Upper Monteith and Lower Beattie Peaks Formations at the Sinclair and Albright fields in westcentral Alberta: some views into the reservoir properties

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Summary

Rocks from Nikanassin strata at the Sinclair, Albright and Knopcik fields in the study area (Figure 1) are the reservoirs for several gas, and mixed oil and gas pools. According to the gamma ray log responses, continuous and discontinuous, medium thick to tickly bedded sandstone packages can be locally mapped adjacent to the stratigraphic boundary of the Monteith and Beattie Peaks formations[1]. However, productive intervals are associated with the Monteith Formation, excluding the overlying Beattie Peaks unit; this log response is especially notable as the formation is buried more deeply (e.g., southwest of the study area). In this work, cores from two wells located in the southeast portion of the Sinclair field, and the north part of the Albright field, respectively, are analyzed sedimentologically and petrographically. This approach provides further insights into several geological factors affecting gas production potential of the investigated intervals.

The present study is based on the analysis of cored intervals from two wells located in the southeastern portion of the Sinclair field, and the north part of the Albright field (Figure 1). Core description, thin section and microprobe analyses are combined to yield a description of the more dominant macroscopic and microscopic features likely affecting the gas flow within the investigated stratigraphic intervals.

Monteith and Beattie Peaks formations at the Sinclair and Albright fields

The Monteith and Beattie Peaks formations are the lower and middle units of the Nikanassin strata in the subsurface of Alberta. These rocks are represented by a Late Jurassic-Early Cretaceous prograding clastic wedge deposited along the eastern margin of the Canadian Cordillera[1,2]. The Nikanassin represents preferentially gas-bearing strata in most areas of the Deep Basin and the Foothills of Alberta and British Columbia[3]. The Monteith and lower part of the Beattie Peaks formations are the only preserved intervals below the sub-Cadomin unconformity in the eastern margin of the basin; although zero-edge sub-crop for these formations is reached further east.

Microscopically, the most remarkable differences between both stratigraphic intervals are the upward increase in grain size and lithic particle content. At the microscopic level, it becomes obvious the abundance of diagenetic minerals and cements plugging back the porous spaces, especially on Beattie Peaks' samples. Sandstones within the Beattie Peaks formation are primarily cemented by quartz overgrowths; however, the presence of subsequent diagenetic clays, calcite, and organic matter staining (pyrobitumen?) completely obliterates any remnant porosity in these rocks. Quartz overgrowths are also the primary cement within Monteith sandstones, with minor dolomite and calcite filling remnant primary intergranular pores. Also within the Monteith, porosity is mostly represented by microporosity in altered feldspar and chert fragments, connected by a network of crenated, seam-like pores. Thus, the presence of elongated seam-like pores is interpreted to represent the dominant flow mechanism in these low permeability gas reservoirs.

