REPLENISHMENT OF THE DISADVANTAGES OF THE PRIOR INFORMATION FOR THE CONSTRUCTION OF THE DETAIL SEISMIC SECTION OF THE PERMIAN SYSTEM (CASE STUDY OF THE BITUMEN DEPOSIT OF THE REPUBLIC OF TATARSTAN)

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ABSTRACT

Nowadays, there is an increasing interest in the tight oil reserves. Such kind of oil have the specific physicochemical properties under conditions of natural occurrence [1]. In this article we consider the solution of the problem of preparing geophysical data for modeling seismic inversion on the example of bitumen deposits. The reservoirs occur at a depth between 150 and 200 m. Thuswise, the accurate processing of geophysical data remains actual.

The seismic inversion is usually understood as a group of algorithms by which a seismic time section is transformed into a section of acoustic impedance [2]. Subsequently, the parameters are used through regression dependencies to the predict properties of the medium: the porosity, saturation, effective thickness.

The basis of the seismic modeling is geophysical data: the acoustic and the formation density log data. This article describes the problem of the synthesis of missing data on the compression wave and the solved density which arises from poor-quality research on the well, the influence of the well itself on the results of the logging and equipment-specific. The feature of this research is the lack of geophysical information in the first 50 meters of the geological cross-section, which for the depth of the deposit makes up almost a quarter of the missing information for seismic modeling.

Keywords: synthetics of geophysical data, rock physics, seismic modeling.

INTRODUCTION

Nowadays, the interest in the deposits of super viscous oils is observed in many countries as the USA, Canada, Colombia, India, Romania [3]. In Russia, the representatives of such deposits can serve as Yaregskoe and Usinskoe fields [4, 5]. The occurrence conditions and petrophysical properties of the rocks of each of the deposits are individual. For example, the deposits of the USA are located at a depth of 1.5 km, Canada's deposits up to 60 meters depth. Yaregskoe and Usinskoe deposits are characterized by carbonate bitumen-bearing rocks.

One of the oil regions of Russia is the Republic of Tatarstan. The object of this article is one of the 450 super viscous oils deposits identified in this region [6]. The deposits of the republic are distinct in their geological characteristics from known deposits in the world, which undoubtedly requires an individual approach to the creation of a model for describing changes in petrophysical rock characteristics. The obtaining of dependencies, which describes the change of the speed characteristics of various rocks is

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fundamentally new moment that takes into account the geological features of the Republic of Tatarstan deposits.

The considered deposit is developed by the method of Steam-Assisted Gravity Drainage (SAGD) [7]. At the interface of the steam chamber and cold oil saturated thicknesses, the heat exchange process constantly occurs, as a result of which the steam condenses into water and together with the heated oil, flows down to the production well under gravity [8]. Nowadays, there are a method for monitoring the thermal chamber in the fields of high-viscosity oils and natural bitumen using seismic exploration at the facilities of the Republic of Tatarstan [9]. For the development of the process of monitoring deposits with the help of seismic operations, it is necessary to know the speed characteristics of the geological environment (with reference to the deposits on the territory of the Republic of Tatarstan).

The aim of this work is the obtaining of the necessary information for seismic modeling based on well logging data and restoring missing geophysical information by synthesizing velocity curves of the geological section.

OBJECT OF INVESTIGATION

The object of the study is the deposit of the Sheshma horizon of the Ufa Stage, which is located in the Republic of Tatarstan. The deposit is located in the zone of the developed infrastructure, in close proximity to the populated areas and branched road.

The sandy unit of the Sheshma horizon is the main oil bearing stratum and it is characterized by a high degree of enriched sandy-silty material [6]. In the horizon, the lower - sandy-clay and the upper - sand units stand out.

The sandy-clay unit is composed of interbedded dense clays, siltstones, sandstones, limestones, marls. Sandstones are polymictic, fine-grained, calcareous, clayey. This unit is characterized by weak oil manifestations.

The sandy unit is composed of weakly cemented and loose, fine and medium-grained sands and sandstones of different degree of cementation, in which the clastic grains are mostly fastened with high-viscosity oil. This reservoir is timed with a productive interval of the deposit.

