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R.B. MacNaughton

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ABSTRACT

Four previously undescribed measured sections are documented through lower and middle Cambrian (Series 2 and Miaolingian) strata of the eastern Mackenzie Mountains, Northwest Territories. These include three exposures of the Mount Clark Formation that are complete or nearly so, and a complete section through the overlying Mount Cap Formation. As in previous reports, Mount Clark Formation is dominated by quartz arenite, with variable bioturbation. Mount Cap Formation is heterolithic, dominated by dark-weathering shale and paler-coloured carbonate rocks. A section through the Neoproterozoic McClure Formation (Katherine Group) also is included, and contains abundant fine-grained siliciclastic strata with lesser sandstone and a distinctive orange-weathering carbonate. Correlations between these sections and one previously documented show the influence of late Neoproterozoic folding, reflected in erosional truncation of the McClure Formation beneath the Cambrian succession, as well as stratigraphic variations in the Cambrian units that reflect the influence of the Mackenzie Arch.

INTRODUCTION

This report documents four new stratigraphic sections through the Cambrian Mount Clark and Mount Cap formations in the eastern Mackenzie Mountains (Figure 1). One section includes an erosionally truncated succession of the McClure Formation (Katherine Group; Neoproterozoic), which underlies the Mount Clark Formation. The sections were measured in support of bedrock mapping activities during the first phase of the Geological Survey of Canada's Geo-mapping for Energy and Minerals (GEM) program (Fallas et al., 2013; Fallas and MacNaughton, 2014a,b,c).

The sandstone-dominated Mount Clark Formation is a hydrocarbon reservoir in the Colville Hills (Hamblin, 1990; Dixon and Stasiuk, 1998; Janicki, 2004; Price and Enachescu, 2009) and may be a potential exploration target beneath Mackenzie Plain (MacLean, 2011) and elsewhere (Pyle and Gal, 2009; Hannigan et al., 2011). Mount Cap Formation is a known source rock (Dixon and Stasiuk, 1998; Pyle and Gal, 2011) and a potential tight gas play (Hannigan et al., 2011). Clearer understanding of the distribution and packaging of these units in the eastern Mackenzie Mountains may reduce exploration risk in the adjacent Mackenzie Plain exploration region and elsewhere, and will contribute to improved models for the Cambrian evolution of the northern Interior Plains (e.g., MacLean, 2011; Sommers et al., 2020).

The present report includes summaries of the Neoproterozoic and Cambrian stratigraphy of the eastern Mackenzie Mountains, and of recent developments in understanding these strata. The main body of the report is a summary of the four measured sections; detailed section notes are provided as well. Although the report is primarily descriptive, comments also are offered on stratigraphic relationships across the sub-Cambrian unconformity in the eastern Mackenzie Mountains. Throughout the report, usage of the terms "Cambrian Epoch/Series 2" and "Miaolingian" reflects the latest international timescale for the Cambrian (Peng et al., 2012; Zhao et al., 2012). Respectively, these terms are effectively equivalent to the trilobite-bearing portion of the Early Cambrian and to the Middle Cambrian of traditional usage. When the phrases "early Cambrian" and "middle Cambrian" are used, they imply the traditional series, with the lower-case lettering of "early" and "middle" reflecting that these are no longer formal terms.

GEOLOGIC CONTEXT

Neoproterozoic and Cambrian lithostratigraphy of the eastern Mackenzie Mountains (Figure 2) was revised significantly during the GEM program (Turner, 2011; Long and Turner, 2012; Turner and Long, 2012; MacNaughton et al., 2013; MacNaughton and Fallas, 2014). That work built on earlier reconnaissance-scale studies by the Geological Survey of Canada (Aitken et al., 1973, 1978; Aitken and Cook, 1974; Aitken, 1981; Norford and Macqueen, 1975).

In the eastern Mackenzie Mountains, Cambrian strata lie unconformably upon the Neoproterozoic Mackenzie Mountains Supergroup (Aitken et al., 1973; Aitken and Cook, 1974; Long et al., 2008). In ascending order, the Mackenzie Mountains Supergroup includes the Tabasco Formation (formerly the H1 map unit; see Turner and Long, 2012), the Tsezotene Formation, the Katherine Group, and the Little Dal Group. The Katherine Group consists of seven formation-scale units, which were originally designated informally as map units numbered from K1 to K7 (Aitken et al., 1978; Long et al., 2008).

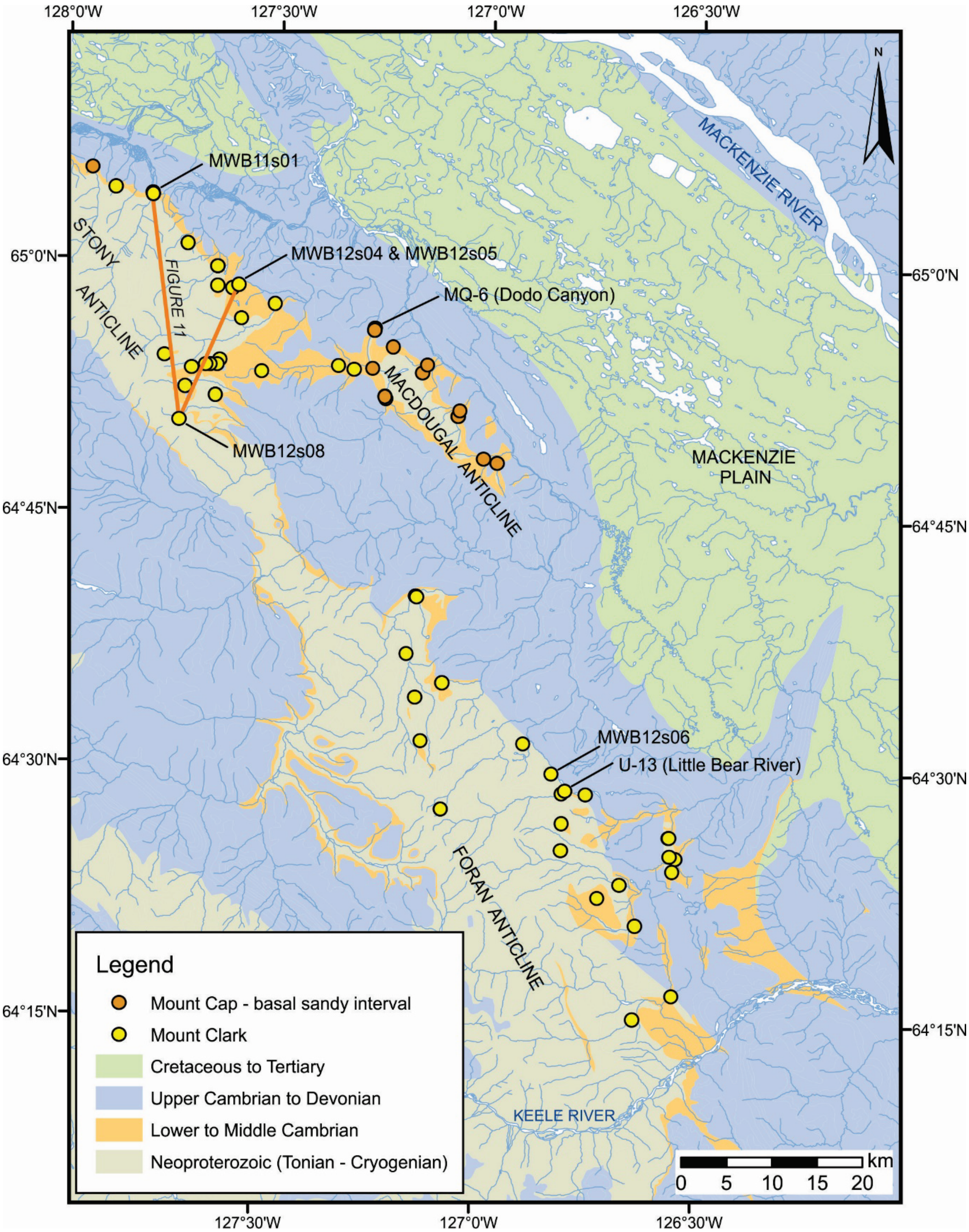


Figure 1: *Location map, eastern Mackenzie Mountains and Mackenzie Plain, modified after MacNaughton et al. (2013). Line of the cross-section shown in Figure 11 is labelled. New sections presented herein are MWB12s04, MWB12s05, MWB12s06, and MWB12s08. MWB11s01 appeared in Hamel and MacNaughton (2013); MQ-6 and U-13 appeared in Aitken et al. (1973). In this part of the Mackenzie Mountains, Stony and Foran anticlines effectively delineate the eastern limit of the Mackenzie Arch.*

More recently, Long and Turner (2012) formalized this under the following names (ascending order): Eduni Formation (K1: sandstone dominated); Tawu Formation (K2: shale dominated); Grafe River Formation (K3: sandstone dominated); Etagochile Formation (K4: shale dominated); Shattered Range Formation (K5: sandstone dominated); McClure Formation (K6: shale dominated, with a stromatolitic dolostone marker); and Abraham Plains Formation (K7: sandstone dominated). Long-standing informal, formation-rank subdivisions of the Little Dal Group (Aitken, 1981) also have been given formal names (Turner and Long, 2012). Only two of these formations are exposed in the region covered by this report. The basal unit of the Little Dal Group is the Dodo Creek Formation (formerly "Mudcracked formation"; Aitken, 1981), consisting of shale interbedded with sandstone and dolomudstone. Above this lies the Stone Knife Formation (formerly "Basinal assemblage"; Aitken, 1981), consisting of variably calcareous and concretionary shale, and a variety of carbonate lithofacies that commonly are stromatolitic.

In the eastern Mackenzie Mountains, relationships around the sub-Cambrian unconformity (Figure 2) reflect three tectonic events. These are: (1) Neoproterozoic regional-scale folding that postdated deposition of the Mackenzie Mountains Supergroup (Fallas et al., 2017); (2) subsequent development of the Mackenzie Arch, a paleohigh that saw intermittent ?Neoproterozoic and early Paleozoic uplift (Aitken et al., 1973; MacNaughton et al., 2016); and (3) early to middle Cambrian (rift-related?) extension (MacLean, 2011; Sommers et al., 2020). The folding, and possibly the early uplift of the Mackenzie Arch, led to regional beveling and erosional removal of more than 1000 m of strata (Aitken et al., 1973) during the Cryogenian and Ediacaran. However, outcrop expression of the resulting angular unconformity generally is subtle due to the broad (up to 100 km) wavelengths of the earlier folds (Fallas et al., 2017).

