ERCB/AGS Open File Report 2011-04

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Acknowledgments

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Abstract

In this report, we present data on a Belly River Group outcrop section located on the eastern side of the South Saskatchewan River valley, 50 km north-northeast of Medicine Hat. Measured outcrop section T17-R3W4-01 includes the uppermost part of the Foremost Formation, a complete section through the Oldman Formation and the lower part of the Dinosaur Park Formation. The report includes a graphic log of the measured section, with an outcrop gamma-ray curve; a detailed description of the section (avoiding lithofacies interpretation but detailing stratigraphic context where appropriate) with selected photos; and the results of biostratigraphic work on a sample from the Foremost Formation.

The lower part of the exposed Foremost Formation consists of two thick sandstone units showing swaley cross-stratification separated by an interval of silty mudstone with thin sandstone and siltstone interbeds and isolated, sandstone-filled gutter casts. The uppermost 2.6 m of the Foremost Formation consist of mudstone, siltstone and several thin coal seams that represent the Taber coal zone. An erosionally based sandstone unit showing trough cross-stratification passing up to inclined heterolithic stratification at the base of the Oldman Formation is identified as the Herronton sandstone zone. Above this sandstone, the Oldman Formation consists mainly of silty mudstone and muddy siltstone with interbedded fining-upward sandstone units, which typically show trough cross-stratification and low-angle inclined stratification. The Dinosaur Park Formation has an erosional contact with the underlying Oldman Formation, and consists of sandstone and sandy siltstone units showing trough cross-stratification, large-scale inclined bedding and inclined heterolithic stratification, and intervals of silty mudstone and muddy siltstone.

Gamma-ray counts for the Foremost Formation and the Herronton sandstone zone are relatively low, suggesting compositional affinity between those units, but counts are consistently higher through the main part of the Oldman Formation. There is a sharp decrease in gamma-ray values at the top of the Oldman Formation and counts for the Dinosaur Park Formation are comparable to those recorded from the Foremost Formation.

1 Introduction

Measured outcrop section T17-R3W4-01 in the Belly River Group, located in the South Saskatchewan River valley in southeastern Alberta (Figure 1), includes the upper part of the Foremost Formation, the whole of the Oldman Formation and the lower part of the Dinosaur Park Formation (Eberth and Hamblin, 1993). This report includes a graphic log of the measured section with an outcrop gamma-ray curve; a detailed description of the section (avoiding lithofacies interpretation but detailing stratigraphic context where appropriate) with selected photos; and the results of biostratigraphic work on a sample from the lower part of the section. The section was measured in August 2009 using an Abney level attached to a 1.6 m Jacob staff.

2 Location

The section is located in Twp. 17, Rge. 3, W. 4th Mer. (abbreviated T17-R3W4), on the north side of White Rock Coulée (Figure 2) on the eastern side of the South Saskatchewan River valley, 50 km north-northeast of Medicine Hat. Its base and top are at the level of the lowest and highest well-exposed bedrock in the area. Appendix 1 contains detailed GPS location data.

3 Description

3.1 0 to 18.1 m: Upper Part of Foremost Formation

The lower part of the measured section, from 0 to 18.1 m, is assigned to the Foremost Formation (Figure 3).

The basal part of the section, from 0 to 2.4 m, consists of pale grey, fine- to very fine grained sandstone with swaley cross-stratification (SCS; Leckie and Walker, 1982) and isolated calcite-cemented concretions (Figure 4). The sandstone is overlain by an interval dominated by variably bioturbated (*Chondrites* locally abundant), dark brown to grey-brown silty mudstone (2.4 to 8.1 m) with thin (generally <1 cm), very fine grained sandstone to siltstone interbeds, commonly showing gently inclined (combined flow?) lamination. Isolated (mudstone-enclosed) gutter casts, up to 1.0 m deep filled with very fine grained sandstone showing hummocky cross-stratification (HCS), are common in the upper 2 m of this interval (Figure 5). The mudstone is overlain by a sharp-based, 7.4 m thick (8.1 to 15.5 m) unit of pale grey, very fine to fine-grained sandstone. This is largely swaley cross-stratified (with well-developed internal scours) but shows horizontal planar stratification towards the top.

The interval from 15.5 to 18.1 m consists mainly of grey-brown, red-brown or dark grey, locally carbonaceous silty mudstone to siltstone. A 30 cm thick coal seam at 16.9 m and a series of thin shaly coal seams immediately below the base of the overlying sandstone at 18.1 m are considered to represent the Taber coal zone.

Results of biostratigraphic analysis of a sample from the Foremost Formation are detailed in Appendix 3.

