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ABSTRACT

This report documents the stratigraphic succession of Lower and Middle Cambrian formations in Hornaday River canyon, northeastern mainland Northwest Territories. Essentially flat-lying strata of the Mount Clark, Mount Cap, and Saline River formations were documented in overlapping sections along the Hornaday River to form a complete composite section. Both the lower, unconformable contact with the Neoproterozoic Boot Inlet Formation and the upper, conformable contact with the Cambro-Ordovician Franklin Mountain Formation are exposed in these sections. The Mount Clark Formation (approximately 78 m thick) consists of cross-bedded, bioturbated quartz arenite with local layers of wacke and was deposited in a high to moderate energy environment, initially over a karsted surface with at least 1-2 m of paleotopography. The Mount Cap Formation (approximately 34 m thick) consists of bioturbated and cross-bedded dolostone interbedded with glauconitic sandstone, deposited in a lagoonal environment. A sharp and possibly unconformable contact separates the Mount Cap Formation from the overlying Saline River Formation. The Saline River Formation (approximately 40 m thick) consists of sandy dolostone, dolomudstone, and mudstone that were deposited in an evaporitic environment. It contains no biogenic structures, but abundant desiccation cracks and halite moulds. Its upper contact with dolostone of the Franklin Mountains Formation is gradational (by interbedding) over 5 - 10 cm.

INTRODUCTION

This report presents the preliminary results of stratigraphic studies of Lower and Middle Cambrian formations exposed in the Hornaday River canyon, northeastern mainland Northwest Territories (NTS sheet 97C/8; Figs. 1 and 2). Cambrian sedimentary rocks exposed in the canyon are the Mount Clark, Mount Cap, Saline River, and Franklin Mountain formations, originally established by Williams (1923) in the Franklin Mountains near Wrigley, NT, approximately 660 km to the south of the present study's location (Fig. 1). These units previously were described at Hornaday River canyon by Aitken

et al. (1973; section MQ-24), albeit in reconnaissance fashion. The Mount Clark, Mount Cap, and Saline River formations are known to be present elsewhere in the northern Northwest Territories in surface and subsurface, including in the Mackenzie Plain, Mackenzie Mountains and Franklin Mountains (Aitken et al., 1973; Dixon and Stasiuk, 1998), and Peel region; but are rarely exposed as a complete succession. The regional picture resulting from previous studies is of an epicratonic basin bounded by cratonic arches to the northwest and southwest, and bordering the craton to the east (Fig. 1), with concentric isopach patterns (Fig. 3) influenced by contemporaneous cratonic arches (Pugh, 1983, 1993; Dixon and Stasiuk, 1998; MacLean, 2011), with significant lateral thickness variability in all three units in the west, near the Mackenzie Arch (Serié et al., 2013), where exposures are generally incomplete, making correlation and comparison of all three formations challenging. Previous studies by Hamblin (1990), Dixon and Stasiuk (1998), and Maclean (2011) discuss the petroleum potential of the understudied 'Cambrian basin' in Northwest Territories. In 1974, gas was discovered in Mount Clark Formation sandstone, and since then the Cambrian basin of the NWT interior plains has been of considerable economic interest (Maclean, 2011). The sands of the Mount Clark Formation act as a reservoir and the shales of Mount Cap Formation and shales and evaporites of the Saline River Formation provide seals, with the Mount Cap Formation shales being the primary source rocks (Maclean, 2011). This study focusses on refining the lithostratigraphy of the three formations, as part of the GSC's 'Geo-mapping for Energy and Minerals' program, the "Shield to Selwyn Geo-transect" project.

REGIONAL GEOLOGY

Williams (1922) identified the Mount Cap Formation as the oldest Paleozoic strata exposed in the area between Fort Simpson and Wrigley, NWT. In a subsequent study, in the Franklin Mountains, Mount Cap Formation was subdivided into three Cambrian formations (establishing Mount Clark, Mount

Cap, and Saline River formations) because of the thickness and vertically variable character of the succession (Williams, 1923). Old Fort Island Formation was identified in the north arm of Great Slave Lake by Norris (1965) and used, instead of Mount Clark Formation, as possible assignments for the oldest Paleozoic rock (Cook and Aitken, 1970; Aitken et al., 1973; Macqueen and Mackenzie, 1973). The publication priority of Mount Clark Formation and the similarities between the two formations led to the abandonment of Old Fort Island Formation (Cook and Stasiuk, 1998). Mount Clark, Mount Cap, and Saline River formations are documented in the Mackenzie Plain (Balkwill and Yorath, 1970; Aitken et al., 1973), Mackenzie Mountains (Serié et al., 2013), interior plains (Cook and Aitken, 1970; Macqueen and Mackenzie, 1973; Hamblin, 1990; Dixon, 1997; Dixon and Stasiuk, 1998), and in Peel region (Pugh, 1983, 1993; Pyle et al., 2006; Pyle and Gal, 2007, 2011, 2014).

Mount Clark, Mount Cap, and Saline River formations were deposited in a semi-enclosed, epicontinental marine basin, during continental subsidence (MacLean, 2011). The initial transgression resulted in the deposition of a variably thick, discontinuous blanket of marine sandstone (Mount Clark Formation), which was followed by clay and carbonate muds (Mount Cap Formation) in a lower energy environment (Dixon and Stasiuk, 1998). Mount Clark Formation is a variably coloured succession of sandstone that is locally cross-stratified or bioturbated with interbedded mudstone and Mount Cap Formation is a succession dominated by dolostone that is extensively bioturbated. Continent uplift or sea-level drop at the end of the deposition of the Mount Cap Formation resulted in an unconformity, which was followed by the deposition of Saline River Formation in more restricted marine conditions and development of evaporite deposits (Dixon and Stasiuk, 1998). Saline River Formation is a succession of dolostone, and evaporite salts. The initial deposition of Cambrian strata occurred in paleodepressions on the Precambrian erosional surface (MacLean, 2011). Dixon and Stasiuk (1998) addressed the correlation of Cambrian strata in the northern interior plains, both in the subsurface and in outcrop, and MacLean (2011) used seismic surveys to further constrain the

correlation of the strata. The depositional limits of Mount Clark, Mount Cap, and Saline River formations in the west is the Mackenzie arch, in the east is the zero-edge of Cambrian strata along the Canadian Shield and Brock Inlier, in the north is the Aklavik arch, and in the south coincident with the present-day Franklin Mountains.

SECTION LOCATIONS

Detailed stratigraphic sections were documented at four locations (Figs 4, 5, and 6) along the Hornaday River, NT (Fig 2). Section 1 (Fig. 7, simplified section; Fig. 8, legend; and Fig. 9, detailed section) was documented approximately 10 km upstream from La Roncière Falls, and included exposures of the unconformity at the surface of the Neoproterozoic Boot Inlet Formation, the complete thickness of the Mount Clark Formation (70 m thick), and the lowest few metres of the Mount Cap Formation (13 m thick) (Fig. 4). In section 2 (Fig. 10), just downstream of the falls, exposures included part of the Mount Clark Formation (58 m thick), the entirety of the Mount Cap Formation (32 m thick), and the lowermost unit of the Saline River Formation (1 m thick; Fig. 5). Section 3 (Fig. 11), a complete stratigraphic section through the Saline River Formation (40 m thick), including the contacts with the Mount Cap and Franklin Mountain formations, was documented approximately 2 km downstream of section 2 (Fig. 2) in two overlapping segments (Fig. 6).

LITHOSTRATIGRAPHY

Mount Clark Formation

The Mount Clark Formation was documented at two different locations on either side of the Hornaday River, NT (Fig. 2). Section 1 was documented above La Roncière Falls, up a steep slope and cliff where the Mount Clark Formation unconformably overlies stromatolitic dolostone (Fig. 12A) of the Neoproterozoic Boot Inlet Formation. The basal contact (Fig. 12B) has at least 1 – 2 m of

paleotopography at this location. The Mount Clark Formation consists predominantly of medium- to fine-grained quartz arenite, but 0.5 cm-thick layers of quartz wacke are also present locally. The lower siliciclastic units of the Mount Clark Formation contain densely spaced *Skolithos* traces, but units higher in the section contain more diverse vertical and horizontal trace fossils. Overlying the Mount Clark Formation are medium crystalline dolostone and glauconitic quartz arenite units of the Mount Cap Formation. The contact between the Mount Clark and Mount Cap formations is sharp, planar, and defined by an abrupt change in lithology from the quartz arenite of the Mount Clark Formation to dolostone of the Mount Cap Formation. The total thickness of the Mount Clark Formation at section 1 is approximately 70 m (Fig. 9).

In section 1 (Fig. 9), unit 1 (0 - 4 m) of the Mount Clark Formation (Fig. 4) is yellow and pale buff weathering, resistant-weathering, cross-stratified (Fig. 12C), medium-grained quartz arenite containing granule- to pebble-sized lithic and quartzose lag material (Fig. 12D), and with bedding thicknesses of approximately 0.5 m. This unit also contains water-escape features (cf. Mathieu et al., 2013), which appear as vertical cylindrical features in the sandstone (Fig. 12E). The talus below the section contains abundant horizontal burrows (Fig. 12F). Paleocurrent measurements (n = 14) from cross-stratified quartz arenite beds in unit 1 (Fig. 13) indicate variable water movement directions, with possible predominance of southeast-directed flow. Units 2 – 14 (4 m – 17.5 m; Fig. 4) are medium orange, medium purple-red, medium blue-green, medium green, pale pink, and medium yellow-orange-weathering, recessive, medium-grained quartz arenite interbedded with quartz wacke. Beds are approximately 0.1 to 2 m thick (Fig. 9) and locally contain *Skolithos*, as well as other vertical (few cm wide and 10s of cm long, with annulated margins) trace fossils (Fig. 14A).Units 15a – 22 (23.5 m – 37.2 m; Fig. 4) consist of dark purple-red, pale purple, rusty, yellow, medium blue-grey, and medium red-brown weathering, recessive-weathering, medium-grained quartz arenite, in beds that are approximately 0.3 to 1.7 m thick, with vertical (1 cm wide and 5 - 10 cm long with circular and ribbed

edges; Fig. 14B) and horizontal trace fossils. Units 23 – 31 (42.7 m – 61.6 m) are pale pink-buff, medium red-brown, and purple weathering, recessive, locally cross-stratified (unit 30; Fig. 14C), medium-grained quartz arenite, preserved as beds 0.2 to 1 m thick, and locally containing U-shaped (unit 25; Fig. 14D) and horizontal (1-2 cm wide, parallel sided) traces (Fig. 14E). The uppermost unit 32 (67.8 m – 68.1 m) is medium purple-red, medium orange and yellow-buff, and medium green-blue weathering, resistant, cross-stratified, medium-grained quartz arenite with bedding thickness of approximately 1 m. The sharp upper contact with the overlying Mount Cap Formation dolostone is documented at this location (Fig. 14F).

Section 2 (Fig. 10) was documented up a steep slope and cliff, below La Roncière Falls (Fig. 2), where the Mount Clark Formation basal units and contact are not exposed (Fig. 5). The Mount Clark Formation at section 2 also is dominated by quartz arenite units (~0.6 m thick) with local layers of quartz wacke (~1 m thick); these lithofacies are poorly lithified near the base. The basal units contain dense *Skolithos* traces, but the units higher in the section contain other vertical and horizontal trace fossils. Sharply overlying the Mount Clark Formation is a complete section of Mount Cap Formation (see below). The incomplete thickness of the Mount Clark Formation at section 2 is approximately 58 m (Fig. 10).

In section 2 (Fig. 10), units 1 - 4 (0 m – 5.1 m; Fig. 15A) of the Mount Clark Formation (Fig. 5) consist of medium orange-brown, and rusty weathering, recessive, poorly lithified, coarse-grained quartz arenite with *Skolithos* traces (Fig. 15B) and local unlithified wacke (unit 2). Units 5 - 24 (5.1 m – 14 m) consist of medium rusty brown, purple-brown, pale green, yellow-brown, pale yellow-green grey, medium grey, and medium brown-weathering, recessive, poorly lithified, fine-grained wacke and medium-grained quartz arenite with local grains of coarse quartz sand. Beds in these units are approximately 0.2 to 0.7 m thick and contain local ripples (units 5 and 9), planar lamination (unit 8),

and vertical (few cm thick and 5 – 10 cm long, cylindrical shaped with ribbed edges; Fig. 15C and D) and horizontal (mm scale, discontinuous and irregular shaped) trace fossils. Units 25 – 33 (14 m – 28.9 m) consist of pale pink, medium grey, pale green-grey, pink-yellow buff, medium purple-red, medium blue-green, and pale buff-weathering, recessive, fine-grained quartz wacke, medium-grained quartz arenite, and some poorly lithified layers (units 32 and 33; Fig. 16A). The bedding thickness of these units is approximately 0.1 to 1 m. Units 34 - 44 (28.9 m – 48.7 m) consist of pale pink-blue and green, pale pink-brown, and pale yellow-green-blue-weathering, resistant, locally poorly lithified (unit 44), medium-grained quartz arenite. Beds are approximately 0.1 to 1 m thick, with local cross-stratification (unit 34; Fig. 16B, unit 36; Fig. 16C and E), planar lamination (upper part of unit 36; Fig. 16E), vertical (unit 34; Fig. 16B) burrows (mm scale with slightly wavy edges), and horizontal (mm scale, discontinuous and irregular shaped) traces. The uppermost unit 45 (48.7 m – 58.1 m) is pale pink- and grey-blue-weathering, resistant, trough-cross-stratified fine-grained quartz arenite with bedding thickness of approximately 1 metre. The sharp upper contact with Mount Cap Formation dolostone is well exposed at this location (Fig. 16F). Paleocurrent measurements from the cross-stratified quartz arenite beds in unit 45 (n = 15) show no distinct pattern (Fig. 17).

Mount Cap Formation

The Mount Cap Formation was documented at the same two locations (Fig. 2) as the Mount Clark Formation. The basal contact of the Mount Cap Formation is placed where quartz arenite-dominated Mount Clark Formation strata are abruptly overlain by basal dolostone of the Mount Cap Formation. The contact between the Mount Clark and Mount Cap formations is exposed in both section 1 (Fig. 14F) and section 2 (Fig. 16F). The total thickness of the Mount Cap Formation is 32 m, as documented in section 2 (Fig. 10).

In section 1 (Fig. 9), basal unit 34 (78.3 m – 79 m) of the Mount Cap Formation (Fig. 4) is medium orange-buff-weathering, resistant, sandy dolostone with average bedding thickness of approximately 0.7 m. Unit 35 (79 m – 85.5 m) is medium green-blue-grey-weathering, recessive, medium-grained quartz arenite with coarse-grained glauconite, with a bedding thickness of approximately 1- 2 cm, and containing horizontal (mm to cm scale, discontinuous and irregular shaped) trace fossils. The uppermost unit 36 (85.5 m – 91.5 m) is medium orange-buff-weathering, resistant, massive, medium crystalline dolostone with no distinct bedding.

The Mount Cap Formation was also documented at section 2, up a steep slope and cliff (Fig. 5), below La Roncière Falls (Fig. 2). The basal contact of the Mount Cap Formation is the same as described above in section 1, but the formation is complete and its upper contact present in this section. The upper contact of the Mount Cap Formation is sharply overlain by the Saline River Formation, characterised by dolostone, including dolomudstone and local sandy dolostone and mudstone units, all lacking trace fossils. The total thickness of the Mount Cap Formation is 32 m (Fig. 10).

In section 2 (Fig.10), the basal unit 46 (58.1 m – 63.3 m) of the Mount Cap Formation (Fig. 5) is medium yellow-brown, and dark brown-weathering, resistant, medium crystalline dolostone with no distinct bedding and with ‘floating’ grains of medium-grained quartz (massive quartzose dolostone) (Fig. 18A and B). Unit 47 (63.3 m – 68.6 m) is medium bluish grey and medium yellow-brown-weathering, recessive, medium-grained glauconitic quartz arenite with horizontal trace fossils and bedding thickness of approximately 1 – 2 cm (Fig. 18B and C). Unit 48 (68.6 m – 77.3 m) is pale pink-brown and golden-brown-weathering, resistant, massive to locally cross-stratified, medium-crystalline dolostone (Figs. 18D and 19A) with glauconite near the lower contact and bedding thickness of approximately 10 cm. Phosphatic clasts are present at the top of unit 48 (Fig. 19B). Unit 49 (77.3 m – 77.6 m) is medium green-grey-weathering, recessive, glauconitic quartzose dolostone (Fig. 19A).

