ERCB/AGS Open File Report 2011-02

Measured Outcrop Section T21-R10W4-01 of the Oldman and Dinosaur Park Formations (Belly River Group), Dinosaur Provincial Park Area, Red Deer River Valley, Southeastern Alberta (NTS 72L/14)

Energy Resources Conservation Board

Alberta Geological Survey

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B. Hathway and G.J. Prior

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Acknowledgments

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Abstract

In this report, we present data on a Belly River Group outcrop section located at the eastern edge of Dinosaur Provincial Park in the Red Deer River valley. Measured section T21-R10W4-01 includes the uppermost part of the Oldman Formation and a complete section through the Dinosaur Park Formation. The Bearpaw Formation is poorly exposed at the top of the section.

The exposed Oldman Formation consists of sandstone units showing low-angle inclined stratification, trough (rarely planar) cross-stratification or ripple crosslamination, and interbedded silty mudstone. In contrast, Dinosaur Park Formation sandstone units, again interbedded with silty mudstone, commonly show inclined heterolithic stratification, concave-up heterolithic stratification or large-scale inclined bedding. The uppermost part of the Dinosaur Park Formation includes intervals of bioturbated marine mudstone and coals of the Lethbridge coal zone. Outcrop gamma-ray counts are relatively high throughout the exposed Oldman Formation section, dropping through the uppermost Oldman sandstone unit to be consistently lower in the Dinosaur Park Formation. This is consistent with the upward deflection to the left noted across the formation boundary in downhole gamma-ray logs.

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 three samples from the upper part of the section.

1 Introduction

Located at the eastern boundary of Dinosaur Provincial Park in southeastern Alberta (Figure 1), measured outcrop section T21-R10W4-01 in the upper Belly River Group includes the uppermost part of the Oldman Formation and the whole of the overlying Dinosaur Park Formation (Eberth and Hamblin, 1993). Bearpaw Formation mudstone is poorly exposed at the top of the section. 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 three samples from the upper part of the section. The section was measured in June 2009 using an Abney level attached to a 1.6 m Jacob staff.

2 Location

The section is located on the south side of the Red Deer River valley in Twp. 21, Rge. 10, W 4th Mer. (abbreviated T21-R10W4; Figure 2). Its base lies within Dinosaur Provincial Park, 240 m west of the eastern park boundary, at the level of the lowest exposed bedrock in the river valley. The top of the section is 225 m east of the park boundary, at the level of the highest well-exposed bedrock. GPS location data are given in Appendix 1.

3 Description

3.1 0 to 19.4 m: Oldman Formation

The lower part of the section, up to 19.4 m, is assigned to the Oldman Formation (Figures 3 and 4). It consists mainly of pale yellow-brown to grey-weathering, normally graded, medium- to very fine grained sandstone beds up to at least 3.3 m thick, interbedded with intervals of silty mudstone (rarely sandy siltstone) up to 5 m thick. Sandstone beds are sharp based and commonly have sharp tops. Thicker units show low-angle inclined stratification or trough (rarely planar) cross-stratification and may have an upper, ripple crosslaminated division. Thinner sandstone beds show unidirectional, ripple crosslamination. Interbedded silty mudstone is generally pale grey-green to grey-brown weathering. Some more resistant intervals are red-brown weathering with abundant plant debris, and in places, root traces. Minor sideritic concretions are found in finer grained intervals and lenticular to laterally persistent (tabular) calcite-cemented concretionary zones are present in the upper divisions of the thicker sandstones.

3.2 19.4 to 72.0 m: Lower Part of the Dinosaur Park Formation

The contact between the Oldman Formation and the overlying Dinosaur Park Formation at 19.4 m is sharp and relatively planar (Figure 4). The Dinosaur Park Formation has a duller, darker, more uniform olive-grey colouration, in contrast to the paler, yellowish to multicoloured Oldman Formation. Sandstones may form rounded, rilled surfaces in both formations, but blocky, steep faces are more common in Oldman Formation sandstone (cf., Eberth, 2005).

The lower part of the Dinosaur Park Formation section, up to 72.0 m, consists of individual beds or amalgamated packages of pale grey sandstone up to 7 m thick interbedded with intervals of silty mudstone up to 4 m thick.

Sandstone beds are sharp based and generally normally graded (basal parts of thicker units may be medium to coarse grained). They may show inclined heterolithic stratification (IHS; in some cases complex, with internal erosion surfaces), which may pass up to ripple crosslamination; trough cross-stratification passing up to sandy IHS or to ripple crosslamination; or large-scale inclined bedding (IBS; Wood, 1989) passing laterally and upsection to sandy IHS. At 60.0 m, a 4 m thick package of grey-brown muddy siltstone and very fine grained sandstone shows concave-up heterolithic stratification (HS; Eberth, 1996) that parallels its sharp, downcutting erosional base. This unit increases in thickness and downcuts