Due to the influence of the Mackenzie Arch, Cambrian strata in the eastern Mackenzie Mountains preserve facies belts (MacNaughton et al, 2013; MacNaughton and Fallas, 2014) that are reflected in recent revisions to the lithostratigraphy of this interval (Figure 2). Cambrian formations can be divided into two unconformity-bounded sequences. The older sequence (Figure 3) consists of the Mount Clark Formation, dominated by quartz arenite (Serié et al., 2009, 2012; Fallas and MacNaughton, 2012), and the overlying Mount Cap Formation, which is dominated by dark-weathering, siliciclastic mud rocks, with variable volumes of carbonate and lesser sandstone (Aitken et al., 1973). Generally, Mount Cap Formation includes a heterolithic lower interval (shale, carbonate, lesser sandstone) and a shale-dominated upper interval. In the eastern Mackenzie Mountains, the Mount Clark Formation is best developed along the eastern flank of Mackenzie Arch. In the MacDougal anticline (easternmost Mackenzie Mountains; Figure 1), the Mount Clark Formation passes laterally into a heterolithic succession of sandstone, mudstone, and carbonate. These strata have been treated lithostratigraphically as a basal interval of the Mount Cap Formation (MacNaughton et al., 2013), although a well-developed, quartz arenite-dominated Mount Clark Formation is present regionally further east in the subsurface of the Interior Plains (Dixon and Stasiuk, 1998). Several reports have documented fossil constraints on the ages of these units (e.g., Aitken et al., 1973; Serié et al, 2009; MacNaughton et al., 2013; Sommers et al., 2020). The Mount Clark Formation and the laterally equivalent, sand-rich basal Mount Cap Formation are generally early Cambrian (Epoch 2), mainly of *Bonnia-Olenellus* Zone age or older. Locally, uppermost strata of

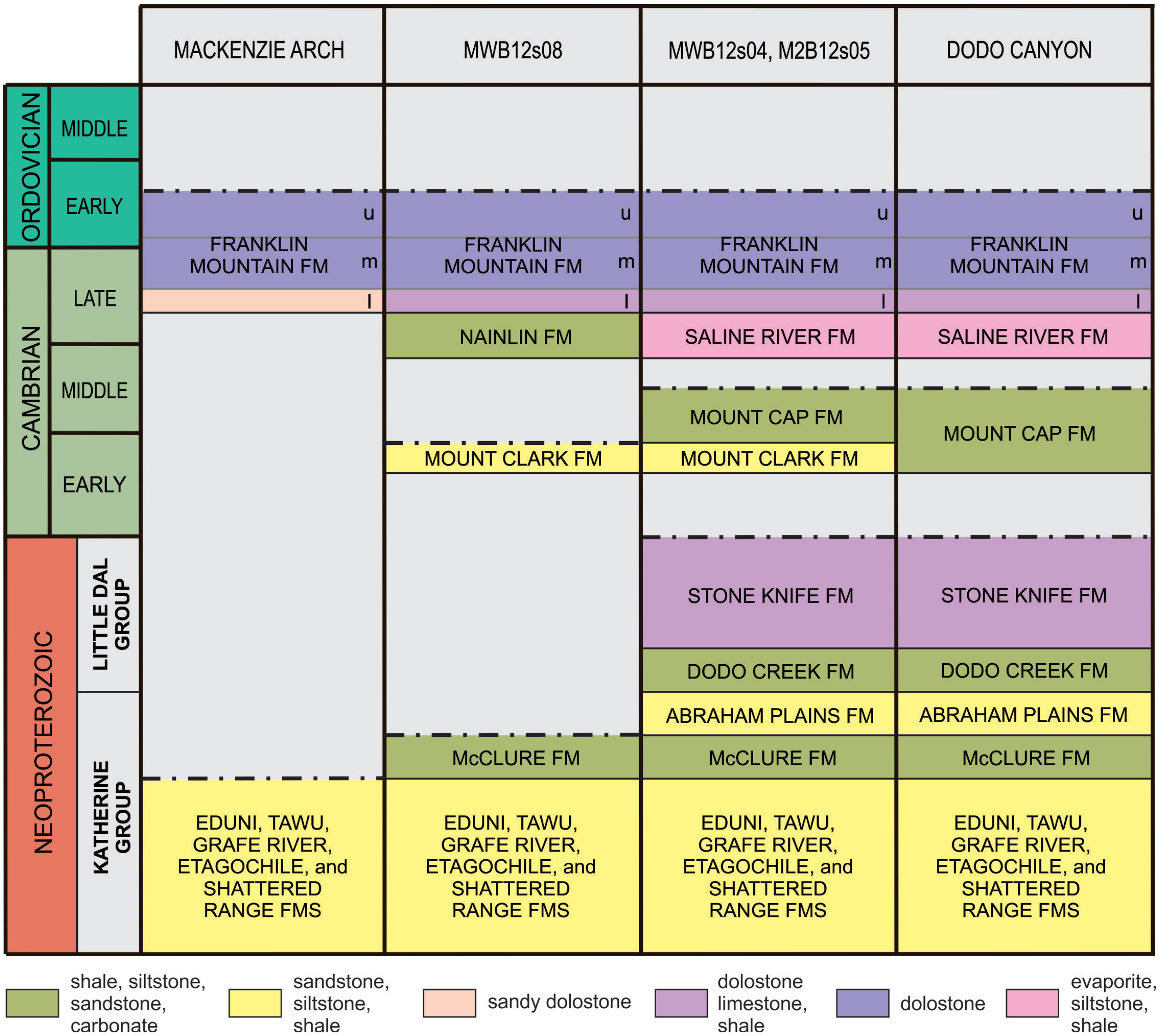


Figure 2: *Proterozoic-Cambrian lithostratigraphy of the eastern Mackenzie Mountains. Figure modified after Hamel and MacNaughton (2013) and MacNaughton and Fallas (2014). See text for discussion and sources. Columns are keyed to locations on Figure 1; note that "Mackenzie Arch" refers to stratigraphy along western flanks of Stony and Foran anticlines (Figure 1).*

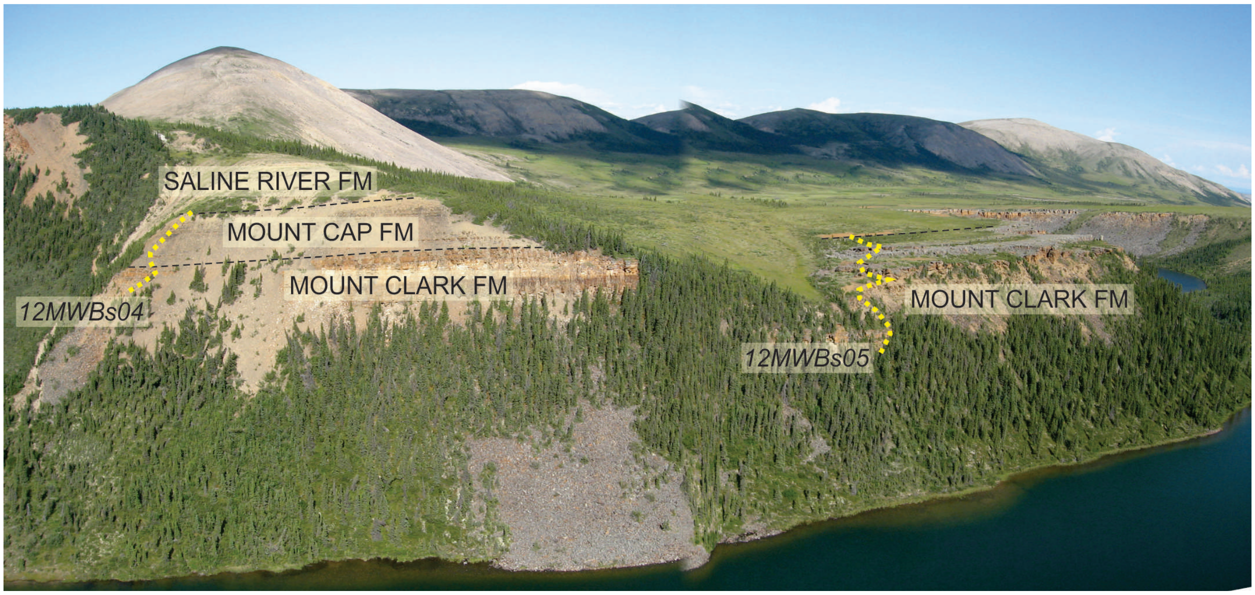


Figure 3: *Oblique aerial view of Cambrian units exposed around measured sections 12MWBs04 and 12MWBs05 (dotted yellow lines); for geographic coordinates, see section notes for these sections. Mount Cap Formation at this site is roughly 35 m thick. Contact between Mount Clark Formation and underlying Stone Knife Formation is not exposed but probably is just below base of cliff exposures. Image is a montage of two photographs by R.B. MacNaughton. NRCAN photo 2020-911.*

these units may be earliest Miaolingian (early middle Cambrian), belonging to the *Plagiura-Poliella* or *Albertella* zones. The youngest trilobites recovered from the Mount Cap Formation also are Miaolingian (middle Cambrian), belonging to the *Glossopleura* Zone.

Mount Cap Formation is separated from overlying strata by a subtle angular unconformity (Aitken et al., 1973; Dixon and Stasiuk, 1998) that defines the base of the second sequence. Siliciclastic strata dominate the lower part of the second sequence. In the easternmost Mackenzie Mountains and further to the east, they are assigned to the Saline River Formation, which consists of siliciclastic mudrock and evaporites, with some carbonate beds (Aitken et al., 1973). To the west, however, along the eastern flank of the Mackenzie Arch, the Saline River Formation passes laterally into the Nainlin Formation, a succession of red-weathering siliciclastic strata ("red beds"), locally containing abundant sandstone and lesser conglomerate (MacNaughton and Fallas, 2014). Locally, Mount Clark Formation preserved adjacent to the Mackenzie Arch is overlain directly by the Nainlin Formation, without intervening Mount Cap Formation. Since no shoreline facies have been mapped in the Mount Cap Formation *sensu stricto*, this relationship suggests that Mount Cap Formation is absent due to post-depositional erosion, probably due to uplift of the Mackenzie Arch (e.g., Aitken et al., 1973). The Nainlin and Saline River formations are probably of mid- to late Miaolingian (mid- to late middle Cambrian) age (Aitken et al., 1973; MacNaughton and Fallas, 2014), and are overlain conformably and gradationally by the thick, dolostone-dominated Franklin Mountain Formation, of Furongian (late Cambrian) to Early Ordovician age (Norford and Macqueen, 1975; Turner, 2011).

PREVIOUS CAMBRIAN STRATIGRAPHIC STUDIES, EASTERN MACKENZIE MOUNTAINS

Aitken et al. (1973) provided the first detailed account of the Proterozoic and early to middle Cambrian stratigraphy of the eastern Mackenzie Mountains. They supported their work with several measured sections that remain important reference points for comparison and regional synthesis. These authors considered the older of the two Cambrian sequences to consist only of the Mount Cap Formation, which was considered to locally have a sandy basal interval. Serié et al. (2009; see also revised edition, 2012) suggested that Mount Clark Formation might also be present in the eastern Mackenzie Mountains, and documented several new, reconnaissance-scale measured sections through the Mount Clark and Mount Cap formations. Pyle and Gal (2011) provided additional descriptive details and petroleum-systems data for several previously published sections in the region. Additional early and middle Cambrian measured sections from the northern Mackenzie Mountains were presented by Pyle and Jones (2009).

The presence of Mount Clark Formation in the eastern Mackenzie Mountains was confirmed during the Geo-mapping for Energy and Minerals Program (Fallas and MacNaughton, 2012; MacNaughton et al., 2013). In addition to measured sections presented herein, Hamel and MacNaughton (2013) documented an additional section through the Mount Clark Formation, including thin-section petrographic descriptions. Also, MacNaughton and Fallas (2014) presented several measured sections through the Nainlin Formation in a paper formalizing that unit. The most recent bedrock geology maps for the eastern Mackenzie Mountains reflect these innovations (Fallas et al., 2013; Fallas and MacNaughton, 2014a,b,c).

Recently, several student thesis projects have been completed dealing with the Mount Clark and Mount Cap formations in various areas (Herbers et al., 2016; Herbers, 2017; Bouchard and Turner, 2017a,b; Sommers, 2018; Bouchard, 2019; Sommers et al., 2020), all of which can be consulted for sedimentological details and interpretations. Additionally, an M.Sc. study at the University of Saskatchewan (N. Handkamer, work in progress) is focused on early and middle Cambrian trilobites from these units in the eastern Mackenzie Mountains.

MEASURED SECTIONS

Locations of measured sections studied during 2012 are shown in Figure 1. Coordinates are provided with the descriptive notes, using NAD83 as map datum. Sections encompass all or part of five Neoproterozoic and Cambrian units (ascending order): Shattered Range Formation, McClure Formation, Mount Clark Formation, Mount Cap Formation, and Saline River Formation.

Measured section 12MWBs04 (Figure 4) included the full thickness of the Mount Cap Formation, and part of the underlying Mount Clark and overlying Saline River formations. Measured section 12MWBs05 (Figure 5) was studied close by, and included the entire exposed thickness of the Mount Clark Formation. Although the base of the Formation is not exposed, the sub-Cambrian unconformity cannot be very far below the lowest outcrop. Combined, the two sections are a valuable stratigraphic control point (Figure 3).

Section 12MWBs06 (Figure 6) lies 4 km northwest of section U-13 of Aitken et al. (1973, p. 108; "Headwaters of Little Bear River"). A much-studied reference section (e.g., Serié et al., 2012; Butterfield and Nicholas, 1996; Fallas and MacNaughton, 2012; Handkamer, 2020), U-13 exposes both Mount Clark and Mount Cap formations but is complicated by faulting (Fallas and MacNaughton, 2014b). Section 12MWBs06 provides an undisturbed record of the Mount Clark Formation and basal beds of the overlying Mount Cap Formation.

