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Issue Article

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THE INFLUENCE OF CLAY ON ACOUSTIC LOGGING DATA AND THE COMPLEX INTERPRETATION OF MATERIALS OF LATERAL, ACOUSTIC AND NEUTRON GAMMA LOGGING

Abstract*: Exploration for oil and gas in Turkmenistan is mainly associated with Mesozoic sediments lying at depths from 5000m to 7000m or more, represented by both terrigenous and carbonate rocks. These deposits are exposed in difficult geological and technical conditions; the reservoir is predominantly of complex structure, which makes it difficult to isolate them due to poor knowledge.*

The identification and assessment of the industrial value of complex reservoirs in the sections of exploration and parametric wells in Turkmenistan is a rather difficult task and is currently not completely solved.

The article considers a method for the complex interpretation of materials of electrical, acoustic and neutron gamma-ray equipment, based on a comparison of porosity values determined according to the data of each of these types of well section studies.

Key words*: Interpretation, geophysical materials, power, heterogeneity, reservoir saturation, granular porosity, elastic waves.*

Language*: English*

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Introduction

The identification and assessment of the industrial value of complex reservoirs in the sections of exploration and parametric wells in Turkmenistan is a rather difficult task and is currently not completely solved. To study carbonate reservoirs in domestic and foreign practice, various methods of complex interpretation of diagrams of geophysical well research methods are used, most of which are based on comparing specific or relative resistance with acoustic and neutron gamma-ray readings.

The value of the carbonate deposits of Turkmenistan is a wide variety of structural forms of their pore space, lithological heterogeneity, low-power formations, etc. [1, 2]. As a result, the geophysical characteristics of carbonate rocks are ambiguous; the relationship established between different parameters for one lithological reservoir difference is often invalid for carbonate reservoirs of another lithology. Due to the low porosity of deep-lying reservoir rocks, the requirements for the accuracy of determining reservoir parameters from geophysical materials are significantly increasing [3].

Experimental work (V.D.Belokon, V.F.Kozyar) has established that the presence of clay material in the rock generally reduces the velocity of elastic waves. However, at low values of clay content, when the clay material is located mainly in the contact zone of the grains that make up the rock, the velocity of elastic waves may increase slightly.

To determine the effect of clay content on the results of acoustic logging, ΔJy and ΔT, and ΔT were compiled. Based on the fact that the relative parameter ΔJy is mainly determined by the volumetric clay content, with an increase in it, a proportional increase in the interval time ΔT is observed in the area of noncollectors (Fig. 1) at Δ*Jy*>0.1. An increase in the interval time ΔT with constant clay content is explained by an increase in open porosity [4, 5].

It can be seen from Fig. 1 that an increase in the relative parameter Δ*Jy* from 0.02 to 0.1 practically does not affect the value of the interval time ΔT. Therefore, we have concluded that it is impractical to make corrections for the influence of clay content in the interval time ΔT at values Δ*Jy*< 0.1.

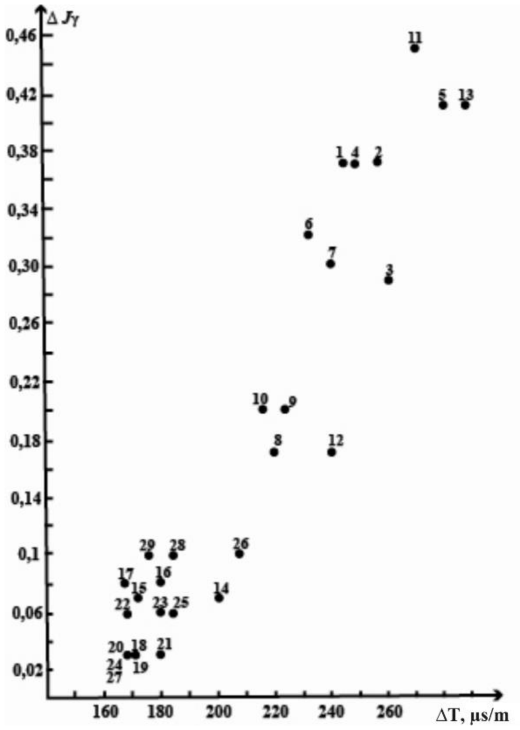

Fig. 1. Comparison of the relative parameter ΔJy and the interval time ΔT (AK), Sabur field, well X1.

