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## Geological Modeling on the Reservoir of Oil Sand in Estuary

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### 1 Introduction

Pore is the major oil and gas reservoir, and its volume and structure determines the gas capacity of shale and the occurrence mode of gas. The development of shale porosity is mainly affected by the content and diagenesis of quartz, clay and some other minerals, the content and maturity of TOC, the strength and time of tectonic activities etc., besides the study of pore's character of shale reservoir is an important prerequisite to exploration and production of shale hydrocarbon and guarantee and improvement of hydrocarbon reserves. Among pores, the organic pores include organic matter pores and biological fossil pores.

### 2 Organic pore types

#### 2.1 Organic matter pores

Organic matter pores are mainly nano porous in shale organic particles, and most of them are formed by organic hydrocarbon generation. Figure 1a and 1b are pictures of organic matter pores of core samples in Wufeng-Longmaxi shale formation in Pengye 1 well captured by Ar ion polished SEM experiment. We can see that the organic matter pores are relatively development and the size of particles are generally nanoscale.

#### 2.2 Biological fossil pores

Biological fossil pores are mainly pores in the biological fossil remains which are not filled by minerals, this part of pores can provide reservoirs for shale gas. Figure 1c, d are graptolite fossils in the rock slice of Longmaxi shale formation in Pengye 1 well and diatom coelom pore in Longmaxi shale formation. These biological fossil pores distribute in shale discretely, so they have poor connectivity, and their contributions to porosity are very

limited.

### 3 Porosity calculation

#### 3.1 Plane porosity of SEM

McCreesh et al (1991) etc. found that plane porosity of rock slice is approximately equal to its porosity, so we can calculate the organic porosity approximately with the ratio of pore area in SEM picture and total area in sight. It is assumed that organic pores are uniformly distributed in the organic portion of shale, and the ratio of pore area in SEM picture and total area in sight in any cross section is equal or similar (plane porosity is equal or similar). So we can derive organic porosity of some depth point approximately from the average ratio of organic pore area in some Ar ion polished SEM pictures (which can better reflect organic pores in organic particles) at the same depth and organic particle area in sight. Therefrom, shale organic pore evaluation model can be established (equation is below).

$$\phi_{\text{organic}} = \frac{\sum_1^n S_{\phi_{\text{organic}}}}{\sum_1^n S_{\text{organic}}} \cdot w(\text{TOC}) \cdot \frac{\rho_{\text{rock}}}{\rho_{\text{organic}}} \times 100\%$$

In the equation:  $\phi_{\text{organic}}$  is organic shale porosity, %;  $S_{\text{organic}}$  is area of organic part in the photo (SEM or Ar ion polished SEM),  $\text{m}^2$ ;  $S_{\phi_{\text{organic}}}$  is pore area of organic part in the photo,  $\text{m}^2$ ;  $w(\text{TOC})$  is shale organic carbon mass percentage, %;  $\rho_{\text{rock}}$  is density of shale,  $\text{kg}/\text{m}^3$ ;  $\rho_{\text{organic}}$  is density of shale organic part, about  $1200\text{kg}/\text{m}^3$ ;  $n$  is number of estimated pictures.

Using the above method, we can get the organic pore plane porosity of sample of Pengye well 1 at the depth of 2156.7m is 3.2%, TOC is 4.12%, the organic porosity is 0.29%, and organic pores are mainly micro pores; the organic pore plane porosity at the depth of 2079.99m is 28.07%, TOC is 1.45%, the organic porosity is 0.9%, and