Section 12MWBs08 (Figure 7) documents the Mount Clark Formation adjacent to the eastern flank of the Mackenzie Arch. Here, the Mount Cap Formation is absent due to erosion beneath the Nainlin Formation. An excellent exposure of the underlying McClure Formation was documented as well, as were the uppermost beds of the Shattered Range Formation.

MEASURED SECTION DESCRIPTIONS

All sections were measured using a jacob's staff. Coordinates in these notes use NAD83 as map datum and were determined using a hand-held GPS unit. Bedding thickness terms follow Ingram (1954). Biostratigraphic determinations for 12MWBs04, 12MWBs05, and 12MWBs06 were provided by N. Handkamer (personal communication, 2021).

Section 12MWBs04 (Figure 4): Section measured near two small lakes in northern NTS 96-D/NW (Fallas and MacNaughton, 2014a). Section extends from uppermost beds of Mount Clark Formation, through Mount Cap Formation, to base of Saline River Formation. Base of section at: 64.97637° N, 127.6077° W; top of section at 64.97636 N°, 127.6066° W. Measured on July 25, 2012, assisted by Christine Deblonde.

Unit	Description	Thickness (m)	Height Above Base (m)
14	**Covered.** Base covered, placed at lowest sandstone talus. Abundant talus of very fine to fine-grained sandstone, maroon, red, or tan on fresh and weathered surfaces. Also maroon to tan shale. Salt casts, polygonal mud cracks, straight-crested symmetrical ripples with wavelengths of approximately 4 cm. Southeastward along the ridge, at approximately the same stratigraphic level as the base of this interval is a small outcrop of pale-weathering sandstone with salt casts. *Base of Saline River Formation at base of unit 14 or within unit 13.*	not measured	
13	**Covered.** Vegetated interval at top of steep hillside.	4.5	47.1
12	**Shale, sandstone, dolostone.** Base covered. Poorly exposed at top of steep hillside. Float is mainly of dark grey shale to siltstone that weathers as chips. In spot outcrops and float are very thin beds of: orange-weathering, very fine-grained sandstone; tan-weathering, dark grey, very finely crystalline limestone; and tan (fresh and weathered surfaces), very finely crystalline dolostone.	3.7	42.6
11	**Shale and limestone.** Base gradational. Semi-resistant. Interbedded shale, dark grey, very thinly fissile, and limestone, dark grey to black, weathering tan to creamy orange, very finely crystalline. Limestone beds 2-20 cm thick, silty, locally sandy, at least partly parallel laminated. Upsection within unit, shale is joined by grey weathering, more blocky siltstone, as well as more beds of dolomitic very fine-grained sandstone, dark grey, weathering tan to orange, as very thin to thin beds in packages up to 30 cm thick. Relict bedforms (dunes?), parallel lamination, current ripples, as well as load casts and/or scours. Horizontal burrows. Resistant beds are more common and thicker upsection within this interval. Units 10 and 11 together make up an upward-shoaling package.	11.1	38.9

10	**Mudstone, sandstone, carbonate.** Base sharp. Unit recessive and mainly covered. Spot outcrops and float suggest dark grey mudstone and tan to brownish grey very fine-grained silty sandstone or siltstone; also grey to tan-weathering limestone and dolostone. At 1.2 m above base of unit is a bed of grey, silty, nodular, burrowed limestone (lime mudstone?) that contains trilobites (trilobites collected as 12MWBs04-24.0 m). Trilobite-bearing interval is approximately 30 cm thick. In upper part of unit, sandy beds disappear and main rock types are dark grey, silty shale and very thin-bedded, very finely crystalline limestone to dolostone (dark grey on fresh surfaces, weathers orange). **GSC loc. C-553199** (field no. 12MWBs04-24.0); 24.0 m: *Glossopleura boccar* (Walcott, 1916b) *Polypleuraspis solitaria* Poulsen, 1927 Age: *Glossopleura* Zone (Miaolingian)	5.0	27.8
9	**Dolostone and shale.** Base gradational. Semi-resistant. Makes an upward-shoaling package with Unit 8. Dolostone, very finely crystalline, contains quartz silt to very fine quartz sand, locally to very fine-grained dolomitic quartz sandstone. Glauconite abundant at some levels. Ripple cross-lamination present in sandier beds. Beds 1-10 cm thick. Up to 30 percent dark grey mudstone or silty shale.	1.3	22.8
8	**Mudstone.** Base sharp. Silty mudstone, dark grey on fresh and weathered surfaces, micaceous; weathers as chips.	1.3	21.5
7	**Dolostone and mudstone.** Base sharp but makes an upward-shoaling package with Unit 6. Resistant. Dolostone, very finely crystalline, containing quartz silt to sand, glauconitic; grey on fresh surfaces, weathers orange. Beds 1-30 cm thick. Three major packets of carbonate, interbedded with lesser grey mudstone. Phosphatic brachiopods are common.	1.4	20.2

6	**Shale and sandstone.** Base covered. Recessive. Lower half of unit covered; float is dark grey shale or mudstone, possibly with grey-weathering, very fine-grained sandstone. Upper half of unit is equal parts very fine-grained quartz sandstone to quartz wacke, locally dolomitic, locally glauconitic, very thin-bedded to very thickly laminated, and mudstone to silty mudstone. Sandstone is grey to dark grey on fresh surfaces, weathers grey to brownish grey; mudstone is dark grey to grey on fresh surfaces, weathers brownish grey. Indeterminate cross-lamination at some levels. Intense horizontal bioturbation at many levels, and large horizontal burrows in float. Contains phosphatic brachiopods and rare trilobite debris.	5.2	18.8
5	**Dolomitic sandstone.** Base sharp. Semi-resistant. Very fine-grained, dolomitic quartz sandstone, medium to dark grey on fresh surfaces, weathers orange to orange-grey; some beds to sandy dolostone. Intensely bioturbated, mainly by horizontal burrows. Rubbly weathering due to some dark grey shale interlaminations.	2.3	13.6
4	**Sandy dolostone.** Base sharp. Resistant. Dolostone, very finely crystalline, containing abundant very fine quartz sand and quartz silt; medium grey on fresh surfaces, weathers orange. Beds 3-30 cm thick, many with crinkled microbial lamination or small stromatolites. Some bedding planes enhanced by stylolites.	1.5	11.3
3	**Sandstone and mudstone.** Base sharp. Semi-resistant. Dominated by very fine-grained quartz wacke, dolomitic and glauconitic; grey to dark grey on fresh surfaces, weathers orange. Beds 3-10 cm thick. Dark grey mudstone partings make up 10-20 percent of the unit. Interval displays a cleavage that probably is due to a nearby fault.	0.5	9.8
	Base of Mount Cap Formation.		
2	**Sandstone.** Base sharp. Resistant with friable zones. Very fine-grained quartz arenite to quartz wacke, but with a great deal of dark grey silt/mud reworked biogenically into the beds. Intense bioturbation, both by indeterminate horizontal burrows but also as a pipe-rock of small (1-3 mm diameter) *Skolithos*. Rare *Rusophycus*. Beds are 5-50 cm thick, mainly 10-30 cm thick, but bedding may be largely biogenic due to burrowers homogenizing the original beds. Float yielded one specimen of a possible trilobite genal spine (collected as 12MWBs04-02A).	7.5	9.3

1	**Sandstone.** Base covered. Resistant. Medium-grained quartz arenite, medium grey on fresh surface, weathering deep reddish brown to rusty, with a rusty-brown weathering rind up to 1 cm deep. Rock is hard, apparently massive (lacks visible sedimentary structures), and may be medium to thick bedded. *Base of section is at base of exposure on hillside, in uppermost part of Mount Clark Formation.*	1.8	1.8

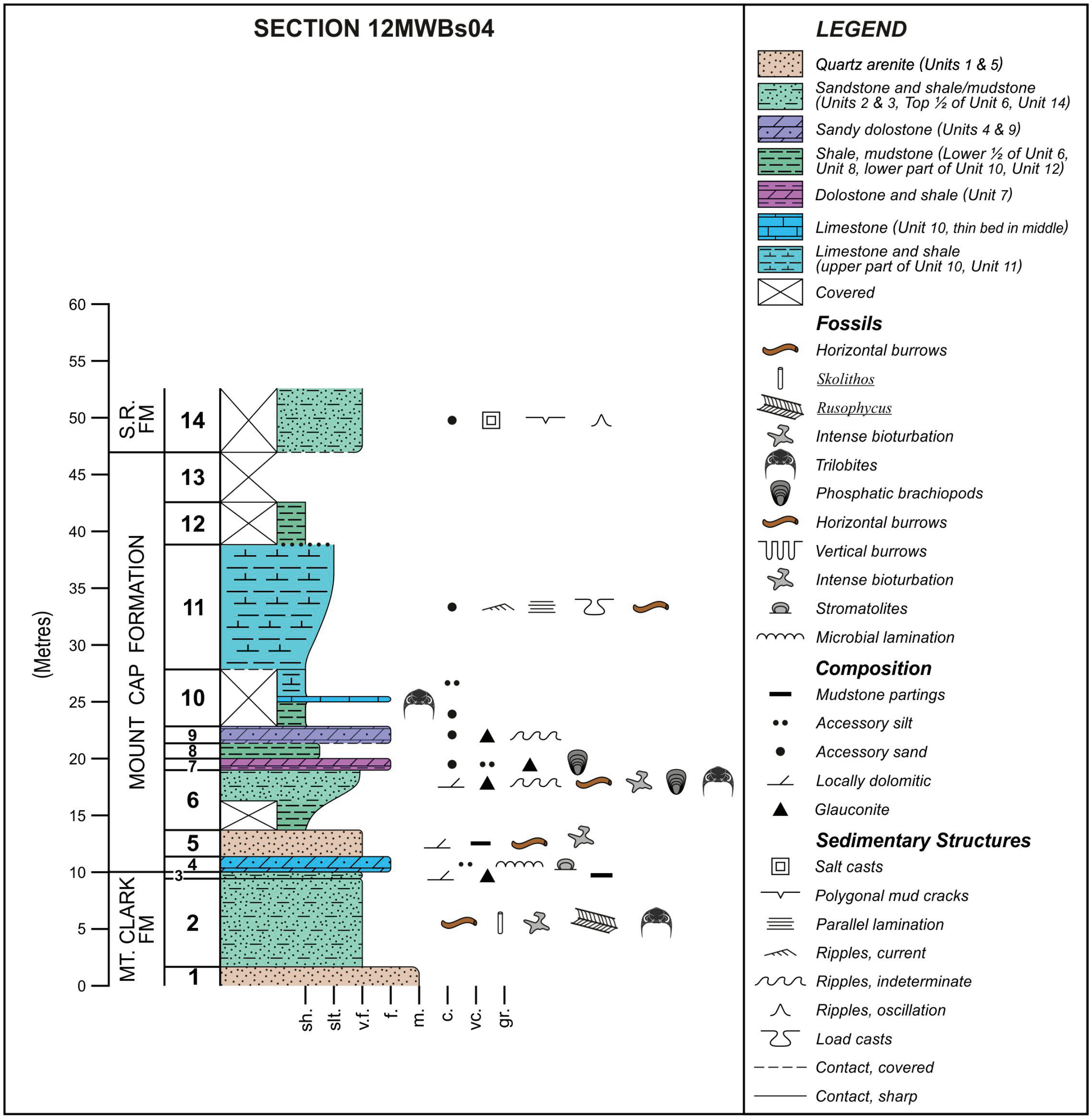


Figure 4: *Graphic log, measured section 12MWBs04. This is a complete section through the Mount Cap Formation. For location, see Figure 1. Abbreviations: "MT. CLARK FM." = Mount Clark Formation; "S.R. FM." = Saline River Formation.*

Section 12MWBs05 (Figure 5): Section measured near two small lakes in northern NTS 96-D/NW (Fallas and MacNaughton, 2014a). Section was measured to include as much as possible of Mount Clark Formation, where it makes accessible cliffs with pinnacles above the lakeshore. Base of section: 64.97443° N, 127.6039° W. Top of section: 64.97542° N, 127.5969° W. Section is a stratigraphic downward extension of 12MWBs04, which was measured a short distance to the west. Measured on July 26, 2012, assisted by Christine Deblonde.

