# Preliminary observations of the Bouvette Formation at Nadaleen Mountain, Yukon (NTS 106C/2, 3)

J.F. Busch*, J.V. Strauss, M.H. Saylor, T.J. Allen, K. Faehnrich
Dartmouth College, Department of Earth Sciences

J.F. Taylor
Indiana University of Pennsylvania, Department of Geoscience

Busch, J.F., Strauss, J.V., Saylor, M.H., Allen, T.J., Faehnrich, K. and Taylor, J.F., 2019. Preliminary observations of the Bouvette Formation at Nadaleen Mountain, Yukon (NTS 106C/2, 3). *In:* Yukon Exploration and Geology 2018, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 19–42.

## Abstract

The Cambrian–Devonian Bouvette Formation outcrops over large parts of central Yukon. Despite its broad lateral and temporal extent, relatively little is known about its age range, facies distribution, depositional history, and significance for early Paleozoic paleogeographic reconstructions of northwestern Laurentia. At Nadaleen Mountain (NTS 106C/2, 3) in east-central Yukon, the Bouvette Formation is remarkably well exposed and provides new insight into the transition between the southeastern Ogilvie platform and northern Selwyn basin. Here, we present preliminary field data collected from this region during 2017 and 2018, including measured stratigraphic sections, biostratigraphy, and detailed imagery acquired from Unmanned Aerial Vehicles (UAVs), in order to test the hypothesis that the Bouvette Formation locally preserves a platform margin reef and forereef succession. These observations not only provide an important new contribution to Yukon's early Paleozoic depositional history, but also identify an exceptional location to study carbonate platform–margin depositional environments.

* james.f.busch.gr@dartmouth.edu

## Introduction

In contrast to the many areas located along the Mackenzie platform and Misty Creek embayment of the Northwest Territories, early Paleozoic platform–basin transitional rocks remain largely unstudied in Yukon (Fig. 1; Morrow, 1999). Reconnaissance observations of the Bouvette Formation at Nadaleen Mountain in 2017 noted the existence of well-preserved platform and platform–margin rocks, which are potentially indicative of the Ogilvie platform–Selwyn basin transition. Basinal and slope deposits fringing carbonate platforms can preserve platform-derived sediments, even during periods of relative low sea level, enabling them to record environmental and ecological changes that are locally lost due to erosion in shallow-water settings. Thus, the Bouvette Formation at Nadaleen Mountain could provide a significant opportunity to better understand early Paleozoic paleontology, sequence stratigraphy, paleogeography, and paleoenvironmental change during the Cambrian–Devonian.

In this paper, the platform and platform–margin rocks exposed in the Nadaleen Mountain area are described based upon measured sections and careful mapping carried out in July 2017 (at Nadaleen Mountain) and August 2018 (south of Nadaleen Mountain; Fig. 2). Specifically, the study aims to: (1) understand the depositional environment of the Bouvette Formation in the Nadaleen Mountain area; and (2) collect fossil material to constrain the age and sedimentation history of the Bouvette Formation along the southwestern edge of the Ogilvie platform. In order to accomplish these goals, we measured a number of closely spaced stratigraphic sections along depositional dip and strike, collected trilobite, coral, and brachiopod fossils, and sampled carbonate rocks for carbon isotope chemostratigraphy and conodont biostratigraphy. Lastly, we collected preliminary UAV imagery to generate three-dimensional depositional models of the study area from integrated field observations, elevation data, and structural measurements. Here, we