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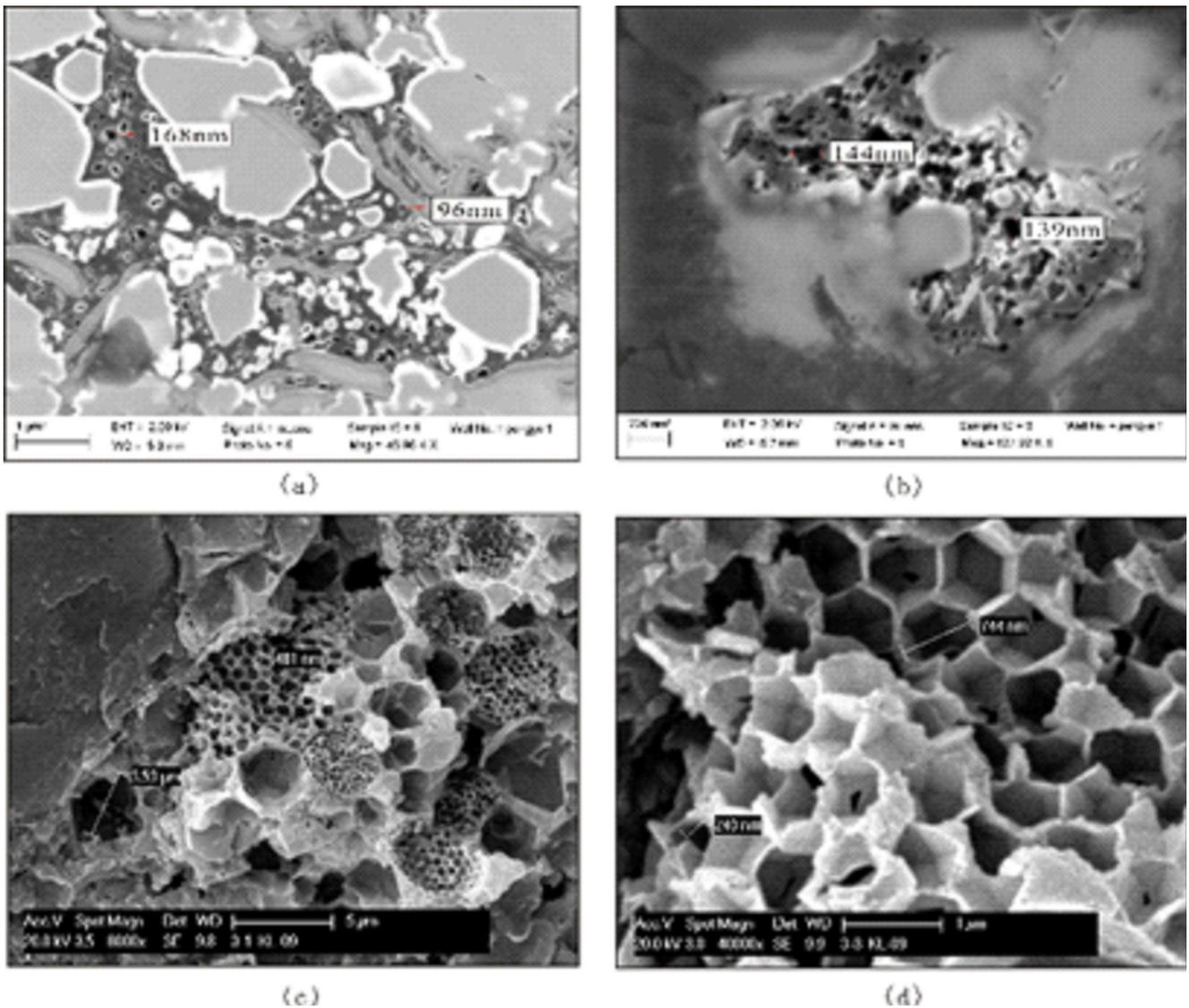


Fig. 1. Mainly types of organic pore of Longmaxi shale in Pengye1 Well

organic pores are mainly micro pores and mesopores, these two kinds of pores contribute to porosity mostly.