Unit	Description	Thickness (m)	Height Above Base (m)
	Top of last spot outcrop is top of measured section.		
19	**Dolostone.** Mostly covered. Spot outcrops of orange-weathering dolostone and sandy dolostone, very finely crystalline; rare grey limestone.	0.3	44.8
	Base of Mount Cap Formation		
18	**Dolomitic sandstone.** Mostly covered. Spot outcrops of orange-weathering, fine-grained dolomitic quartz sandstone; thin bedded; horizontal burrows.	0.6	44.5
17	**Sandstone.** Base sharp, possibly erosional. Semi-resistant. Fine-grained quartz sandstone, pale orange-brown on fresh surfaces, weathers brown; sand grains well rounded; some dark brown mudstone intraclasts. Beds 3-20 cm thick, with parallel lamination and indeterminate ripple cross-lamination. Horizontal burrows are present on slabs in float but bedding is well preserved. Top of unit is very dolomitic and locally has an orange weathering tone.	0.4	43.9
16	**Sandstone.** Base sharp. Resistant. Fine-grained quartz sandstone; fresh surfaces white or tan, with dark flecks; weathered surfaces white to pale orange-brown. Beds mainly 20 cm thick. Trough cross-bedding, indeterminate ripple cross-lamination. Bed tops bioturbated (but not the entire bed); vertical burrows (*Skolithos*) and horizontal burrows (*Palaeophycus* and/or *Planolites*) are common. Capped by a thin (less than 10 cm) intraclast conglomerate.	1.1	43.5

15	**Sandstone.** Base gradational. Fine-grained quartz sandstone, as for unit Unit 14 but lacks thinner-bedded material. Beds are very homogenized and original bedding may be obliterated. Biogenically produced "beds" are 30-40 cm thick but relict bedding, where visible, commonly is only 5-10 cm thick. Vertical burrows are much more common in some beds (nearly "pipe rock") but horizonal burrows also are abundant. (Where relict bedding is present, it has some vertical burrows. Perhaps vertical burrows came first, then were reworked by the prevalent horizontal burrows?) Unit is resistant and makes a bench, the upper surface of which exposes many vertical burrow intersections.	2.1	42.4
14	**Sandstone.** Base sharp. Resistant. Forms a prominent bench. Fine-grained quartz arenite. Grain well rounded; fresh surfaces are white, pale grey or pale tan; weathers grey to rusty orange; lichen cover obscures many surfaces. Beds 3-20 cm thick, intensely reworked by horizontal burrows. Top interval looks like a single bed but may be several beds, totally homogenized. Rare current ripple cross-lamination. Vertical burrows present in some beds but horizontal bioturbation dominates. Unit 14 consistently has a thinner-bedded lower half and thicker-bedded upper half; the upper half has more in common with the overlying beds in Unit 15.	1.5	40.3
	Units 9-13 make up an upward coarsening package		
13	**Sandstone.** Base sharp. Resistant, forming a prominent bench. Quartz arenite, mainly fine-grained, lesser medium-grained. Grains very well rounded. Fresh surface is white with dark flecks; weathers tan to light brown with heavy lichen cover. Maroon staining at base of unit, orange staining at top. Very blocky. Trough cross-bedding is abundant and where sets can be seen through the lichen they are 10-50 cm thick, possibly up to 70 cm. Sets wedge out as in "festoon" bedding. Some bedding planes show trough outlines (or possibly scours?) but nothing from which paleoflow can be measured. Current ripples cap some beds. Possibly some parallel lamination or parallel bedding.	3.8	38.8
	Line of section crossed contact between units 12 and 13 at: 64.974427° N, 127.601221°W.		

12	**Dolomitic sandstone.** Poorly exposed, except in cliffs. Mainly rubble. Spot outcrops of fine-grained, dolomitic quartz sandstone. Earthy tan on fresh surfaces, weathers orange. Very thin-bedded. Possible indeterminate cross-lamination.	0.4	35.0
	Followed top of Unit 11 to east along top cliff to find base of Unit 12		
11	**Sandstone.** Base sharp. Resistant. Fine-grained, siliceous quartz sandstone, grey on fresh and weathered surfaces. Beds 2-12 cm thick. Low angle cross-bedding, low-angle ripples, trough cross-bedding. Some horizontal burrows.	1.0	34.6
10	**Sandstone, minor siltstone.** Base covered. Mainly very fine-grained quartz arenite to quartz wacke; some beds siliceous, others calcareous. Fresh surfaces pale tan, weathers tan to light brown. At base of unit, beds are 1-3 cm thick and tend to be more calcareous, whereas at top of unit beds are 2-5 cm thick and generally more siliceous. Light brown siltstone accounts for 20-30 percent of lower part of unit but less than 10 percent of upper part; unit is therefore an upward coarsening package. Ripple cross-lamination, horizontal burrows, robust *Cruziana*.	4.3	33.6
9	**Sandstone and mudstone.** Covered. Float suggests very thin-bedded, very fine-grained sandstone, tan to brown on fresh and weathered surfaces, interbedded with brown to dark grey weathering mudstone and shale.	2.5	29.3
	Units 5-8 are an upward-coarsening and -thickening package		
8	**Sandstone.** Base sharp, possibly erosional. Resistant. Fine-grained quartz arenite, light greyish tan on fresh surfaces, weathers medium brownish grey, some rusty spots. Contains up to 10 percent by volume of a rusted-looking mineral phase. Very low-angle cross-stratification to parallel lamination; sets are 30-50 cm thick and the rock breaks into flags 2-4 cm thick. Parting lineation locally preserved. Layers of mud-clast conglomerate. One thin mudstone layer with overlying sand bed loaded into it. Rare trilobite thoracic debris.	4.4	26.8

7	**Sandstone.** Base gradational. Semi-resistant to resistant. Lithologies are as for Unit 6 but generally there is less siltstone and many of the sandstone beds are 10-20 cm thick. At base of unit are beds with well-developed low-angle cross-lamination to cross-beds (possibly hummocky cross-stratification); some such beds have parting lineation when split along laminae. Much horizontal burrowing; some beds are highly bioturbated but less so than in Unit 6. Topmost 50 cm is siltier than the rest of the unit. Trilobites and phosphatic(?) brachiopods found in locally derived float. **GSC loc. C-553201** (field no. 12MWBs05-07); From float, likely from 19.9-22.4 m, possibly 19.9-33.6 m: *Olenellus terminatus* (Palmer and Halley, 1979) Age: *Bonnia-Olenellus* Zone (Cambrian Epoch 2) *Correlated top of Unit 6 to southeast along hillside to base of resistant strata. Section measuring resumed at: 64.974446° N, 127.602984° W.*	2.5	22.4
6	**Sandstone and siltstone.** Base covered. Semi-resistant. Three lithofacies present. (1) Quartz arenite, very fine to fine-grained, locally slightly silty; pale grey on fresh surfaces, weathers light brown. Makes up approximately 45 percent of the unit. Two subfacies of quartz arenite: (a) beds 1-3 cm thick, possible ripple cross-lamination and parallel lamination, horizontal burrows common; (b) beds 3-10 cm thick, low-angle cross-lamination or hummocky cross-stratification, few burrows. (2) Quartz wacke to quartz arenite, very fine-grained; tan on fresh surfaces, weathers light brown; horizontal burrows present but no obvious primary sedimentary structures. Makes up approximately 45 percent of the unit. (3) Siltstone, light brownish grey to light brown on fresh and weathered surfaces; present mainly as interlaminations between sandstone beds. Makes up 10-20 percent of the unit.	2.8	19.9
5	**Sandstone and siltstone.** Covered but there is clearly a sharp break between this and Unit 4. Float suggests very thin-bedded, very fine-grained quartz arenite to quartz wacke, brown on fresh and weathered surfaces, interbedded with brown siltstone.	1.5	17.1

4	**Sandstone.** Base covered. Resistant. Fine-grained quartz arenite, grey on fresh surfaces, weathers light grey. Rare dark grey mudstone flecks, as intraclasts or introduced biogenically. Thin bedded, possible trough cross-stratification. Vertical burrows. Unit capped by 20 cm of fine to medium-grained quartz arenite, rusty weathering, with horizontal bioturbation and relict trough cross-stratification. At top of this upper interval is a single set (5-10 cm thick) of small-scale trough cross-stratification, preserving relict low-relief, 3D bedforms on top surface, with no sign of burrows.	0.9	15.6
3	**Covered.** Tree interval; section not safely accessible in the waterfall gully, but clearly consists of resistant quartz sandstone with bedding up to at least medium thickness.	1.5	14.7
2	**Sandstone.** Base sharp, possibly erosional. Resistant. Quartz arenite, fine to coarse-grained, mainly medium-grained. Fresh surfaces mostly grey, some are tan to light tan with dark grey mud chips; weathers tan with rusty weathering zones. Beds are 1-2 cm thick. Less well indurated than Unit 1 but shows no sign of silty matrix or carbonate cement. Beds variably preserve parallel lamination and ripple cross-lamination; some may be massive. No obvious bioturbation.	4.2	13.2
1	**Sandstone.** Base covered. Resistant. Heavy lichen cover on many surfaces. Fine to medium grained quartz arenite, with very well-rounded grains and silica cement throughout; white, pale cream, or pale tan on fresh surfaces, weathers tan to light grey. Beds 5-30 cm thick. Trough cross-stratification and possible low-angle cross-bedding. Beds high in unit preserve recognizable current ripple cross-lamination. Beds may be packaged in sets that each are roughly 1.5 m thick. Degree of bioturbation highly variable, absent from some beds, but ranging to beds that are completely bioturbated by indeterminate horizontal burrows, including sporadic 3-10 cm thick layers where bedding is completely obliterated by bioturbation that has biogenically mixed dark grey siltstone into very fine to fine-grained quartz sandstone. Some beds preserve spaced vertical burrows and have indeterminate ripples at their tops; vertical burrows can variously resemble *Rosselia* or thinly lined *Skolithos linearis*.	9.0	9.0
	Base of section at lowest exposure of Mount Clark Formation quartz arenite, below a small waterfall in the trees.		

