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Research Advances

The Existence and Significance of Two Kinds of Effective Reservoirs in Deep Water Area of the Western Qaidam Basin

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Objective

Deep-water deposit has become one of the greatest potential and economic areas for petroleum exploration. In the western Qaidam Basin, the deep-water sedimentary area account for nearly 2/3 of the basin area, but the related reports is less. Scholars generally believed that the salt water medium can inhibit the extension of the sand (Qian et al., 1984). Therefore, the sand in the lacustrine area was lacking, and for the deep-water carbonate area, it was considered as a "biological desert"(Warren, 2016). Lack of large-scale reef-building creatures makes it difficult to form efficient reservoirs. However, the author and some scholars have discovered seismites (Shi et al., 2009) and mixed rocks (Xu et al., 2014) in the deep-water area of the saline lacustrine basins, and the mixed rocks composed of organic-rich mudstone, siltstone, and lacustrine carbonate. Obviously, it is very hard to explain these questions through traditional salt lake sedimentary theory. As petroleum prospectors, we must resolve four aspects of doubt: Firstly, whether the sands were developed in the deepwater area of saline lake; Secondly, it is a confusion that the matrix pores were developed in the lacustrine carbonate rocks of saline lake; Thirdly, whether the lacustrine carbonate rocks in saline lake can be effectively dissolved remains a mystery; Fourthly, the brittle strata containing saline were more likely to be transformed into breccias needs to be implemented. Focusing on the above four major puzzles, we applied targeted experimental simulations, with a view to providing theoretical support for the petroleum exploration in the deep water area of the saline lacustrine basins.

Methods

The experiments were divided into four groups. The first group experiment was a flume comparison experiment between fresh and salt water, specific experimental conditions are shown Appendix 1. The second group experiment had been conducted an electron probe test to analyze the composition of dolomite in the salt Lake basin. The third group experiment had designed to simulate rocks in the study area with fresh water and 0.2% acetic acid, the rocks are composed of lacustrine carbonates, mudstones, evaporates and clastic rocks, with the main minerals composed of dolomites and calcites (31.2%), clay minerals (28%), quartz and feldspar (25.6%), anhydride (6.3%), halite (5.6%), pyrites (3.3%) and glauberites (2.2%). The reaction temperature was 108°C, the pressure was 50 MPa (Corresponding to the paleotemperature and formation pressure at the depth of the source rock during the peak period of hydrocarbon generation), and the freshwater temperature was 25°C, and the pressure was 1 MPa (corresponds to temperature and atmospheric pressure when surface is exposed). The fourth group experiment was structural simulations for about late depositional reconstruction.

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Results

The first experimental results are shown in Fig. 1. The fine sands in salt water are characterized with longer transport distance (16%) and wider distribution (37%) than freshwater. Therefore, salt water medium top-off effect can produce hypopycnal flow.

In the second group experiment, we found that a large amount of dolomite can be formed in the penecontemporaneous process, and its molecular formula is $Ca(Mg_{0.96}Fe_{0.04})(CO_3)_2$. During the process, when one Ca^{2+} molecules is replaced by Mg^{2+} , the volume shrinks to form shrinking intercrystalline poresthe due to the Mg^{2+}

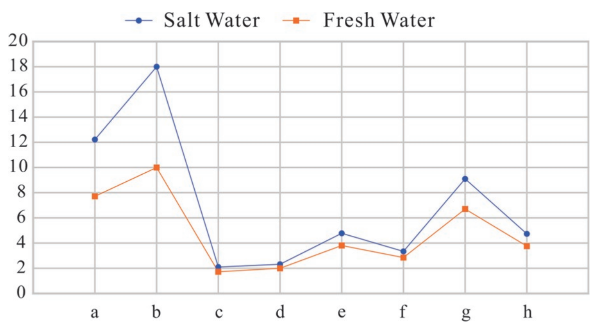

Fig. 1. Comparison of the the main parameters of the simulation flume results with salt water and fresh water
a-Density of distributary channel (m^2); b-width of distributary channel (cm); c-broadening rate (m/10day); d-elongation rate (m/10day); e-sand body width (m); f-sand body length (m); g-sand body area (m); h-sand body thickness (m).

ion radius (0.078 nm) is smaller than the Ca^{2+} ion radius (0.106 nm). At the same time, a large number of intercrystalline pores were observed under scanning electron microscope in carbonate rocks (Fig. 2). The pore size is small but numerous with a single aperture range of 0.4-5μm, which lay the foundation for oil and gas accumulation and long-term stable production.

