Fluid-rock Interactions Induced by CO_2 from Deep Strata in Lacustrine Sandstones

Wei Wei[1], Peng Lu[2], Xiaomin Zhu[3]

[1]Beijing Research Center Aramco Asia Beijing;
[2]EXPEC Advanced Research Center, Saudi Aramco;
[3]College of Geosciences, China University of Petroleum, Beijing

Abstract

Chagan sag is considered to be the most prospective exploration area in Yin-E Basin, China-Mongolia frontier area. Of particular interest, the Ba2 Member of the Lower Cretaceous Bayingebi Formation is a typical lacustrine fan-delta sandstone reservoir with an average porosity of 10% and permeability of 7.7 mD. Carbonate cements are the most dominant diagenetic mineral and ubiquitous in the Ba2 Member with a general content of 10% to 34%. Although some researchers believe that CO_2 intrusion from deep strata led to the abundant carbonate cementation and reservoir porosity evolution, the tightening conditions and mechanisms remain unclear. The aim of this study is to determine the likely conditions that lead to the tightening of the fan-delta sandstone reservoir due to CO_2 intrusion and to evaluate the spatial distribution of carbonate cements and clay transformation in the heterogeneous reservoir. This study presents a case study with a real-world context and reactive transport approach for simulating intruded CO_2-water-rock reactions in the Lower Cretaceous clastic rock reservoir, in Chagan Sag, using log-based depth and thickness, mineralogy assemblages, paleo-temperature, and hydrostatic pressure. The model is a 60 m×100 m 2D model with the depth around 2300 km. It is comprised of several sandstone-mudstone interbeds, according to the well log and core data. CO_2 intrudes into the Ba2 reservoir from the lower boundary for 10,000 years. Based on petrographic analyses, the primary minerals in the model involve quartz, andesine, k-feldspar, chlorite, and the secondary minerals are calcite, ankerite, kaolinite, illite, and albite. Results show that the pH decreases from 9 to 5.5~6 during the CO_2 injection. Gas saturation in the mudstone is higher (around 0.14) than that in fan-delta sandstone (around 0.06). The total dissolved amounts of primary minerals are in the sequence of andesine > k-feldspar > chlorite. Meanwhile, the secondary cementation abundances are in the sequence of ankerite > illite > quartz. The porosity and permeability decrease 2%~3% and 0.03 md, respectively. Compared with mudstones, the extent of cementation and dissolution reactions in the fan-delta sandstones is less. Modeling results indicate that the abundance ankerite generation is related with chlorite and andesine dissolution and CO_2 intrusion, and the illitization is related with k-feldspar dissolution. The mudstones are prone to cementation, which may prevent the further compaction and protect porosity of the interval sandstone.