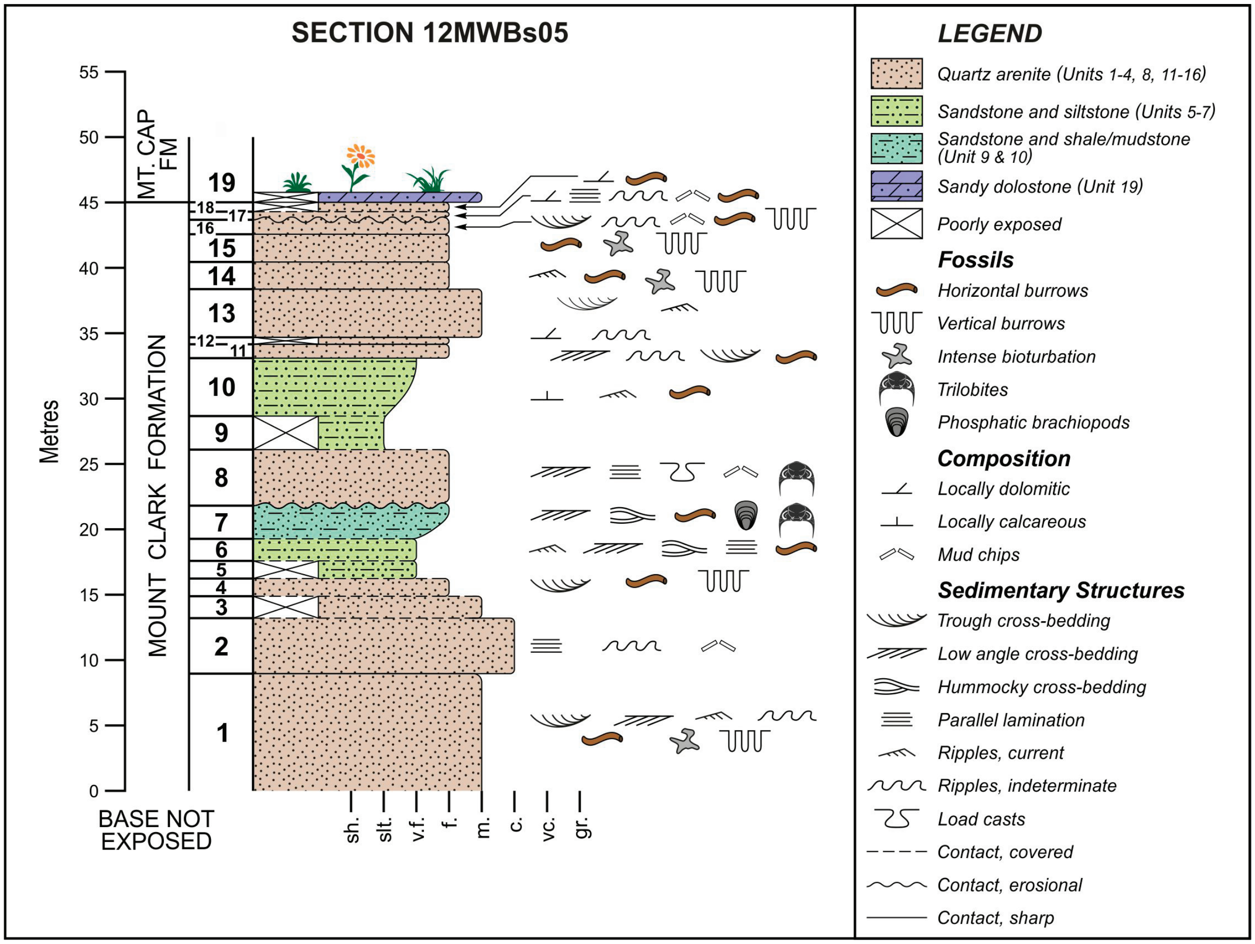


Figure 5: *Graphic log, measured section 12MWBs05. Although the base of the Mount Clark Formation is not exposed, this section is thought to include nearly its entire thickness. For location, see Figure 1. Abbreviation: "MT. CAP FM." = Mount Cap Formation.*

Section 12MWBs06 (Figure 6): Measured section through basal Cambrian sandstone (Mount Clark Formation). Section measured in southwest corner of NTS 96-D/NE (Fallas et al., 2013), approximately 4 km northwest of a section measured along Little Bear River by J.L. Usher during Operation Norman (his section U-13; Aitken et al., 1973). Base of section at: 64.50447° N, 126.8534° W. Top of section at: 64.50584° N, 126.8507° W. Measured on July 27, 2012, assisted by Christine Deblonde.

Unit	Description	Thickness (m)	Height Above Base (m)
	Section ends at top of talus of dark-weathering shale, where plant cover takes over.		
6	**Shale, minor limestone.** Base sharp. Recessive, mostly local talus. Shale, dark grey on fresh and weathered surfaces, thinly fissile, weathering as chips. Minor very thin beds of tan-weathering, very fine-grained quartz sandstone in float. At 3.4 m above base of unit, there is a 20-30 cm thick package of trilobite-bearing, thin-bedded, concretionary limestone, microcrystalline to very finely crystalline, possibly silty, dark grey on fresh surfaces, weathers grey. **GSC loc. C-553204** (field no. 12MWBs06 – 20.4 m); 20.4 m: *Olenellus terminatus* (Palmer and Halley, 1979) Age: *Bonnia-Olenellus* Zone (Cambrian Epoch 2)	7.5	24.5
	Base of Mount Cap Formation		
5	**Sandstone and mudstone.** Base sharp. Semi-resistant. Very fine to fine-grained quartz arenite to quartz wacke; most silt and mud appears to have been introduced by bioturbation. Grains very well rounded. Intensely bioturbated by horizontal burrows; relict indeterminate ripple cross-lamination. Also present is silty mudstone, gray on fresh and weathered surfaces. Beds mostly 1-10 cm thick, rarely 10-20 cm. Unit consists of three packages of roughly equal thickness. Basal package contains 80 percent sandstone that is at least locally calcareous, is brown on fresh surfaces and weathers orange, and is interbedded with up to 20 percent mudstone. Medial package is 60 percent sandstone that is grey on fresh and weathered surfaces, interbedded with 40 percent mudstone. Upper package consists of 80 percent sandstone, grey on fresh surfaces, weathering grey or brownish grey, interbedded with 20 percent mudstone.	3.9	17.0

4	**Sandstone.** Base sharp. Resistant. Significant lichen cover. Fine-grained quartz arenite, pale tan and pale grey on fresh surfaces, weathers pale grey. Beds 2-10 cm thick. Horizontal and vertical burrows are common but current ripple cross-lamination also is well preserved.	2.0	13.1
3	**Sandstone, siltstone, mudstone.** Base sharp. Semi-resistant. Very fine to fine-grained quartz wacke, light to medium brown on fresh surfaces, weathers light brown to orange, possibly with dolomitic cement in orange beds. Beds very thin, interlaminated with grey siltstone and mudstone, which also has been biogenically worked into the sandstone beds. Horizontal burrows of a range of sizes are present.	4.0	11.1
2	**Sandstone.** Base not exposed. Resistant. Fine-grained quartz arenite, light tan or light grey on fresh surfaces, weathers grey with heavy lichen cover. Beds thin to thick, some may be very thick. Trough cross-stratification, ripple cross-lamination, horizontal burrows; vertical burrows (*Skolithos linearis*) are rare, except in lowest thick bed exposed in stream cut, which has a "piperock" fabric with burrows 1 cm in diameter and at least 25-30 cm long.	4.1	7.1
1	**Sandstone, locally pebbly.** Contact covered but obviously sharp and possibly erosional. Unit not well exposed, consisting of outcrop, subcrop, and cover. Fine-grained quartz arenite, locally with quartzose granules and small pebbles. Weathers tan, light grey (fresh colour not recorded). Thin to medium bedded. Trough cross-stratification. No burrows noted.	3.0	3.0
	Base of Mount Clark Formation		
Not measured	**Dolostone.** Resistant. Dolostone, orange-weathering. Beds 10-30 cm thick, irregular, with stromatolites.		
	Section begins in uppermost beds of Stoneknife Formation (Little Dal Group).		

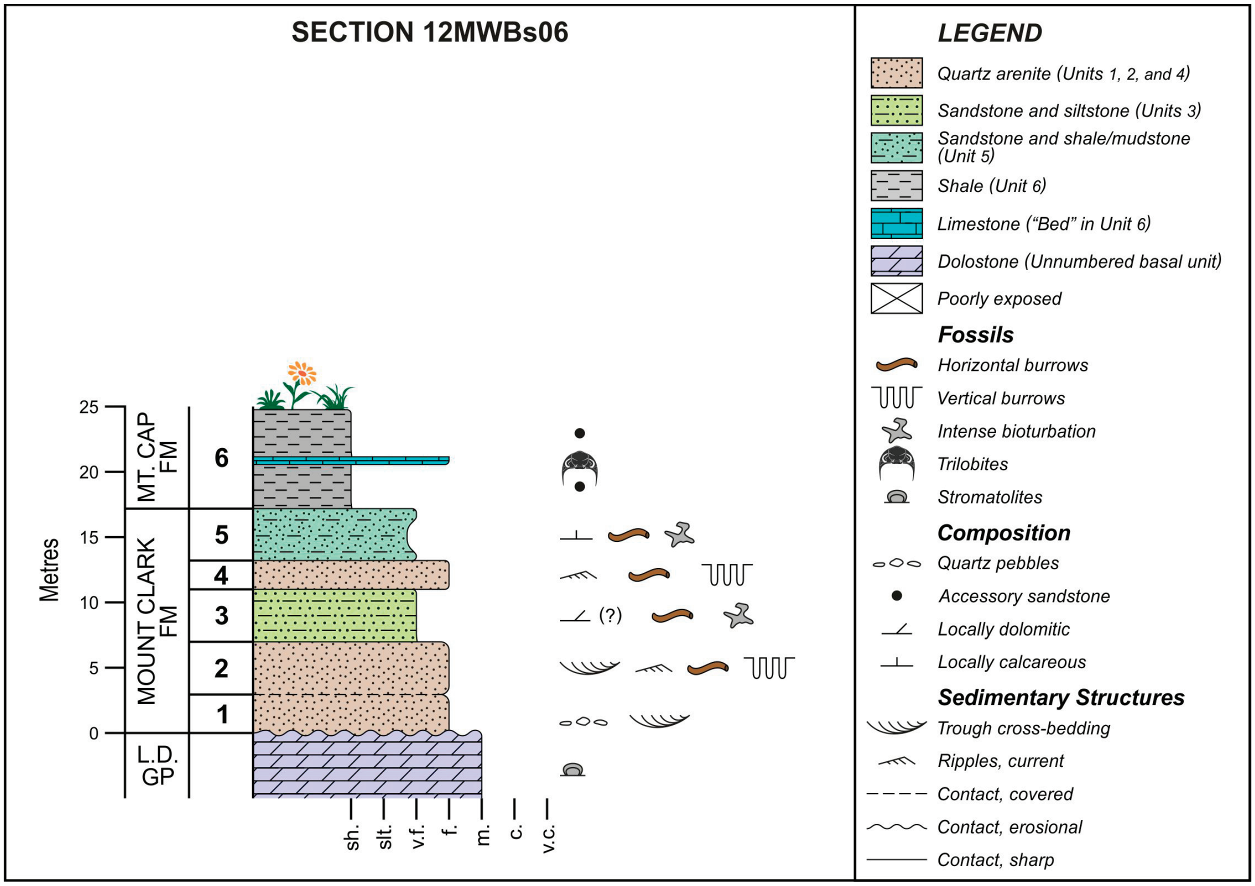


Figure 6: *Graphic log, measured section 12MWBs06. This is a complete section through the Mount Clark Formation, close to the Little Bear River reference section (U-13) of Aitken et al. (1973). This unfaulted section corresponds to the fault-affected basal part of section U-13. For location, see Figure 1. Abbreviations: "L.D. GP." = Little Dal Group; "MT. CAP FM." = Mount Cap Formation.*

Section 12MWBs08 (Figure 7): Measured section through the upper part of Katherine Group and through the overlying Mount Clark Formation. Section measured in NTS 96-D/NW (Fallas and MacNaughton, 2014a) at headwaters of a tributary to Stony Creek. Exposure is relatively continuous along a boulder-strewn creek bed. Base of section is at: 64.84326° N, 127.7164° W. Top of section is at: 64.84132° N, 127.7177° W. Measured on July 29, 2012, assisted by Christine Deblonde.

Unit	Description	Thickness (m)	Height Above Base (m)
	Top of section is at top of exposure of Mount Clark Formation. Above, there is no exposure and the creek cuts only a very shallow gully across a gently sloping grassy plain. Given the marked change in weathering profile, it is inferred that the top of the section is at or near the top of the Mount Clark Formation, but the thickness for the Mount Clark Formation should be considered a minimum value. In this region, the Mount Clark Formation is overlain unconformably by the Nainlin Formation (MacNaughton and Fallas, 2014a), which is recessive in its lower interval.		
17	**Sandstone.** Base sharp. Resistant. Very fine to fine-grained quartz arenite, white on fresh surface, weathers pale grey. Exceptionally siliceous and hard. Beds 10-20 cm thick and very regular. Bedding planes intensely reworked by horizontal burrows.	6.3	110.3
16	**Sandstone.** Base sharp. Fine-grained quartz sandstone, white on fresh surfaces, weathers pale grey. Beds are 20-70 cm thick; bedding is thinner upsection within the unit. Trough cross-stratification. Horizontal burrows present on bedding planes.	2.0	104.0
15	**Sandstone.** Base sharp. Fine-grained quartz arenite, can be pale grey or fresh and weathered surfaces, or orange on fresh surfaces, weathering orange-brown. Beds 10 cm thick, with intense horizontal bioturbation.	1.0	102.0
14	**Sandstone.** Base sharp. Fine-grained quartz arenite, fresh surfaces white, weathers white to medium grey. Beds 20-40 cm thick, with trough cross-stratification and planar lamination. No burrows noted. In basal 1.5 m of unit, there are vein-like zones of differential cementation, like those seen in Unit 9.	12.0	101.0

