Lithologic and Stratigraphic Analysis of the Frenchman Formation in the Chambery Coulee, Southeast of Eastend, Saskatchewan, Canada

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May 21, 2015

Abstract

The Frenchman Formation in the Chambery Coulee is predominantly composed of two lithostratigraphic units: a sand-dominated unit and a clay-dominated unit. These repeating units are found throughout the valley. Five vertical transects were performed between May 15–16, 2015. The features, textures and structures of the strata were described and subsequently correlated on a cross-section. The clay-dominated sedimentary units for far more frequent in the section of the valley studied. This is believed to be related to a relatively low energy depositional environment. Thereby, sand-dominated units indicate periods of higher energy due to fluvial activity and/or infrequent high energy events in the floodplain.

Introduction

Based on identifiable plant remains that were found to be associated with fossils from a *Tyrannosaurus rex* in the Frenchman Formation in southwestern Saskatchewan, McIver (2002) set out to better understand the paleoenvironment of the region. She found that the region would have been a mesothermal climate without significant winter frost, but with seasonal precipitation. Due to the deciduousness of the flora content studied, McIver (2002) remarks that important questions regarding how large herbivores and therefore large carnivores could subsist during winter without vegetation and how migration may have been a contributing factor for their survival. Kupsch (1957) reviewed previous works and examined 49 sections from the Frenchman Formation to better correlate it within surrounding formations and the contents within.

The data collected for this report was performed on May 15–16, 2015 in the Chambery Coulee southeast of Eastend, Saskatchewan (Figure 1). Data was collected together with five members that included, Werner Beylefeld, Katie Mackenzie, Robert Nodge, Michael Taylor and the writer. In total, five transects were performed in vertical sections along two south facing lobes of the valley slope (Figure 2). GPS coordinates and elevations for the base of each of the five transects are as follows:

- Transect 1: N 49º 23' 00.7", W 108º 29' 39.1"; 950 m
- Transect 2: N 49º 23' 01.0", W 108º 29' 39.9"; 995 m
- Transect 3: N 49º 23' 01.1", W 108º 29' 43.5"; 872 m
- Transect 4: N 49º 23' 01.5", W 108º 29' 41.7"; 902 m
- Transect 5: N 49º 23' 01.7", W 108º 29' 42.0"; 919 m

Unfortunately, due to errors in the GPS device used, elevation data is widely imprecise, but for the purposes of this study, will be assumed to be within approximately 10 m of the average of the five transects or 927.6 m. The base of the five transects started at ground level and each ended at the top of conformable hematite-bearing bentonitic clay unit. Across the five transects, between nine and eleven units were identified with some units being laterally discontinuous throughout the section. The data was compiled into a cross-section on May 17, 2015 at the University of Regina, in Regina, Saskatchewan, Canada. The selected datum for this report and the associated cross-section is based on the top of the first appearance of the repeated hematite-bearing bentonitic clay unit. Additionally, data was examined from a few related studies to help guide this report which may be referenced in the final section of this report.

Geologic Setting

The Frenchman Formation is widespread throughout southwestern Saskatchewan and southeastern Alberta, most notably in the Cypress Hills (Kupsch, 1957). It is overlain by fluvial sediments of the Ravenscrag Formation that were deposited after the terminal Cretaceous extinction event and is marked by a coal seam (McIver, 2002). An erosional surface is found at the base of the Frenchman Formation, and in places can be found to overlie either the Bearpaw Formation, Eastend Formation, Whitened Formation, or its most complete stratigraphic sections the Battle Formation (Kupsch, 1957). The Frenchman Formation increases in thickness to the northeast of Eastend, Saskatchewan and it ranges in thickness from 9 m to more than 68 m (Kupsch, 1957).

Lithologic Characteristics of Sedimentary Units in the Chambery Coulee

In the following section, characteristic features of each of the units from all five transects will be discussed. Transect 2 has the most complete section and therefore will be the basis for this analysis. Additionally, particularities or absences of features or entire units will be noted where necessary.

