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A measured section through the Monteith Formation along Sikanni Chief River, Mount Withrow map area (NTS 94G/06), NE British Columbia

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ABSTRACT

In Trutch map area (NTS 94G), northeast British Columbia, detailed lithostratigraphy and sedimentology of the Monteith Formation (Minnes Group; Jurassic-Cretaceous) and overlying Bullhead Group (Lower Cretaceous) are problematic. During GSC's Central Foreland NATMAP Project, bedrock mappers recognized the probable presence of Monteith Formation strata in Trutch map area. This report presents a detailed stratigraphic section through the Monteith Formation, measured along Sikanni Chief River near the mouth of Chicken Creek (Mount Withrow map area; NTS 94G/06). At this site, the Monteith Formation is dominated by very fine- to medium-grained, quartz-rich sandstone, with lesser volumes of siltstone and shale. Sandstone lithofacies are variably: very thin to thin bedded and current-rippled; thin to thick bedded and trough cross-stratified; or thin bedded with wave ripples and hummocky cross-stratification. The succession was deposited in shallow-marine to marginal-marine environments, possibly including deltaic settings.

INTRODUCTION

This report presents a detailed measured section (MWB-00-03) through the Monteith Formation in Mount Withrow map area (NTS 94G/06), northeastern British Columbia. The section was measured by the author during field work conducted in Trutch map area (NTS 94G) as part of the Geological Survey of Canada's Central Foreland NATMAP Project (Lane et al., 1998; Lane 2004). In the course of bedrock mapping, M.P. Cecile observed that outcrops along Sikanni Chief River near the mouth of Chicken Creek exposed a largely continuous section through the entire thickness of the Monteith Formation (Minnes Group; Jurassic-Cretaceous). The author measured the section over four days during the summers of 2000 and 2001. The section overlaps in large part with D.F. Stott's section 61-4 (Stott, 1973), which was less detailed but included overlying strata not measured during the present work.

STRATIGRAPHIC CONTEXT

During the Central Foreland NATMAP Project's work in Trutch map area, the lithostratigraphy of post-Triassic units that lie below the shale-dominated Buckinghorse Formation (Figure 1) was found to be problematic. Where preserved, the shale-dominated

Fernie Formation (Jurassic) is readily recognizable (Stott, 1998; MacNaughton, 2006). Subdivision of sandier strata lying between the Fernie and Buckinghorse formations proved challenging, necessitating reconsideration of conclusions reached by earlier workers. For example, Stott (1973, 1998) had considered the Monteith Formation to occur only in the southwestern part of Trutch map area, and assigned the strata described herein to the Gething Formation. More recent mapping (Cecile et al., 2000) indicates that the Monteith Formation is more widely preserved, a view supported by preliminary biostratigraphic data (Hinds, 2002; Hinds and Spratt, 2005). Difficulties also exist in the subdivision of the Bullhead Group (Lower Cretaceous) in the Trutch region (Figure 2). Stott (1973, 1998) assigned Bullhead Group strata in Trutch entirely to the Gething Formation, whereas Gibson (1992) tentatively assigned a basal interval of the Bullhead Group to the Cadomin Formation. Distinguishing between Monteith and Gething formations in Trutch map area is complicated by the occurrence of similar lithofacies in both units. Where the intervening, conglomeratic Cadomin Formation is well developed, as in the section described here, it provides a marker for the top of the Monteith Formation, but the Cadomin Formation is patchily distributed in Trutch map area (M.P. Cecile, pers. comm., 2001). These issues demonstrate the need for additional, detailed study of the Minnes and Bullhead groups in Trutch map area.

Although Currie and Cecile (1999) assigned the strata documented in this report to the Monteith Formation, the presence of Cadomin Formation–and thus of a complete Monteith Formation section–was recognized by M.P. Cecile only during mapping in 2000. Published GSC maps do not reflect the presence of Cadomin Formation in this area.

LOCATION AND ACCESS

Section MWB-00-03 is exposed in outcrops along the north bank of Sikanni Chief River, downstream (east) from the mouth of Chicken Creek (Figure 2). Measuring commenced within the Pardonet Formation (Triassic), which here forms a resistant-weathering rib. Coordinates for the base of the section are E498011, N6347140 (all coordinates NAD 83). The section extends upstream to just west of the mouth of Chicken Creek, ending at a prominent rib of conglomerate that marks the base of the Cadomin Formation. Measuring was terminated at base of Cadomin Formation, at coordinates

E497829, N6347108.

Access to the section is by a short walk from Grassy-Chicken Creek Road. This gravel-surface, petroleum-development road branches west from the Alaska Highway at a point approximately 7.5 km south of the Buckinghorse River highway crossing. From Grassy-Chicken Creek Road, the section is reached by following the east bank of Chicken Creek or by walking along cut lines and abandoned wood roads. The river valley on the north bank of Sikanni Chief River is steep along the section's route, but access to the riverbank can be obtained readily at several points downstream from the mouth of Chicken Creek.

The section is in the west limb of Pink Mountain Anticline, which trends approximately NW-SE in the immediate region (Currie and Cecile, 1999). Beds dip moderately to the southwest. The section can be studied easily along its thickness, except around the mouth of Chicken Creek, where high water in the creek channel can hamper access to approximately 5 m of the section.

SUCCESSION AND THICKNESS OF FORMATIONS

A graphic log for section MWB-00-03 is presented in Figures 3 and 4; the detailed, written log is provided in the Appendix. The base of section MWB-00-03 lies 5.0 m below the top of the Pardonet Formation, which here consists of fetid, fossiliferous limestone. Zonneveld et al. (2004) have provided a detailed account of this unit in Trutch map area. The Pardonet Formation is overlain, apparently sharply, by a covered interval (9.6 m thick). Exposures of this interval were viewed at a distance on the opposite shore of Sikanni Chief River, where they appear to consist of dark-weathering shale. The covered interval may represent a thin succession of Fernie Formation, which is of highly variable preserved thickness in Trutch map area (Stott, 1998; Hinds, 2003).

The base of the Monteith Formation is covered, but is at or near the 14.6 m level in the section, at which level the first outcrop of sandstone occurs. Exposures viewed across Sikanni Chief River suggest a sharp contact between the Monteith Formation and the underlying (probable) Fernie Formation. Total measured thickness for Monteith Formation is 192.8 m, which compares well with the thickness of 196.6 m reported by Stott (1973; Stott's thickness converted from Imperial to metric units) for the same interval. Exposure within the

Monteith Formation is largely continuous. About 20 percent of the section is covered, but most covered intervals are less than 4 m thick and lithologies generally can be inferred from float or subcrop. Covered intervals are recessive and probably underlain by shale or siltstone. The Monteith Formation is described in more detail in the next section of this report.

