Method of complex interpretation of results well logging (TABC Gintel) for the terrigenous rocks sections Tersko-Sunzhensky petroleum region

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Abstract. A brief overview of the proposed method of processing and interpretation of well logging data in Terrigenous deposits. And also presents results of data well survey with its application using the example terrigenous deposits Tersko-Sunzhensky petroleum region. The findings suggest that the interpretation of the results of the GIS, as described TABC gives accurate information to determine geological characteristics and hydrocarbon saturation Lower Cretaceous terrigenous deposits of the Tersko-Sunzhensky petroleum region.

1. Introduction
As the problems solved by well logging methods become more complex, the problem of studying complex collectors also increases.

Special attention is paid to manifolds with polymineral matrix composition, complex structure of capacitive space and multicomponent composition of fluid, as well as low-permeability clay manifolds. The identification of such collectors within the productive horizon is very important in the development of oil and gas fields.

The non-optimality of well logging complex and research technology, imperfections of metrological support, methods of individual and complex interpretation of well logging data are added to the objective difficulties of solving the set tasks.

Well logging methods are very diverse and use all kinds of physical fields (electric, electromagnetic, nuclear radiation, gravitational, mechanical stresses, thermal). No geological problem can be solved by any of the well logging methods alone. Hence the need for integrated application of well logging methods and interpretation of the results.

2. Methods and materials
The current state of the industry makes it possible to create an information and computing system, within the framework of which it is possible to implement a generalized algorithms mic approach to the complex interpretation of well logging data, which implements the entire arsenal of currently existing methodological approaches in Russia and abroad with the use of various systems of petrophysical models and connections. Developing this direction, the Gintel system developed the technology of integrated processing and interpretation of well logging ESKS-TABC data, within the
framework of which there is a “Technique of automated restoration of rock properties in terrigenous section according to well logging data in the Gintel system.”

The TABC methodology uses various algorithm schemes for processing and interpreting well logging data based on the use of petrophysical model systems, stochastic connections, quantitative and qualitative criteria and limitations. At the same time, it considers the use of collector rock properties both all known petrophysical models based on single and two-component rock models (sandstones, clay sandstones containing wet clay) and the use of a system of petrophysical models describing a three-component model of sand-aleurite-clay rock, which allows to restore the full volume of structural and thermic model of the well logging according to the data of the well logging. Optimal selection of computational circuits and systems of petrophysical models and connections is determined in the process of adaptation of TABC procedure to specific geological conditions of studied section. When processing well logging data in the computer system, the method of interpretation modeling is used, which provides multiple determination of rock properties with assessment of reliability of found geological characteristics of the section on the basis of automated use of core data, results of tests, materials of trial or current operation on the date of logging in each well.

Results of processing of well logging data by wells shall be prepared in accordance with the requirements of regulatory documents of State Commission for Mineral Reserves. In addition, they can be exported in various accepted formats for input to software complexes that perform geological modelling of oil and gas deposits and calculation of hydrocarbon reserves therein, for example, to the currently used Pertel (Schlumberger) and Irap RMS (Roxar) packages in oil companies. [6, 7].

3. Results

This article discusses the principles of using the TABC technique to determine the calculated parameters of oil-bearing formations of lower-Cretaceous deposits of the Tersko-Sunzhensky oil-and-gas region (TSOGR).

In order to determine the physical properties of such rocks as terrigenous deposits of lower chalk according to well logging data (on the date of logging), it is necessary to use a system of petrophysical models, which should take into account the peculiarities of change of properties of terrigenous deposits and their oil saturation. Which can be different in values depending on the geographical location [10]. Justification of the petrophysical support system for sediments lower chalk in various fields of the Tersko-Sunzhensky oil and gas region was carried out taking into account a number of factors:

1. In the vast majority of wells there are data of electrometrics, acoustic and radioactive methods, cavernometry necessary for study of rock properties. All logging data are recorded by equipment developed in the 1970s.

2. Core studies are often performed by determining a standard set of physical properties of rocks: porosity, absolute air permeability, bound water saturation by centrifugation, bulk density, specific electrical resistance measured under atmospheric and formation conditions under full and partial water saturation of samples with water with mineralization of about 80 g/l. Granulometric analysis is performed on some part of cores. There is a description of a small collection of grinding. Sand, aleurite and clay fractions were formed on a special core collection, and natural gamma activity and cationic exchange capacity were measured on these fractions. There is no data from the capillarimetry study.

Laboratory analysis was carried out on kerns from wells of various deposits in small volumes (Carabulak-Achaluki, Starogrozvenskoe, Oktiabrsksy, Akhlovsky, Malgobek-Voznesenskoe, Eldarovskiy, Hayan-Kortovskoe, Yastrebenny, Bragunskoye). The depth of core sampling is not related to well logging data – only the slipping intervals within which the core was sampled for testing are known. Therefore, the generalization of the core data can only be carried out in an integrated form. In justifying the petrophysical support, the core and well logging data were independently linked by the authors.

