IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 6, June 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

The Determination of Lithological-Capacitive Properties of Rocks According To Geological-Technological Research in the Drilling Process

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ABSTRACT

Numerous works in the field of development of scientific foundations in the field of fundamental technologies, in the conditions of abnormally high pressures in all larger scientific research, as regards the modernity of the main technologies while drilling oil and gas wells. The article reveals the theoretical and scientific-methodological basis of appliaction of the drilling fluids in view of reservoir properties of the rocks in situations of the abnormally high formation pressure. This line of research is very relevant for countries with a complex structure of oil-producing and gas-bearing rocks, with the frequently replaced structure of the layered structure of the oil and gas strata. This study can also be interesting in the design of oil and gas structures with complex geological and technical characteristics.

KEYWORDS: Drilling fluids, abnormally high formation pressure, complex geological and technical characteristics, composition of drilling mud, oil and gas fields.

I. *INTRODUCTION.*

As is known, the development of a system for calculating the characteristics of a geological section requires an analysis of the objectively existing, identified in practice, qualitative and quantitative relationships between various characteristics that affect the drilling process, exploration and discovery of the interrelationships between the geological, geophysical, mechanical and technological characteristics of the section. The study of lithological- capacitive characteristics of rocks in the geological section is one of the most important tasks of exploration drilling, the solution of which allows for the timely development and correction of the well construction program.

Usually, when assessing lithological-capacitive properties and lithological partition of the section, the results of analysis of the cuttings and interpretation of Geographic Information System (GIS) are used. However, in testing of the cuttings, the accuracy of quantitative assessments depends on the conditions for movement of the drilled particles along the wellbore, the intensity of their mixing, and a number of subjective factors. The use of GIS materials to study the lithological features of the section makes it possible to more accurately perform the partition of the rocks. But this information cannot be obtained while drilling.

More effective for the purposes of operational lithological partition of rocks in the drilling process is the method based on the analysis of the mechanical rate of penetration as an indicator

of the strength of the sediments to be opened, and constituting the basis of the Geological-Technical Research (GTR). The strength properties of rocks depends on the lithological composition and structural-texture features, as well as on the magnitude of the resulting stress vector created at the bottom of the well. Other things being equal, the magnitude of the critical stress (the ultimate strength of the rocks) is directly proportional to the cohesion between the individual rock particles and the differential pressure on the bottom of the well. Thus, the rate of penetration increases as the grain size increases and the bond between the individual components of the rock is disturbed by pore pressures or when cementing of the deposits is poor [1]. The drilling data also makes it possible to quickly evaluate the pore pressure both qualitatively and quantitatively, which is very important in making decisions in the drilling process. The effectiveness of forecast estimates increases with the combined use of both technological and geological and geophysical information.

As the analysis of the literature on the evaluation of the characteristics of well sections, as well as the regularities of change in the rate of penetration with depth shows, the presence of such interrelationships makes it possible to further study the geological section, assess geological characteristics that were not previously estimated, and improve the accuracy of previously estimated characteristics.

Thereby, in order to assess the geological characteristics of the rocks composing a section of the deposit (lithology, filter-capacitance parameters, mechanical properties, and barometric characteristics of the reservoir), data that have been subjected to statistical processing has been used in various studies.

The analysis of the studies, as well as the results of drilling, shows that the actual levels of the characterization of the process are subject to strong fluctuations, and are of a random nature, which was not considered in the applied methods and systems. In this regard, obtaining accurate estimates of the characteristics of the geological section is significantly hampered. On the other hand, as noted in a number of works, in particular in [2,3], this circumstance introduces considerable difficulties in a number of cases when establishing the position of the line of normal clay compaction from drilling data and the associated definition Intervals of transition to zones of increased pressures. In such cases, data is usually smoothed. The essence of the various methods by which the smoothing is performed is reduced to replacing the actual levels of the series with calculated ones that have much less volatility than the original data.

In the practical use of drilling results, it is necessary to obtain a definite regularity, even in the case of noise in them. Therefore, there is a need to study some random processes against the background of other (impulses) [4]. This circumstance was considered by the authors [5] in

drawing up the corresponding program, which we used during the calculations. In this case, the automatic selection method was used for processing.

The change in the statistics of automatic selection makes it possible to judge whether the system is homogeneous, i.e. By its value, calculated for the index of the drilling, it is possible to determine homogeneous intervals.

