SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 03 **Volume:** 131

Published: 05.03.2024 **http://T-Science.org**

Issue Article

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EVALUATION OF THE CAPACITIVE PROPERTIES OF CARBONATE RESERVOIRS BY LATERAL LOGGING CURVES AND THE INFLUENCE OF CLAY CONTENT ON NEUTRON GAMMA LOGGING DATA

***Abstract**: 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.*

This paper summarizes the results of experimental and methodological studies conducted over a number of years in Turkmenistan. It describes methods for determining porosity by lateral logging and taking into account the influence of clay, as well as methods for isolating and evaluating reservoirs of complex structure. These techniques and methods of interpretation are intended for the study of carbonate deposits of the Jurassic and Cretaceous oil and gas fields of Turkmenistan and are recommended for testing in all geophysical organizations conducting research on complex carbonate reservoirs.

***Key words**: Geophysics, solution, opening, acoustic, lateral, water saturation, lithology, inflow, clay, carbonate, rock.*

***Language**: English*

***Citation**: Deryaev, A. R. (2024). Evaluation of the capacitive properties of carbonate reservoirs by lateral logging curves and the influence of clay content on neutron gamma logging data. *ISJ Theoretical & Applied Science, 03 (131),* 51-57.

***Soi**: http://s-o-i.org/1.1/TAS-03-131-7 ***Doi**: crossref https://dx.doi.org/10.15863/TAS.2024.03.131.7

***Scopus ASCC**: 2209.*

Introduction

To study the electrical parameters of well sections in the geological conditions of Turkmenistan, the method of three-electrode lateral logging has received the greatest application. The method for studying carbonate sections is especially important when the layers are opened using highly mineralized harsh solutions, while the effectiveness of other electrical methods is sharply reduced.

In most of the known methodological recommendations for the identification and assessment of complex reservoirs by field geophysics methods in sections of deep wells, it is assumed that block porosity, determined by relative resistance, is practically independent of lithology, i.e. it is assumed that the established relationship $P_p = f\,(K_p)$ is valid for any lithological differences of carbonate rocks.

However, a comparison of the porosities determined by neutron-gamma logging (NGL) and acoustic logging (AL) and relative resistance of water-saturated granular reservoir formations shows that in most cases the porosity determined by relative resistance is significantly lower than for NGL and AL. Especially large discrepancies are observed for dolomites and their differences. This in some cases led to errors in determining the nature of reservoir formations [1, 2, 3].

We have carried out works that are the first attempts to establish a connection $P_p = f\,(K_p)$ for various lithological differences of reservoir rocks found in sections of Turkmenistan.

A graphical method of joint processing of acoustic and lateral logging data is used according to a well-known technique used to refine the values of the interval time of the elastic wave path through the rock skeleton of the section under study.

The results of the determination of lithology by core, geophysics, reservoir testing and analysis of reservoir water samples were used in the construction. The layers were selected, from which tributaries of reservoir waters were obtained during testing, and the layers that, according to geophysical data, are confidently characterized as water-saturated [4, 5].

Fig. 1 (a, b) illustrates the results of studies for dolomites, limestones of water-saturated, slightly clay. At the same time, the relative resistances of the layers were assumed that the lateral logging AR (apparent resistivity) corresponds to the specific resistance of the part of the formation unaffected by penetration - in this case, $\rho^{LL}f/\rho_{p.d}$. The side logging AR was corrected for the influence of the well diameter, reservoir capacity and the resistance of the host rocks. The scale of the abscissa axis (ΔT) is assumed to be linear, the scale of the ordinate axis (P_p) obeys the law $\sqrt{\frac{1}{P_p}}$.

Fig. 1 (a, b) shows graphs of the dependence of $P_p = f\,(\Delta T)$, corresponding to different values of the structural coefficient m, characterizing the features of the structure of the pore space of the rock and included in the well-known Archie equation:

$$P_p = \frac{\rho_f}{\rho_f} = \frac{1}{K_p{}^{\tau}} \quad (1)$$

(in the accepted coordinate system, such a graph is straightforward only for the case when m=2).

