QUANTITATIVE COMPARISON OF PORE SPACE VOLUME DISTRIBUTIONS IN POLISH TIGHT SANDSTONES RESERVOIRS

M. Jedrychowski*[1], P. Krakowska[2], E. Puskarczyk[2], M. Habrat[2] & P. Madejski[3]

[1]AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Poland
[2]AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, Poland
[3]EDF Polska S.A., Poland

Keywords: x-ray tomography, sandstones, pore space, geomaterials and geoengineering

Summary: X-ray computed tomography was used to investigate and compare pore space in sandstone samples representing different geological regions in Poland. It was shown that samples from Warsaw Anticlinorium and Lublin Synclinorium have the highest porosity. Comparison of pore space revealed that despite different well location, both samples share similar pore volume distribution and so the same value of average pore volume.

1. INTRODUCTION

Unconventional tight gas deposits gains nowadays much attention due to industrial importance of hydrocarbones exploration which, unfortunately, needs special stimulation such as hydraulic fracturing, since gas contained in tight gas deposits is closed in isolated pores. Hence, spatial and volume distribution of pores as well as shape of pore channels are strongly reflected in the reservoir potential. This is the reason why detailed insights into the pore space development provided thanks to high resolution X-ray computed tomography are so crucial in this context. Sandstones located in different regions of Poland are regarded as potential tight gas reservoirs, e.g. Rotliegend sandstones [1-4]. Therefore, this work aims to characterise and compare, in a quantitative way, several sandstone samples in terms of the developed pore space. The long term goal of this study is to gather and analyse the most relevant parameters for sandstones reservoir exploration.

2. EXPERIMENTAL METHOD

X-ray computed tomography (micro-CT) is used in order to characterize pore space in tight sandstones reservoirs cored from depth greater than 3000 m. All the analysed samples represents different well location in Poland, as shown in Table 1.

Table 1. List of the investigated samples.

No.	870	871	877	894 and 890	896
Location	Warsaw Anticlinorium	Peribaltic Syneclise	Lublin Synclinorium	Pomeranian Anticlinorium	Holy-Cross Mountains Anticlinorium
Depth [m]	4106	3460	3034	4500|4650	3045
Permeability [mD]	0.036	0.023	0.023	<0.010	<0.010
Porosity [%] (from CT data)	3.54	1.90	3.31	0.22	0.01

Micro-CT measurements were performed in Laboratory of Micro and Nano Tomography at Faculty of Physics and Applied Computer Science, AGH University of Science and Technology in Poland. The equipment used consists of GE Nanotom S 180n device, in which cone beam is generated by X-ray tube (57 W power and 180 kV working voltage) and recorded by the Hamamatsu 2300×2300 pixel 2D detector. The reconstruction of the measured 2D data was done using back-projection technique implemented in Feldkamp algorithm. Resolution of the data

* e-mail: Mariusz.Jedrychowski@fis.agh.edu.pl

obtained was 0.8x0.8x0.8 μm. Segmentation of pore space was done using Fourier based filtering combined with semi-automatic thresholding (see abstract entitled *A new method of pore space segmentation in highly noised micro-CT 3D data applied for Polish shale gas deposits*). Example of extracted pore space is presented in Fig. 1(b). All these operations as well as further analysis were performed in ImageJ software [5].

3. RESULTS

Based on the porosity calculations (Table 1), samples can be divided into three groups. First group: 870, 871 and 877 shows good development of pore space and thus it is analysed in more details. Second group: 894 and 890 has much lower reservoir potential, while third group - sample 896 - exhibits very poor development of pore space. Average volume is 1394 μm^3, 1345 μm^3 and 1200 μm^3 for sample 870, 877 and 871, respectively. Further analysis reveals that samples: 870 and 877 have almost the same pore space in terms of volume distribution, whereas sample 871 has higher fraction of smaller pores at an expense of lower fraction of larger pores - Fig. 1(a).