Units 50 – 51 (77.6 m – 82.8 m) consist of medium pink-brown and yellow, medium brown-weathering, resistant, medium-crystalline dolostone with a phosphatic hardground at the upper contact and bedding thickness of approximately 0.5 m. Units 52 - 53 (82.8 m – 86.6 m) consist of dark green-grey-weathering, recessive, medium-crystalline dolostone with floating medium-grained quartz particles (massive quartzose dolostone) with horizontal trace fossils and bedding thickness of approximately 1 - 2 m (Fig. 19C and D). The uppermost units 54 – 55 (86.6 m – 90.4 m) consist of pale yellow, medium-brown and medium pinkish-brown-weathering, resistant, massive, medium-crystalline dolostone with burrow-mottles, planar lamination, and bedding thickness of approximately 2 m (Fig. 19E). The sharp upper contact of the bioturbated Mount Cap Formation with the Saline River Formation is exposed in both the La Roncière Falls (section 2; Fig. 19F) and waterfall sections. Various horizontal ichnofossils (*Cruziana* ichnofacies) are present on bedding-planes in the talus below the section (Fig. 20A-F).

Saline River Formation

The lowermost units of the Saline River Formation are exposed at the La Roncière Falls section, (section 2, Fig. 10) but only the basal unit was accessible and documented (Fig. 5). Unit 56 of section 2 (90.4 m – 91.7 m) is medium green-grey-weathering, recessive, sandy dolostone consisting of medium-grained quartz grains in medium crystalline dolostone. Beds are approximately 0.2 m thick and contain planar lamination, asymmetrical ripples, desiccation cracks and halite moulds. Slabs of dolostone containing desiccation cracks, intraclasts (mudstone and dolomudstone), synaeresis cracks, and halite casts are abundant in the talus below the Saline River Formation (Fig. 21A-F).

The waterfall section (section 3; Fig. 11) of the Saline River Formation was documented in two overlapping sections. The lower section (30.7 m; Fig. 6A) starts at the sharp contact with dolostone of the Mount Cap Formation, contains numerous covered intervals, and ends at a minor fault separating

the uppermost green mudstone beds of the Saline River Formation from a cliff of the basal Franklin Mountain Formation. The upper section (9.5 m; Fig. 6B) is at the base of the waterfall (Fig. 6C), where the uppermost Saline River Formation and its abrupt contact with the basal Franklin Mountain Formation are well exposed. Together, these two overlapping sections yield a total thickness of 40 m for the Saline River Formation. The Saline River Formation is dolomudstone, medium crystalline dolostone, and mudstone, with local interbedded quartzose dolostone.

The main section of the Saline River Formation is exposed in the stream-bed below a waterfall (Fig. 2) that flows into the Hornaday River downstream of La Roncière Falls, and in the hillside above it (Fig. 6A-C). Dolostone with lithic intraclasts (mudstone and dolomudstone), desiccation cracks, ripples, and halite casts were in talus below the outcrops of the Saline River Formation (Fig. 22A-D). The basal contact with dolostone of the Mount Cap Formation is exposed (Fig. 23A) but not accessible. In section 3A (Fig. 11A), the lowermost unit 1 (0 m – 1 m) is medium bluish green-grey-weathering, recessive, sandy dolostone with planar lamination, asymmetrical ripples, and desiccation cracks. The bedding thickness of these units is approximately 1 m (Fig. 23B). Units 2 – 6 (1 m – 12.9 m) consist of medium green-grey, rusty yellow-brown, pale green, and buff-weathering, recessive, medium crystalline dolostone and very finely to finely crystalline dolomudstone with local asymmetrical ripples (unit 2) and planar lamination (unit 2) and bedding thicknesses of approximately 0.4 m (e.g., unit 6 in Fig. 23C). Units 7 – 14 (12.9 m – 24.1 m) (Fig. 11A) consist of yellow-buff, medium buff, pale brown, medium grey, and medium blue-grey-weathering, recessive, poorly lithified, medium-quartzose medium-crystalline dolostone and medium-crystalline dolostone with local planar lamination (unit 9 and 12), asymmetrical ripples (unit 8), desiccation cracks (unit 11), and intraclasts, and bedding thicknesses of approximately 0.5 – 1 m (e.g., unit 7 in Fig. 23D, unit 9). Unit 15 (22.6 m – 24.7 m) is medium orange-yellow-buff-weathering, resistant, finely to very finely crystalline dolomudstone with bedding thickness of approximately 0.1 m. The uppermost unit 16 (24.7 m – 30.7

m) of the Saline River Formation is dominated by medium green-grey-weathering, recessive, finely to very finely crystalline dolomudstone, with sparse and poorly exposed sandy dolostone and dolomudstone beds, all of which are poorly exposed and in layers approximately 0.5 m thick. The section ends where the hillside underlain by Saline River Formation abuts a cliff of Franklin Mountain Formation along an inferred fault with a few metres of displacement (Fig. 6C).

The second section of the Saline River Formation (section 3B; Fig. 6B) at the waterfall exposes the uppermost 9.5 m of the formation and its contact with the overlying Franklin Mountain Formation (Fig. 11B). In section 3B, the basal units 1- 8 (0 m – 3.1 m) consist of medium buff, medium blue-green-grey, pale buff, and medium grey-weathering, resistant medium crystalline dolostone, sandy medium-crystalline dolostone, and finely to very finely crystalline dolomudstone with local planar lamination (unit 1) and bedding thicknesses of approximately 0.1 m (Fig. 24A). Units 9 – 15 (3.1 m – 6.8 m) consist of medium orange-buff, medium green-grey-weathering, recessive, poorly lithified mudstone, and dolomudstone with planar lamination and bedding thicknesses of approximately 0.1 m (Fig. 24B – D). The poorly exposed uppermost units 16 – 22 (6.8 m – 9.5 m) consist of medium orange-buff, medium green-grey, medium blue-grey, and medium grey-weathering, recessive, and poorly lithified medium crystalline dolostone and dolomudstone with bedding thicknesses of approximately 0.1 m (Fig. 24E - F). This uppermost mudstone unit correlates with the mudstone at the top of the lower segment of Saline River Formation (section 3A; Fig. 11A), but in the second section its upper contact with the Franklin Mountain Formation is intact and well exposed (Fig. 6A). The contact between the Saline River Formation and Franklin Mountain Formation is gradational through interbedding over several decimetres.

DISCUSSION

The Cambrian stratigraphic units described in this report have been documented in numerous areas in NWT in both surface and subsurface, and isopach maps have been compiled (Hamblin, 1990; Pugh, 1993; Dixon 1997; Dixon and Stasiuk, 1998). Although some previous work attempted to identify and explain correlatable subunits (e.g. Pugh, 1983), in other cases the stratigraphic descriptions are generalised and unaccompanied by interpretation. Thus, the distribution and thickness patterns of the Mount Clark, Mount Cap, and Saline River formations are reasonably well known, but their regional stratigraphic patterns (variations in depositional sequences) and their stratigraphic evolution are less clear.

The Hornaday River exposures are near the northeastern limit of the basin's exposure area, as shown by regional isopach maps (Hamblin, 1990; Pugh, 1993; Dixon 1997; Dixon and Stasiuk, 1998), and consequently could be expected to exhibit thinner formations and more near-shore facies than are present in the thicker succession to the southwest, in the central and western parts of the basin. The Mount Clark Formation is dominated by sandstone with abundant cross-bedding, and by units of burrowed sandstone (*Skolithos* ichnofacies). Based on these characteristics, the formation represents comparatively high-energy nearshore paleoenvironments preserved during early Cambrian transgression, a common paleoenvironment described from basal Paleozoic sandstones in northern Canada (Hamblin, 1990; Dixon and Stasiuk, 1998; MacNaughton et al., 2013; Durbano et al., 2015). Strikingly similar strata of the Quyuk Formation, 350 km to the northeast on Victoria Island, have been interpreted as a nearshore to offshore tidally influenced succession (Durbano et al., 2015). As documented by previous authors (Dixon and Stasiuk, 1998; MacLean, 2011), the Mount Clark Formation's thickness varies geographically because of the paleotopography of the underlying unconformity surface; this phenomenon was noted at the outcrop-scale in section 1 of this study,

where the thickness of the basal cross-stratified unit varied by several metres along the outcrop due to relief on the unconformable contact with the Neoproterozoic Boot Inlet Formation.

In the Hornaday River sections, the basal contact of the Mount Cap Formation is knife-sharp and separates strata of markedly different lithofacies: cross-bedded quartz arenite of the Mount Clark Formation and bioturbated dolostone of the basal Mount Cap Formation. The contrast across the contact, together with the complete absence of lithofacies that are shared between the two formations, argues for a disconformable contact (Pugh, 1983, 1993; MacLean, 2011), but biostratigraphic data from previous studies (Williams, 1922) have not identified a significant hiatus to date and, in other parts of the basin, the contact is regarded as conformable (MacNaughton et al., 2013).

The Mount Cap Formation at Hornaday River consists of two contrasting rock types that alternate across knife-sharp contacts: massive, burrow-mottled or cross-bedded dolostone, and glauconitic, centimetrically layered, cross-laminated sandstone with profuse horizontal traces (*Cruziana* ichnofacies). A carbonate factory developed three times, when terrigenous sediment delivery was low, in an environment that was clement enough to harbour burrowing organisms. Hardgrounds near the top of at least one of the three carbonate intervals suggests that the carbonate system gradually experienced sediment-starvation that was eventually followed by abrupt renewal of terrigenous sand delivery. The abundance of glauconite suggests slow sediment accumulation and anoxic conditions just below the sediment-water interface. The cause of these abrupt alternations between carbonate-dominated and terrigenous-dominated sedimentation is not clear, but there appears to be a regionally consistent stratigraphy throughout the basin away from the Mackenzie arch (three dolostones separated by terrigenous intervals; Pugh, 1993), suggesting a possible eustatic influence or basin-scale tectonic events.

Although the Mount Cap Formation seems to have some geographically persistent lithological characteristics, it exhibits a pronounced thickness increase from northeast (Hornaday) to southwest (Mackenzie Mountains eastern ranges), across the centre of the Cambrian epicratonic basin and approaching the Mackenzie arch on the southwestern side of the basin. In this southwestern area, the formation contains dark shale, sandstone, and limestone (Aitken et al., 1973) that do not closely resemble the strata described in this report, suggesting a deeper-water and perhaps oxygen-challenged, linear depocentre on the flank of the Mackenzie arch (cf. MacNaughton et al., 2013). The Mount Cap Formation in the eastern Mackenzie Mountains was most recently interpreted as gradationally overlying, and partly laterally equivalent to, the Mount Clark Formation, as a consequence of arch-parallel facies belts that deepened eastward into a local depocentre flanking the Mackenzie arch (MacNaughton et al., 2013), and records an overall paleoenvironment and a sedimentary system that differ substantially from those recorded in contemporaneous strata at Hornaday River.

At the basal contact of the Saline River Formation in the Hornaday River section, desiccation-cracked, unburrowed, sandy, argillaceous dolostone abruptly overlies burrowed dolostone of the Mount Cap Formation; the abrupt change in lithofacies suggests an unconformable contact, as noted elsewhere in the basin (Aitken et al., 1973; Pugh 1983, 1993; Hamblin, 1990; Dixon and Stasiuk, 1998; Pyle et al., 2006; MacLean, 2011;). In contrast, the upper contact exhibits an abrupt but conformable transition, by interlayering, from mudstone/siltstone of the uppermost Saline River Formation to terrigenous-poor dolostone of the Franklin Mountain Formation. The greenish terrigenous mudstone typical of the Saline River Formation remains a conspicuous, though carbonate-diluted, component of the lower Franklin Mountain Formation.

The Saline River Formation at Hornaday River contains ample evidence of subaerially exposed, desiccated paleoenvironments, but, unlike other documented sections to the southwest, contains no

conspicuous sulphate evaporites. Evidence of shallow to marginal-marine deposition under restricted conditions is also preserved in the Nainlin Formation, a red-weathering siliciclastic unit that is understood to be a shallow-water equivalent of the Saline River Formation near and on the Mackenzie Arch (MacNaughton and Fallas, 2014). Halite casts, however, are locally abundant in the section, suggesting an environment so distant from the connection to ocean water and from the basin centre that gypsum had already been extracted by the time the brine reached this site. It is perplexing, then, that dolostone and halite moulds co-occur in the section without intervening gypsite, as would be expected if dolostone units represent cyclic 'freshening' by eustatically introduced influxes of marine water.

The location(s) of connection(s) to the open ocean during accumulation of the Saline River Formation is unclear based on isopachs (Hamblin, 1990; Pugh, 1993; Dixon 1997; Dixon and Stasiuk 1998; MacLean, 2011), and the regional stratigraphy of the formation too poorly constrained to provide any hints, but the configuration of arches (Fig. 1) and location of the basin's cratonic edge near the study location preclude any nearby connection. The Hornaday River location was near the edge of a deep (probably subtidal) evaporite basin that, in its centre, progressed to halite saturation during deposition of the Saline River Formation (Fig. 25).

SUMMARY

The Mount Clark, Mount Cap, and Saline River formations were documented at decimetric scale in four overlapping sections in the Hornaday River canyon (Brock Inlier, NWT), near the northeastern exposure limit of their epicratonic basin, yielding a complete stratigraphy for each of the formations (Fig 7). In general, the descriptions resemble those in reconnaissance-level reports of previous authors (Williams, 1922, 1923; Norris, 1965; Balkwill and Yorath, 1970; Cook and Aitken, 1970; Aitken et

al., 1973; Hamblin, 1990; Dixon, 1997; Dixon and Stasiuk, 1998; Pyle et al., 2006; Pyle and Gal, 2007, 2011, 2014), but the present study contains a greater level of detail regarding sediment texture, paleobiological content, and stratigraphic packaging. The basal contact with the Neoproterozoic Boot Inlet Formation is unconformable, the contacts among the three formations are very sharp, and the characteristics of each formation are not generally carried into the basal units of the overlying formation, suggesting that the formational contacts may be disconformable. Regionally, the Cambrian successions are thinner near the craton and closest to the Mackenzie Arch, in comparison to the depocentre, which could allow for contacts between formations to be conformable in the depocentre but disconformable or unconformable inland and near the arch. In contrast, the contact of the Saline River Formation with the Franklin Mountain Formation is gradational. The Mount Clark Formation (70 m thick) consists predominantly of cross-stratified and burrowed sandstone, with moderate lateral variability in thickness, stratigraphic content, and sedimentary texture between the sections documented in this study; it was probably deposited in a high-energy, nearshore environment under humid climate conditions. The Mount Cap Formation (32 m thick) consists of alternating intervals of variably bioturbated dolostone and glauconitic sandstone with profuse horizontal traces, and represents a low-energy lagoonal environment. The Saline River Formation (40 m thick) consists of mudstone, dolomudstone, and fine- to medium-grained sandstone with local desiccation cracks and halite moulds, and was deposited in a restricted, intermittently subaerially exposed environment under arid climate conditions.