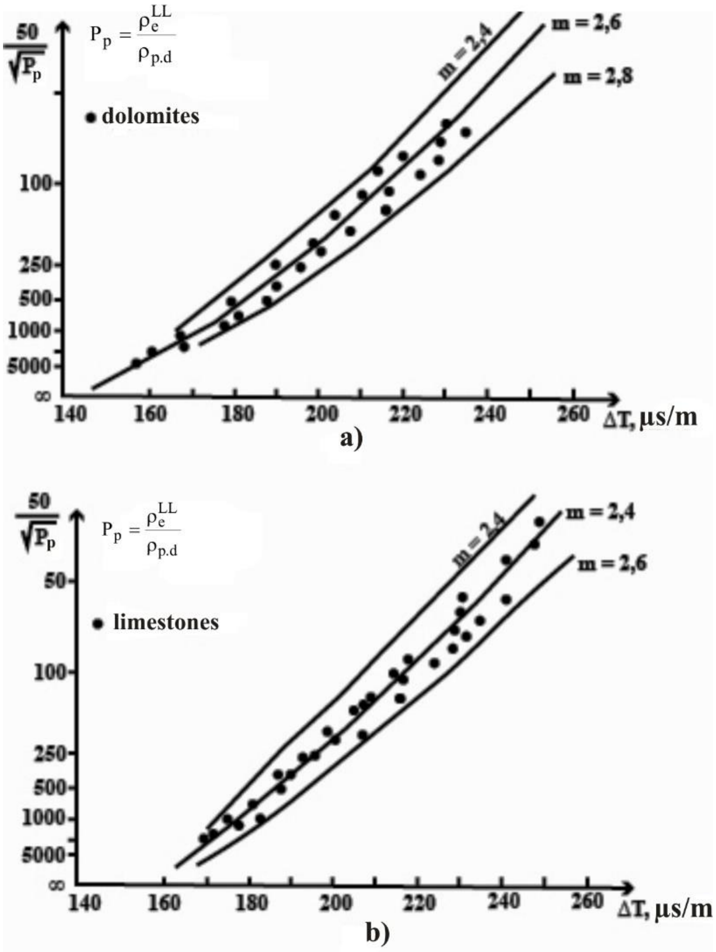

Fig. 1 (a, b). Determination of the structural coefficient m of the Archie equation for carbonate rocks of the Central part of Turkmenistan

As can be seen from the above figures, the structural coefficient *m* for dolomites is by ratio $P_p = \frac{\rho_e^{LL}}{\rho_{p.d}}$ it is in the range of 2.4-2.8 (on average 2.6). For limestones, t varies in the range of 2.3-2.6 according to the $\rho_{p.d}$.

With an increase in the accuracy of determining the resistivity of the formation, the range of changes in the structural coefficient will decrease. For dolomites, *m* will tend to 2.6, and for limestones to 2.4, which corresponds to the structural coefficients of similar rocks [6,7].

It follows from the above figures that when determining porosity by the relative resistance of the formation, it is advisable to use the dependence for dolomites and limestones (Fig. 2).

Despite the fact that the established structural coefficients are approximate, they are of great practical importance in the complex interpretation of NGL, AL and LL data, since so far there is no definition of P_p by core for carbonate deposits in the Central and Southwestern part of Turkmenistan [8,9].