The overlapping of the productive formation of sandstones are "lingula clays" [10]. The thickness of the formation of lingula clay variates from 3 to 30 m in the deposit. These clays are calcareous with interlayers of marls and limestones with the remains of shells of brachiopods Lingula Orientalis Gol and Lingula Credneri Gein. Based on the characteristic brachiopod complexes, a stratigraphic description of Permian system deposits in the territory of the Republic of Tatarstan was carried out.

DATA PROCESSING METODOLOGY

The transformation of petrophysical parameters into seismic attributes is based on the using of well logging data. One of the important parameters, which is used in the interpretation of seismic data and is obtained on the basis of acoustic (AL) and formation density logging (FDL) is the acoustic rigidity parameter [11]. However, the data on AL and FDL are usually not available for all wells or for the entire study interval. In this situation, other geophysical methods are used to solve the problem of synthesizing missing data of acoustic and density logging [12] with an acceptable degree of reliability.

The presence of the continuous elastic rock characteristics throughout the wellbore interval is a necessary condition for the integration of wellbore and seismic data. Due to technological causes and measurement conditions, often the data of the methods AL and FDL can be significantly distorted, which requires the use of empirical modeling for the correction of these methods.

The procedure of the empirical modeling involves assessing the quality of geophysical materials and the correction of logging data [12]. The evaluation of the quality of acoustic and formation density logging is performed by using the core data or valid reference media with the known characteristics. The correction of measurements is carried out by means of empirical connections of the indications of these methods with other methods of geophysical studies of wells. The empirical relationships are strictly applicable only for those conditions and the set of data on which they were obtained.

RESULTS AND DISCUSSION

For processing, geophysical data for 15 wells were considered. The logging complex is represented by methods of radioactive logging, neutron logging, resistivity logging and acoustic logging. A composite geophysical data plate of the initial data is presented in Figure 1. Acoustic logging was performed in 10 wells out of 15.