The base of the Cadomin Formation is 207.4 m above the base of the section, at the sharp base of the first bed of chert-pebble conglomerate encountered in the section. Only the basal conglomerate bed of the Cadomin Formation (2.0 m) was measured. Above the base this conglomerate bed, Section 61-4 of Stott (1973) recorded a 30.9 m thick interval of sandstone, pebbly sandstone, and conglomerate (commonly with chert pebbles). Above the conglomerate-bearing interval, Stott (1973) recorded a further 22.3 m of sandstone, siltstone, and shale before reaching the limit of exposure in the axis of a small syncline. This uppermost interval may be part of the Gething Formation.

SUMMARY OF MONTEITH FORMATION

Summary of Lithofacies

In section MWB-00-03 (Figures 3 and 4; Appendix), the Monteith Formation consists of grey- to tan-weathering, quartz-rich sandstone with lesser grey- to brown-weathering siltstone and shale. Sandstone lithofacies in the section can be assigned to three broad groups.

1. *Very thin- to thin-bedded, generally very fine-grained sandstone*. Beds of this lithofacies generally are current-rippled and commonly are interbedded with mudstone or siltstone, or display mudstone partings. Other sedimentary structures include lensen bedding, mud flasers, convolute lamination, load casts, and rare synaeresis cracks. Very sparse paleocurrent measurements (n=2) from current ripples indicate paleoflow roughly to the west.
2. *Thin- to thick-bedded, very fine- to medium-grained sandstone*. Beds of this lithofacies commonly are cross-stratified. In some beds the character of the cross-stratification cannot be determined, but trough cross-stratification is common. Recognizable channel cross-sections are present in several packages

of this lithofacies. Current ripples, parallel bedding, mudstone intraclasts, and conglomerate lags also occur. Paleocurrent measurements from cross-beds (n=7) indicate paleoflow mainly to the west, with a lesser mode to the east.

3. *Thin-bedded, very fine- to fine-grained sandstone*. Beds of this lithofacies commonly display low-angle cross-lamination or hummocky cross-stratification, wave ripples, or normal grading, and commonly are interbedded or interlaminated with shale or mudstone.

Siltstone is generally laminated and blocky to fissile, in some cases weathering as "poker chips". Shale is generally well laminated, locally with a papery weathering aspect. Some shale beds are dark grey to black. Shale and siltstone units locally can contain beds of silty shale or shaley siltstone. Lithofacies in the section generally are well indurated, though rare sandstone and siltstone beds can be friable.

The section alternates roughly between intervals dominated by sandstone and intervals in which sandstone is interbedded with shale and siltstone. In exposed intervals, the thickest shale accumulations are roughly 1 m in thickness, and individual siltstone accumulations may reach thicknesses of just under 4 m. Covered intervals, which may be underlain by shale or siltstone, can be significantly thicker (up to almost 10 m for unit 27).

Summary of Lithofacies Packaging

Parts of the section show well-developed packaging, defined by trends in grain size and bedding thickness. Successions can be recognized that are characterized either by: upward coarsening of grain sizes and upward thickening of beds; or by upward fining of grain sizes and upward thinning of beds. Packages that thin and fine upward are best developed in the intervals between unit 9 and unit 25 and between unit 68 and unit 100. Such packages generally have erosional bases and consist of a basal interval of trough cross-bedded, fine-grained sandstone that passes gradationally upsection into an interval of current-rippled, very fine-grained sandstone interbedded with siltstone or shale. Good examples of such packages include the sandstone-dominate successions consisting of units 92-94 and units 95-100. Units 16-18 comprise a siltstone-rich example that lacks trough cross-bedded sandstone.

Packages that coarsen and thicken upward commonly have a basal interval of shale or siltstone, which passes gradationally upsection into a sandstone-dominated interval characterized by combinations of ripples (including wave ripples), low-angle cross-lamination, hummocky cross-stratification, and parallel bedding. Examples of such successions include units 18-20, units 33-37, and units 42-45. The upward-coarsening package defined by units 79-82 is capped by a unit of trough cross-stratified sandstone (unit 82). Some upward-coarsening packages lack a basal unit of shale or siltstone, consisting instead of a succession of interbedded to interlaminated sandstone and siltstone in which the proportion of siltstone decreases gradationally upward within the package. Units 104 and 105 each are examples of such a package.

COMMENTS ON SEDIMENTOLOGY OF MONTEITH FORMATION

Detailed interpretation of Monteith Formation sedimentology in Trutch map area is beyond the scope of this report, and ideally will require study of additional sections. Thus, only preliminary sedimentological interpretations will be offered here.

Monteith Formation strata exposed to the south of Trutch map area have been interpreted in terms of a deltaic to marine depositional system by Stott (1998). Such an interpretation also seems applicable to Monteith Formation strata described in the present report. The sandstone-dominated character of the succession is consistent with a shallow-marine to marginal-marine setting. The presence of wave ripples, low-angle cross-lamination, and hummocky cross-stratification in many beds points to a wave-influenced or wave-dominated system. Upward-coarsening packages described above display features reminiscent of successions deposited by prograding, wave-dominated shorefaces and by prograding deltas (cf., Bhattacharya and Walker, 1991). Similarly, the upward-fining packages may have been deposited in fluvial channels or fluvial-dominated distributary channels (Bhattacharya and Walker, 1991; Miall, 1992). Additional features that may be consistent with a deltaic or delta-influenced environment include synaeresis cracks (possibly reflecting mixing of saline and fresh waters) and well-developed soft-sediment deformation structures (reflecting high rates of sedimentation). Tidal influence is suggested by the presence of lensen bedding and mud flasers in some beds and the weakly developed

bimodality of paleocurrents from trough cross-beds, but the evidence for this is sparse.

ACKNOWLEDGEMENTS

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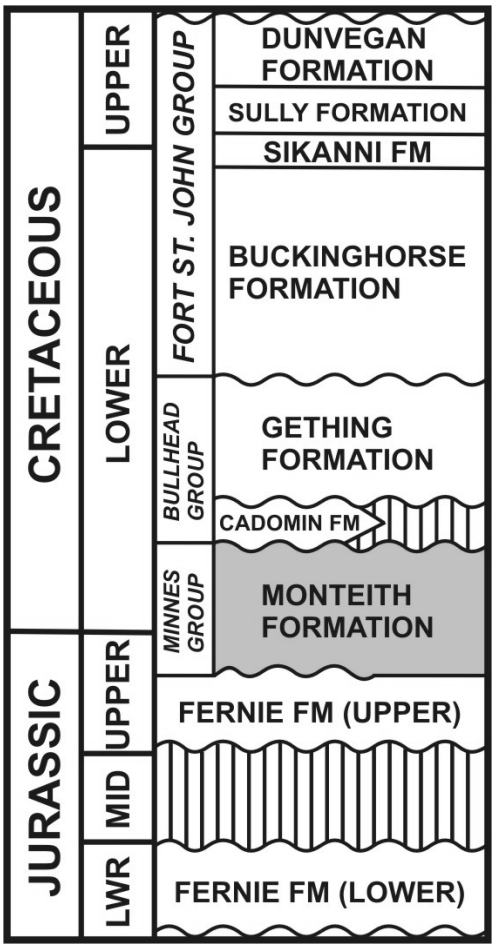

Figure 1: Table of Jurassic and Cretaceous formations recognized in Trutch map area during the Central Foreland NATMAP Project. Modified after Lane et al. (1999), Hinds and Spratt (2005), and MacNaughton (2006).

