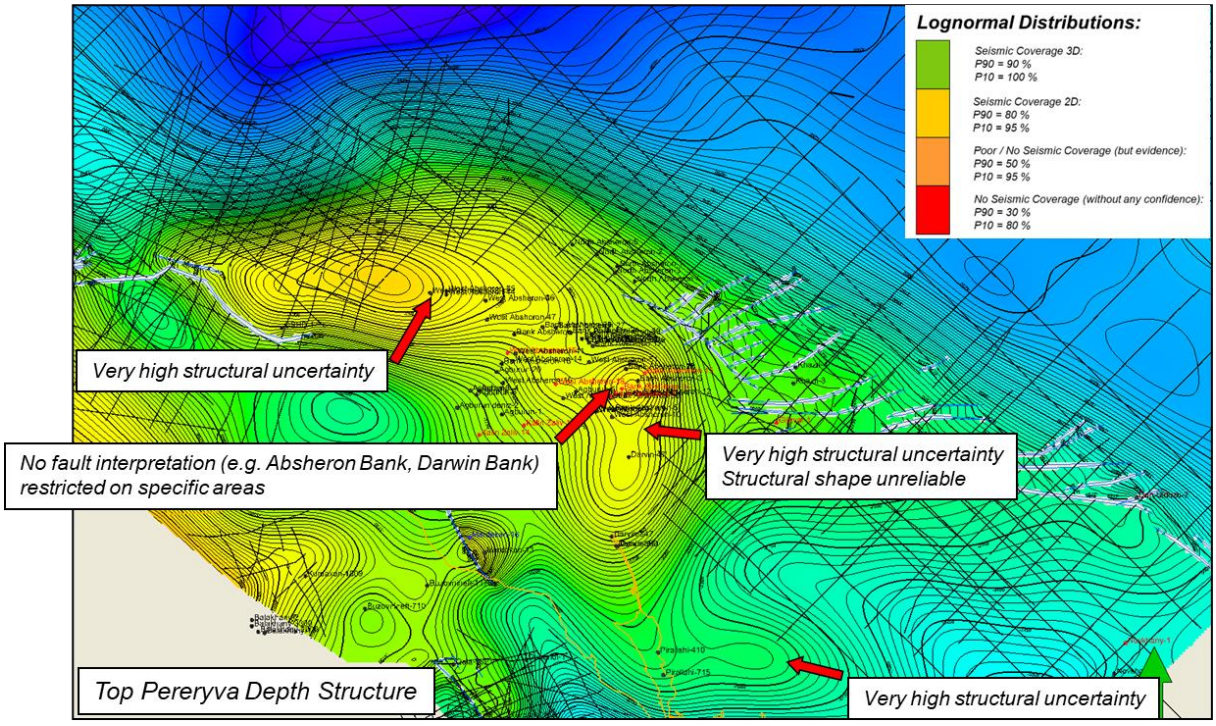

Figure 7. Volumetric parameters. Area uncertainty

The calculation of the resource volumes is based on the Depth maps. The depth maps, the formation tops of the reference wells, the petrophysical evaluation and the fault Seal and top Seal risks were incorporated with estimation of resources and reserves and supplied with reservoir property data for the potential Mesozoic play. Applied column height estimates: Lognormal, P99 = Crest, P1 = 300 m

