DETAILED PARAMETRIZATION OF THE PORE SPACE IN TIGHT CLASTIC ROCKS FROM POLAND BASED ON LABORATORY MEASUREMENT RESULTS

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Introduction

Detailed parametrization of the pore space in tight clastic rocks is a key in understanding the porosity distribution and processes of the fluid flow through the pore space, especially important in hydrocarbons exploration. The paper presents the combination of various laboratory measurement results. Pore space parametrization was based on the computed X-ray tomography and brought many useful information regarding the pore volume, shape, size, as well as the skeleton analysis.

Samples and methods

Research material consisted of Paleozoic 20 tight sandstone and 11 mudstone samples, from deep wells located in Poland. Several laboratory methods were carried out on core samples: computed X-ray tomography (CT), nuclear magnetic resonance spectroscopy (NMR), as well as pulse and pressure decay permeability method (PDP). CT provides 2D and 3D images of material for qualitative and quantitative analysis of selected objects: minerals or pores. Highly specialized algorithms are necessary to obtain the proper visualization and quantitative information from objects. CT data was processed in newly developed software poROSE, in which many geometrical parameters were implemented for the proper analysis. Following, exemplary parameters were taken into consideration in pore space characterization: Volume, Thickness, Anisotropy, Elongation, Flatness, Sphericity, Feret diameter, Feret Breadth, Feret Shape, Shape Factor, 1st Circularity Coefficient, 2nd Circularity Coefficient, Malinowska Coefficient, Blair-Bliss Coefficient, Danielsson Coefficient, Haralick Coefficient, 1st Intermediate Features Coefficient, 2nd Intermediate Features Coefficient, Simplified Malinowska Factor, Feret Coefficient, Feret Diameter, Elongation, Compactness; from the skeleton analysis: Junctions, Isolated Objects, Branches, End Branches, Coordination Number; as well as the result of spherical and ellipsoidal pore analysis. Calculations referred to the objects: pores and microfractures. The goal of the analysis was also to combine parameters from the CT and NMR, PDP, so an effort was made to search for the relationships between the different parameters.

Results

All 31 samples were analysed qualitatively and quantitatively. Exemplary visualization of the Cambrian tight sandstone is presented in Figure 1. Detailed skeleton analysis provided information about the Average Coordination Number. Average Coordination Number in many cases was a negative number. That is example of poorly developed pore space. Only 2 from 11 sample from the mudstones group was a positive value and only 10 from 20 samples in sandstone group, what indicated that sandstones are characterized by more complex structure. Number of Junctions varied from 6 to about 31686, for average 3701 in sandstones, while in mudstones from 31 to 2210, with average 668. It means that sandstones are characterized by pores with complicated shapes, so after skeletonization resulted in higher number of Junctions. However, the number of Junctions and Branches is not very high, as for conventional rocks. It is worth paying attention to the strong relationships between following parameters from different laboratory methods: logarithmic mean of transverse relaxation time from NMR and number of Junctions from CT, logarithm of absolute permeability from PDP and Anisotropy from CT, T2 cut-off from NMR (for bulk water irreducible and moveable fluid volume) and Elongation from CT.

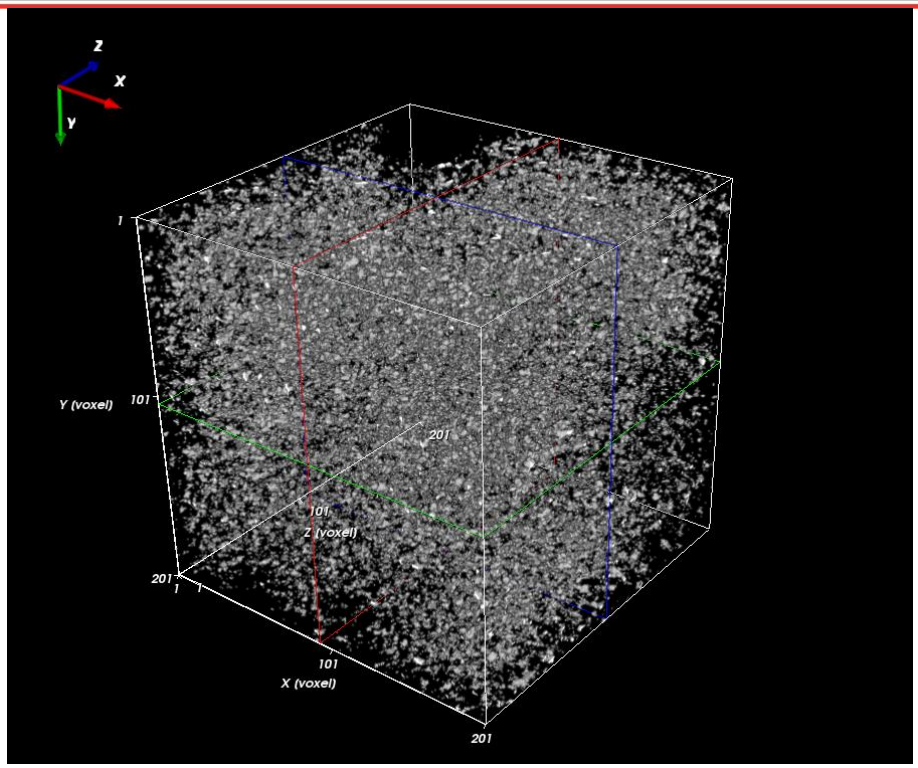

Figure 1. *3D image of the tight sandstone pore space (core sample from Cambrian, depth of present deposition: about 3400 m). Visualization was made in poROSE software.*

Conclusions

Computed X-ray tomography allowed for complex parametrization of the pore space in the tight clastic rocks. Skeleton analysis provided the information about quality of the pore connections. Strong relationships between parameters were observed, including different laboratory methods.

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References

Cnudde V., Boone M., 2013. High-resolution X-ray computed tomography in geosciences: A review of the current technology and applications. Earth-Science Reviews, 123, 1-17.

Krakowska P., Puskarczyk E., Jędrychowski M., Habrat M., Madejski P., 2018. Innovative characterization of tight sandstones from Paleozoic basins in Poland using X-ray computed tomography supported by nuclear magnetic resonance and mercury porosimetry. Journal of Petroleum Science & Engineering, 166, 389-405.

Zhang L., Lu S., Xiao, D., Li B., 2017. Pore structure characteristics of tight sandstones in the northern Songliao Basin, China. Marine and Petroleum Geology, 88, 170-180.