Oil and gas perspectives of pliocene-miocene in South-East of Absheron Peninsula based on latest 3D data

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ABSTRACT

The paper is devoted to hydrocarbon perspectives in Pliocene and Miocene in south-east of Absheron peninsula based on 3D seismic data. Paper starts with brief description of history of commercial hydrocarbon production across the peninsula, the oldest oil-gas region of the world. It is noted that major production targets here are within Productive Series (PS) of Lower Pliocene. Oil and gas perspectives of this part of Absheron peninsula is related to PS and underlying deposits, studied in general by seismic survey. Kala suite of PS includes all major hydrocarbon horizons exploited currently. The general scheme of Kala suite layers is given in the paper. According to cyclo-stratigraphic model of Kala layers designed by data from several wells a large number of unconformity surfaces have been outlined evidencing unstable paleogeography and paleomorthology of sedimentation. Due to the absence of Paleogene-Miocene deposits available for studies in recovered part of section, we have used similar fields and regional paleogeographic maps for this region. Data analysis made it possible to derive that most favorable conditions for hydrocarbon accumulations in Paleogene-Miocene reservoirs is on Absheron peninsula. In Miocene the unrecovered oil resources is attributed majorly to reservoirs of Diatom suite and Chokrak horizon. The expected deposit types are lithological-stratigraphic and tectonically sealed. It must be noted that one of major tectonic factors of realization of oil and gas resources and hydrocarbon migration is presence of faults sufficiently outlined by 3D seismic data. The paper also considers major risks of exploration for traps in Paleogene-Neogene.

KEY WORDS: Pliocene-Miocene, Kala suite, seismic survey, vertical seismic profiling, time section, anomaly of “bright spot” type.

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Recibido: 23/04/2019 Aceptado: 15/05/2019

Perspectivas de petróleo y gas del plioceno-mioceno en el Sureste de la Península de Absheron según los últimos datos en 3D

RESUMEN

Este artículo estudia las perspectivas de hidrocarburos en el Plioceno y el Mioceno en el sureste de la península de Absheron, sobre la base de datos sísmicos en 3D. El documento comienza con una breve descripción de la historia de la producción comercial de hidrocarburos en la península, la región de petróleo y gas más antigua del mundo. Se observa que los principales objetivos de producción aquí se encuentran dentro de la Serie Productiva (PS) de Plioceno Inferior. Las perspectivas de petróleo y gas de esta parte de la península de Absheron están relacionadas con el PS y los depósitos subyacentes, estudiados en general por medio de un estudio sísmico. El paquete de Kala de PS incluye todos los principales horizontes de hidrocarburos explotados actualmente. El esquema general de las capas de la suite Kala se presentan en este trabajo. De acuerdo con el modelo ciclo-estratigráfico de las capas de Kala diseñadas por datos de varios pozos, se ha delineado un gran número de superficies de disconformidad que evidencian una paleogeografía inestable y una paleoortología de la sedimentación. Debido a la ausencia de depósitos del Paleógeno-Mioceno disponibles para los estudios en parte recuperada de la sección, hemos utilizado campos similares y mapas paleogeográficos regionales para esta región. El análisis de los datos permitió deducir que las condiciones más favorables para las acumulaciones de hidrocarburos en los reservorios del Paleógeno-Mioceno se encuentran en la península de Absheron. En el Mioceno, los recursos petrolíferos no recuperados se atribuyen principalmente a los reservorios de la suite Diatom y el horizonte Chokrak. Los tipos de depósitos esperados son litológico-estratigráficos y sellados tectónicamente. Cabe señalar que uno de los principales factores tectónicos de la realización de los recursos de petróleo y gas y la migración de hidrocarburos es la presencia de fallas suficientemente delineadas por datos sísmicos 3D. El documento también considera los principales riesgos de exploración de trampas en Paleogene-Neogene.

PALABRAS CLAVE: Plioceno-Mioceno, suite Kala, levantamiento sísmico, perfil sísmico vertical, sección de tiempo, anomalía del tipo de "punto brillante".

Introduction

Absheron peninsula is one of the major oil-gas bearing regions of Azerbaijan. History of commercial hydrocarbon production here is approximately two centuries taking into account the first well spud here down to 21 m depth by percussion drilling method. The well was drilled under the supervision of V.N.Semenov in 1846 in Bibi-Eybat village nearby to Baku (currently the area is considered as the outskirts of Baku). Until now the major production targets in Absheron peninsula and Azerbaijan section of Caspian sea include

suites of Productive Series (PS) attributed to the Lower Pliocene [Mamedov, (2018)]. For the last years the geoscientists attempt to study underlying Miocene deposits with expected presence of hydrocarbon accumulations.

In the south-eastern plain part of Absheron peninsula the Zyrya, Karachukhur-Zykh, Hovsan oil and gas fields are located (Fig.1). Production from Karachukhur field started since 20-ies of the last century while production from the other areas started since the end of 40-ies, that is after the end of World War II [Aliyeva, Aliyev, Huseynov, Babayev & Mamedov. (2008)].

