Hydrothermal alteration of the Cambrian dolomite: petrography and geochemical evidence from deep cores (7200-8500 m) in the Tarim Basin, Northwestern China

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Abstract

The Tarim Basin in northwestern China is one of the major hydrocarbon producing basins in China with oil/gas production mostly from karsted Ordovician limestone reservoirs at burial depths approximately from 4,000-6,000 m. In order to evaluate the potential for hydrocarbon reservoirs in the deeper Cambrian carbonate rocks, a deep exploration well, Tashen-1, was drilled in 2006 to a depth of about 8,500 m, at the carbonate platform margin based on seismic data. This deep well cored five intervals of Cambrian rocks from 7,200 m to 8,400 m; all these carbonate rocks were completely dolomitized. Contrary to the conventional wisdom that deeply buried carbonate rocks generally have low porosity owing to cementation associated with pressure solution, the dolomitized core samples below 8,000 meters still preserve excellent intercrystalline and vuggy pores with porosities ranging from 0.6% to 9.1% and permeability from 0.03 to 34 x 10^3 μm^2.

Three types of dolomite, including two kinds of replacement dolomite and one type of cement, were identified in these Cambrian core samples. The replacement dolomite includes fine crystalline matrix dolomite with well preserved precursor lithologic texture; and coarse crystalline matrix dolomite with precursor textures completely destroyed. In addition, minor white saddle dolomite also occurs as cement in vugs and fractures. Despite distinct petrographic differences among the three types of dolomite, their oxygen, carbon and Sr isotopes overlap with each other with oxygen isotopes from -6 to -14‰ PDB, carbon isotopes from -1 to 1‰ PDB, and Sr isotopes from 0.7088 to 0.7093. This, together with the homogenization temperature (110 to 160 ^oC) measured from two phase aqueous inclusions in the saddle dolomite cements, suggests that saddle dolomite was probably related to hydrothermal fluids in a relatively closed system that was buffered by the geochemistry of host dolostones.

The results of this study suggest that Cambrian dolomite rocks in the Tarim Basin locally occur as excellent reservoirs in spite of deep burial. Hydrothermal processes played a critical role in formation of the dolomite reservoirs in this unusual deep burial setting. The occurrence of a regional seal for hydrocarbon traps, however, is a critical issue that needs to be addressed in assessing the possible deep dolomite play in the Tarim Basin.