3.2 18.1 to 63.0 m: Oldman Formation

The erosionally based sandstone unit at the base of the Oldman Formation (18.1 to 23.0 m) has a trough cross-stratified basal division, which passes up into sand-dominated inclined heterolithic stratification (IHS; Figure 6). This unit represents the 'Herronton sandstone zone' of Eberth (2005; D. Eberth, pers. comm., 2010), which lies above the Taber coal zone but shares compositional affinities with the Foremost Formation rather than the overlying Oldman Formation (see discussion of gamma-ray data below). This led Eberth (2002, 2005) to include his Herronton sandstone zone in the Foremost Formation, adjusting the contact between the Foremost and Oldman formations upsection compared with earlier work. In this report, we follow Russell and Landes (1940) and Eberth and Hamblin (1993) in placing the top of the

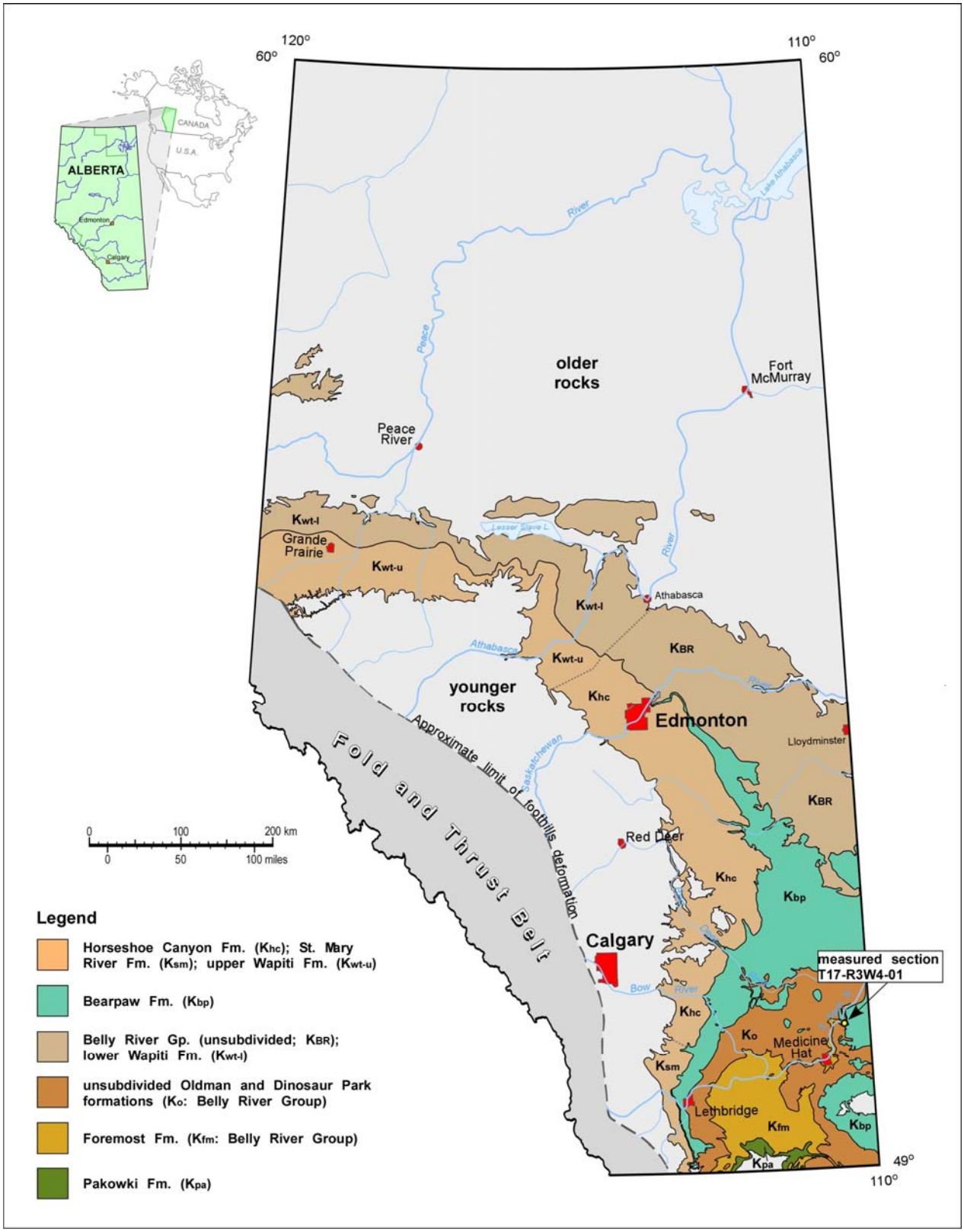

Figure 1. Simplified geological map (modified from Hamilton et al., 1999) showing the distribution of Belly River Group and surrounding rocks in Alberta and the location of measured section T17-R3W4-01.