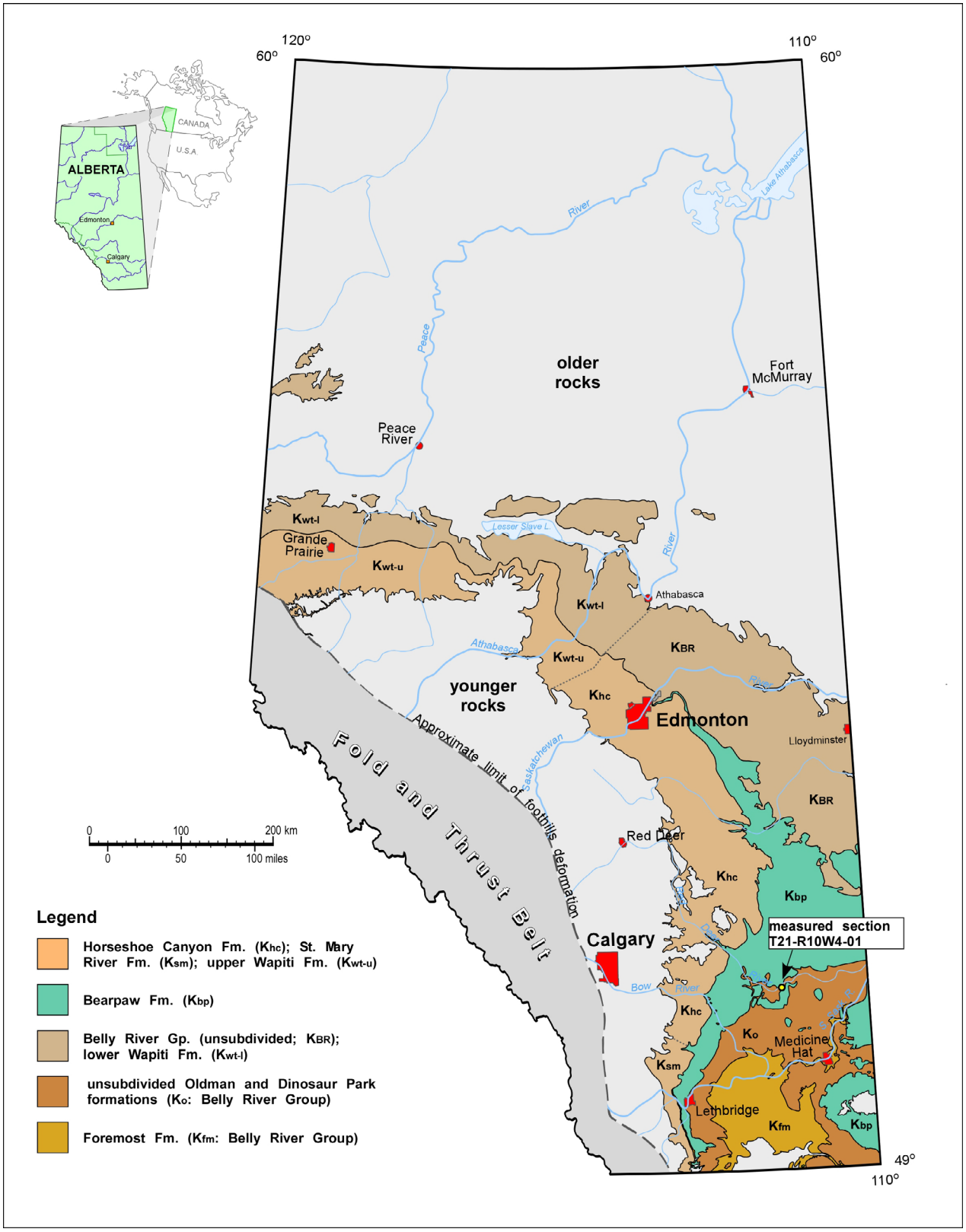

Figure 1. Simplified geological map (modified from Hamilton et al., 1999) showing the distribution of Belly River Group, Bearpaw Formation and surrounding rocks in Alberta and the location of measured section T21-R10W4-01.

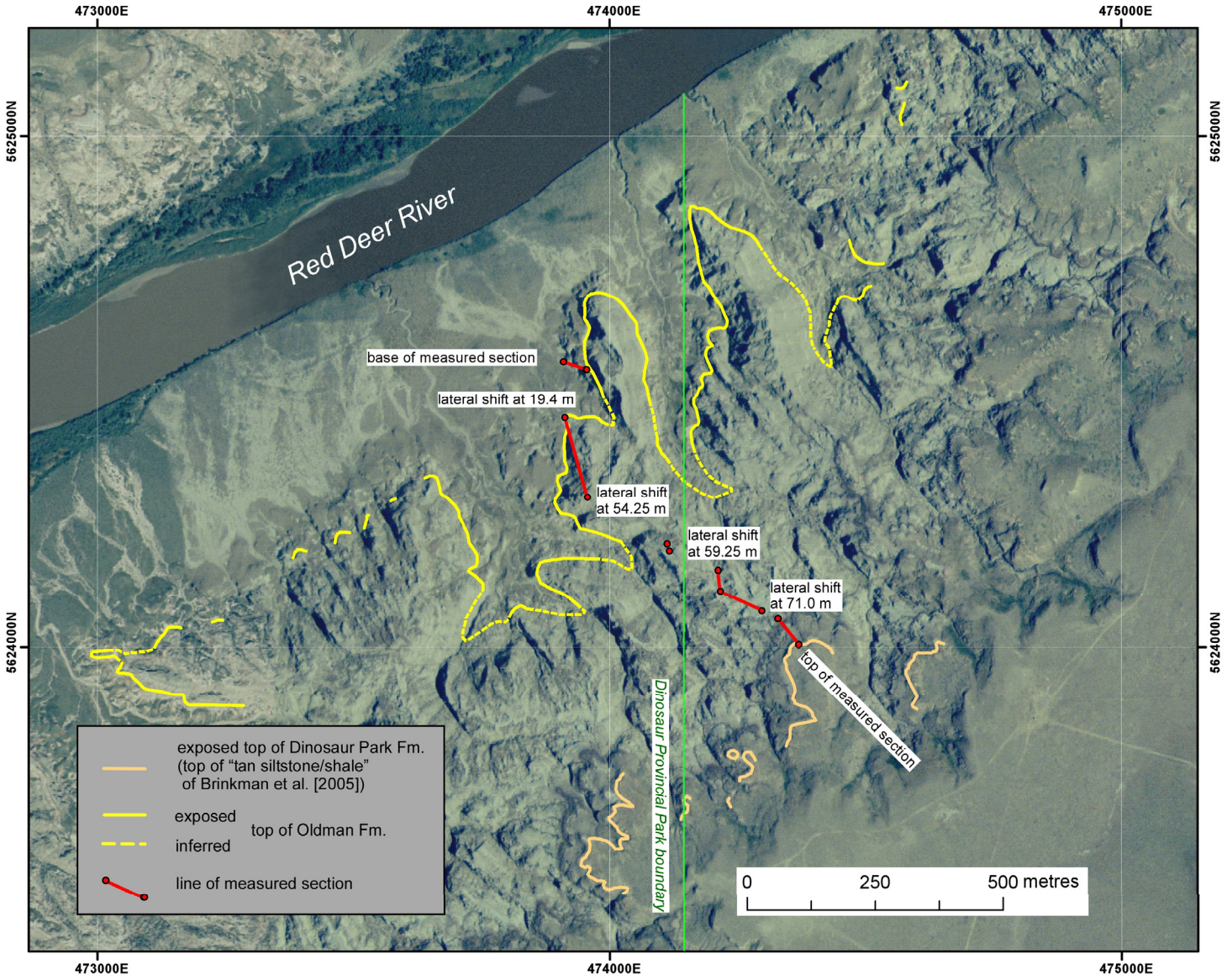

Figure 2. Location of measured section T21-R10W4-01 (southeastern Alberta) plotted on 1 m resolution orthorectified airphoto base with 1 km grid (UTM Zone 12, NAD 83). Position of exposed tops of Oldman and Dinosaur Park formations based on ground observation and colour airphoto interpretation.

