[PS]Understanding the Isolated Pores in Bakken Shale Using SANS Method*

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Abstract

Unconventional shale plays are now one of the most important sources of energy in the world. Pore structure in shale formations is a very significant parameter, which could affect the storage and transport properties of the oil and gas. Fluid invasion methods are commonly being used for pore structure characterization. However, these fluid invasion methods can only detect the connected pores while they cannot give any information about the isolated pores. In fact, many isolated pores exist in shale gas or oil formations that could store a significant volume of hydrocarbons which could become flow paths during hydraulic production. Understanding the isolated pores can assist in better evaluating the reservoir performance. In this paper, we collected several samples from Bakken Shale and analyzed the pore structures by using Small Angle Neutron Scattering (SANS) and N_2 adsorption. Pore Size Distribution (PSD), porosity, and specific surface area from these two methods were calculated and compared. The results showed that the Bakken samples have a very small porosity value (less than 1%) and a very larger specific surface area (larger than 180995 cm^{-1}). In this study, SANS and N_2 adsorption can detect pores in the similar size range (2-200 nm). The specific surface area measured by SANS is larger than the one detected by N_2 adsorption, indicating the existence of the isolated pores.

The pore information from the SANS data and N_2 adsorption exhibited fractal and multifractal behaviors. The fractal dimension calculated from the SANS data is larger than the value derived from N_2 adsorption indicating that the pore structure derived from SANS is more complicated. Moreover, the pore size distribution calculated from SANS data is more heterogeneous. The isolated pores in Bakken Shale can increase the complexity and heterogeneity of the pore structures. The effects of rock composition on PSD showed that pores with size less than 200 nm in feldspar and in organic matter were mostly found to be isolated pores. We did not find any connected clay pores with a size less than 200 um that would exist in these Bakken Shale samples.

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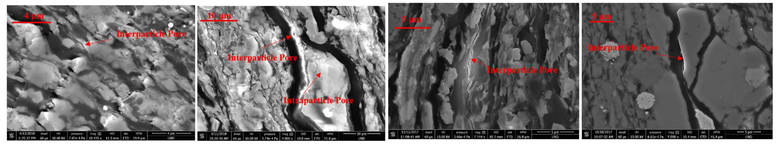
Abstract

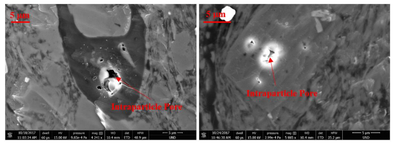
In this paper, we collected several samples from Bakken shale and analyzed the pore structures by using small angle neutron scattering (SANS) and N_2 adsorption. Pore size distribution (PSD), porosity and specific surface area from these two methods were calculated and compared. The results showed that the Bakken samples have a very small porosity value (less than 1%) and a very larger specific surface area (larger than 180995 cm^{-1}). In this study, SANS and N_2 adsorption can detect pores in the similar size range (2-200 nm). The specific surface area measured by SANS is larger than the one detected by N_2 adsorption, indicating the existence of the isolated pores. The pore information from the SANS data and N_2 adsorption exhibited fractal and multifractal behaviors. Moreover, the pore size distribution calculated from SANS data is more heterogeneous. The isolated pores in Bakken shale can increase the complexity and heterogeneity of the pore structures. The effects of rock composition on PSD showed that pores with size less than 200 nm in feldspar and in organic matter were mostly found to be isolated pores

Samples

	Quartz, wt%	Pyrite, wt%	Feldspar, wt%	Clay, wt%	Dolomite, wt%	Zeolite, wt%
# 1	35.3	9.0	14.4	41.3	--	--
# 2	60.3	2.4	8.1	20.8	8.4	--
# 3	42.5	8.5	13.6	35.4	--	--
# 4	47.6	2.6	--	39.2	7.8	2.8
# 5	45.5	6.7	13.2	26.0	7.4	1.2
# 6	38.4	4.2	6.5	43.8	7.1	--



(a) (b) (c) (d)



(e) (f)

Fig. 1. FE-SEM images of selected Bakken Shale samples.

Results (SANS)

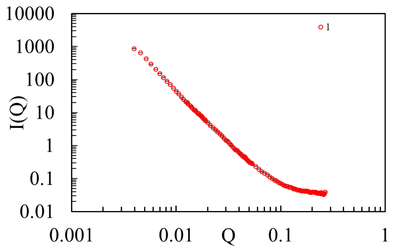


Fig. 2. The absolute scattering cross section (I(Q)) versus the scattering vector(Q) of Sample #1.

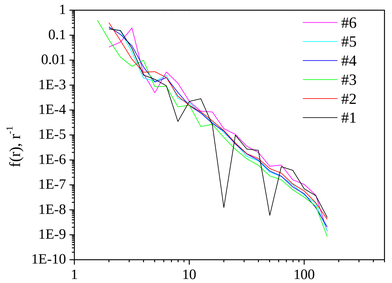
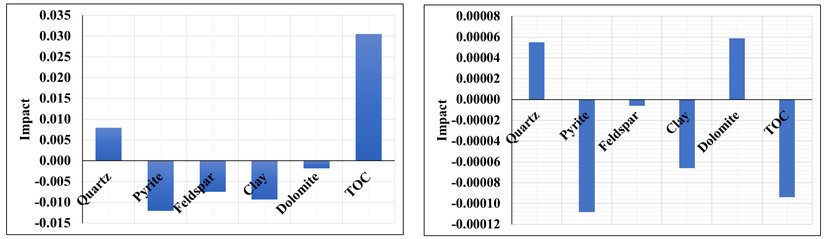


Fig. 3. Pore size distribution of the Bakken Shale samples.

Results (Comparison of SANS and N_2 adsorption)

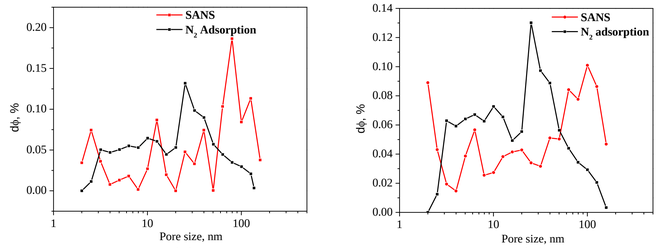
Table 3 Surface area and heterogeneity index comparison

Samples	Surface area		Heterogeneity index	
	SANS,cm^{-1}	N_2 ,m^2/g	$\Delta\alpha_{SANS}$	$\Delta\alpha_{N2}$
# 1	187507.00	2.66	2.7988	0.9466
# 2	264364.00	4.84	2.6168	0.8924
# 3	327287.00	3.68	2.6174	0.9302
# 4	316198.00	3.22	2.5154	0.7906
# 5	248293.00	3.09	2.5481	0.9246
# 6	180955.00	2.74	2.5673	1.0898



(a) (b)

Fig. 4. Effect of the mineral compositions on the pore volume of shale by (a) SANS and (b)N_2 adsorption analysis.



(a) (b)

Fig. 5. Pore size distributions of samples #1(a) and #2(b).

Conclusions

- The pore surface area detected by the N_2 adsorption was found to be the smaller than the value from the SANS, which was attributed to the isolated pores in the shale samples.
- Pores with size less than 200 nm in organic matter were mostly found to be isolated pores. No abundant clay pores (connected and isolated) exist in these Bakken Shale samples.

References

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