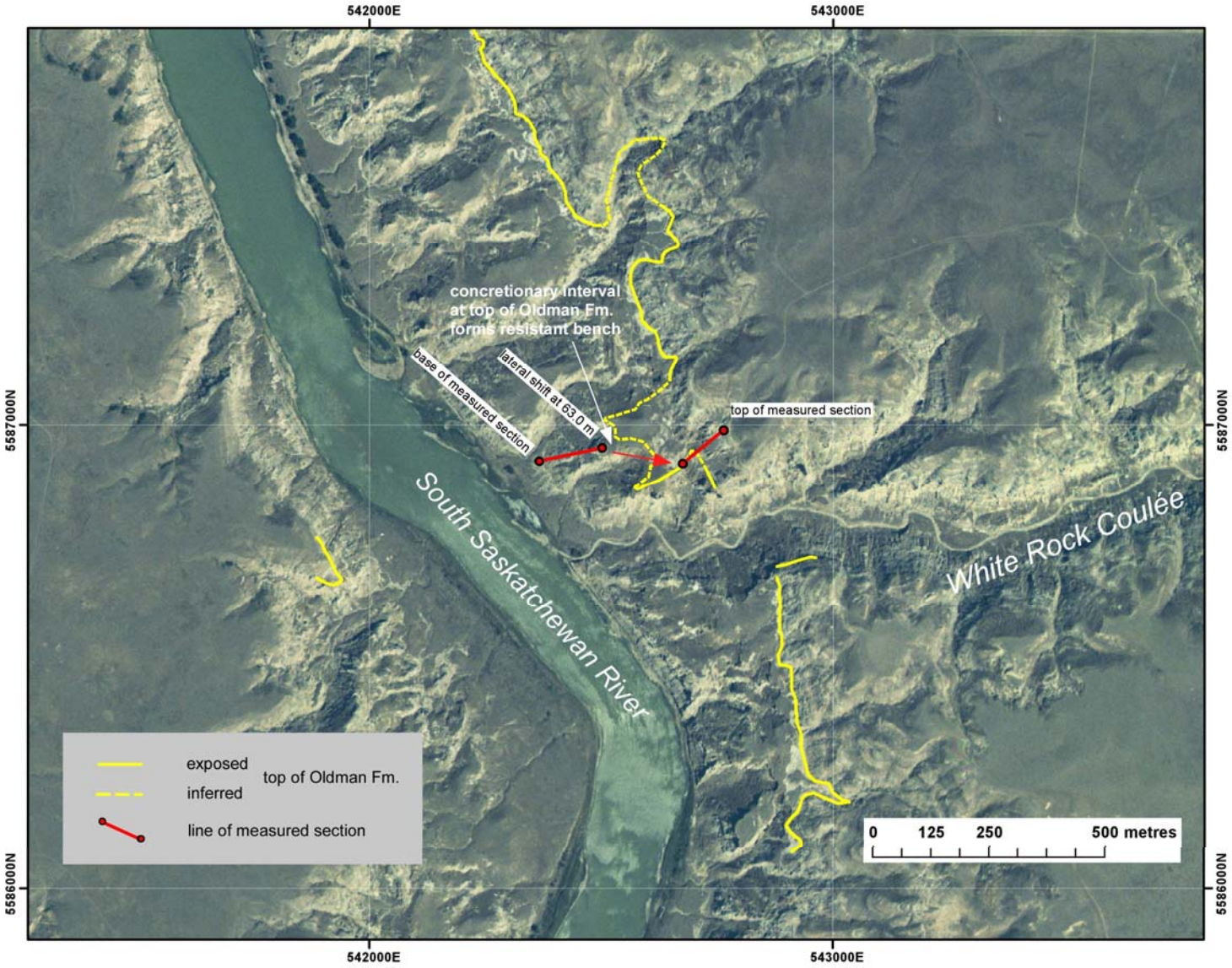

Figure 2. Location of measured section T17-R3W4-01 (southeastern Alberta) plotted on 1 m resolution orthorectified airphoto base with 1 km grid (UTM Zone 12, NAD 83). Position of exposed top of Oldman Formation based on ground observation and colour airphoto interpretation.