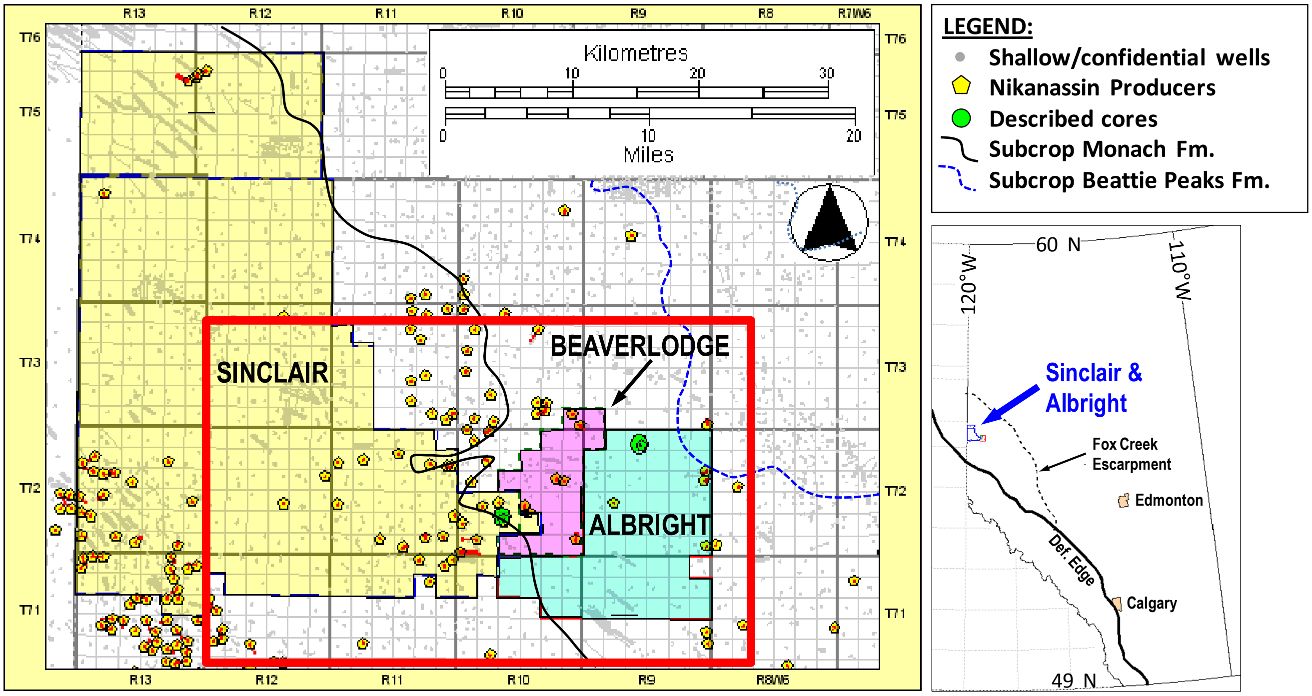

Figure 1 – Location of the study area and the described cores used for this study. Wells with gas production from undifferentiated Nikanassin strata are highlighting the wells with. Subcrop edges indicated for the Monach and Beattie Peaks Formations are from Miles, 2010.