13	**Sandstone.** Base sharp. Resistant. Fine-grained quartz arenite. White to very pale tan or pale grey on fresh surfaces, weathers white or tan; some Liesegang banding. Nearly all bedding planes show intense horizontal bioturbation. Some suggestions of minor vertical burrowing. Beds that are 5-10 cm thick are completely reworked by burrowing, or nearly so. Beds that are 10-30 cm thick have bioturbated tops but preserve trough cross-stratification.	5.1	89.0
12	**Sandstone.** Base sharp. Resistant. Fine-grained quartz arenite; grains very well rounded; white, very pale tan or pale grey on fresh surfaces, weathers white or very pale tan, with Liesegang banding. Beds 10-50 cm thick, mainly 20-30 cm thick. Trough cross-stratification. Large horizontal burrows atop some beds.	3.6	83.9
11	**Sandstone.** Base gradational at first bed with well-defined trace fossils, all horizontal. Otherwise, unit is as for Unit 10.	2.2	80.3
10	**Sandstone.** Base sharp. Fine-grained quartz arenite, white to pale tan on fresh surfaces, weathers pale tan to creamy grey. Beds 10-20 cm thick. Trough cross-stratification. No burrows.	1.5	78.1
9	**Sandstone and conglomerate.** Base irregular and erosional. Resistant. Unit appears to be an interval of disturbed bedding and possibly near *in situ* brecciation or differential cementation in which it is very difficult to make out internal structure. At least locally appears to be a conglomerate of pebbles to cobbles of quartz arenite in a matrix of fine-grained quartz sandstone, but it may be that only the basal 0.5 m is truly a conglomerate. Fresh surfaces are white, pale grey, or pale tan; unit weathers pale grey. Bedding is very irregular and beds appear massive internally.	1.5	76.6
8	**Sandstone.** Base not well exposed but clearly sharp and almost certainly erosional. Resistant. Fine to medium-grained quartz arenite. Basal 30 cm is dominately fine-grained, brown to light orange brown on fresh surface, weathers brownish ochre; contains trough cross-stratification. Balance of unit is pale pink to pale grey on fresh surfaces, weathers pale pinkish grey to pale tannish grey, with some liesegang staining; beds 10-30 cm thick, with trough cross-stratification, especially in the lower half; some parallel laminated beds. No burrows noted.	6.5	75.1
	Base of Mount Clark Formation.		

7	**Siltstone.** Base covered at creek level, sharp on hillside. Recessive. Siltstone to muddy siltstone, dark on fresh surface, weathers brown to grey. Laminated but blocky weathering. Up to 20 percent shale, dark grey on fresh and weathered surfaces. Less than 10 percent very fine-grained quartz wacke to quartz arenite, dolomitic, very thin-bedded. Unit weathers greenish-blue and is friable near contact with overlying Unit 8.	9.8	68.6
6	**Sandstone, dolostone, mudstone.** Base gradational. Semi-resistant. Contains three lithofacies. (1) Very fine-grained quartz wacke to sandy siltstone, dolomitic, compact; deep brownish red on fresh and weathered surfaces; beds 1-10 cm thick with parallel or low-angle lamination, short-wavelength (5-6 cm) wave ripples, and indeterminate cross-lamination; comprises up to 70 percent of unit. (2) Very finely crystalline dolostone containing abundant quartz silt; beds 1-10 cm thick with stromatolitic textures; comprises up to 20 percent of unit. Weathers brownish-red (fresh colour not recorded). (3) Mudstone, red to green (fresh and weathered surfaces), present as very thin interbeds; contains polygonal mud cracks.	2.9	58.8
5	**Dolostone to dolomitic siltstone.** Base gradational. Resistant. Very finely crystalline dolostone with abundant quartz silt, grading to dolomitic quartz siltstone; light to medium grey on fresh surfaces, weathers orange to orange-brown. Beds 1-40 cm thick, mainly 5-20 cm. Parallel or low-angle cross-lamination in some beds; other beds have low-relief stromatolites and possible thrombolite fabrics.	2.7	55.9
4	**Sandstone with carbonate lens, minor shale.** Base gradational. Semi-resistant to resistant. Upward continuation of sandier-upward cycle from Unit 3. Fine-grained quartz arenite; silica and dolomite cements, dolomitic more common in upper part of unit; light brown on fresh surfaces, weathers brown to orange brown with a few ochreous layers. Beds are 1-29 cm thick, mainly 3-10 cm, with sharp bases; gutter casts, current and wave ripple cross-lamination, the latter locally bundled. Approximately 10 percent of unit is shale, dark grey on fresh and weathered surfaces, as very thin interbeds or interlaminae. At halfway level of the unit, exposed only in inaccessible cliff above the creek, is a carbonate lens, roughly 0.7-0.8 m thick, with significant upper-surface relief. Lens may preserve faint stromatolitic textures, suggesting a carbonate buildup. At creek level, same interval is shale and siltstone.	4.3	53.2

3	**Siltstone and sandstone.** Base sharp. Recessive. Lithologies as described for Unit 2; an additional sandier-up cycle. At base, 80 percent shale, dark grey on fresh and weathered surfaces; at top of unit, shale accounts for 20 percent of section. In addition to structures noted for Unit 2, gutter casts are common, including some isolated examples. Possible hummocky cross-stratification or combined-flow ripples.	7.4	48.9
2	**Siltstone and sandstone.** Base sharp. Recessive; lower half of unit is not well exposed. Dominated by silty shale to siltstone, dark grey on fresh and weathered surfaces, that weathers as chips, or as plates in siltier intervals. Up to 30 percent very fine to fine-grained quartz arenite, which mainly is siliceous, and brown on fresh and weathered surfaces, or less commonly dolomitic, in which case it is orange-brown on fresh and weathered surfaces. Sandstone is very thin to thin-bedded. Beds have sharp bases and tops, and are massive to parallel-laminated to rippled (possible tempestites?). Unit is packaged as two upward-sandier "parasequences" of roughly equal thickness.	37.0	41.5
	Base of McClure Formation		
1	**Sandstone.** Base covered but sharp. Resistant. Fine to medium-grained quartz arenite, grains very well rounded; white on fresh surface, weathers pale grey to pale greyish-tan; extensive Liesegang banding obscures internal structure of beds. Beds 30 cm to 1 m thick; indeterminate cross-stratification, although the irregular character of bedding is suggestive of trough cross-stratification.	4.5	4.5
	Base of section is at base of topmost package of quartz arenite in Shattered Range Formation. Below is fine-grained quartz arenite, brown on fresh and weathered surfaces, very thin to medium-bedded, with current ripples and trough cross-stratification; interbedded with up to 20 percent fissile mudstone, dark grey on fresh and weathered surfaces.		

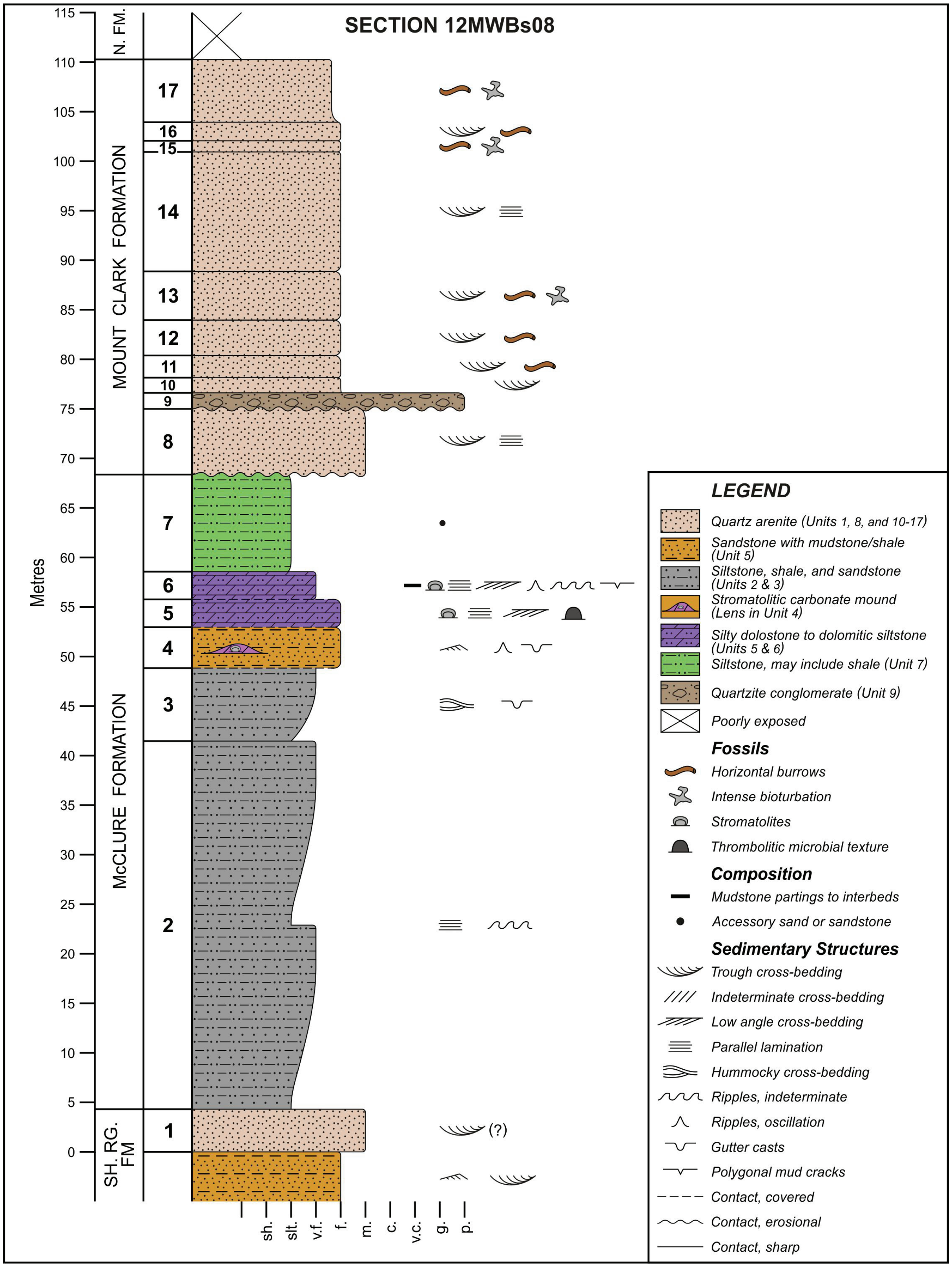


Figure 7: *Graphic log, measured section 12MWBs08. This is a complete section through the (erosionally truncated) McClure Formation, and near-complete through the Mount Clark Formation. For location, see Figure 1. Abbreviations: "SH. RG. FM" = Shattered Range Formation; "N. FM." = Nainlin Formation.*

OBSERVATIONS ON INDIVIDUAL FORMATIONS

Shattered Range Formation

Shattered Range Formation corresponds to the K5 division of earlier workers (Aitken et al., 1978; Long and Turner, 2012). Measured Section 12MWBs08 (Figure 7) included the uppermost 4.5 m of Shattered Range Formation. This consisted of medium to thick-bedded, cross-stratified, quartz arenite, and was underlain by a succession of interbedded fine-grained quartz arenite with up to 20% dark grey shale (not studied). At its type section (Long and Turner, 2012), and in a measured section presented by Hamel and MacNaughton (2013), the Shattered Range Formation is more uniformly sandstone-dominated than at 12MWBs08.

McClure Formation (Figure 8)

McClure Formation corresponds to the K6 unit of earlier workers (Aitken et al., 1978; Long and Turner, 2012). Section 12MWBs08 (Figure 7) preserves 64.1 m of McClure Formation. This is significantly less than thicknesses reported elsewhere in the easternmost Mackenzie Mountains (e.g., 123 m at Dodo Canyon: Long and Turner, 2012; 180 m in an unnamed canyon; Hamel and MacNaughton, 2013), reflecting significant erosion of the upper part of the Formation.

In measured section 12MWBs08, the lower 48.7 m of McClure Formation consists of three upward-coarsening successions with mudrock-dominated bases and more sandstone-rich tops (Figure 8A). Above the third upward-coarsening package is a heterolithic package (5.6 m thick) of orange-weathering, stromatolitic dolostone, mudstone, and dolomitic sandstone (Figure 8A,C). The balance of the formation (9.8 m) consists of siltstone, lesser shale, and minor sandstone (Figure 8B). The prevalence of mud rocks establishes the similarity of these strata with the type section and other exposures of McClure Formation (Long and Turner, 2012).

