

Diagenetic evolution of tight sandstone
and the formation of an effective
reservoir in the Lower Member 3 of
the Shahejie Formation, Bohai Bay
Basin, East China

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Heterogeneity in the physical properties of tight sandstones is mainly caused by complex fluid-rock Interactions during the burial process. The tight sandstone oil in the Bohai Bay Basin, East China, has great development potential but it is unclear how effective reservoirs were formed, and this is a significant reason why exploration in the deep reservoir is so difficult. Here we studied the diagenetic evolution of the tight sandstone of Lower Member 3 of the Shahejie Formation, Linnan Sag, Bohai Bay Basin, by using cores, thin sections, XRD, SEM, grain-size analysis, high-pressure mercury intrusion porosimetry, fluid inclusions, and carbon and oxygen stable isotopes. Compaction, replacement, cementation and dissolution diagenesis are identified; all four processes mainly occur in the A phase of mesodiagenesis. The interaction of formation burial, thermal evolution of organic matter and dehydration of gypsum leads to the alternating presence of three stages of alkaline fluids and two stages of acidic fluids. The average dissolution porosity of the dissolution sandstone facies is greater than the lower limit of the porosity for the effective reservoir in the study area, which is key to the formation of effective reservoirs. By determining differential diagenetic evolution sequences of tight sandstone reservoirs under the constraints of different lithologies where sandstone is interbedded with mudstone, we are able to elucidate the formation of the effective reservoir. By coupling the thermal evolution of organic matter and the dehydration of gypsum with differential diagenetic evolution and the porosity evolution of reservoir, we are able to establish a reservoir genetic model that involves alternating seepage of organic acids and alkaline brines. This study proposes a new method for target-based diagenesis simulation by integrating the discrete element method, the quartet structure generation set method, and morphological algorithms. The predicted porosity, permeability, and pore size distribution of the simulated digital rocks are in good agreement with the experimental values, which validates the high accuracy of the simulation method. Based on these three-dimensional multi-mineral evolution models, the evolution trends of porosity and permeability during the sedimentation and diagenesis process were elucidated, revealing the variation in reservoir quality in the studied area.

