Origin and Distribution of Carbonate Cements With Implications for Reservoir Quality in Tight Gas Sandstones, Dongying Depression, Bohai Bay Basin, China

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ABSTRACT

Carbonate cements are the most abundant authigenic minerals in tight gas sandstone reservoirs in the Eocene Es4 interval and mainly occur in four phases: poikilotopic blocky calcite and dolomite, and isolated pore-filling ferroan calcite and ankerite. Highest abundances of calcite and dolomite cements (>25%) occur within 0.6m of sandstone-mudstone contacts and decrease abruptly towards the center of sandstone bodies. Positive δ13CPDB values for calcite and dolomite (-0.65‰ to +5.59‰) in the upper unit of Es4 interval (Es4s) suggest that dissolved carbon was mainly derived from methanogenic fermentation of organic matter in adjacent mudstone. In contrast, δ13CPDB values for dolomite are depleted (-7.45 to -2.57‰) in the lower unit of Es4 interval (Es4x) due to microbial sulfate reduction (MSR) in adjacent mudstone. The scarcity of detrital carbonate debris in sandstones also supports that internal sources were minor contributors to these non-ferroan carbonates. Ferroan calcite and ankerite occur in relatively low contents (<5%) at sandstone-mudstone contacts and are more concentrated towards the center of sandstone bodies. δ13CPDB for ferroan carbonates in Es4s are slightly depleted (+1.04 to +3.29‰) relative to calcite and dolomite and, thus, probably indicate a mixture of carbon derived from dissolution of early-formed calcite and dolomite in the sandstones, and minor contributions of organic carbon from adjacent mudstones. Depleted δ13CPDB in ankerite (-7.12 to -3.7‰) in Es4x are consistent with derivation from the early-formed dolomite. The origin and distribution of carbonate cements have significant implications for reservoir quality: 1) calcite and dolomite are resulted from microbial alteration of organic matter in adjacent mudstones; distribution patterns of these cements are related to the depositional facies and architecture of the sandstone-mudstone succession; 2) ferroan calcite and ankerite are products of local diagenetic redistribution of early-formed calcite and dolomite during burial; the redistribution of ferroan carbonates was controlled by diffusive transport of dissolved carbonate species over distances less than a few meters, and 3) tight carbonate-cemented zones commonly occur along the top and base of sandstone bodies with retention of partial or total primary porosity in the middle sections of sandstone bodies; the tightly cemented zones serve as fluid-flow barriers for petroleum resulting in significant heterogeneity.