Chemostratigraphic Differentiation Between Time-Equivalent Low Accommodation Incised Valley Systems in a Foreland Basin Setting: An example from the Lower Cretaceous Horsefly Unit of the Basal Quartz Formation in Southern Alberta, Canada

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Low-accommodation, non-marine settings commonly contain significant oil and gas accumulations. The development of rigorous stratigraphic frameworks in such low-accommodation settings is often problematic due to polyphase erosion and incision resulting in lithologically similar, but chronostratigraphically different units being juxtaposed. Furthermore, the common lack of regionally extensive marker beds and poor biostratigraphic control make correlation problematic. Therefore, alternative stratigraphic techniques that enable each depositional tract to be characterized regardless of its spatial distribution are required.

In the study area (Fig. 1), the Basal Quartz Formation is generally less than 100m thick and is composed of dominantly fluvial to estuarine sandstones and pedogenically altered claystones. Previous work has demonstrated that within the Basal Quartz Formation, there are two stacked cycles, each recording upward increasing sediment maturity ((Zaitlin *et al.,* 2002), Fig. 2). 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 units.

Whole rock geochemical data derived from both claystones and sandstones can be used to differentiate between the Horsefly, BAT and Ellerslie units (Fig. 3). It is also demonstrated that within the Horsefly unit significantly different geochemical signatures exist between eastern (i.e., Whitlash) and western drainages (i.e., Taber-Cutbank).

Chemostratigraphy, the technique of sediment characterization using variations in inorganic whole rock geochemistry, has previously been applied to characterization of the fine grained lithologies within the Basal Quartz Formation (Ratcliffe *et al.,* 2004). That study demonstrated that variations in the geochemistry of claystones provide a means to differentiate the Horsefly, the BAT and the

Ellerslie. This paper demonstrates that geochemical data for sandstones can be used to differentiate between these lithostratigraphic units based on changes that relate to major variations in palaeoclimate and sediment provenance through time (Fig 3).

In more detail by integrating geochemical data and sedimentological criteria, it is possible to model sediment dispersal patterns within individual units. For example, within the Horsefly clear geochemical differences are exhibited between the eastern (Whitlash) and western (Taber-Cutbank) drainages. These variations are attributed to differences in accommodation and surface residence times which effect weathering and reservoir alteration between the two drainages. Zaitlin *et al.* (2002) demonstrated that the Horsefly was deposited in two discrete valley systems, separated by a paleohigh (Zone of Flexure on Fig. 1). Channel width: depth and thickness: depth versus distance plots for each drainage show that the Whitlash system becomes thinner and narrower to the north, tentatively suggesting a south to north drainage system. In contrast, the Taber-Cutbank trunk incised valley system becomes wider and shallower toward the north (Vulcan Structure), typical of a northward flowing valley system.

Geochemically, the major differences between the Horsefly of the Whitlash and Taber-Cutbank systems are (Fig. 4):

1) Lower K/Al and Rb/Al values of the component sandstones (Fig. 4), reflecting a greater proportion of kaolinite within the Horsefly of the Whitlash system.
2) Lower K/Al and Rb/Al values of the component claystones (Fig. 4), including those where palaeosol development is evident, reflecting a greater proportion of kaolinite within the Horsefly of the Whitlash system.

The inferred abundance of kaolinite within both the sandstones and the claystones, including the palaeosols, of the Whitlash Horsefly suggests that these sediments have been subjected to more prolonged or more intense syndepositional weathering. This evidence supports the hypothesis that the Whitlash was an area of lower accommodation and increased residence time than the Taber-Cutbank system during deposition of the Horsefly.

Further support for the Whitlash being a tributary of the Taber-Cutbank is provided by the two most southerly wells of the Whitlash (4-5-1-9W4 and 8-34-3-11W4; Fig. 1). The Horsefly sandstones in these two wells have similar K/Al and Rb/Al to others in the Whitlash, however, the Zr/Al (zircon abundances) and Na/Al values (plagioclase abundances) of the Horsefly sandstones in these wells are similar to those of the Taber-Cutbank (Fig. 4). This suggests that the sediment provenance of the Taber-Cutbank strongly influenced the southerly parts of the Whitlash drainage and probably reflects a confluence of the two valley systems along the Township 1-3 areas (Fig 1.). However, the Taber-Cutbank provenance signal appears not to have extended into the northern part of the Whitlash drainage.

The study also demonstrates that the Horsefly in the Taber-Cutbank generally has higher zircon contents (modelled using Zr/Al values) but lower plagioclase feldspar contents (modelled using Na/Al values) than the Horsefly within the Whitlash I.V (Fig. 4). 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 systems have been sourced from different sediment provenances. Additional data from the Montana area which lies to the south of the current study area is required to test the hypothesis that the two drainages are sourced from two different provenances.