A comparison of the values and ΔT also shows that at ΔJy>0.1, the position of the points is controlled by the amount of clay, with an increase in its point of movement to the right, which corresponds to an increase in ΔJy. fig. 2 it is also particularly clear that the clay material has practically no effect on the value under existing conditions. Thus, when ΔJy varies from 0.1 to 0.45 (ΔT varies from 210 to 288 μs/m), it varies within 4.5-10.00 mm, while no regularity is observed depending on the resistance of the relative parameter ΔJy

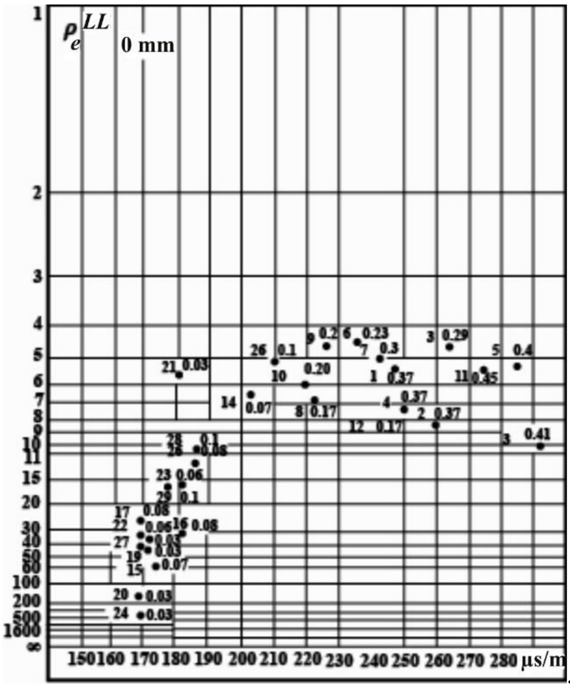

Fig. 2. Comparison of the effective comparison and the interval time of T (AK) Sabur field, well X1

Figure 3 shows the position of water-saturated layers in the system without taking into account clay content and taking it into account. At values of ΔJy>0.1, the points will significantly mix to the left towards the line of 100% water saturation for layers of different lithologies [6, 7].

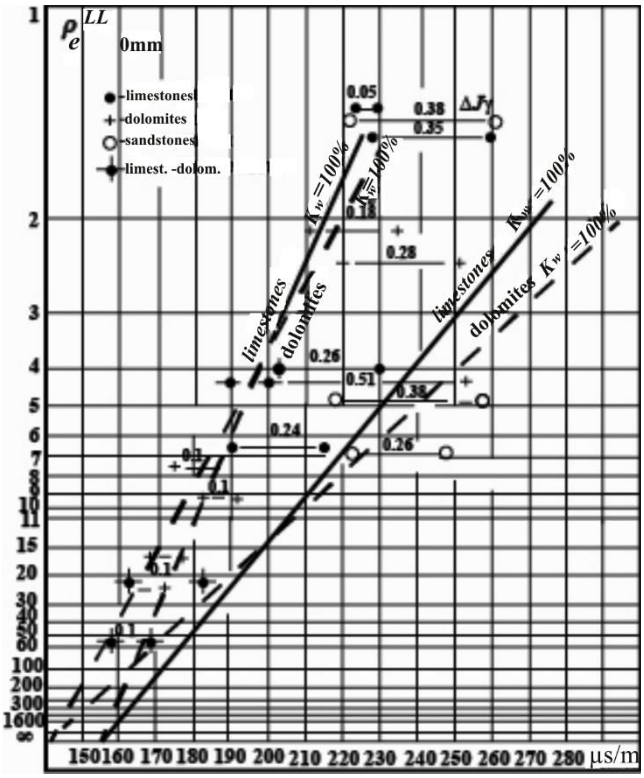

Fig. 3. The influence of clay on the interval time ΔT(AK), Sabur field, well X2.