The basal unit from Transect 2 is absent from the other four sections. This unit is made up largely of unconsolidated sand that is predominantly laminated. Patches of vegetation and mud cracks were observed on the surface. Embedded gypsum crystals were common, as were small lenses of reasonably consolidated siltstone. Oxidation marks were common and seemed to be associated with roots. Thickness from ground surface to the next unit was 0.75 m. Grain size was 250–350 μm and they were sub-rounded. This unit was separated from the above sand unit due to a difference in colour which was a yellow orange.

Above the basal unit from Transect 2 is another predominantly unconsolidated sand unit. This unit is distinct from the basal unit by colour, structures and grain textures. This unit was also originally considered to be two units in Transect 1, but have been combined for this report for correlative purposes. This unit is correlative with the basal unit from the other four transects. The grains were well-sorted, and had a grain size of 177–250 μm. In a small 0.24 m portion of the upper part of this unit in Transect 1, grain size was noted to be 250–350 μm and grains were sub-rounded. Oxidation was observed in most transects. The grains were sub-angular to angular. Surface cover included various vegetation, such as cacti, and bentonitic popcorn texture and mud cracks. When wet, the colour of this unit was moderate olive brown. The colour was dusky yellow when dry. Cross lamination was observed to have a southeast trend. The average thickness of this sand unit was 0.80 m, with a maximum thickness in Transect 5 of 1 m and a minimum thickness of 0.54 m.

Above the unconsolidated sand unit is a primarily sand unit with silty clay lenses. This unit is relatively uniform throughout the five transects. The average thickness was 1.86 m, with the maximum thickness of 2.44 m observed in Transect 2 and a minimum thickness of 1.19 m in Transect 3. The measured grain size was 88–125 μm. Black organic material was seen throughout the unit. Burrows were also reasonably common. The colour of the unit when wet and dry were yellow and light yellow respectively. The cover layer was primarily bentonitic popcorn mud and some unconsolidated silt. Oxidation was observed in transects 3–5. Laminations were observed in most transects. In transects 4–5 clay lenses were notably more red in colour. Gypsum fibres were observed in Transect 1.

Overlying the sand unit with interbedded clay and silt is a largely silty clay unit that has an average thickness of 1.52 m. Maximum and minimum thicknesses were 3.20 m in Transect 3 and 0.64 in Transect 1. Colour of the unit when wet was yellowish grey, and when dry it was greyish yellow. Vegetation was not observed on the bentonitic popcorn texture surface cover. Similarly to the unit discussed above, oxidation was only observed in transects 3–5. It was noted that transect 5 is more brown than the other transects, this is believed to be due to increased oxidation. Trace fossils of leaves and twigs were observed in Transects 3–4. Laminations were observed in Transect 2 and 5.

Overlying the silty clay unit is the selected datum for this report. The maximum thickness for this unit was observed in Transect 5 with 1.19 m and its minimum thickness was observed in Transect 3 with 0.19 m. The average thickness amount all the transects was 0.57 m. When wet, the unit had a reddish black colour, and when dry it was dark reddish grey. There is a notable purplish hue to this unit that is due to it being hematite bearing. The lithology of this unit is largely silty clay. Grass patches occurred in transects 4–5. A sharp contact exists between this unit and the above unit.

Above the datum is a silty clay unit is another silty clay unit that has wet and dry colours of greyish olive and grey respectively. Roots and patches of grass were observed on the surface. The surface features included both mud cracks and bentonitic popcorn structures depending on the transect. The average thickness of this unit is 1.18 m. The maximum thickness was observed in Transect 5 and the minimum thickness was seen in Transect 2. Small calcite crystals were observed in most sections. These readily reacted with the HCl acid that was provided. It is believed that the calcite is largely responsible for why this unit is more consolidated than the clay observed above.

