NEXT SHALE 2017

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Navigating the Future of Unconventional Resources

The Influence of Residual Fracturing Fluid on Methane Migration in Nano Fractures and Pores in Marine Shale

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Content

Ⅰ Background Overview

Ⅱ Main Results

Ⅰ. Background Overview

- **Large amounts of water is used in shale,10%-60% flowback rate**
- **How Residual Fracturing Fluid exist and influence?**

large amounts of water

Volume fracturing

Ⅱ. Main Results

1.Filling / adsorbing in shale fractures

2.The presence of water is benefit to the diffusion of methane

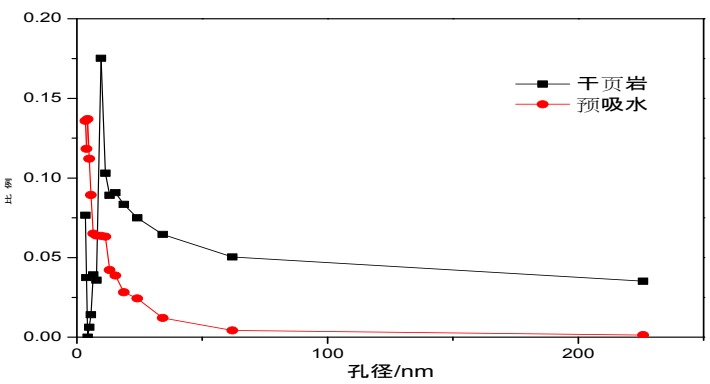
3.Residual water has no damage to shale reservoir

1. filling /adsorbing in shale fractures

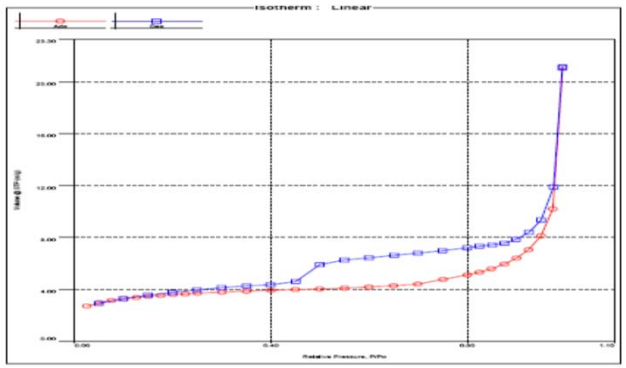
- **Working fluid effects porosity of shale**

BET : 100mesh soak time 30min

serial number	index	original	water	actived water
1	specific surface(m²/g)	13.19	14.65	12.46
2	pore volume(cc/g)	0.037	0.015	0.014
3	Pore size（nm）	9.92	4.01	4.45