Figure 2: Photograph of Monteith Formation along Sikanni Chief River, downstream from mouth of Chicken Creek. Photograph taken from base of section MWB-00-03, looking upriver. Beds dip westward (upstream). Resistant strata at lower right are uppermost beds of Pardonet Formation. Single-headed arrow points to approximate base of Monteith Formation. Double-headed arrow points to promontory of rock (unit 96 in measured section) immediately upstream from mouth of Chicken Creek; section continues upstream several metres past this promontory. Some intervals are exposed among the trees rather than along the riverbank. Person (immediately above single-headed arrow) provides scale. Photograph was taken on a day with low, hazy overcast.

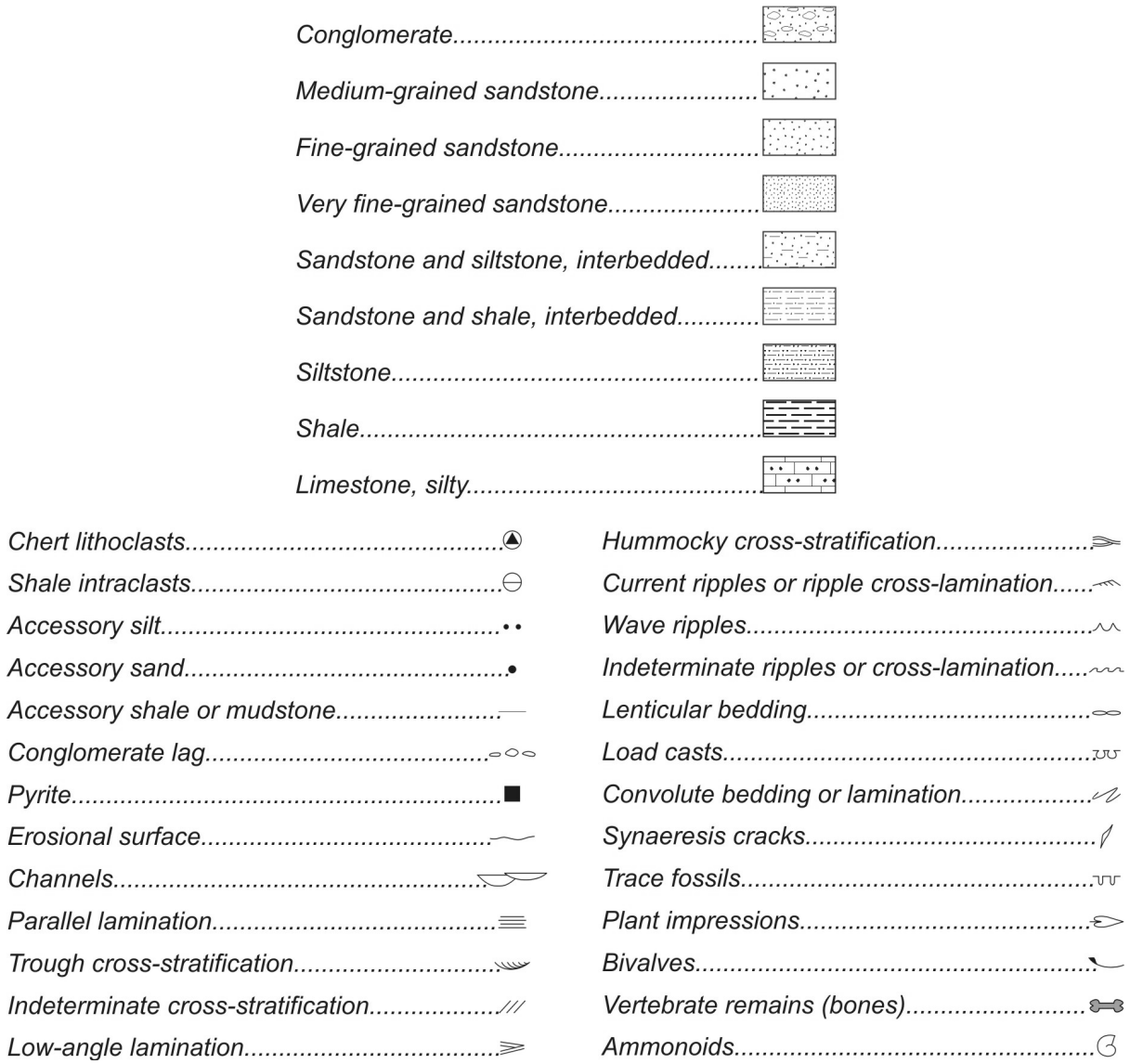

Figure 3: Legend of rock types, sedimentary features, and fossils to accompany measured section MWB-00-03 (Figure 4).