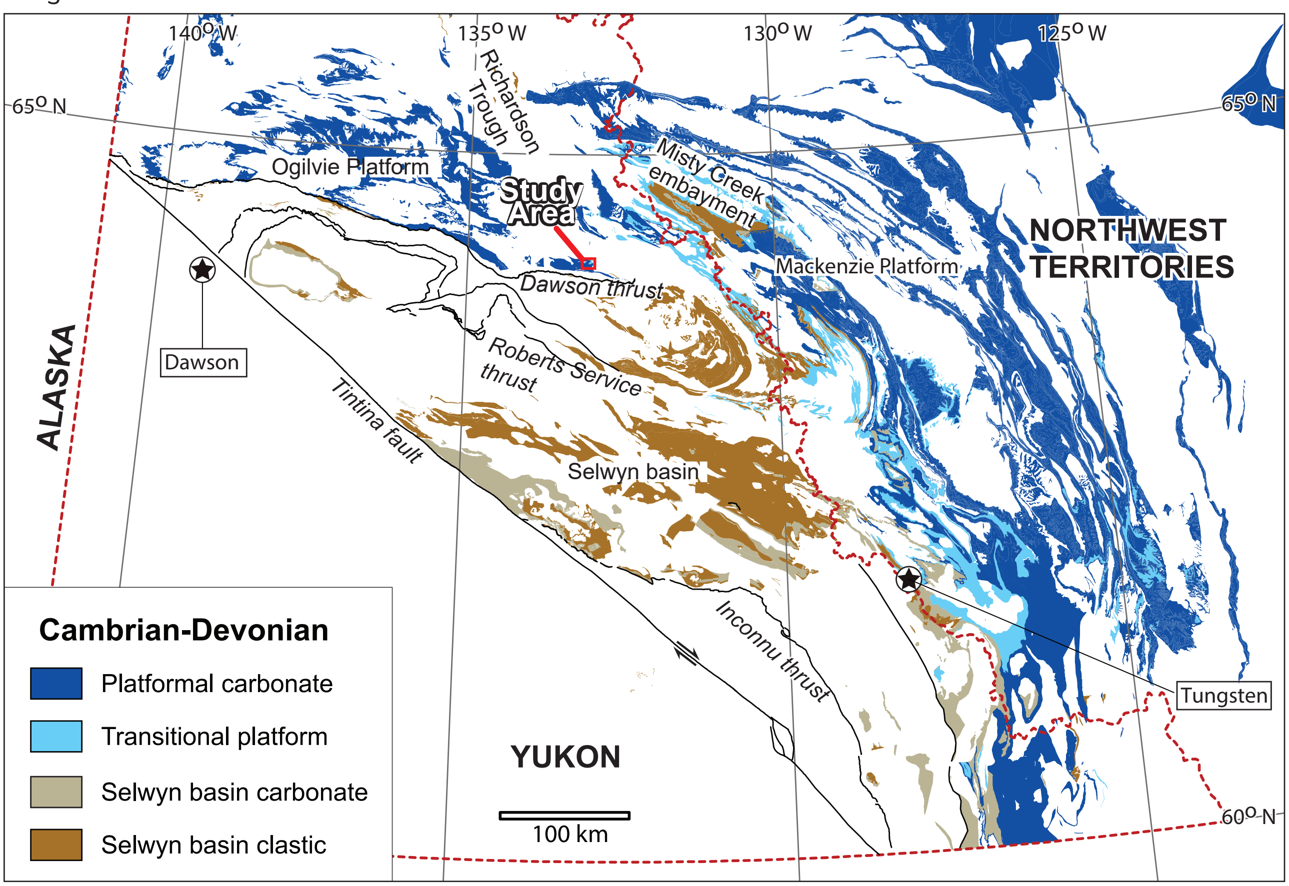


***Figure 1.*** *Simplified geological map of Proterozoic and Paleozoic strata in the northern Canadian Cordillera after Moynihan et al. (accepted). The study area lies north of the Dawson fault, within the Rackla Belt of the Wernecke Mountains and forms part of the arcuate Selwyn–Mackenzie fold-thrust belt.*

present some preliminary field observations and biostratigraphic data from our fieldwork and provide initial interpretations of the depositional history of the Bouvette Formation.

# Geological Background

## Regional Background

Several major paleogeographic features in northwestern Canada have been identified as important regions of sedimentation during Neoproterozoic–early Paleozoic time. Much of central and western Yukon is underlain by Paleozoic shallow-water carbonate and siliciclastic rocks comprising a region known as the Yukon block (Lenz, 1972). Cambrian–Devonian shallow-water carbonate rocks of the Yukon block comprise an isolated platform, referred to as the Ogilvie platform, that was separated from the main continent-fringing shallow-water depositional system of the Mackenzie-Peel shelf (referred to here as the Mackenzie platform) by the Richardson trough, a narrow N-trending deep-water basin (Fig. 1; Lenz, 1972; Norris, 1985, Cecile, 1982; Cecile *et al.*, 1997; Pyle, 2012). East of the Nadaleen Mountain area, the Ogilvie platform and Mackenzie platform are separated by a deep-water trough called the Misty Creek embayment; to the south exists the much more extensive deep-water Selwyn basin (Fig. 1; Cecile, 1982; Morrow, 1999). Collectively, these shallow-water carbonate rocks of the Ogilvie and Mackenzie platforms form the northwestern edge of the so-called Great American Carbonate Bank (Pyle, 2012).

