Sulfate Mineralization, Thermochemical Sulfate Reduction, and Burial Diagenesis in Ordovician and Silurian HTD Reservoirs, Central Appalachian Basin

C.D. Laughrey, Pennsylvania Geological Survey

Hydrothermal dolomite (HTD) reservoirs in the Ordovician Trenton/Black River Limestone and Silurian Lockport Dolomite produce significant quantities of natural gas in the central Appalachian basin. The Lockport Dolomite also is a potential CO_2 sequestration target. The aerial extent of dolomitization is significantly different in the two reservoirs. HTD in the Trenton/Black River is restricted to fractured rocks in structurally low synclinal sags oriented en echelon to basement faults. Dolomitization in the Lockport is regional over much of the central Appalachian basin. Dolomite textures, porosity fabrics, and associated mineralization, however, are essentially identical in the two units and reflect the dominance of mesogenetic and telegenetic processes during burial diagenesis. The emplacement of calcium sulfate as a by-product of dolomitization was an important component in the textural evolution of these rocks. Anhydrite and gypsum partially replace dolomite and occur as cements in both fabric selective and non-fabric selective pores. Gypsum is restricted to relatively shallow reservoirs where it is partially replaced by anhydrite. Deeper dolostone reservoirs contain anhydrite interpreted as either dewatered gypsum or as primary anhydrite. Authigenic pyrite, bitumen, and methane occur as inclusions within the sulfate minerals. H_2S is produced from some of the dolomite reservoirs. The mean $\delta_{34}S$ of this gas is 14.7 permil which suggests that thermochemical sulfate reduction (TSR) of gypsum and anhydrite is the source of the sour gas. Additional evidence for TSR includes the presence of late solid bitumen and pyrobitumen, replacement of $CaSO_4$ by calcite, and reprecipitation of calcite and dolomite with Ca from dissolved sulfate minerals. Anhydrite and sulfur are sometimes concentrated on stylolite surfaces and authigenic metal sulfides are abundant in the dolostones. There is significant secondary porosity development associated with these burial diagenesis processes. Commercial gas accumulations in the Trenton/Black River and Lockport reservoirs are directly linked to the formation of this secondary porosity. These same diagenetic processes, however, also contribute to further cementation and porosity reduction as well as the generation of CO_2 and the concentration of N_2 in the rocks.