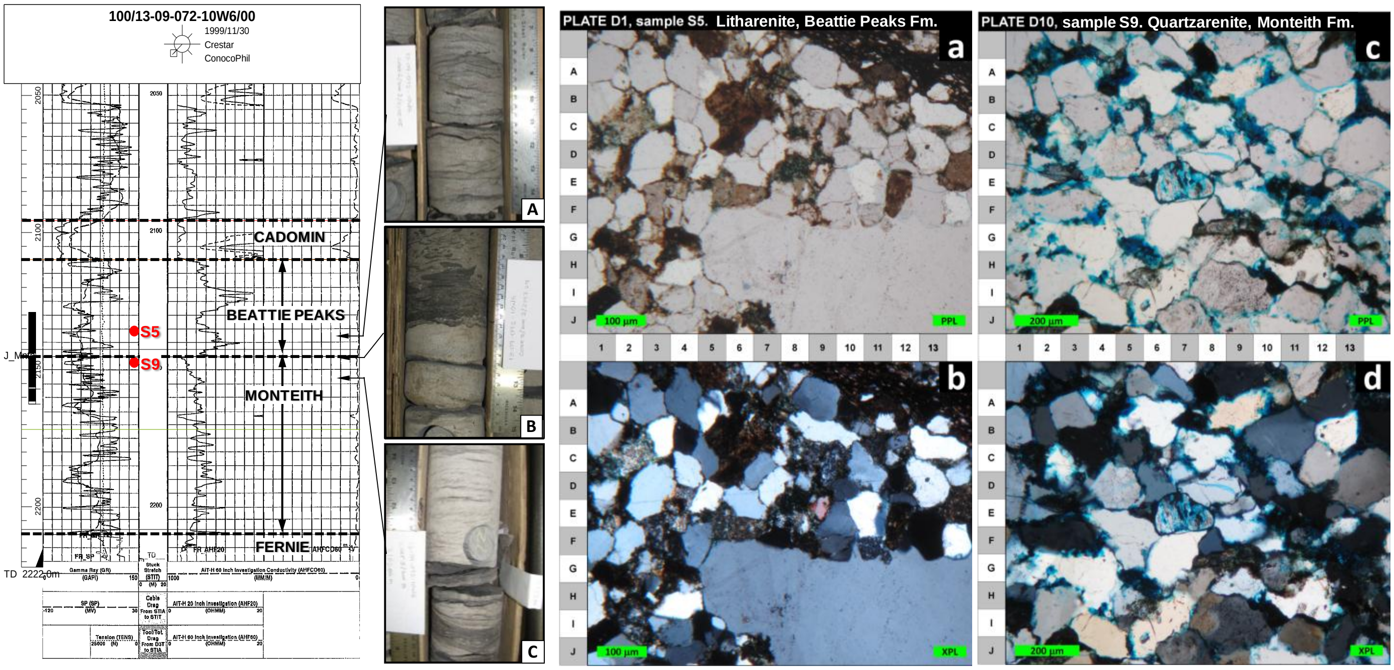

Figure 2 – Interpreted well log illustrating the Monteith / Beattie Peaks formations boundary at location 13-09-072-10W6. Red circles labeled S5 and S9 indicate the location of the two thin section plates to the right. Core photographs for specific depths within cores 2 and 3 are located in the second column of the figure, with core diameter equal to 3.5 inches for scale. Notice the abrupt contact in the central picture, marking the interpreted boundary between the Beattie Peaks and Monteith formations. Thin section microphotographs from samples S5 and S9 (identified in the well log) are displayed in the two columns to the right, with the upper and lower pictures taken under plane polarized, and cross-polarized light, respectively. Blue dye epoxy in the thin sections highlights the porous spaces, especially visible in the microphotographs from sample S9.