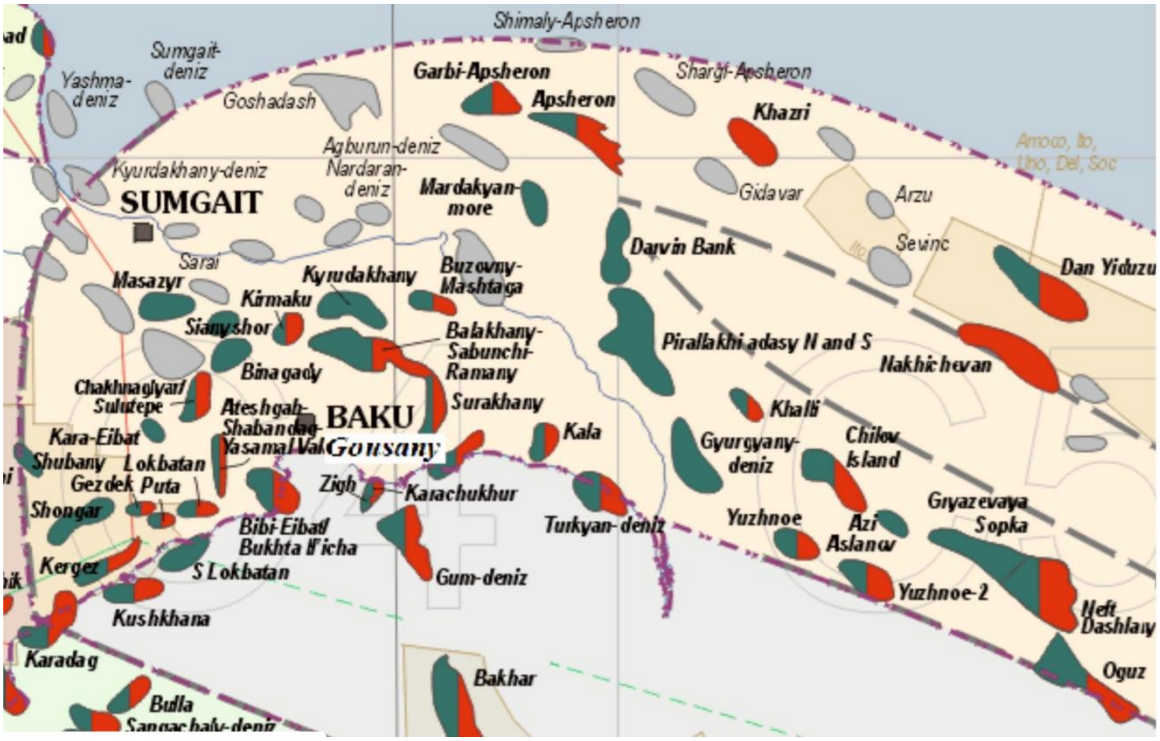


Fig.1. Perspective oil-gas fields of Absheron peninsula and adjacent areas

The output from wells in all fields were high, as for example, the output from wells in Zyrya field constituted 300 000 – 600 000 m^3 per day and 50-130 t of condensate per day (from all targets of Kymakyalty and Kala suite (KaC)). The highest oil accumulations in Karachukhur-Zykh field are attributed to Kirmakyalty, Kirmaky (KC) and Kala suite (KaC), which refer to Pliocene deposits. According to latest geological and geophysical data the Hovsan field is attributed to the far east flank subsidence of Karachukhur-Zykh fold, where Kala suite is pinching out in upward direction, overlaying eroded surface of Pontian with

sharp angular unconformity [Bochkarev, et al. (2002)]. In this area in section of Kala suite four production targets with total thickness of 250-350 m are identified. The most productive parts of these targets are the lower parts with relatively high thickness while pinching out top parts are less producing. The major producing targets in Hovsan field are attributed to Kala suite with outlined four horizons: KaC_1, KaC_2, KaC_3 and KaC_4.

1. Problem Statement

The major production targets are within Productive Series (PS) of the Lower Pliocene as all indicated suites are the suites of PS. Oil and gas presence perspectives in this area of Absheron peninsula are related to PS and underlying deposits, which are majorly studied by seismic survey. Until now some problems of hydrocarbon accumulations presence in Lower Pliocene and underlying them Pontian and Miocene deposits were not studied sufficiently.

2. Research Questions

The south-eastern part of Absheron peninsula was repeatedly studied by downhole seismic survey (seismic logging and VSP -Vertical Seismic Profiling) and 2D and 3D seismic survey. We aimed to perform the critical analysis of all acquired data on the basis of new approach to geological problems to be solved.

3. Purpose of the Study

The major purpose of this study is to identify perspectives of lower horizons of PS, as well as underlying Pontian and Miocene deposits based on seismic data available for this field and neighboring fields, which are currently under production.

4. Research Methods

Kala suite, which includes major oil and gas horizons under production currently is sufficiently studied by drilling. The general sketch of Kala suite layers with upper part studied sufficiently by drilling and perspective lower part is given below. It can be clearly seen from the figure that according to well logging data the lithological-stratigraphic border dividing into two portions is outlined (Fig.2). The lower part is most probably represented by sandstones deposited in the transgressive phase of evolution in this area of Absheron peninsula, while the upper part is characterized by complete and incomplete regressive cycles. Wavy line in the figure shows the border of stratigraphic unconformity, which could be synchronously tied to variation border of thermal and pressure system [Buryakovskiy, (1991)]. This is indicated by low values of resistivity, "clay line" on SP curve. It should be noted that under conditions of overpressure the values of resistivity, SP, AL and NGL are most frequently tend to the lower values.