The comparison of the data of mechanical logging with data from other methods reflecting lithology shows [5] that the rate of penetration in sandstones is 3-5 or more times higher than the drilling speed in clay rocks. It was shown in [6] that between the lithology index, which takes the relative parameter $\alpha_{пс}$, and the mechanical speed, there is a close direct relationship: the larger the value of the parameter $\alpha_{пс}$, the higher the mechanical speed.

To improve the drilling process of the rocks with an increase in the parameter $\alpha_{пс}$ is also indicated in [7].

II. The presence of the relationship between lithology and drilling of rock allows lithological partition of the section based on drilling data, and also to solve the inverse problem in the case of the need for forecasting the drilling process by geological and geophysical information.

Thereby, in some works, an attempt was made to derive dependencies between the parameters representing these information arrays on the basis of a large volume of geological, geophysical and technological information obtained from the data of drilling wells in the fields of Russia, Azerbaijan, Kazakhstan, and others.

According to the drilling and geophysical studies of wells, a statistical analysis was performed and dependencies of the sigma-logging difference parameter numerically equal to the ratio of the span of the sigma-logging points to the large value and the "drilling strength" (drilling index) by sigma-logging from the parameter $\alpha_{пс}$, in example of a section of one of the deposits. The observed dependencies are approximated as follows: the difference parameter of sigma-logging

$$\Delta\sigma=0,62\alpha_{пс}^{1,94} \quad (1)$$

The index of the drilling as per sigma-logging

$$\sqrt{\sigma_0} = 0,54 - 0.22\alpha_{ПС} \quad (2)$$

As the analysis showed, the difference parameter is also closely related to the clay rocks. From Fig. 1, which shows such a dependence, it is evident that with the increase in the difference parameter of sigma-logging the value of clay content decreases, obeying the exponential law:

$$C=78,6\exp(-4,18\Delta\sigma)$$

The presence of these links makes it possible to use the difference parameter of sigma-logging to solve various geological, geophysical and technological problems.

The relationship between the values of the difference parameter of sigma-logging and the parameter $\alpha_{пс}$, as well as the clay content, is the basis for the assumption of its possible connection with the continuity of rocks, which was proposed in [8] as a characteristic necessary for a more complete account

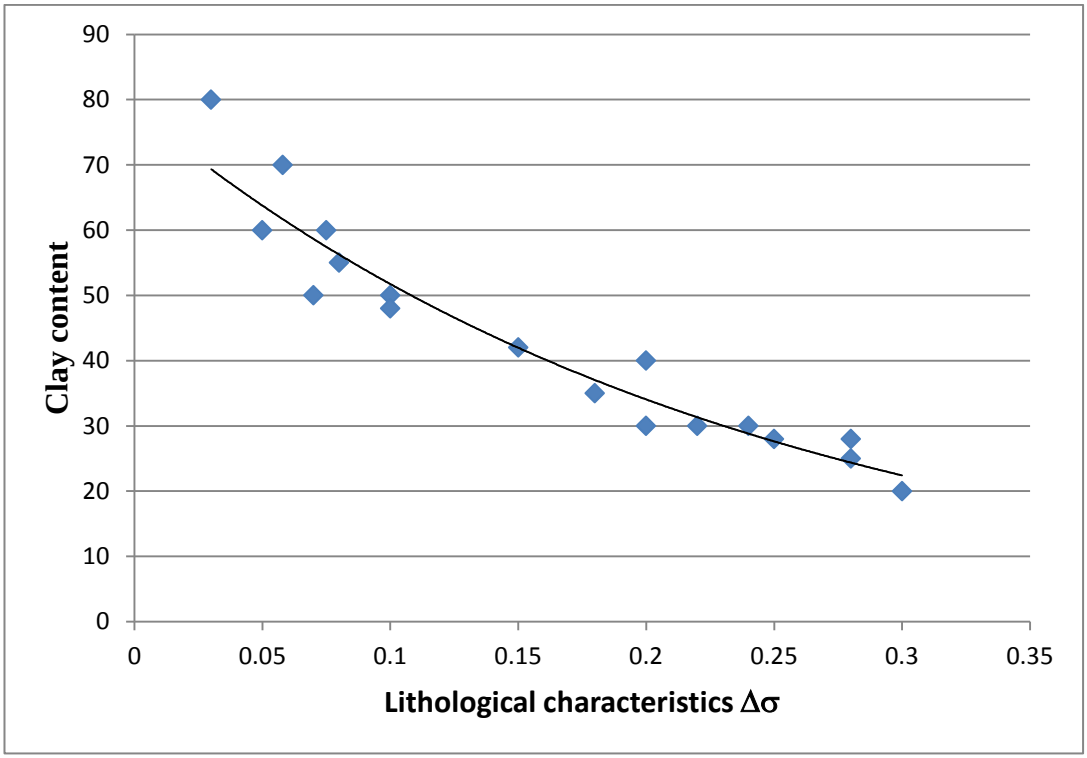

Figure 1. The dependence of the clay content on the lithological characteristic Δσ of the complex of parameters of rock properties in the classification of the drill cuttings.