An earlier measured section reported by Hamel and MacNaughton (2013; their measured section 0901S) provides a point of comparison. In that section, McClure Formation (called K6 in the report) contained a basal succession of fine-grained siliciclastics overlain by dolostone; these strata were of comparable thickness to the similar siliciclastic-to-carbonate succession just described from 12MWBs08. However, Hamel and MacNaughton (2013) reported an additional, overlying succession within the McClure Formation, consisting of more than 100 m of additional strata, including a second siliciclastic-to-dolostone package. Given that 12MWBs08 lies closer to the axis of Mackenzie Arch than does 0901S, it is likely that the upper part of the McClure Formation was removed during latest Proterozoic or earliest Cambrian uplift and erosion that removed the Abraham Plains Formation at this locality (see below). This also is reflected in a subtle angular relationship between beds of the McClure Formation and the overlying Mount Clark Formation at the 12MWBs08 locality (Figure 8C).

Mount Clark Formation (Figure 9)

Mount Clark Formation was documented in all four sections. The abrupt, erosional base of the formation is best exposed at stream level along section 12MWBs08 (Figure 8B). The base of the Mount Clark Formation is covered but clearly abrupt in 12MWBs06 (Figure 6), which includes the complete thickness of the unit (17.0 m). Section 12MWBs05 (Figure 5) includes nearly the entirety of the Mount Clark Formation (measured 44.5 m) as well, except for a talus-covered interval at the base (Figure 3), whereas the nearby 12MWBs04 included only the uppermost 9.3 m of the unit (Figure 4).

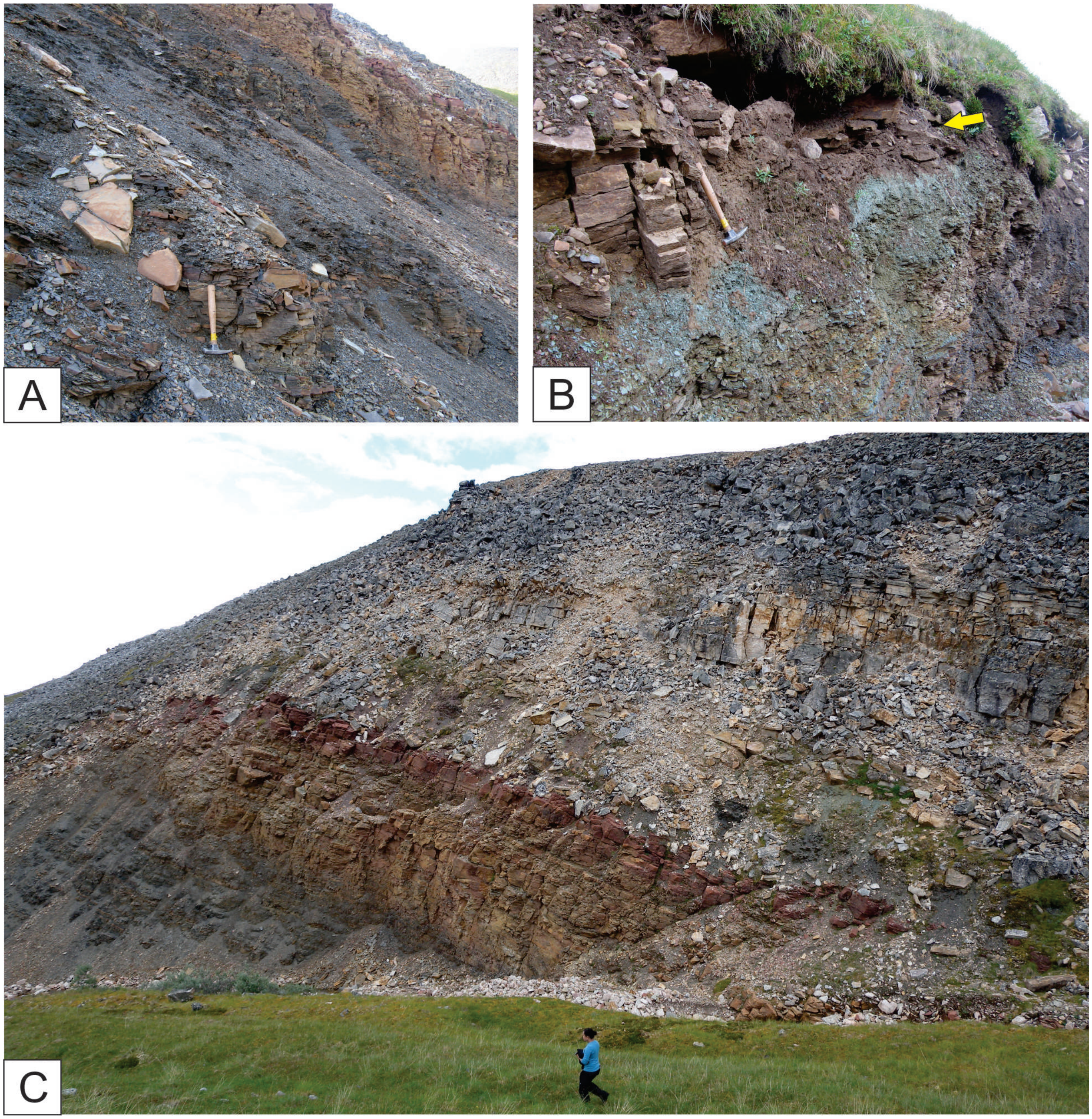


Figure 8: *Outcrop photographs of McClure Formation. All photographs taken at section 12MWBs08. For geographic coordinates and descriptions of units referred to in captions, see section notes. (A) Interbedded grey siltstone and shale with sandstone, comprising top of unit 2 and all of unit 3. Orange-weathering strata above this belong to units 4-6. Basal beds of Mount Clark Formation can be seen higher in cliff. Hammer handle is 30 cm long. Photograph by R.B. MacNaughton. NRCAN photo 2020-912. (B) Contact (arrow) between friable, weathered mudstone of McClure Formation (unit 7) and basal quartz arenite beds of Mount Clark Formation (unit 8). Hammer handle is 30 cm long. Photograph by R.B. MacNaughton. NRCAN photo 2020-913. (C) Overview of uppermost McClure and basal Mount Clark formations. Mount Clark Formation is the resistant, tan to pale grey-weathering sandstone on the upper part of the slope. Note apparent angular discordance between bedding in the two units. Person in foreground is 1.52 m tall. Photograph by K.M. Fallas. NRCAN photo 2020-914.*

In section 12MWBs08 the contact between the Mount Clark Formation and overlying strata (probably the Nainlin Formation; see below) is not exposed. However, an abrupt change in weathering character at the top of the section probably corresponds closely to the position of the contact. Thus, the measured thickness of 41.7 m for Mount Clark Formation in this section may be nearly complete, albeit possibly reduced by erosion related to pre-Nainlin Formation uplift of the Mackenzie Arch.

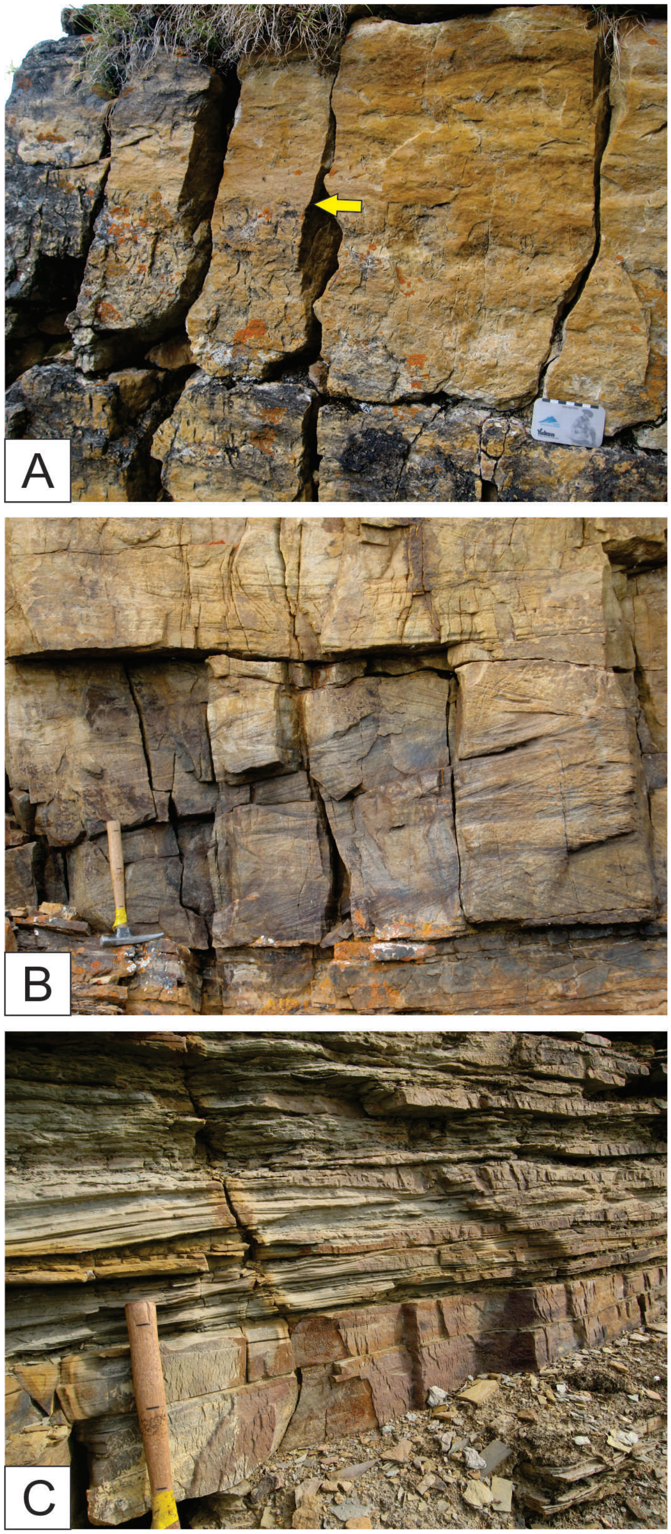
Quartz arenite dominates all published sections of Mount Clark Formation in the eastern Mackenzie Mountains (e.g., MacNaughton et al., 2013; Serie et al, 2013; Hamel and MacNaughton, 2013; Bouchard and Turner, 2017b; Handkamer, 2020; this work). In the sections documented for the present work, lithofacies can be subdivided as follows:
1. Thin- to medium-bedded quartz arenite, commonly with trough cross-stratification or ripple cross-lamination; preservation of primary sedimentary structures is highly variable depending on the intensity of horizontal or (less commonly) vertical bioturbation (Figure 9A).
2. Medium- to thick-bedded, trough cross-bedded quartz arenite. This lithofacies lacks bioturbation and generally is highly cemented, producing cliffy exposures (Figure 9B).
3. Very thin- to thin-bedded, variably silty quartz arenite, commonly with abundant horizontal bioturbation. Ripple cross-lamination and hummocky cross-stratification are preserved locally, depending on intensity of bioturbation (Figure 9C).

The third lithofacies is well-exposed in section MWBs05, where it yielded specimens of the trilobite *Olenellus terminatus* (*Bonnia-Olenellus* Zone; N. Handkamer, personal communication, 2021) from float likely derived from unit 7 (19.9-22.4 m; GSC loc. C-553201). This is the first report of trilobites from within the Mount Clark Formation and agrees with inferences about the unit's age based on fossils from the overlying Mount Cap Formation. It also supports the correlation between the Mount Clark Formation and the basal, sand-rich unit of the Mount Cap Formation in the McDougal anticline (MacNaughton et al., 2013).

Mount Cap Formation (Figure 10)
The base of the Mount Cap formation is well exposed in two sections. Although section 12MWBs06 exposes only the basal 7.5 m of the unit, consisting of dark grey shale with minor horizons of dark grey limestone, the abrupt contact with the underlying Mount Clark Formation is well exposed (Figure 10A). A limestone 3.4 m above the base of the Mount Cap Formation (GSC loc. C-553204) preserved a number of cephalons (head shields) of the trilobite *Olenellus terminatus* (*Bonnia-Olenellus* Zone; N. Handkamer, personal communication, 2021).