Detailed cyclo-stratigraphic model of Kala suite designed according to data acquired from several wells shows the large number of unconformity surfaces of various scale. This proves the inconsistency of paleogeography and paleogeomorphology of this area of sedimentation.

Taking into account the absence of Paleogene-Miocene deposits in recovered part of section we study similar fields and regional paleogeographic maps for this region. In this paper we study Muradkhanly field, where oil accumulations have been discovered in deposits of Upper and Middle Eocene (Fig.3) and Jafarly field in the Middle Eocene [Shilov, Jafarov, (2011)]. Reservoirs are made of rocks of weathering layer and terrigeneous rocks deposited near the migration source. It can be seen from paleogeographic map that terrigeneous-carbonate rocks are accumulated in Eocene-Later Cretaceous period [Khalifa-zade, Talybly, Mursalov, (2006)].

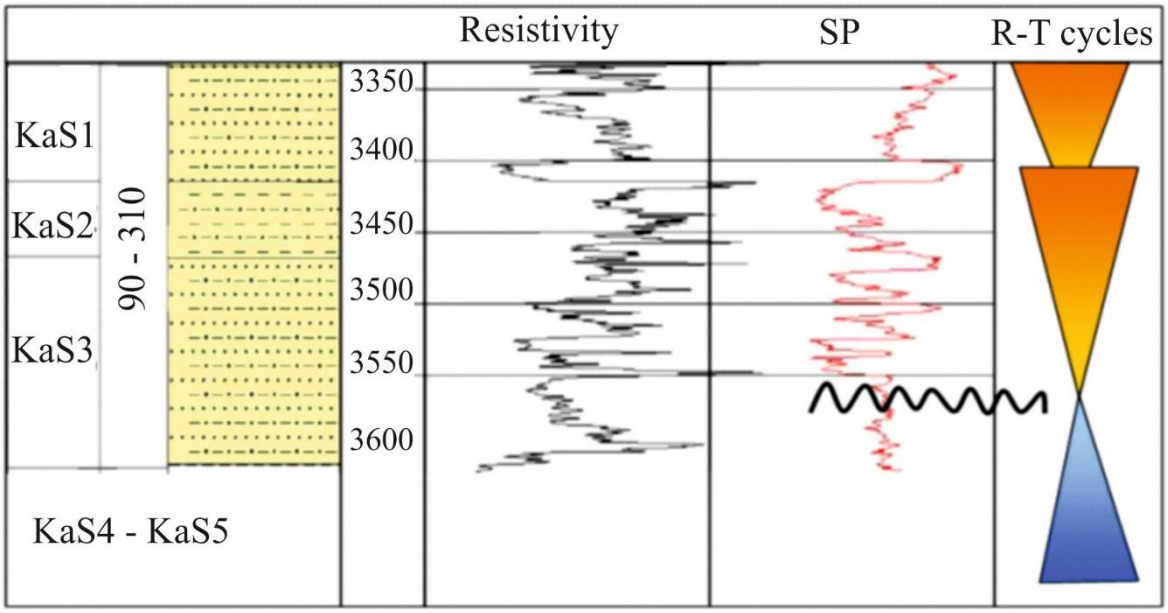


Fig.2 General scheme of Kala suite structure

SOUTH MURADKANLY – JAFARLY BLOCK
Map of drilling down to Middle Eocene
(the structure is outlined on top of marl layers of Middle Eocene)
Scale 1:25000