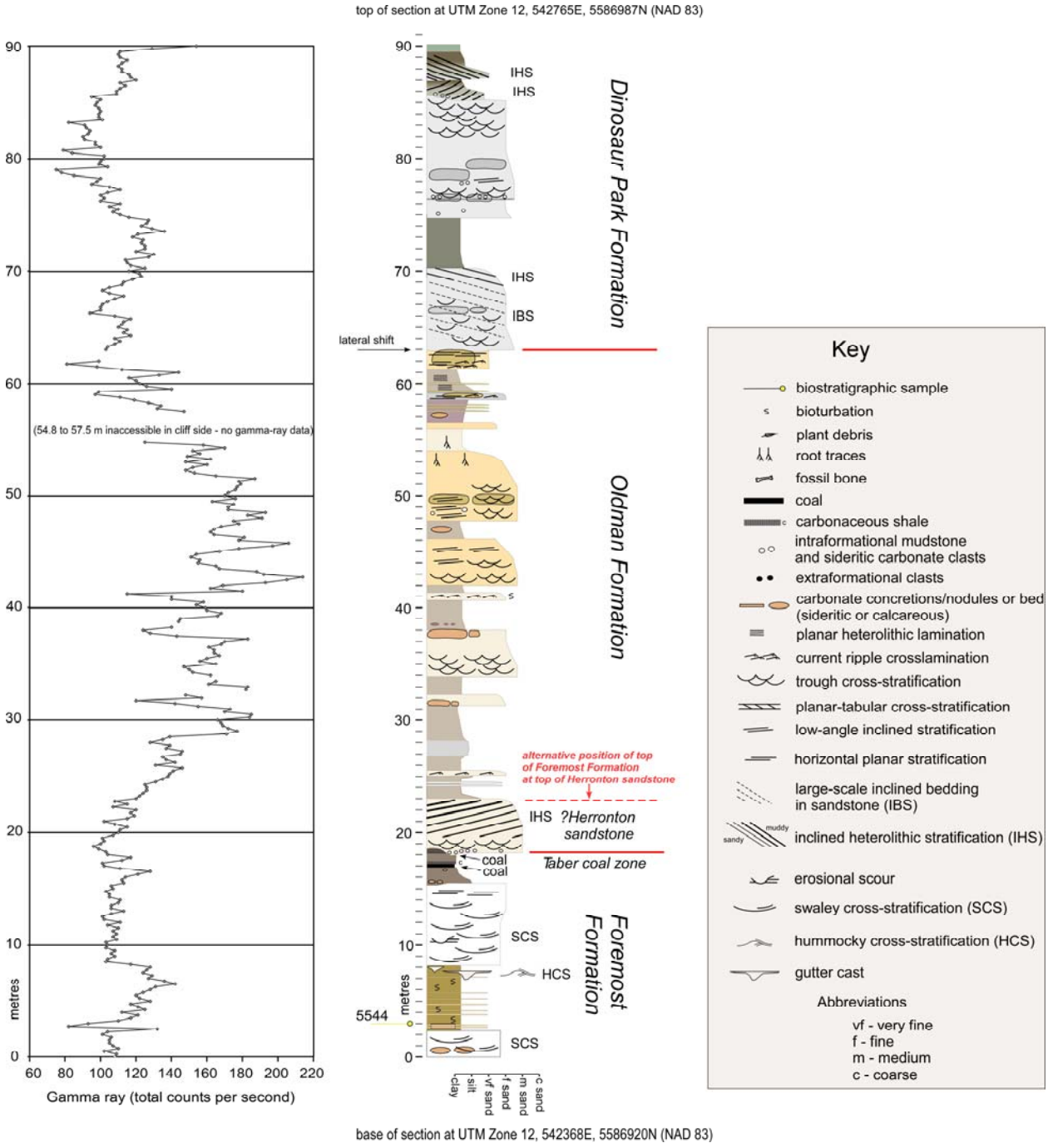

Figure 3. Graphic log of measured section T17-R3W4-01 (southeastern Alberta) with outcrop gamma-ray curve. See large-format version in Appendix 2 for descriptive notes.

Figure 4. Swaley cross-stratified sandstone in Foremost Formation at 1.5 m in measured section T17-R3W4-01 (southeastern Alberta). Ten centimetre intervals on Jacob staff.

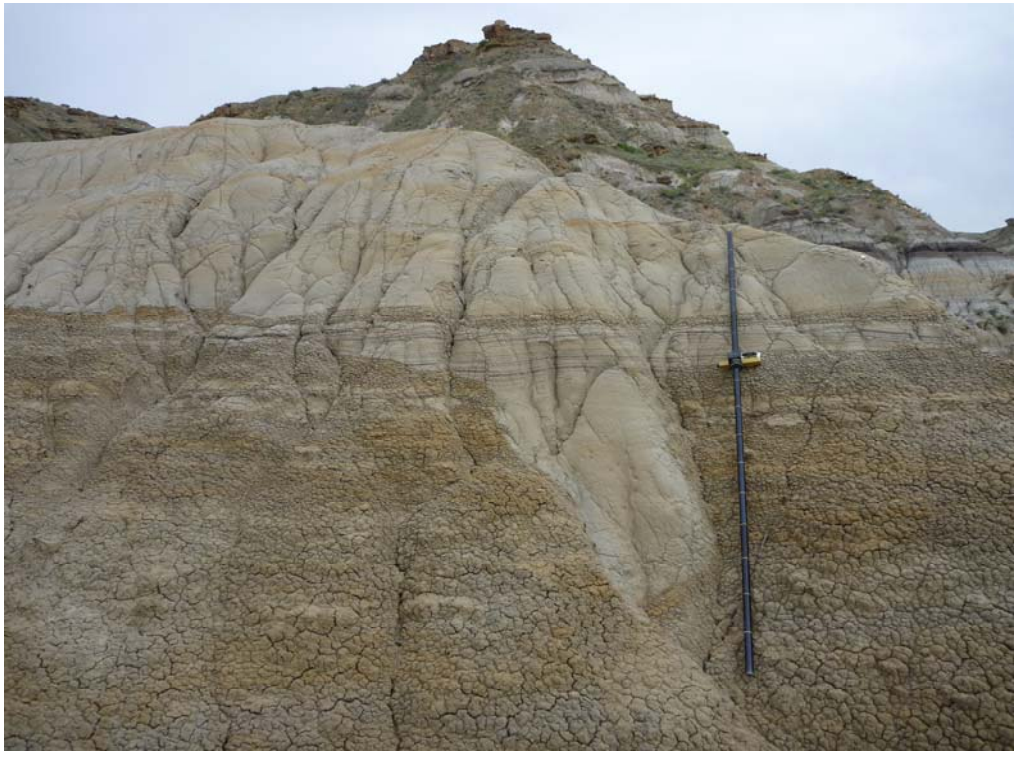

Figure 5. Steep-sided, sandstone-filled gutter cast in Foremost Formation immediately below sharp base of sandstone at 8.1 m in measured section T17-R3W4-01 (southeastern Alberta).