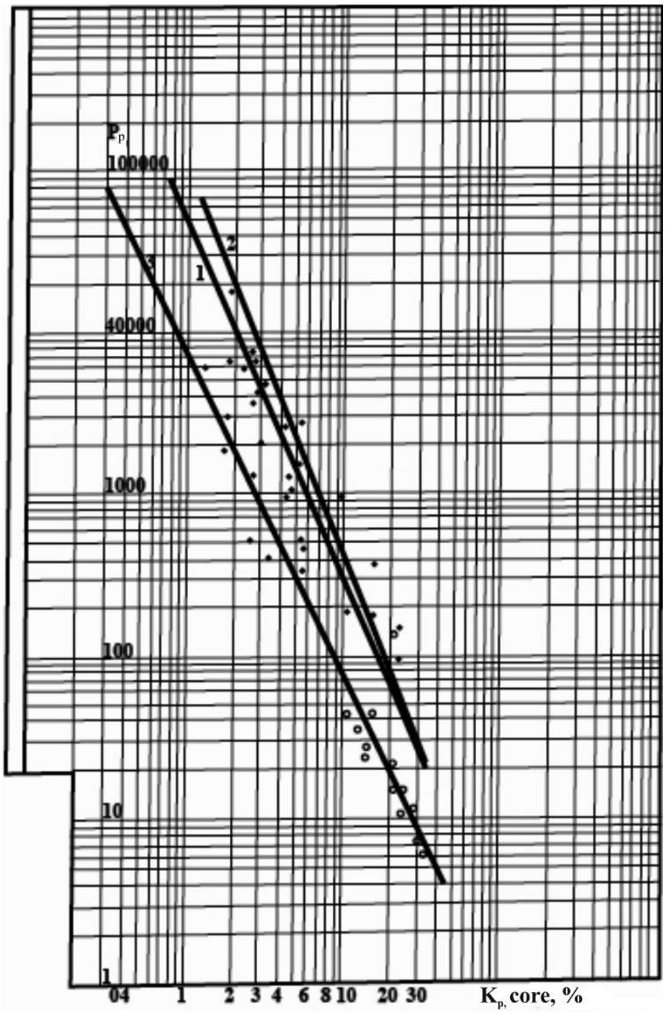

Fig. 2. Dependence of the porosity parameter ($P_{p\ geof.}$) on the porosity (K_{Core}) for limestones (1), dolomites (2), sandstones and siltstones (3) of the Mesozoic of Turkmenistan.

According to the obtained dependencies, the coefficients of open porosity were determined for a large number of water-saturated (by testing through an operational column) layers. A comparison of the results of the K_p^{LL} definitions for layers with granular porosity shows that for a sample of 187 formations, the mathematical expectations M are 4,499 and 4,205, respectively (Fig. 3). The high similarity of the results indicates a high reliability of the coefficients of open porosity determined by lateral logging data [10,11].

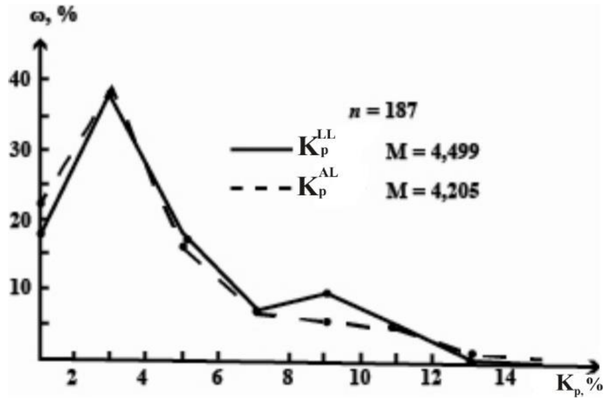

Fig. 3. K and K_p distribution curves of rocks with granular porosity

Consideration of the influence of clay on neutron gamma-ray logging data. Known methods for determining the porosity of carbonate rocks by the NGL method are applicable only in cases where the bulk clay content of rocks does not exceed units of percent. With a higher clay content, a significant part of the hydrogen content will be accounted for by clay material. Therefore, making amendments to K_p^{NGL}, taking into account the influence of clay, is of great practical importance.

The initial data for the quantitative assessment of porosity can be used diagrams of GL, NGL. Their use is due to the fact that the first mainly characterizes the bulk clay content of rocks, the second - their total hydrogen content [12-15].

