

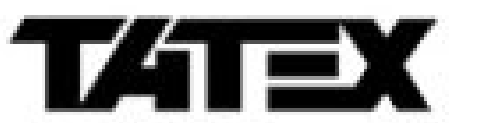
A COMPARATIVE STUDY OF PORE-SIZE DISTRIBUTIONS FROM NMR AND CAPILLARY PRESSURE MEASUREMENTS IN CARBONIFEROUS CARBONATES OF THE DEMKINSKOYE FIELD, REPUBLIC OF TATARSTAN

A.N. Afanaseva^{1*}, A.V. Fattakhov¹, V.E. Kosarev¹, R.R. Kharitonov², R.R. Minnebaev², D.S. Fayryshin²

1 – Kazan Federal University, Institute of Geology and Petroleum Technologies

2 – CLSC «Tatech»

* - AnNAfanaseva@stud.kpfu.ru



INTRODUCTION

The necessary information for assessing the filtrate and capacitance properties of reservoir rocks and for the correct process of calculating hydrocarbon reserves is not only the value of the porosity fractions, but also the nature of the pore size distribution, the shape of the voids, the number and ratio of large pores.

SUBJECT OF RESEARCH

Analysis was performed on core plugs extracted from the Vereian horizon (Middle Carboniferous) of the Demkinskoye oil field, Republic of Tatarstan.



Fig.1 - The core plugs from the Vereian horizon

METHODOLOGY

As part of this work, the pore size spectra obtained by two methods were compared: nuclear magnetic resonance and capillarimetry using a centrifuge. Core plugs saturated with brine model were centrifuged at 12 stages using an ultracentrifuge. For some samples, the transverse relaxation time (T_2) spectra were measured on an NMR analyzer using a CPMG pulse sequence prior to the centrifugation process.

FORMULAS FOR CALCULATION

$$P_c = 1.09 \cdot 10^{-9} \cdot \Delta\gamma \cdot n^2 \frac{9rl+4l^2}{36} [1]$$

P_c – capillary pressure, MPa;

$\Delta\gamma$ – difference in fluid densities, g/cm³;

n – centrifuge speed (revolutions per minute)

r – height of capillary rise, cm;

l – core length, cm.

$$P_c = \frac{2 \sigma \cos Q}{R_c} [2]$$

σ – interfacial tension;

Q – interfacial contact angle;

R_c – radius of capillary.

$$\frac{1}{T_2} = \rho \frac{S}{V} = \frac{3\rho}{R} [3]$$

T_2 – NMR transverse relaxation time;

ρ – NMR surface relaxivity;

$\frac{S}{V}$ – surface-to-volume ratio of the pore.

RESULTS

A fairly uniform distribution is observed in the obtained pore size distributions from capillarimetry data. At the same time, obtaining the most complete information about large pores is typical for those core plugs for which the presence of a "first bend" is observed on the capillary pressure curves.