Failure to account for clay content can lead to errors in estimating the saturation pattern of reservoirs with granular porosity by graphical comparison $\frac{1}{\sqrt{\rho_e^{LL}}} = f((\Delta T)$·

Amendments for the influence of clay content are made according to the formula

$$K_p^{AL} = \frac{\Delta T = \Delta T_{sk}}{\Delta T_{liq} = \Delta T_{sk}} = K_{cl}\frac{\Delta T_{cl} = \Delta T_{sk}}{\Delta T_{liq} = \Delta T_{sk}}$$

where K_{cl} is the volumetric clay content determined by the double difference parameter ΔJy;

$\Delta T_{cl.}$ is the interval time in clay layers lying near the reservoir formation under study [8, 9].

However, in the studied carbonate sections, cases of absence of clay layers are not uncommon. In these cases, ΔT_{cl} can be determined with sufficient accuracy by the schedule of changes in the interval time ΔT with depth in clays, based on the actual materials of the study of wells in the Central part of Turkmenistan (Fig. 4).

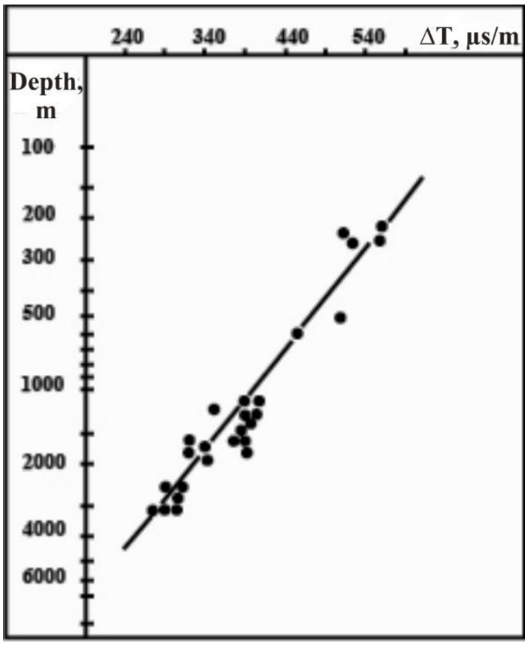

Fig. 4. Variation with depth of interval time ΔT in clays.

Complex interpretation of materials of the lateral, acoustic and neutron gamma method. When studying carbonate reservoirs in domestic and foreign practice, various methods of complex interpretation of well geophysical research data are used. Most of them are based on comparing the specific (relative) resistances with the readings of neutron or acoustic logging, depending ondepending on the porosity of the rocks [10, 11]. More complete and confident information about the studied rocks can be obtained by a comprehensive interpretation of the diagrams of electrical, acoustic and neutron gamma logging [12].

According to the NGL data, the total porosity of rocks can be determined, and the results of the assessments are significantly influenced by the lithology of rocks. When using the dependence $\Delta J_{n\gamma} = f(K_p)$ for limestones, the determined K_p values of dolomites will be overestimated by ~3%, and sandstones will be underestimated by 3-4%. [13, 14].

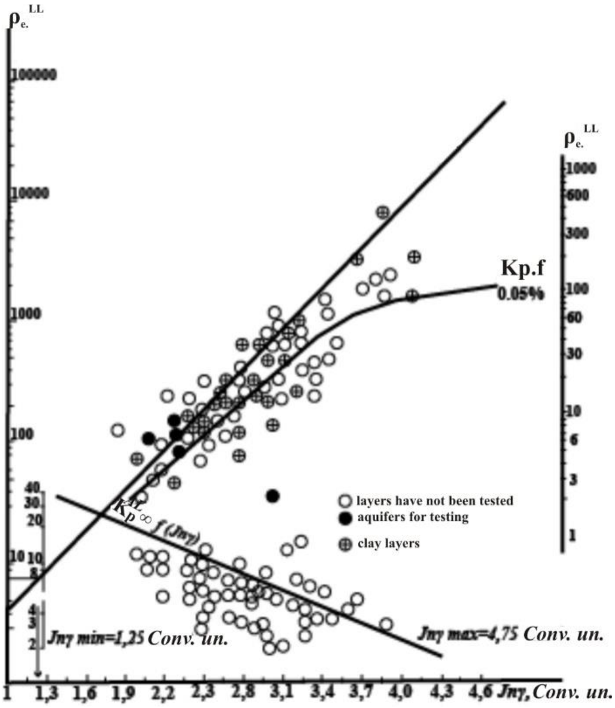

Fig. 5. The results of a comprehensive interpretation of AL-LL-NGL materials (Sabur field, well X1).