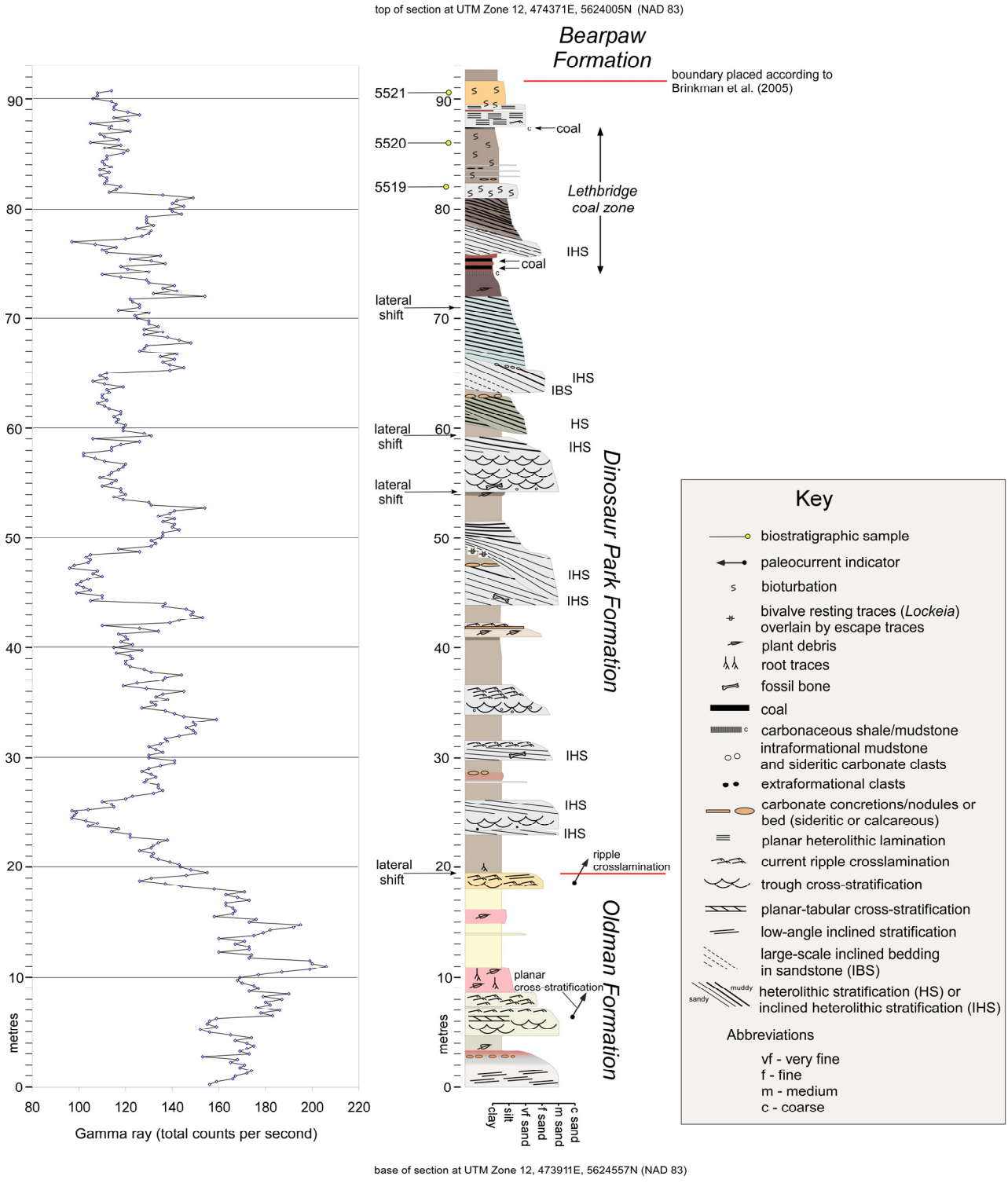

Figure 3. Graphic log of measured section T21-R10W4-01 (southeastern Alberta) with outcrop gamma-ray curve. See large-format version in Appendix 2 for descriptive notes.