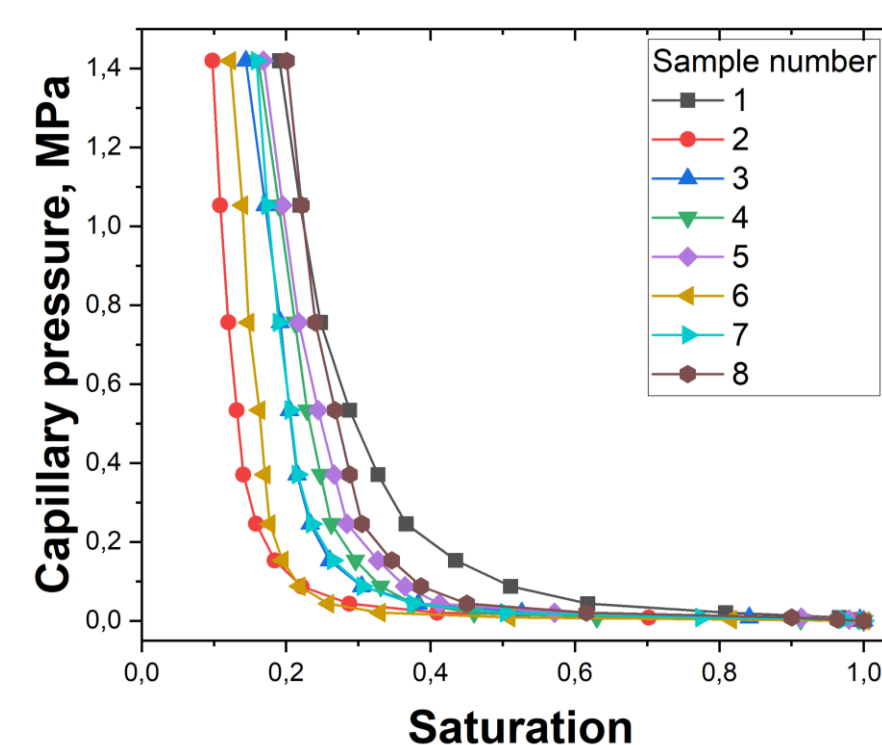


Fig.2 - Capillary pressure data for eight core plug samples from the Vereian horizon (Middle Carboniferous) of the Demkinskoye oil field

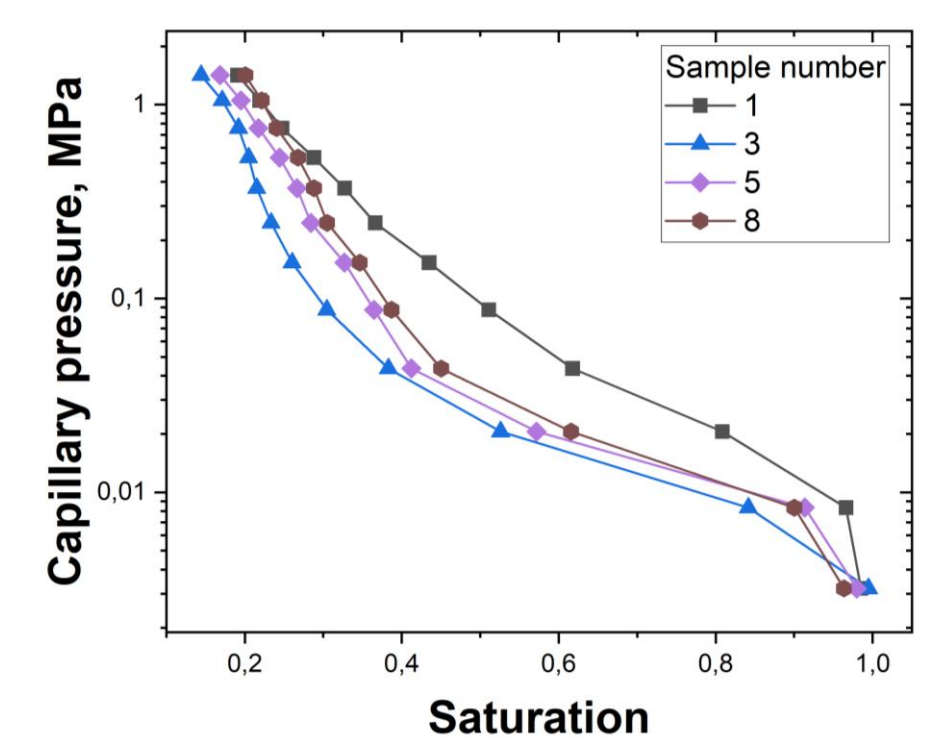


Fig.3 - Capillary pressure data for four core plug samples from the Vereian horizon on a logarithmic scale