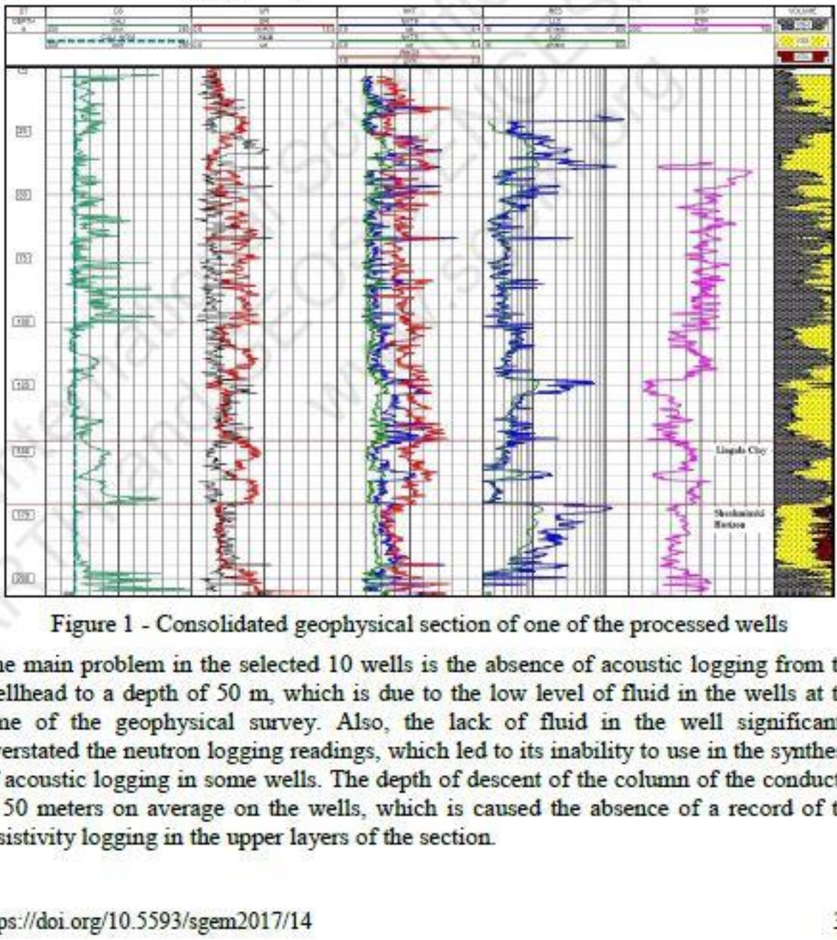

Figure 1 - Consolidated geophysical section of one of the processed wells

The main problem in the selected 10 wells is the absence of acoustic logging from the wellhead to a depth of 50 m, which is due to the low level of fluid in the wells at the time of the geophysical survey. Also, the lack of fluid in the well significantly overstated the neutron logging readings, which led to its inability to use in the synthesis of acoustic logging in some wells. The depth of descent of the column of the conductor is 50 meters on average on the wells, which is caused the absence of a record of the resistivity logging in the upper layers of the section.

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After the selection of 10 wells with varying degrees of quality and acoustic recording intervals, the acoustic logging readings were normalized [13]. The reference interval for normalization was chosen as the "lingual clay" section. The results of this procedure lead to a uniform range of indications of interval time in identical lithotypes, excluding the variations of indications which are associated with the technology of research and instrumental error. The figure 2 shows the histograms of the distribution of the time interval of the longitudinal wave (DTP) in the reference interval before and after normalization. According to geophysical studies, the reference interval of lingular clays is characterized by: interval time of the longitudinal wave in the range 400 ÷ 480 us; According to the density logging data in the range of 2.17 ÷ 2.32 g/cc.

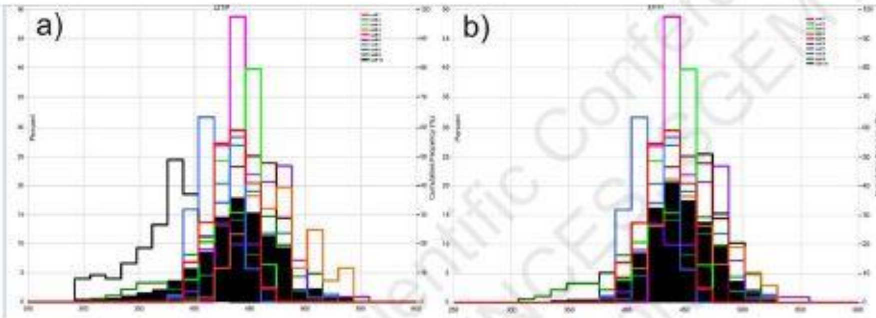

Figure 2 - Histograms of the distribution of DTP readings in the reference interval before (a) and after (b) normalization.

The next stage of the work was the choice of a geophysical method for synthesizing missing data. Using the example of a well with the most complete complex of geophysical data with available records to the well head, the distortion of the absence of liquid level and the presence of a conductor in the work presents a method of synthesis, which in each well was carried out individually. The analysis of the correlation of the acoustic logs for the following dependencies: acoustic and neutron logging, acoustic logging and resistivity logging, acoustic logging and normalized gamma logging curve was made in the this well. The analysis of the degree of correlation of acoustic log data with other methods of geophysical studies revealed the fact that the most suitable for synthesizing is the neutron logging curve (Figure 3).

Thus, in the treated wells, the synthesis of the acoustic logs was performed, choosing the best correlation coefficient between the real curve and the curve chosen for the synthesis for each well individually. On the cross rafts, the correlation coefficient was determined and the most acceptable result was selected. In addition, the distribution histograms were monitored in the reference interval of "lingula clays" in order to exclude the differences in the interval time of the longitudinal wave travel in a single formation and lithotype.

