Origin of sulfate in the Lower Triassic Montney tight gas play: late diagenetic processes and isotope signature

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Over the past decade, the Early Triassic Montney Formation has evolved as western Canada's leading unconventional tight gas play. It is a complex succession, which consists primarily of siltstone deposited in a westward-thickening, lower shoreface to offshore environment. H_2S concentration in gas-producing wells is relatively high in the Montney Formation in western Alberta raising concern over both economic and environmental issues. To address this concern, several aqueous and stable isotope geochemistry-based studies have been undertaken focused mostly at the distribution, occurrence, and source of H_2S in the formation. However, the relationship between diagenetic and geochemical processes and water/rock interactions prompting H_2S generation has poorly been investigated. The current study particularly focuses on spatial variations in the late diagenetic events that caused H_2S generation and presents the preliminary results of detailed petrographic (optical and cathodoluminescence (CL) microscopy) and scanning electron microscopy (SEM) observations using a large regional core sample set from 12 wells located in western Alberta and north-eastern British Columbia.

The examined samples are mostly laminated dolomitic siltstone with dolomite, calcite, pyrite, anhydrite, and gypsum as the significant late diagenetic minerals. Dolomite occurs as two main types, non-ferroan (D1) and ferroan (D2), and displays a dull red to bright orange luminescence or non-luminescence under CL. D2 formed explicitly in the east, occasionally replaces the inclusion-rich D1 dolomite. Some dolomite crystals exhibit rounded crystal cores possibly of detrital origin. Similarly, two different types of non-ferroan (C1) and ferroan calcite (C2) are identified with C1 being replaced by D1. Little or no calcite cement is observed in the east of the study area. Pyrite framboids and euhedral crystals formed during early to late stages of diagenesis. Late diagenetic euhedral pyrite enclosing tiny crystals of dolomite, quartz and feldspar, is overgrown with framboids. Anhydrite occurs as blocky and poikilotopic cement as well as replacive form. With a substantial increase in abundance to the east (western Alberta), it encloses or replaces dolomite and calcite crystals. Poikilotopic and euhedral tabular gypsum is only observed in the east. The high H_2S concentration in western Alberta coincides with noticeable change in type and abundance of sulfate phases.

The occurrence of framboidal and euhedral pyrite highlights the role of bacterial and/or thermal sulfate reduction in H_2S generation. It suggests that the basement fault network may have played a key role in transferring sulfate-rich basinal brine in western Alberta and feeding the system with required dissolved sulfate for bacterial/thermal sulfate reduction. The system was regularly supplied with dissolved sulfate resulting in production of H_2S through bacterial/thermal sulfate reduction and formation of ubiquitous late stage anhydrite from extra sulfate influx. Further detailed trace element, sulfur, and oxygen isotope analysis will assist in unravelling the process(s) controlling high H_2S generation in the study area.