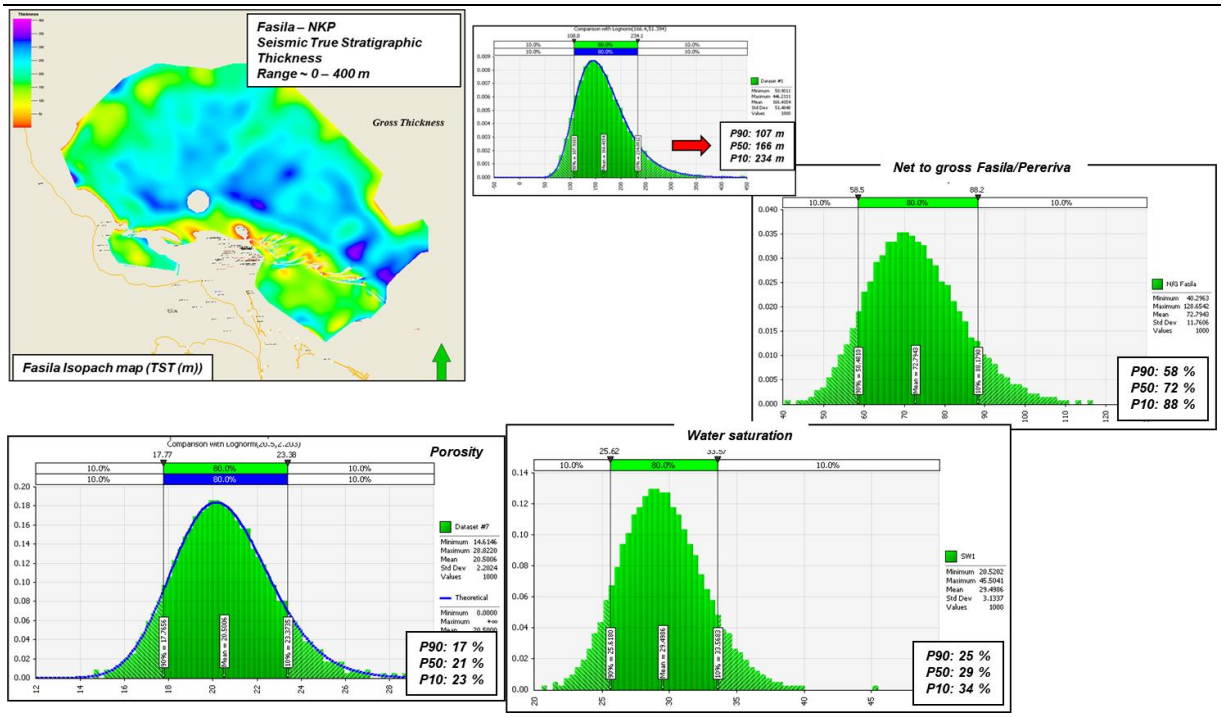

Figure 8 Fasila/Pereriva. Volumetric parameters

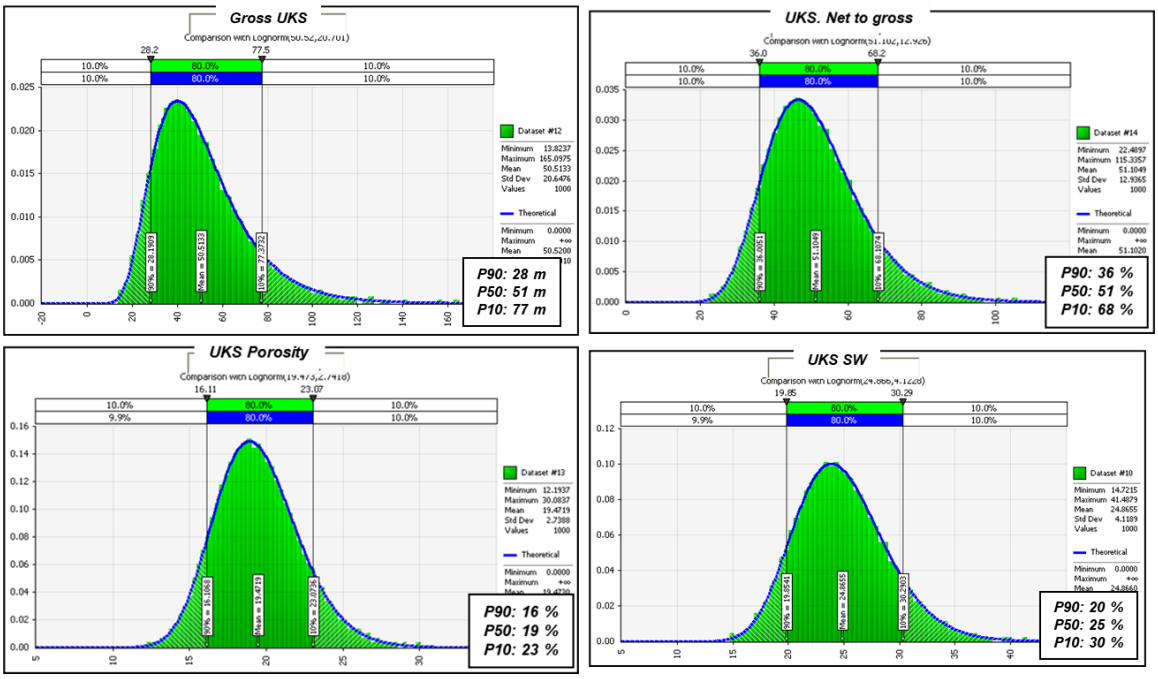

Figure 9. Upper Kirmaki sandy (UKS) Volumetric parameters

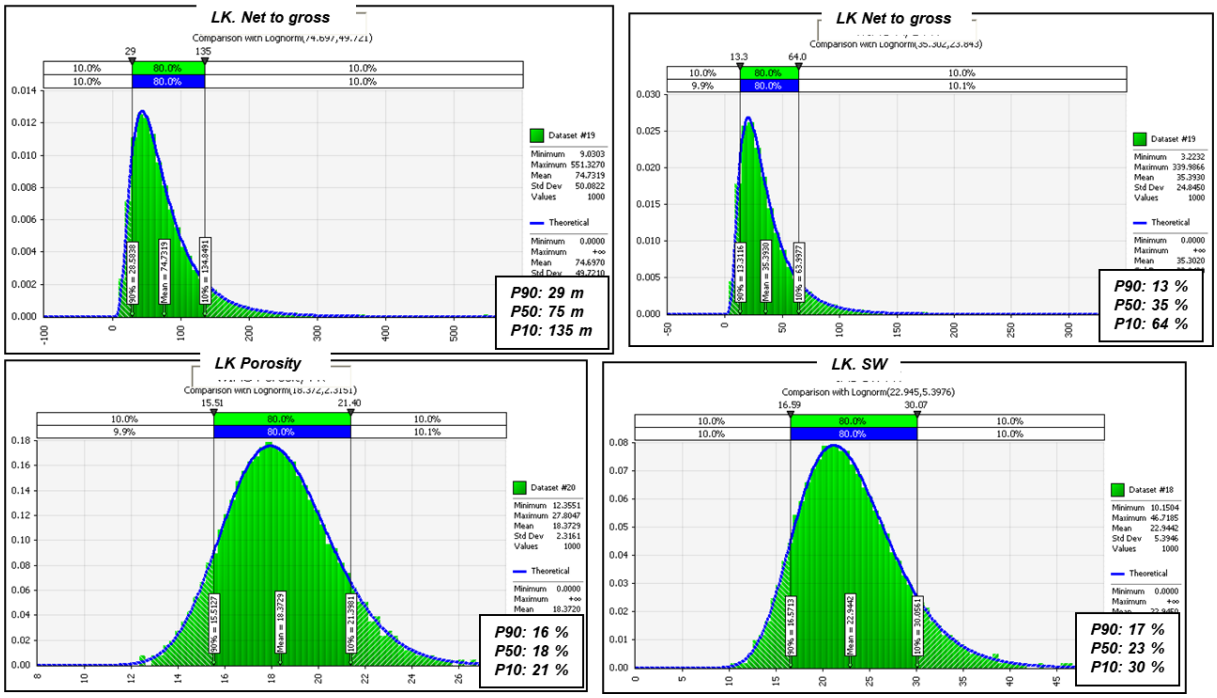

Figure 10. Lower Kirmaki (LK) Volumetric parameters

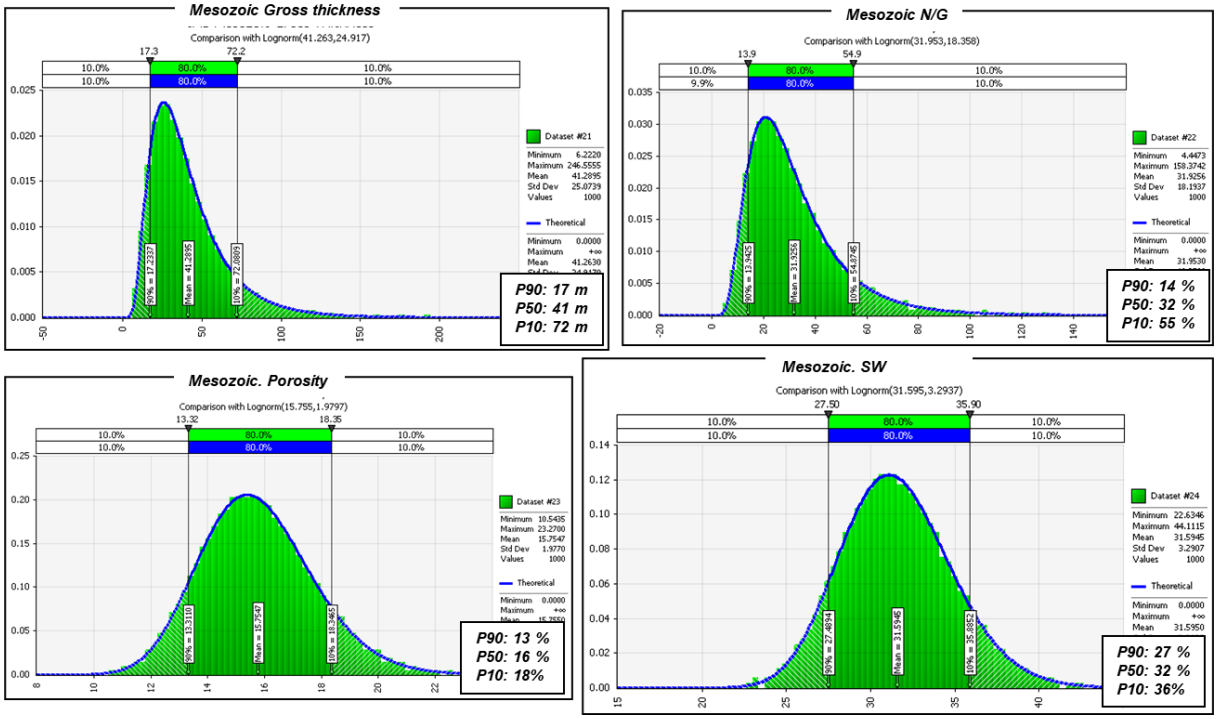

