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Reflnement of Structural Lithofacies of Pirallahi Island and Darwin Banks Based on Comparative Analysis

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Уточнение литофаций структур острова Пираллахи и банки Дарвина на основе сравнительного анализа

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field, saturation, sandstone, clay, silt, rock, facies, correlation, facies model, fault, area, petrophysical, petrophysical, logging, recoverable reserve, archipelago, age.

Currently, an increased interest in the discovery of previously laid down productive horizons in oil and gas fields with a long development period and in the extraction of residual oil leads to deep and thorough investigation, assessment of the mineralogical composition of rocks and lithofacies characteristic based on geological, geophysical, hydrogeological and other data.
The deposits of Darwin Bank and Pirallahi Island are located in the eastward of the Absheron Peninsula, in the northwestern part of the Apsheron Archipelago, on the anticline zone of the Absheron Bank, Darwin Bank, Pirallahi Island, "Gurgandeniz".
The southeastern periclinal of the Darwin Bank field borders the northern part of the Pirallahi Island field, and these two fields are separated from each other by fracture.
Two fields are considered in the research work. These fields considered in the study belong to the class of long-term development fields that are in the final stages of development.
These fields from a tectonic point of view belong to complicated (complex) structures. Even though it has been processed since the last century, it contains a large amount of oil reserves. For this reason, the structural and tectonic field structure, lithofacial composition, in-place and recoverable reФserves, development parameters are important. The issue we are considering is the distribution and clarification of lithofacies characteristics of the fields. The neighboring fields of the Darwin Bank and Pirallahi Islands are poorly studied and researched from the lithofacial point of view. We investigated the types of facies for the QD, QA and QaLD series of strata in the fields and compared them by compiling 3D models. As a result, changes were observed both in the areal and vertical directions.

Ключевые слова:
месторождение, насыщенность, песчаник, глина, алеврит, порода, фация, корреляция, фациальная модель, разлом, площадь, петрофизические, каротаж, извлекаемый запас, архипелаг, возраст.

В настоящее время повышенный интерес к открытию ранее заложенных продуктивных горизонтов на нефтегазовых месторождениях с длительным сроком разработки и к извлечению остаточной нефти приводит к глубокому и тщательному изучению, оценке минералогического состава пород и характеристики литофаций на основе геологических, геофизических, гидрогеологических и других данных.
Месторождения банки Дарвин и острова Пираллахи расположены в восточной части Апшеронского полуострова, в северо-западной части Апшеронского архипелага, на антиклинальной зоне Апшеронской банки, банки Дарвин, острова Пираллахи, «Гургандениз».
Юго-восточная периклиналь месторождения банка Дарвин граничит с северной частью месторождения острова Пираллахи, и эти два месторождения отделены друг от друга разломом.
В исследовательской работе рассмотрены два месторождения, которые относятся к классу месторождений с большим периодом разработки и находящихся на ее последней стадии. Оба месторождения с тектонической точки зрения относятся к сложноструктурным. Несмотря на то что месторождения разрабатываются с прошлого века, они имеют достаточно большой запас нефти. По этой причине являются важными структурно-тектоническое строение месторождений, литофациальный состав, балансовый и извлекаемый запас, параметры разработки. Расположенные рядом месторождения банка Дарвина и остров Пираллахи с литофациальной точки зрения были слабо изучены и исследованы. В данной работе были исследованы типы фаций осадочных пород свит КС, ПК и КаС построены 3D-модели, а также проводились сравнения этих моделей. В итоге изменения наблюдались как по площади, так и по глубине.

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Introduction

Currently, an increased interest in the discovery of previously laid down productive horizons in oil and gas fields with a long development period and in the extraction of residual oil leads to to deep and thorough investigation, assessment of the mineralogical composition of rocks and lithofacies characteristic based on geological, geophysical, hydrogeological and other data.

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The southeastern periclinal of the Darwin Bank field borders the northern part of the Pirallahi Island field, and these two fields are separated from each other by fracture No. 2 (Fig. 1).

Structurally, these deposits are classified as complex structures. The reason for this is the presence of longitudinal and transverse tectonic deformations (faults) in the structural framework, as well as fracture thrust (break-thrust), flushing of zones in the uppermost (roof) part of several suites, the occurence of a coastal basin and an island in the process of sedimentation, etc (Fig. 2).

The research of the conditions for the formation of these structures suggested that some uplifts developed independently from the beginning of sedimentation process, while others, on the contrary, after a certain period of time, the development process was stopped [5–10].

Research methodology

Studies of the thicknesses and lithofacies characteristics of the Productive Strata (PS) suites in the northwestern part of the Absheron Archipelago suggest that these sediments accumulated in the Paleovolga river delta.