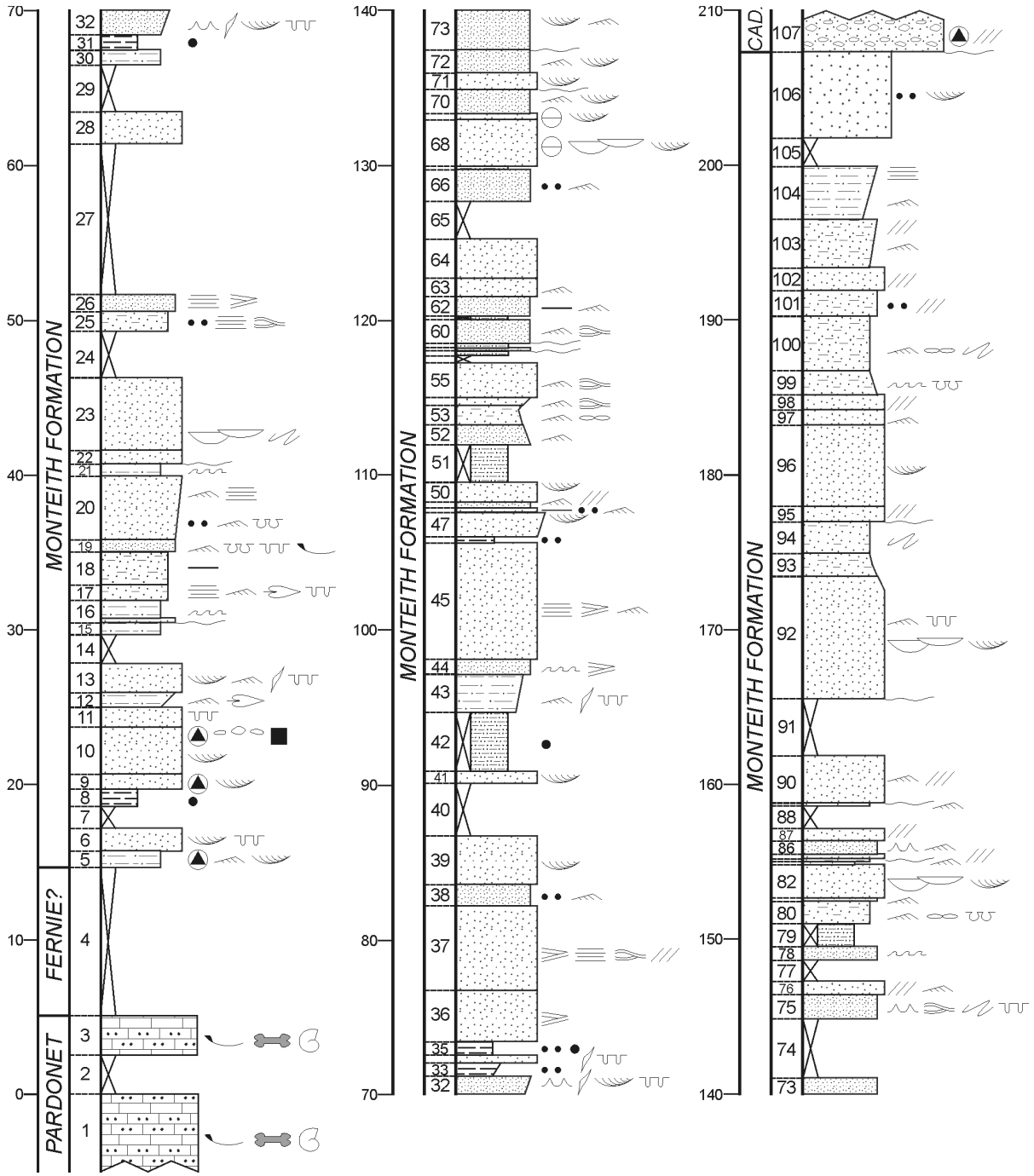

Figure 4: Detailed graphic log of measured section MWB-00-03 through Monteith Formation; see Figure 3 for legend. Section profile mimics sediment grain-size, to emphasize presence of upward-fining and upward-thinning packages. Unit numbers are given immediately beside and to the left of lithic logs. Vertical scale is in metres. "CAD." = Cadomin Formation.

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APPENDIX: Section MWB-00-03

Monteith Formation, Sikanni Chief River, around mouth of Chicken Creek, on west limb of Pink Mountain Anticline. Mount Withrow map area (NTS 94G/06), northeastern British Columbia.

Section measured by: Robert B. MacNaughton, GSC-Calgary
Assistants: Cory Bass, Ryan Fraser, Michael McQuaid
Dates measured: June 25, 2000; July 6, 2000; July 15, 2001; July 22, 2001
Base of section: E498011, N6347140 (NAD 83)
Top of section: E497829, N6347108 (NAD 83)

N.B. In the following descriptions, terms for bedding thickness follow Ingram (1954):

Very thick bedded = thicker than 1 m
Thick bedded = 30-100 cm
Medium bedded = 10-30 cm
Thin bedded = 3-10 cm
Very thin bedded = 1-3 cm
Thickly laminated = 0.3-1 cm
Thinly laminated = thinner than 0.3 cm

Unit	Description	Thickness (m)	Above base
	CADOMIN FORMATION		
	(Unit 107 cores the second prominent rib of rock extending into the Sikanni Chief River, upstream from the mouth of Chicken Creek. Cadomin Formation continues upriver, but exposure becomes less continous and more given to weathering out as inaccessible cliffs along the river.)		
107	**Conglomerate** Base erosional. Heavy moss cover. Grey-weathering conglomerate is clast-supported and consists of small pebbles in a matrix of fine- to medium-grained, quartz sandstone. Main clast lithologies are quartz and light grey and dark grey chert. Clasts are subangular to well rounded; sphericity is highly variable. May be thick bedded, locally massive, locally cross-stratified.	2.0	209.4
	MONTEITH FORMATION		
106	**Sandstone** Heavy moss and lichen cover. Medium to thick-bedded, fine- to coarse-grained (mainly medium-grained) sandstone. Trough cross-stratification present at several levels. Local enclaves and interbeds of dark-weathering siltstone. May coarsen upward by loss of siltstone.	5.6	207.4
105	**Covered**	1.8	201.8
104	**Sandstone and shale, interbedded** Base sharp. Exposure poor. Unit is a mixture of very thin- to thin-bedded, very fine-grained sandstone with some current ripple cross-lamination, and of dark grey-weathering shale. Shale is more common in lower part of unit, hence, unit coarsens upward. Sandstone in upper 1.0 metre of unit displays well-developed, flaggy, parallel bedding.	3.5	200.0
103	**Sandstone and siltstone, interbedded** Base sharp. Very thin- to thin-bedded, very fine-grained sandstone. Current-ripple cross-lamination; locally cross-bedded in upper 1.0 m. Up to 30% of unit is grey-weathering, blocky siltstone, which occurs as interbeds in lower half of unit, and as rare partings in upper half (i.e., unit coarsens upward).	3.1	196.5
102	**Sandstone** Base sharp. Light grey-weathering, medium- to thick-bedded, very fine- to fine-grained sandstone. Individual bed thicknesses irregular along outcrop; some pinching and swelling of beds. May be cross-stratified.	1.5	193.4
101	**Sandstone** Base gradational. Outcrop rubbly and lichen covered. Grey-weathering, thin-bedded, very fine-grained silty sandstone with minor interbeds of dark grey-weathering siltstone. Irregular cross-stratification in sandstone beds?	1.6	191.9

