Chemostratigraphy as an Exploration Tool in Low-Accommodation Incised Valley Systems; An Example From the Lower Cretaceous Basal Quartz in Southern Alberta, Canada

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Summary

Although many oil and gas accumulations occur in fluvially deposited low-accommodation Incised Valley settings, successful exploration is often hampered by the difficulty encountered when attempting to develop regionally robust stratigraphic frameworks.

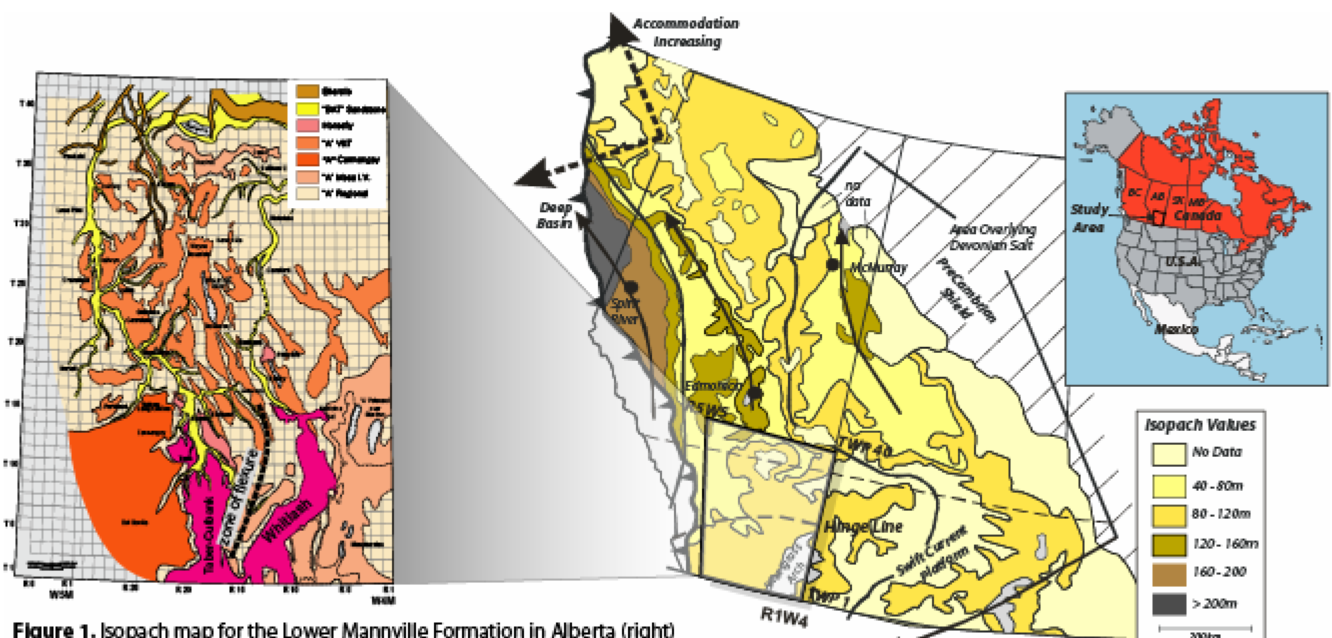

Figure 1. Isopach map for the Lower Mannville Formation in Alberta (right) and subcrop map of the component units within the Lower Mannville Formation (left)

Development of such stratigraphic frameworks is vitally important when there is potential for the juxtaposition of sandstone reservoirs that while superficially appearing similar can have markedly different reservoir properties. Using the Basal Quartz of southern Alberta as an example, this paper demonstrates how by integrating the results of regional mapping studies with mineralogical and whole rock inorganic geochemical data (i.e. chemostratigraphy), a better understanding of the stratigraphy, paleogeography and distribution of reservoirs in a low accommodation, fluvially dominated foreland basin setting can be achieved.