Figure 11. Mesozoic Volumetric parameters

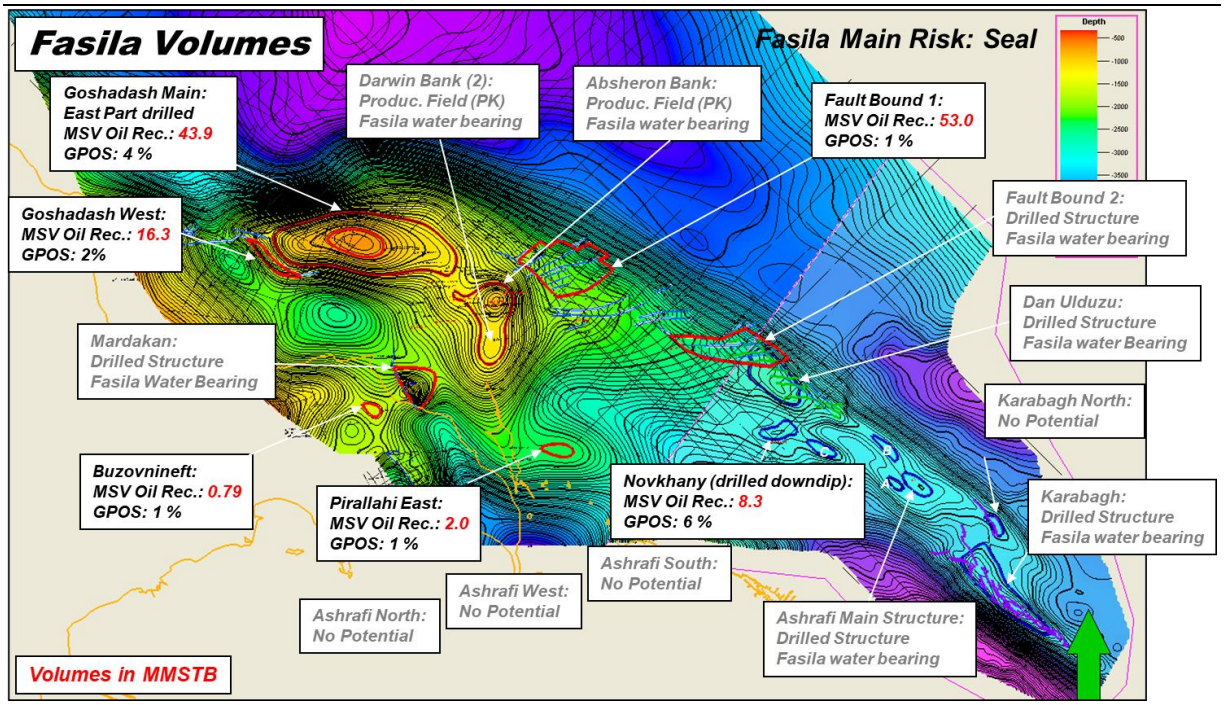

Figure 12. Fasila/Pereriva Volumetrics & Risking

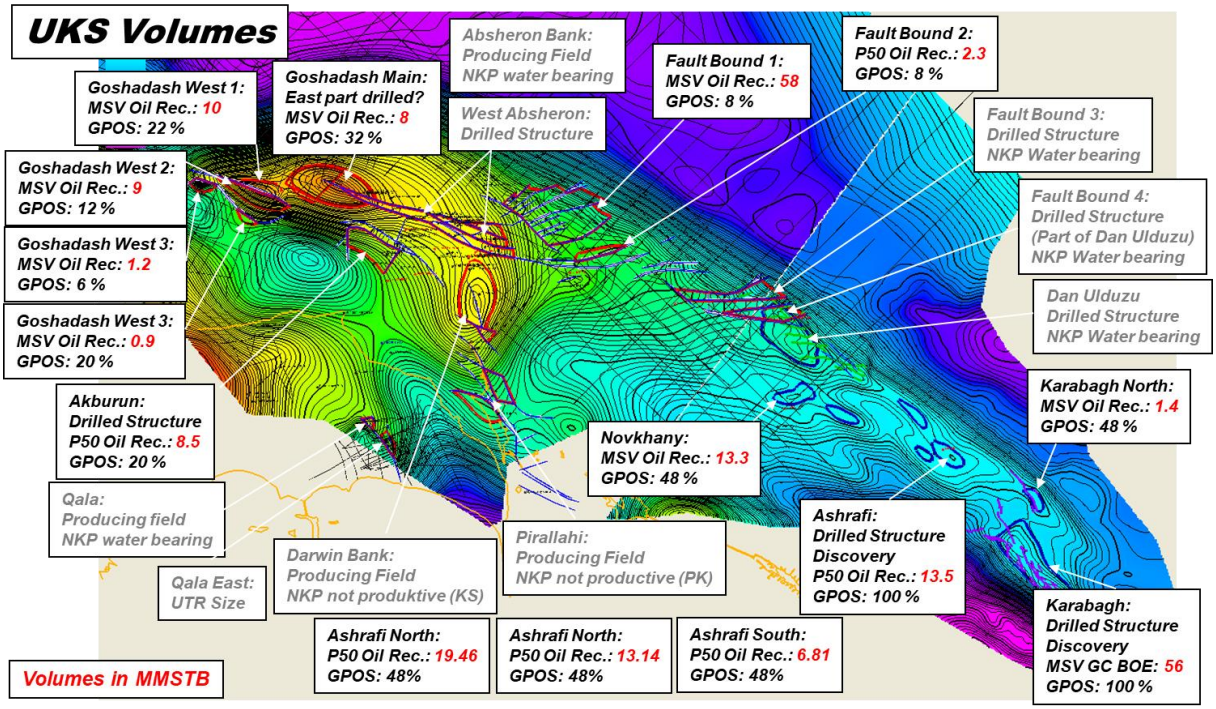

Figure 13. Upper Kirmaki sandy suite Volumetrics & Risking

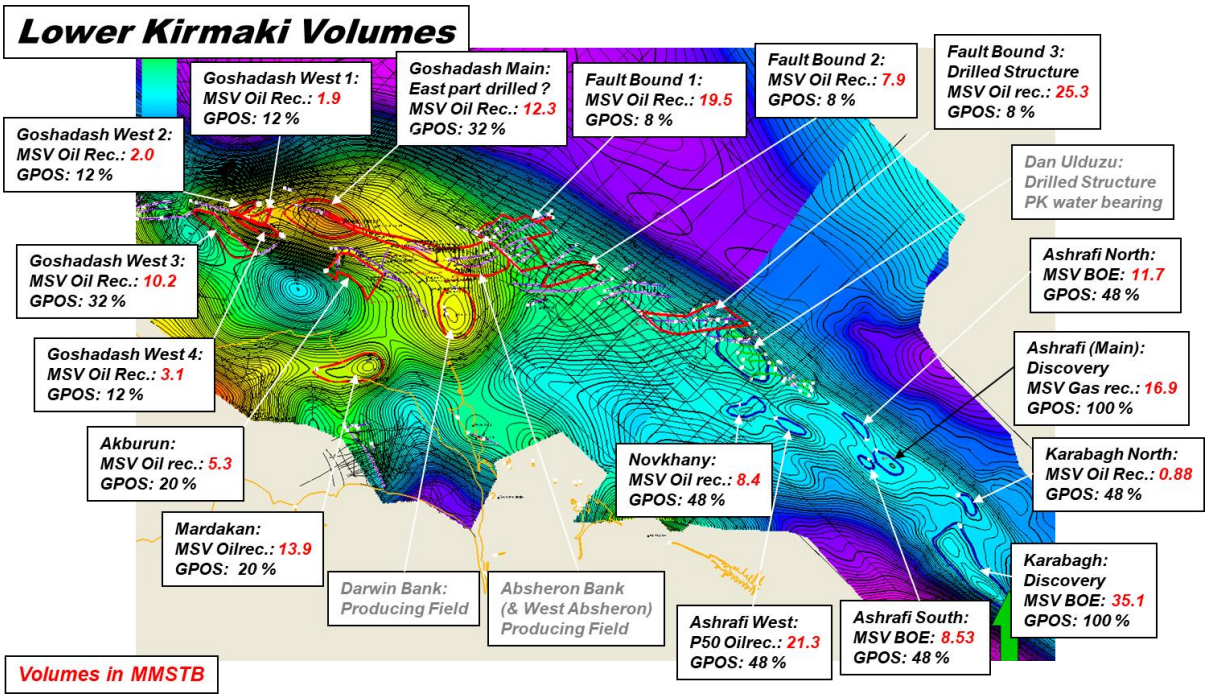

Figure 14. Lower Kirmaki suite Volumetrics & Risking