Acoustic logging readings depend mainly on the intergranular porosity and lithology of rocks. If the porosity is determined under the assumption that the rock is represented by limestone (ΔTsk = 155 μs/m), then for dolomites the Kp value will be underestimated by ~3%, for sandstones (ΔTsk = 172 μs/m) it will be overestimated by ~3% [15].

The block porosity, depending on the lithology, is determined by the established dependencies P=*f*(K_p), shown in Fig. 6. Note that a certain amount of porosity in BC is influenced by porosity, the presence of fracturing and the nature of saturation. Clay content has practically no effect due to the significant (150-250 g/l) mineralization of reservoir waters.

The total porosity is determined from the NGL diagrams, but the values obtained may be distorted by the influence of lithology and clay content. According to acoustic logging, porosity close to block porosity can be found, which also depends on the lithology and clay content of rocks [16].

The task of interpretation is to determine porosity by acoustic, neutron gamma radiation and relative resistances, to identify and correctly interpret the regular deviations of the found values from the porosity of water-saturated granular limestones.

Due to the low porosity of compacted deep-lying carbonate rocks, errors in its determination by geophysical methods increase significantly, therefore, the requirements for the accuracy of recording acoustic and neutron gamma-ray logging diagrams increase [17]. The resulting diagrams are not always of high quality (the error is more than ± 5%). To increase the accuracy and unambiguity of interpretation, it is necessary to make repeated measurements of AL and NGL in carbonate strata.

To clarify the dependence of the total porosity on the NGL readings, as well as to correlate the readings of all three methods, graphs of the relationship of relative resistance from the NGL readings and porosity calculated from acoustic logging from the NGL readings are plotted on one form (Fig. 5). As a result, two points correspond to each formation intersection on the graph, one with coordinates $J_{n\gamma}$ and $P_п$, the other with $J_{n\gamma}$ and K_p^{AL}.

For granular water-saturated limestones $K_p^{NGL} = K_p^{AL} = K_p^{LL}$, the line of granular limestones is a line of equal porosity.

To identify the influence of lithology, lines for dolomites and sandstones are plotted in Fig. 6. On the graphs $K_p^{AL} = f\left(K_p^{NGL}\right)$ $K_p^{LL} = f\left(K_p^{NGL}\right)$, the lithology lines are calculated according to the parameters of the skeleton (ΔT_{sk} =155 μs/m, $\Delta T_{sk\ d}$ = 141 μs/m and $T_{sk\ p}$ = 172 μs/m). When comparing K_p^{AL} and K_p^{LL} (see Fig.6) regardless of the lithology of the rocks, the calculated K_p values are on the limestone line. The actual position of the layers depends on the type of reservoir and the nature of its saturation. The influence of fracturing will contribute to the displacement of points downwards, oil and gas saturation - up from the limestone line.

The following conclusions can be drawn from the considered graphs:

- the influence of lithology on the results of porosity determinations is significant;

- lithology has the opposite effect on porosity, determined by acoustic and neutron gamma-ray image data, which facilitates the lithological separation of rocks;

- to determine porosity by relative resistance, it is necessary to use $P_p = f(K_p)$ bonds depending on the lithology [18].

Thus, the following porosity ratios can be applied to separate rocks by lithology:

$K_p^{AL} = K_p^{LL} = K_p^{NGL}$ - for granular water-saturated limestone;

$K_p^{AL} > K_p^{LL} > K_p^{NGL}$ - for sandstones, calcareous sandstones;

$K_p^{AL} < K_p^{LL} < K_p^{NGL}$ - for dolomites, dolomitized limestones.

As an example, the determination of the lithology of sediments exposed by the X1-Sabur well using this technique is given (see Fig. 6) and further quantitative interpretation of the materials of geophysical research, as a result of which the filtration and capacitance properties were evaluated depending on the lithology and the separation of rocks according to the prevailing type of porosity was carried out. The results obtained correspond to the concepts of well sections in the Western part of the Central Karakum Mountains [19].