The Bouvette Formation (Morrow, 1999) comprises an approximately 500 to 1500 m thick Cambrian to Devonian shallow-water carbonate succession that outcrops extensively throughout the Yukon block. The formation was originally considered to be map unit "CDb" during Operation Porcupine (Norris, 1985); it was later formally defined by Morrow (1999). The Bouvette Formation is characteristically very resistant, and often forms steep peaks and spires in linear mountain ranges oriented parallel or subparallel to regional strike in northern Yukon (Morrow, 1999). Despite this resistance to weathering, the Bouvette Formation commonly forms very coarse-grained talus or scree fields throughout these extensive exposures, so it is generally quite challenging to measure detailed stratigraphic sections of these strata.

At its type section in the Ogilvie River map area (NTS 116G; Morrow, 1999), the Bouvette Formation (864 m thick) unconformably overlies unnamed Proterozoic siliciclastic rocks of the Wernecke or Windermere supergroups. Five units are distinguished within the type section, beginning with basal beds of stromatolitic doloboundstone interbedded with intraclast rudstone and grainstone locally containing tepee structures (Morrow, 1999). The second unit consists of thick-bedded finely crystalline or oolitic grey dolograinstone with intervening beds of doloboundstone containing discontinuous lenses of rudstone breccia with localized mudcracks (Morrow, 1999). A rhythmic repetition of shoaling-upward cycles in this unit are marked by thick-bedded oolitic dolograinstone and skeletal dolowackestone grading upwards into doloboundstone. The third unit is similar to the second but contains fewer interbeds of oolitic dolograinstone and rudstone breccia (Morrow, 1999). The fourth unit contains thick intervals of very resistant vuggy sucrosic dolostone with abundant fenestral fabric separated by interbeds of doloboundstone and dolograinstone (Morrow, 1999). The fifth unit is a light grey and resistant massive to thick-bedded coarsely crystalline vuggy dolostone with discontinuous bands of chert. Here, shale of the Road River Group conformably overlie the Bouvette Formation (Morrow, 1999).

Throughout other areas of Yukon, the Bouvette Formation is generally dominated by rubbly exposures of sucrosic dolostone with a notable paucity of well-preserved fossil material (Morrow, 1999). Sparse facies variation includes intervals of fossiliferous pelletal limestone with tentaculitids, brachiopods, colonial corals, and solitary corals in the upper part of the section in the Wind River map area (NTS 106E) near the Knorr Block (Morrow, 1999). Near Royal Mountain (NTS 106E), an incomplete section of the Bouvette Formation is entirely composed of limestone with facies that include abundant stromatolitic boundstone and fossiliferous wackestone that passes laterally into shale of the Road River Group in the Richardson trough (Morrow, 1999).