Unit	Description	Thickness (m)	Above base
100	**Sandstone and siltstone, interbedded** Base gradational. Dark grey- to (locally) rusty-weathering, thin-bedded, very fine-grained, silty sandstone (70% of unit). Current-ripple cross-lamination; local lensen bedding; local convolute bedding. Dark grey-weathering, blocky to fissile siltstone (30% of unit). Unit forms upward-fining and upward-thinning package with Units 98-99. Paleocurrent direction: 264° (current ripple)	3.5	190.3
99	**Sandstone and siltstone, interbedded** Base gradational by addition of siltstone and rippled sandstone. Thin- to medium-bedded, fine-grained sandstone. Sandstone beds are sharp to erosionally based, and locally may be loaded. Dark grey-weathering, fissile siltstone occurs as interbeds, comprising 10% or less of volume at base of unit, 20-30% at top of unit. Thus, unit fines upward.	1.6	186.8
98	**Sandstone** Base sharp. Light grey- to tan-weathering, thin- to medium-bedded, fine-grained sandstone. Cross-stratification. Bedding: 175°/70°	1.0	185.2
97	**Sandstone** (Nature of base not recorded, but presumably sharp.) Grey- to light-grey to tan- to rusty-weathering, thin-bedded, fine-grained sandstone. Current-ripple cross-lamination. *Unit 96 forms the first major rib of rock to extend into Sikanni Chief River, upstream from the mouth of Chicken Creek.*	0.9	184.2
96	**Sandstone** Base sharp. Light grey- to tan-weathering, thin- to medium-bedded, fine-grained sandstone. Cross-stratification (trough cross-stratification?) *Units 93-95 were viewed across a deep, fast-flowing channel at the mouth of Chicken Creek. Thickness values are approximate. Descriptions are not based on close examination of beds.*	5.3	183.3
95	**Sandstone** Base sharp, possibly erosional. Grey- to tan-weathering, thin- to medium-bedded, probably very fine- to fine-grained sandstone. Some bedding surfaces downlap onto basal contact.	~1.0	178.0
94	**Sandstone and siltstone, interbedded** Base gradational. Grey- to rusty orange-weathering, very thin- to thin-bedded, probably very fine-grained sandstone. Dark siltstone or shale, as partings and thin interbeds, comprise up to 40% of unit. Possible soft-sediment slumping. Bedding has a “rubbly” appearance.	~2.0	177.0

Unit	Description	Thickness (m)	Above base
93	**Sandstone and siltstone, interbedded** Base gradational by upward fining and thinning. Grey- to rusty orange-weathering, very thin- to thin-bedded, probably very fine-grained sandstone. Dark-weathering partings and thin interbeds of siltstone or shale comprise up to 30% of unit.	~1.5	175.0
92	**Sandstone** (Thickness may be slightly inaccurate: upper contact was sighted in across channel at mouth of Chicken Creek.) Base sharp, probably erosional. Grey-weathering, very thin- to thick-bedded (most commonly medium-bedded), fine-grained sandstone. Unit is dominated by at least six sets of lateral-accretion bedding of roughly equal thickness. Within lateral accretion sets, probable trough cross-stratification is common in medium to thick beds, and thin beds are current-ripple cross-laminated and commonly bioturbated. “Cut and fill” stratigraphy is relatively common. Unit thins upward and may fine upward in its uppermost beds.	8.0	173.5
91	**Covered**	3.6	165.5
90	**Sandstone** Base sharp, possibly erosional. Interval poorly exposed. Thin- to medium-bedded, very fine- to fine-grained, quartz sandstone. Thin beds preserve current-ripple cross-lamination; medium beds have possible cross-stratification.	3.1	161.9
89	**Sandstone and siltstone, interbedded** Very thin-bedded, current-rippled, very fine-grained sandstone with dark-weathering siltstone partings.	0.2	158.8
88	**Covered**	1.4	158.6
87	**Sandstone** Base sharp. Grey- to tan-weathering, medium-bedded, very fine- to fine-grained sandstone. Possible cross-stratification.	0.8	157.2
86	**Sandstone** Base sharp. Very thin- to medium-bedded (most commonly thin-bedded), very fine-grained sandstone. Poorly preserved wave and current ripples.	0.9	156.4
85	**Sandstone** Base sharp, locally erosional. Single bed of grey-weathering, fine-grained sandstone. Indeterminate cross-stratification. Bed thickness varies by 20-30 cm along outcrop. Locally weathers rusty or sulphur yellow.	0.3	155.5
84	**Sandstone and siltstone, interbedded** Base gradational. Very thin-bedded, current-rippled, very fine-grained sandstone, interbedded in roughly equal volumes with dark grey-weathering, platy siltstone. Unit locally displays a sulphur-yellow weathering colour.	0.2	155.2

Unit	Description	Thickness (m)	Above base
83	**Siltstone** Base sharp. Interval strongly weathered and friable. Dark grey, grey- to rusty-weathering siltstone to sandy siltstone. Generally massive, but with some suggestions of relict lamination. Weakly developed paleosol horizon?	0.2	155.0
82	**Sandstone** Base sharp to erosional. Thin- to thick-bedded, very fine- to fine-grained, quartz sandstone. Cross-stratified (probably trough cross-stratification). Bedding irregular with some "cut and fill" stratigraphy. Uppermost 10-20 cm locally is somewhat friable.	2.1	154.8
81	**Sandstone** Base sharp. Thin-bedded, grey-weathering, very fine-grained sandstone. Some current ripple cross-lamination. Local pinching and swelling of bed thicknesses. Minor "cut and fill" stratigraphy.	0.2	152.7
80	**Sandstone and siltstone, interbedded** Dark grey, grey- to rusty-weathering, very fine-grained sandstone and silty sandstone. Current ripples, lensen bedding, local loading. Dark grey-weathering, irregularly parted siltstone comprises 10-50% of unit. (No bedding thickness data recorded.)	1.5	152.5
79	**Covered** Subcrop suggests dark grey siltstone is dominant.	1.4	151.0
78	**Sandstone** Light grey- to (locally) rusty-weathering, thin-bedded, very fine-grained, quartz sandstone. Probable, but indeterminate, ripples.	0.9	149.6
77	**Covered**	1.4	148.7
76	**Sandstone** Base sharp. Light grey- to tan-weathering, thin- to medium-bedded, very fine- to fine-grained, quartz sandstone. Indeterminate cross-stratification. Possible current ripples on some bed tops.	0.9	147.3
75	**Sandstone** Medium to dark grey, light grey- to tan-weathering, very thin- to medium-bedded (commonly thin-bedded), very fine-grained, quartz sandstone. Indeterminate ripple cross-lamination; some wave-rippled bedding planes. Possible low-angle lamination (hummocky cross-stratification?). Convolute lamination and bedding. Poorly preserved trace fossils, including *Helminthopsis*-like burrows (on soles) and escape structures. Wave-ripple crest trend: 141°	1.6	146.4
74	**Covered**	3.7	144.8