A comparative analysis of the values of the parameters on the core taken from different deposits showed that in the graphs of the comparison of the parameters, for example porosity, permeability and bound water saturation (Figure 1), or relative resistance and porosity (Figure 2), while maintaining a
uniform pattern of the parameters relationship, there is a wide variation of points, which makes the establishment of stochastic bonds, which are usually used in traditional approaches to the interpretation of well logging data, uncertain.

The location of the points on the correlation connections reflects the natural and significant changes in the properties of the lower chalk rocks lying at different depths within the Tersko-Sunzhensky oil and gas bearing region. Therefore, it was concluded that in justifying petrophysical models of the interpretation of well logging data, it is necessary to use a different approach to the determination of relationships from the construction of stochastic dependencies of the type “core-core,” core-well logging”.

This approach should be based on the application of generalized petrophysical models that establish physically sound relationships between the parameters, and the verification of the execution of such linkages on the entire collection of core samples, regardless of where they are taken within the lower chalk thickness.

This approach was developed and applied by the authors of the TABC methodology [6] and is considered as adaptation of the set of accepted petrophysical connections to the studied rocks based on the use of mathematical modeling methods. In the process of adaptation, two problems are solved: 1) the applicability of the system of petrophysical models to describe the properties of the studied rocks is proved; and 2) the values of empirical coefficients, which are included in the formulas and adjust them for use in determining the properties of rocks in section, are established.

Therefore, in justifying the petrophysical support of the technique of interpretation of well logging data, the approach to the study of petrophysical patterns and evaluation of parameters of petrophysical connections was applied. It consists in mathematical modeling using actual core data on Lower Cretaceous sediments of known generalized petrophysical patterns inherent in terrigenic rocks and identified by petrophysics to date in the study of many types of sand-aleurite-clay rocks of different mineral composition.

The system of petrophysical models developed by V.S. Afansyev, [7] was used as the basis for the research. To date, this model system has already been successfully adapted to many geological sections of Western Siberia (mesose), Timano-Pechor Province (paleose), West Caucasus (kynose), Egypt (mesose and kynose) and other geological areas.

This system is based on a three-component model of sand-aleurite-clay rock. It follows from this model that the rock consists of a structural framework and pore space. The structural framework is folded with sand, aleurite and clay fractions, carbonate cement, primary rock debris and various other minerals.

**Figure 1.** Comparison of porosity of absolute permeability of rocks: a – change of comparable values at different deposits, b – dependence $K_{pp} = f (K_p, S_{q.sv})$
The proposed model takes into account the influence of aleurite material on the physical properties of rock along with the clay component. This model also takes into account the change in the physical properties of the structural framework of the rock as a function of the ratio of its fractional composition, the change in the charge of the forming fractions of the particles, the mineralization of the produced water, the oil and gas saturation and the reflection of these changes in the adsorption processes and physical properties, which are determined by the well logging data.

An important step in the interpretation of well logging data for wells is the assessment of the reliability of certain geological properties of rocks. One example of the evaluation of the reliability of the developed methodology (comparison of the results of interpretation using the proposed methodology with the results of well testing) is shown in Figure 3.

For the three-component model of terrigenic rock a system of petrophysical equations is justified, describing physical properties of rocks and readings of well logging methods as a function of petrophysical characteristics of rocks and their fluid saturation taking into account thermobaric conditions of rock formation in section.

Underlying the creation of a system of generalized petrophysical models is the notion that terrigenic sediments are generally characterized by common basic petrophysical patterns. They form physical properties of specific sand-aleurite-clay deposits depending on actual structural-mineralogical composition of rock skeleton, hydrogeological and thermodynamic conditions of rock formation and actual oil and gas saturation of rock collectors.

In the development of petrophysical models for the interpretation of well logging data for terrigenic rocks, a comprehensive analysis of theoretical and experimental petrophysical studies carried out by many scientists in Russia and other countries was carried out and special studies were carried out.

The author together with the developer of the proposed system S.V. Afanasyev carried out studies on adaptation of the system of petrophysical models in geological conditions of alb-pharmacy rocks of lower chalk and application of the method of TABC for interpretation of well logging data at fields of Tersko-Sunzhensky oil and gas bearing region [3, 5].

To determine effect of adsorption effect on physical properties of rock, parameter is used, which determines electric charge of pore channels, formed by particles, which form rock skeleton and is expressed in form of capacity of cationic exchange of rock Q, mol/l, determined in units equivalent to value of concentration of ions in electrolyte, which saturates pore space of rock.
The natural radioactivity model takes into account the contribution to the GC curve readings of the sand, aleurite and clay structural components of the rock skeleton.

On the basis of the synthesis of petrophysical survey data for many geological objects, a model has been developed to estimate the content of residual water in the rock. This model determines the total content of two components: the volume of water of the double electric layers formed as a result of integral adsorption processes in the rock pore system, and the volume of molecular bound water controlled by the content of fine-grained (aleurite) structural component in the rock [1, 2].
The absolute permeability of terrigenic rock is calculated from the theoretical model \( C_{rc} = \frac{1}{K_p, K_{whv}} \) developed using Kozeni's equation and expressing it taking into account the proportion of bound water in \( K_{wsv} \) rock presented by V.N. Kobranova [8, 9].

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