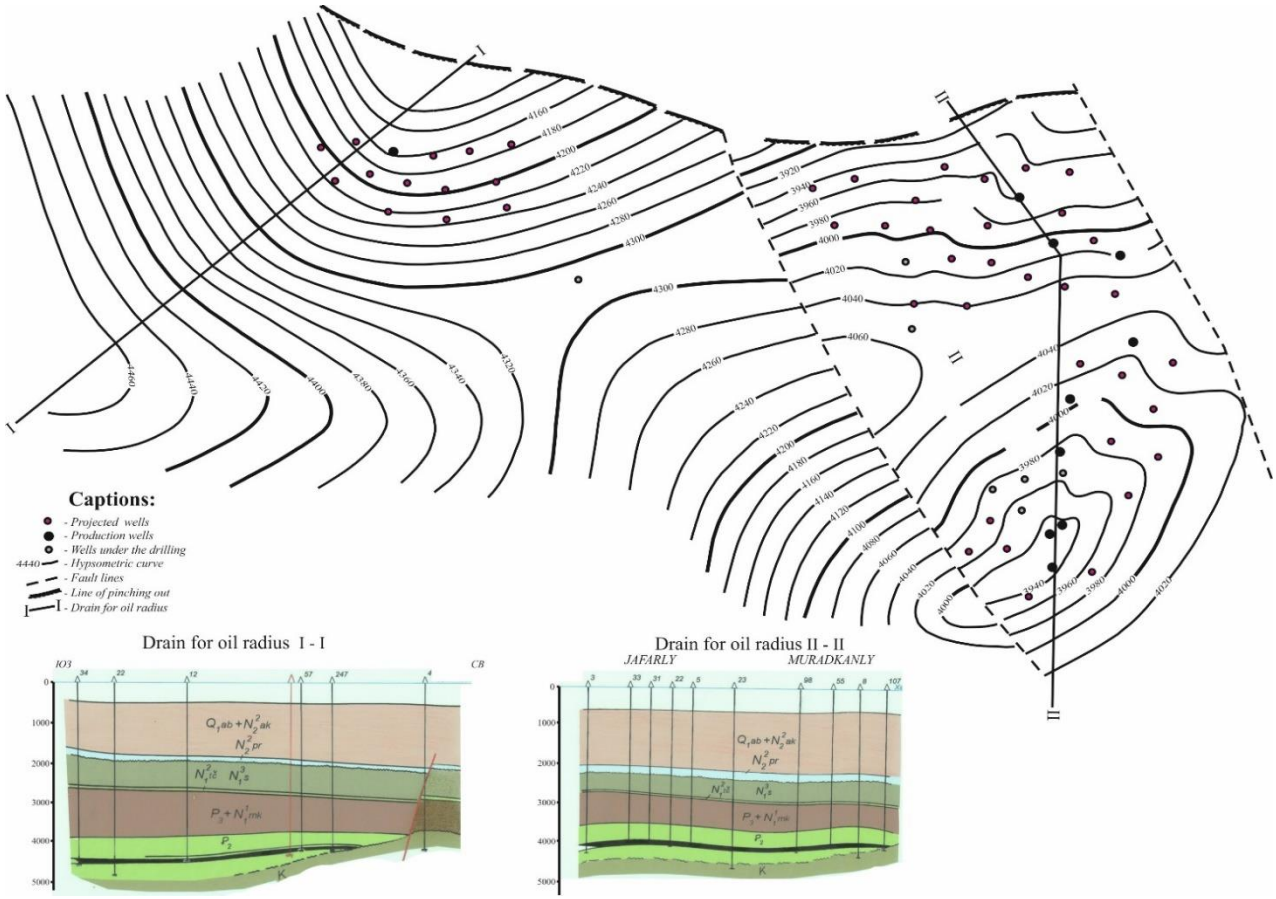


Fig.3 Structure map and geologic section of Muradkhanly field.

It is considered that most favorable conditions for hydrocarbon accumulations in Paleogene-Miocene reservoirs are identified in Absheron oil-gas region [Abdullayev, Riley, Bowman, (2012)]. Undiscovered oil resources in Miocene across the territory of peninsula are majorly attributed to reservoirs of Diatom suite and Chokrak horizon. Expected deposit types: lithologic-stratigraphic and tectonically sealed [Marroquin, Brault, Hart (2009)].

Based on available seismic survey data and interpretation results we suppose that hydrocarbon traps ranges are quite wide for the lower part of sedimentary section (Paleogene-Miocene): stratigraphic, tectonic, lithological, combined. Performed seismic survey, i.e. multi-attribute analysis of impulse wave pattern identified unconformable burial of Paleogene-Miocene and Productive Series (PS), which is most probably triggered generation of lithological - stratigraphic traps Neff, Runnestrand, Butler, (2001)].

In 2010 Vertical Seismic Profiling (VSP) has been applied in one of the wells of Hovsan field. VSP data processing and interpretation displayed abnormally low values of seismic wave velocities at 3900-4250 m depth interval (Fig.4), characteristic for shallow depths. According to some researchers this evidences the presence of overpressure zone. This notion has been further proved by drilling recovering Miocene deposits at these depths [Ahmadov, Akhundlu, Giyasov, (2012), Ahmadov, T., Akhundlu, A., Giyasov, N. (2012)].