The spreading of terrigenous sediments brought by the Paleovolga River, along with the flows of the delta feeder in the northeastern part of the Absheron archipelago, had a significant impact on the uplifts, which were still in the consedimental development.

Coarse-grained sand deposits are centered in the tributaries of the delta, and clay is predominantly collected in the inter-tributary zones. During this period, the thickness decreases towards the top of the uplifts that are in consedimentary development. Disjunctive dislocations arise on uplifts that are subject to more intense tectonic movements, and the sediments gathered in these zones are crushed and creep down from the fold to the limbs. Sediments are centred in synclinal depressions, and are transferred by deep-water currents to abyssal depth [11–18].

Naturally, lithofacies is characterized by a decrease in the size of rock particles towards deep sea and an increase in the degree of stratification. The presence of clay pans prevails in zones formed in deep sea conditions far from the delta.The size of the rock particles depends on the distance from the delta and the depth of the sea.

As a result of different paleogeographical conditions, the deposits located close to each other, during the process of sedimentation, some areas have similarities, and in some areas, different types of facies have formed. In order to prove this, we performed a facies interpretation of the geophysical logging data. All wells of these fields were investigated and facies were correlated through the sections (Fig. 3).

On the correlation diagram of the Darwin Bank field, an increase in grittiness from the top downward is observed throughout the section in the Kirmaky suite (KS). At the same time, it should be noted that in the upper part

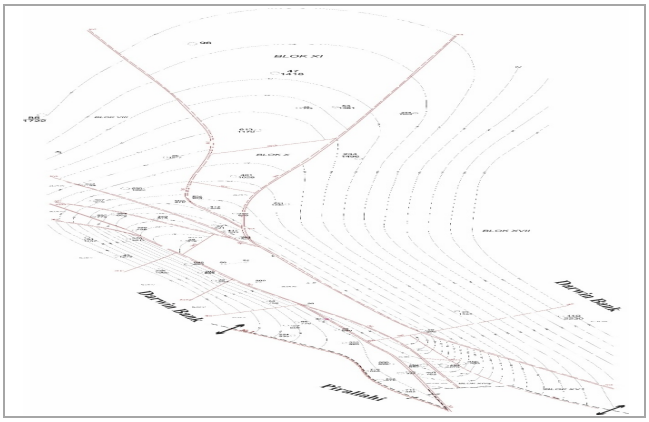


Fig. 1. Structural map of the Darwin Bank fields

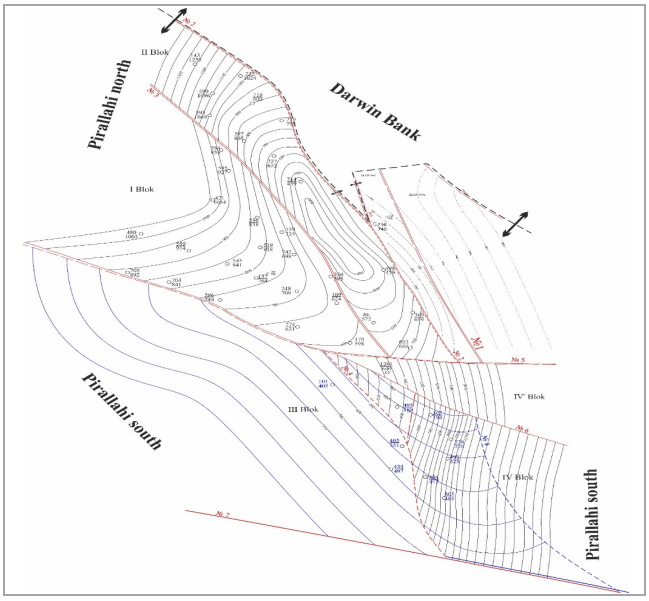


Fig. 2. Structural map of the Pirallahi fields

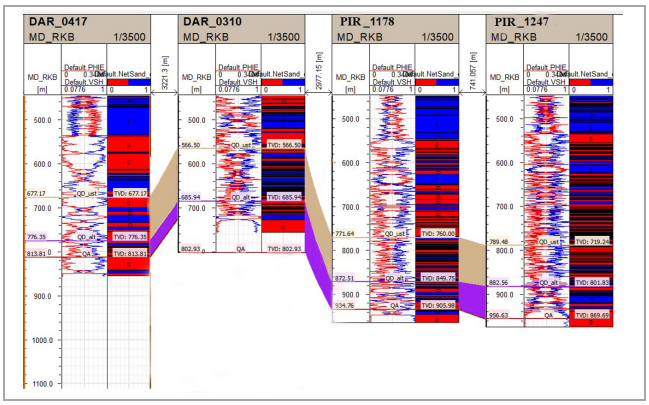


Fig. 3. Lithofacies correlation of the Darwin and Pirallahi fields

of the KS_{upper} horizon, clay content is high and in the direction of the lower part, the clay content decreases in percentage terms and sandy interbeds appear.In the KS_{lower} horizon, the grittiness increases and, in percentage terms, the clay content is low. In the study of the well log of the Pirallahi KS field, as in the Darwin bank field, consists mainly of alternations of sandy and clay rocks.The $KS_{upper}$is represented by clayey rocks. In the KS_{lower}horizon, there is also an increase in grittiness (psephicity) from top to bottom. In both fields, the process of sedimentation of KS corresponds to the same paleogeographic conditions. But