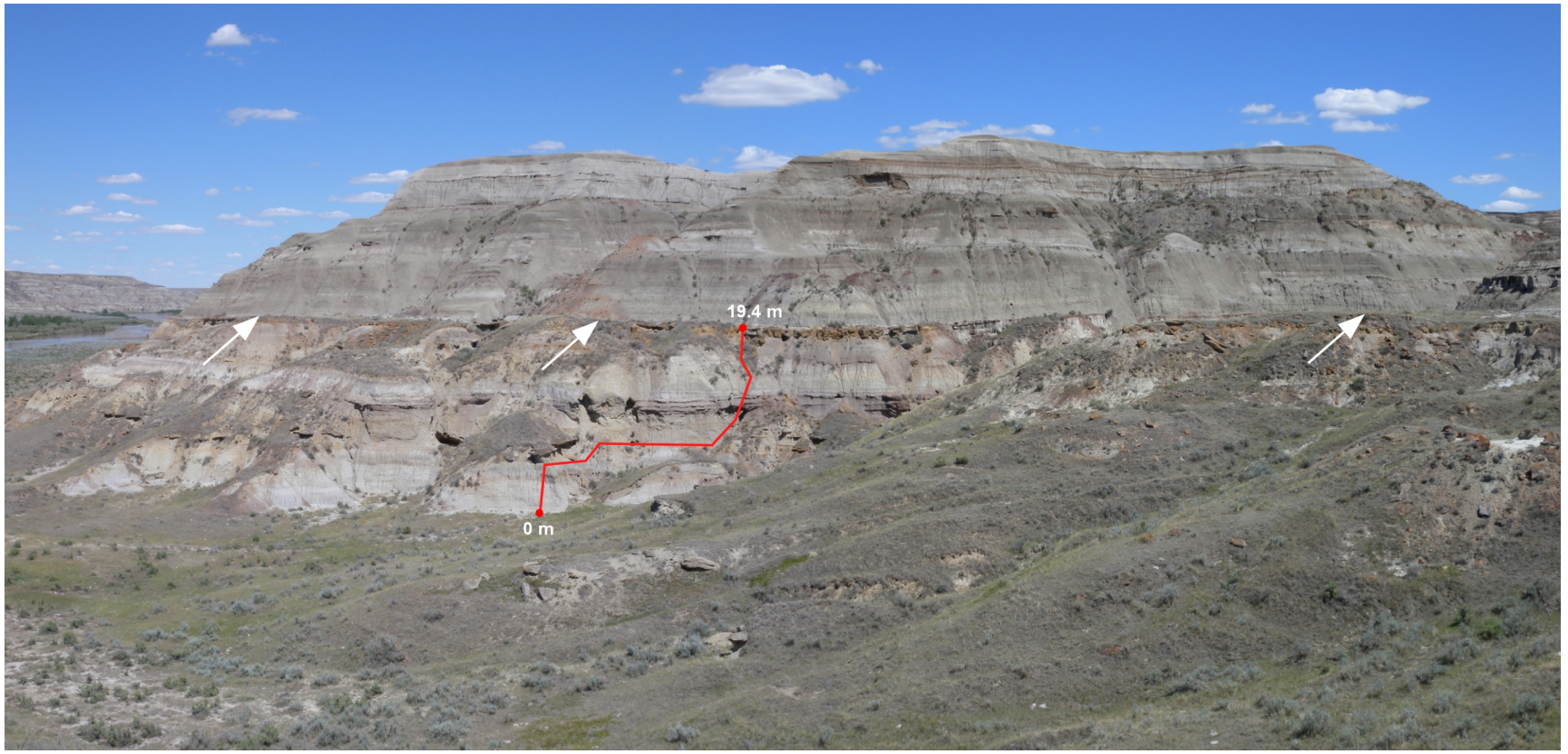

Figure 4. View of lower part of measured section T21-R10W4-01 (red line), southeastern Alberta. White arrows indicate top of Oldman Formation.

farther (into the top of the underlying sandstone unit) out of the line of the measured section (Figure 5). Mudstone or sideritic intraclasts and dinosaur bone occur in the lower parts of thicker sandstone units. Isolated chert pebbles up to 2 cm across are present in the lower part of the lowermost Dinosaur Park Formation sandstone package (23.5 m), which overlies about 4 m of silty mudstone at the base of the formation, but were not seen elsewhere. At 48.5 m, abundant lenticular-shaped resting traces of the ichnogenus *Lockeia* (Figure 6A), attributed to unionid bivalves (Johnston and Hendy, 2005), occur at the base of a sandstone unit with IHS. Shaft-like escape traces with meniscate laminae are developed in the overlying sandstone (Figure 6B).

Below 72.0 m, silty mudstone intervals are generally pale olive grey-brown (rarely chocolate brown or red-brown) and massive in appearance, with a well-developed 'popcorn-weathering' surface crust. Sideritic nodules are relatively rare but locally form some discrete horizons.

3.3 72.0 to 91.6 m: Upper Part of the Dinosaur Park Formation

The interval of carbonaceous shale, coal, heterolithic fine-grained sandstone and siltstone packages, and marine mudstone from 72.0 to 91.6 m in the measured section represents the upper part of the Dinosaur Park Formation. It includes the Lethbridge coal zone (MacDonald et al., 1987), here used to refer to all strata bounded by the lowermost and uppermost coal seams (see discussion in Glombick, 2010), although in other studies in the area (e.g., Eberth, 2005; Brinkman et al., 2005) that term refers to a more loosely defined 15 to 20 m thick interval at the top of the Dinosaur Park Formation.

The interval from 72.0 to 74.0 m consists mainly of dark grey to brown carbonaceous silty mudstone passing up to chocolate brown mudstone, representing a clear change from the lower part of the Dinosaur Park Formation. A very carbonaceous, locally coaly shale at 74.0 m is considered to mark the base of the Lethbridge coal zone *sensu stricto*. The interval above this, up to 76.0 m, consists of red-brown mudstone with abundant plant debris and two coal beds (30 and 25 cm thick). This is overlain, with a sharp erosional contact, by a 5 m thick, upward-fining, fine-grained sandstone (pale grey) to muddy siltstone (grey-brown, locally very carbonaceous) unit showing well-developed IHS (76.0 to 81.0 m). The unit is complex, with internal erosion surfaces. In the slope located 300 m east of the measured section (Figure 7), at least two well-developed upward- and laterally fining packages with IHS are present within this interval. The interval from 81.0 to about 82.3 m consists of mid-grey–weathering silty mudstone and very fine grained sandstone. This interval is intensely bioturbated, unlike the underlying package with IHS, and contains fairly abundant plant debris. In the slope to the east (Figure 7), the relatively planar base of this unit can be seen to truncate the IHS at the top of the package beneath. It passes gradationally up into a 5 m thick (82.3 to 87.4 m) interval of dark grey-brown, slightly silty mudstone with minor thin (<1 cm), generally laterally impersistent units of low-angle (?hummocky) laminated, very fine grained sandstone to siltstone, which become less abundant in the upper part of the interval, and horizons of discoidal orange sideritic concretions up to 1 cm thick and 30 cm across. This 5 m thick mudstone interval shows some bioturbation and likely represents the 6 m thick vertebrate-bearing marine mudstone interval within the Lethbridge coal zone described by Brinkman et al. (2005). At 87.4 m, the mudstone is overlain by 5 cm of dark, very carbonaceous mudstone, locally grading to coal, which is considered to mark the top of the Lethbridge coal zone *sensu stricto*.

The thin, coaly interval at the top of the Lethbridge coal zone is overlain by a 2.1 m thick interval (87.4 to 89.5 m) of pale, slightly greenish grey, flat-laminated (locally crosslaminated), very fine grained sandstone and carbonaceous siltstone (Figure 8). A laterally persistent, resistant, 10 cm thick unit of dark red-brown–weathering, fissile and platy 'paper' shale is present within the upper part of this interval (base at 88.9 m). The top of the flat-laminated interval is gradational and bioturbated, passing up into a 2.1 m thick (89.5 to 91.6 m), distinctively orange-brown–weathering, silty mudstone unit that contains abundant fine plant debris and appears to be intensely bioturbated. The top of this interval (91.6 m) is likely to