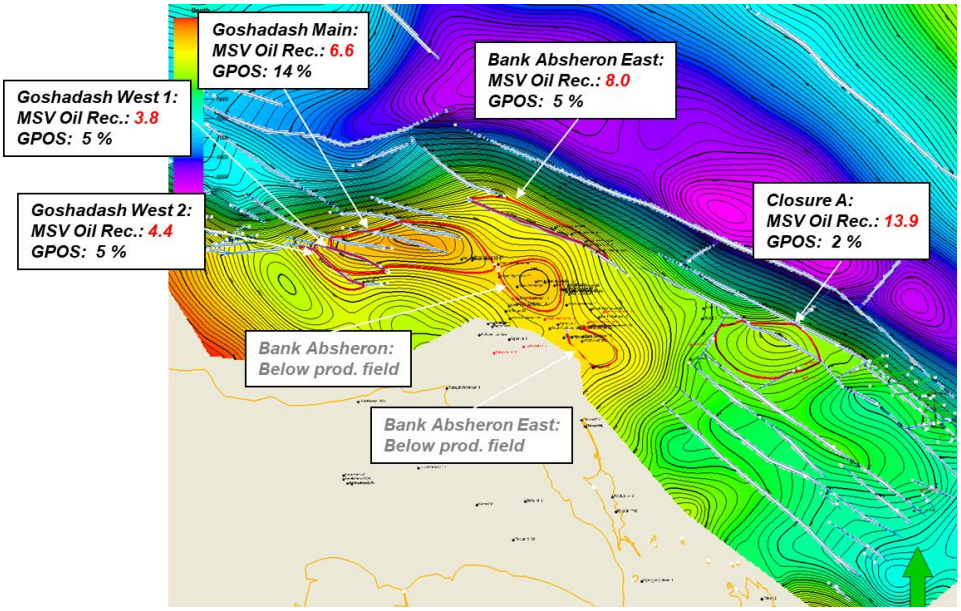

Figure 15. Mesozoic Volumetrics & Risking

Methodology. Area Depth graphs were derived from the Top Fasila/Pereriva, Top NKP, and Top Mesozoic reservoir. Intercalated reservoir layers were attached to the area depth graph in the Montecarlo program.

For the definition of compartments all interpreted faults on reservoir levels were combined to a general fault trend map. A structural model was superimposed to separate the structure with N-S trending faults. The last closing contour and well data were used to define polygons/compartments to further subdivide the structure into meaningful structural compartments. Fig.16; 17; 18 and 19

