Microscopic characteristics analysis of tight sandstone reservoir: A case study from Chang 6 sandstones of Yanchang Formation in Longdong area, Ordos Basin

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1.Geological background

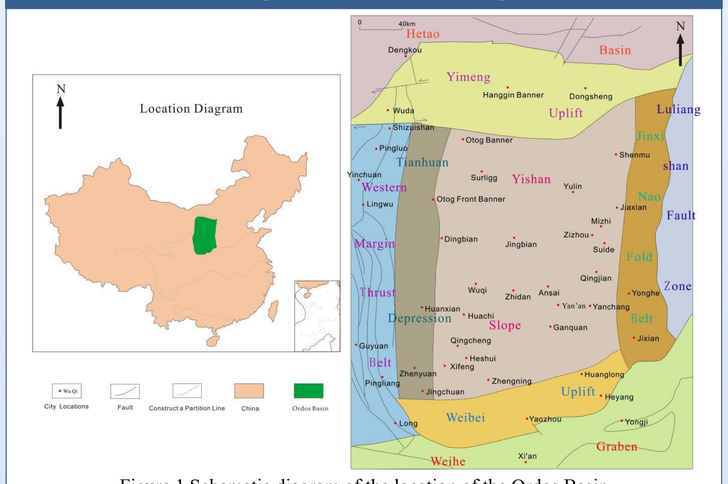


Figure 1 Schematic diagram of the location of the Ordos Basin

- The Ordos Basin is located in central and western China and is the largest craton sedimentary basin in China. It is mainly composed of six first-level structural units: Weibei Uplift, Jinxi Nao Fold Belt, Yimeng Uplift, Tianhuan Depression, Western Margin Thrust Belt and Yishan Slope. The total area is $37\times10^4km^2$.
- The Yishan slope in the middle of the basin is simple in structure, with no secondary structural units, and only some nose-like uplifts developed in the tertiary structure. The oil is mainly distributed on the Yishan Slope.

2.Petrological characteristics

- Core lithology and structural characteristics

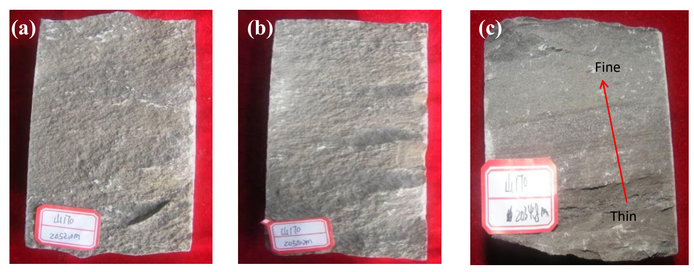


Figure 2. (a) Shan 170, Chang 6, 2052m, Block of fine sandstone; (b) Shan 170, Chang 6, 2055.2m, Gray blocky fine sandstone; (c) Shan 170, Chang 6, 2234.8m, Rhythm change of granularity

- Sand body structure characteristics of outcrop section

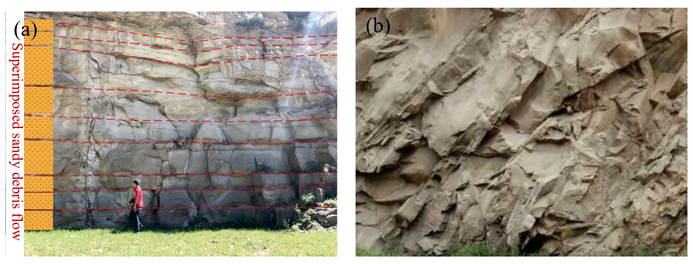


Figure 3.(a) Chang 6 Continuous superposition type; (b) Chang 6 Sandy debris flow continuous superimposed sand body, Tongchuan beach section;

2.Petrological characteristics

Feldspar sandstone, feldspar lithic sandstone, and lithic feldspar sandstone are the rock types of the reservoirs present in the Chang 6 members in the Ordos Basin (Figure 4).