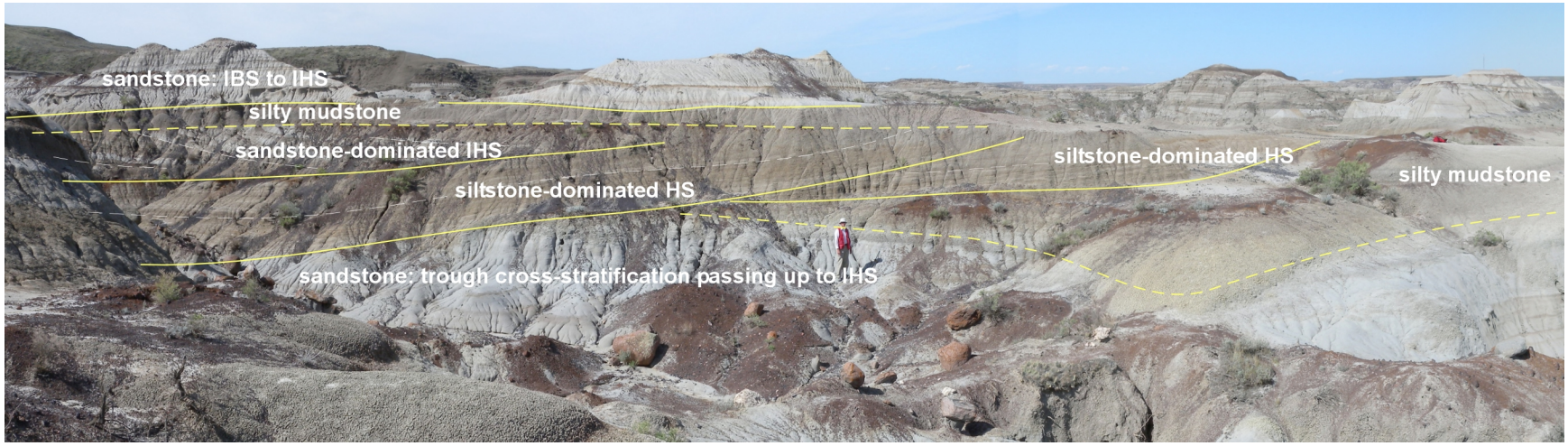

Figure 5. Geometry of units showing inclined heterolithic stratification (IHS), concave-up heterolithic stratification (HS) and large-scale inclined bedding (IBS) in Dinosaur Park Formation, at 57 to 65 m level in measured section T21-R10W4-01, southeastern Alberta. Solid yellow lines represent sharp erosional contacts and dashed yellow lines represent gradational contacts. Section was measured in the central area where the figure is standing.

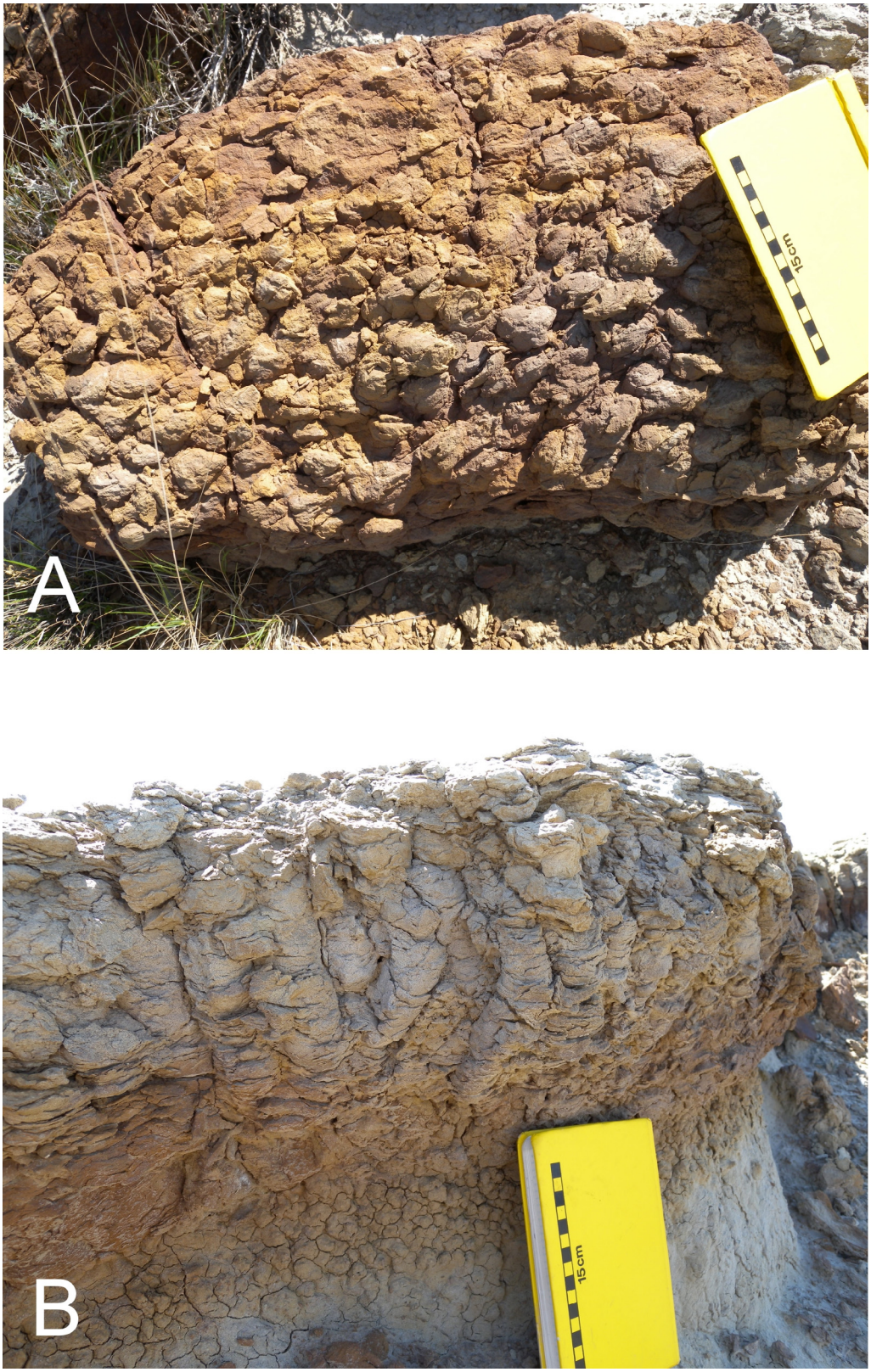

Figure 6. A) Lenticular-shaped trace fossils of the ichnogenus *Lockeia* on the basal surface of sandstone at 48.5 m in measured section T21-R10W4-01, southeastern Alberta (view is of base of sandstone unit in a loose block). B) Shaft-like escape traces with meniscate laminae in overlying sandstone.