Shale pore size distribution

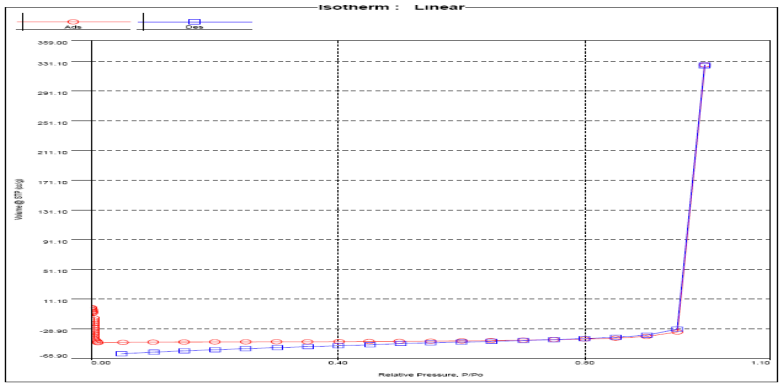


Adsorption and desorption isotherms of nitrogen on shale after pre-wetted

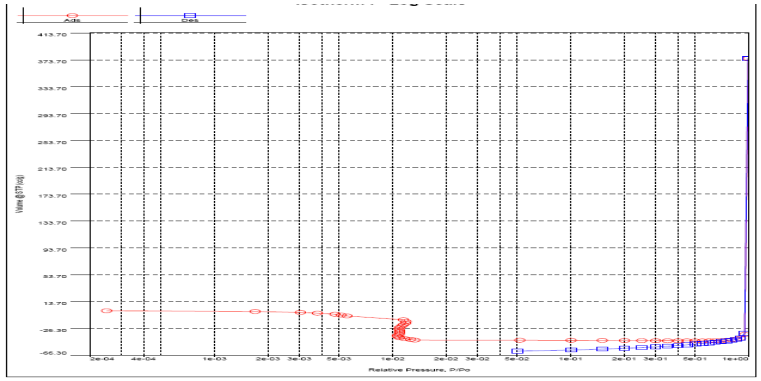
- **The liquid enters the surface of core and does not enter the microporous.**

1.Filling / adsorbing in shale fractures

- **Effect of working fluid on shale porosity**



Soak 3d

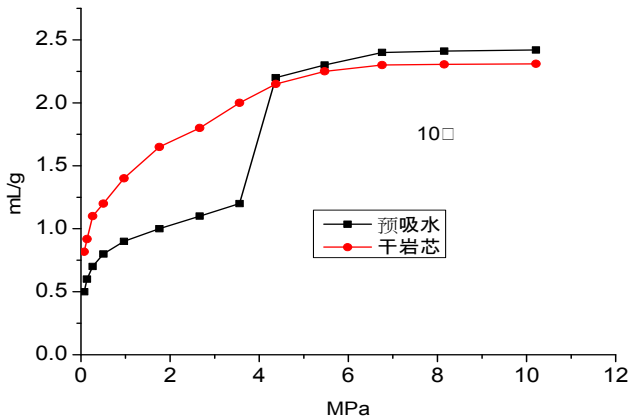


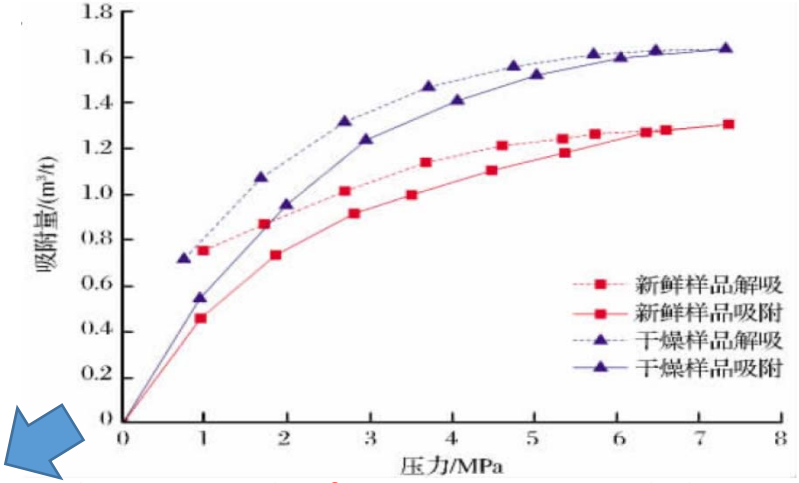
Soak 7d

- **Soaked 3d or 7d， water enter into nano fracture, fill and absorb**

2.The presence of water is benefit to the diffusion of methane

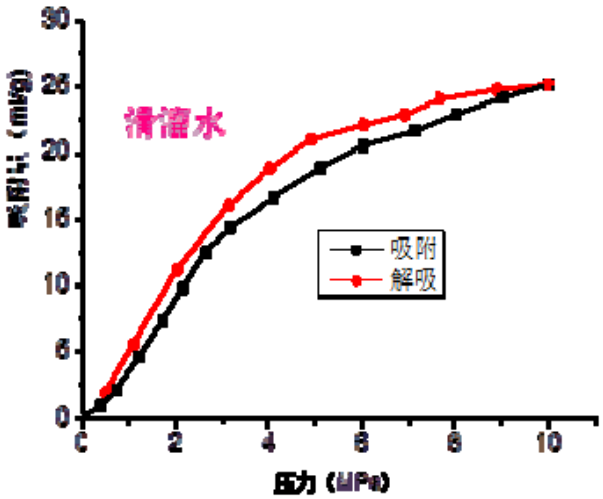
- **Water has a positive effect on shale gas**