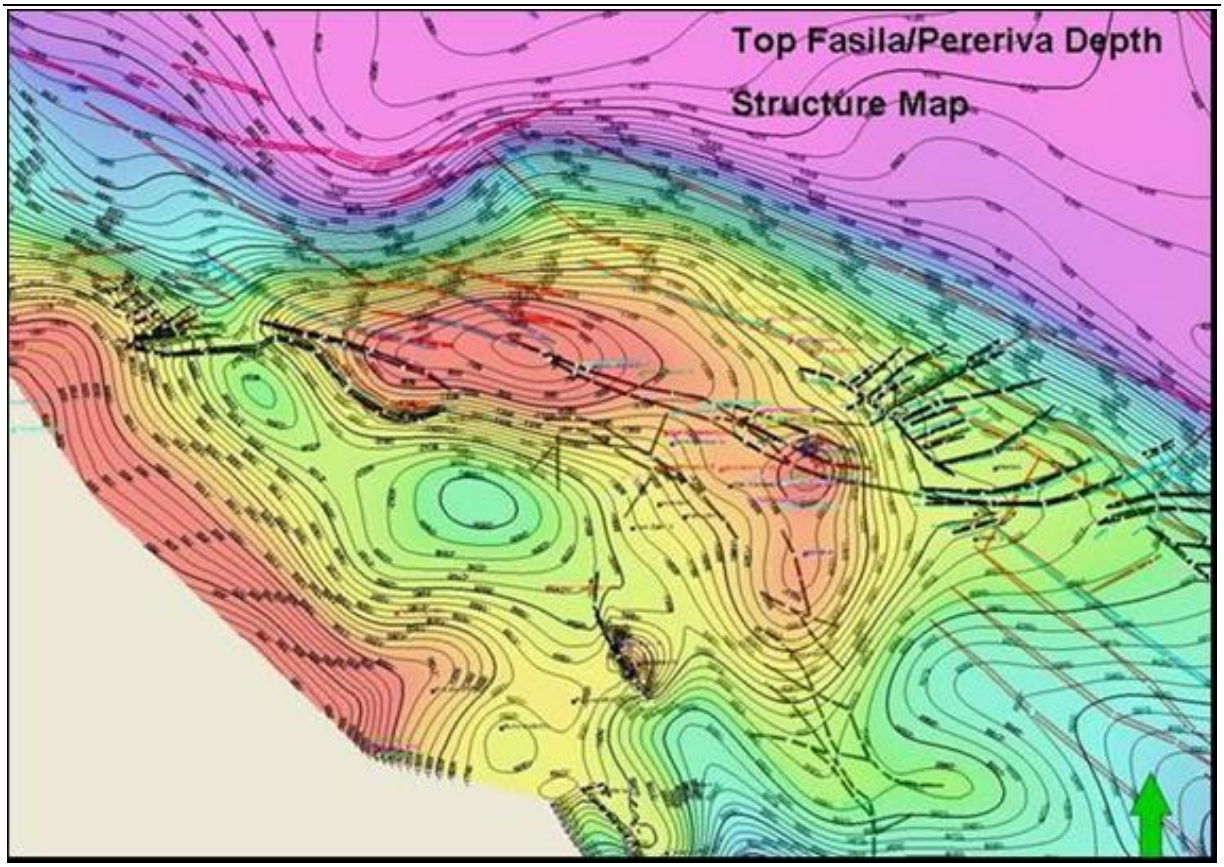

Figure 16. Top Fasila/Pereriva depth map

Reservoir input parameters are sums & averages from petrophysical interpretation for the Productive Series and the Mesozoic deposits. Since the Productive Series consists of five stacked reservoir layers, these layers were individually evaluated and consolidated. The consolidation was carried out for individual reservoir layers, and polygons and also consolidated in total.