Unit	Description	Thickness (m)	Above base
73	**Sandstone** Base erosional, with up to 0.3 m relief. Tan to light grey, tan- to (locally) rusty- or gossanous weathering, thin- to medium-bedded, very fine- to fine-grained sandstone. Weathering obscures internal structures, but beds overall resemble those in Unit 72. Possible small-scale, lateral-accretion bedding in exposure high on cliff. Bedding: 175°/65° Paleocurrent direction: 259°, 269° (cross-beds); 256° (current ripple)	3.6	141.1
72	**Sandstone** Base sharp. Tan to light grey, tan- to rusty-weathering, thin- to medium-bedded (10 cm-thick beds especially common), very fine- to fine-grained sandstone. Individual bed thicknesses can change by up to 50% along outcrop, but "cut and fill" packaging is not developed. Current-ripple cross-lamination. Possible, small-scale, trough cross-stratification.	1.5	137.5
71	**Sandstone** Base erosional, with at least 0.4 m relief. Tan to light grey, tan- to rusty-weathering, medium-bedded, fine- to (locally) medium-grained sandstone. Trough cross-stratified throughout. Unit pinches out updip in cliff exposure. Approximate paleocurrent direction: roughly to present-day west (poorly exposed cross-beds).	1.1	136.0
70	**Sandstone** Base sharp. Tan to light grey, tan- to rusty-weathering, medium-bedded, very fine- to fine-grained, quartz sandstone. Beds dominated by ripple cross-lamination, with minor, possible trough cross-stratification.	1.5	134.9
69	**Sandstone** Base sharp. Medium-bedded, fine-grained sandstone. Cross-stratified throughout, but lacks "cut and fill" bedding. Cross-bed foresets are asymptotic to base of beds, suggesting trough cross-stratification. Black, carbon-rich, shale intraclasts.	0.4	133.4
68	**Sandstone** Base sharp. Medium- to thick-bedded, fine- to (locally) very fine- or medium-grained sandstone. Individual bed thicknesses highly variable along outcrop. Beds display "cut and fill" stratigraphy, with strongly erosional, amalgamated bases. Good trough cross-stratification throughout unit. Rare siltstone partings. Some beds display weathered-out intraclasts.	3.1	133.0
67	**Siltstone** Base sharp. Black, grey-weathering, friable siltstone, locally with a greenish-yellow (sulphur?) efflorescence. Partings very poorly developed.	0.2	129.9
66	**Sandstone** Poorly indurated and friable, particularly the lower half of the unit. Very fine-grained sandstone, commonly silty. Beds are very thin in lower part of unit, thin in upper part, and display current-ripple cross-lamination.	2.1	129.7

Unit	Description	Thickness (m)	Above base
65	**Covered**	2.4	127.6
64	**Sandstone** Base gradational. Light to medium grey, grey-weathering, thin- to medium-bedded, very fine- to fine-grained sandstone. Some pinching and swelling of bedding; heavy lichen cover obscures internal structure of beds.	2.5	125.2
63	**Sandstone** Base gradational. Light grey-weathering, very thin- to thin-bedded, very fine- to fine-grained sandstone. Beds commonly amalgamated. Current-ripple cross-lamination, in some cases almost large enough to be considered small-scale trough cross-stratification.	1.2	122.7
62	**Sandstone** Base gradational. Grey-weathering, locally gossanous-weathering, very thin-bedded, very fine-grained sandstone. Current ripples. Up to 10% of unit is dark grey-weathering shale flasers, partings, and very thin interbeds.	1.2	121.5
61	**Siltstone** Base sharp. Poorly exposed, recessive-weathering interval of dark grey-weathering siltstone that weathers into chips.	0.2	120.3
60	**Sandstone** Base sharp to erosional. Dark grey, medium to light grey-weathering, thin- to medium-bedded, very fine-grained sandstone. Rippled (current ripples?); possible hummocky cross-stratification. Minor shale partings in basal part of unit. Unit may display weakly developed upward-thickening trend.	1.6	120.1
59	**Siltstone** Base sharp. Dark grey, light grey-weathering, roughly fissile to platy siltstone, locally to sandy siltstone.	0.3	118.5
58	**Sandstone** Base sharp to erosional. Two thin to medium beds of massive, very fine-grained sandstone.	0.2	118.2
57	**Siltstone** Dark grey, light grey-weathering, roughly fissile siltstone (80% of unit). Very thin-bedded, current-rippled sandstone (no grain-size recorded; probably very fine grained, by analogy with similar units).	0.3	118.0
56	**Covered** Probably dark grey siltstone.	0.5	117.7
55	**Sandstone** Base gradational. Medium grey, brown- to orange-weathering, very thin- to (mainly) medium-bedded, very fine- to fine-grained sandstone. Current ripples; possible hummocky cross-stratification. Some pinching and swelling of bedding. Beds commonly amalgamated; rare shale or siltstone partings. Forms upward coarsening package with Units 53 and 54.	2.2	117.2

Unit	Description	Thickness (m)	Above base
54	**Sandstone and siltstone, interbedded** Base gradational. Grey, light grey- to rusty- to tan-weathering, very fine-grained sandstone. Well-developed current-ripple cross-lamination; possible small-scale hummocky cross-stratification. Dark grey- to grey-weathering siltstone and shale. At base of unit, sandstone is thickly laminated, with up to 20% siltstone as partings and interlaminations. At top of unit sandstone is very thin to thin bedded (most commonly very thin bedded), with minor siltstone and shale as partings. Thus, the unit coarsens and thickens upward.	0.5	115.0
53	**Sandstone and siltstone, interbedded** Base gradational. Grey-weathering, laminated to very thin-bedded, very fine-grained, silty sandstone, commonly current rippled. Dark grey-weathering siltstone that breaks into chips. Local lenticular bedding. Sandstone comprises >70% of lower part of unit. In upper part of unit, sandstone accounts for <40% and occurs only as laminae, i.e., unit fines and thins upward.	1.3	114.5
52	**Sandstone** Base covered. Grey, tan- to orange-brown- to rusty-weathering, very fine-grained quartz sandstone with accessory feldspar. Two styles of bedding in sandstone. Medium to thick beds are massive, locally with current-rippled tops. Thin beds are current rippled. Thin beds dominate in upper part of unit, where they contain grey shale partings (i.e., unit thins and fines upward). Sandstone beds sharp based, locally amalgamated. Sharp-based, 15 cm-thick bed of dark grey- to brownish grey-weathering, massive siltstone occurs 0.8 m above unit base. Bedding: 162°/60°	1.2	113.2
51	**Covered** Strongly recessive notch with abundant, dark grey-weathering, “poker-chip” siltstone in float.	2.5	112.0
50	**Sandstone** Base sharp. Medium- to thick-bedded, fine-grained sandstone. Bedding is very irregular and blocky, suggesting presence of (trough?) cross-stratification. Units 48-50 comprise an upward-thickening and -coarsening succession.	1.2	109.5
49	**Sandstone** Base gradational. Very fine-grained sandstone; very thin bedded at base of unit, thin to medium bedded at top (i.e., thickens upward). Current rippled to cross-stratified.	0.4	108.3
48	**Sandstone** Base sharp. Very thin-bedded, current-rippled, very fine- to fine-grained sandstone, with dark-weathering shale and siltstone as partings.	0.3	107.9