References

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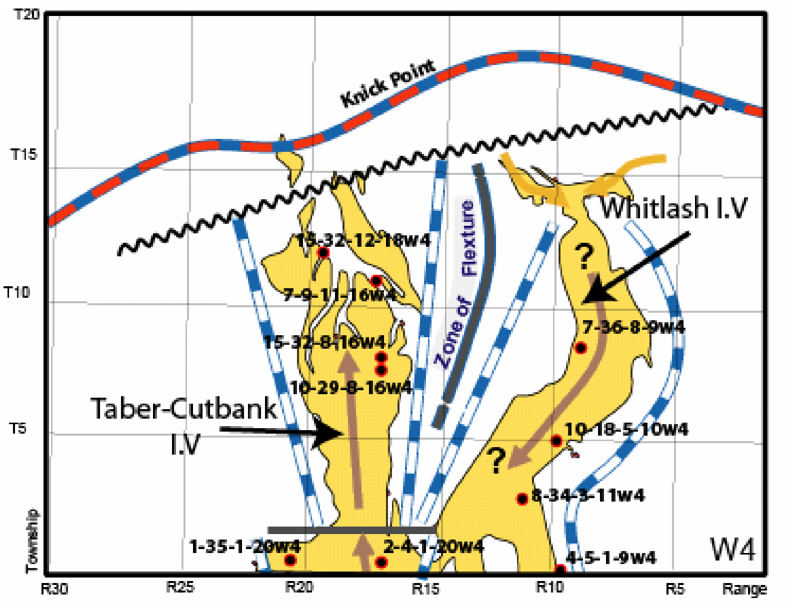

Figure 1. Location map of study wells placed on a palaeogeographic reconstruction taken from Zaitlin et al. (2002)

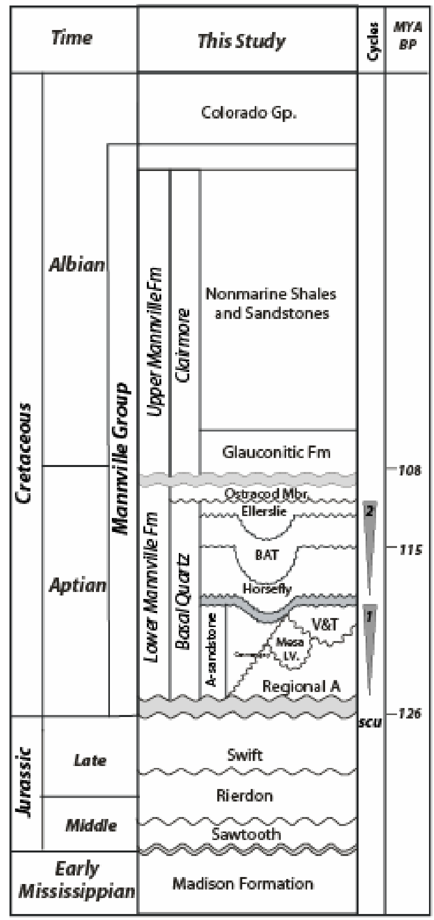

Figure 2 Stratigraphic summary.

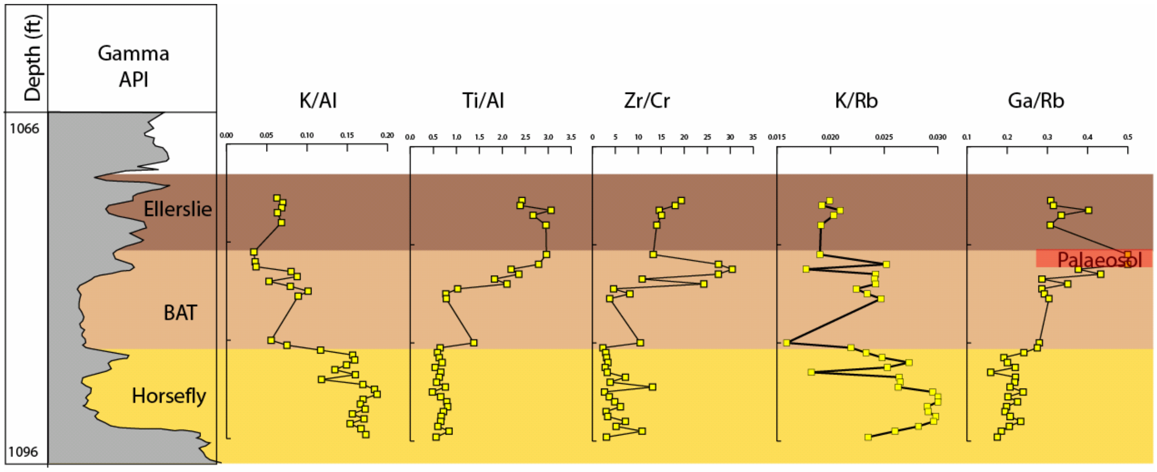

Figure 3. Geochemical logs constructed for sandstone samples in well 15-32-10-18-w4, demonstrating the marked changes in geochemistry of the Horsefly, BAT and Ellerslie.

