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Lithological Model of the Zykh Field of Azerbaijan Based on 3D Seismic Data

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Abstract

This paper discusses current issues related to modeling the lithology of oil and gas-bearing rocks in the old field Zykh using new technologies for processing and interpreting 3D seismic data and geophysical research of wells (GRW) to increase the resource base of the field. The purpose of this research is to identify the most promising lithological sections and intervals of the section that have higher reservoir properties according to the data of 3D and GRW seismic integration. The subjects of research are 3D seismic data and logging curves of geophysical research of wells (GRW), a priori geological and geophysical data accumulated during the period of exploration and operation of the field. The object of research is the Zykh field. The paper presents a brief history of geological and geophysical study, stratigraphy and lithology of the deposition that make up the section of the Zykh field. Research result: Analysis of the obtained data shows that even within individual tectonic blocks (segments), the lithology of fields is variable and one or another fraction dominates during the transition from one block to another. The same is observed in sections A-B, which crosses the field from north to south. Modeling of deposition lithology was not carried out in all segments (tectonic blocks) of fields, but it should be noted that there are not very many of them. Conclusion: The problem was solved successfully, the field was divided into separate tectonic blocks (segments) based on 3D seismic data, and a lithological model was built for each segment using 3D seismic data and GRW of wells. Examples of modeling of lithology on the example of one of the segments of the model of the lower part of the productive layer (layers PF and KaF) are shown in the form of maps and sections.

Keywords: Oil and Gas, Mud Volcano, 3D Seismic Survey, Tectonic Blocks, Lithological Model, Seismic Records, Processing and Interpretation of Seismic Data, Time and Depth Sections

1. Introduction

The Zykh oil and gas field is located in the South-Eastern part of the Absheron Peninsula, East of Baku [1]. The study of this field began in the XIX century by laying an exploration well within the Karachukhur field, located directly near it. In the 30 s of the XX century, geological and geophysical surveys were also conducted on the area under study, 2D seismic surveys were repeatedly conducted with single and multiple profiling, and 3D seismic surveys were conducted in 2012. Based on the results of geological and geophysical work and deep drilling within the study area, the Zykh field was discovered andputintooperationin1935 [2]. Currently,thefieldisinthefinalstageofdevelopment.

General information about the study of previous works by geophysical methods within and near the work area is shown in Fig.1

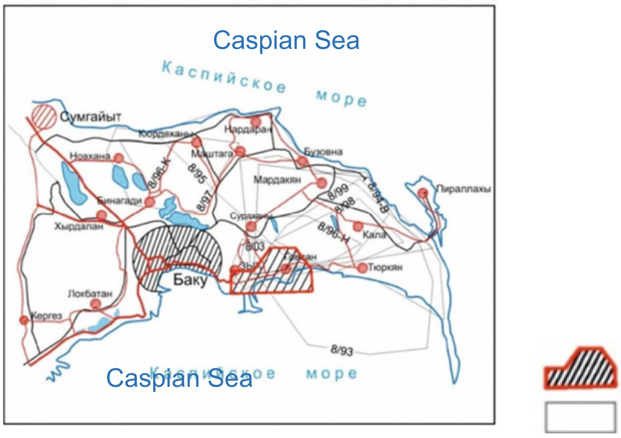

Figure1: Scheme of Study of the Area of Work by Seismic Surveys

1.1. Legend

contour of work CDP (3D common depth point); contour of previous years' work **Fig. 1.** Scheme of study of the area of work by seismic surveys. The discoverer was well 12, which resulted in the production of industrial oil from the Balakhan formation of the productive thickness. Upper and middle Absheron deposits are exposed in the field. Wells opened a section oftheentirePliocenecomplexofdepositsuptothePonticstage.Neogenedepositswithin the work area are represented in the Miocene and Pliocene volumes [1-3]. Oil-bearing capacity of Zykh field is confined to the eight objects of the productive thickness: Kalinskaya (KaF), Podkirmanskaya (PF), Kirmakinskaya (KF), Nadkirmanskaya clay (NKC) and Balakhanskaya formations (layers VI, VII, VIII, IX). The Kalinskaya formation (KaF) is the lowest formation of deposition of the productive thickness, and is separated from the upper layer by a 4-meter clay interlayer. The total thickness of the KaF is 60 m with an average depth of 2600 m; the weighted average oil-saturated thickness is 7.5 m. Only the upper part of the Kalinskaya formation was opened by wells during drilling.