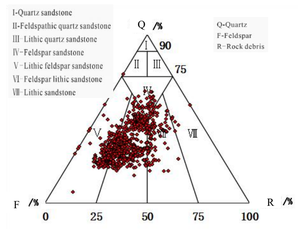
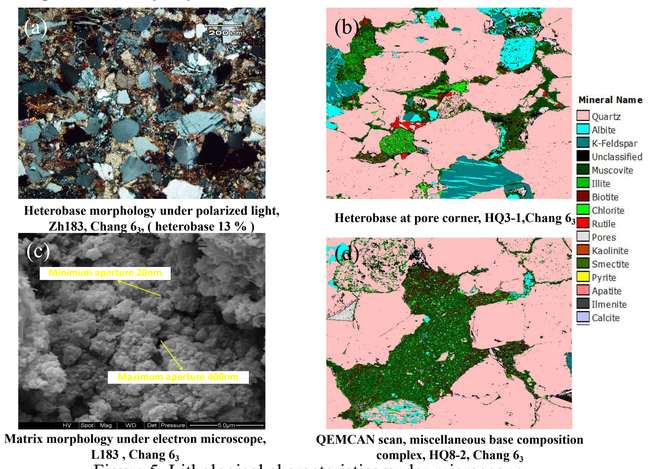


Figure 4. Rock composition of the Chang 6 Reservoir in the Ordos Basin

- **The microscopic characteristics of the promiscuous matrix : ① The surface of the slice is ' dirty '; ② Filling pore corner ; ③ Poor crystal shape of clay minerals ; ④ Complex composition, mainly clay minerals.**



Heterobase morphology under polarized light, Zh183, Chang 6_3, (heterobase 13 %)

Heterobase at pore corner, HQ3-1,Chang 6_3

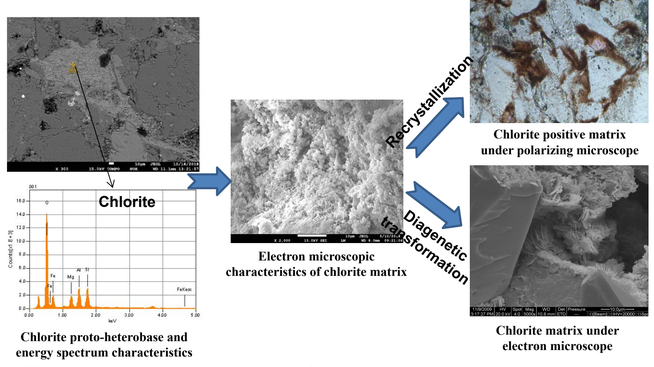
Matrix morphology under electron microscope, L183 , Chang 6_3

QEMCAN scan, miscellaneous base composition complex, HQ8-2, Chang 6_3

Figure 5. Lithological characteristics under microscope

3.Clay minerals

- The matrix of Huaqing Chang 6_3 is mainly composed of fine-grained clay minerals. The original matrix is in a slag-like and mixed state. The matrix after recrystallization and diagenesis has a layered structure and characteristic crystal form, forming a matrix micro-nano pore dominated by intergranular pores of clay minerals.



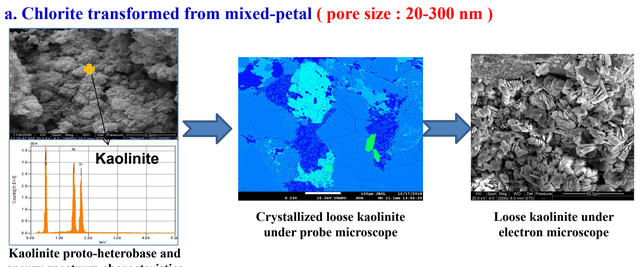
Chlorite positive matrix under polarizing microscope

Chlorite proto-heterobase and energy spectrum characteristics

Electron microscopic characteristics of chlorite matrix

Chlorite matrix under electron microscope

a. Chlorite transformed from mixed-petal (pore size : 20-300 nm)