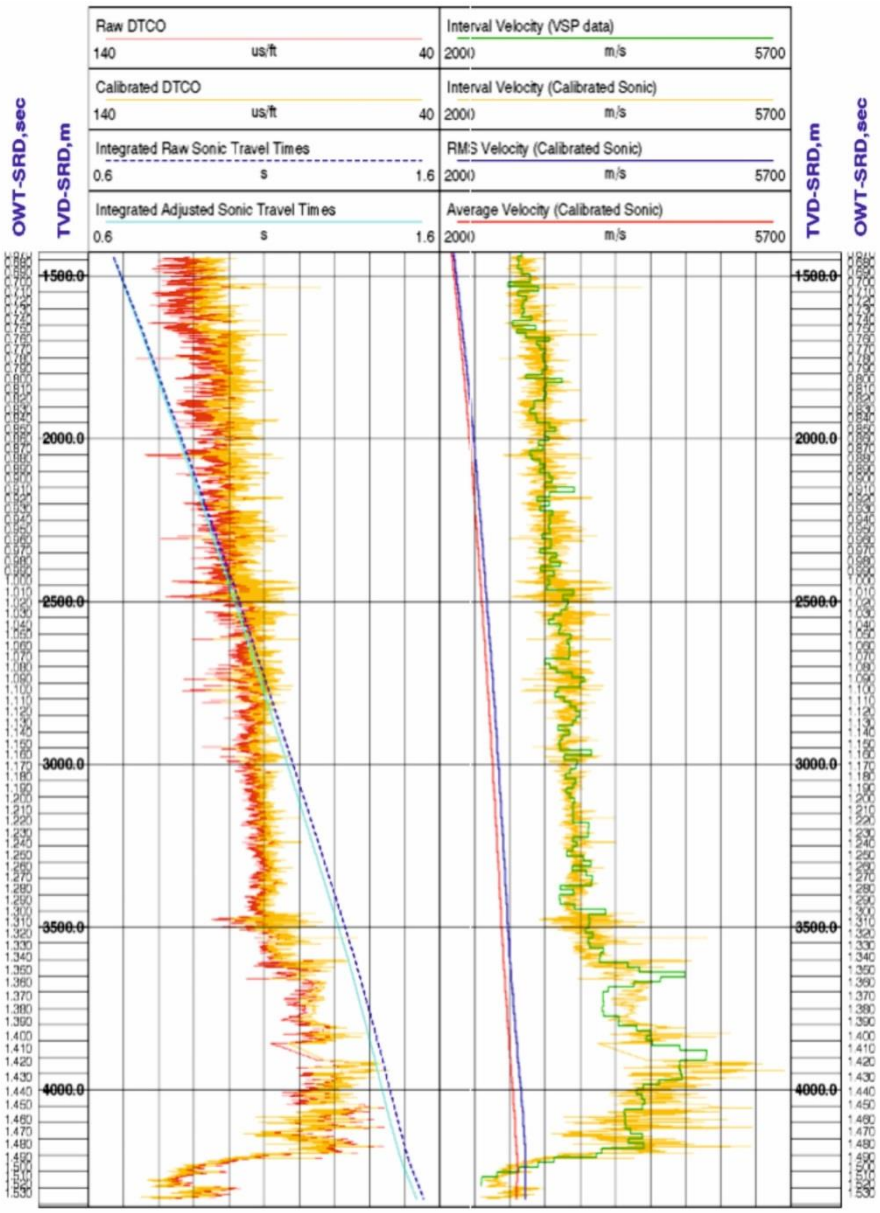


Fig.4. Abnormally low values of seismic waves evidencing overpressure zone presence

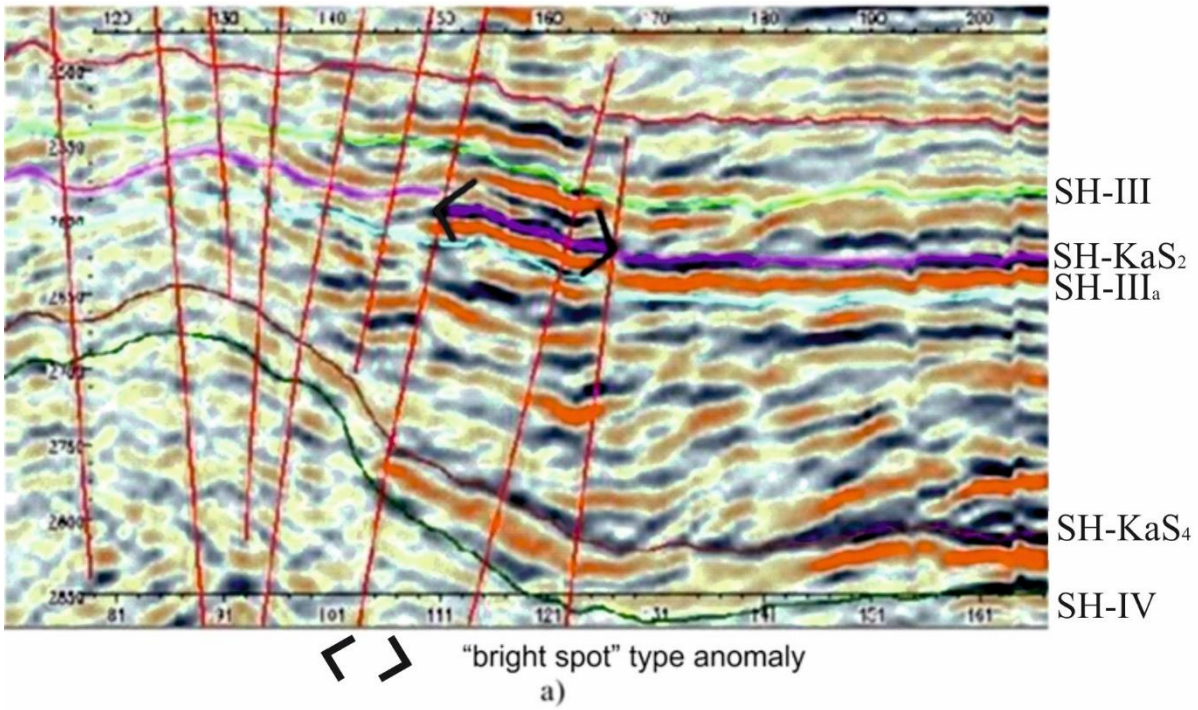
5. Findings

It has been indicated earlier that the major perspectives of areas under the study are related to Kala suite where several production targets are identified. Analysis of geological evolution, paleostructural objects displayed that folded belts attributed to the fields under the study are characterized by different ages of burial and variation of evolution intensity during various phases of geologic age. Study of genesis and paleogeography of sedimentation basin identified that Productive Series (PS) in Absheron peninsula was developing in coastal