The Basal Quartz in the study area (Fig. 1) is a classic example of a fluvial - estuarine sequence deposited in a low accommodation foreland basin setting. Furthermore, it has been extensively drilled and cored, providing an ideal dataset for detailed stratigraphic studies that can provide insights for exploring similar, but less extensively developed, provinces. Lithologically, the Basal Quartz comprises predominantly medium grained, fluvial to estuarine sandstones and pedogenically altered claystones. Regional studies have demonstrated that within the Basal Quartz, there are two stacked cycles, each recording upward increasing sediment maturity (Zaitlin *et al.,* 2002). The upper of these two cycles is further sub-divided into three informal units, in stratigraphic order, the Horsefly, the Bantry – Alderson – Taber (BAT) and the Ellerslie. The work of Zaitlin *et al*. (2002) was based on regional mapping and identification of subtle changes in mineralogy between the three units (Figs. 2 & 3). Here, we will initially demonstrate that each of these units has a distinctive whole rock inorganic geochemical “fingerprint” after which lateral changes in mineralogy and geochemistry of the Horsefly unit will be considered in more detail, before postulating a depositional model that explains the observed data.

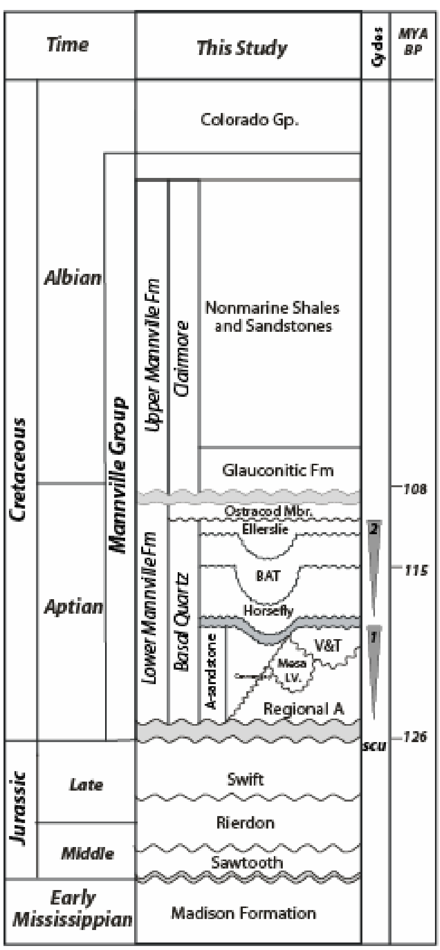

Figure 2. Stratigraphic Summary

The Horsefly, BAT and Ellerslie are all interpreted to be present in well 15-32-10-18W4, which is here used as a “type section” In this core, three stacked sandstones, each separated by an unconformity are present (Fig. 4). However, each stratigraphic unit has a markedly different whole rock geochemistry in both claystone and sandstone lithologies (Figs. 3 and 4). By combining the results from well 15-32-10-18W4 with those of Ratcliffe *et al*. (2004), who characterized the fine-grained deposits of the Basal Quartz using whole rock geochemistry (Fig. 3), it is possible to place any Basal Quartz well-bore penetration into one of the three informal units defined by Zaitlin *et al*. (2002). This approach of using whole rock inorganic geochemistry data to characterize and correlate sediments is commonly referred to as chemostratigraphy.

The lowermost unit of the Basal Quartz, namely the the Horsefly, was deposited in two discrete valley systems separated by a paleodrainage divide (Zone of Flexure on Fig. 1) (Zaitlin *et al*., 2002). Channel dimension data show that the western valley system, the Taber-Cutbank Valley, becomes wider and shallower to the north, as would be expected from a south - north flowing system. However, data from the eastern valley system, namely the Whitlash Valley, lead Zaitlin *et al*. (2002) to postulate that this valley system is a north - south flowing tributary of the Taber-Cutbank Valley (Fig. 1). Here, we present evidence from whole rock inorganic geochemical data and thin section observations that support this hypothesis put forward by Zaitlin *et al*. (2002).

Geochemically, the Horsefly unit in the Whitlash and Taber-

Cutbank valleys are markedly different (Fig. 6). Both the sandstones and claystones of the Taber-Cutbank Valley have higher K/Al and Rb/Al values than the equivalent lithologies of the Whitlash Valley. These geochemical changes are interpreted to indicate that the Whitlash Valley system was deposited in a lower accommodation setting than the Taber-Cutbank valley system and that the sediments of the former valley were subjected to more prolonged and intense weathering than those of the Taber- Cutbank Valley. This interpretation is