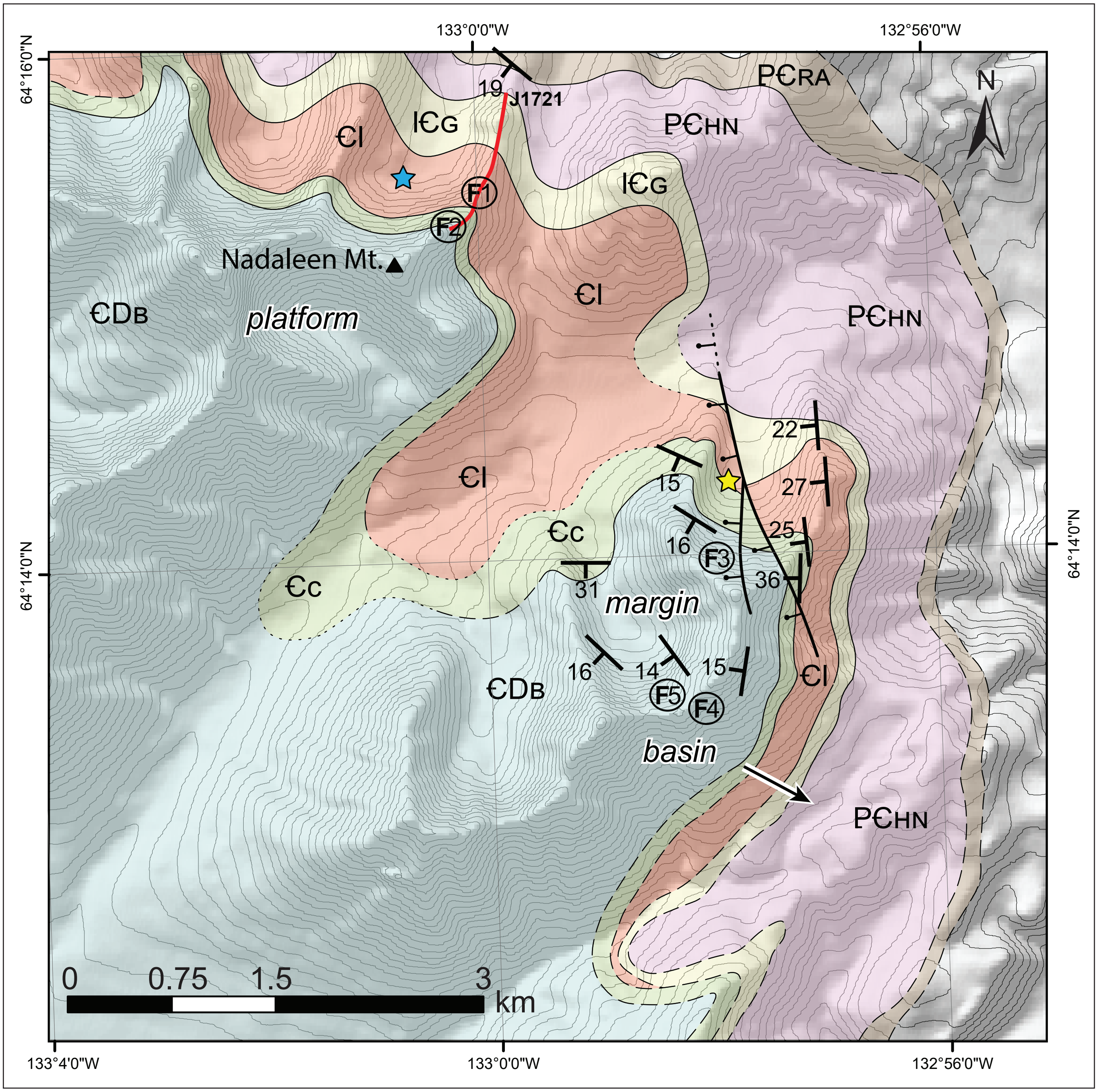


**Figure 2.** *Preliminary geological map of NTS 106C/2, 3 (scale 1:40 000) based on our field observations and modifications from Colpron (2012a) and Colpron et al. (2013). Elevation contour interval is 20 m. See legend on next page.*

### Cambrian–Lower Devonian

#### Cambrian Furongian to Devonian

**ЄDB** BOUVETTE FORMATION: *light to dark grey weathering resistant limestone; locally fossiliferous*

**Єc** UNNAMED CONGLOMERATE: *dark brown to green-weathering clast-supported conglomerate; clasts are locally dominated by mafic volcanic with localized recrystallized limestone and chert; minor intervals of siltstone and sandstone; laterally and vertically transitions to matrix and clast-supported rudstone*

#### Cambrian Miaolingian–Furongian

**Єl** UNNAMED LIMESTONE: *dark brown-weathering platy lime mudstone and calcareous shale with rare fossil material; some intervals of carbonate rudstone*

#### Cambrian Series 2–Miaolingian

**lЄG** GULL LAKE FORMATION: *dark brown-weathering sandstone, siltstone, shale, and matrix-supported conglomerate; locally heavily bioturbated; upper part of unit is marked by a medium to thick-bedded quartz arenite*

### Neoproterozoic–Cambrian Hyland Group

#### Ediacaran to Lower Cambrian

**PЄHN** NARCHILLA FORMATION: *dominantly maroon, brown, and olive green shale and slate with local hematite and calcite-cemented quartz arenite and siltstone*