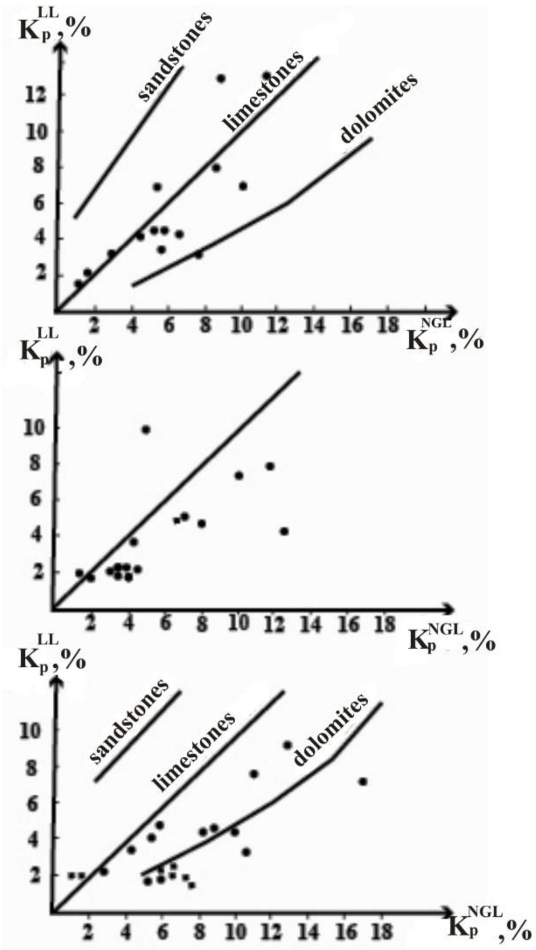

Fig. 6. The results of a comprehensive interpretation of the materials of AL, LL, NGL (Sabur field, well X1).

References:

1. Deryaev, A.R. (2022). Zadachi issledovaniya dlya metoda odnovremennoj razdel'noj ekspluatacii mnogoplastovyh mestorozhdenij. *Innovacionnye nauchnye issledovaniya* №2-2 (16) – Ufa: Nauchno-izdatel'skij centr “Vestnik nauki”, pp. 43–51.