Podkirmanskaya formation (PF) on the field is the main operating entity. The size of the field is significant, the length of 4.2 km with a width of 1500 m, the height of the field is 250–490 m. The effective oil-saturated thickness as a whole for the PF of the field reaches maximum values – 36.4 m, the total thickness of the reservoir – 123– 132 m. It should be noted that the section of the Zykh field does not differ from the synchronous section of other areas of the Eastern Absheron. A distinctive feature of the PF section is an increase in its total capacity, mainly due to an increase in the capacity of the Surakhanskaya, Balakhanskaya, and Kalinskaya formations. Tectonically, according to, the area under study is located within two major structural elements: the Kura (northern part) and the South Caspian (southern part) depressions. In the south of the section, the South Caspian depression is complicated by the Absheron-Kobystan trough [4]. Zykh square is part of the East Absheron synclinorium and covers the Zykh section of the Karachukhur-Zykh anticline. The Karachukhur-Zykh anticline is the extreme southern elevation of the Sarygayabashy-Shah-Deniz anticline zone, which includes the largest oil and gas fields in Azerbaijan.

The main objective of these studies is to build a detailed three-dimensional lithological model of the Zykh field, taking into account its disjunctive structure, prepare for the determination of petrophysical properties and drawing up a detailed model of oil and gas prospective objects, in order to achieve an increase in the resources of Pliocene and Pleistocene reservoirs. Construction of a detailed three-dimensional lithological model of the field to select optimal schemes for the development of oil deposits based on refined geological models, preparation of geological and geophysical justification before the exploration of hydrocarbon (HC) deposits. The aim of this research is to refine the lithological model of the Zykh field and preparethenecessarydataforconstructingamoredetailedlithologicalandpetrophysical model of the studied field [5,6].

2. Methods and Materials

Loading the source data consisted of converting the necessary information to PETREL compatible formats [7–9]. The initial digital information for constructing a lithological model of the Zykh field was:

- 196 wells for layers VIII and IX, 122 wells for the PF formation and 83 wells for the KaF formation (depth on the roof and bottom of the layers; inclinometry data.
- The coordinates of the wellheads and layers crossing, the trajectory of the wells).
- 148 and 135 wells for formations VIII and IX, 81 wells for the PF formation and 52 wells for the KaF formation (parametric GRW curves: lithology, saturation, porosity, oil saturation).
- Structural surfaces on the roof and bottom of stratigraphic horizons [5].

Quality control of the source data after loading was performed visually in a software package developed by PETREL and Schlumberger [8–10].

3. Results and Discussions

The prepared digital data sets were checked for systematic errors and matched to create a correct model. First, we started constructing a three-dimensional geological grid based on the constructed 2D structural surfaces [11,12]. Discrete three-dimensional grids were constructed based on stratigraphic marks on the roof and bottom of the layers, as well as constructed rift models. The grid type is Corner point, where the cell edges can form arbitrary corners. The Corner point type is currently the most common grid type, as it is more convenient forsubsequent hydrodynamic modeling. The vertical structure gridtype is proportional for all simulated layers. This type of grid describes best the geological model, corresponds to the concept of deposition of productive deposits, corresponds to the density of drilled wells and the seismic study of the area. Figure 2 shows the geometric areal parameters of 3D grids for the layers of the upper and lower sections of the PT, respectively. Figure 3 shows fragments of saturation cubes with vertical and general parameters of 3D grids. The size of the 3D grid of layers VIII and IX of the Zykh field along the XYZ coordinate axes was 170 × 319 × 460 cells. The size of the 3D grid of the PF and KaF layers of the Zykh field along the XYZ coordinate axes was 146 × 300 × 240 cells. In space, the X-axis is directed to the east, the Y-axis to the north. The dimension of cells along the lateral of geological grids is on average 15 × 15 m. The vertical dimension of the layers was determined by the total thickness of the formation, the degree of its heterogeneity, the minimum values of the thicknesses of permeable and impermeable layers, as well as the number of thin layers. Then we started averaging the well data: the well data contains the following parametric curve necessary for constructing a lithological model: a discrete lithology curve (reservoir – not reservoir) [13,14]. The quantization step of continuous GRW curves in depth was 0.2 m. Averaging involves two stages: determining the grid cells through which the well passes and determining the weighted average value of the parameter in each such cell.