Source:zhaoyuji, Study of Impact Factors on Shale Gas Adsorption and Desorption

- ✓ 4-10MPa,methane and water form hydrates
- ✓ total adsorption and desorption capacity of the prewetted shale core is close to that of the dry shale core
- ✓ water presence in formation helps to desorb methane



The desorption of methane in the pre-absorbed active carbon（25℃）

2.The presence of water is benefit to the diffusion of methane

- **In nano-fractures, the structure and properties of water are changed, the flow resistance is basically the same as methane gas**

Macroscopically, diffusion coefficient of water is **2.3 × $10^{-9}m^2/s$**

diffusion coefficient of Methane in nano tube is $10^{-7}m^2/s$

The diffusion coefficient of methane in nanochannels

Pressure (MPa) / Diffusion coefficient (×$10^{-7}m^2/s$) / Condition	5	10	15	20
Organic pore	1.60	1.20	0.95	0.75
Quartz pore	1.90	1.30	1.10	0.82
Organic layer	2.90	1.80	1.40	1.20
Illite layer	3.55	1.85	1.45	1.20
Unconfined	5.80	2.60	1.80	1.15

diffusion coefficient of water is 3.0×10^{-5}-1.19×$10^{-7}m^2/s$

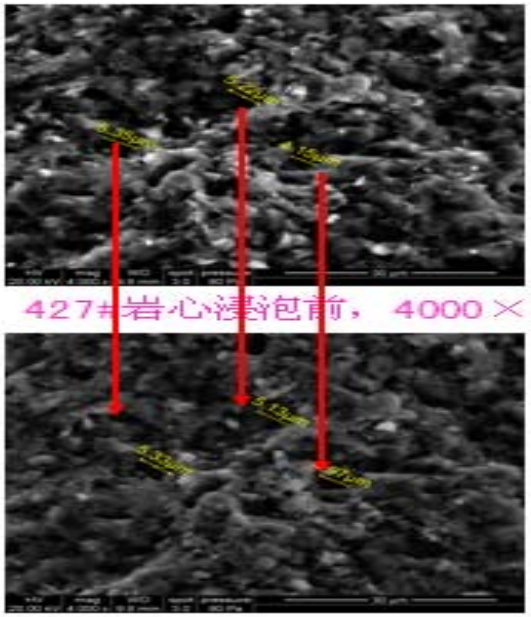
The diffusion coefficient of water in nanochannels

Pressure (MPa) / Diffusion coefficient (×$10^{-7}m^2/s$) / Pipe diameter	15	30	48	60
(9,9)	44.43	23.07	16.86	9.21
(10,10)	59.84	29.24	22.47	11.10
(12,12)	156.07	126.95	98.12	52.34
(14,14)	29.27	22.60	9.35	8.04
(16,16)	25.19	14.47	7.86	1.19

Source： Ou Zhipeng， Molecular dynamics of methane diffusion in nano-pore space
Zou Guiming, Study on the Molecular Diffusion in Nano-porous Materials by Molecular Dynamics Simulation

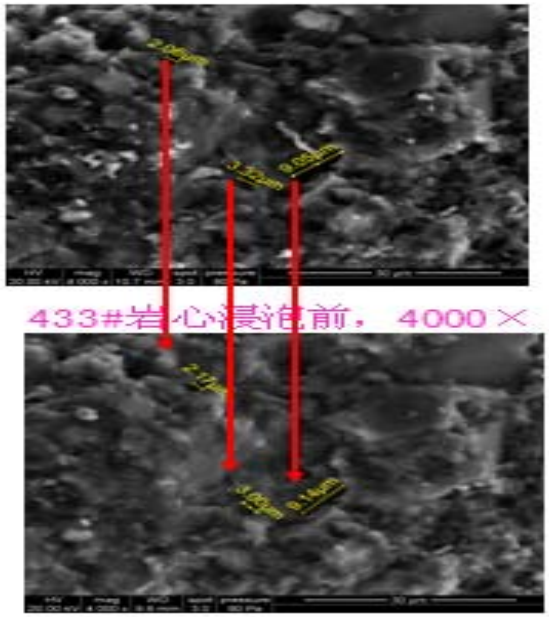
3.Residual water has no damage to shale reservoir