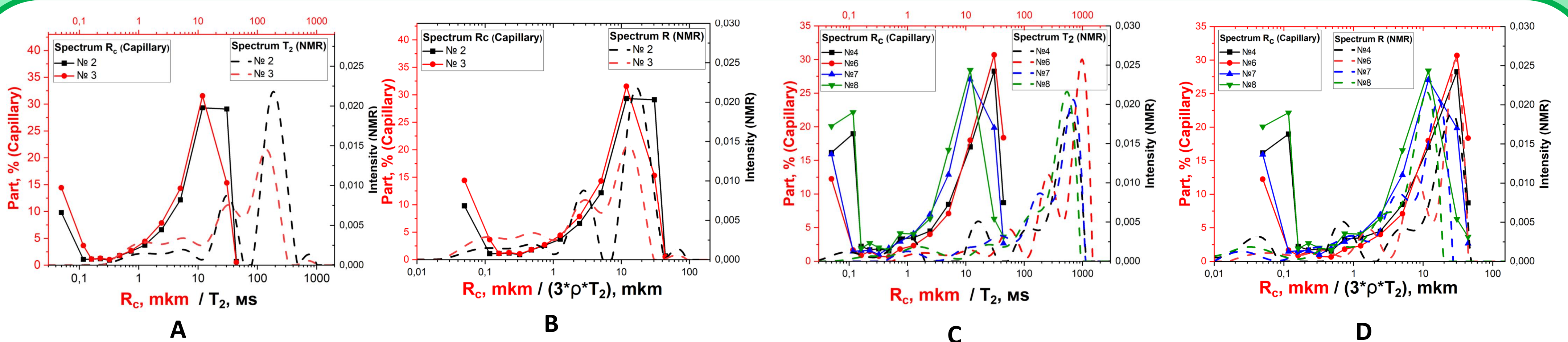


Fig. 4 – A and B: Pore size distribution according to capillarimetry data (solid lines with symbols); T_2 time spectrum (A) and pore size distribution spectrum from NMR data (B) (dashed lines) for core plug samples №2 and №3 of the Vereian horizon; C and D - the same for samples №4, 6, 7, 8

Table 1 - The values of the surface relaxivity parameter for 6 core plugs of the Vereian horizon

№, core plug number	ρ , mkm/ms
2	0,030
3	0,030
4	0,014
6	0,010
7	0,008
8	0,007

A calibration procedure was applied to the NMR T_2 spectra, aligning them with the pore-throat size distribution obtained from capillarimetry to enhance the characterization of the pore space architecture. The displacement value is reflected in the value of the surface relaxivity parameter, which characterizes the surface of the pore space. The values of the surface relaxivity parameter were obtained for 6 core plugs of the Vereian horizon (Table 1). According to the obtained parameter values, two groups of samples are distinguished among the samples of the Vereian horizon. 2 and 3 are samples for which the relaxivity is approximately 0.03 $\mu\text{m}/\text{ms}$, and samples 4,6,7,8 for which the relaxivity is from 0.007 to 0.014 $\mu\text{m}/\text{ms}$. According to the micro-description of the core, both groups belong to oil-saturated limestones. However, they are attributed to different strata of the Vereian horizon according to logging data.

CONCLUSIONS

As a result of this work, pore size distributions were constructed for core plugs of the Vereian horizon of the Demkinskoye oil field of the Republic of Tatarstan using capillarimetry and nuclear magnetic resonance methods. The values of the surface relaxivity parameter for a part of the studied core plugs were obtained. The results obtained can be used to adjust the development process of the Demkinskoye oil field, as well as to improve the quality of interpretation of the results of nuclear magnetic logging.

REFERENCES

- 1 - MaKFi K., Rid Dzh., Zubizaretta I. Laboratornye issledovaniya kerna: gid po luchshim praktikam. — M.—Izhevsk: Institut komp'yuternykh issledovaniy, 2018. — XVI, 912 s.
- 2 - Rodivilov D. B., Kantemirov YU. D. Makhmutov I. R., A. V. Akin'shin. Prakticheskoe rukovodstvu po petrofizicheskomu modelirovaniyu neftegazonasyshchennosti: monografiya; OOO «Tyumenskii neftyanoi nauchnyi tsentr». — Tyumen': IPTS «EhkspresS», 2023. — 144 s. 10.
- 3 - Dzhaferov, I. S. Primenenie metoda yadernogo magnitnogo rezonansa dlya kharakteristiki sostava i raspredeleniya plastovykh flyuidov / I. S. Dzhaferov, P. E. Syngaevskii, S. F. Khafizov — Moskva: Khimiya, 2002. — 437 s.