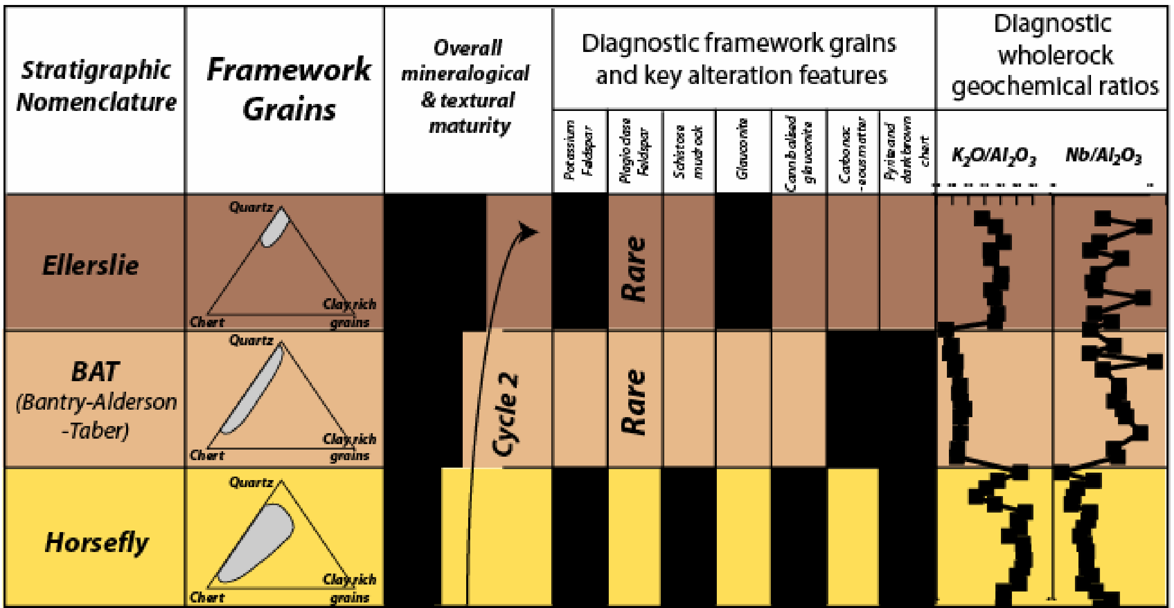

Figure 3. Mineralogical and geochemical differentiation of the Horsefly, BAT and Ellerslie. Whole rock geochemical data are derived from silty claystone lithologies (from Ratcliffe *et al.*, 2004). See Fig. 4 data for sandstone lithologies

supported by petrographic data that the sandstones of the Whitlash Valley have suffered greater feldspar dissolution than those of the Taber-Cutbank Valley. Furthermore, the Horsefly in the Taber-Cutbank generally has higher Zr/Al values and lower Na/Al values than it does in the Whitlash Valley. Changes in these two parameters can be interpreted to imply that the sandstones of the Taber-Cutbank Valley contain more zircon and less plagioclase and/or mica than do those of the Whitlash Valley. Although with the current dataset, it is not possible to postulate the exact sediment provenance, the inferred changes in detrital mineralogy indicate that the Horsefly sandstones in the Whitlash and Taber-Cutbank valleys have been sourced from different sediment provenances. Petrographic analyses indicate that the Horsefly sandstones of the Whitlash Valley have been subjected to less transportation, implying that they are derived from a relatively local source. The sandstones of the Taber-Cutbank, however, have been transported a greater distance, supporting the whole rock geochemical evidence of two different sediment provenances.