Overlying the silty clay unit is an unit that is primarily clay. The thickness of this unit is relatively uniform throughout the transects with an average thickness of 0.57 m. The colour when wet was greyish red. The colour of the unit when dry was black. This is the second appearance of the purplish-hue lithology. It was observed to have a mud crack surface in Transect 1. A 0.50 m thick portion at the end of this unit is heavily oxidized in Transect 5. This layer of oxidation is largely visible throughout the valley (Figure 6). Just east of the third transect, there is a large, highly fractured and highly reactive to HCl boulder that appears to be associated with the oxidation layer just mentioned. This boulder is a sandstone with calcitic cement that has been significantly weathered. A considerable amount of flora trace fossils were observed in Transect 5.

Above the clay unit is another silty clay unit that has an average thickness of 0.71 m. This unit is predominantly consolidated. The grain size of the silt is 62–88 μm. There is very little vegetation on the mud crack surface cover. The clay sediments break apart into large flaked. The colour of the unit when wet is olive brown. The colour of the unit when dry is greyish yellow.

Trace fossils of twigs and leaves were noted in transects 3–5. The oxidation layer mentioned in the previous unit is observed in Transect 5 of this unit.

A largely unconsolidated cliff-forming sand unit overlies Transect 1 and Transect 2. The thickness of the unit in Transect 1 was 2.58 m. The thickness of the unit in Transect 2 was 2.10 m. When observed from a distance, this unit clearly pinches out towards the west. Similar to the basal sand unit, the direction of flow in this sand unit trends to the southeast. Trough cross laminations were observed in Transect 1 (Figure 3). Burrows, roots and sporadic vegetation patches were seen. There is an anomalous cylindrical sandstone structure that cuts across this unit (Figure 4). This structure is considerably fractured and fragments were observed on the valley floor as well as the adjacent valley wall. It has been cemented by calcite and was exceptionally reactive when tested with HCl. Large concretions were also observed in Transect 1 (Figure 5).

The unit overlying the unconsolidated sand unit in transects 1–2 and overlying the silty clay unit in transects 3–5 is a predominantly clay unit that has an average thickness of 1.37 m. When wet the sediment was olive brown and when dry the sediment was greyish yellow. There was small amounts of vegetation that covered the mud crack surface cover.

The final unit observed for this report is another purplish-hue unit that is similar to the datum. When wet it had a colour of brownish black and why dry it was brownish grey. It had an average thickness of 0.93 m. Transects 4–5 were prominently covered in vegetation. Surface cover that was not vegetated showed mud cracks.

Stratigraphy of the Chambery Coulee

The stratigraphy of the Chambery Coulee is based primarily on two or three repeatable units of sand, silty clay and clay lithologies. In the section described for this report, the sand units are less common, but are all the basal units on the valley floor. They tend to form cliffs or very steeply dipping slopes. This is due to their resistance to weathering relative to the silty clay and clay units. The sedimentary structures of the basal unit and the second sand unit observed in Transect 1 and Transect 2 both trend towards the southeast indicating a consistent flow direction over time. Sedimentary structures in the silty clay and clay units were less common, but laminations were not uncommon. The silty clay and clay units form gently sloping bodies that are much more susceptible to erosion and weathering compared to the sand units.

Interpretations and Discussion of Sedimentary Environments within the Chambery Coulee

McIver (2002) remarks that the Frenchman Formation is largely made up of two distinct facies: one that is sand-dominated and a second clay-dominated. Kupsch (1957) referred to these lithostratigraphic units as lithosomes, which are defined as lithostratigraphic body which is mutually intertongued with one or more bodies of different lithologic components (Wheeler and Mallory, 1956). The units examined for this report would seem to agree with these analyses. However, the sand dominated lithosomes were not well represented, only appearing in one basal unit and small portion in the first and second transects and the rest being clay-dominated with some strata abundant in silty sediments.