2. Deryaev, A.R. (2022). *Vskrytie produktivnyh gorizontov burovym rastvorom na uglevodorodnoj osnove dlya odnovremenno-razdel'noj ekspluatacii*. Sbornik statej Mezhdunarodnoj nauchno-prakticheskoj konferencii "Nauka v sovremennom obshchestve: zakonomernosti i tendencii razvitiya". (pp. 35-39). Ufa: Izdatel'stvo OOO "Omega sajns".
3. Deryaev, A.R. (2022). *Sovremennoe sostoyanie izuchennosti bureniya napravlennyh i mnogozabojnyh skvazhin s razdel'noj ekspluataciej odnovremenno neskol'kih gorizontov (zarubezhnyj opyt)*. Sbornik statej mezhdunarodnogo nauchno-issledovatel'skogo konkursa "Akademicheskaya nauka na sluzhbe obshchestvu". (pp.170-178). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
4. Bagrinceva, K.I. (1999). *Usloviya formirovaniya i svojstva karbonatnyh kollektorov nefti i gaza*. – M.: Izdatel'stvo RGGU.
5. Gubajdullin, A.A., Musin, K.M., Nuritdinova, G.N., Nafikov, A.Z., & Kandaurova, G.F. (2003). Differenciaciya slozhno postroennyh karbonatnyh kollektorov bashkirskogo yarusa. Trudy 12-go Evropejskogo simpoziuma. *«Povyshenie nefteotdachi plastov»*. Kazan', pp. 609-612.
6. Deryaev, A.R. (2022). Rekomendacii po kompleksnomu vnedreniyu s razdel'noj ekspluataciej odnovremenno neskol'kih gorizontov na gazovyh mestorozhdeniyah Turkmenistana. *Problemy nauki* №1 (69) – M: Izdatel'stvo "Problemy nauki", pp.16-21.
7. Deryaev, A.R. (2022). Ohrana nedr i okruzhayushchej sredy pri razrabotke gazovyh mestorozhdenij metodom odnovremennoj razdel'noj ekspluatacii. Nauchnyj zhurnal *Metod Z* №2 (4) – Sankt-Peterburg: Izdatel'stvo: GNII «Nacrazvitie», pp.12-14.
8. (1988). *Interpretaciya rezul'tatov geofizicheskih issledovanij neftyanyh i gazovyh skvazhin: Spravochnik*. Pod redakciej V.M. Dobrynina. M.: Nedra.
9. Bagrinceva, K.I. (2010). Tipy i svojstva karbonatnyh kollektorov nizhnej permi i devona na sushe i v akvatorii Pecherskogo morya. Bagrinceva K.I., Strel'chenko V.V., Stupakova A.V, *Geologiya nefti i gaza*. - №5.
10. Deryaev, A.R., & Orazklychev, K. (2015). *Sposob odnovremenno-razdel'noj dobychi nefti i gaza iz mnogoplastovoj zalezhi odnoj skvazhinoj*. Patent № 644 ot 08.06.2015. (nomer zayavki 15/101320).
11. Deryaev, A.R., & Orazklychev, K. (2015). *Sposob odnovremenno-razdel'noj i sovmestnoj ekspluatacii neskol'kih produktivnyh gorizontov odnoj skvazhinoj i ustrojstvo dlya ego osushchestvleniya. Patent № 643 ot 08.06.2015.* (nomer zayavki 14/101317).
12. Bagrinceva, K.I. (2007). Rol' treshchin v razvitii slozhnyh tipov kollektorov i fil'tracii flyuidov v prirodnyh rezervuarah. Bagrinceva K.I., CHilingar G.I. *Geologiya nefti i gaza*. №5.
13. Deryaev, A.R. (2022). *Osobennosti bureniya naklonno-napravlennyh skvazhin i tekhnologiya ih odnovremennoj razdel'noj ekspluatacii.* "Fundamental'naya i prikladnaya nauka: sostoyanie i tendencii razvitiya". Monografiya. (pp.76-96). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
14. Deryaev, A.R. (2022). Treatment of drilling mud with "PACS-T" additive. "Innovative approaches in the modern science" Proceedings of CXV international scientific – practical conference. *International scientific journal* №7 (115) – M., pp. 74–77.
15. Deryaev, A.R. (2022). *Rekomendacii po burovomu rastvoru dlya bureniya sekcii 295,3 mm otkrytogo stvola naklonno-napravlennoj skvazhiny*. Sbornik statej II Mezhdunarodnoj nauchno-prakticheskoj konferencii "Nauka, obshchestvo, tekhnologii: problemy i perspektivy vzaimodejstviya v sovremennom mire". (pp.7-11). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
16. Deryaev, A.R. (2022). Provedenie promyslovyh ispytanij kompleksnoj ingibirovannoj dobavki KAIR-T na neftegazovyh ploshchadyah Turkmenistana. *Problemy sovremennoj nauki i obrazovaniya №1(170)* – M: Izdatel'stvo "Problemy nauki", pp.11-17.
17. Deryaev, A.R. (2022). Osnovnye perspektivy razvitiya i inzhenernoe planirovanie burovyh rabot dlya rezul'tativnosti gorizontal'nogo bureniya. *Nauka, tekhnika i obrazovanie* №1 (84) – M: Izdatel'stvo "Problemy nauki", pp.33-38.
18. Deryaev, A.R. (2022). Metody opredeleniya tekhnologicheskih pokazatelej effektivnosti odnovremennoj razdel'noj ekspluatacii. Nauchnyj zhurnal *Metod Z* №1(3) – Sankt-Peterburg: Izdatel'stvo: GNII «Nacrazvitie», pp.8-10.
19. Geldimyradov, A. G., & Deryaev, A.R. (2022). *Razrabotka gazokondensatnyh mestorozhdenij metodom odnovremennoj razdel'noj ekspluatacii.* «Instrumenty i mekhanizmy ustojchivogo innovacionnogo razvitiya» Monografiya vypusk №67. (pp.22-37). Ufa: Nauchnoe izdanie: NIC "Aeterna".