ACKNOWLEDGEMENTS

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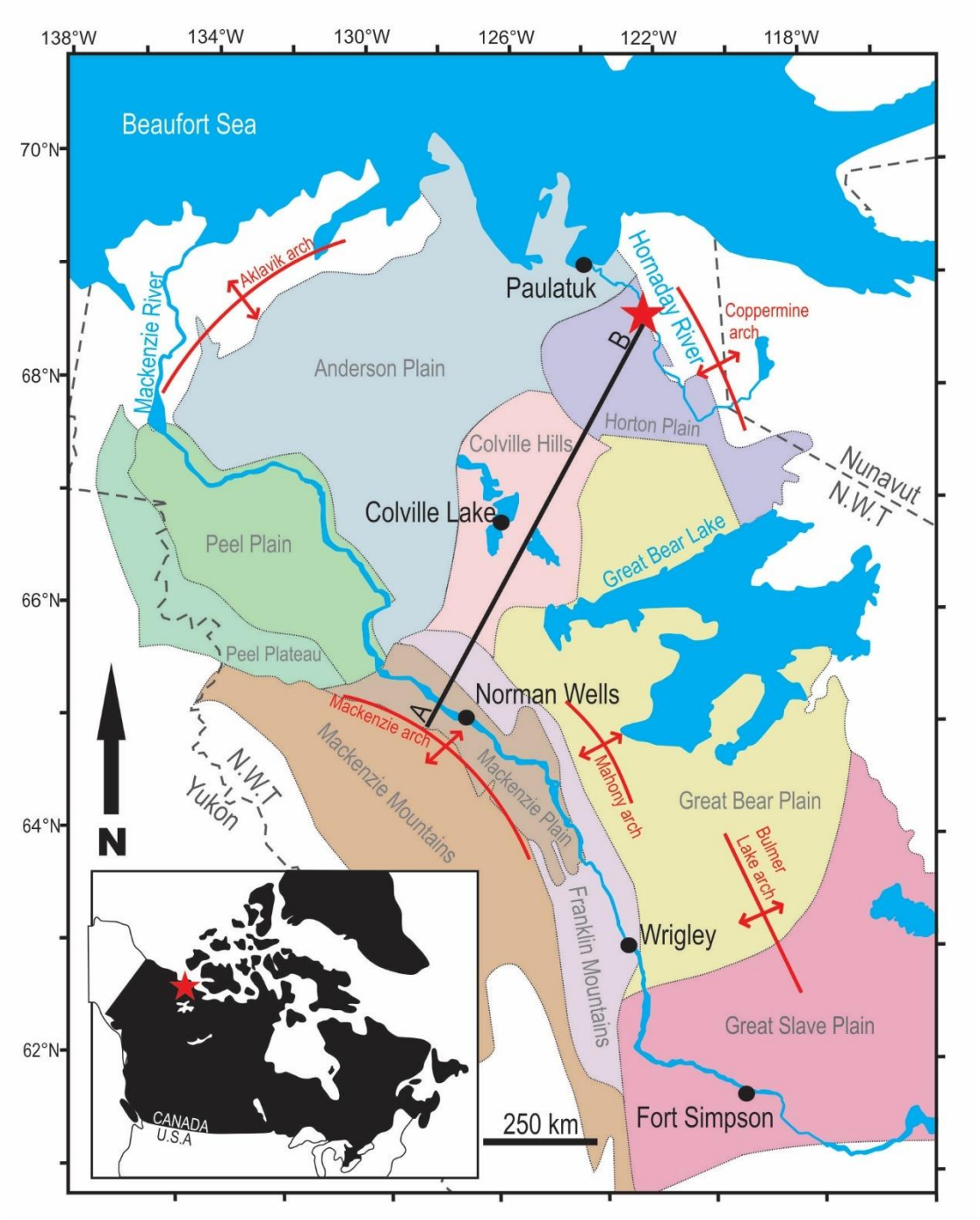

Figure 1. Location of the study area (red stars) in the mainland of Northwest Territories, Canada and geological areas (modified from Mossop, 2004). Location of Cambrian arches after Hamblin (1990) and Dixon & Stasiuk (1998). Cross-section A – B through the centre of the epicratonic basin is depicted in Fig. 25.

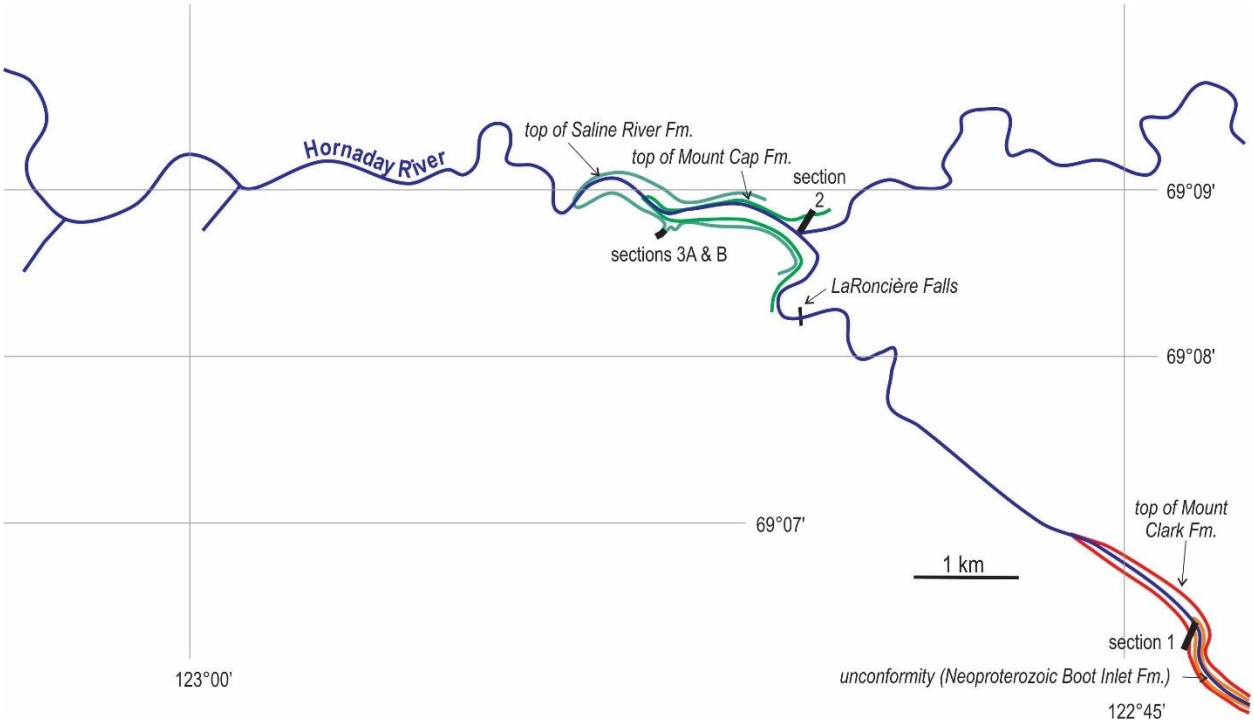

Figure 2. Locations of the measured sections of Mount Clark, Mount Cap and Saline River formations, in Hornaday River canyon.

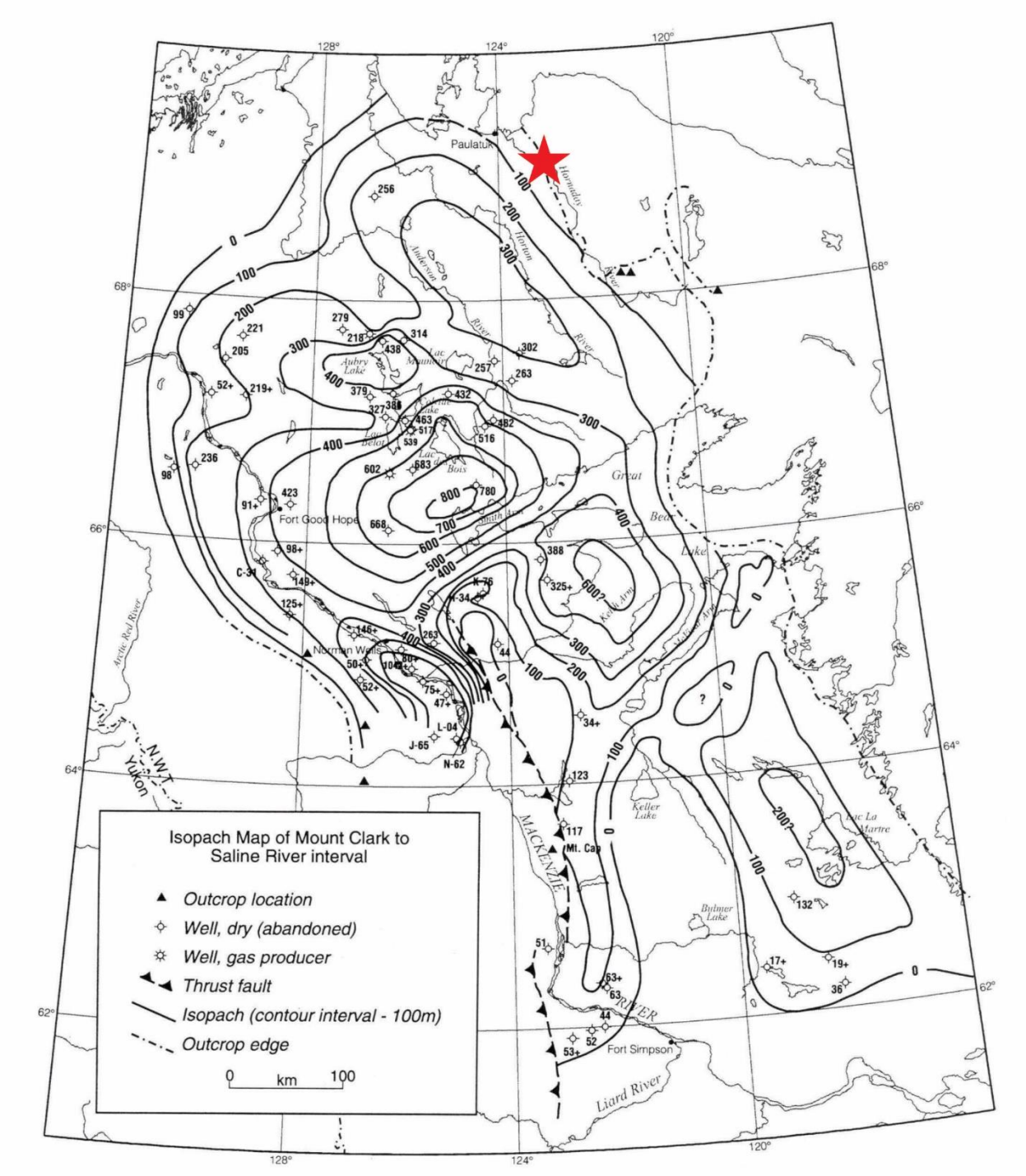

Figure 3. Isopach map for Mount Clark, Mount Cap, and Saline River formations (from Dixon & Stasiuk, 1998). Figure republished here with the permission of the Canadian Society of Petroleum Geologists. Location of this study's measured sections shown by red star. Note the isopach map is slightly inaccurate in the vicinity of the study area because collectively, the three formations are approximately 144 metres thick.

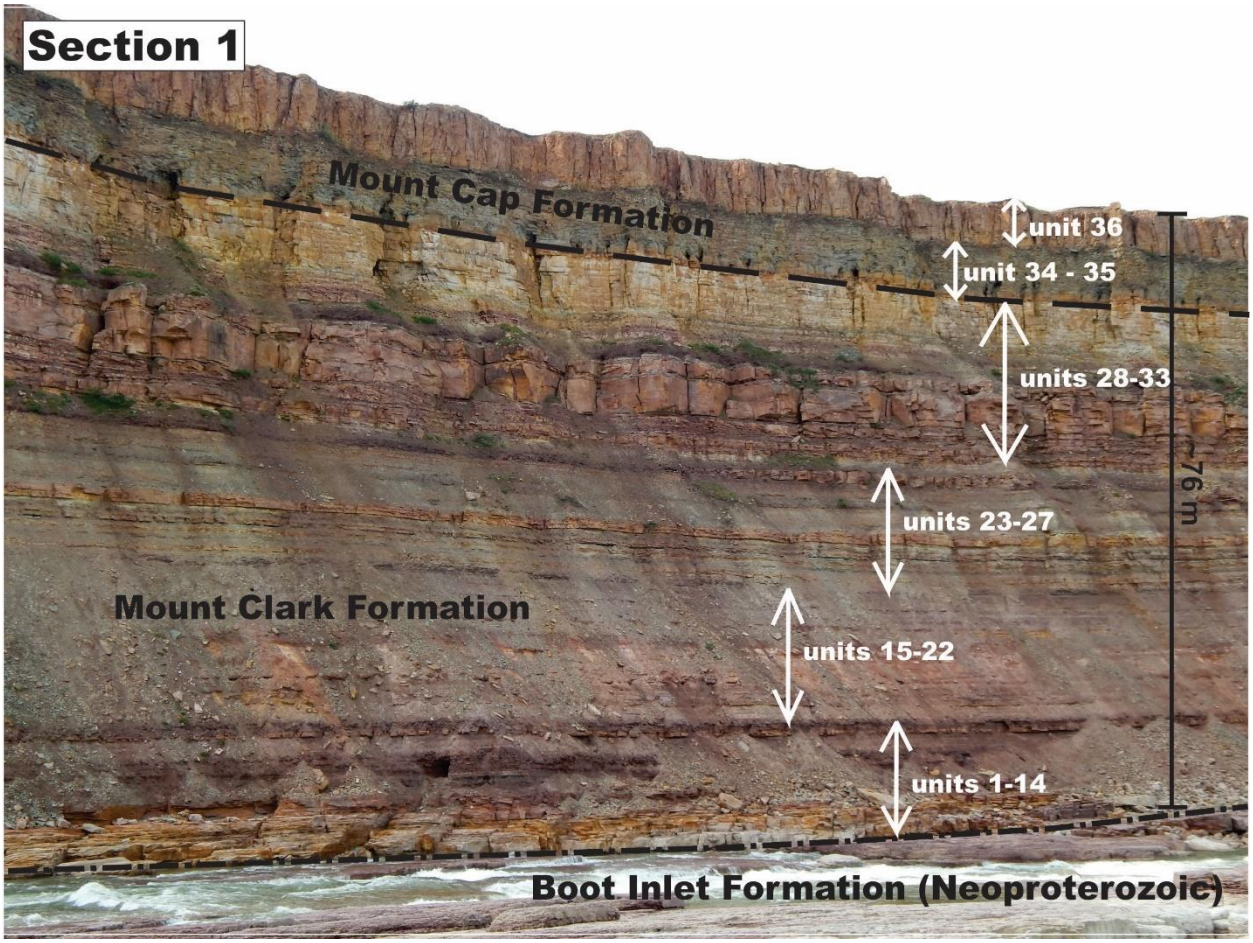

Figure 4. Section 1, the ‘unconformity’ section of Mount Clark and lower Mount Cap formations, total thickness (black line), documented units (white arrows) and contact (black dashed lines). The unconformable contact (black dashed and dotted line) of Mount Clark Formation and underlying Boot Inlet Formation (Neoproterozoic) has 1 - 2 metres of paleotopography at this location.

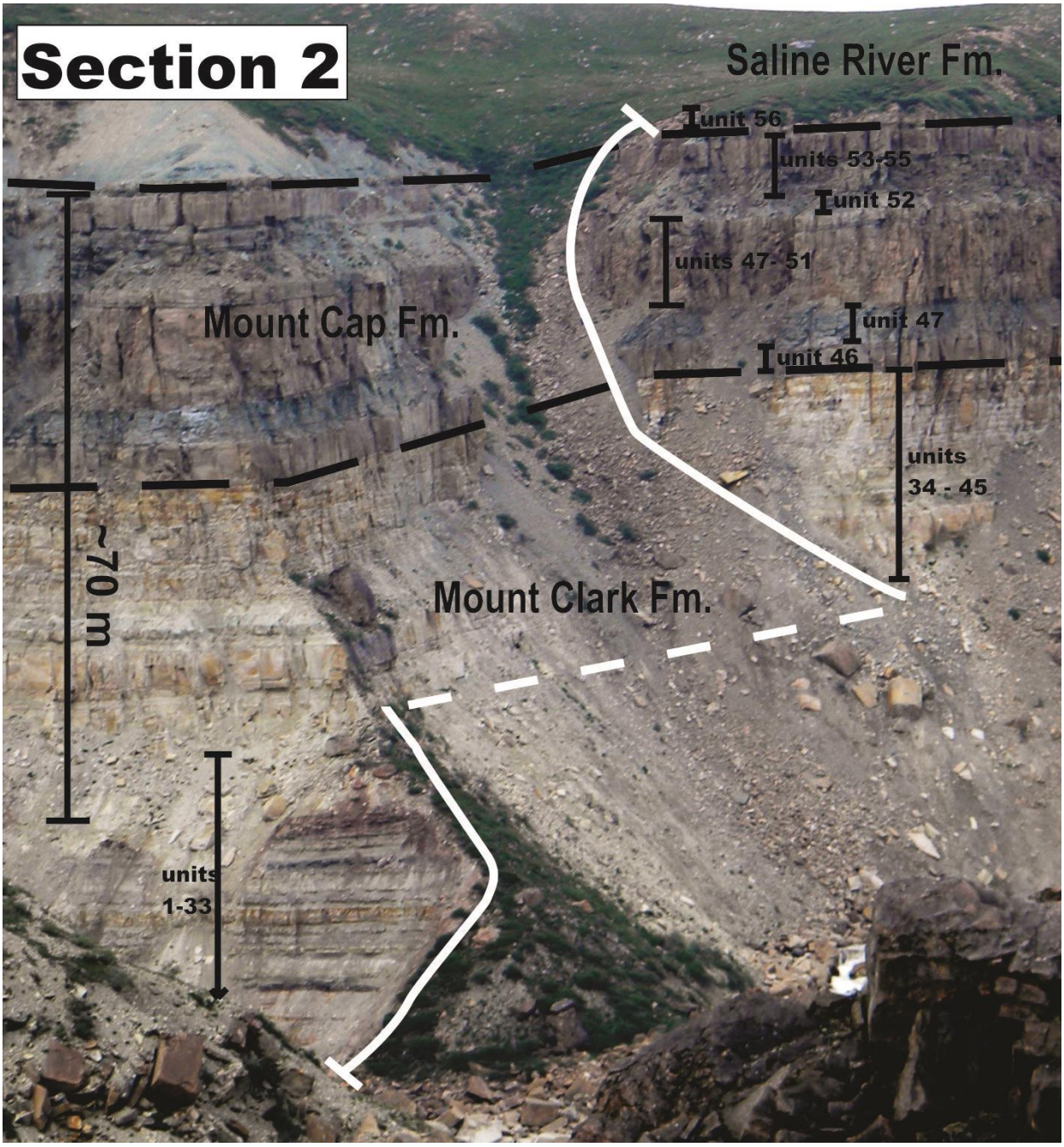

Figure 5. Section 2, the ‘La Roncière Falls’ section of Mount Clark (incomplete), Mount Cap (complete), and lowermost Saline River formations, showing the section measured (white line), documented units (thin black lines) and contacts (black dashed lines).