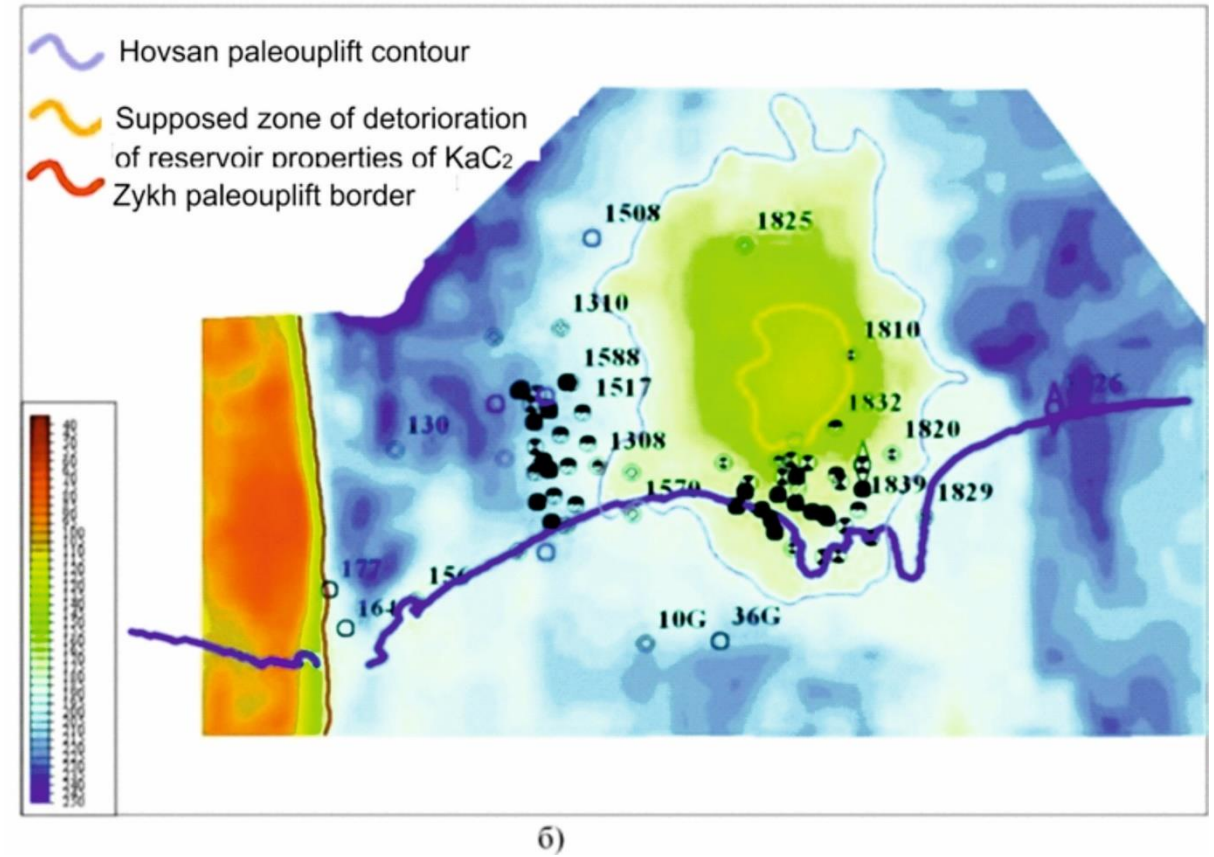
area of marine basin and made of Absheron type of sediments with quartz as a major rock type. This rock type is featured by relatively good roundness of grains composing sandy rocks and prevailing of sandy fraction over aleurolite and clay [Khalifa-zade, Talybly, Mursalov, (2006)]. According to Ch.M.Khalifazade and et.al the sedimentation occurred under conditions of shelf divided by uplift zones and emerging over the sea level in some cases. In Kala and Kirmakyalty basins the ancient islands were developed during Pre-Pontian and Pontian and some of them were existing until Upper-Kirmaky period. Sedimentation was due to supporting provinces with high concentration of quartz [Levyant, Ampilov, et al. (2006)]. It must be noted that the basin is developed as a result of tectonic process and inflow of large rivers controlled by climate processes and paleorelief. All these factors significantly influenced the flow rate and quantity of water in paleorivers. At the same time, mountain areas surrounding the basin from the west underwent uplifting and were the suppliers of enormous amount of fragmentary materials to sedimentation zones (Fig.5) [Markovskiy, (1973)].