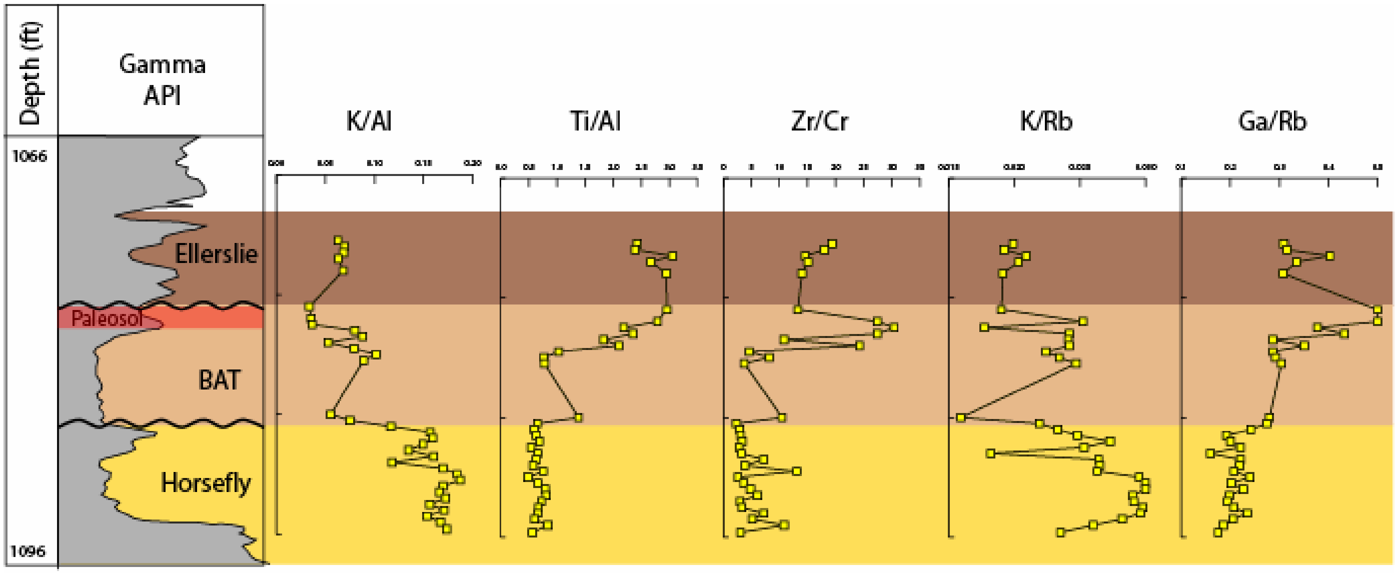

Figure 4. Geochemical logs constructed for sandstone samples in well 15-32-10-18-w4.

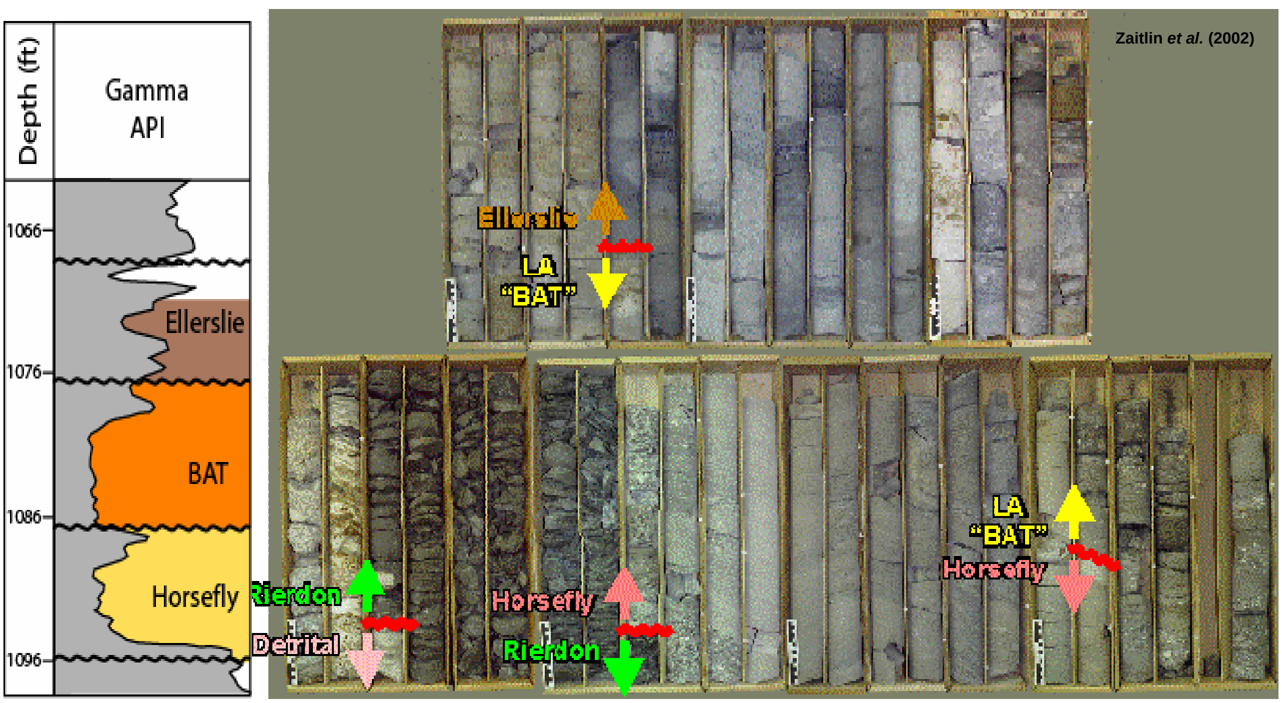

Figure 5. Core photograph of the type well 15-32-10-18W4 displaying the Horsefly, BAT and Ellerslie sequences.

