

EXPERIMENTS TO EVALUATE OF ORGANIC POROSITY IN SHALE GAS EXPLORATION

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Introduction

A significant part of the total porosity in the case of shale porosity, is due to the loss of organic matter as a result of processes of hydrocarbons generation. Because of the hydrophobic properties of the organic matter (wet - oil), the entire pore space is occupied by hydrocarbons. Thus, the exact determination of development porosity resulting from the loss of organic matter has important implication for resource potential assessment in shale formation. These systems have their own specificity, all the elements of the petroleum system in one element, constitutes both a source of generation and migration, accumulation and sealing. The formations of shale gas space for the accumulation of hydrocarbons produced along with the transformation of kerogen and for its estimation, should take into account all information related to thermal changes. The amount and size distribution of organic porosity depends on the quality, quantity and thermal maturity of the organic matter. The formation of organic porosity is found to be a coincident with the onset of oil generation and reaches maximum when labile content of kerogen is converted to hydrocarbons. Experiments to recognize changing porosity due to loss of organic matter after pyrolysis were conducted using shale samples from low Paleozoic formation.

Results

Silurian, Ordovician and Cambrian samples were selected for experimental works. These rocks in terms of geochemical properties are characterized by a relatively high generation potential although partially depleted. The samples represents the Sasino formation of which thermal maturity level is at around 1,0 % VR which corresponds to the main phase of liquid hydrocarbon generation. Thermal maturity next to the initial composition of the kerogen, is crucial for the estimation of the size of organic porosity, because it is a function of hydrocarbon potential. Therefore, work aimed to determine the relationship between the distribution of porosity in organic matter, total porosity, whose value can be estimated on the basis of profiles of well logging are carried out. The approach that are presented in this paper was to using empirically fixed relationship between geochemical parameters and porosity. Organic porosity is calculated directly from the hydrogen ratio (HI) which requires a reconstruction to the initial conditions, before the beginning of generation processes (HI₀). Observations from SEM (scanning electron microscope) confirmed the connection between the development of the pore space due to the decomposition of organic matter. The value of organic porosity was calculated depending on the applied model adopted according to the literature data [2], [1] significantly different from each other and tend to reflect on their universality in relation to the Paleozoic shales in the Polish conditions.

Other methods which can be used for the assessment of pore space which could accumulate hydrocarbons in formations of shale are: Dean Stark method and classical method of mercury porosimetry. Such measurements were performed for the majority of samples from the Sasino formation and from upper Cambrian shales and for samples which are the subject of pyrolysis experiments. The results of the study are presented in Table 1.

Table 1. Geochemical measurements results for Paleozoic samples

Sample No	Formation	TOCo [%]	ΔTOC [%]	HIo [mgHC/g TOC]	ΔHI [mgHC/g TOC]	T _{max} /Tr [°C/]	Total porosity [%]	Φ ₁ [%]	Φ ₂ [%]	Dean Stark saturation		
										water	oil	gas
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Ordovician	7,06	1,46	394	243	444 0,50	9,86	4,32	1,20	7,64	8,92	82,54
1bis			4,87		393							
2	Silurian	4,86	0,73	364	201	443/ 0,49	5,97	4,51	0,70	13,83	5,51	80,66
2bis			4,63		171							
3		6,07	0,47	401	222	444/ 0,48	9,48	8,15	0,93	bp	bp	bp
3 bis			1,79		395							
4	Cambrian	5,37	0,47	170	104	430 0,46	4,27	2,81	0,31	43,43	10,7	50,0
4bis				3,18		169						

1bis- additional Rock-Eval pyrolysis after isothermal heating at 800°C

Total porosity – results from measurement (mercurimetric method)

Φ₁- organic porosity calculated according to Kuchinskiy, 2013

Φ₂- organic porosity calculated according to Chen & Jiang, 2016

Alternative calculation according to formula:

$$\Phi_{2org} = 1,2 [TOC_o * \alpha * f * T_r (1 - 0,833 TOC/100)] \rho_b / \rho_k$$

where :

a – parameter related to kerogen type (HI_o/1200)

f- expulsion indicator

ρ_b – rock density

ρ_k – kerogen density

Theoretical calculations were supported by the experiments designating the curve of sorption for the samples before and after pyrolysis. For all samples was noticed the increase of the specific surface area connected with the loss of organic matter after the pyrolysis.

Conclusion

The method, which included more geochemical parameters such as: expulsion ratio, specific gravity of kerogen, transformation ratio and kerogen type coefficient, seems to be more adequate to evaluation of secondary (organic) porosity. However, both methods are only approximations, because of mistakes made during the reconstruction of original geochemical parameters (HI_o, TOC_o) and assessment of expulsion ratio.

Theoretical calculations, were supported by the experiments, designating the curve of sorption for the samples, before and after pyrolysis. For all samples, the increase of the specific surface area connected with the loss of organic matter after the pyrolysis, was noticed. Comparing pore volume relative to the pore diameter of the sample, before and after heating, we can see the changes in pore diameter distributions from bimodal to unimodal .

References:

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- Kuchinskiy V., 2013. Organic porosity study: porosity development within Organic Matter of the Lowe Silurian and Ordovician Source Rocks of the Poland Shale Gas trend. Oral presentation given at AAPG Annual Convention, Pennsylvania, May 2013