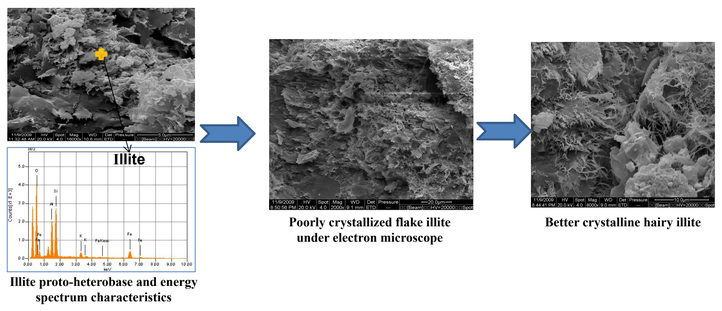
Kaolinite proto-heterobase and energy spectrum characteristics

Crystallized loose kaolinite under probe microscope

Loose kaolinite under electron microscope

b. Kaolinite is transformed from hybrid-book page (micro-nano pore size : 50-400nm)

4.Reservoir pore type



Illite proto-heterobase and energy spectrum characteristics

c. Illite is transformed from hybrid to hairy (micro-nano pore size : 50-2000nm)

Table 1 Statistical table of Chang 6_3 pore types in Huaqing area

Area	Intergranular pore (%)	Feldspar dissolution pores (%)	Rock debris dissolved pore (%)	Intergranular dissolved pore (%)	Heterobase dissolved pore (%)	Microfissure (%)	Intercrystalline pore (%)	Others (%)	Face rate (%)
Chang 6_3	1.41	0.61	0.12	0.04	0.02	0.03	0.03	0.00	2.24

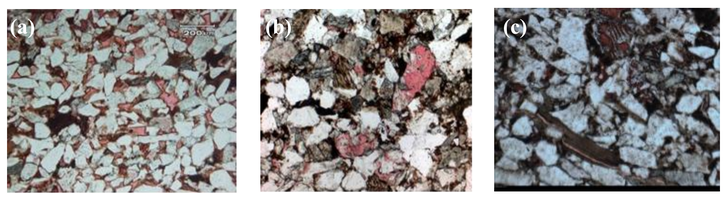
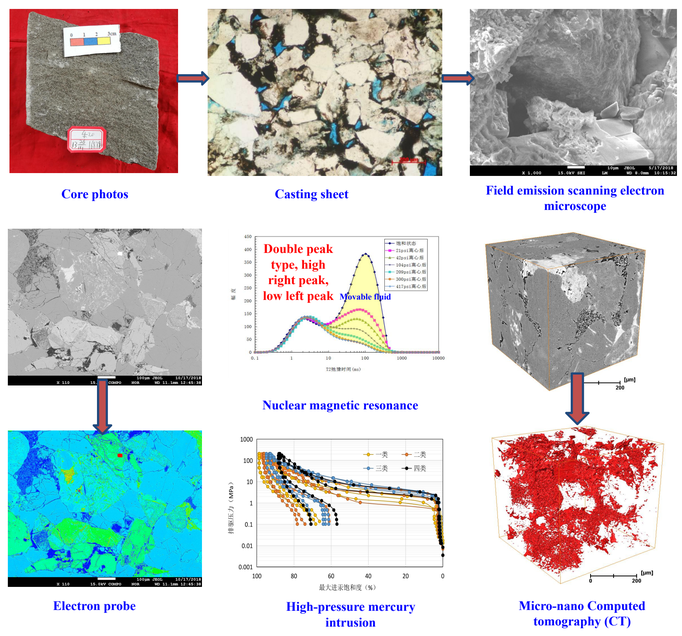


Figure 7. Chang 6_3 reservoir sandstone pore types in Huaqing area (a) B111, 2114.0 m, Intergranular pores; (b) B115, 2210.2m, Feldspar dissolved pore; (c) B123, 2092.1m, Muddy mica micro-cracks