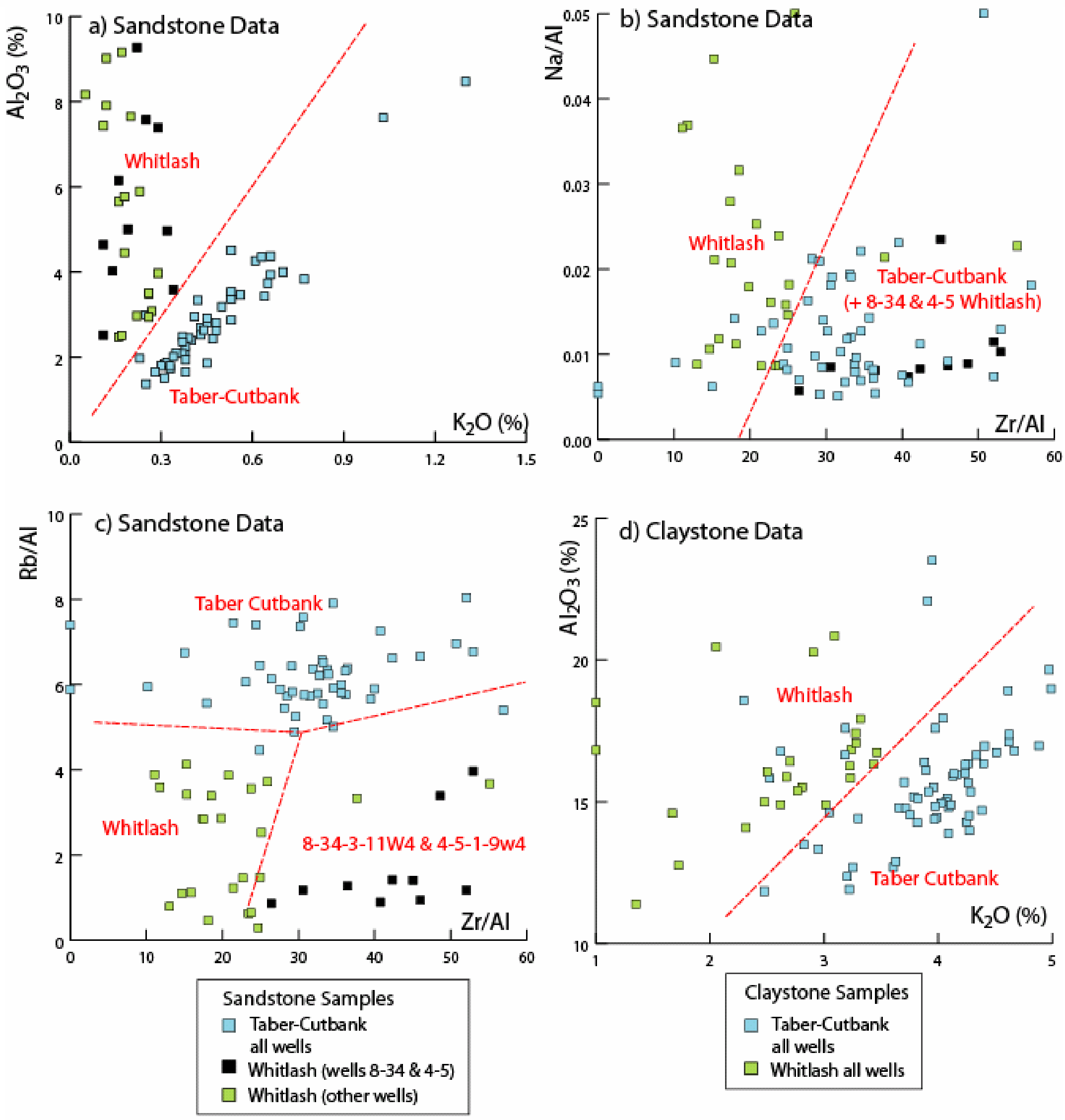

Figure 4. Binary diagrams constructed to demonstrate a-c) differentiation of Whitlash I.V. Horsefly from Taber-Cutbank I.V. Horsefly using sandstone data d) differentiation of Whitlash I.V. Horsefly from Taber-Cutbank I.V. Horsefly using claystone data.