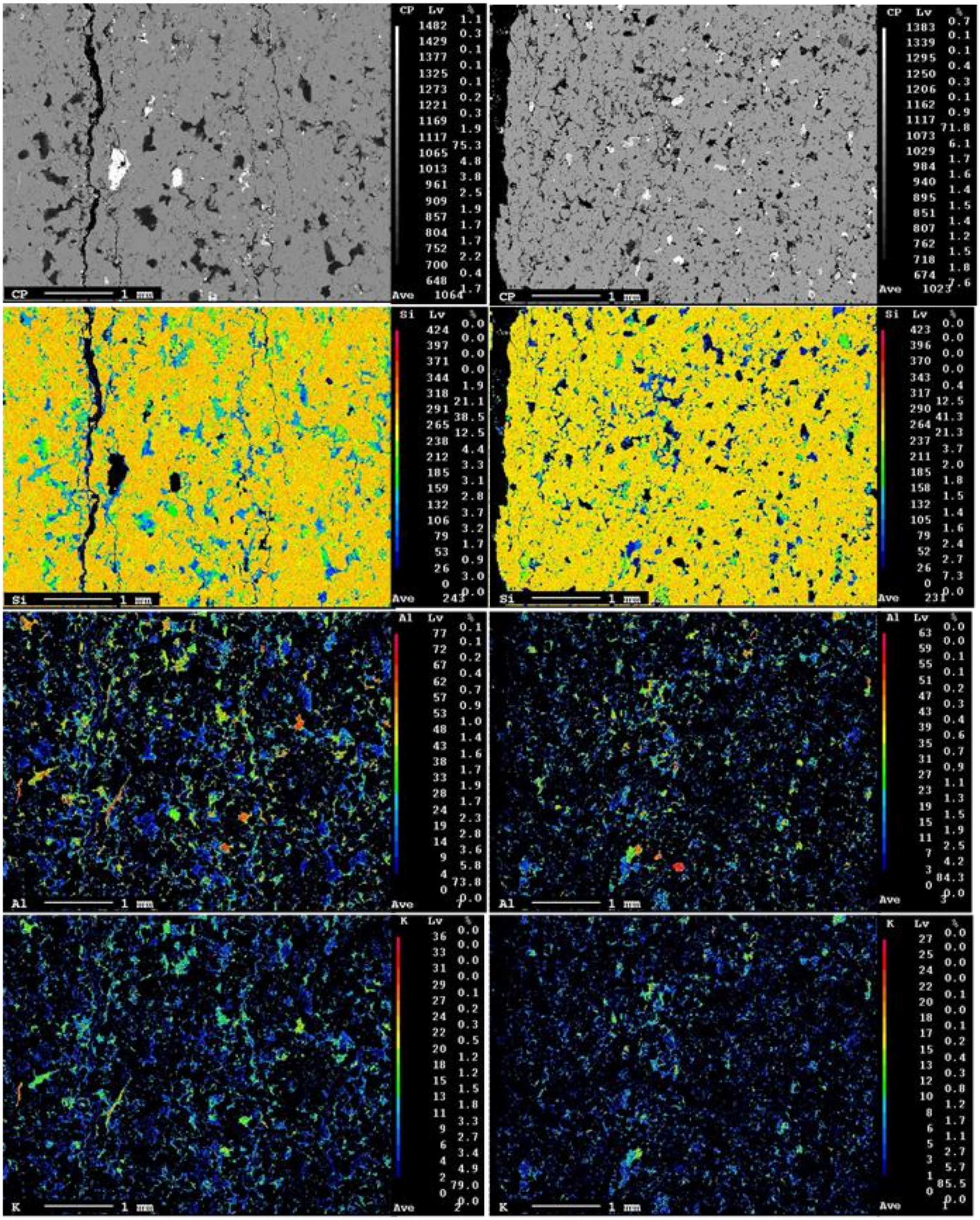

Figure 3 – BSE + CEM photomicrographs that shows the distribution of Silica (Si), Aluminum (Al), and Potassium (K) from a portion of thin section slides prepared from subsurface cores. Samples correspond to the Beattie Peaks (left; corrected depth: 2128.03 m), and Monteith (right; corrected depth: 2150.50 m) formations from location 13-09-072-10W6.

Porosity and permeability values reported from routine core analysis measurements range between 1% and 15%, whereas permeability is 0.01 md and 2 md for both formations, respectively. In most cases, permeability is 1 to 2 orders of magnitude larger within the Monteith, compared to the Beattie Peaks Formation. From the described cores, the Monteith Formation is represented by very fine to fine sand-sized, light grey to light brown sub-litharenite. Detrital fragments are mostly very angular to sub-rounded monocrystalline quartz, with minor amounts of chert and shale fragments. In contrast, for the Beattie Peaks sandstones, grain size is usually larger (very fine to lower medium sand-sized) with up to 45% of detrital fragments (e.g., non-quartz), making them a litharenite. This detrital content gives these rocks a dark grey, sand & pepper appearance on core-sized samples.

Considering this difference in mineralogy, the interpreted geological boundary between the Monteith and Beattie Peaks formations is found to be usually abrupt. Although the nature of this contact shows some evidence of multiple, locally present erosional surfaces, it is rather associated with overlying channel-like deposits from prograding coastal plain facies. In well logs, this mineralogical change is associated with an abrupt upwards increase in resistivity values, reflecting the reduced porosity of the overlying Beattie Peaks Formation.

Figure 3 shows images of backscattered electron (BSE) and chemical elemental maps (CEM) gathered from thin section samples using a JEOL JXA 8200 electron probe microanalyzer, available in the Geoscience Department at the University of Calgary. This probe emitted a beam current of 20nA with an accelerating voltage of 15kV. In this figure, elemental maps for Silica (Si), Aluminum (Al), and Potassium (K) are shown from samples S2 (Beattie Peaks Fm.) and S10 (Monteith Fm.) from location 13-09-072-10W6. The original detrital framework of the samples is slightly visible in the BSE and silica CEM (Figure 3). Dark spots in the BSE image correspond to solidified organic rich stains (within microporosity in detrital fragments). This microporosity was frequently associated with previous alteration of feldspars, shale and chert fragments. The relative abundance of organic-rich staining (pyrobitumen?) in the Beattie Peaks compared to the Monteith Formation sandstones infers it was a better pathway for upwards liquid hydrocarbon migration.

Low intensity values in the aluminum CEM (green and blue colors in Figure 3,) are interpreted as clay particles in both rocks, whereas high intensity pixels are more likely associated with feldspars and other detrital aluminum-silicate fragments. According to this interpretation, clay minerals are more abundant in the sample from the Beattie Peaks Formation. Moreover, these clays are usually found forming a coating rim around detrital fragments (Figure 2, Plate D1), and between enfacial quartz overgrowth contacts in adjacent quartz grains. Thus these clay rims / lineaments can be interpreted as evidence of pre-existing slot-like pores in these rocks.

For the case of the Beattie Peaks formation, these features are no longer open being completely blocked by clay minerals. On the other hand, they seem to be at least partly open within the Monteith formation, thus providing some degree of connectivity for microporosity that is present within chert and feldspar fragments.

Conclusions

The relatively low production potential observed for the Beattie Peaks formation is likely due to sequential stages of pore occlusion by quartz, clays, calcite and organic matter (probably pyrobitumen) during the diagenetic history of these rocks. These materials completely filled the pores, leading to near zero storage capacity. In addition, the reduced amount of porosity (and associated pore water) is also reflected in the relatively high resistivity of these rocks. The dominant pore structure in the underlying Monteith formation is dominantly represented by seam-like pores from quartz overgrowths and microporosity from altered feldspar and chert fragments. While the crenated pores provide the flow capacity, the later contributes to the storage capacity of the rocks.

Acknowledgements

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