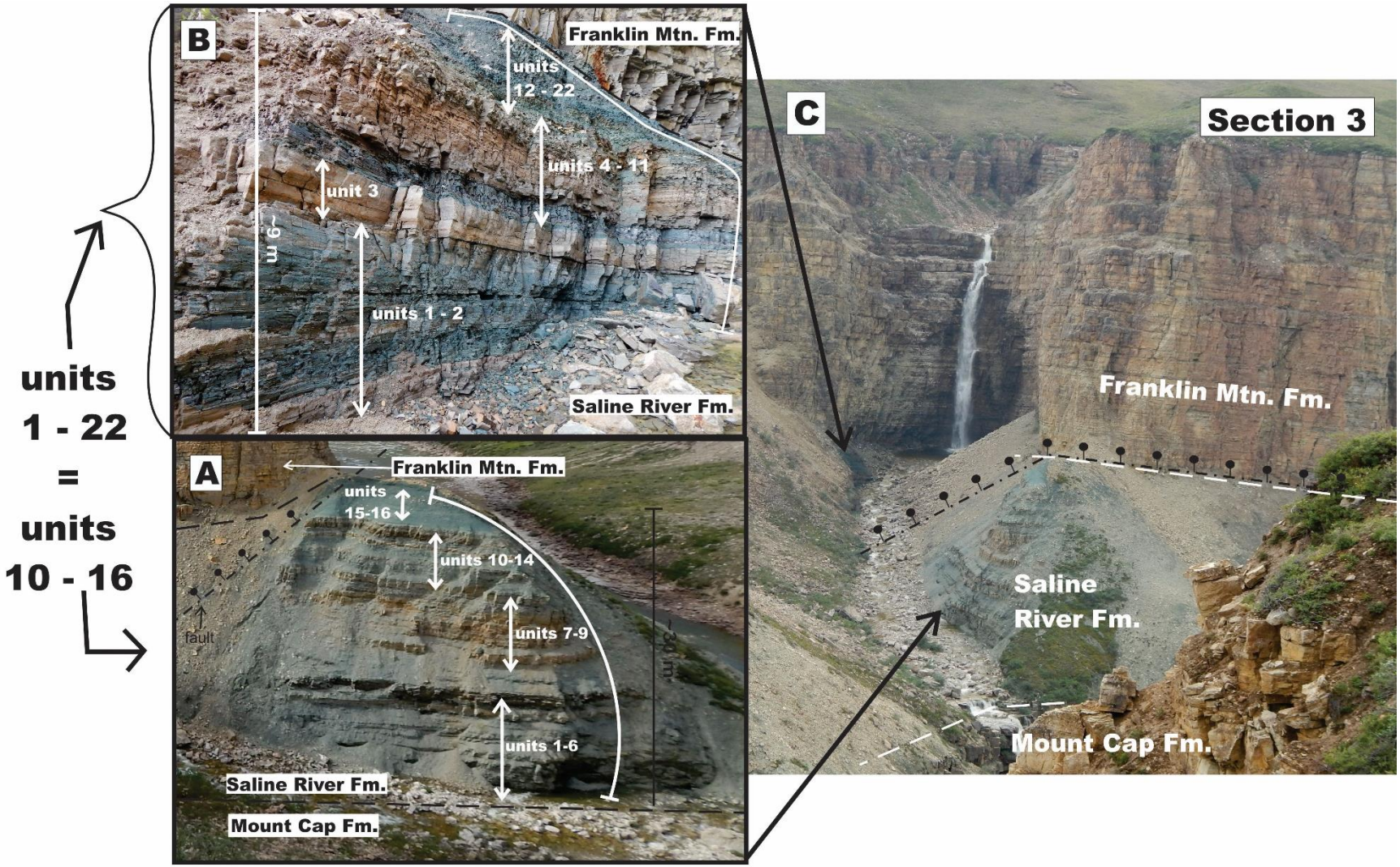

Figure 6. Section 3, the two 'waterfall' sections of Saline River Formation. (A) Section 3A, the lowermost units of Saline River Formation, showing the section line (white line), total thickness (black line), documented units (white arrows), fault (black dashed and dotted line) and contacts (black dashed line). (B) Section 3B, the uppermost units of Saline River Formation, showing the section line (white line), total thickness (black line), documented units (white arrows), and contacts (black dashed line). (C) The location of the two documented sections relative to each other and the waterfall, which flows into the Hornaday River, showing a minor fault (black dashed and dotted line) and contacts (white dashed line).

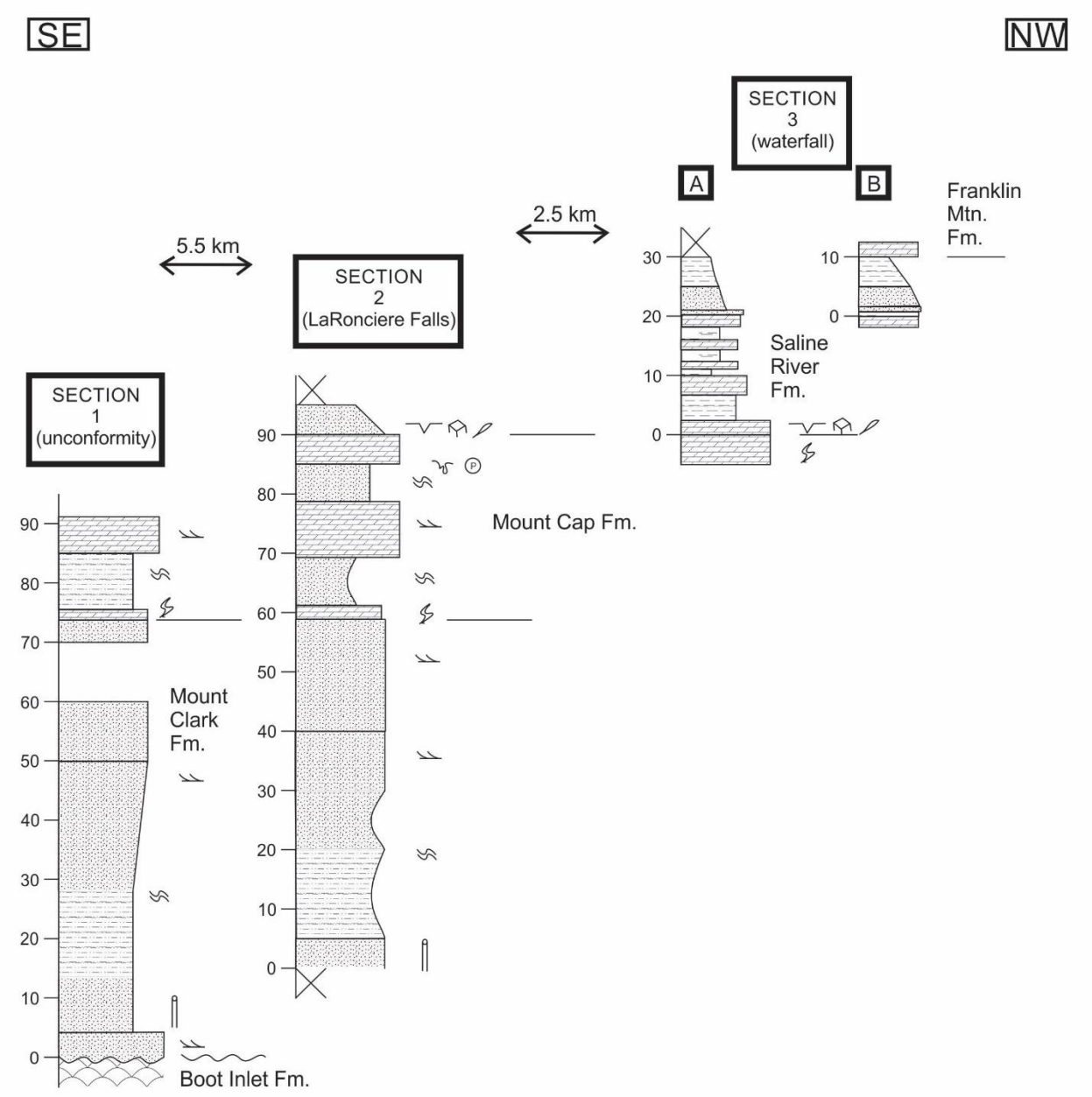

Figure 7. Simplified correlation of the four documented stratigraphic sections along the Hornaday River, NT (legend; Fig. 8). A simplified section of section 1, 'unconformity'; section 2, 'La Roncière Falls'; and sections 3A & B, 'waterfall'. Sections are 'hung' on formation contacts, or (for 3A and 3B) correlatable lithostratigraphic units.

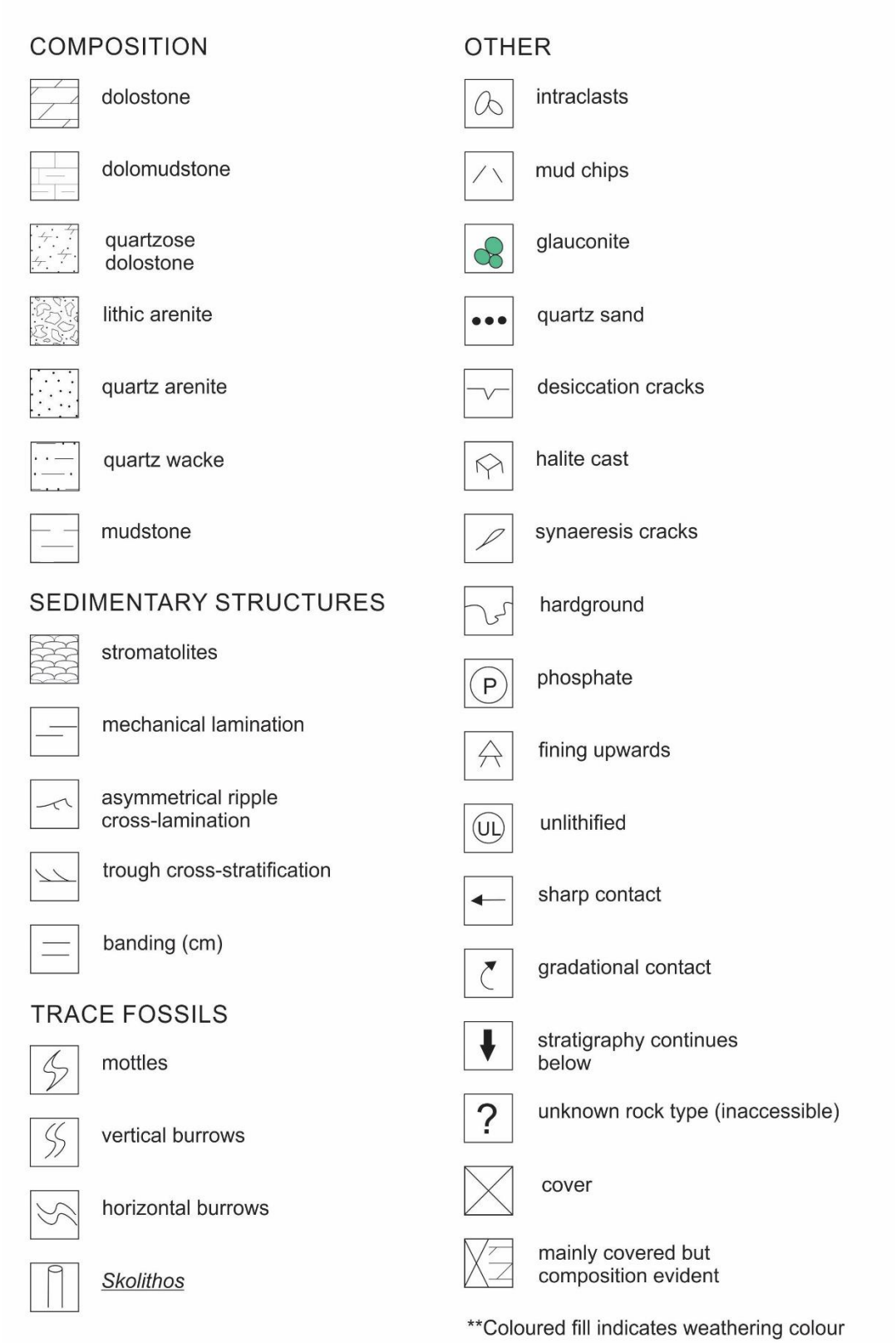

Figure 8. Legend for the simplified sections in Figure 7 and stratigraphic sections in Figures 9 - 11.

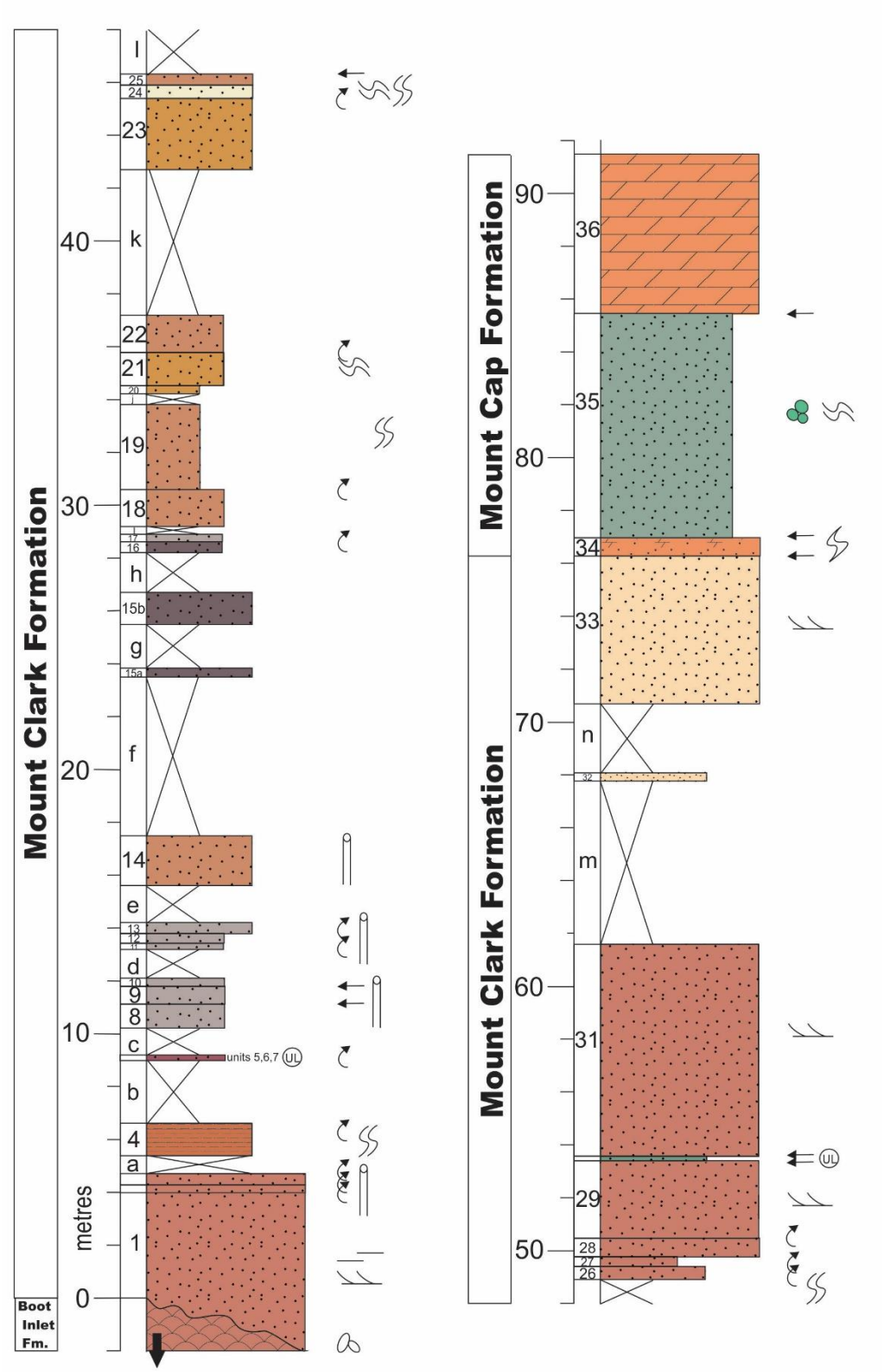

Figure 9. Stratigraphic section 1, ‘unconformity’ (section 1, Fig. 2), of the Mount Clark and Mount Cap formations measured above La Roncière Falls. The profile of the logs indicates the weathering profile and the coloured fill indicates weathering colour.