- soak 10d at room temperature



427#岩心浸泡前， 4000×

427#岩心浸泡后， 4000×



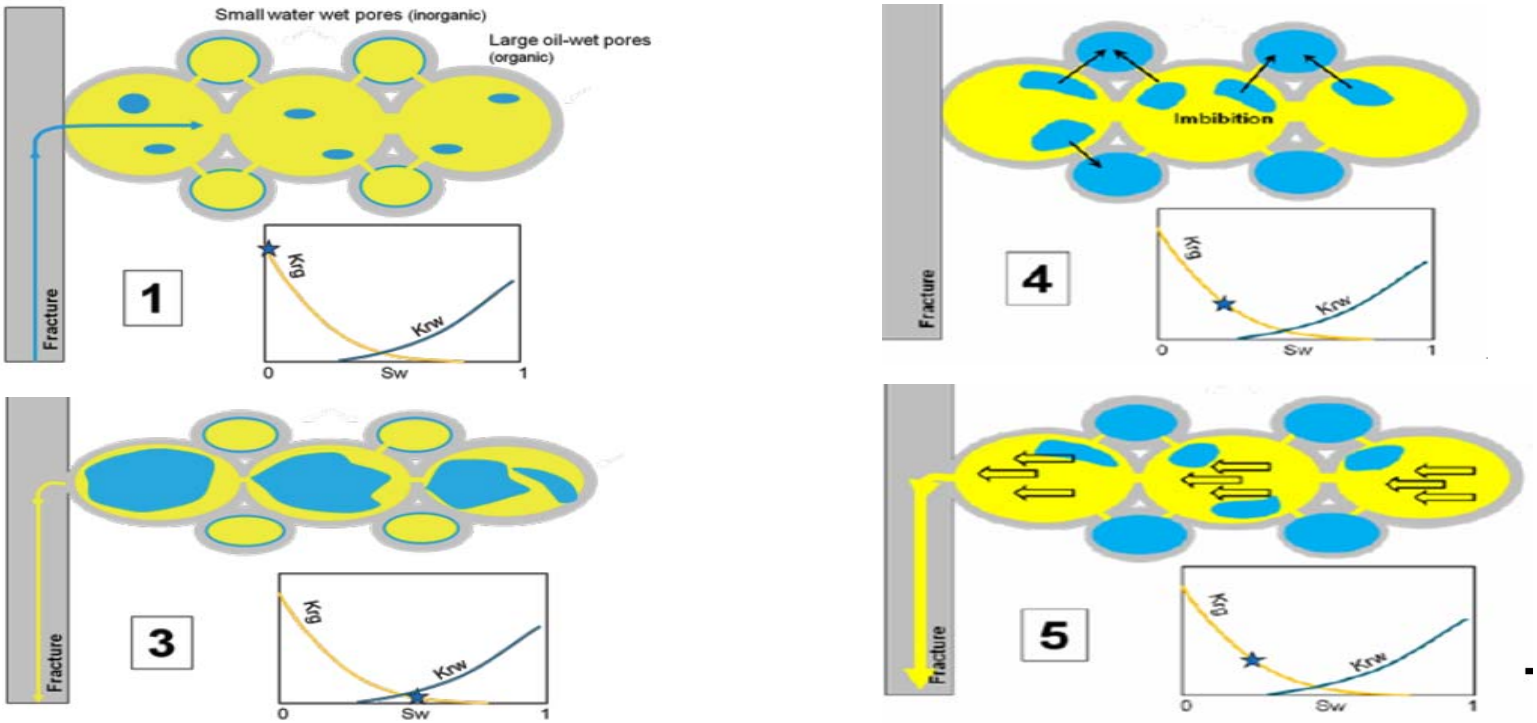
433#岩心浸泡前， 4000×

433#岩心浸泡后， 4000×

- SEM： after soaking， There was not deposit on the surface of the core and the fractures unchanged after soaking because no expansion.

3.Residual water has no damage to shale reservoir

- Discharge pressure return stage， Permeability increase in shale



source： SPE167698

- Under the action of external force, fracturing fluid enter into organic big hole
- Dialysis effect, the liquid into the small hole, big hole unobstructed
- Discharge pressure return stage, no obvious water lock effect for shale gas

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Thanks !