The difference in sediment provenance identified from changes in the whole rock geochemical data between the two valley systems indicates that although homotaxial, the Horsefly in the two valley systems cannot have been deposited synchronously by a single northward flowing river system. Evidence for greater residence time at the surface from both petrographic and geochemical data implies that accommodation was decreasing to the east, making a NE flowing drainage system in the Whitlash valley improbable. When combined with the valley architecture data, these lines of evidence strongly suggest that the Horsefly sandstones in the Whitlash Valley were deposited by a north -south flowing river system that drained into the south - north flowing Taber-Cutbank Valley system.

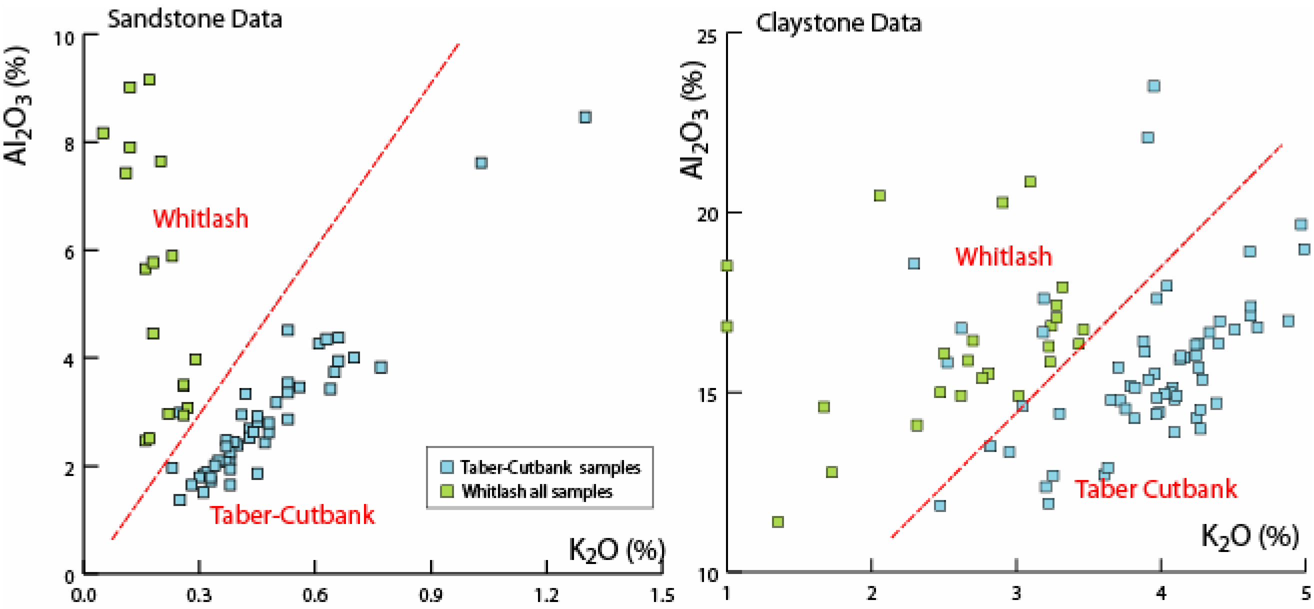

Figure 6. Binary diagrams constructed to differentiate of the Horsefly in the Whitlash and Taber-Cutbank valleys using sandstone and claystone data.

References

Ratcliffe, K.T., Wright, A.M., Hallsworth, C., Morton, A., Zaitlin, B.A., Potocki, D. & Wray, D.S. 2004. Alternative correlation techniques in the petroleum industry: an example from the (Lower Cretaceous) Basal Quartz, Southern Alberta. *Bulletin of the American Association of Petroleum Geologist*, 88, pp. 1419-1432.

Zaitlin, B. A., Potocki, D., Warren, M.J., Rosenthal, L. & Boyd, R. 2002. Depositional styles in a low accommodation foreland basin setting: an example from the Basal Quartz (Lower Cretaceous), southern Alberta: Bulletin of the Society of Canadian Petroleum Geologists, v. 50, pp. 31-72.