Figure 6. Sandstone showing trough cross-stratification passing up into inclined heterolithic stratification. Base of unit (at base of 1.6 m Jacob staff) is at 18.1 m in measured section T17-R3W4-01 (southeastern Alberta). This unit represents the Herronton sandstone zone of Eberth (2005).

Foremost Formation at the top of the Taber coal zone (18.1 m). However, the alternative position of the boundary at the top of the Herronton sandstone zone (23.0 m) is also indicated on Figure 3.

The interval from 23.0 to 33.9 m consists mainly of grey-brown silty mudstone, with minor siltstone, and a number of thin fine- to very fine grained sandstone units, one of which shows ripple crosslamination. The interval from 33.9 to 54.0 m also includes thick intervals of silty mudstone and muddy siltstone, but is dominated by thicker (up to 6 m), pale grey to cream, sharp-based, normally graded, medium- to very fine grained sandstone beds showing trough cross-stratification and low-angle inclined stratification. The upper part of the Oldman Formation (54.0 to 63.0 m) consists of muddy siltstone and thinly bedded to laminated siltstone and very fine grained sandstone, with several thicker sandstone units showing horizontal planar stratification to ripple crosslamination. The carbonate-cemented top of the uppermost Oldman Formation sandstone commonly forms a well-developed bench beneath the less resistant basal Dinosaur Park Formation sandstone.

3.3 63.0 to 90.0 m: Lower Part of Dinosaur Park Formation

The pale grey sandstone unit at the base of the Dinosaur Park Formation rests with a sharp, erosional contact on orange-yellow weathering sandstone or siltstone at the top of the Oldman Formation (Figure 7). The basal sandstone unit (63.0 to 70.3 m) is pale grey and fines upward from fine to medium to very fine grained. It shows large-scale inclined bedding (IBS; Wood, 1989) with smaller scale, trough