hereby, at the Darwin field, in the crest of reservoir of the structure, the sedimentation process was interrupted, thereby proving that at that time the sea level was shallow. Closer to the crest, an increase in the size of the rock particles and grittiness (psephicity) is observed. The limbs and periclinals are similar to the Pirallahi field [19–25].

When comparing the Lower Kirmaky Suite (LK), significant differences can be seen. Because (LK) is subject to inherent variability not only between fields, but also within the field itself. The same layers of the LK suite can change dramatically throughout the reservoir in the Darwin Bank field. In particular areas of the field, a fine-grained alternation of sand and clay is observed, while heavy sand bands are observed in some areas. This confirms that the conditions of sedimentation are the same in all areas of the field.Oil fields are mainly located in sandy interbed. The LK horizon can be divided into 3 parts in terms of facies in the Pirallahi field (LK1, LK2, LK3).The sand content decreases significantly from top to bottom and is replaced by clay rocks.This indicates the presence of different paleogeographic conditions in the sediments during the LK period.Consequently, the Darwin Bank does not include LK sediments in the crest and adjacent areas.The predominance of coarse-grained rock grains and sandy rocks is due to the presence of coastal and bar facies in this area.Along the edges of the structure, the amount of sand and the grain size are decreased, while the clay content of the rocks increases.Therefore, the increase of sand in sediments in the upper part of the LK and decrease of clay content in the Pirallahi field is associated with the depth of the sea at this time [26–31]. Thus, at the beginning of the LK suite period, the sea was relatively deeper, and by the end of the period, the depth began to decrease.This directly affected the formation of facies.

Discussion of results

The study of facies should not be limited to logging data only.These parameters, which are important in the distribution of reserves, the identification of new prospecting sites and the calculation of risks, should be determined in terms of area and capacity of the field.For this purpose, a 3D facies model of the Darwin Bank and Pirallahi field was developed (Fig. 4).This model, which is very important for satisfactory tracking of the distribution, allows to monitor changes in separate layers of the formations.

The Kala Suite (KaS) in the Darwin Bank field was identified based on the lithological characteristics of exploration wells based on rock samples taken from the wells. KaS consists of poorly sorted rocks, a small amount of sandstones (sandrocks) and siltstones (aleurolites), alternating with thin sandy, clayey siltstones.The study of the lithological and petrographic features of this rock mass showed that both poorly and well graded rocks are found in the area of the field.KaS consists of fine-grained sands and grey-brown sandy clays at the Pirallahi field. The sands are sometimes calciferous (limestone).The sandy facie of southern Pirallahi is a coastal facie [32–39].

The Lower Kirmaky Suite (LK) of the Darwin Bank field covers a large area. This suite is one of the main oil and gas formations of the Lower Pliocene and is well distinguished according to logging data over the entire area.The LK suite is characterized by high grittiness (69–92 %) and consists of sand and sandstone, medium and coarse quartz sands (arenaceous quartz), as well as aleurite and clay in small quantities.The rocks of this suite are generally distinguished by high grittiness. Only over the Pirallahi area, the rocks are scattered and consist of gray clays and alternating fine-grained thief sands and medium and coarse-grained quartz