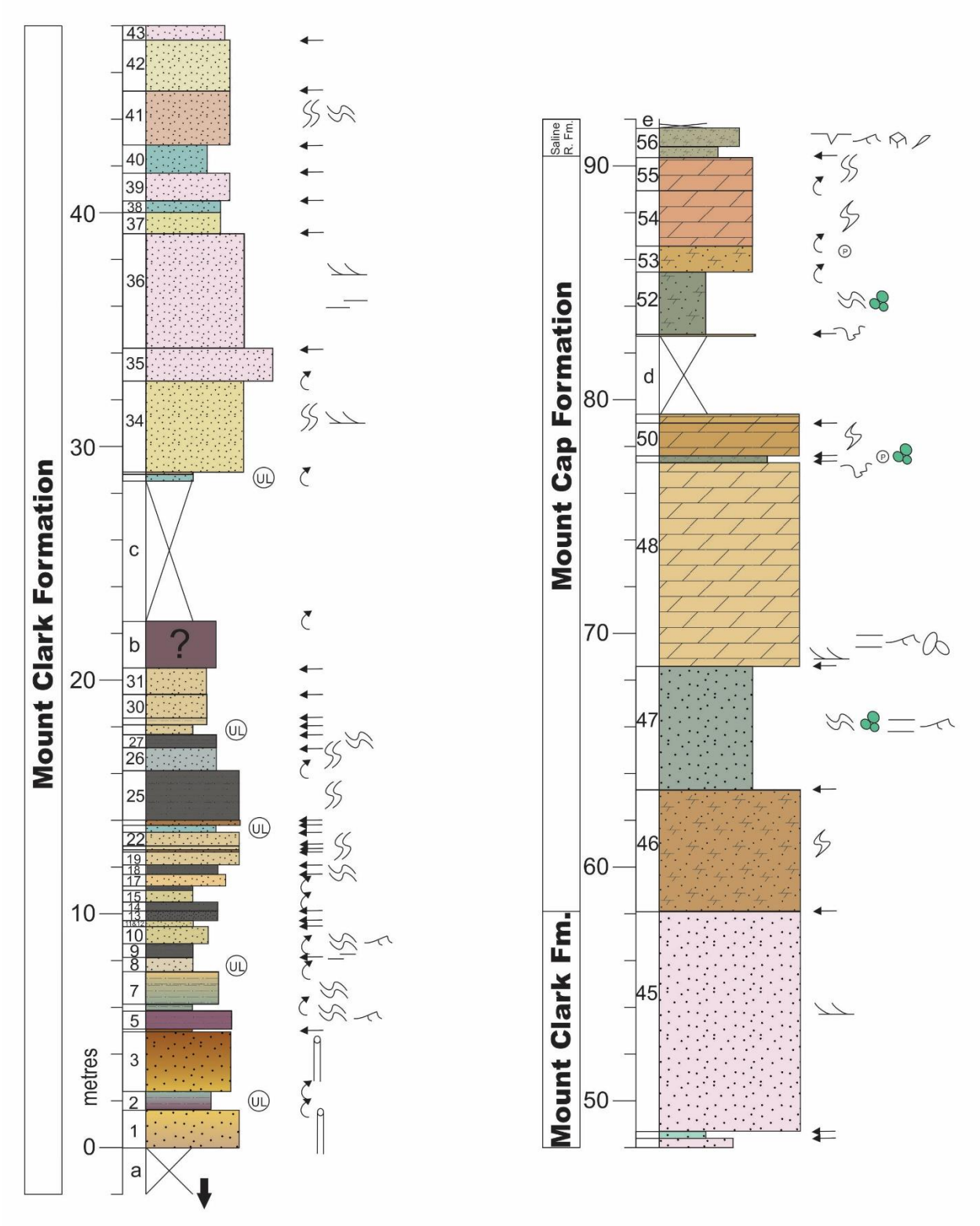

Figure 10. Stratigraphic section 2, ‘La Roncière Falls’ (section 2, Fig. 2), of the Mount Clark, Mount Cap and Saline River formations measured below La Roncière Falls. The profile of the logs indicates the weathering profile and the coloured fill indicates weathering colour.

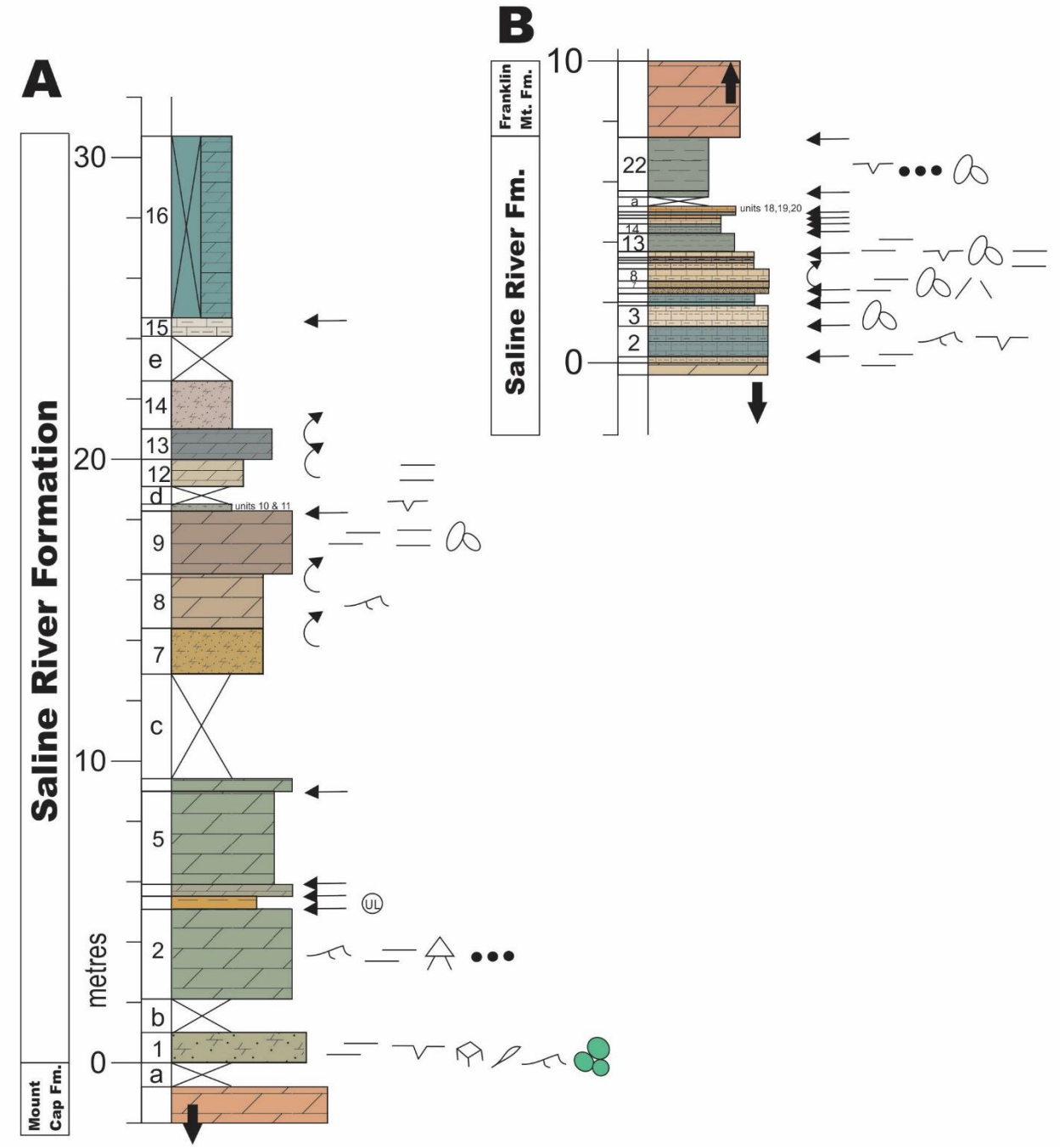

Figure 11. Stratigraphic section 3A & B, ‘waterfall’ (section 3, Fig. 2), of the Saline River Formation measured near a waterfall flowing into Hornaday River, NT. The profile of the logs indicates the weathering profile and the coloured fill indicates weathering colour.

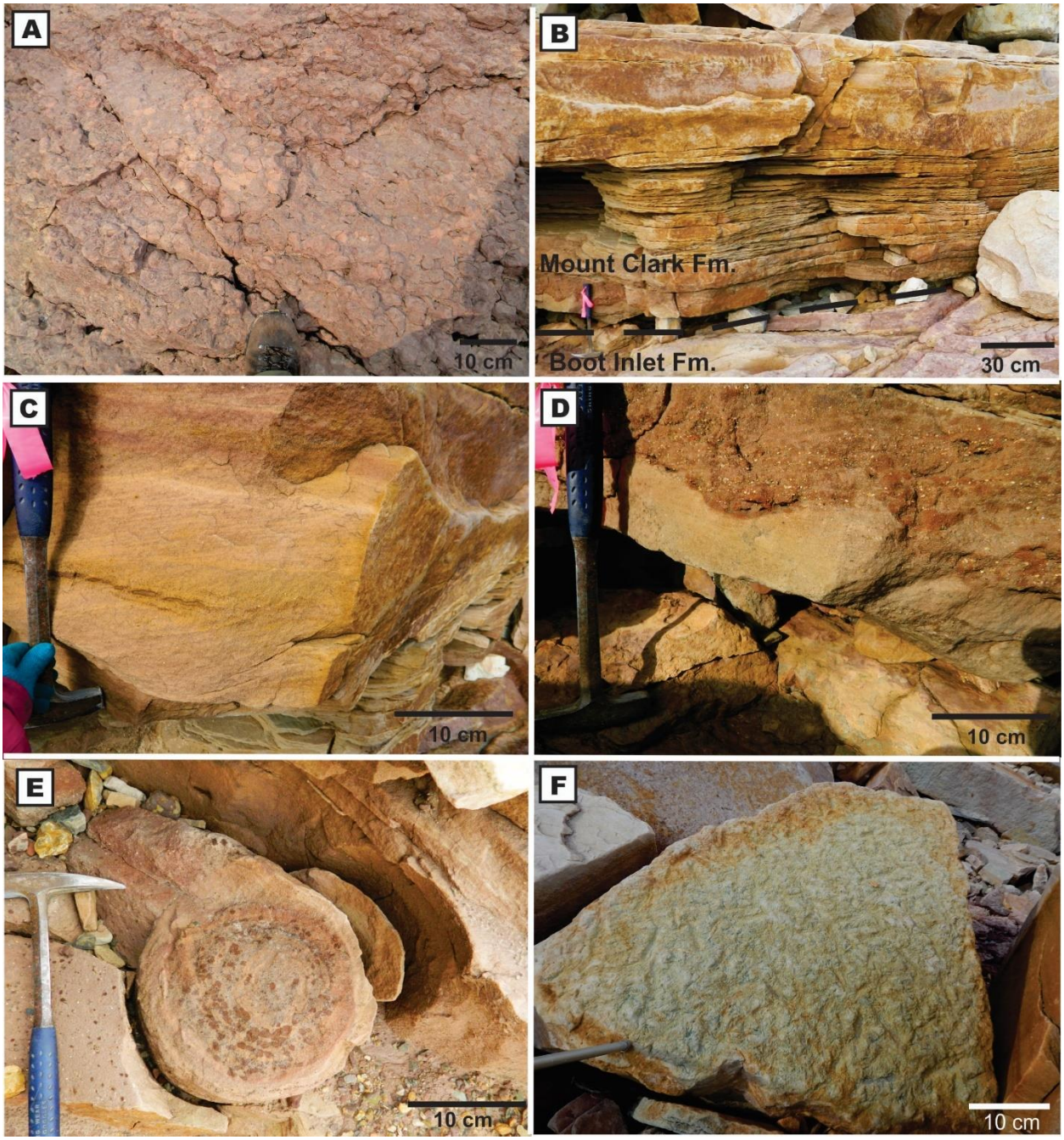

Figure 12. Mount Clark Formation in the 'unconformity' measured section (section 1, Fig. 9). (A) Bedding-plane view of upper biohermal unit of the Boot Inlet Formation showing conspicuous circular cross-sections of columnar stromatolites. (B) Basal quartz arenite of Mount Clark Formation unconformably overlying the Boot Inlet Formation. (C) Cross-stratification in unit 1. (D) Lag material from the unconformable surface, cross-stratified within basal quartz arenite. (E) Water-escape feature in the basal quartz arenite (cf. Mathieu et al., 2013). (F) Horizontal burrows in talus derived from middle part of Mount Clark Formation.

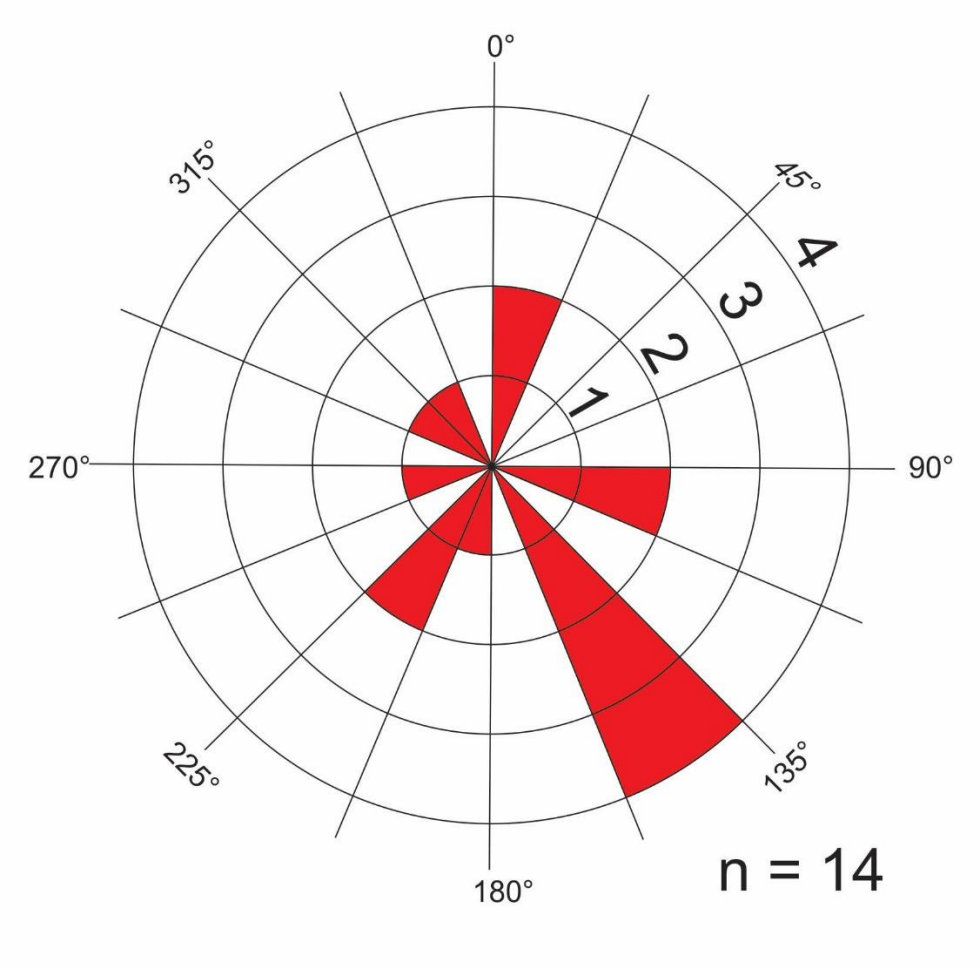

Figure 13. Rose diagram of paleocurrent measurements from the cross-stratified quartz arenite unit 1 of the Mount Clark Formation (Figs. 9 and 12) in the ‘unconformity’ measured section.