This work was financed by the National Centre for Research and Development in Poland, programme LIDER, project no. LIDER/319/L–6/14/NCBR/2015: *Innovative method of unconventional oil and gas reservoirs interpretation using computed X-ray tomography*. Authors thank Polish Oil & Gas Company and Orlen Upstream for the data and core samples.

References

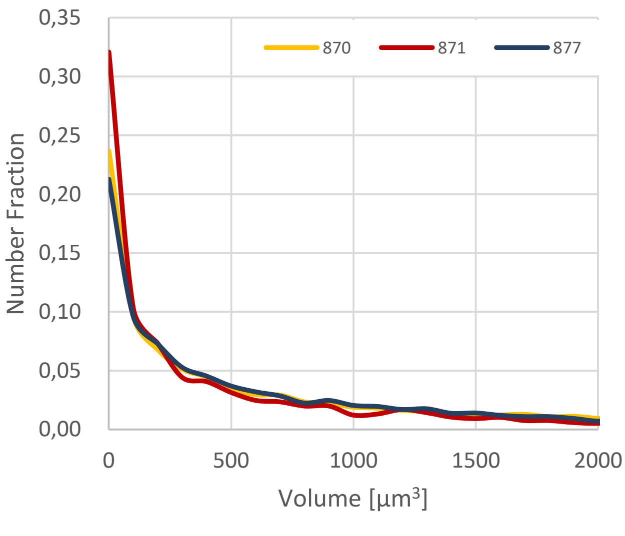
[1] H. Kiersnowski, A. Buniak, M. Kuberska & A. Srokowska-Okońska. Occurrence of natural tight gas in Polish Rotliegend sandstones. *Polish Geological Review* 58 (4), 335–346, 2010.

[2] P. Poprawa & H. Kiersnowski. Tight gas reservoirs in Poland. *Bulletin of Polish Geological Institute National Research Institute* 439, 173–180, 2010.

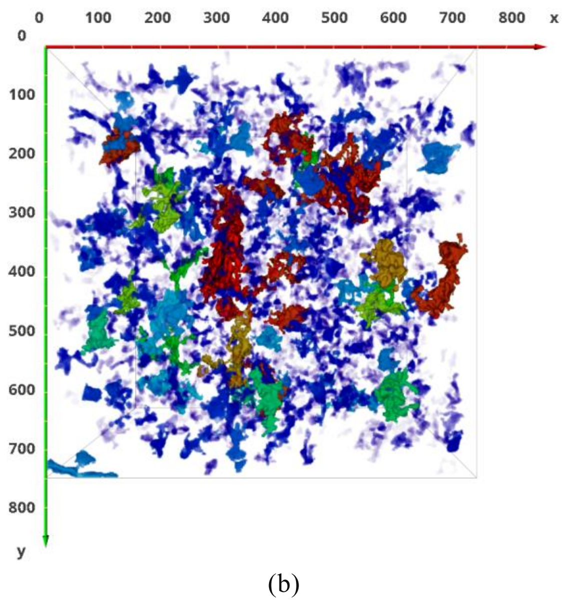
[3] G. Semyrka, J. Jarzyna, R. Semyrka, M. Kaźmierczuk & L. Pikulski. Reservoir parameters of lithostratigraphic successions of the lower Paleozoic strata in the Polish part of the Baltic region based on laboratory studies and well logs. *Geological Quarterly* 54/2, 227–240, 2010.

[4] P. Such, G. Leśniak & M. Słota. Quantitative characteristic of porosity and permeability in Rotliegend sediments with potential tight gas accumulations. *Polish Geological Review* 58 (4), 347–351, 2010.

[5] C.A. Schneider, W.S. Rasband & K.W. Eliceiri. NIH Image to ImageJ: 25 years of image analysis. *Nature methods* 9(7), 671–675, 2012.



(a)



(b)

Figure 1: (a) Normalized pore volume distribution for samples: 870, 871, 877; (b) 3D visualization of the pore space in sample 877: 1 voxel corresponds to 1.6 x1.6 x 1.6 μm^3, color represents volume value: transparent dark-blue – more than 5000 μm^3, red – more than 400000 μm^3