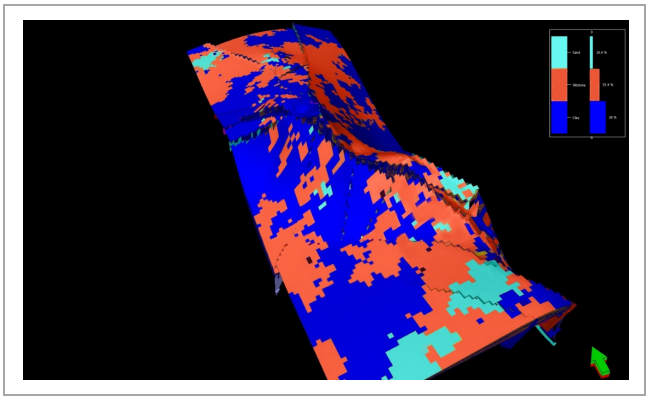


Fig. 4. 3D Facial Modeling of the Darwin and Pirallahi Fields

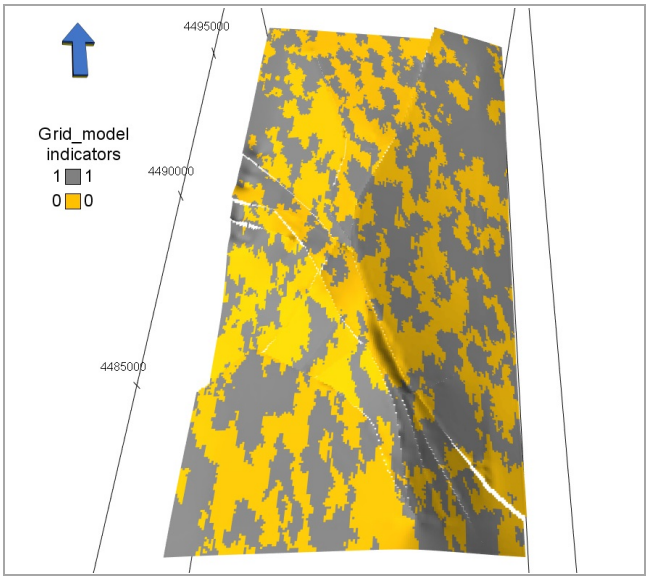


Fig. 5. Reservoir and non-reservoir papameters distribution model for the Darwin and Pirallahi fields

sand (arenaceous quartz).Black sands, pebbles up to 4 mm in diameter are sometimes found.There is an increase of grittiness from bottom to top [25, 40–43].

The Kirmaky suite (KS) of the Darwin Bank field is one of the most common oil suites. The difference of this suite from other suites is the repeated alternation of different types of rocks. From a lithological point of view, the horizons of the Kirmaky suite consist of alternating sand and clay. The KS sediments are subject to extensive facies changes towards bottom of horizon, throughout the section; the thickness of the clays decreases, the size of the grains in the sand bands increases, and the lithological-reservoir properties of aleurolite-siltstone rocks improve.The Kirmaky suite at the Pirallahi field is represented by an alternation of mostly fine-grained gray and brown sands and clays.Hard or soft thief sands are common in this suite. The thickness of the suite is 10–70 m and increases towards the incompetent fold.In the upper part of the suite, the thickness of the clay section (clay parting) increases up to 65 m, and the grittiness increases towards bottom of formation.

One of the main goals of studying the data on the fields listed above is to divide the reservoir and non-reservoir rocks into groups.In the oil industry, the determination of the reservoir and non-reservoir parts of fields is critical information. 3D reservoir distribution models were constructed (Fig. 5). For a detailed analysis, distribution in the vertical direction was carried out over 100 spots

(cells). The models built for these fields are reliable resources for defining oil and gas accumulations and estimating reserves.

The change in facies in the fields is one of the reasons for the change in a number of other parameters. For example, the distributions of carbonate content, porosity and permeability were considered. Significant changes in the average values of the parameters for the suite of the KS are not observed. According to the dataon LK suite, these changes are observed: In the Darwin field, the reservoir rocks of the LK suite are represented by nongraded rocks.Hereunder, the petrophysical properties of sands, sandrocks, aleurites and siltstones differ significantly [44–53]. Based on the analysis of rock samples, the carbonate content is 14.6 %, the average porosity is 18.1 %, and the permeability is $116.6 \cdot 10^{-15}$ m^2 within these limits. Based on the results of core studies taken on the island of Pirallahi and according to the results of the data from more than 600 different analyzes, the LK suite was studied in detail.In the studied rocks, the carbonate content is within 22.0 %, the porosity is 22.0 %, and the permeability is $425 \cdot 10^{-15}$ m^2.

Conclusion

Based on geological and geophysical materials, sedimentary rocks are divided into reservoir and non-reservoir groups and 3D models are constructed 3D facies models were constructed to monitor lithofacies changes in the fields

The KS, LK and KaS horizons adjoin from the crest of reservoir towards limbs in the Darwin Bank field. The KaS horizon adjoins to the southern part at the Pirallahi field. This is the reason for the formation of lithofacies variability.

In the Darwin Bank field, the LK suite was mainly composed of sandy rocks, but in the Pirallahi field, this suite consisted of clay rock in the lower part, and sandy interbed in the upper part. Different physical-geographical conditions and the formation of different lithofacieswere observed in these fields during period of the LK suite.

The sediments during the period of the KS suite consisted of sandstone in the lower part, and argillaceous facies in the upper part. Consequently, for both fields, the physical and geographical conditions during this period were similar. The only difference is the prevalence of sand facies of coastal origin in the adjoining zone at the Darwin Bank field.

The adjunction of sedimentary rocks of the Productive stratum in the arch and near the arch indicates the existence of conditions for the formation of non-anticline traps and, at the same time, the accumulation of hydrocarbons.

Changes in field parameters have been compared, and the obtained results will be used for a more accurate study and development of fields in further work.

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