Study on Genesis of Reservoir Pores of Lower Cretaceous in N Depression

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Abstract

The lower Cretaceous reservoirs in N Depression are buried deeply and have strong compaction and cementation, and the oil reservoirs discovered at present are concentrated in the secondary pores. The pore structure and diagenetic evolution of lower Cretaceous sandstone in N Depression are analyzed by using the data of cast thin section, scanning electron microscope, X-ray diffraction and capillary pressure curve, and the main controlling factors of reservoir properties are revealed. The sandstone reservoir has undergone three stages of diagenetic evolution, which are early A, B and middle A. The secondary pore is the main pore structure of sandstone reservoir, which can be divided into two vertical secondary pore zones. The secondary pores mainly include inner pores of dissolved particles, inner pores of dissolved interstitial materials, and so on. The main reasons for the formation of secondary pores are the dissolution caused by atmospheric fresh water leaching, organic acid and clay mineral transformation caused by the thermal evolution of organic matter.

Keywords

N Depression; Lower Cretaceous; Diagenesis; Secondary Pore.

1. Overview of the Study Area

The low stand fan of the Lower Cretaceous Nantun Formation and Tongbimiao Formation in N Depression is a favorable accumulation area for oil and gas, and the low stand fan is often wrapped by source rocks in the background of deep-water basin, which is conducive to the formation of lithologic reservoirs (Zou Caineng et al., 2006; Isway, 2005). The fan delta sand body is buried deeply, the compression action is strong, and the pores are small, and the discovered oil and gas reservoirs are all produced in the secondary pores. Whether to find the factors controlling the nature of secondary pores and determine the distribution of high-quality reservoirs has become an urgent problem to be solved in exploration and production. In this paper, the Lower Cretaceous Nantun Formation and Tongbimiao Formation in N Depression are taken as the target layer. The petrology characteristics, pore structure and main controlling factors of pore evolution of clastic rock reservoir are studied by using cast thin sections, scanning electron microscopy, X-ray diffraction and electron probe testing methods in 20 Wells. It provides theoretical basis for oil and gas exploration and development in the study area.

1.1 Geological Setting

Nanbel Depression is a secondary tectonic unit of Tamzag Basin with a tectonic pattern of two depressions and one uplift (Fig 1). N Depression is a southward extension of China Beier Depression. It is connected to the Beier-Buinol Uplift in the east, to the Balan-Shabalag uplift in the west in a nearly monoclinal form, and to the Tanan Depression in Tamzag Basin in the south in a low uplift.

During the sedimentary period of Nantun-Tongbimiao Formation, the N depression was at the peak of rift development, and the tectonic subsidence accelerated in the whole area, resulting in a wide range of lake encroaching in the whole area, and the fan delta sedimentary system was widely developed, distributed along the root of the deep fault in a fan pattern. The deep lake area was mainly distributed in the eastern secondary depression, and a series of sublacustrine fans developed in the deep depression. The main sources come from three directions, namely, the west steep slope of the North trough, the east steep slope of the South trough and the north gentle slope. The sand bodies of fan deltas are mainly found in the frontal subfacies. In the front subfacies, the underwater distributary channel is the most developed, and its shape is controlled by the underwater geomorphology, with fan-shaped lobes distributed and transverse sand bodies contiguous. The thickness of fan sandstone is about 80 ~ 320m, and the thickness of single sand is larger, generally 10 ~ 15m, and more than 20m is also common. The Nantun Formation is mainly composed of black ash, dark gray mudstone and silty mudstone deposited in lacustrine facies, mixed with gray argillaceous siltstone and siltstone, and the developed dark mudstone is the most important source rock in N Depression.

