Falher and Cadomin Diagenesis and Implications for Reservoir Quality

Nicholas B. Harris[1]

[1]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada

Abstract

The Barremian – Aptian Cadomin Formation and the Lower Albian Falher Member of the Spirit River Formation of northwestern Alberta are both are significant hydrocarbon reservoirs in the deep basin part of the Western Canada Sedimentary Basin. Equivalents of parts of the Lower and Upper Mannville of central and eastern Alberta (Hayes et al., 1994), these units are characterized by intervals of coarse sediments, notably including conglomerates, because of their proximity to the Cordilleran Uplift to the west. A series of regressive Falher tongues extending north and northeast into the basin have been designated A through at least F, with a Falher G identified and described by Zonneveld and Moslow (2004); these are sandwiched between finer grained basinal sediments of the Wilrich Member. The coarse tongues of Falher sediment are interpreted as strandline and shoreface deposits (Caddel and Moslow, 2004). While Cadomin lithologies are similar, depositional environments are interpreted as alluvial fan deposits derived from the Cordillera, locally reworked by a northward-flowing paleo-Spirit River.

In both formations, porosity and permeability values are generally low. Falher porosities are rarely greater than 15% at depths of 1700 to 2000 metres and rarely greater than 8% at depths of 2500 to 3000 metres. Porosities in this Cadomin dataset range from 0 to 8%from 2400 to 2900 metres burial depth. Permeabilities are generally less than 10 mD at depths of 2400 to 3000 meters but many are locally as high as 1000 mD at 1700 to 2000 metres in the Falher.

The two formations share many common characteristics. Reservoir lithologies include sandstones and conglomerates. All conglomerate and some sandstone samples are lithic arenites in composition, with chert as the dominant lithic fragment; in some samples, as much as 90% of the sedimentary grains are chert. A small fraction of the sandstones is quartz arenites.

Rock composition strongly influences diagenetic trends and in turn reservoir quality. Quartz arenite sandstones are strongly cemented by quartz and/or calcite, largely accounting for their low porosity, an observation similar to that of Cant and Ethier (1984). Cement volumes are lower in conglomerates and litharenite sandstones, but intergranular volume is also lower, indicating greater porosity loss due to compaction. Compaction included both mechanical compaction and pressure solution, the latter providing a significant source of quartz cement. Clay minerals, in particular kaolinite and less commonly mixed layer illite/smectite, are locally significant, affecting both porosity and permeability.

The smaller amounts of quartz cement in the lithic arenites are associated with presence of small, randomly arranged quartz crystals, from 1 to 5 μm in diameter. Consistent with observations from other formations (Aase et al., 1996; French et al., 2012), the presence of microcrystalline quartz appears to retard the formation of macrocrystalline quartz cements that are substantially responsible for porosity loss in quartz arenite samples.

Original rock composition and diagenesis not only influence the absolute amount of porosity but also the type of porosity present. Quartz arenite sandstones have lower overall porosity but a higher proportion of primary macro-porosity. Litharenite sandstones and conglomerates have higher overall porosity but a higher proportion of secondary porosity. Secondary pores are largely developed in chert grains; these pores are typically a few microns in diameter and while they are connected to the network of large pores and provide storage volume for hydrocarbons, they contribute relatively to the overall permeability of the rock.

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