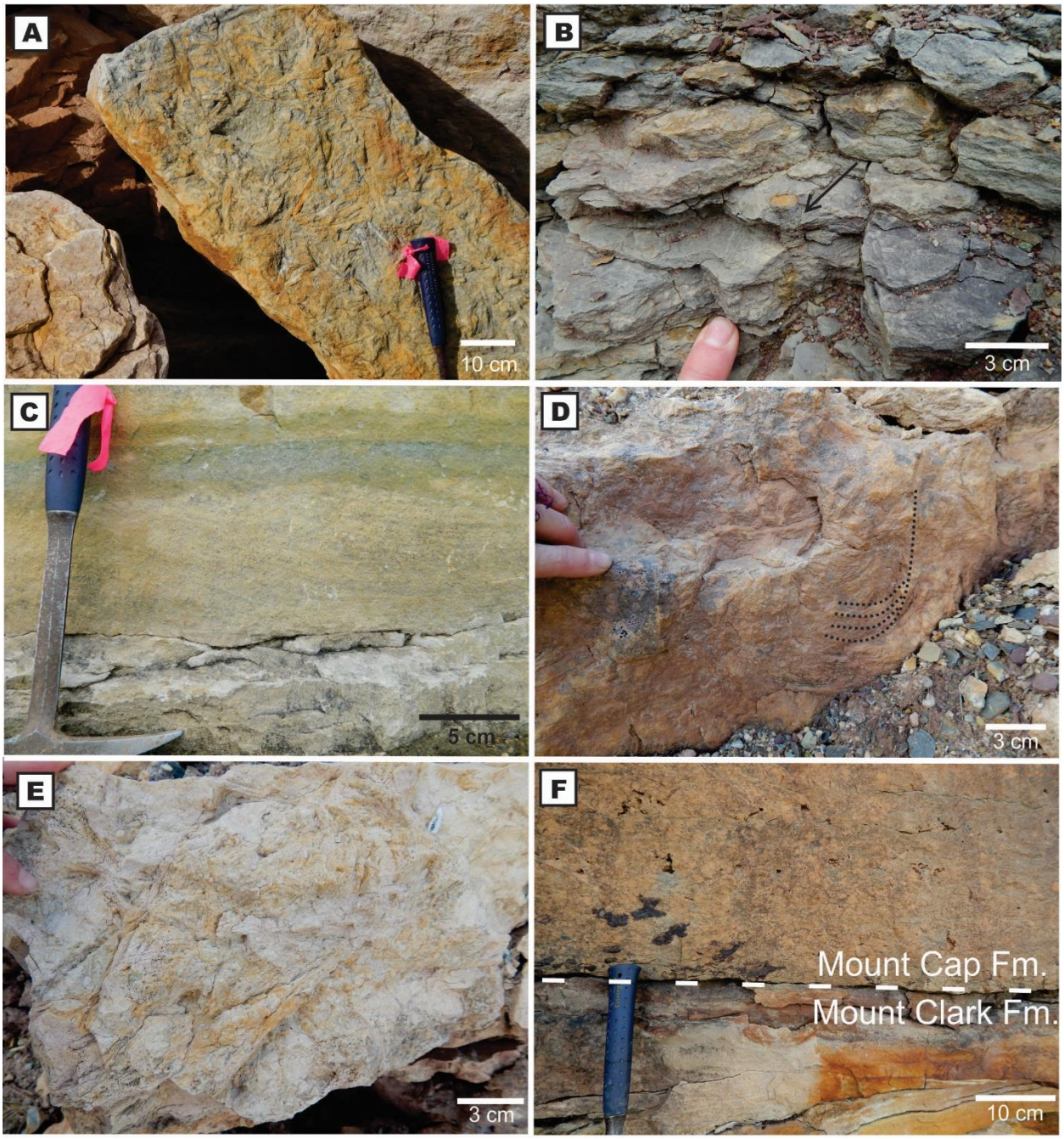

Figure 14. Mount Clark Formation in the 'unconformity' measured section (section 1, Fig. 9). (A) Horizontal burrows in talus derived from middle part of Mount Clark Formation. (B) Vertical burrow in quartz arenite of unit 19 (black arrow). (C) Cross-stratification in uppermost quartz arenite (unit 31). (D) U-shaped trace in unit 26. (E) Horizontal burrows in talus derived from middle part of Mount Clark Formation. (F) Abrupt contact between quartz arenite (unit 33) of the Mount Clark Formation and dolostone (unit 34) of the Mount Cap Formation.

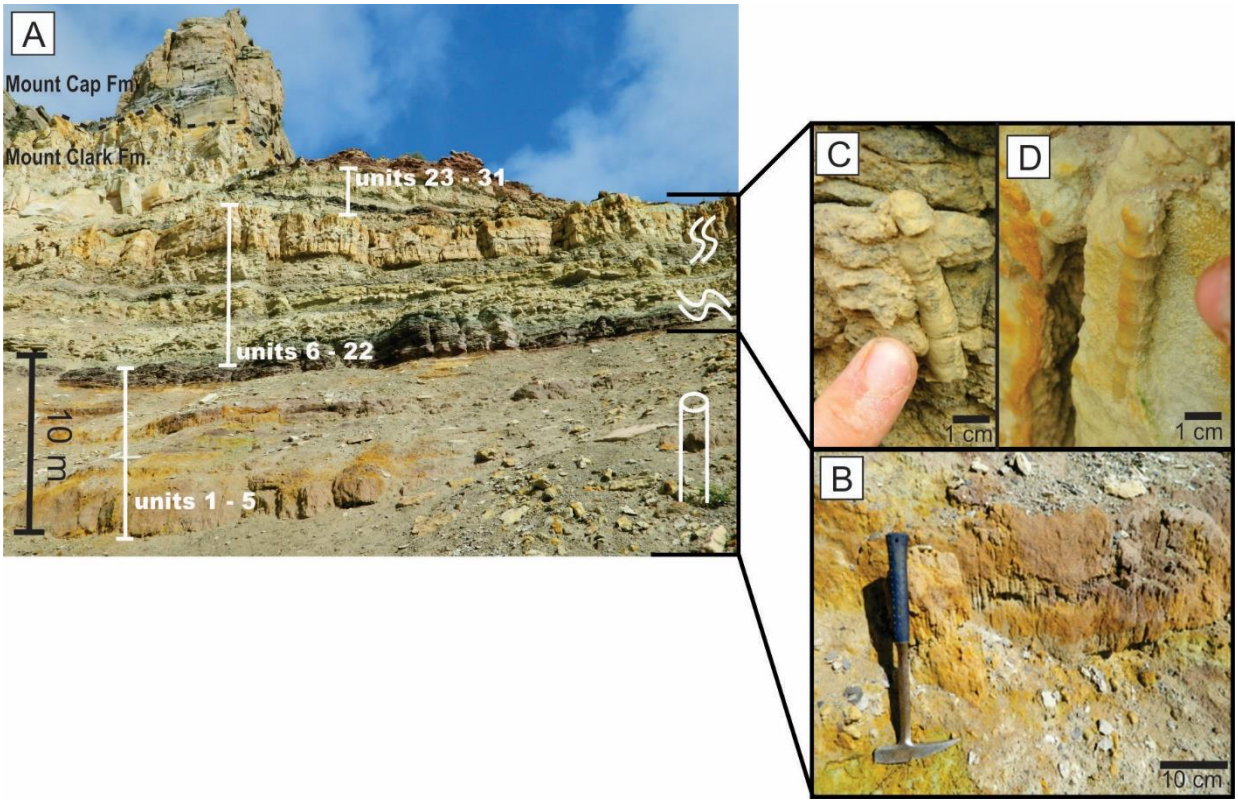

Figure 15. Mount Clark Formation in the 'La Roncière Falls' measured section (section 2, Fig. 10). (A) Lowermost units (white lines) of the stratigraphic section and contact (black dashed line). Symbols (Fig. 8; legend) show the dominant burrow types in three parts of the section. (B) Poorly lithified quartz arenite with *Skolithos* traces. (C&D) Vertical burrows in quartz arenite.

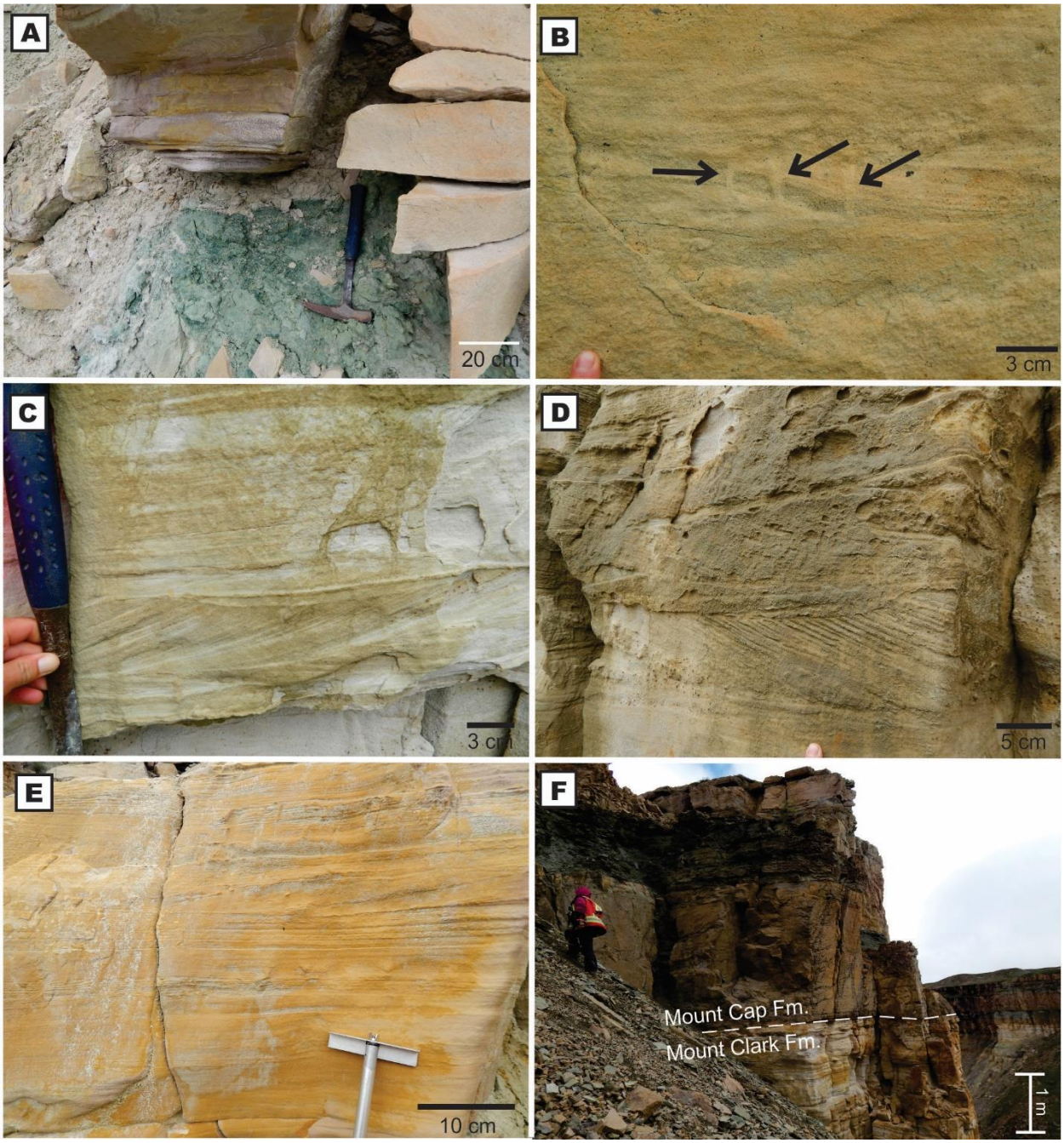

Figure 16. Mount Clark Formation in the 'La Roncière Falls' measured section (section 2, Fig. 10). (A) Recessive, unlithified quartz arenite of units 32 & 33, below a resistant, cross-stratified quartz arenite unit 34. (B) Sparse vertical burrows (arrows) in quartz arenite unit 34. (C&D) Trough cross-stratification in the lower part of quartz arenite unit 36. E) Planar lamination in upper part of quartz arenite unit 36. F) Upper abrupt contact between Mount Clark (sandstone) and Mount Cap (dolostone) formations.

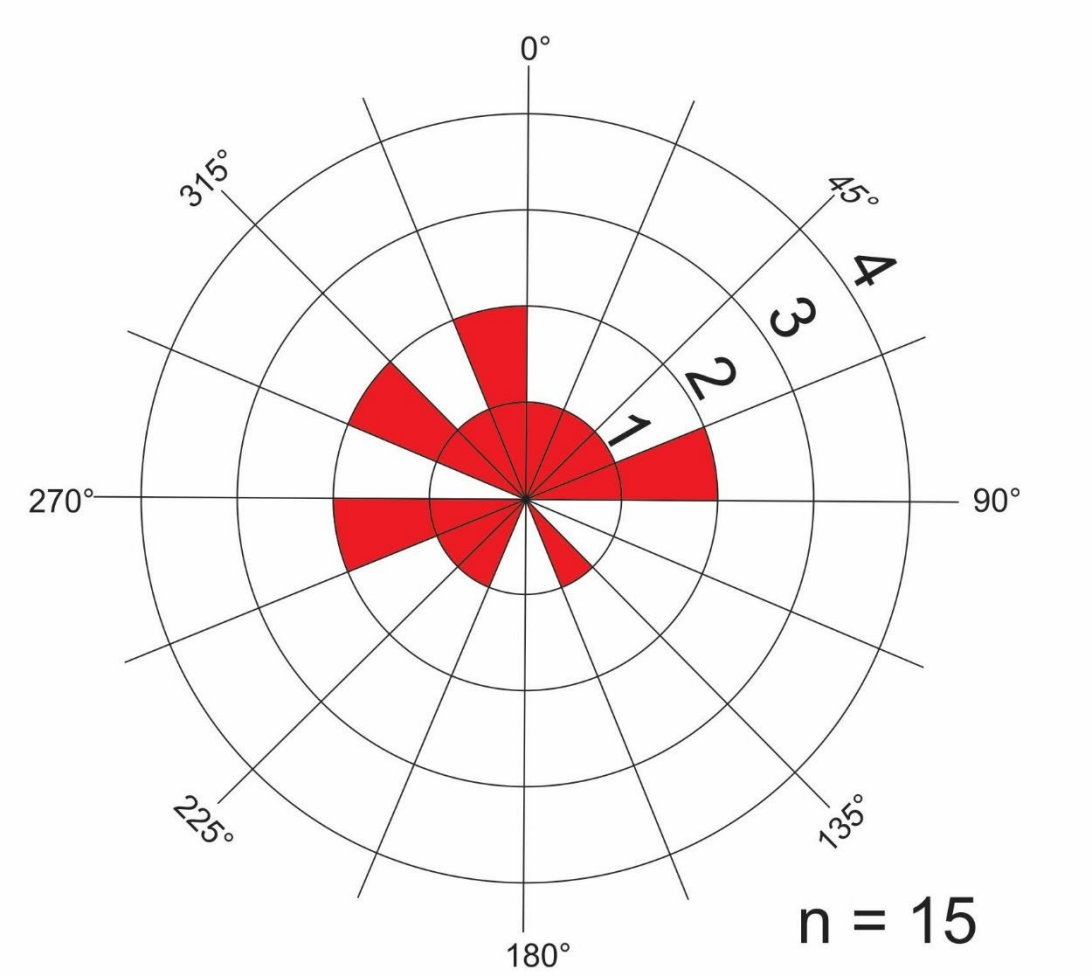

Figure 17. Rose diagram of paleocurrent measurements from the cross-stratified quartz arenite unit 45 of the upper Mount Clark Formation (Figs. 10 and 16) in the ‘La Roncière Falls’ measured section.