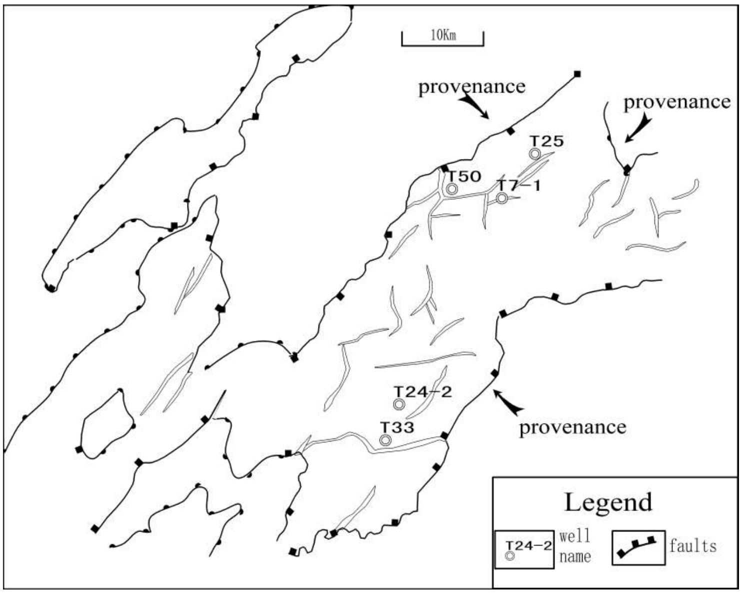

Fig.1 The top surface map in the study area

2. Characteristics of Secondary Pore Development

Based on thin section identification and image analysis of the cast and comprehensive study of scanning electron microscopy data, the pore classification of clastic rocks was referred to (Di Shixiang et al., 1991; Qiu Yilan et al., 1997), the identification criteria of pore types and the genesis of pores in volcanic rock reservoirs (Sruoga et al., 2007), and classified the types of secondary pores into five categories: internal pores in dissolved particles, internal pores in dissolved interstitials, intergranular pores, super-large pores, and dissolved fracture pores (Fig. 2). The intergranular porosity is the intergranular and granular edge dissolution into tooth shape, harbor shape, arc shape and so on. The edge of the detrital particles can be seen dissolved under the thin section of the cast body to form a harbor or sawtooth shape. This type of pore is found in various rock types, but is more common in lithic arkose and tuffaceous sandstone. For example, the throat between feldspar particles is dissolved and connected from both sides to form a long strip of holes between the dissolved particles, or the edge of the feldspar particles is dissolved into a ring, forming the dissolution pores between the feldspar particles. The pores in the solution caulk developed vitrified pozzolanic solution pores and calcite solution pores. The inner hole of the corrosion particle includes the inner hole of feldspar particle, the inner hole of feldspar mold and the inner hole of glass chip. The dissolution and dissolution of feldspar are more common, and the dissolution and dissolution are often along the cleavage surface or the defect part of the crystal surface, and sometimes only the external outline of feldspar is retained to form the mold hole. The pores whose diameter is equal to or greater than the

ISSN: 2414-1895 DOI: 10.6919/ICJE.202411_10(11).0009

average diameter of the clastic particles are composed of both the mold pores and the primary intergranular pores, but the proportion of the two can not be estimated. The characteristic of the hole of solution fracture is that the edge of the fracture has the traces of dissolution and dissolution caused by the flow of fluid.

Significant longitudinal porosity increases occur in the depth segments 1800-2200m and 2600-2800 (Figure 2). In the first zone of secondary pore development, the maximum porosity is 30%, and the average is about 25%. In the second section of secondary pore development, the porosity is up to 25% and 20% on average. The depth of secondary pore development may be different in different structural positions. The depth of secondary pore development is deeper in the depression, and shallower in the gentle slope zone and steep slope zone. The distribution characteristics of secondary pores in N depression are related to the diagenetic evolution history of sandstone. According to the study on the changes of Ro and clay minerals in N Depression, the sandstone in the study area has undergone three stages: early rock A stage, early rock B stage and middle rock A stage after deposition (Figure 3). When the buried depth is less than 800m, the rocks are basically in the early diagenetic stage A, when the paleogeothermal temperature is 65℃, the organic matter is immature, the consolidation state of the rocks is loose, and the primary pores are developed. The diagenesis is mainly mechanical compaction, and the clay minerals are mainly montmorillonite and dolomite. When the buried depth is between 800 and 1200m, the rocks are in the early B stage, the paleogeothermal temperature is 65℃ ~ 85℃, the Ro is 0.35 ~ 0.5%, the organic matter is low mature, the primary pores are still developed, and a small number of secondary pores can be seen, and the smectite begins to significantly transform into the I/S mixed layer, and the smectite layer accounts for 50% ~ 70% of the mixed layer. When the buried depth is between 1200 and 2500m, the rocks enter meso-diagenetic stage A, the paleogeothermal temperature is 85℃ ~ 140℃, the Ro is 0.5 ~ 1.3%, the organic matter is mature, the pores are mainly secondary, the dissolution and late carbonate cementation develop, the clay layer minerals emerge from the interlayer water, and the hairline autogenous illite, foliaceous and pile-autogenous chlorite can be seen under scanning electron microscopy.