The proposed method of accounting for the clay content of carbonate rocks is as follows:

- the curves of GL and NGL are compared in a semi-logarithmic coordinate system. As a result, a field of points will be obtained (Fig. 4) with coordinates *Jγ* - GL readings in mcR/h and *Jnγ* - NGL readings in conventional units. All points (layers) are located in a right-angled triangle, the hypotenuse of which is drawn along the points characterizing the layers in which the hydrogen content is due only to the presence of clay material, i.e. inefficient porosity (non-collector layers). When comparing *Jγ -Jnγ*, layered processing of GL and NGL diagrams is carried out, i.e. all layers in the study interval are highlighted. The position of the non-collector line is controlled by the readings of NGL and GL in dense limestones, dolomites and clays;

- the NGL readings are translated to K_p^{NGL} using the Δ*Jnγ*= *f* (K_p) dependence (the method of two support layers);

- using the line characterizing the layers where the hydrogen content is associated only with the presence of clay material, transfer the NGL porosity scale to the *Jγ* scale, thus we obtain the values of ΔK_p, i.e. the porosity attributable to the clay material [16,17];

- the difference between the total porosity determined by NGL and the porosity of the K_p, which falls on the share of clay material, will give the porosity value corrected for the influence of clay. The sequence of determining ΔK_p is shown in Fig. 4.

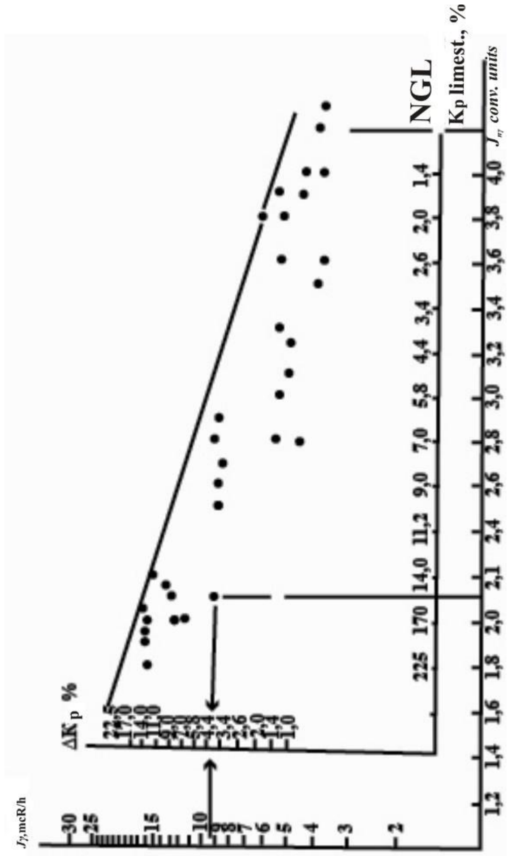

Fig. 4. Determination of the ΔK_p correction for the influence of clay content (well X1 - East. Kumbet, interval 4200-4690m)

The *Jy* - K_p comparison was carried out based on materials from more than ten wells. Figure 5 shows the resulting graph of the dependence of *Jy* - Δ K_p, which is recommended to be used for quality control of GL materials [18, 19].

The long-term practice of using GL diagrams for quantitative definitions of K_{cl}, C_{gl} shows the stability and reliability of the SP-62 (TEKU) equipment in the geological and technical conditions of the Central part of Turkmenistan.

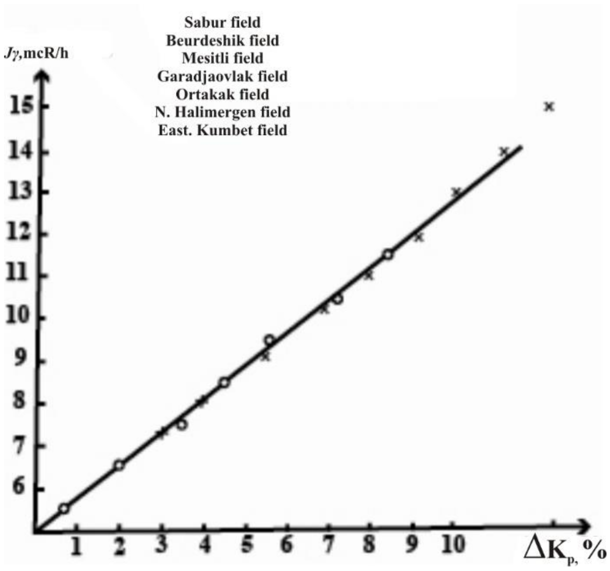

Fig. 5. The relationship between the readings of GL (Jy) (and porosity (ΔK_p), which falls on the share of space occupied by clay material (carbonate rocks).Central Karakum Mountains

Porosity coefficients determined by NGL diagrams, taking into account the influence of clay content, more reliably reflect the real capacitive properties of clay reservoirs.