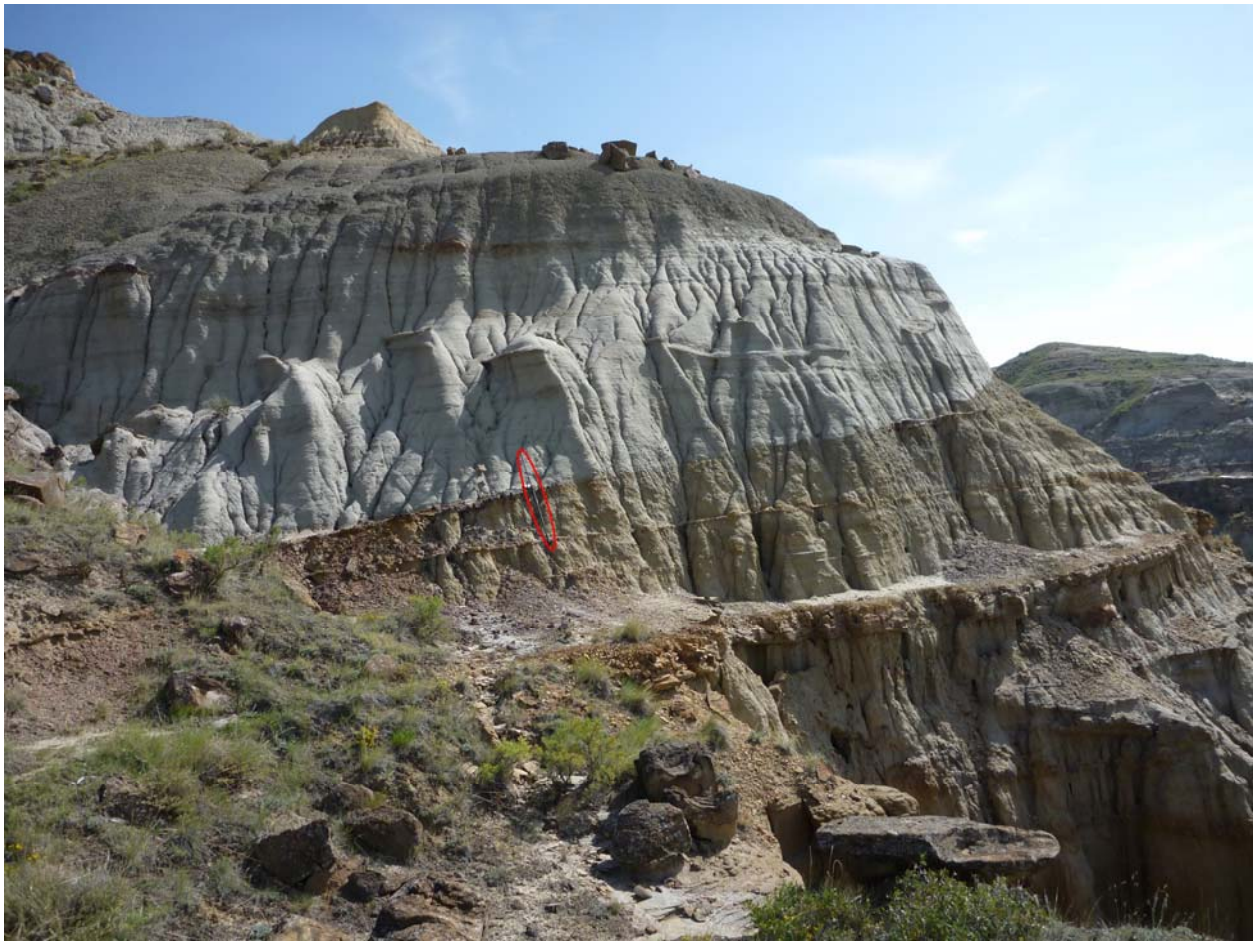

Figure 7. Erosional contact of pale grey basal Dinosaur Park Formation sandstone with underlying orange-yellow weathering Oldman Formation sandstone and siltstone. Bluff is 90 m southeast of contact in measured section T17-R3W4-01 (542738E, 5586874N, UTM Zone 12, NAD 83). Jacob staff (ringed in red; 1.6 m long) at contact for scale.

cross-stratification, passing up to sand-dominated IHS. It is overlain by olive grey-brown, popcorn-weathering muddy siltstone with no apparent structure (70.3 to 74.6 m). The overlying pale grey sandstone package (74.6 to 85.8 m) includes two sharp-based, amalgamated units. The thicker, upper unit is largely trough cross-stratified (possibly with cryptic IBS) and contains large, hoodoo-forming calcite concretions.

The sandstone is overlain by an erosionally based package of fine-grained sandstone to silty mudstone with well-developed IHS (85.8 to 89.5 m) and a locally developed basal sideritic intraclast lag. The package with IHS passes up into grey-green silty mudstone at the top of the exposed section. Figure 8 gives an overview of the complex geometry of units within the Dinosaur Park Formation in the area of the measured section.

4 Gamma-Ray Data

The methodology for collecting the outcrop gamma-ray data shown in Figure 3 is detailed in Appendix 4.

Gamma-ray counts are consistently low for the Foremost Formation sandstone units and slightly higher for the mudstone intervals. The sandstone unit with IHS at the base of the Oldman Formation (18.1 to 23.0 m), which represents the Herronton sandstone zone of Eberth (2002, 2005), shows low gamma-ray

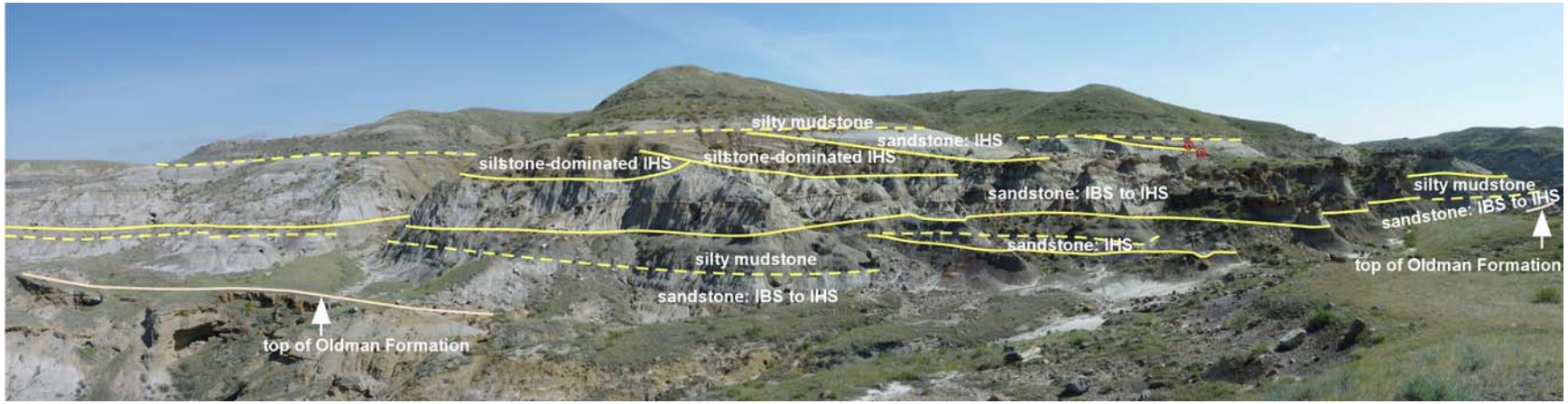

Figure 8. Panoramic view looking east-northeast towards the upper part of measured section T17-R3W4-01 (from 542584E, 5587016N, UTM Zone 12, NAD 83). Sandstone units in Dinosaur Park Formation show inclined heterolithic stratification (IHS) and large-scale inclined bedding (IBS). Figures at right (circled in red) are on the line of the measured section. Solid yellow lines represent sharp erosional contacts and dashed yellow lines represent gradational contacts.

values similar to those obtained from the underlying Foremost Formation sandstones with SCS, suggesting compositional affinity with those units. Gamma-ray counts rise through a transitional interval above the Herronton sandstone zone (23.0 to 28.5 m) to be consistently higher through the main part of the Oldman Formation, with the highest values recorded from sandstones rather than mudstones. The lowest counts were generally obtained from carbonate concretions (e.g., 31.75, 38.0, 59.0 m).