Building a lithological model (using the Simulation method). The construction of a lithology cube (LITO) is based either on modeling petrophysical properties, or on constructing a cube of the effective thickness coefficient (sandiness) for the reservoirnon-reservoir parameter and assigning a unit value to cells with the calculated parameter value higher than the boundary value. When constructing the lithology cube of the Zykh field, the geological features of the simulated field are taken into account in the distributionof thereservoir saturationtypeverticallyand intheplan. Taking intoaccount the complex geological structure of the field, lithological modeling was performed in each tectonic block (segment of the model) separately. Thus, 13 models were built for the layers of the Balakhanskaya formation and 18 models for the layers of the Podkirmakinskaya and Kalinskaya formations. After that, the models were combined into a single cube of the lithology distribution. Figure 4 shows the model segment numbers for the upper (layers VIII and IX) and lower (PF and KaF) sections of the productive section, respectively. The yellow color shows the numbers of segments in which the simulation was performed, and the blue color shows that the simulation was not performed, as there are no productive wells in both layers.

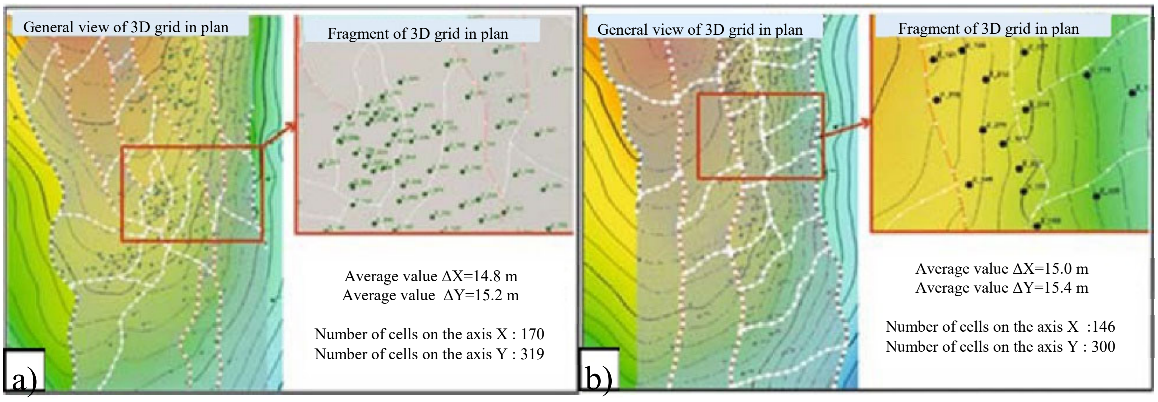

Figure 2: Geometrical Parameters of the 3D Grid of Layers VIII and IX (a) and PF and KaF

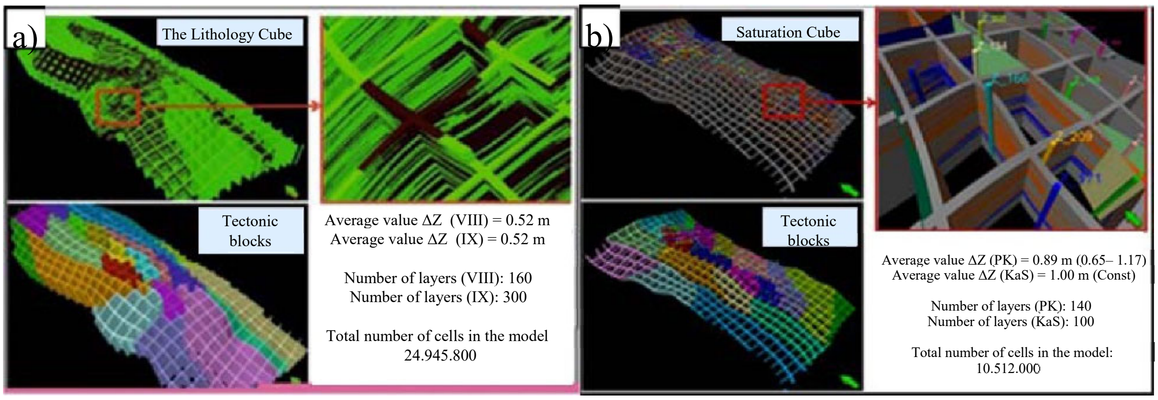

Figure 3: Geometric Parameters of the 3D Grid of Layers VIII and IX (a) and PF and KaF (b)