Through the third group experiment, we were surprised to find that salt minerals in the saline lake basin were more easily dissolved under the action of fresh water. So we speculate that there is a short period of exposure n the saline lake basin lacking the reef-building organisms, which can cause large-scale dissolution and become an effective reservoir (Fig. 3).

The fourth group experiment reveals that brittle formations can form a large number of fractures in the compressive stress background of anticlines, and produce interlayer breccia pores derived from interlayer gliding. So we are sure that a large number of breccia pores in the carbonate rocks in the deep water area of the saline lake basin composed the most effective reservoir under the late tectonic action.

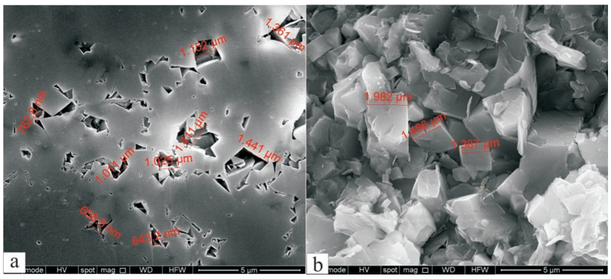

Fig. 2. Ultra-microscopic electron scanning electron microscope imaging results (a, b) of XX well in Qaidam Basin
(a) Image taken by splitting in argon of SEM showing the morphological; (b) Image of fresh-section morphology of dolomicrite taken by scanning electron microscopy (SEM) showing samples

Conclusions

By taking the Qaidam Basin as an entry point, a systematic study of the deep-water reservoirs in the saline lacustrine basin was applied to break the traditional concept and it is of great significance for the future development of the saline lacustrine basin sedimentology.

(1) The deep-water district of the saline lacustrine basin is not traditionally considered to have no exploration value, and its abundant remaining resources are one of the important directions for future oil and gas exploration.

(2) The salt water medium is beneficial to the formation of hypopycnal flow. The fine-grained sand coexisting with hydrocarbon source rocks develop in the deep water area, which is one of the most important types for exploration.

(3) The saline lacustrine basin lacking the platform facies and reef-building organisms show huge pote-ntial of exploration in deep-water areas , with a complicated pore-slit-hole multiple reservoir.

Acknowledgements

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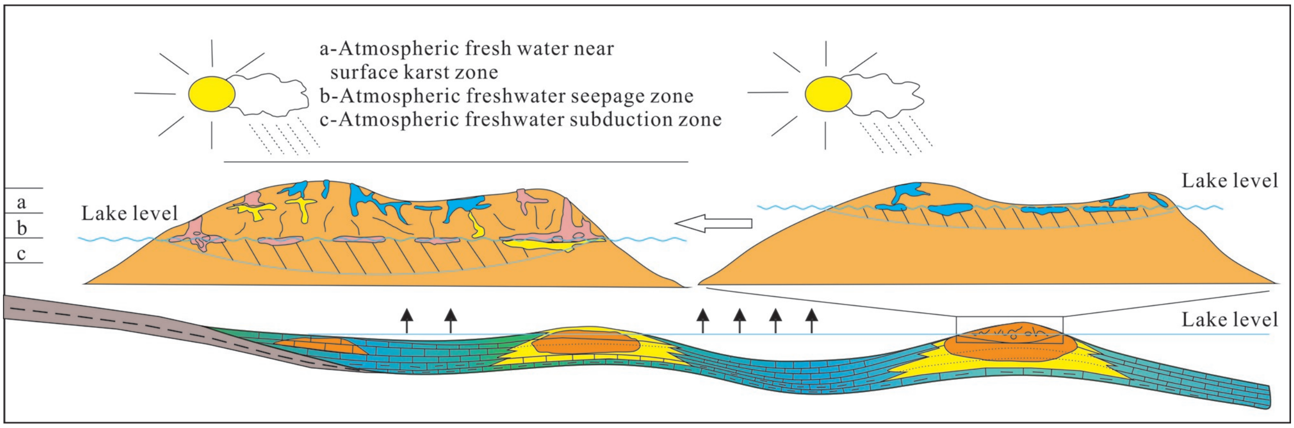

Fig. 3. Carbonate storage model during the middle and late exposing periods of lake retreat in western of the Qaidam Basin.