The sharp decrease in gamma-ray counts at the top of the Oldman Formation is consistent with the upward deflection to the left noted across the formation boundary in downhole gamma-ray logs associated with cored intervals by Eberth and Hamblin (1993), and in outcrop gamma-ray data from a measured section in Dinosaur Provincial Park (Hathway and Prior, 2011). Counts for the Dinosaur Park Formation are comparable to those recorded from the Foremost Formation, again with slightly higher counts for mudstone-dominated intervals. Higher counts for the grey-green silty mudstone at the top of the section (90.0 m) suggest a large bentonitic component.

5 Summary

Measured outcrop section T17-R3W4-01 includes the uppermost 18.1 m of the Foremost Formation, a complete section through the Oldman Formation, here 44.9 m thick, and the lower 27.0 m of the Dinosaur Park Formation.

The lower part of the exposed Foremost Formation consists of two thick sandstone units showing SCS separated by an interval of silty mudstone with thin sandstone and siltstone interbeds and isolated gutter casts filled with sandstone showing HCS. The uppermost 2.6 m of the Foremost Formation consist of mudstone and siltstone with several thin coal seams that represent the Taber coal zone.

A 4.9 m thick, erosionally based sandstone showing trough cross-stratification passing up to IHS at the base of the Oldman Formation is identified as the Herronton sandstone zone of Eberth (2002, 2005). Above this sandstone unit, the Oldman Formation consists mainly of silty mudstone and muddy siltstone with interbedded, sharp-based, fining-upward sandstone units up to 6 m thick, which typically show trough cross-stratification and low-angle inclined stratification.

The Dinosaur Park Formation section consists of sandstone and sandy siltstone units up to 9 m thick, showing trough cross-stratification, IBS and IHS, and intervals of silty mudstone and muddy siltstone. The basal Dinosaur Park Formation sandstone unit has a downcutting, erosional contact with the underlying Oldman Formation.

Gamma-ray counts for the Foremost Formation and the Herronton sandstone zone are relatively low, suggesting compositional affinity between those units, but counts are consistently higher through the main part of the Oldman Formation. There is a sharp decrease in gamma-ray values at the top of the Oldman Formation and counts for the Dinosaur Park Formation are comparable to those recorded from the Foremost Formation.

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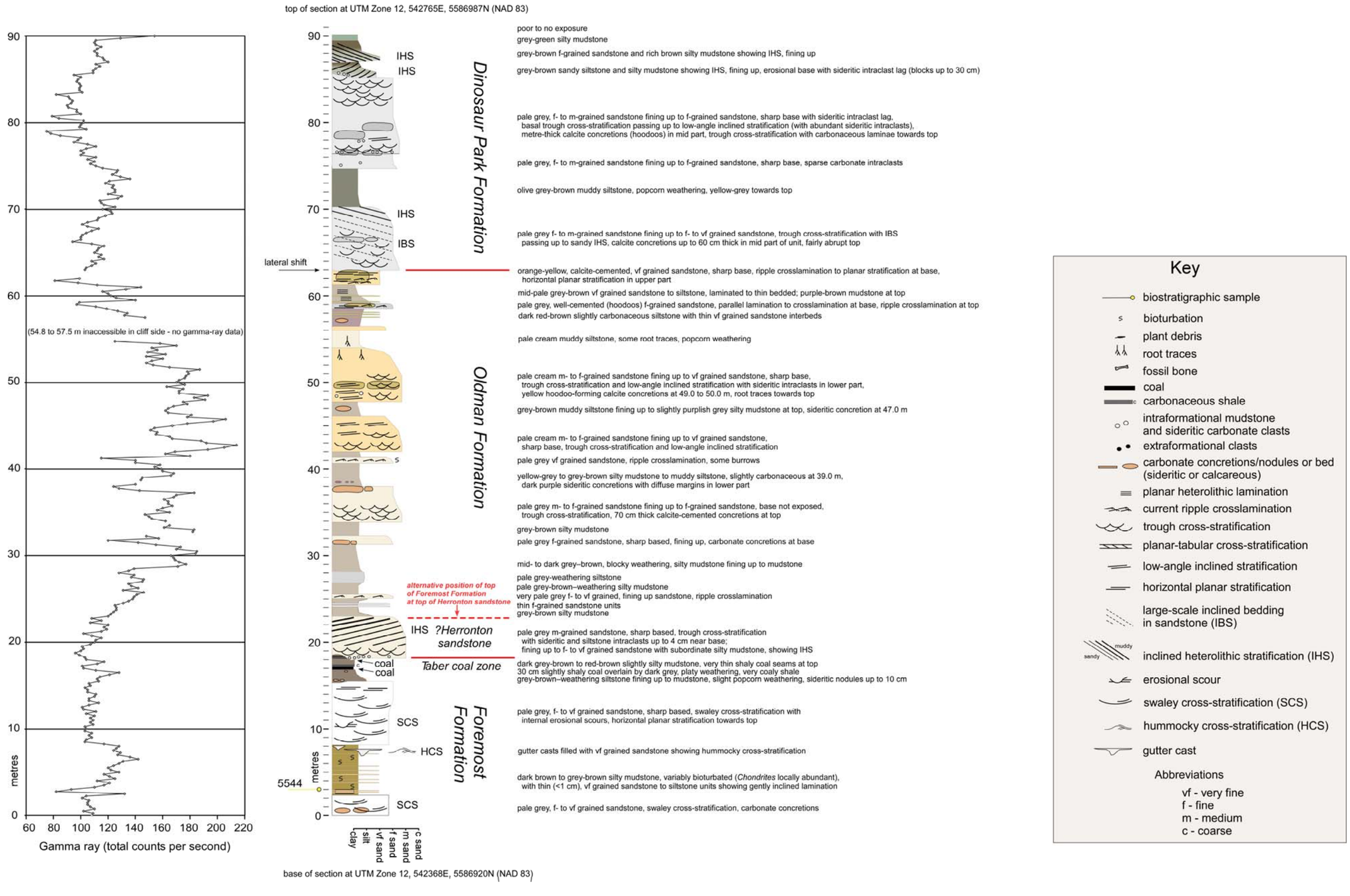
Appendix 1 – GPS Location Data for Measured Outcrop Section T17-R3W4-01