### Neoproterozoic Rackla Group

#### Ediacaran to Lower Cambrian

**PЄRA** ALGAE FORMATION: *dark to light-grey limestone and dolostone; variably dolomitized with intervals of cross-lamination and sandy/silty limestone*

### Symbols

contact–defined, approximate, covered

normal fault

bedding

(F1) fossil locality with interpreted age

2017 camp location

2018 camp location

measured section

### Fossil Collections

| Map # | Age | Map Unit | ID | Date | Fossil Type |
|---|---|---|---|---|---|
| F1 | Cambrian, Series 2-Miaolingian | Єl | John Taylor | 2018 | *Bonnia or Kootenia* genus?, trilobite |
| F1 | Cambrian, Miaolingian-Furongian | Єl | John Taylor | 2018 | *Psuedagnostus*, agnostid arthropod |
| F1 | Cambrian, Furongian (Jianshanian Stage) | Єl | John Taylor | 2018 | *Loganopeltoides*, trilobite |
| F1 | Cambrian, Furgonian (Paibian-Jianshanian Stage) | Єc | John Taylor | 2018 | *Irvingella* genus, trilobite |
| F2 | Upper Ordovician | ЄDB | R. Blodgett | 2017 | *Grewingkia* sp., solitary rugose coral<br>*Septentrionites*? sp., tabulate coral<br>*Paleofavosites*, favositid tabulate coral |
| F2 | Upper Ordovician | ЄDB | R. Blodgett | 2017 | *Maclurites* sp., gastropod |
| F3 | Late Ordovician-Early Silurian | ЄDB | R. Elias | 2018 | *Palaeophyllum* sp., colonial rugose coral<br>streptelasmatine, solitary rugose coral |
| F4 | Late Ordovician-Early Silurian | ЄDB | R. Elias | 2018 | *Catenipora* sp., halysitid tabulate coral<br>*Paleofavosites*, favositid tabulate coral |
| F5 | Late Ordovician-Early Silurian | ЄDB | R. Elias | 2018 | *Palaeophyllum* sp., colonial rugose coral |

**Figure 2.** Map legend.

The Bouvette Formation ranges in age from early Cambrian (Series 2) to early Devonian (Morrow, 1999). The lower Cambrian Series 2 age constraint is based upon the occurrence of poorly preserved archeocyathids in what was originally mapped as unit 8 (Green, 1972) and later assigned to the Bouvette Formation in the Coal Creek inlier, Ogilvie Mountains (Fritz, 1982; Mustard *et al.*, 1988). The uppermost beds of the Bouvette Formation are highly diachronous and range in age from Middle Ordovician to Early Devonian (Morrow, 1999). These upper age constraints are assigned based upon the presence of pre-Devonian undetermined fossil material and Middle or Late Ordovician tabulate corals in the Hart River map area (NTS 116H) and Early Devonian brachiopods, stromatoporoids, and tabulate corals collected in the Wind River map area (NTS 106E; Morrow, 1999). Drill core intersections of the Bouvette Formation recovered from Eagle Plain yielded Late Ordovician echinoderms, rugose corals, brachiopods, and stromatoporoids near its upper contact with the Road River Group (Morrow, 1999).

In the southern Wind River map area and southeastern Hart River map area parts of the Yukon block, Morrow (1999) suggests the Bouvette Formation conformably overlies fine-grained carbonate rocks of the Upper Cambrian Taiga Formation; however, Fritz (1997) reported an erosional unconformity marking the contact between the Bouvette and Taiga formations (Fig. 3). Over large swaths of the central and western Yukon Block, the Bouvette Formation unconformably overlies Proterozoic strata of the Quartet and Gillespie Lakes groups (Morrow, 1999). These relationships indicate the Bouvette Formation onlapped basement paleo-highs while transitioning conformably into deeper water carbonate settings following early to middle Cambrian extension (Morrow, 1999). The Bouvette Formation passes westward into the Cambrian–Ordovician Jones Ridge Formation of east-central Alaska and western Yukon (Fig. 3; Brabb, 1967; Norris, 1982; Taylor *et al.*, 2015). To the north of the study area, the Bouvette Formation of the Ogilvie platform passes into basinal shale of the Road River Group in the Richardson trough; to the east, the Bouvette Formation transitions into argillaceous limestone of the Rabbitkettle Formation in the Misty Creek embayment (Fig. 3; Cecile 1982; Morrow, 1999). On the eastern side of the Misty Creek embayment, the Mackenzie platform equivalent of the Bouvette Formation consists of the Cambrian–Ordovician Franklin Mountain and Ordovician–Silurian Mt. Kindle formations (Cecile, 1982); farther south, the Bouvette Formation is equivalent to the Cambrian–Ordovician Haywire Formation (Fig. 3; Gordey and Anderson, 1993). Throughout most of its extent, the Bouvette Formation is overlain by, and interfingers with, shale of the Road River Group (Morrow, 1999).