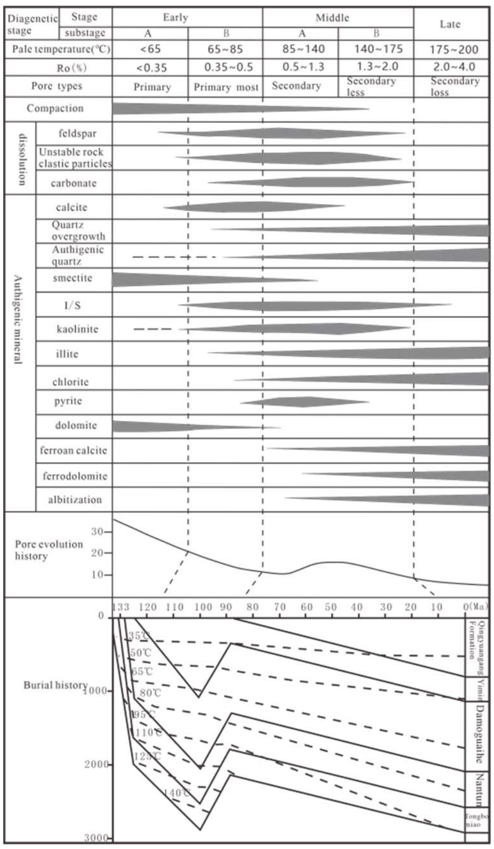

Fig.2 Diagenetic evolution profile

3. Genetic Mechanism Analysis of Secondary Pores

3.1 Secondary Pores Related to Hydrocarbon Generation and Expulsion from Source Rocks

The secondary pore zone of N Depression is below the threshold of hydrocarbon generation and expulsion of 1700m, which indicates that the development of secondary pore is related to hydrocarbon generation and expulsion of source rock. In the process of thermal degradation of sedimentary organic matter into hydrocarbons, oxygen-containing groups are first removed to form organic acids and phenolic compounds (Guo Chunqing et al., 2003; Zhu Xiaomin et al., 2007; Liu Wei et al., 2006), after ionization and dissociation of organic acids, H+ can be produced, and then acidic formation water is produced, which enters adjacent reservoirs and dissolves carbonate particles, cements and alumino-silicate framework particles, ultimately leading to the increase of reservoir porosity.

3.2 Secondary Pores Associated with Atmospheric Water Leaching

Atmospheric water leaching has a certain influence on the development of longitudinal upper secondary pore zone (Yang Xiaoning et al., 2004; Huang Sijing et al., 2003). Hydrothermal experiments of rock confirm that under the action of atmospheric water, sandstone is prone to corrosion, forming corrosion pits, corrosion holes, etc., the corrosion mainly occurs in feldspar minerals, if the sandstone contains calcareous cement, these carbonate minerals are also prone to corrosion. Therefore, under the action of atmospheric water, the sandstone is easy to form secondary pores, mainly the dissolution pores in the grains of minerals.

4. Conclusion

The lower Cretaceous sandstone reservoir in N depression has undergone three stages: early A stage, early B stage and middle A stage. The secondary pores mainly appeared in meso-diagenetic stage A, which was characterized by dissolution and late carbonate cementation.

Longitudinally, it can be divided into two secondary pore zones, which exist under the threshold of hydrocarbon generation and expulsion. The main reasons for the formation of secondary pores are the leaching of atmospheric fresh water, the dissolution of organic acids formed by the thermal evolution of organic matter and the transformation of clay minerals.

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ISSN: 2414-1895
DOI: 10.6919/ICJE.202411_10(11).0009

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