Unit	Description	Thickness (m)	Above base
47	**Sandstone** Base gradational but abrupt. Basal part of unit is thin-bedded, very fine- to fine-grained sandstone, in which beds are laterally continuous. Upper part of unit is medium-bedded, fine- to (rarely) medium-grained sandstone, in which bedding is irregular (trough cross-stratification?). Thus, unit coarsens and thickens upsection.	1.6	107.6
46	**Silty shale** Base sharp. Dark grey-weathering, silty shale.	0.4	106.0
45	**Sandstone** Base sharp. Unit strongly resembles Units 36 and 37. Grey- to rusty-weathering, thin- to medium-bedded, fine-grained sandstone. Dominantly thin bedded in lower part of unit, medium bedded at top (thickens upsection). Well-bedded, with common parallel-lamination and possible low-angle lamination. Current ripples on very thin and thin beds.	7.5	105.6
44	**Sandstone** Base gradational, but abrupt. Medium- to thick-bedded, fine-grained, quartz sandstone. Some bed tops slightly wavy. Possible low-angle lamination.	1.0	98.1
43	**Sandstone and shale, interbedded** Base covered, apparently gradational. Grey-, tan-, and (rarely) rusty-weathering, very thin-bedded, very fine-grained sandstone to silty sandstone (70-90% of unit). Sandstone is current rippled with common horizontal burrows, including *Gordia*. Dark-weathering, silty shale (10-30% of unit) occurs as partings and interbeds. Synaeresis cracks noted in local float. Unit may coarsen up subtly into Unit 44.	2.4	97.1
42	**Siltstone** Base sharp. Unit is largely covered. Spot outcrops suggest interval consists of dark grey-weathering siltstone and (lesser?) silty sandstone.	3.8	94.7
41	**Sandstone** Grey- to tan-weathering, thin- to medium-bedded, very fine- to fine-grained, quartz sandstone. Trough cross-stratified. Bedding: 160°/65° Paleocurrent direction: 128° (cross-bed)	0.8	90.9
40	**Covered**	3.4	90.1
39	**Sandstone** Base sharp. Medium- to thick-bedded, fine-grained sandstone. Trough cross-stratified. Beds pinch and swell laterally to some extent but are too poorly exposed in three dimensions to permit study of this feature.	3.2	86.7
38	**Sandstone** Base gradational. Very thin-bedded, very fine-grained, silty, quartz sandstone. Possible current ripples. Minor siltstone. Unit coarsens up subtly.	1.3	83.5

Unit	Description	Thickness (m)	Above base
37	**Sandstone** Base gradational. Grey- to rusty-weathering, thin- to medium-bedded, very fine- to fine-grained, quartz sandstone. Generally flat-bedded with suggestions of low-angle lamination (hummocky or swaley cross-stratification?) within beds. Bedding locally flaggy. Some irregular-shaped beds may contain high-angle cross-bedding, but heavy lichen cover precludes certainty on this point.	5.5	82.2
36	**Sandstone** Base sharp. Lichen-covered, resistant unit forms high cliff and is difficult of access. Grey- to rusty-weathering, thin- to medium-bedded, very fine- to fine-grained, quartz sandstone. Bedding generally very flat and regular; some low-angle laminae within beds.	3.3	76.7
35	**Shale** Base sharp. Dark grey, yellow- or grey-weathering shale to shaley siltstone. Gypsiferous efflorescence. A single thin bed of very fine-grained sandstone bed occurs halfway up the unit.	0.9	73.4
34	**Sandstone** Base gradational. Medium-bedded, fine-grained sandstone. Synaeresis cracks; burrows. With Unit 33, makes a subtle upward-coarsening succession.	0.5	72.5
33	**Shale** Base very sharp. Dark grey, yellow- or grey-weathering shale to shaley siltstone. Gypsiferous efflorescence. Rare, very thin beds of very fine-grained sandstone, particularly near top of unit.	0.9	72.0
32	**Sandstone** Base gradational. Dominated by very thin- to thin-bedded sandstone. Basal 0.4 m of unit consists of very thin-bedded, very fine-grained, quartz sandstone with dark grey shale partings and interbeds. Balance of unit is dominated by thin-bedded, very fine-grained, quartz sandstone with dark-weathering shale and siltstone partings. Thus, unit thickens and coarsens upward. Wave ripples and synaeresis cracks are common; trough cross-stratification occurs in some beds. Indeterminate horizontal burrows.	2.7	71.1
31	**Shale** Base sharp. Dark grey, yellow- or dark grey-weathering shale to shaley siltstone. Gypsiferous efflorescence. Rare, very thin beds of very fine-grained sandstone.	1.0	68.4
30	**Sandstone and shale, interbedded** Irregular beds of rusty-weathering, thin-bedded, very fine-grained sandstone with dark-weathering shale as partings.	1.0	67.4
29	**Covered**	3.0	66.4

Unit	Description	Thickness (m)	Above base
28	**Sandstone** Poorly exposed. Medium- to thick-bedded, very fine- to fine-grained, quartz sandstone. Apparently massive. Bedding thins to top of unit.	2.1	63.4
27	**Covered**	9.7	61.3
26	**Sandstone** Base sharp. Grey-weathering, thin- to medium-bedded, very fine-grained sandstone. Beds are sharp based and variably massive, parallel-laminated, or with shallowly dipping laminae.	1.1	51.6
25	**Sandstone and siltstone, interbedded** Dominated by grey-weathering, very thinly laminated to thin-bedded siltstone to silty, very fine-grained sandstone, with rare, sharp-based, thin beds of very fine-grained sandstone. Most sandstone beds are massive or display a massive base and overlying parallel-laminated interval; such beds resemble distal tempestites. Possible micro-hummocky cross-stratification.	1.3	50.5
24	**Covered**	3.0	49.2
23	**Sandstone** Base sharp. Medium grey, light grey- to tan-weathering, thin- to medium-bedded, very fine- to fine-grained, quartz sandstone. Bedding is irregular, with much pinching and swelling of units. Lower two-thirds of unit may preserve a series of small channels; some beds in this interval appear convoluted. Bedding: 148°/75°	4.6	46.2
22	**Sandstone** Base sharp to erosional. Medium- to thick-bedded quartz sandstone is light grey to pinkish-tan of fresh surfaces, weathers grey, light grey, and rust. (No grain-size data recorded, but probably very fine or fine grained, by analogy with associated, similar units.)	0.9	41.6
21	**Sandstone and shale, interbedded** Base sharp. Dark grey- to (less commonly) rusty-weathering, very thin-bedded, very fine-grained sandstone to silty sandstone (60-70% of unit) interbedded with dark grey-weathering siltstone to shaley siltstone (30-40% of unit). Possible current ripples (poorly exposed).	0.8	40.7
20	**Sandstone** Base sharp. Resistant unit has heavy lichen cover. Very fine- to fine-grained sandstone. At base of unit, sandstone is thin to medium bedded, rippled, and locally loaded; at top of unit, sandstone is medium to thick bedded, rippled, and possibly parallel laminated. Lower half of unit contains up 20% interbeds of dark grey, laminated to platy siltstone. Thus, unit thickens and coarsens upward. Bedding: 165°/42°	4.1	39.9