5.Pore throats analysis method

- Full-scale characterization of microscopic pore throat



6.HPMI pore characterization

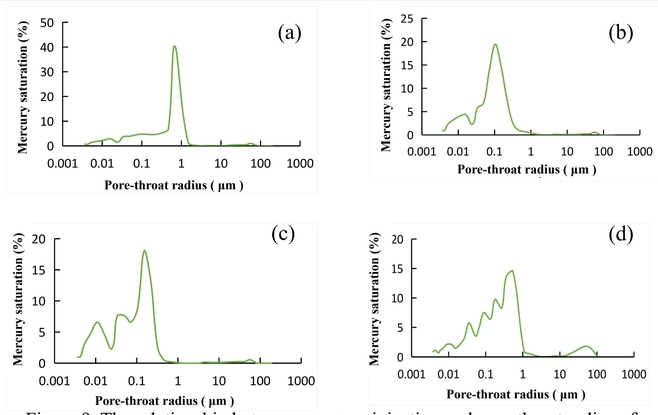


Figure 9. The relationship between mercury injection and pore throat radius of Chang 6 reservoir in Huaqing area (a) B64, 2129m; (b) B64, 2127.4m; (c) B432, 2237.02m; (d) L338, 2241.6m;

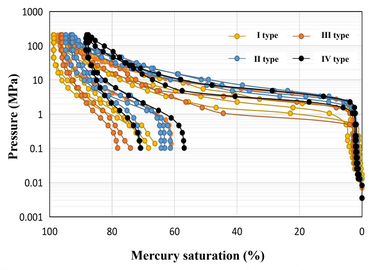


Figure 10. The capillary pressure curve of Chang 6 reservoir in Huaqing area

7.LTNA throat characterization

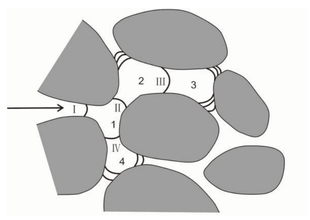


Figure 11. Schematic diagram of mercury entry route (I. II. III. IV is throat serial number : 1.2.3.4 is pore serial number)

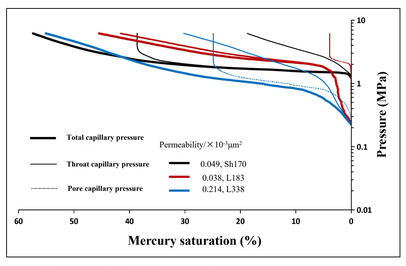


Figure 12. LTNA capillary pressure curve

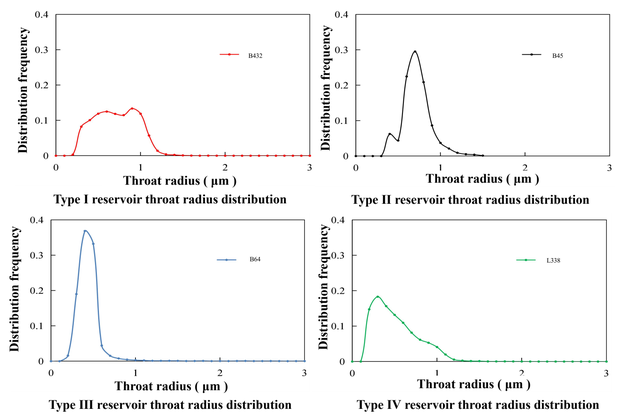


Figure 13. The throat radius classification of Chang 6_3 samples in the study area

8.Conclusions

- The sandstone in the study area is mainly lithic feldspar sandstone and feldspar lithic sandstone, and the interstitial material is mainly clay minerals..
- The reservoir pore types are mainly residual intergranular pores, dissolution pores, and micropores.
- The pore throats are mainly distributed in the range of 0.004-100 μm, less distributed less than 0.1 μm, and more than 1 μm.
- The pore radius of each sample is concentrated between 60-348 μm.
- The throat radius of each sample is dispersed between 0.12-1.5 μm, and the roaring type is fine-micro roar type, showing strong heterogeneity.
- The throat mainly controls reservoir permeability, and the proportion of small throat increases with the decrease of permeability.

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