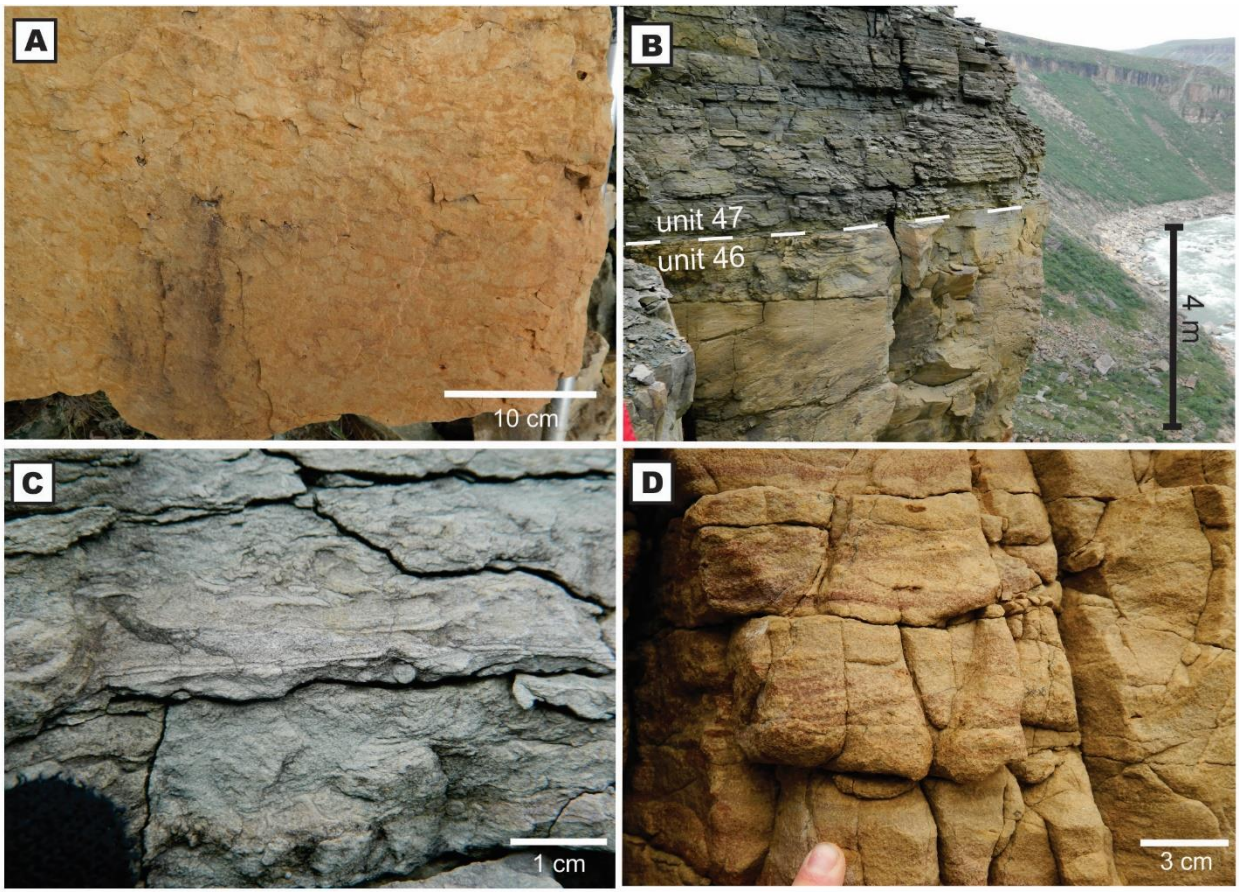

Figure 18. Mount Cap Formation at the ‘La Roncière Falls’ measured section (section 2, Fig. 10). (A) Basal mottled dolostone (unit 46). (B) Contact between units 46&47 showing a sharp transition from a dolostone (unit 46) to a bioturbated glauconitic quartz arenite (unit 47). (C) Bioturbated glauconitic quartz arenite unit 47. (D) Trough cross-stratification in dolostone unit 48.

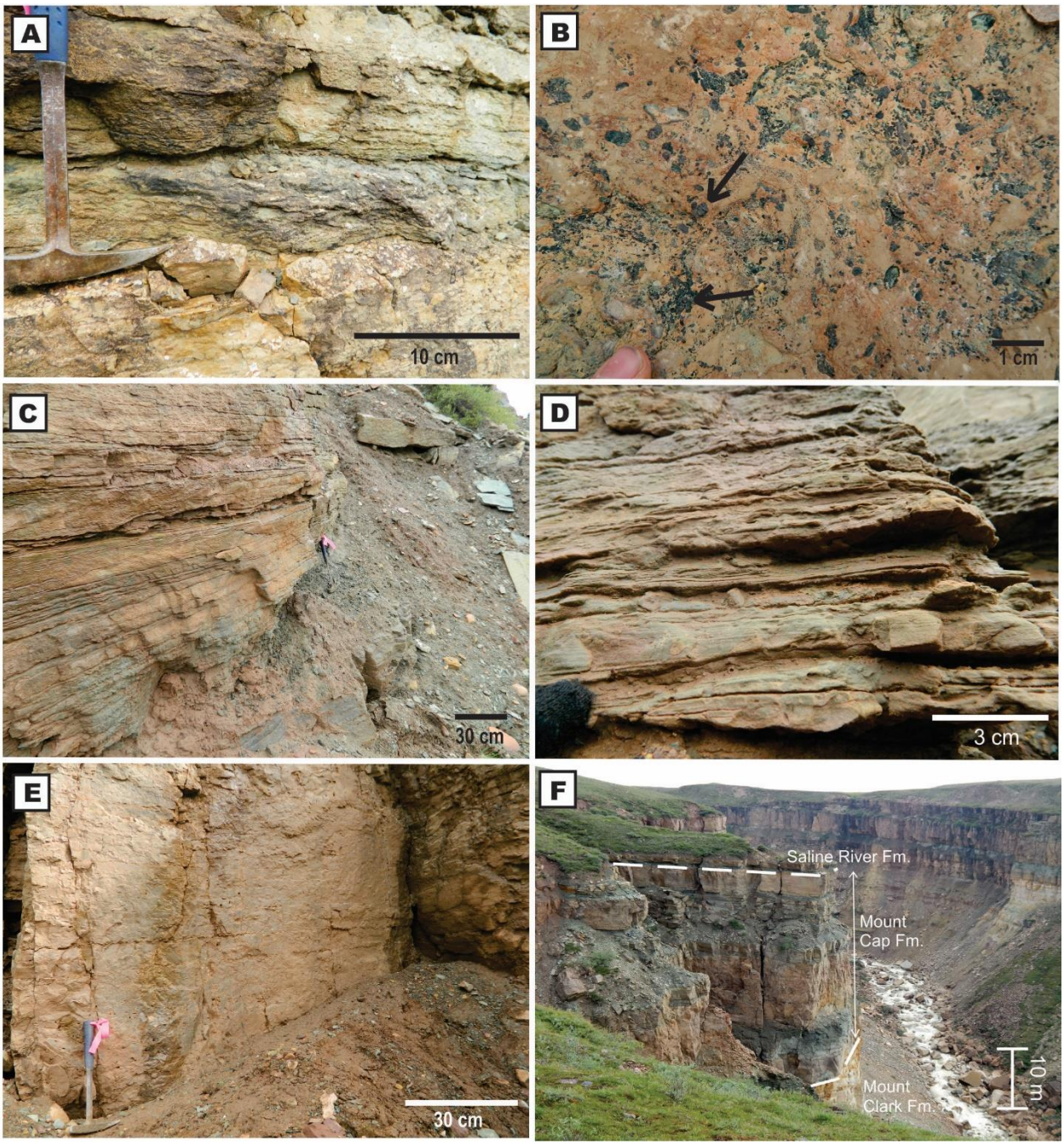

Figure 19. Mount Cap Formation at 'La Roncière Falls' measured section (section 2, Fig. 10). (A) The hammer head is at the contact between unit 48 and unit 49, showing the sharp contact between a dolostone (unit 48) and glauconitic quartzose dolostone (unit 49). (B) Phosphatic clasts (arrows) at the top of unit 48 (bedding plane). (C&D) Parallel recessive bedding in dolostone of unit 52. (E) Resistantly weathering dolostone of unit 53. (F) Sharp contact between Mount Cap (resistant bioturbated dolostone) and Saline River (recessive, green quartzose dolostone) formations.

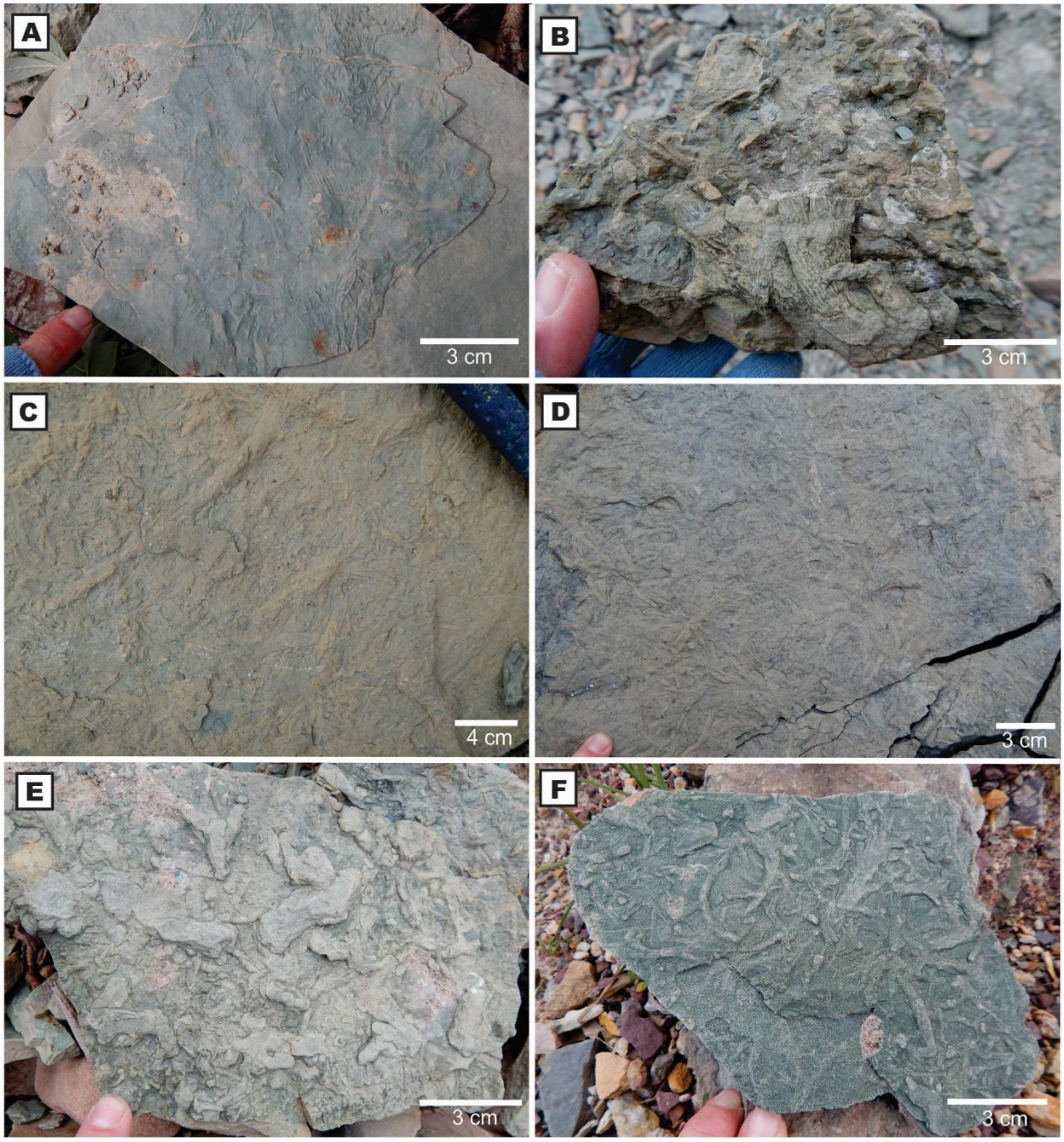

Figure 20. (A-F) Representative trace fossils in Mount Cap Formation talus at the ‘La Roncière Falls’ measured section (section 2, Fig. 10).

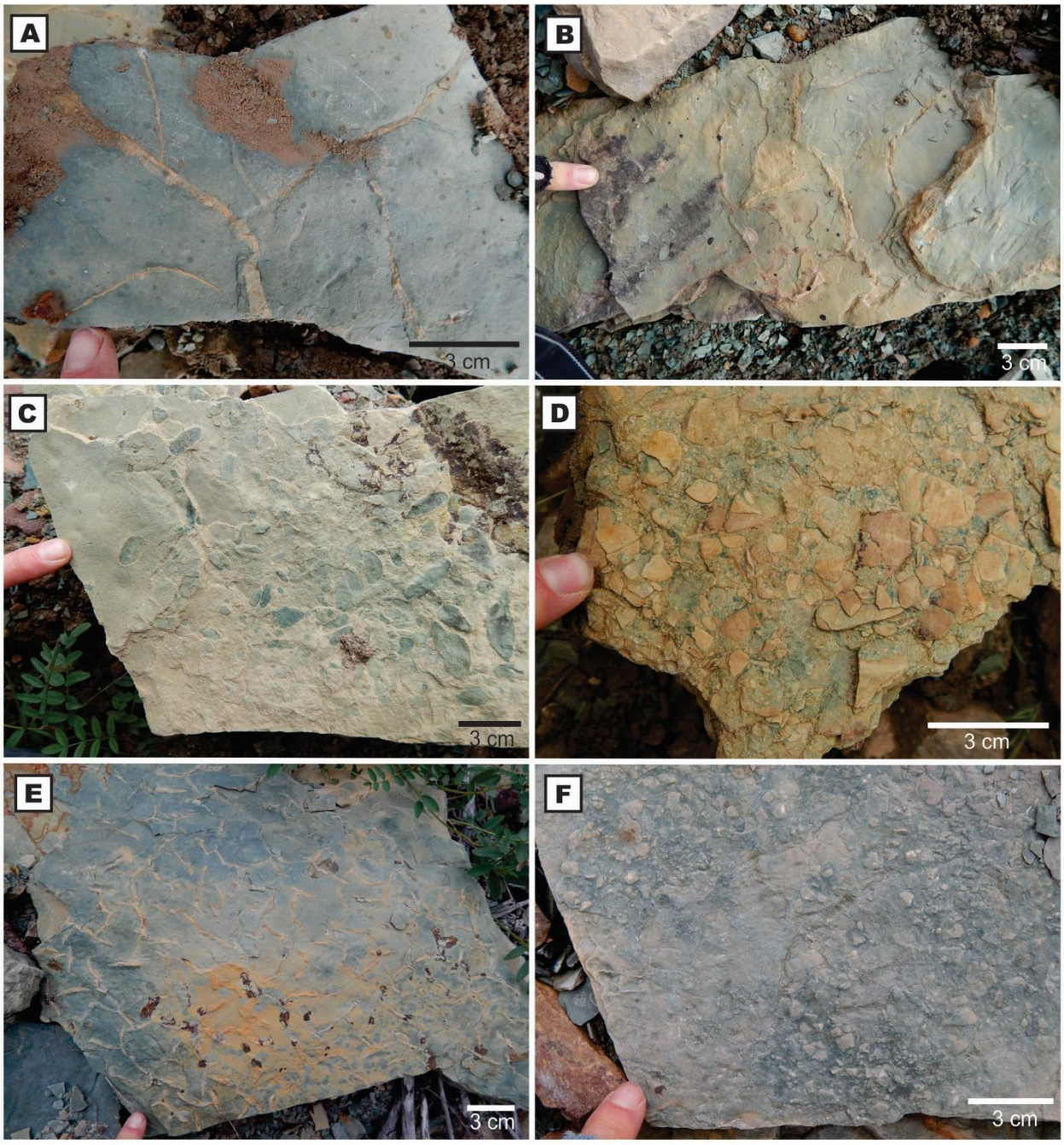

Figure 21. Features in talus below the Saline River Formation at the ‘La Roncière Falls’ measured section (section 2, Fig. 10). (A&B) Desiccation cracks. (C&D) Intraclasts. (E) Synaeresis cracks. F) Halite casts.

