1 Introduction

Permeability of Member-6, Member-7, and Member-8, Triassic Yangchang Formation in Ordos Basin is lower than $10^{-3}$ μm$^2$, so sandstone in those formations are typical tight reservoir (Zhao et al., 2012a, 2012b; Yang et al., 2013). Because of the maximum flooding event of Late Triassic during deposition of Chang-7 Member, the lacustrine basin had a wide range of deposition area and abundant gravity flow sandbodies deposited in the center of the lacustrine basin (Yang et al., 2007, 2013). As wonderful allocation relation between widely distributed sandbodies and high quality source rocks, Chang-7 member has considerable resource potential for tight oil (Yang et al., 2005, 2007).

2 Dissolved Pore is the Main Type of Tight Reservoir

Distribution range of porosity is (0.5 to 12.3) %, with main distribution range is (6 to 12) %. Average porosity is 7.4% and minima porosity is 7.5%. Distribution range of permeability is (0.02 to 7.83) $\times 10^{-3}$ μm$^2$, with main distribution range is (0.05 to 0.2) $\times 10^{-3}$ μm$^2$. Average permeability is 0.17$\times 10^{-3}$ μm$^2$ and minima permeability is 0.1$\times 10^{-3}$ μm$^2$. There is a positive correlation between porosity and permeability of samples with permeability lower than 0.2$\times 10^{-3}$ μm$^2$. Chang-7 Member is a typical tight reservoir.

Pore types include residual intergranular pore, intragranular dissolved pore, feldspar dissolved pore, lithic dissolved pore, moldic pore, etc. In other words, secondary solution pores are main type of tight reservoir with the average areal porosity is 2.5%. However, many kinds of cements filled in the pores, such as microcrystalline quartz, carbonate, and illite, etc.

3 Micron-size Pores and Nano-scale Throats Compose Pore-throat Net System of Chang-7 Tight Reservoir

Pore-throat net system of tight reservoir was described by comprehensive use of casting thin section, laser scanning confocal microscope, scanning electronic microscope, field-emission scanning electronic microscope, industrial computed topography, nuclear magnetic resonance, and high pressure Hg injection. ① Types of pore was observed by casting thin section, but diameter of pores that can be detected by this instrument are always more than 10μm. ② Using laser scanning confocal microscope, diameter of pores that could be found is lower than 40μm. Pores with diameter above 4μm can account for more than 70% of all pores that can be detected and pores with diameter between 4μm to 10μm account for 50% of all pores. Through 3D view, pores with diameter lower than 100μm always distribute discretely, so connectivity among pores is poor. As amounts of pores increase and diameter of pores become wider, connectivity become better and porosity increase. Pores with higher diameter account for more volume of all pores. ③ Diameter of pores that can be found by SEM range from 5μm to 100μm. Types of pores include residual intergranular pore, intergranular dissolved pore, and intragranular dissolved pore. Using FESEM to observe samples processed by Ar-ion milling, diameter of inter-clastic grains pores and dissolved pores are wider than 2μm, and pores among clay minerals aggregation are mainly nano-scale. ④ Using industrial CT, diameter of pores mainly range from 2μm to 10μm, diameter of throats mainly range from 1μm to 4μm, pore-throat volume ratio range from 2.22 to 15.99. Porosity range from 1.02% to 7.39%, volume of connective pores
account for 29.2% to 70.7% of all pores and average is 49.78%. Porosity of pores range from 0.87% to 5.22%, and porosity of throats range from 0.08% to 2.17%. The wider the pore and throat the better the porosity. According to $T_2$ spectrums, spectrum peaks correspond to 1ms and 100ms, so distribution of pores were divided to 4 kinds: unimodal type (mainly small pores), bimodal type (mainly small pores), bimodal type (mainly large pores), bimodal type (volume of small pores equivalent to large pores). We speculated that zone of small pores correspond to the pores with diameter between 20nm to 2μm, and zone of large pores correspond to the pores with diameter between 1μm to 100μm. In all, pores with diameter above 2μm are dominant part of all pores. Based on high pressure Hg injection data, all radius of pore-throat are lower than 735nm. Radius distribution histograms that are gotten from capillary pressure curves have bimodal or multi peak, and radius corresponding to main peak is lower than 73.5nm. Bimodal or multi peak imply that sorting of pores and throat is poor and tight reservoir has sever pore-throat diameter distribution interval. Large pore-throat made more contribution to permeability and radius of pore-throat contributive to permeability range from 73.5nm to 735nm.

Micron-size pores and nano-scale throats compose pore-throat net system of Chang-7 tight reservoir. Dominant diameter of pores is wider than 2μm, and pore-throat with radius between 73.5nm to 735nm made more contribution to permeability.

4 Because of Compaction and Cementation, Reservoir had Become Tight before Oil Accumulation Period

Diagenesis types include compaction, cementation, and dissolution. Grain size of sands is fine. Content of lithic fragments and clay minerals are high, so sandstones had weak ability to resist compaction with depth of burial. Ductile grains had been bending and deforming. In sometimes, some ductile grains with flowing shape fill in pores. However, contact relation between grains show point to line contact, and concave to convex contact is uncommon, so compaction may have not reached the maximum level. Cementation types include carbonate cement, clay mineral cement, quartz overgrowth, and microcrystalline quartz. Carbonate cement include calcite, ferrocalcite, and ankerite. Early calcite cements are microcrystalline. Ferrocalcite and ankerite cements are sparite and crystal stocks. Carbonate cements fill in intragranular pores and dissolved pores and these cements have integral crystalline form implying that these cements formed after dissolution. Illite is the dominant type of clay minerals cement. Wire strand illites that may have 2-3 period growth stage fill in pore as pad form, bridge form and filling form, and block pores and throat. Quartz overgrowth and microcrystalline quartz also fill in intragranular pores and dissolved pores. Early carbonate, feldspar, and lithic fragments were dissolved to form dissolved pores. However, late carbonate cements and secondary quartz always filled in dissolved pores, as a result, improving role of dissolution to reservoir may be counteracted by late cement.

Compaction and cementation played a negative role to reservoir. Based on thin section identification, compaction and cementation respectively made porosity decreased as 83% and 15% of primary porosity. Compaction is the dominant factor that made reservoir become tight. As burial depth increasing, porosity decreased to 10% at middle of early Cretaceous. The end of early Cretaceous was the main accumulation period, so reservoir had become tight before oil accumulation period.

References