In section 12MWBs04, the contact between the Mount Cap and Mount Clark formations is more gradational (Figure 4). Here, the Mount Cap Formation can be subdivided into two intervals. A heterolithic lower succession (Figure 10B) consists of 29.6 m of dark-coloured shale, dolostone to sandy dolostone, limestone, and sandstone. Bioturbation is common and trilobites and phosphatic brachiopods are present at several horizons. A collection from a carbonate bed 14.7 m above the base of the formation (GSC loc. C-553199) included specimens of *Glossopleura boccar* and *Polypleuraspis solitaria*, belonging to the *Glossopleura* Zone (N. Handkamer, personal communication, 2021).

Figure 9 (on next page): *Outcrop photographs of Mount Clark Formation. All photographs taken by R.B. MacNaughton at section 12MWBs05. Photographs to illustrate the main lithofacies discussed in the text of the report. For geographic coordinates and descriptions of units referred to in captions, see section notes. (A) Thin- to medium-bedded quartz arenite (unit 1) with abundant vertical burrows. Arrow points to a contact between beds that are burrowed (below) and unburrowed (above). Centimetre scale bar. NRCAN photo 2020-915. (B) Trough cross-bedded, medium to thick-bedded quartz arenite, from an exposure of unit 13 some distance away from the section route. Hammer handle is 30 cm long. NRCAN photo 2020-916. (C) Thin bedded quartz arenite and silty sandstone with well-developed ripple cross-lamination and possible hummocky cross-stratification (unit 7). Hammer handle is 30 cm long. NRCAN photo 2020-917.*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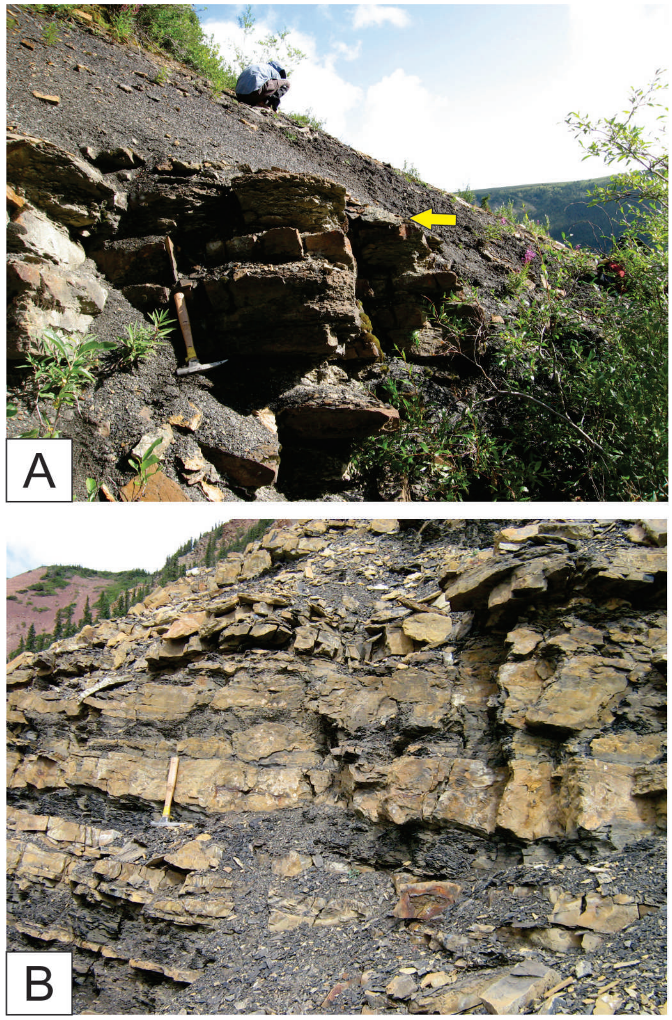

Figure 10: *Outcrop photographs of Mount Cap Formation. In both photographs, hammer handle is 30 cm long. For geographic coordinates and descriptions of units referred to in captions, see section notes. (A) Contact (arrow) between sandstone at top of Mount Clark Formation (unit 5) and overlying dark grey shale of basal Mount Cap Formation (unit 6). Person is at trilobite locality (see Figure 6). Measured section 12MWBs06. Photograph by R.B. MacNaughton. NRCAN photo 2020-918. (B) Interbedded dark grey shale and tan-weathering beds of limestone and lesser sandstone, measured section 12MWBs04 (unit 11). Photography by C. Deblonde. NRCAN photo 2020-919.*

Section 12MWBs04 also contains a poorly exposed, shale-dominated upper interval (8.2 m) of the Mount Cap Formation (Figure 3). The bipartite subdivision in this section mimics that documented in other exposures (Aitken et al., 1973; Serié et al., 2013). The measured thickness of 37.8 m for the Mount Cap Formation at this location should be treated as a minimum value in light of regional erosion beneath the overlying Saline River Formation (Aitken et al., 1973).

Saline River Formation

Saline River Formation is present at the top of section 12MWBs04, where it consists of poorly exposed, very fine- to fine-grained sandstone and shale that weather maroon, red, or tan. Float and spot outcrops preserve salt casts, polygonal mud cracks, and wave ripples. Aitken et al. (1973) documented better-exposed, relatively complete sections through Saline River Formation but the unit is generally not well exposed and even relatively complete sections tend to be deeply weathered or tectonized, hampering study (Bouchard and Turner, 2017b).

In the region adjacent to the crest of the Mackenzie Arch, Saline River Formation passes (south)westward into the Nainlin Formation (MacNaughton and Fallas, 2014). The two units are both shale-rich, but the Nainlin Formation is sandier and lacks evaporites. Based on exposures mapped near section 12MWBs08 (MacNaughton and Fallas, 2014), the covered interval above the Mount Clark Formation in that section is thought to be underlain by the Nainlin Formation.

INFLUENCE OF PROTEROZOIC AND CAMBRIAN TECTONICS ON STRATIGRAPHY

As noted above, Neoproterozoic and lower Paleozoic stratigraphic relationships in the eastern Mackenzie Mountains were influenced by late Neoproterozoic regional folding and by uplift of the Mackenzie Arch. A simplified cross-section (Figure 11) shows stratigraphic relationships between three localities: a composite of sections 12MWBs04 and 12MWBs05 (this work); section 12MWBs08 (this work); and section 11MWBs01 of Hamel and MacNaughton (2013). Neoproterozoic folding (Fallas et al., 2017) and subsequent erosion may have led to the removal of roughly two-thirds of the McClure Formation and all of the Abraham Plains Formation between 11MWBs01 and 12MWBs08. It also is reflected in reappearance of those units and the preservation of the basal Little Dal Group near 12MWBs04/12MWBs05 (Fallas and MacNaughton, 2014a). Early Paleozoic influence by the Mackenzie Arch is illustrated by changes in Cambrian stratigraphy between 12MWBs08, on the immediate flank of the Arch, and the other two localities that are more distal from the Arch (i.e, farther northeast from the Foran and Stony anticlines). At 11MWBs01 and 12MWBs04/12MWBs05, the Mount Clark Formation is overlain by the Mount Cap Formation, which in turn is overlain by the Saline River Formation. By contrast, at 12MWBs08, the Mount Cap Formation is not present, probably due to post-depositional erosion related to uplift of Mackenzie Arch (Aitken et al., 1973). The overlying strata are mapped as part of the Nainlin Formation (Fallas and MacNaughton, 2014a), reflecting arch-adjacent coarsening of clastic facies and loss of evaporites relative to the more regionally extensive Saline River Formation of Mackenzie Plain and the Interior Plains.

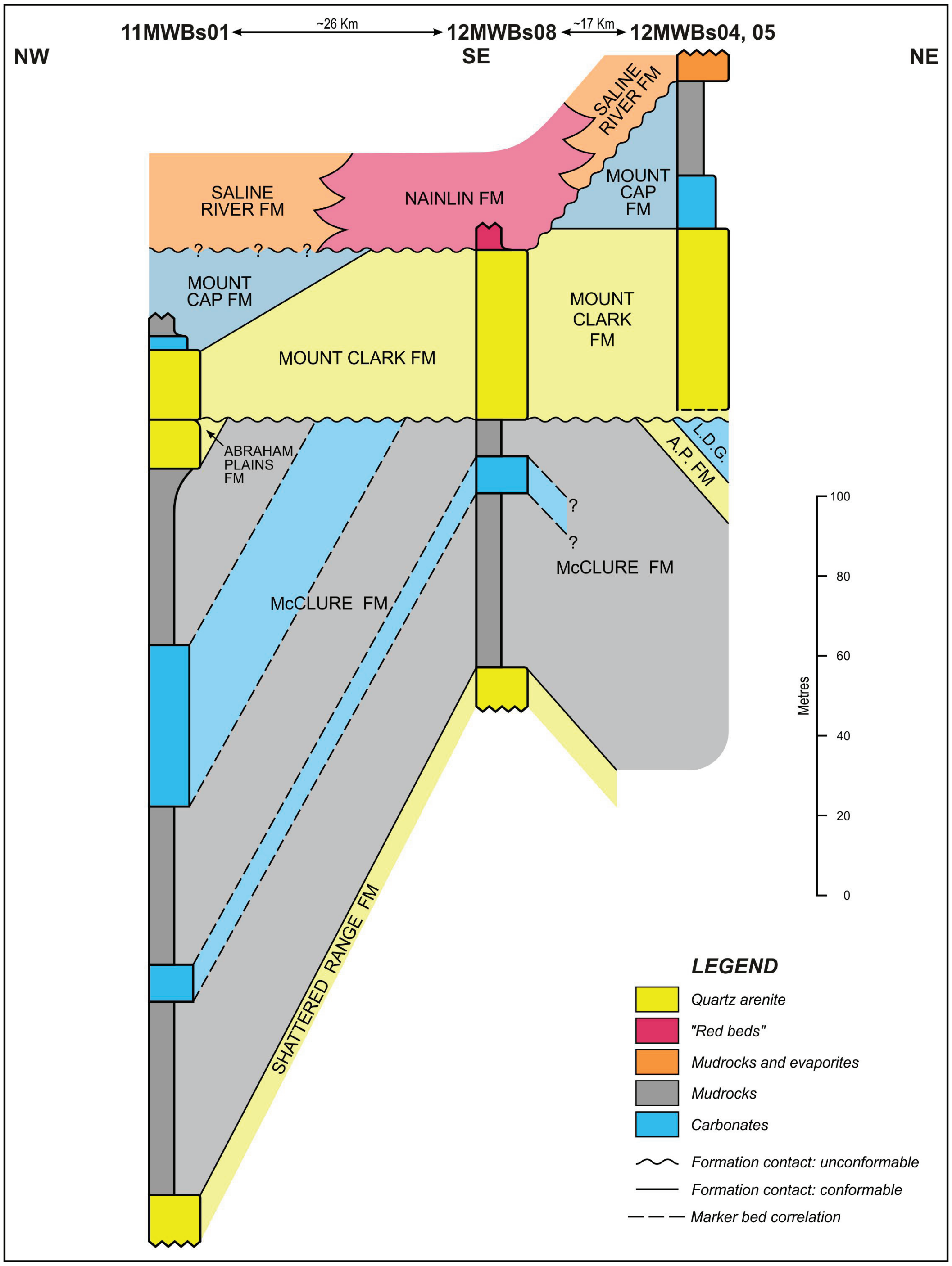

Figure 11: *Simplified stratigraphic cross-section showing angular truncation of Mackenzie Mountains Supergroup beneath sub-Cambrian unconformity and variation in Cambrian unit distributions relative to Mackenzie Arch. 12MWBs08 is adjacent to the Mackenzie Arch, whereas the other two sections are further away. Arrangement of Proterozoic units below composite section 12MWBs04,05 is schematic but constrained by geological map patterns (Fallas and MacNaughton, 2014a). Although large-scale folds are present in the Mackenzie Mountains Supergroup (Fallas et al., 2017), the apparent folding seen in the MacClure Fm and associated units in this cross-section is an artefact of section locations on one limb of such a fold. Abbreviations: FM = Formation; L.D.G. = Little Dal Group; A.P. = Abraham Plains.*

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