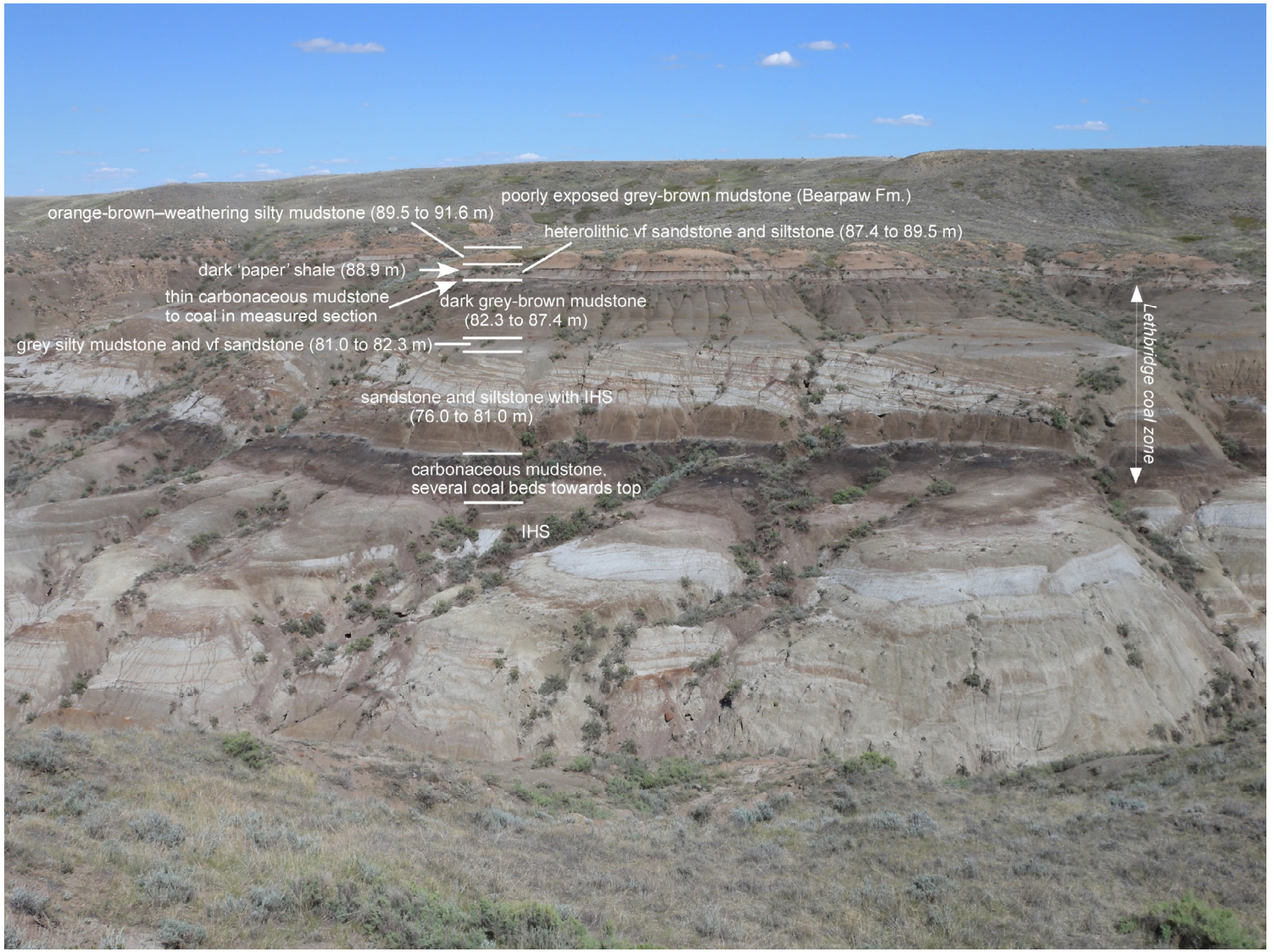

Figure 7. View of west-facing slope located 300 m east of top of measured section T21-R10W4-01, southeastern Alberta. Units in the upper part of the Dinosaur Park Formation (including the Lethbridge coal zone) are indicated, with their corresponding heights in the measured section. Abbreviations: IHS, inclined heterolithic stratification; vf, very fine grained.