The sand-dominated units represent regions and/or periods of higher fluvial energy in the environment. While the clay-dominated units indicate periods of calmer activity where finer-grained sediments could settle and accumulate. These units appear to repeat in a somewhat predictable manner, which would seem to indicate that the processes that influenced this environment were relatively cyclical. Examining flora content in the Frenchman Formation, McIver (2002) found that the vegetation was typical of that found in a flood plain. Because of its geographical size, it seems likely that this region would have been a flat floodplain geomorphology which are typical in medium to large river systems (Huggett, 2011). Due to its largely clay-dominated lithosome content, it seems reasonable that this would have likewise been a low-energy cohesive floodplain (Charlton, 2008). The sand-dominated strata could possibly have resulted from fluvial activity or infrequent high-energy flooding events. This would help to explain its relative scarcity in the units examined.

Conclusions

1. The sediments of the Frenchman Formation in the Chambery Coulee were likely deposited in a floodplain sedimentary environment. This is suggested based on flora fossils found in the region by previous authors and the relatively widespread arrangement and repetition
2. The flow of direction of the fluvial deposits trend to the southeast. This is based on sedimentary structures found in cross laminated sand deposits.
3. The relative absence of sand deposits compared to clay-dominated strata are indicative that this environment was a relatively calm environment, with sand deposits indicating rare events or fluvial systems within the floodplain.

References

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Figures

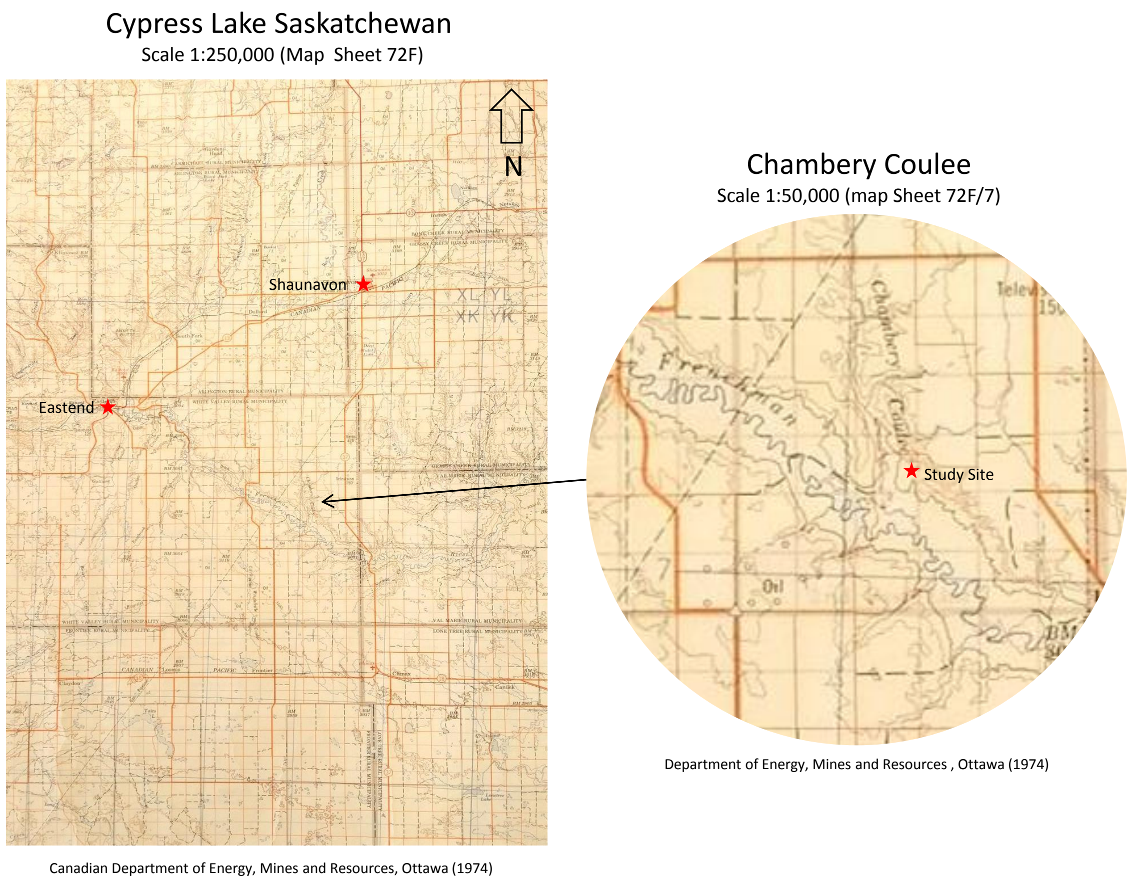

Figure 1 – Base map from the area of study. From Canadian Department of Energy, Mines and Resources, Ottawa (1974).

