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Pore fluid evolution, distribution and water-rock interactions of carbonate cements in red-bed sandstone reservoirs in the Dongying Depression, China

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The compositions, distribution and its interaction with rocks of the evolving pore fluids controls the distribution of carbonate cements and reservoir storage spaces [1]. The reservoir quality of the red -bed sandstone reservoirs in the Dongying Depression was investigated by an integrated and systematic analysis including carbonate cement petrology, mineralogy, carbon and oxygen isotope ratios and fluid inclusions. The investigation was also facilitated by probing the mineral origins, precipitation mechanisms, pore fluid evolution and distribution, and water-rock interaction of carbonate cements and their influences on reservoir quality. Completely fill the intergranular volume (CFIV) calcite cements formed during the shallow burial stage exhibit heavier carbon and oxygen isotopic compositions, and the input of evolving pore fluids in the interbedded mudstones is the main material source for the CFIV carbonate cement precipitation. Ferro-calcite, dolomite, and ankerite cements filling pores between sand grains displayed slightly lighter carbon and oxygen isotopic compositions and were formed during a late period. Organic CO₂ and associated feldspar dissolution are the main material source for this carbonate cement precipitation. Ca²⁺, Fe³⁺, and Mg²⁺ released by the clay mineral conversion in the reservoirs are also important elemental sources [2]. Higher ferro-carbonate content indicates stronger effects of organics on carbonate cement precipitation. The carbon isotope ratios of CO₂ equilibrated with the CFIV calcite cements along the boundaries of the red-bed sandstones are affected by CO₂ from the atmosphere in sedimentary water. The fluid concentration process during burial results in heavier oxygen isotope ratios of fluids during the precipitation period of the CFIV calcites. The carbon isotope ratios of CO₂ equilibrated with the ferro-calcite cements suggests a principal contribution from organics. The oxygen isotope ratios of fluids continue to increase, reflecting the fact that the water-rock interaction process leads to a higher salinity of formation fluids. The carbon isotope ratios of CO₂ equilibrated with dolomites and ankerites continue to decrease, indicating that the effect of CO₂ from organics becomes more significant. Oxygen isotope ratios of fluids are distinctly lower, which might be due to lower salinities of formation fluids caused by ferro-calcites precipitation. The distribution of pore fluids with varied properties in different periods controls the distribution of carbonate cements and reservoir spaces through the water-rock interaction. Pore fluids from nearby mudstones move from the edge to the center of sandbodies, causing strong calcite cementation along the sandbody boundaries and form tight cementation zones. The effects of pore fluid from interbedded mudstone gradually weakened from the boundary to the center of sandbodies. Pore fluids associated with organic acids and organic acid decarboxylation are mainly distributed in the internal portion of sandbodies, causing the dissolution of feldspar and the precipitation of ferro-carbonate cements. Affected by the tight layers along the boundaries of sandbodies, fluids therefore could not flow inside the boundaries during the late stage and the effect on reservoirs increases gradually from the sandbody boundary toward the centre. The distribution and evolution of pore fluids caused the zonal distribution of carbonate cements in the sandbodies over different periods. This may be advantageous to preserve the reservoir porosities as indicated by the distribution of high-quality reservoirs in the red-bed sandbodies.

References:

[1] Dutton S P (2008) Calcite cement in Permian deep-water sandstones, Delaware Basin west Texas: Origin, distribution, and effect on reservoir properties. AAPG Bull 92: 765-787

[2] Boles J R and Franks S G (1979) Clay diagenesis in Wilcox sandstones of southwest Texas: implications of smectite diagenesis on sandstone cementation. J Sediment Petrol 49: 55-70