The above graphical construction *Jy = f (Jny)* can also be used to determine the maximum values of HA in cases where there are no layers of pure clays in the section. The maximum value of GL corresponding to a layer of pure clays is determined as follows. The point corresponding to 30-40% of porosity - depending on the depth of the section under study - on the NGL scale, using the "hypotenuse" line of dependence) *Jy* = *f* (*Jny*), is transferred to the GL scale. It is recommended to take the obtained value as the maximum [20, 21].

References:

1. (1984). *Litofizika i neftegaznosnost' triasovyh otlozhenij zapada Turanskoj svity*. (p.130). M.: Nauka.
2. 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.
3. 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".
4. Deryaev, A.R. (2023). *Harakteristika produktivnyh gorizontov i opredelenie fiziko-himicheskih svojstv produkcii dlya razrabotki mestorozhdenij metodom odnovremennoj razdel'noj ekspluatacii.* Sbornik stat'ej mezhdunarodnoj nauchno-prakticheskoj konferencii. CHast' 1. (pp.31-43). Kazan': Izdatel'stvo «Omega Sajns».
5. 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.
6. 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".
7. (1982). *Interpretaciya rezul'tatov geofizicheskih issledovanij razrezov skvazhin*. - M.: Nedra.
8. 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).
9. 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).
10. Deryaev, A.R. (2022). *Opredelenie harakteristiki kollektorskih svojstv produktivnyh plastov (gorizontov) i ih neodnorodnosti dlya odnovremenno razdel'noj razrabotki mestorozhdeniya.* Sbornik statej Mezhdunarodnogo nauchno-issledovatel'skogo konkursa "Nash vybor - nauka", (pp.8-12). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
11. 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".
12. Gurbanov, V.Sh., Sultanov, L.A., Valiev, S.A., & Babaev, M.T. (2015). Litologo-petrograficheskie i kollektorskie harakteristiki mezokajnezojskih otlozhenij severo-zapadnoj chasti YUzhno Kaspijskoj vpadiny. *Vestnik Permskogo nacional'nogo issledovatel'skogo universiteta. Geologiya. Neftegazovoe i gornoe delo.* №17, pp.5-15.
13. 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.
14. 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.

15. Gurbanov, V.Sh., Gasanov, A.B., Narimanov, N.R., Sultanov, L.A., & Ganbarova, Sh.A. (2017). Fizicheskie harakteristika i fil'tracionno-emkostnye svojstva perspektivnyh neftegaznosnyh gorizontov v nizah produktivnoj tolshchi na suhoputnyh ploshchadyah Azerbajdzhana (Na primere mestorozhdeniya Kalamaddin), *Vestnik Permskogo nacional'nogo issledovatel'skogo universiteta. Geologiya. Neftegazovoe i gornoe delo*. T.16, №3, pp.204-214.
16. (1979). *Metodicheskie rekomendacii po provedeniyu issledovanij i interpretacii dannyh nejtronnogo karotazha s serijnoj apparaturoj RK*. M.: VNIIYAGG.
17. (1982). *Interpretaciya rezul'tatov geofizicheskih issledovanij razrezov skvazhin*. M.: Nedra.
18. 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”.
19. (1972). *Metodicheskie rekomendacii po kolichestvennoj interpretacii dannyh karotazha.* - M.: VNIIGeofizika.
20. Basin, Ya.N., Kuharenko N.K., & Tyukaev, Yu. V. (1968). *Metodika opredeleniya poristosti karbonatnyh plastov po dannym nejtronnogo karotazha s serijnoj apparaturoj radioaktivnogo karotazha.* – M.: VNIIYAGG.
21. 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.
22. 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.
23. 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.
24. 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”.
25. (1974). *Spravochnaya kniga po dobyche nefti*., pod.red.SH.K. Gimatudinova. (p.704). M.: Nedra.