The GPS location data for measured outcrop section T17-R3W4-01 in southeastern Alberta were obtained using Garmin® GPSMAP® 60CSx hand-held units. The UTM co-ordinates are Zone 12, NAD 83. The ± values indicate estimates of horizontal error generated by the GPS units.

Easting	Northing	Horizontal Error (±)	Elevation (m)	Comment
542368	5586920	6	615	base of measured section (0.0 m)
542503	5586949	3	677	63.0 m in measured section (top of Oldman Formation – significant shift above this point)
542677	5586915	4	676	63.0 m in measured section (base of Dinosaur Park Formation – after significant section shift)
542765	5586987	6	700	90.0 m in measured section (top of well-exposed section)

Appendix 2 – Graphic Log of Measured Outcrop Section T17-R3W4-01 (Southeastern Alberta) with Outcrop Gamma-Ray Curve. Large-Format Version of Figure 3 with Descriptive Notes.



Appendix 3 – Biostratigraphic Sample from Measured Outcrop Section T17-R3W4-01

A sample was collected from the Foremost Formation in the lower part of measured outcrop section T17-R3W4-01 (southeastern Alberta) for biostratigraphic analysis. Splits from were sent to D. McNeil (Geological Survey of Canada, Calgary) for foraminiferal analysis and to G. Dolby & Associates Ltd. (Calgary) for palynological study. Details of sample preparation and analytical methodology are given in McNeil (2010) and Dolby (2010). Results are detailed below.

Sample 5544 (3.0 m): bioturbated grey-brown mudstone with thin very fine grained sandstone units (Foremost Formation)

D. McNeil

Foraminifera: *Haplophragmoides* sp. – 2 fragments
Washed Residue: Trace of greyish clay and very fine grained sandstone with black mineralization of unknown origin. Traces of bone, plant and coaly fragments.
Age: indeterminant

G. Dolby

Age: Early Campanian
Environment: restricted marginal marine, paralic
Remarks: Dinocysts are much rarer here than in sample 5535 (Foremost Formation sample from Pinhorn Provincial Grazing Reserve, Hathway et al., 2011) and there is a mix of species rather than single species dominance. Species include *Chatangiella* aff. *Decorosa*, *C.* cf. *ditissima*, *Isabelidinium acuminatum*, *Laciniadinium* sp., *Scuticabolus lapidaries*, cf. *Vesperopsis* sp.
The angiosperm pollen assemblage has elements in common with sample 5535, such as *Aquilapollenites turbidus*, *A. trialatus*. However, there are also specimens of *Tricolporopollenites scabratus*, *Fibiapollis* cf. *punctatus*. The latter is particularly numerous.
The spore flora is dominated by abundant *Cyathidites* spp. and *Laevigatosporites* spp. and there are specimens of *Hazeria* spp. and *Umbosporites callosus*. An Early Campanian age is indicated. The rich terrestrial flora but very small marine contribution suggests a restricted, swamp dominated, paralic setting.

Appendix 4 – Outcrop Gamma-Ray Methodology

Gamma-ray values, in counts per second, were measured on outcrop section T17-R3W4-01 (southeastern Alberta) at nominal measurement intervals of 0.25 m using a hand-held GR-135 spectrometer. The counting time was 10 seconds and total counts were measured (above a lower threshold of 20 keV). Each measurement was obtained by placing the base of the front part of the GR-135 (near the detector) directly against the outcrop at the measurement location. Measurement locations were chosen to be as planar as possible over areas approximately 0.5 m in diameter. If necessary, loose material was scraped away to expose outcrop before the gamma-ray data were collected.

GR-135 Specifications

Manufacturer: SAIC (Mississauga, Ontario)
Model: Exploranium® GR-135 Plus "The Identifier" (GR-135GEO, geophysical model)
Year of Manufacture: 2007
Version: 6V01.02
Detector: sodium-iodide (thallium) [NaI(Tl)] detector with a 65 cm^3 (4.0 cu in.) volume (38 mm in diameter and 57 mm in length)
Stabilization: external cesium (^{137}Cs) source (stabilization completed daily)
Mode: manual (search mode)
Count Rate Measurement: counts per second
Sample Time: 10 seconds
Scan Window: total (above lower threshold of 20 keV)
Averaging: off
Channels: 1024