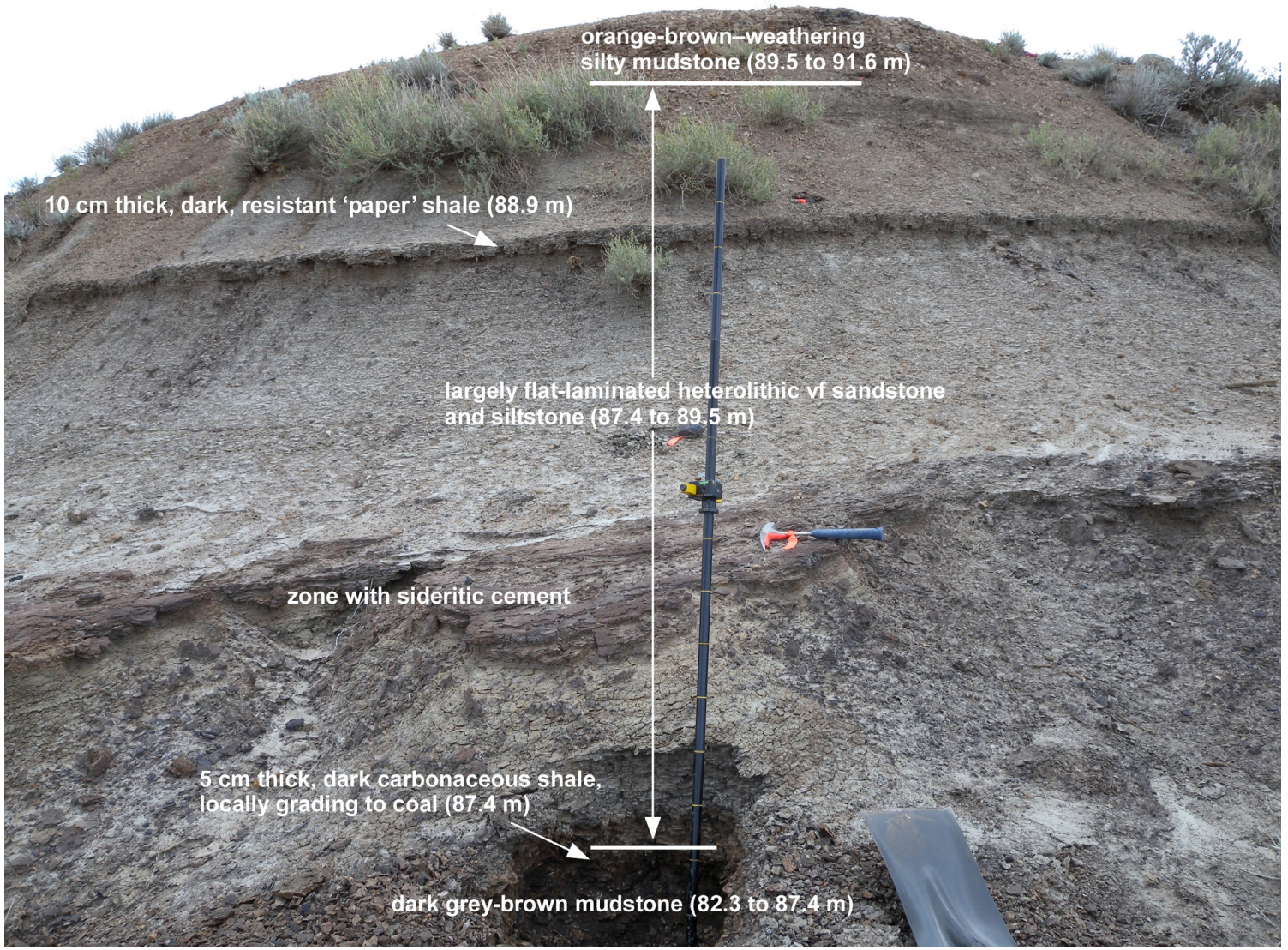

Figure 8. Detail of units in the uppermost part of measured section T21-R10W4-01, southeastern Alberta (87 to 89.5 m, uppermost Dinosaur Park Formation). The top of the Lethbridge coal zone at 87.4 m is exposed in the pit at the base of the photo. Orange-brown–weathering talus from the 89.5 to 91.6 m silty mudstone covers much of the upper part of the interval beneath. Abbreviation: vf, very fine grained.

represent the top of the “predominantly non-marine” “tan siltstone/shale” interval of Brinkman et al. (2005), which they consider to mark the top of the Dinosaur Park Formation.

The results of biostratigraphic analysis of three samples from the upper part of the Dinosaur Park Formation are detailed in Appendix 3.

Above the poorly exposed contact at 91.6 m, poorly exposed, dark grey-brown–weathering mudstone at the top of the section is assigned to the Bearpaw Formation.

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 relatively high throughout the exposed Oldman Formation section, dropping through the uppermost sandstone unit to be consistently lower in the Dinosaur Park Formation. This 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). Lower counts were recorded for the coarsest Oldman Formation sandstones (e.g., 4.7 to 6.5 m) and sideritic concretion horizons (2.75 m), but even these rock types show gamma-ray values comparable to the highest recorded from Dinosaur Park Formation mudstone intervals. Within the Dinosaur Park Formation, the coarsest sandstone intervals again show the lowest gamma-ray counts (e.g., 23.5 to 26.0 m; 44.0 to 48.5 m). Gamma-ray values for the section above 81.0 m, including the 82.3 to 87.4 m marine mudstone interval, are relatively uniform and significantly lower than those recorded for mudstones lower in the Dinosaur Park Formation.

5 Summary

Measured outcrop section T21-R10W4-01 includes the uppermost part of the Oldman Formation and the whole of the overlying Dinosaur Park Formation. Bearpaw Formation mudstone is poorly exposed at the top of the section.

The exposed Oldman Formation consists of sandstone units showing low-angle inclined stratification, trough (rarely planar) cross-stratification or ripple crosslamination, and interbedded silty mudstone. Dinosaur Park Formation sandstone units, again interbedded with silty mudstone, commonly show IHS, concave-up HS or IBS. The uppermost part of the Dinosaur Park Formation includes intervals of bioturbated marine mudstone and coals of the Lethbridge coal zone. Outcrop gamma-ray counts show a marked and sustained drop passing from the Oldman Formation up into the Dinosaur Park Formation, consistent with the upward deflection to the left noted across the formation boundary in downhole gamma-ray logs.

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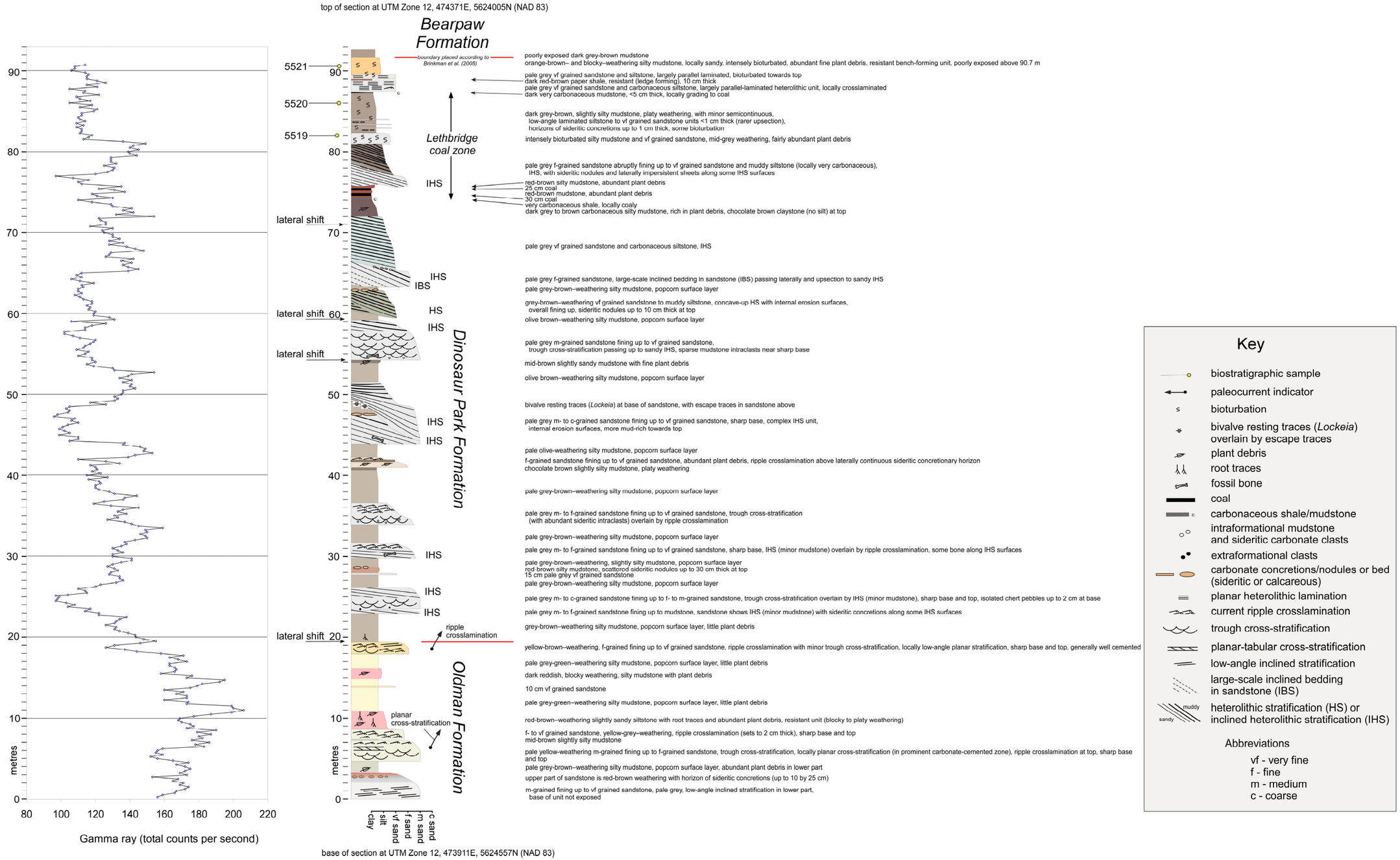
Appendix 1 – GPS Location Data for Measured Outcrop Section T21-R10W4-01