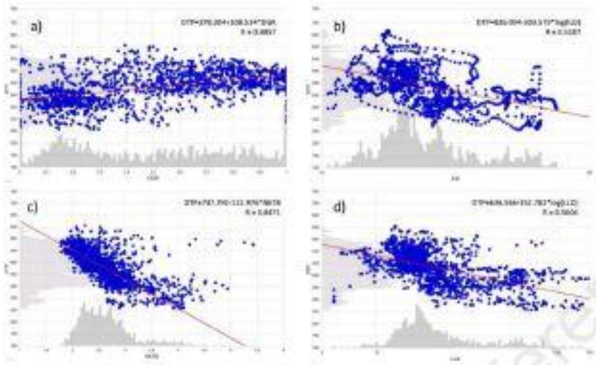

Figure 3 - Correlation between the acoustic curve and a) the normalized gamma logging curve, b) induction logging, c) neutron logging, d) lateral logging.

The lack of a qualitative measurement of neutron logging and the recording of resistivity logging in the interval from the wellhead to a depth of 50 m in half of the treated wells led to the impossibility of synthesizing the neutron logging curves having the best correlation coefficient. The only possibility was the synthesis of acoustic logging using natural radioactivity logging data. This approximation of the synthetic curves gave a difference on the histograms of the DTP distribution, which was edited to well data with the best correlation coefficient of the synthetic and original curves by additive correction. This assumption was made exclusively in the intervals of not recording acoustic logging in problem wells in the interval from the wellhead to 50 m.

The results of synthesizing sonic logs from the missing data of the upper part of the section are shown in Figure 4, 5. The histogram in Figure 4 shows the adapting of the synthesized curves in the section from 0 to 50 m. These indicates show a good correlation between the selected geophysical curves for synthesis and the consistency of the obtained results. According to the acoustic and density logging curves (Figure 5), the five more layers are distinguished in the interval from 0 to 50 meters. The segregated strata can be subdivided into approximately two lithologic differences. The first is characterized by a density in the interval 2.1 ÷ 2.2 g/cc, according to the curve of the interval time 475 ÷ 530 us. The second lithotype is characterized by density in the interval 2.4 ÷ 2.5 g/cc, according to the acoustic logging curve in the range of 365 ÷ 420 us.

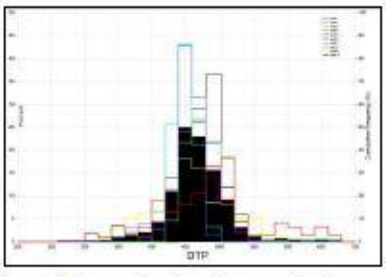

Figure 4 - The adapting of the synthesized curves in the section from 0 to 50 m.

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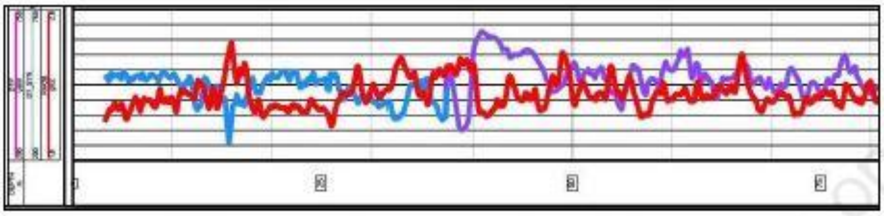

Figure 5 - Example of registered and synthesized acoustic logging curves.

CONCLUSION

The geological model created by the analysis of seismic data, as a rule, relies on the data of geophysical studies of wells. Thus, there is a direct relationship between the quality and quantity of the information about the well and the accuracy of seismic modeling.

In this article, the problem was solved to fill the lack of a priori information for constructing a detailed seismic section of one of the bitumen deposits of the Republic of Tatarstan. The final result of the work was the production of synthetic curves in the missing areas with a certain degree of reliability and the use of logged data from the AL and FDL in the area from the wellhead to a level of approximately 50 meters.

Thus, this work shows the possibility of synthesizing missing information on the velocity and density properties of rocks. It is worth remembering about some approximation of the obtained results to the natural distribution of acoustic characteristics in the seams. Undoubtedly, the synthetic curves can not directly replace real geophysical well data. But the obtained data, which was received from empirical relationships with a certain degree of accuracy can complete the lack of information, integrate synthetic curves in the project and significantly increase it's informative value.

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