**3.2 Chemical Kinetics Calculation Of Porosity**

We can use chemical kinetics method to calculate the transforming ratio of hydrocarbon formation  $F(R_o)$ , and then we can restore original organic carbon  $TOC_0$  and original hydrogen index  $I_{H_0}$ , also we can use material balance principle to calculate organic porosity which is formed by hydrocarbon generation  $\phi_{organic}$ . Calculating equation is below.

$$\phi_{organic} = P \cdot TOC_0 \cdot I_{H_0} \cdot F(R_o) \cdot \frac{\rho_{rock}}{\rho_{kerogen}} / 1000$$

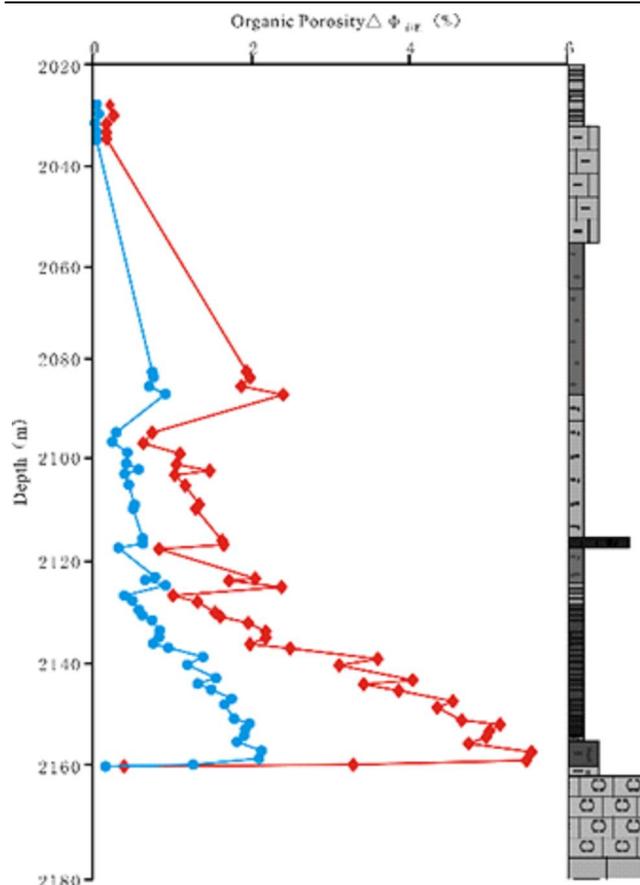
$$P = \frac{S_{\phi有机} / S_{有机}}{I_{H_0} \cdot F(R_o) / 1000} \text{ 或 } P = \frac{V_{椭圆}}{V_{圆}} = \frac{ab^2}{r^3}$$

In the equation:  $\phi_{organic}$  is organic shale porosity formed

by hydrocarbon generation;  $TOC_0$  is shale original organic carbon;  $I_{H_0}$  is shale original hydrogen index;  $F(R_o)$  is transforming ratio of hydrocarbon formation;  $\rho_{rock}$  is density of shale;  $\rho_{kerogen}$  is density of kerogen;  $P$  is compressibility of organic pore, which is 0.4. in this equation, compressibility of organic pore  $P$  is calculated from the statistic result of short and long axis of organic pore aperture in SEM pictures (Lu shaungfang,1996).

**3.3 Porosity Correction**

However, a series of changes occur to rocks in diagenesis (such as compaction, cementation and so on), the organic porosity calculated merely by chemical kinetics method is relatively greater. So it is assumed that the effect of diagenesis in different depths segment are the same, so we can get organic porosity through adding up organic pore plane porosity by Ar ion polished SEM, and then we can



**Fig. 2.** Comparison of the organic porosity of Longmaxi shale before and after correction with organic plane porosity

proofread porosity calculated from chemical kinetics method with equal ratio. In this way, more relatively more reliable organic porosity data can be gotten, and it is convenient to analysis organic porosity.

#### 4 Results and Discussion

After correction and calculation, we can get the organic

pore range of shallow water shelf in Longmaxi shale formation in Pengye 1 well is between 0.052%-0.083%, and the average value is 0.0616%; organic pore range of deep water- half deep water shelf is between 0.198%-1.589%, and the average value is 0.72%; the organic pore range of deep water- half deep water shelf in Wufeng shale formation is between 0.122%-1.71%, and the average value is 1.2%. The overall value decreases from bottom to top.

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