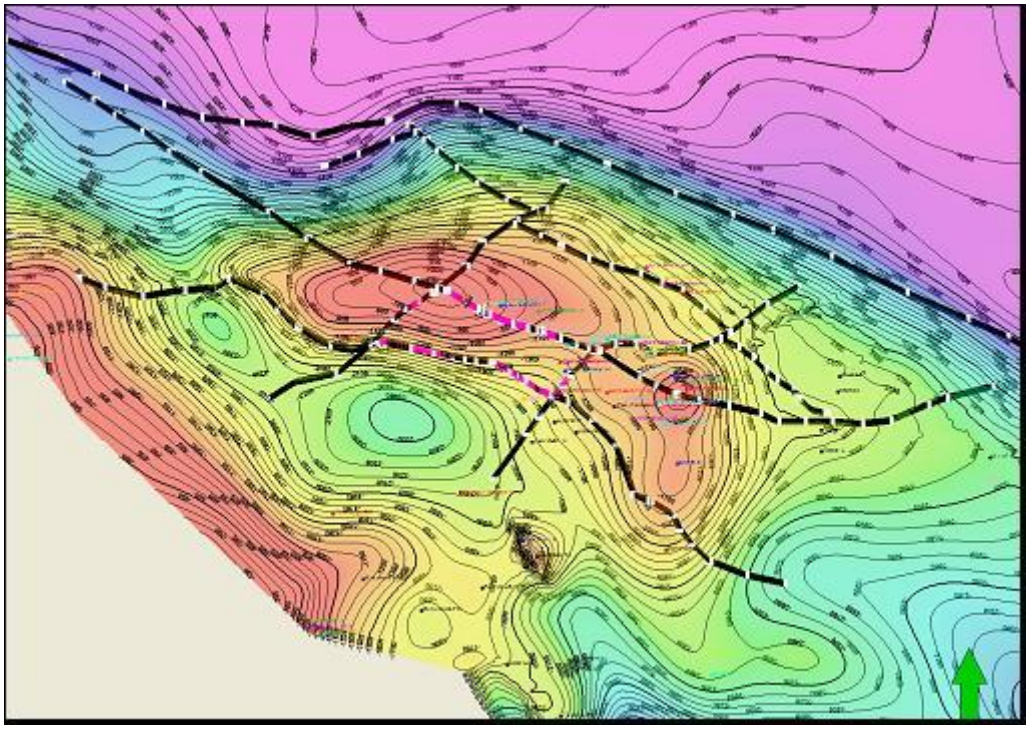

Figure 17. Top Fasila depth map with lowest closing contour

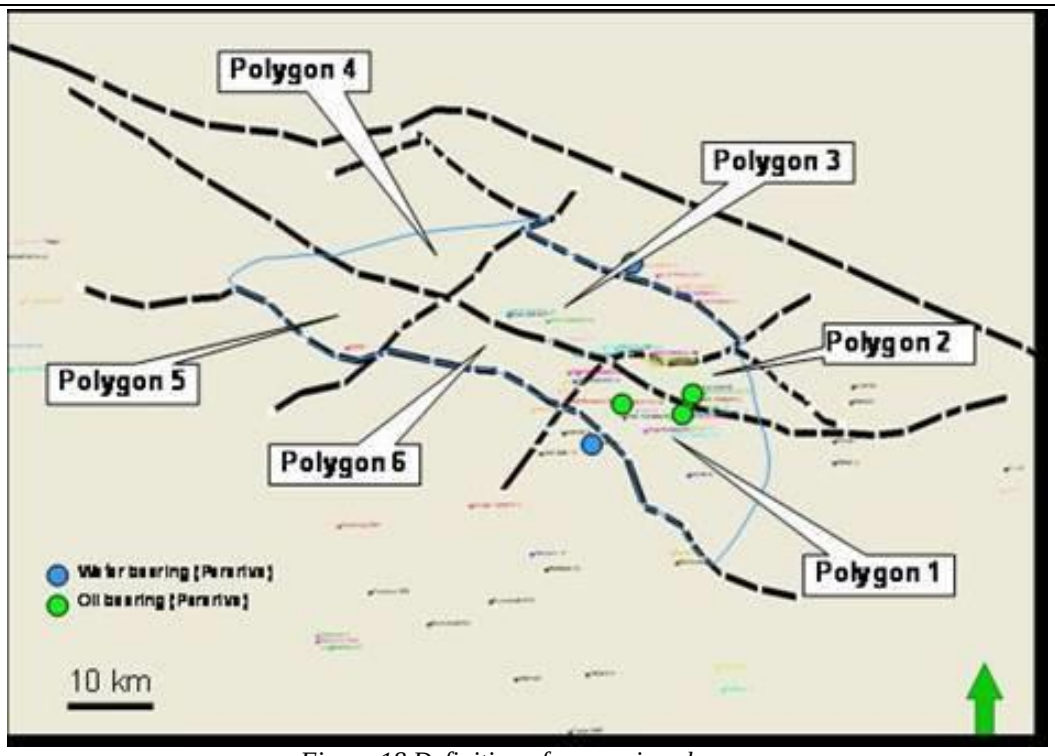

Figure 18 Definition of reservoir polygons

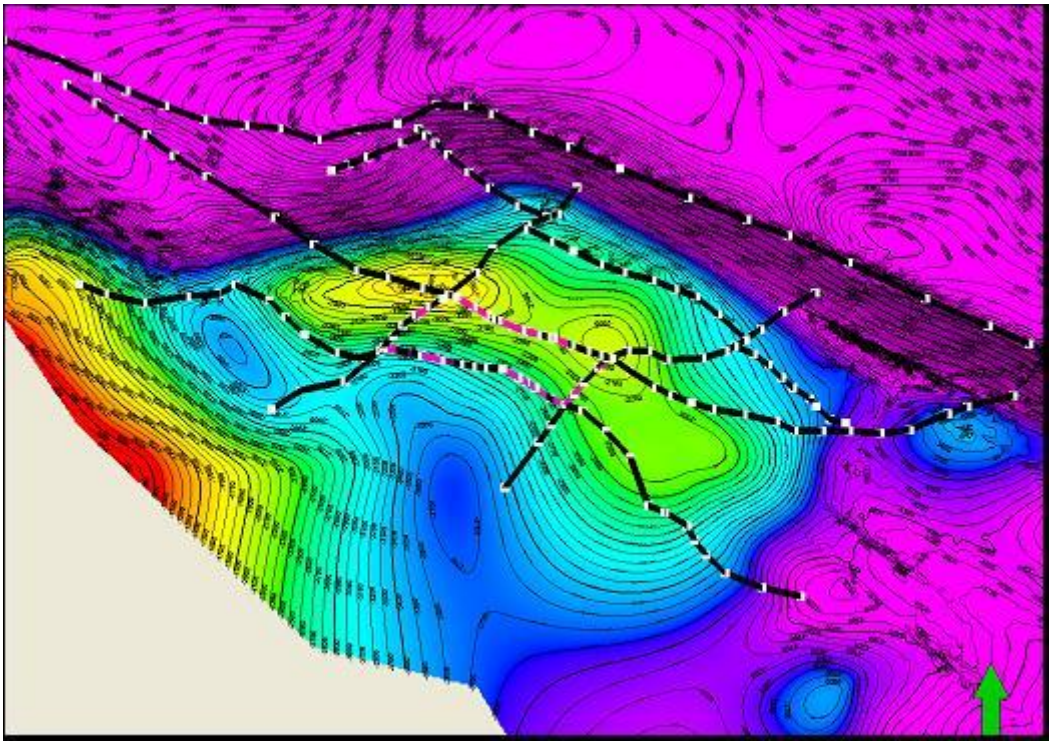

Figure 19 Top Mesozoic depth map

Technical Results.

Productive series Interval.

- Individual resource volumes per individual reservoir layer and polygon are described in Tab. 1

- **The overall consolidated resource volumes for the Productive Series of the entire Bank-Apsheron area totalling 80.3 MMBBL.**

- **The overall consolidated resource volumes for the Mesozoic of the entire Bank Apsheron area is totalling 21.4 MMBBL**

- **The consolidated resource volumes for the Gosha Dash area amount to 16.1 MMBBL**. This area is undrilled and, based on the structure map available, has to be defined as being an integral part of the Bank Apsheron structure. Therefore, this part of the structure is not identified as exploration, but as an appraisal & development target for future wells.

Mesozoic Interval:

- A structure at the Mesozoic interval is identified on 2D seismic data. This structure is of a potential exploration nature, but very risky due to expected severe internal compartmentalization, and very limited knowledge of the charge mechanism for the Mesozoic, reservoir properties.