Unit	Description	Thickness (m)	Above base
19	**Sandstone** Base sharp. Rusty-weathering, very thin- to thin-bedded, very fine-grained sandstone, with minor, dark grey mudstone partings and interbeds. Current-ripple cross-lamination, local loading. Bedding within unit may define small-scale inclined heterolithic stratification. Horizontal and vertical burrows locally present. One bed has a thin layer of possible bivalve moulds.	0.8	35.8
18	**Siltstone** Base gradational. Dominated (80-90%) by dark grey siltstone, rarely to silty shale. Lesser (10-20%) rusty-weathering, very thin- to thin-bedded, very fine-grained quartz sandstone. Uppermost 20-30 cm of unit weathers light grey. Units 16-18 make an upward-fining package.	2.1	35.0
17	**Sandstone and siltstone, interbedded** Base gradational. Rusty-weathering, very thin- to thin-bedded, very fine-grained sandstone. Sandstone massive, parallel laminated, or with poorly preserved current ripples; good plant-stem impressions; local, sporadic bioturbation. Up to 40% of unit is dark grey- to rusty-weathering, blocky siltstone to silty shale.	1.0	32.9
16	**Sandstone and shale, interbedded** Base erosional; up to 40cm relief on basal contact. Basal part of unit (up to 0.6 m) is rusty- to grey-weathering, medium-bedded, very fine-grained, quartz sandstone. Upper part of unit is thin- to medium-bedded, commonly rusty- to gossanous-weathering, very fine-grained quartz sandstone with up 10% thin interbeds of dark grey shale. Sandstone beds commonly have irregular tops.	1.5	31.9
15	**Shale and sandstone, interbedded** Poorly exposed. Dominated by dark grey-weathering, thinly laminated shale. Very thin-bedded, very fine-grained quartz sandstone comprises approximately 30% of unit.	0.8	30.4
14	**Covered** Probably underlain by dark grey shale (see Unit 15).	1.8	29.6
13	**Sandstone** Base gradational. Medium to dark grey, medium grey-weathering, thin- to medium-bedded, very fine- to fine-grained quartz sandstone, and very thin-bedded silty sandstone. Medium beds display trough cross-stratification; very thin and thin beds preserve current-ripple cross-lamination and abundant bioturbation, including locally common *Skolithos*, indeterminate horizontal burrows, and poorly preserved resting traces. Possible poorly preserved synaeresis cracks. One possible gutter cast. Medium beds occur only in uppermost part of unit, hence, unit thickens and coarsens upwards slightly. Paleocurrent direction: 093° (cross-bed)	1.9	27.8

Unit	Description	Thickness (m)	Above base
12	**Sandstone and shale; interbedded** Base gradational at first shale bed. Medium to dark grey, medium grey-weathering, thin-bedded, very fine-grained, silty, quartz sandstone, with probable current ripples, some bioturbation, and a possible plant-stem impression. Dark grey-weathering, thin-bedded, poorly fissile shale comprises 40% of unit at base, decreasing to nil at top of unit.	0.9	25.9
11	**Sandstone** Base sharp. Medium to dark grey, medium grey-weathering, thin- to medium-bedded, fine-grained, quartz sandstone. Bed tops are irregular, possibly bioturbated; internal structures not visible. Bedding may be slightly thinner at top of unit than at bottom.	1.3	25.0
10	**Sandstone** Base gradational. Medium to dark grey, medium grey-weathering, medium-bedded, fine-grained quartz sandstone with minor lithic fragments and trace feldspar. Upper 0.5 m of unit is a mixture of fine-grained sandstone and medium-grained, granule-bearing sandstone. Possible small-scale trough cross-bedding. Unit is capped by a rusty-weathering, single-grain lag of granules and small pebbles, including chert clasts; lag surface locally pyritic. Paleocurrent direction: 122° (cross-bed)	3.0	23.7
09	**Sandstone** Base very sharp; unit forms a prominent bench on the riverbank. Light grey, grey- to (locally) rusty-weathering, thin- to medium-bedded, fine-grained quartz arenite. Cross-bedding well-developed: presence of clearly asymptotic toesets suggests trough cross-bedding, and small-scale 3D-dune topography is locally preserved. Basal 15 cm of unit is pebbly and granular sandstone with well- to very well-rounded quartz and chert clasts. Bedding: 154°/31°; 160°/30° (somewhat variable accross outcrop) Paleocurrent directions (all from cross-beds): 289°, 310°, 322°	1.0	20.7
08	**Shale** Recessive-weathering, black, medium to dark-grey weathering, very thinly laminated shale. Some papery lamination. A single, black-stained, erosionally based bed of sandstone occurs with its top 10 cm below top of unit. Sandstone bed thickness varies from 3-15 cm.	1.1	19.7
07	**Covered**	1.5	18.6
06	**Sandstone** Base gradational. Light grey, tan- to grey-weathering, thin- to medium-bedded, fine-grained, locally medium-grained, quartz sandstone. Bedding irregular. Possible trough cross-bedding shows through lichen cover. May be bitumen stained in places. Top surface of unit may be bioturbated.	1.4	17.1

Unit	Description	Thickness (m)	Above base
05	**Sandstone and shale, interbedded** Light grey, grey-weathering, very thin- to thin-bedded, very fine-grained sandstone, locally with chert pebbles. Bedding is irregular, locally ripple cross-laminated to small-scale (trough?) cross-bedded. Dark grey shale common between sandstone beds? *Base of Monteith Formation is covered, but lies at or just below base of Unit 05. Exposures on opposite bank of Sikanni Chief River suggest base of Monteith Formation is sharp.*	1.1	15.7
	FERNIE FORMATION?		
04	**Covered** Rare exposures on opposite shore of river look like dark grey to black shale, suggesting that this covered interval represents a thin Fernie Formation.	9.6	14.6
	PARDONNET FORMATION		
03	**Limestone, silty limestone, siltstone; interbedded** Lithologies similar to those in Unit 01, but bedding is dominantly thin, siltstone is a minor component, and pinch-and-swell bedding is much less common. A spectacular, 20 cm thick bone bed, consisting of 70-80% bone fragments in limestone matrix, occurs 1.4 m above unit base. Bivalve packstone and wackestone beds are common.	2.6	5.0
02	**Covered**	2.4	2.4
01	**Limestone, silty limestone, siltstone; interbedded** (not measured) Dark grey, grey-weathering, thin- to medium-bedded, bioclastic limestone (packstone to wackestone), locally with very high concentrations of bones and bivalves; locally has impressions of ammonoids. Beds tend to pinch and swell, developing a "dome and basin" topography on exposed bedding surfaces. Dark grey, grey-weathering, thin to medium bedded silty limestone resembles limestone but lacks abundant bioclasts. Dark grey, dark grey-weathering, thin- to medium-bedded, calcareous siltstone. Bedding: 161°/24°	-	-