Fig. 5. Schematic map of South-Caspian basin and adjacent areas in Lower Pliocene (Kroonenberg et al., 2005)

It should be noted that analysis of lithology and facies of Pliocene display presence of different facies with both deltaic and coastal marine origin. Rhythmicity of deposits across the study area was related to alteration of depositional conditions. Based on paleostructural design and available data it can be supposed that Kala suite was developing generally under marine conditions due to drifting out of a large amount of depositional material by deltaic water flows and distribution of its major mass within the limits of paleostructure, located in the central part of study area (Δt maps). Analysis of time thicknesses made it possible to suppose that during developing of Kala suite the large river delta existed in the study area. Obviously, development of a number of deltaic channels and distributaries were related to gentle slopes and small depths of coastal part of basin where the delta evolution occurred. Analysis of time thicknesses maps between seismic horizons attributed to KaS-2 and SH-IV, which in a conditional time scale represents a surface paleorelief by start time of Kala suite evolution allowed to outline areas most favorable for sand accumulation (Fig.6). High values on time thickness map correspond to subsided areas of paleorelief. Thus, traps were developing on the south-east and western slopes of paleostucture, where oil accumulations of Hovsan field were discovered. Along the eastern slope of high-amplitude structure located in the western part of study area the lens consisting mainly of sand was developing making the base for Zykh oil field.



a)



б)

Fig.6. Time section fragment (a) and map of time thicknesses between seismic horizons attributed to KaC_2 and СГ-IV deposits at the top of Pontian (b)

In total within Zykh-Hovsan area 321 wells were drilled with 105 wells of these (comprehensive set of data are available) recovering Kala suite. Structural mapping on the basis of seismic survey data supported by seismo-geological, seismo-stratigraphic, paleomorphological and facies analysis has been applied as a major technique while study of Kala suite.

Figure 7 shows major faults outlined in the study area by previous researches [Levyant, Ampilov, et al. (2006)]. Our view on tectonic model of East Hovsan field is as the following. This conclusion has been derived on the basis of acquired data [Sheriff, Geldart, (1987)]. Along the ancient deposits on the paleouplift axis we can clearly observe feathering faults crossing sedimentary deposits up to Kala suite layers inclusively. It must be noted that presence of faults is one of the major tectonic features for realization of oil and gas potential and hydrocarbon migration. In this case, East Hovsan is not the exclusion and from this point of view the more reliable tectonic model must be designed. In this case, faults are not only the formation fluid discharge zone, but also hydrocarbon migration path along the lower deep buried horizons of Miocene deposits (Fig.6a). Our studies by use of kinematic and dynamic features of fault tracing on seismic records, as well as modelling [Lobusev, Lobusev, Nazarova (2008)] allowed us to observe quite a different image (Fig.8) of disjunctive dislocation development, where the major zone of tectonic fault is outlined.