- GPOS is currently estimated to range between 5-10% max. The entire Mesozoic below the Bank-Apsheron area is undrilled to date. Only one well penetrated Mesozoic at the edge of this structure in a very down-dip position.

Table 1.

Resource volumes of all reservoir layers in Banka Apsheron/Gosha Dash area

			MMBBL, Recoverable reserves , MSV unrisked	GPOS%	Comment
polygon 1	Productive series	Pereriva/Fasila	1.9	100	
		upper Kirmaki sandy (UKS)	0	100	proved water bearing by well
		Kirmaki	0	100	proved water bearing by well
		lower Kirmaki (LK)	21.3	100	
		Kalinskaya (KaS)	3.04	100	
		Mesozoic (oil case)	13.7	5-10%	
polygon 2	Productive series	Pereriva/Fasila	1.91	100	
		upper Kirmaki sandy (UKS)	0	100	proved water bearing by well
		Kirmaki	0	100	proved water bearing by well
		lower Kirmaki (LK)	14.9	100	
		Kalinskaya (KaS)	1.75	100	
		Mesozoic (oil case)	11.4	5-10%	
polygon 3	Productive series	Pereriva/Fasila	21.5	24	
		upper Kirmaki sandy (UKS)	5.9	12	
		Kirmaki	4.5	12	
		lower Kirmaki (LK)	9.06	30	
		Kalinskaya (KaS)	3.45	30	
		Mesozoic (oil case)	22.4	5-10%	
polygon 4	Productive series	Pereriva/Fasila	23.6	23	
		upper Kirmaki sandy (UKS)	1.95	11	
		Kirmaki	1.21	11	
		lower Kirmaki (LK)	2.71	28	
		Kalinskaya (KaS)	1.01	28	
		Mesozoic (oil case)	34.06	5-10%	
polygon 5	Productive series	Pereriva/Fasila	24.6	23	
		upper Kirmaki sandy (UKS)	3.05	11	
		Kirmaki	1.95	11	
		lower Kirmaki (LK)	4.29	28	
		Kalinskaya (KaS)	1.6	28	
		Mesozoic (oil case)	17.3	5-10%	
polygon 6	Productive series	Pereriva/Fasila	39.3	23	
		upper Kirmaki sandy (UKS)	2.57	11	
		Kirmaki	1.67	11	
		lower Kirmaki (LK)	3.65	28	
		Kalinskaya (KaS)	1.34	28	
		Mesozoic (oil case)	11.3	5-10%	

Conclusion:

- The Bank-Apsheron, West-Apsheron and the Gosha Dash area have been identified to have the highest potential in the Lower Productive Series (LK, LKS) of the transition zone offshore Azerbaijan. **Total resource volumes are 80,3 MMBBL.**
- SOCAR has been producing recently from the Bank-Apsheron field from the Productive Series. West-Apsheron was drilled by SOCAR but was not developed. **The only undrilled area left in the entire Bank-Apsheron area is Gosha Dash with 16,1 MMBB.** Gosha Dash is viewed as a target for potential field extension (appraisal and development) for SOCAR.

The remaining exploration potential below Bank-Apsheron and West-Apsheron is the Mesozoic identified on 2D seismic at approximately 2000m depth.

- **The Mesozoic is currently evaluated to have 21,4 MMBBL for the entire area** with a very low GPOS of 5-10%. The GPOS of 32% is a result of the consolidation and is viewed as high. To reach a sound geological understanding of the Bank-Apsheron structure a dedicated 3D seismic survey, covering the entire structure, would be needed targeting the Productive Series and the Mesozoic. There is upside exploration potential, in the shallow water Transition zone of the Apsheron area, which is the undrilled area next to Apsheron bank: Sumgait Sea, Kurdakhani Sea with undeveloped Kalin Zaliv field, where a couple of wells discovered oil and gas but due to lack of infrastructure, the discoveries are not on production yet. Production is ongoing in the onshore part of the Shurabad field, but the offshore part is not developed yet. North Apsheron Four, Yashma Sea One, Kurkachidag Sea One, Mardakan Sea Five wells and Agburun Sea Four wells failed due to technical and geological reasons. Only one well in the North Apsheron prospect during the testing process gave weak oil flow within the Apsheron bank area. Agburun (four wells) Sea, Mardakan Sea (five wells) Arzu (one well) & Gilavar (one well) prospects are drilled but due to technical and geological reasons there are commercial discoveries are not found. Khazri & Noukhnay had a discovery of gas condensate but due to the absence of infrastructure, the discovery is not in production yet. East Apsheron, Gosha Dash, Sevinj, Gatl Gunu,, Sumgatit Sea, & Kurdakahni Sea are not drilled yet.

In general, the entire transition zone (land-sea) of the Apsheron shallow waters presents a good exploration potential for oil and gas and modern 3D seismic should be recommended, if drilling in the Mesozoic, then use horizontal drilling from the shore as similar work is being done in the North Sea. The recent unsuccessful results of drilling for technical reasons on the Gosha dash structure once again confirm that drilling on the Mesozoic deposits deserves a special approach and preparation. The drilling of exploratory wells in the Mesozoic in Azerbaijan was carried out by unsatisfactory core sampling and non-compliance with the complex field geophysical works.

Special Gratitude

I would like to express my gratitude to my ex-colleague Dr.Thomas Kraft from the Wintershall company, with whom we worked together on a regional study of the North Absheron Trend. Despite different views on calculating the reserves of individual areas of the Absheron Trend, he played an important role and provided valuable advice on constructing structural maps.

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