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Regional Stratigraphic and Diagenetic Framework for the Basal Cambrian Sandstone, Alberta

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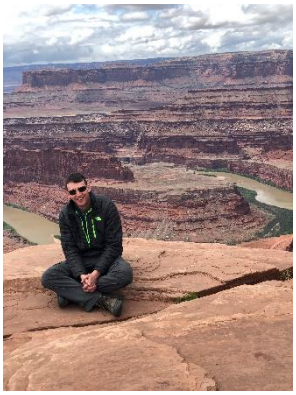
Abstract

The Basal Cambrian Sandstone (BCS), 25-100 m thick at burial depths of 1000-3600 m has become the focus of increasing Carbon Capture and Sequestration (CCS) efforts in western Canada. Shell's Quest facility, for example, has sequestered >7 Mt of CO2 in the BCS near Fort Saskatchewan since 2015 and applications for additional Hubs have been received by the government. Despite increasing activity, public domain data related to the interval's sedimentology and stratigraphic architecture is sparse (Desjardins et al., 2013; Herbers et al., 2022). To address this limitation on the unit's characterization, twenty-eight cores have been investigated and provide new data from which a regional stratigraphic and diagenetic framework can be developed with direct implications for characterization and modeling of its properties.

Four facies associations consisting of fourteen distinct facies indicate the presence of 1) open-marine, 2) deltaic, 3) terrigenous channel fill, and 4) tidally-dominated subtidal depositional systems on a regionally extensive shelf. Deposition of anomalously thick intervals of BCS dominated by estuarine mouth-bar deposits in proximity to Cold Lake, a region with significant oil sands development in Cretaceous deposits, preserve evidence of syn-depositional faults that created extra accommodation. Facies within the BCS become more fluvially dominated towards the southern portion of Alberta, where the BCS becomes alluvial-fluvial in nature with characteristic "bell-shaped" gamma curves calibrated to core data. Towards the southwest and western portion of the province a substantial decrease in the net-gross sand is observed. This is attributed to a transition to distal offshore marine depositional environments with increased mudstone. Stacking patterns in the BCS have been interpreted to record three regionally mappable transgressions, each demarcated by a flooding surface. BCS deposition terminates with a large maximum flooding surface (MFSx) that deposits fully marine offshore mudstone atop of marginal-marine tidally-influenced strata. Above this MFSx a series of marine progradational parasequences are preserved.

Burial diagenesis of the BCS and the associated impacts on porosity and permeability has been evaluated from core data. Interstitial clay and silt were found to be a critical control on permeability and even a 2-3% increase in clay content has been found to reduce vertical and horizontal permeability by three orders of magnitude, even in coarse-grained sediments. Feldspar content varies greatly with certain facies containing up to ~10% potassium feldspar. The BCS becomes increasingly feldspathic up-section, which can be tied to depositional cycles within a transgressive system. Additionally, evidence for secondary porosity is observed in abundant leached quartz grains suggesting the circulation of highly alkaline fluids. Petrographic and XRD results show that cements, mechanical and chemical compaction, and grain size sorting play a significant role in controlling the distribution of porosity and permeability. A better understanding of these relationships is critical to understanding injectivity of the formation and should be incorporated in associated geological models.

Biography



Dave Herbers is a geologist at the Alberta Geological Survey currently working on CCS/CCUS initiatives. He received his B.Sc. in geology from the University of Alberta in 2013, and his M.Sc. in geology from the University of Alberta in 2016. After graduation he spent 5 years working at Husky Energy/Cenovus in heavy oil and deep basin development. Dave has worked the basal Cambrian and Lower Paleozoic since 2013, working on intervals across Western Canada and the Canadian Arctic. He has spent a significant amount of time describing and interpreting basal Cambrian intervals in the Mackenzie Mountains, Colville Hills, and Great Slave Lake regions in addition to his work on the Basal Cambrian Sandstone within Alberta.