The continuity according to [8] characterizes the whole complex of disturbances in the surface of the rock by a system of pores, caverns and cracks that facilitate the penetration of drilling mud into the rock. There are four categories of rocks in continuity: from strongly fractured, porous, permeable rocks (I category) to dense, clay rocks and anhydrite (IV category). The comparison of the categories of continuity of rocks with values of the difference parameter

shows that rocks of the fourth category of continuity are placed in the interval of values of $\Delta\sigma\varepsilon$ [0;0.11), for $\Delta\sigma\varepsilon$[0.11;0.26) - the third, and for $\Delta\sigma\geq0.26$ - the second and first [8].

With such a correlation, it becomes possible to link the main estimated characteristics of the geological section with parameters determined from the data of drilling wells. At the same time, an assessment that allows for quantitative calculations is carried out by expressing the results of the analysis with the help of categories the number of which fixes a certain type of breed. However, the analysis showed a closer relationship between such characteristics as sandiness and double relative characteristic of sigma-logging, which is obtained by dividing the current values of the relative difference parameter of sigma-logging by its maximum value in the borehole section. This dependence is linear in nature, and two dependences are observed in the region of variation of the characteristics under consideration (Figure 2): at values of the double relative parameter from 0.042 to 0.75 (Figure 2, a):

$$\Pi = 56{,}88\ \Delta\sigma` + 17{,}35; \quad (4)$$

At $\Delta\sigma` = 0{,}75 \ldots 1$:

$$\Pi = 59{,}31\Delta\sigma` - 26{,}85; \quad (5)$$

Where Π is the sandiness, %; $\Delta\sigma`$- ` - double relative parameter of sigma-logging

Geological and technological information obtained in the process of drilling wells can be used not only to make a decision in the drilling process. The accumulation of such information can also be used to generalize the results of the drilling for the purpose of classifying the geological section by drilling process, as well as evaluating the filtration-capacitive characteristics. Therefore, one of the most promising is the search for links between the geophysical and technological characteristics of the section, which would allow, after some transformations, to coordinate these data with the indicators evaluated during the drilling of the well.

Such connections are also necessary to ensure that during the drilling process it is possible to evaluate the characteristics determined from well logging data, especially in those sections where they were not conducted or conducted in a limited volume.