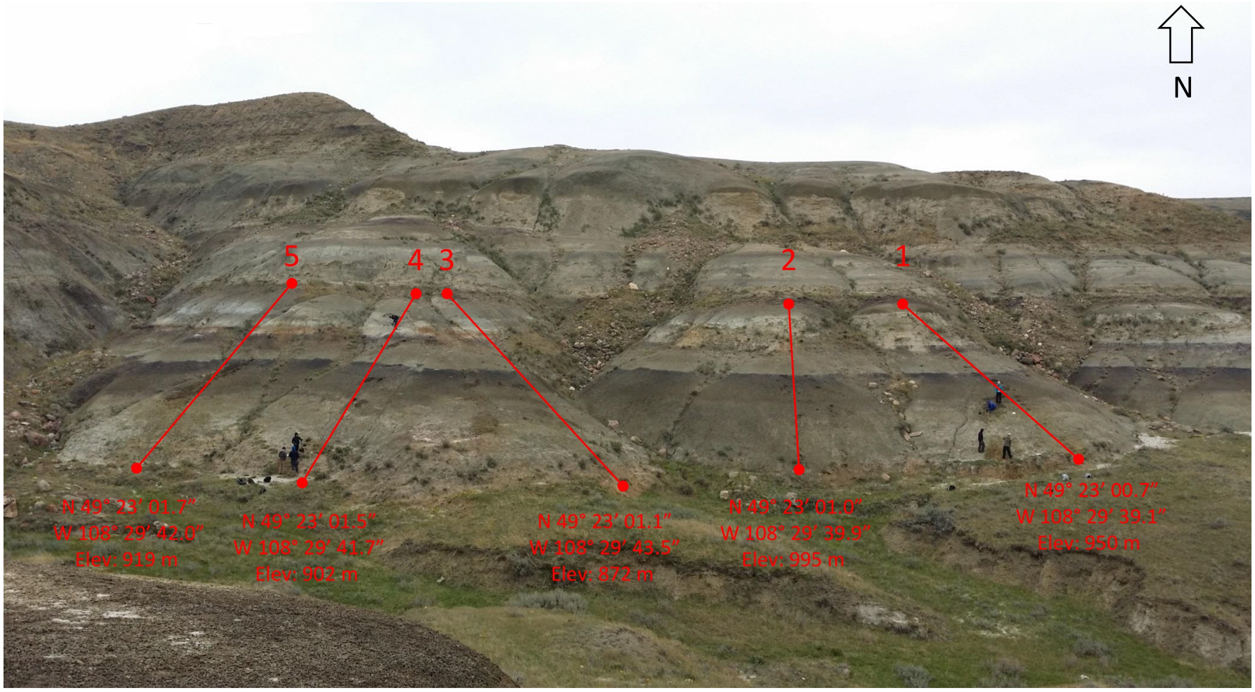

Figure 2 – This photograph shows the paths taken between each transect. Elevation data is unreliable and not accurate. Photo credit: Robert Nodge, 2015.

Figure 3 – Trough cross-bedding in sand unit at Transect 1. Photo credit: Robert Nodge, 2015.

Figure 4 – A large cylindrical calcite-cemented sandstone body was observed protruding from a sand unit near the top of Transect 1. HCl bottle for scale. Photo credit: Robert Nodge, 2015.

Figure 5 – Large concretions were observed in the upper unconsolidated sand unit in Transect 1 and Transect 2. Photo credit: Robert Nodge, 2015.

Figure 6 – Oxidation layer that is visible throughout most of the valley in the study area. This photograph is taken from Transect 5. Photo credit: Robert Nodge, 2015.