Below thereisa method for constructinga"Lithology"cube fore achofthesegments: preparing a continuous SAT_cont lithology curve for modeling the sandiness parameter (taking into account the nature of saturation). Reservoirs with a water-saturated reservoir are assigned an index [−1]. The current indexing allows separating water-saturated bodiesfromoil-saturatedbodiesbasedontheresultsofconstructingthesandinessparameter, butifthebodyistwo-phaseinsaturationandhasaWSR,thisapproachintroducescertain errors when determining the geometry of bodies in volume [15]. In this connection, when modeling, the reservoirs of wells that open a water-saturated reservoir in bodies that have a WSR are also assigned an index [1]. The nature of saturation in such bodies was determined after the stage of constructing a cube of connected volumes. The results of modeling lithology on the example of one of the segments of the model of the lower part of the productive strata (layers PF and KaF) are shown in Fig. 5.

4. Conclusion

Analysis of the obtained data shows that even within individual tectonic blocks (segments), the lithology of deposits is variable and one or another fraction dominates during the transition from one block to another. The same is observed in sections A-B, which crosses the field from north to south. Modeling of lithology of the deposits was not in all segments (tectonic blocks) fields, it should be noted that there are not many such segments.

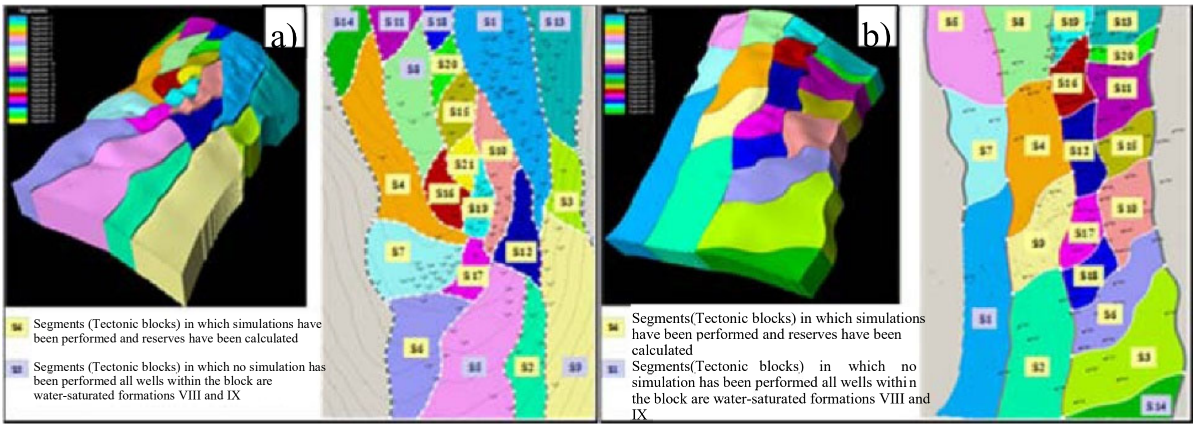

Figure 4: Segment Numbers for Modeling Layers VIII and IX (a) and Layers PF and KaF (b)

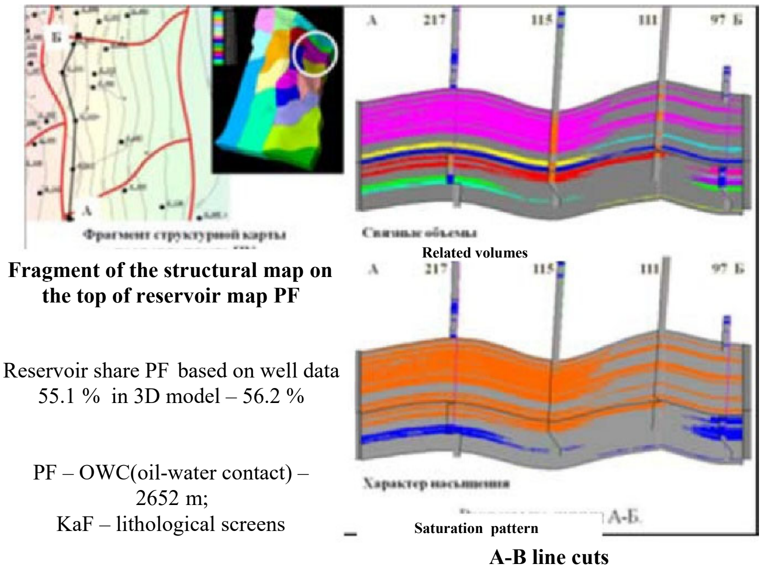

Figure 5: Modeling of Lithology A-B Line Cuts

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