The GPS location data for measured outcrop section T21-R10W4-01, in southeastern Alberta, were obtained using Garmin® GPSMAP® 60CSx hand-held units. The UTM co-ordinates are NAD 83, Zone 12. The ± values indicate estimates of horizontal error generated by the GPS units.

Easting	Northing	Horizontal Error (±)	Elevation (m)	Comments
473911	5624557	0.5	644	base of measured section (0.0 m) – 1st GPS unit
473911	5624557	0.7	643	base of measured section – 2nd GPS unit
473957	5624542	1.6	659	19.0 m in measured section
473914	5624448	0.9	663	20.5 m in measured section (at base of 2nd part of section)
473958	5624294	4.1	701	52.5 m in measured section
474114	5624202	3.2	704	54.25 m in measured section; base of next part of section
474118	5624188	1.6	706	59.25 in measured section; significant section shift above this point
474214	5624150	2.9	719	59.15 m (top of sandstone) in measured section; after significant section shift
474218	5624109	2.7	715	63.35 m (base of sandstone) in measured section; after section shift
474299	5624070	2.1	721	71.0 m in measured section (before shift)
474330	5624055	0.8	721	72.0 m in measured section (base of subsection)
474371	5624005	1.5	740	90.7 m in measured section (top of well-exposed section)

Appendix 2 – Graphic Log of Measured Outcrop Section T21-R10W4-01 (Southeastern Alberta) with Outcrop Gamma-Ray Curve. Large-Format Version of Figure 3 with Descriptive Notes.



Appendix 3 – Biostratigraphic Samples from Measured Outcrop Section T21-R10W4-01

Three samples were collected from the uppermost part of measured outcrop section T21-R10W4-01, southeastern Alberta, for biostratigraphic analysis. Splits from all three were sent to D. McNeil (Geological Survey of Canada, Calgary) for foraminiferal analysis, and a split from one was sent 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 5519 (82.0 m): mid-grey mudstone and very fine grained sandstone (Dinosaur Park Formation)

D. McNeil

Foraminifera: *Trochammina albertensis* Wickenden – 66 counts
Seed Cuticle: *Costatheca* sp. – 1 count
Miscellaneous: bone fragments are rare; plant fragments are rare
Washed Residue: fine-grained sandstone, glauconite and coaly particles common
Age: Late Campanian
Comment: *Trochammina albertensis* in high abundance suggests a low salinity, marginal marine or coastal paleoenvironment

Sample 5520 (86.0 m): dark grey-brown mudstone (Dinosaur Park Formation)

D. McNeil

Algal Cysts: *Leiosphaeridia*? sp. – 3 counts
Miscellaneous: plant fragments
Washed Residue: pale greyish brown clay with abundant macerated organic matter
Age: indeterminant
Comment: terrestrial sediment

G. Dolby

Age: mid-Late Campanian
Environment: brackish; estuarine/lagoonal
Remarks: This is an extremely rich assemblage dominated by spores and pollen but with a restricted marine/brackish dinocyst association. The initial count revealed in excess of 120 specimens of a dinocyst referable to *Spinidinium* sp. Other dinocyst species are rare and include *Palaeohystrichophora infusiorides, Chatangiella decorosa, Odontochitina operculata, Oligosphaeridium pulcherrimum. C. decorosa* is characteristically mid-Campanian but it occurs rarely and sporadically in the Early Maastrichtian.
There is a rich and diverse assemblage of the *Aquilapollenites* group including *A. quadrilobus, A. trialatus, A. claroreticulatus, A. centus, A.* cf. *venustus, A.* aff. *drumhellerensis, Mancicorpus* spp., *M. tripodiformis.* Other angiosperms include *Cranwellia rumseyensis, Pulcherripollenites krempii.* This pollen assemblage can be assigned to the mid-Late Campanian *Triprojectus unicus* Zone of Sweet et al. (1989).
The dominance of *Cyathidites* spp. with abundant *Taxodiaceae* spp., *Laevigatosporites* spp. and bisaccate pollen, together with the single-species dominated dinocyst assemblage indicates a brackish estuarine or lagoonal setting.

Sample 5521 (90.6 m): orange-brown–weathering silty mudstone (Dinosaur Park Formation)

D. McNeil

Foraminifera: *Bathysiphon*? sp. – 9 fragments
Washed Residue: greyish orange clay with abundant black grains of uncertain origin
Age: indeterminant
Comment: *Bathysiphon* sp. assemblages suggest a muddy marine substrate

Appendix 4 – Outcrop Gamma-Ray Methodology

Gamma-ray values, in counts per second, were measured on measured outcrop section T21-R10W4, 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 of 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