## Study Area

Paleozoic platformal carbonate rocks of the Nadaleen Mountain study area overlie the Neoproterozoic to Cambrian Rackla Group and Narchilla Formation (Fig. 2) and are locally juxtaposed against Paleozoic slope and basinal rocks assigned to the Road River and Earn groups along the Kathleen Lakes fault (Blusson, 1974; Colpron *et al.*, 2013; Moynihan, 2016). Regionally, this area is known informally as the Rackla belt, referring to a metallogenic trend which closely follows the Dawson thrust at the northern edge of the Selwyn basin (Colpron, 2012b). In the study area, Paleozoic sedimentation commenced with siliciclastic strata of the Narchilla and Gull Lake formations, which are succeeded by an unnamed Cambrian limestone unit and an unnamed Cambrian conglomerate (Fig. 4; Colpron, 2012b; Moynihan, 2016; *this contribution*). The Bouvette Formation, which marks the establishment of a stable carbonate platform in the region, unconformably overlies the unnamed Cambrian conglomerate (Figs. 2 and 4). These strata were examined within two NNE-facing cirques at the base of Nadaleen Mountain (2017), and three NNE-facing cirques ~3 km south of Nadaleen Mountain (2018; Fig. 2). The Bouvette Formation is well-exposed in these cirques and reasonably accessible by foot traverse. The Neoproterozoic to Paleozoic units exposed adjacent to Nadaleen Mountain dip moderately to the west-southwest and are cut by several high-angle normal faults trending NNW (Fig. 2); these strata are generally well-preserved and undeformed. Within the study area, our team measured 27 stratigraphic sections of the Neoproterozoic to Paleozoic units (see Figure 5).