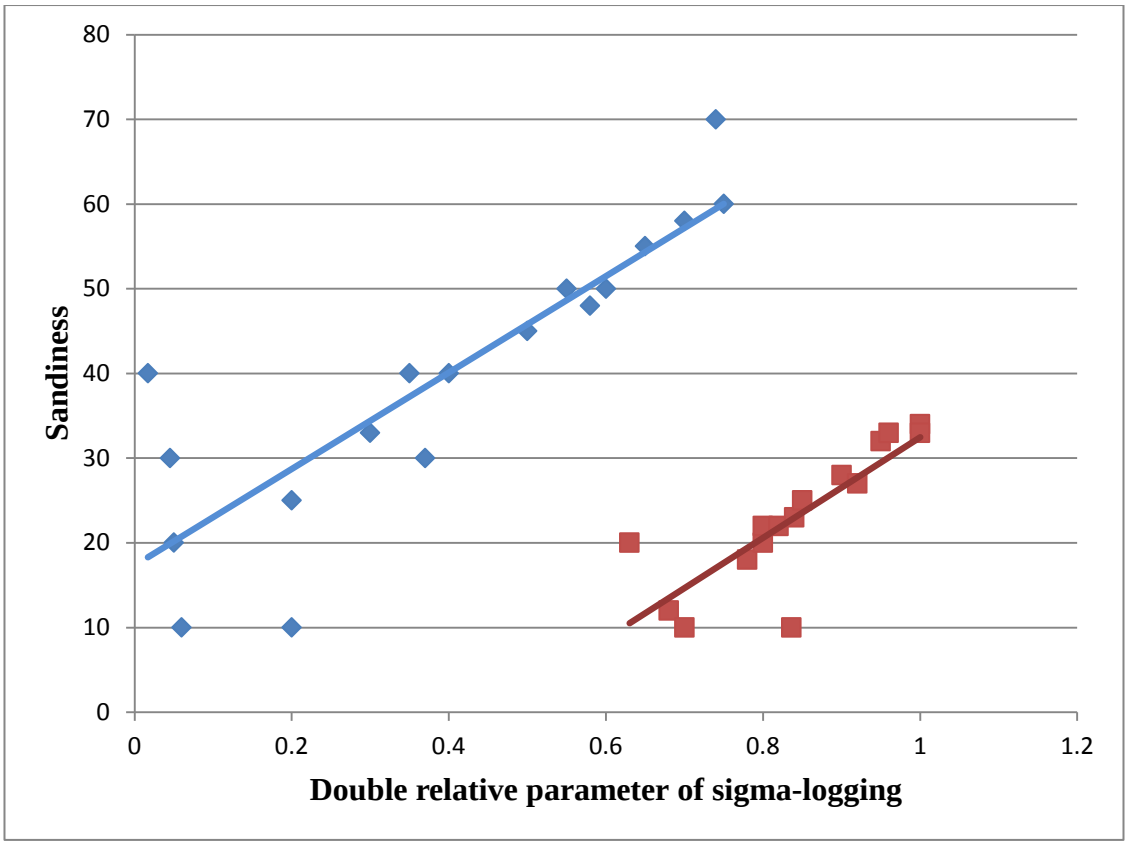

Figure 2. The relation of the sandiness of rocks on the double relative parameter of sigma-logging:
a) for the values of Δσ`=0,05...0,75; b) for the values of Δσ` =0,75...1.

In other words, the presence of such relationships allows one to have an idea of lithology from the drilling data, to obtain information about the clay content and sand content and other characteristics of the geological section, which are necessary for solving both geological and technological problems. This is very important, especially when drilling operations are conducted in areas where there is no information on the section of the drilled well or is available in a limited volume.

III. *RESULTS*

According to the data of complex geological and technological studies, during the drilling of one of the deposits lithological and filtration-capacitive characteristic, were obtained.

Numerous observations show that when drilling wells under normal conditions and relatively constant values of mode parameters, the mechanical penetration rate decreases with depth. This is explained by the increase in the density (and the hardness associated with it) with the depth of the rock. However, in the transition zones and zones of increased reservoir (pore)

pressures, the rate of penetration increases. The researchers explain this circumstance by lack of compaction of rocks, which leads to an increase in their porosity, as a result of which the hardness decreases, and they are drilled at a relatively high speed. At the same time, while drilling the wells, as is known, the differential pressure, i.e., affects the mechanical speed - the difference between the hydrostatic pressure of the mud column and the reservoir pressure. Reducing this pressure also causes the growth of the mechanical speed.

These regularities formed the basis for the allocation of zones of abnormally high reservoir (pore) pressures at the mechanical rate of penetration. On their basis, various methods have been developed and for the last several years, making up the bulk of geological and technological research in the process of drilling wells.

Thus, comprehensive information on drilling wells allows us to obtain the regularities necessary for studying the geological section in the process of drilling a well.

The results of the GTR at the present time make it possible to reliably determine the zones of increased pressures on a real time scale [6,9,10].

As noted in [9], the results of the GTR are consistent with the measurements of reservoir pressures and the behavior of the well in the course of their operation in the fields of Western Siberia.

The geophysical and petro physical characteristics of the deposits of the Upper Jurassic of Western Siberia complicate the use of traditional approaches for estimating pore pressures by GIS, despite a rather comprehensive set of these studies [9].

In work [10] it is noted that a set of developed programs allows the operative evaluation of pressures on mechanical logging, core parameters, drilled cuttings and GIS data. The density and design of the well are also adjusted.

The "complex methodological approach" according to [9-12], developed in "Kubangazgeofizika", allows estimating pore pressures, constructing and refining the line of normal compaction, assessing the stability of the wellbore and the recommended mud density and, at any given time, assess the degree of plasticity of clays and category of danger of column collapse.

In general, numerous works in this direction show an increasing interest of researchers in this area, which is currently one of the main stages in drilling wells provided by leading companies.

As the review of various studies shows, the most accurate assessment of the characteristics of geological sections based on drilling technological data is possible with a deep analysis of information and identification of the various models that form the basis of the respective programs to the real conditions under consideration.

CONCLUSIONS

In the papers considered in the abstract:

- the use of sigma-logging parameters was suggested and their relationship with the lithological characteristics of the section was demonstrated;
- relations have been obtained that allow to evaluate the rock lithology in the process of drilling according to the technological data of drilling;
- suggested calculation schemes and methods for determining pore pressures

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