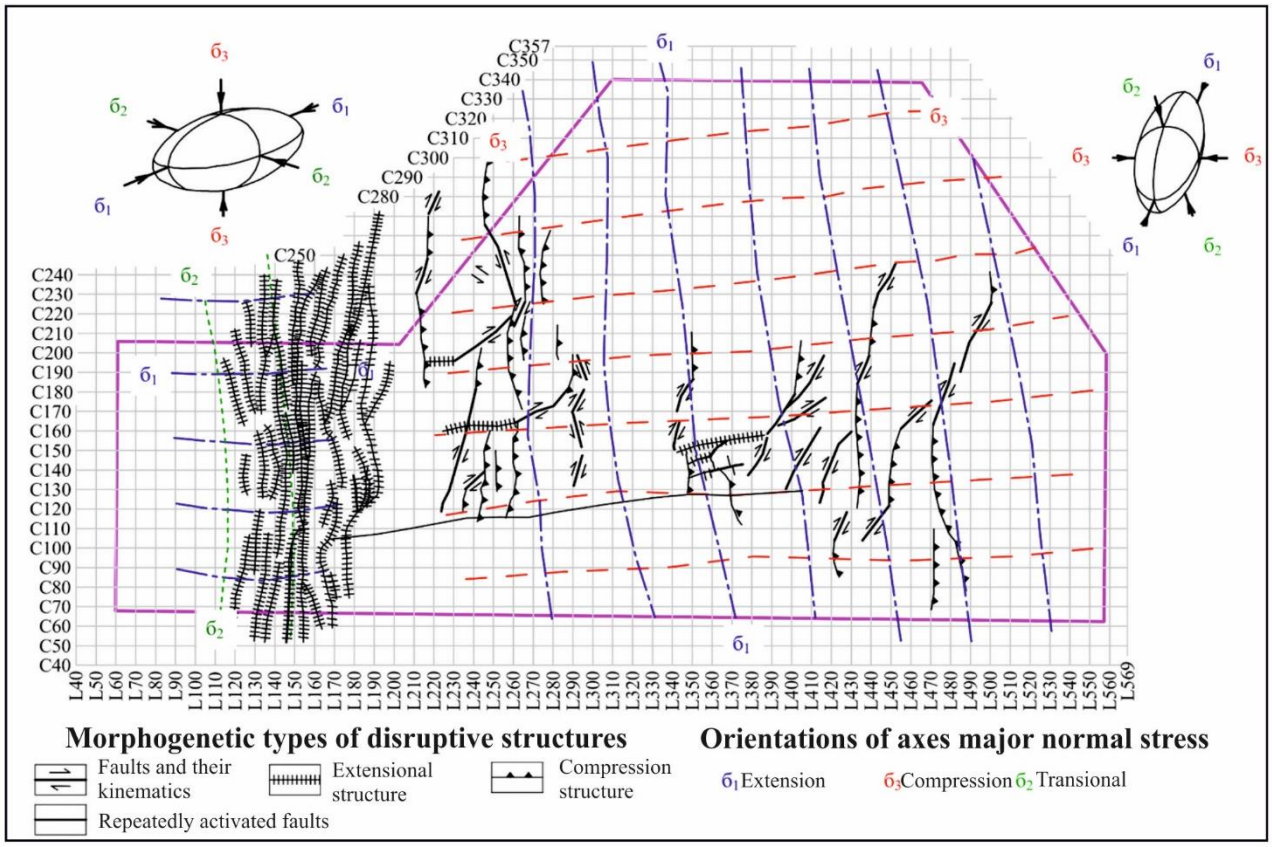


Fig.7. Structural display of tectonic stress field

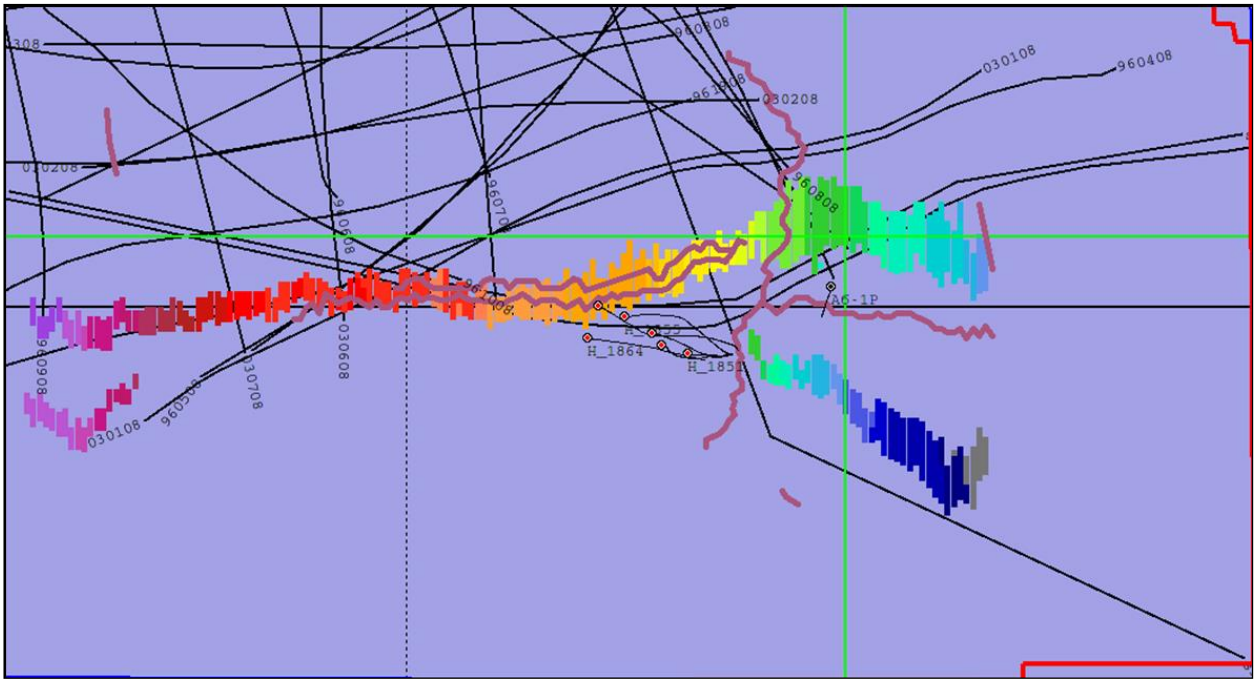


Fig.8. Outlined major zone of fault.

Conclusion

Regional studies identified that this area was under favorable paleogeographical conditions and stratigraphically complete (or quite complete) sections were accumulating here.

Oil system has large perspectives due to huge amount of oil-source rocks from Miocene and Eocene (Koun suite). Perspective reservoirs presence is expected in deposits of Maikop and Chokrak. Except for terrigeneous reservoirs in Diatom suite, in section of Meotis and Sarmatian (Upper Miocene) fractured dolomites and limestones are expected to be perspective hydrocarbon targets.

Major risks in exploration for traps below Kala suite consists in presence of reservoirs as well as complicated geological setting (ultra depths, high pressure and temperatures). Thus, in our point of view hydrocarbon perspectives within the limits of the south-east of Absheron peninsula is related to exploration of hydrocarbon traps in section of Paleogene-Neogene related to terrigeneous-carbonate reservoirs in Eocene, sandy-aleurite deposits in Maikop and Chokrak, terrigeneous reservoirs in Diatom overlaid by thick impermeable clay layer. This creates conditions favorable for hydrocarbon accumulations providing the proximity of oil-gas source rocks.

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