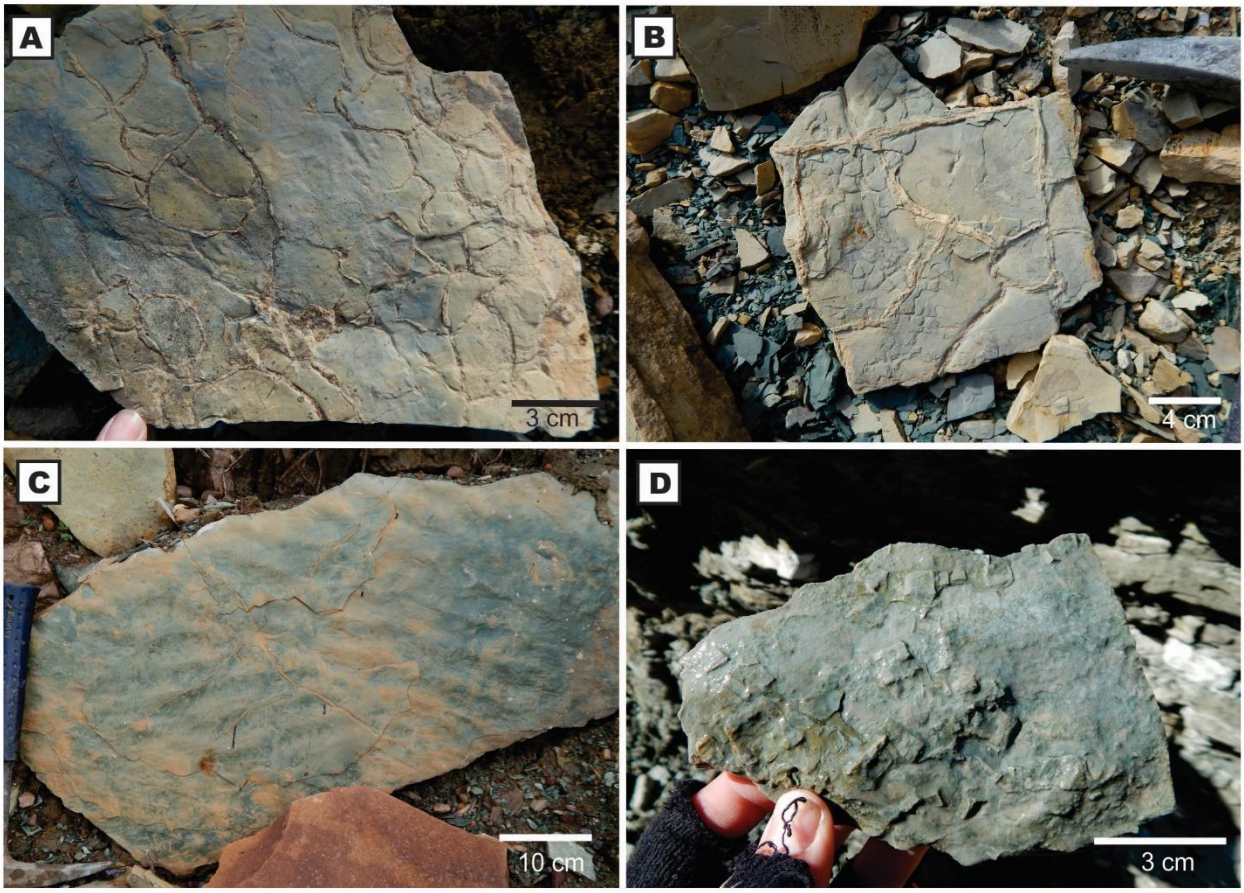

Figure 22. Features in talus below the Saline River Formation at the ‘waterfall’ measured section (section 3, Fig. 11). (A&B) Desiccation cracks. (C) Symmetrical ripples. (D) Halite casts.

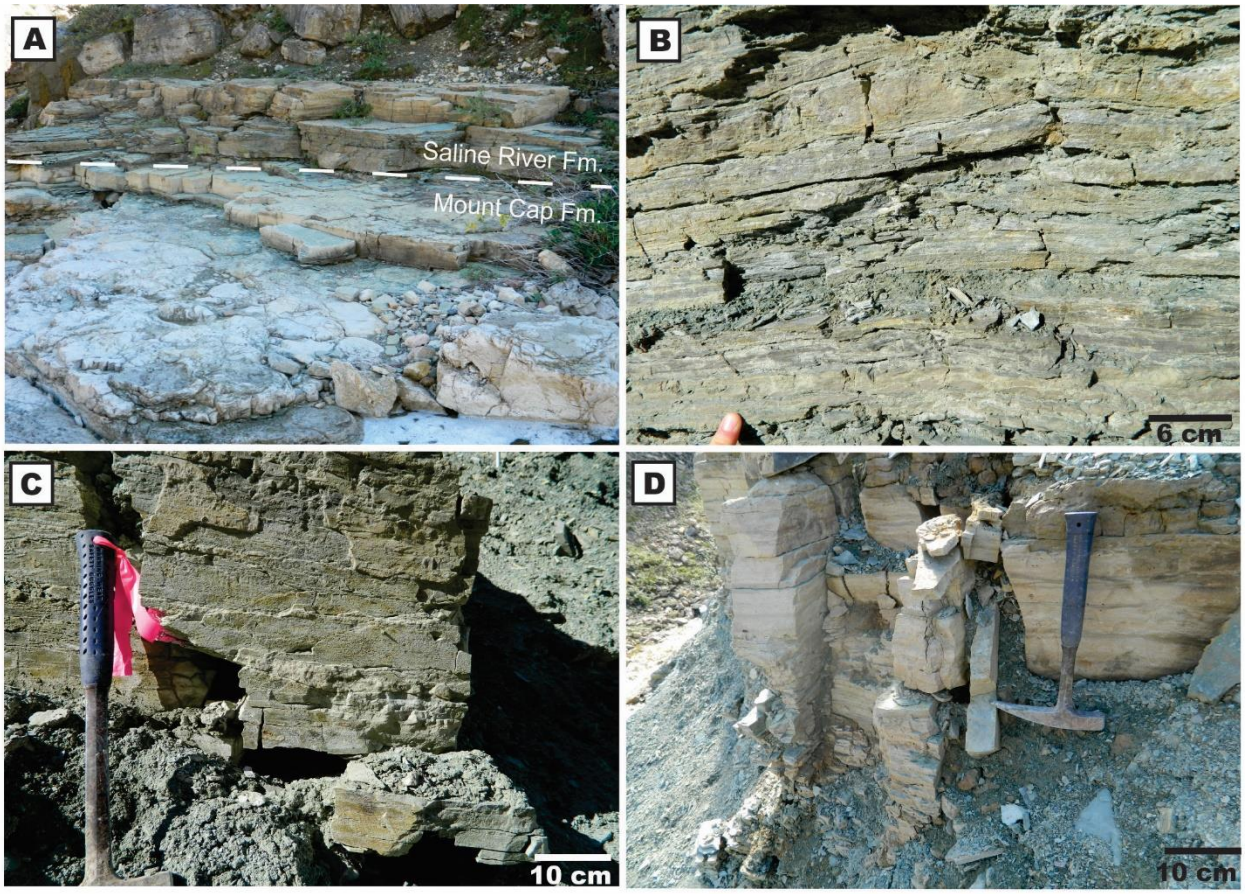

Figure 23. Saline River Formation at the ‘waterfall’ measured section (section 3, Fig. 11). (A) Contact between the uppermost dolostone unit of the Mount Cap Formation and the lowermost quartzose dolostone unit of the Saline River Formation. (B) Resistant dolomudstone of unit 2. (C) Dolostone of unit 6. (D) Quartzose dolostone of unit 7.

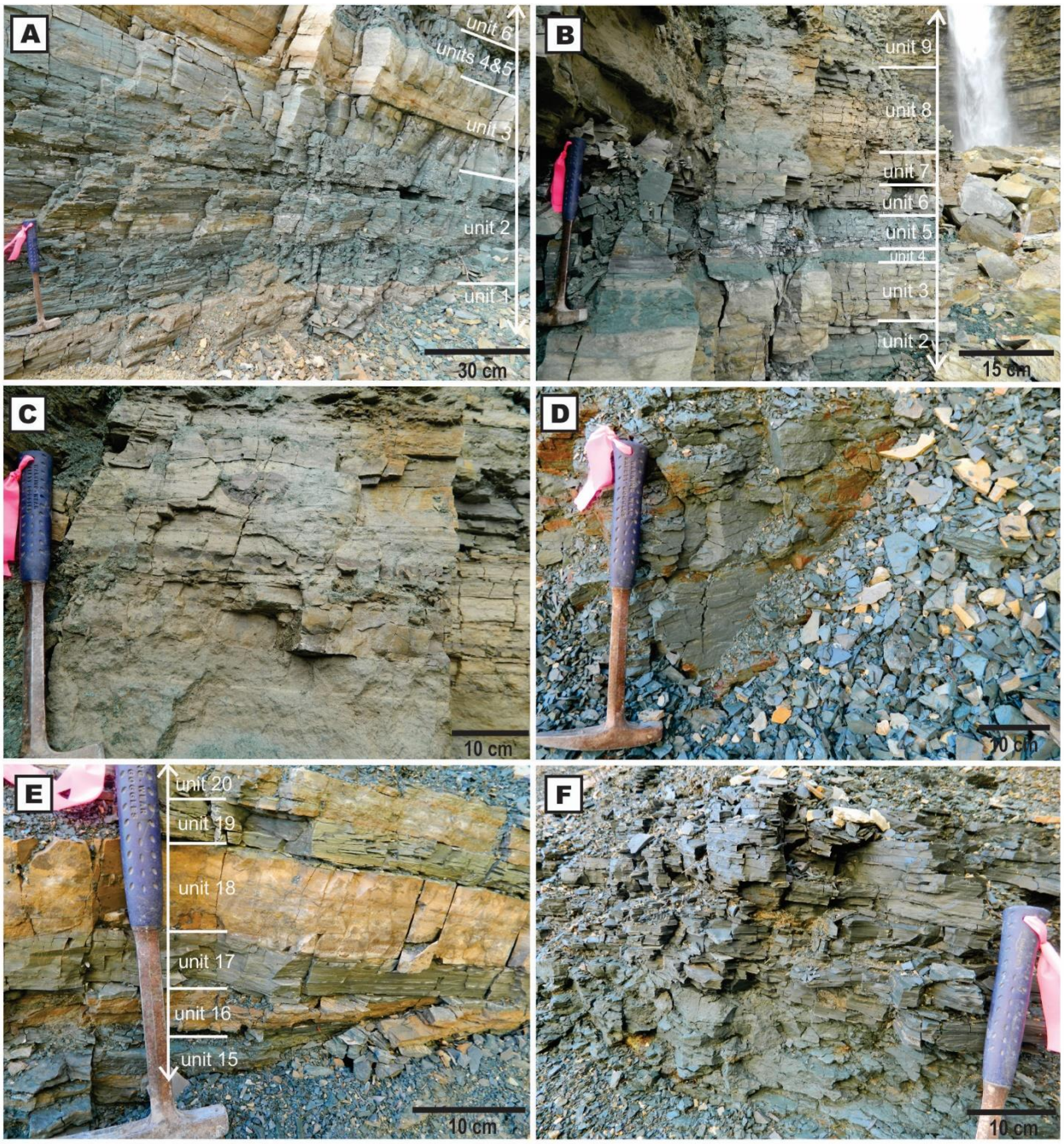

Figure 24. Section 3B (Fig. 6B) of upper Saline River Formation at the waterfall measured section (Fig. 11B). (A) Units 1 – 6, resistant dolostone and green-grey-weathering mudstone. (B) Units 2 - 9, medium grey sandy mudstone, orange-buff and blue green quartz arenite with planar lamination and resistant buff dolostone. (C) Units 7 – 8, medium buff-weathering, resistant quartz arenite and mudstone. (D) Unit 12, green-blue-grey recessive, fissile mudstone. (E) Units 15 – 20, orange-buff dolostone and green fissile mudstone. (F) Unit 21, green-grey friable sandy mudstone and green-grey fissile, parallel-laminated mudstone.

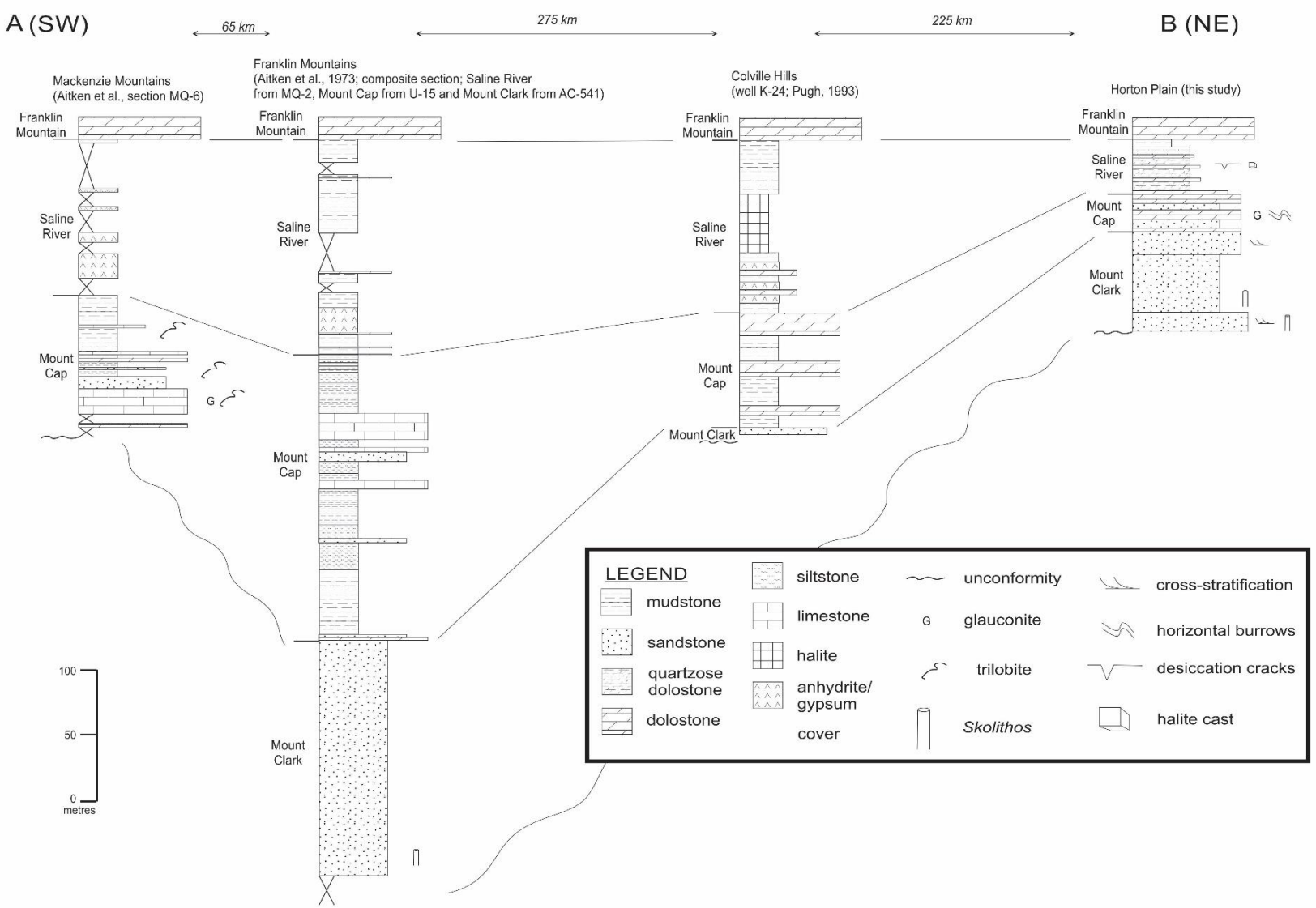

Figure 25. Cambrian stratigraphy across the NWT epicratonic basin, from A (southwest; Mackenzie Mountains near Mackenzie arch; Fig. 1) to B (northeast; near eastern limit of the basin; Hornaday River exposure; this study), illustrating thickness and lithofacies differences across the basin. Sections are hung from the base of the Franklin Mountain Formation.