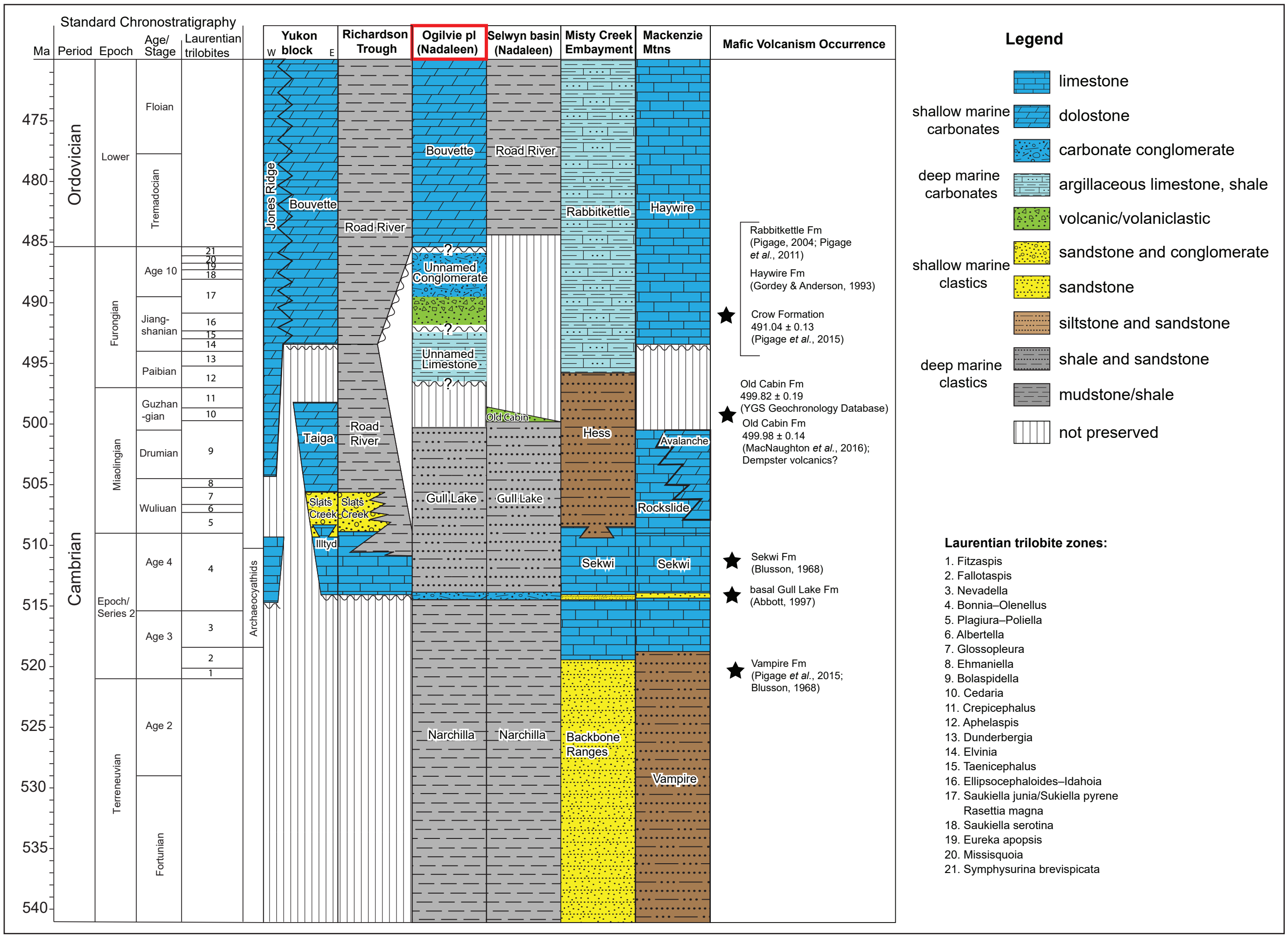


***Figure 3.*** *Correlation of early Paleozoic stratigraphy across NW Canada. Some boundaries are approximate due to limited fossil and geochronological age data. Modified from Moynihan et al. (accepted). The time scale is after Cohen et al. (2013; updated). Data for the Yukon block are after Fritz (1997) and Morrow (1999); for the Richardson trough after Norris (1985) and Fritz (1997); for the Misty Creek embayment after Cecile (1982); for the Ogilvie platform after Mustard et al. (1988) and Colpron et al. (2013); for the Selwyn basin from Cecile (2000), Colpron et al. (2013), and Moynihan (2014); for the Mackenzie Mountains after Gordey and Anderson (1993).*

# Stratigraphy of the Nadaleen Mountain Area

## Ediacaran–Cambrian Rackla Group

### *Algae Formation* (PCRA)

The Ediacaran–Cambrian(?) Algae Formation (Cecile, 2000) forms a resistant carbonate unit divided into two members. In the type area (NTS 105O/14), the lower member is composed of a flaggy limestone with minor chert and argillite, and an upper member of dolostone and cross-bedded arenaceous dolostone and limestone (Cecile, 2000). Elsewhere in the Nadaleen Mountain area, the Algae Formation consists of lime mudstone and oolitic grainstone, silty to sandy limestone and subordinate intraclast rudstone (Colpron, 2012b; Moynihan, 2014; Moynihan et al., accepted). Regionally, the thickness of the Algae Formation ranges from approximately 80 to 350 m, reaching ~150 m at Nadaleen Mountain. Here, the rocks are exclusively dark to light grey dolostone that are variably recrystallized with fabric-destructive dolomitization. The dominant facies consists of thin to thick-laminated silty to sandy dolomitic grainstone with common ripple cross-lamination. In the intervals that are heavily dolomitized, there is local brecciation, veining, and development of zebra or saddle dolomite textures.

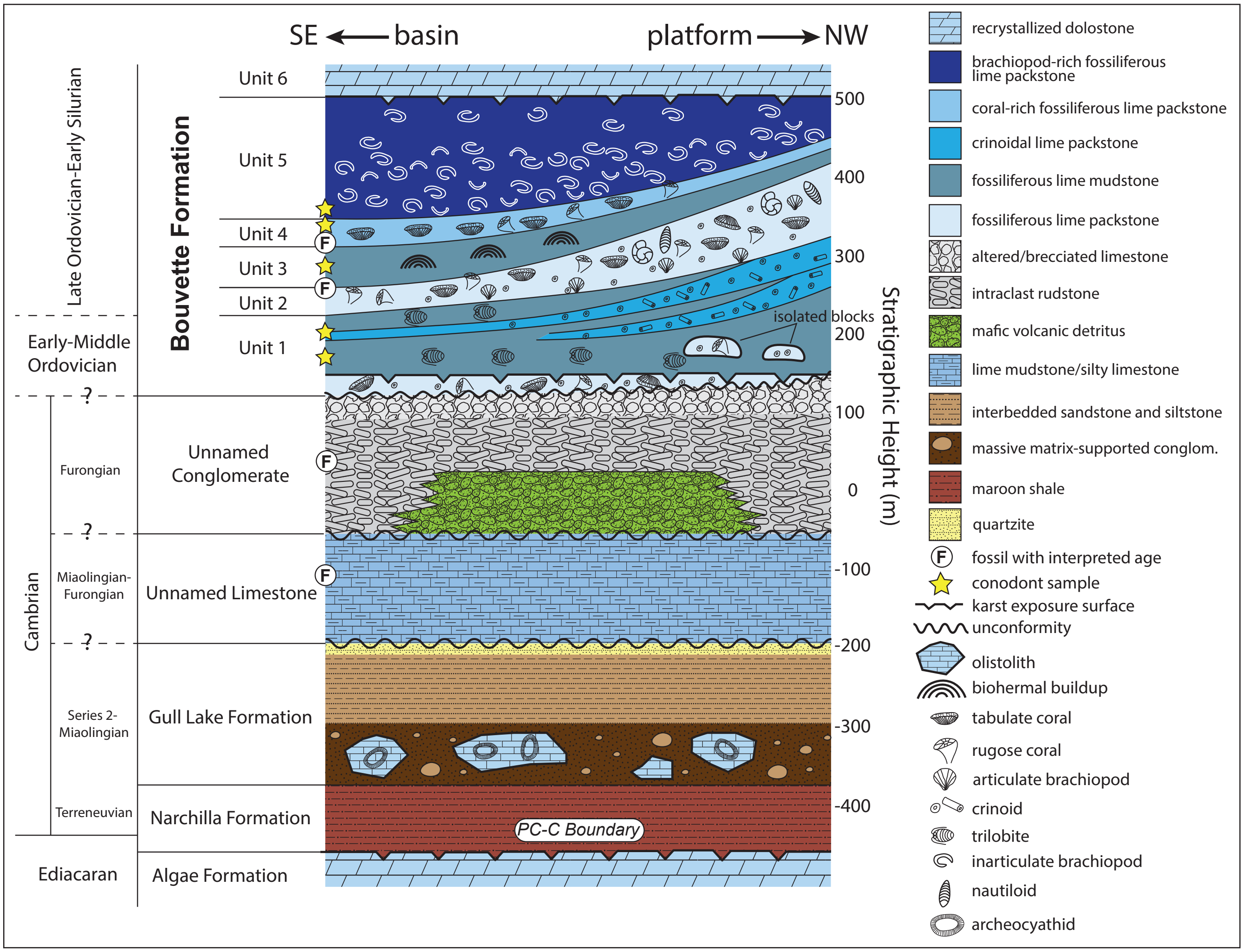


***Figure 4.*** *Schematic stratigraphic column of Neoproterozoic-Paleozoic strata in the Nadaleen Mountain study area. Sedimentary unit geometries and thickness changes are drawn schematically to capture broad trends observed across the study area. Horizontal axis is not drawn to scale.*

## Ediacaran–Cambrian Hyland Group

### *Narchilla Formation* (PCHN)

The lower Cambrian Narchilla Formation (Gordey and Anderson, 1993) is a dominantly fine-grained siliciclastic succession that disconformably overlies the Algae Formation in the study area (Colpron, 2012b; Moynihan, 2014; Moynihan et al., accepted). At its type section, the contact is interpreted as conformable (Gordey and Anderson, 1993; Cecile, 2000). In the Nadaleen Mountain area, a locally recognized erosional surface separates the Narchilla and Algae formations and is expressed as an approximately 1 to 5 m thick matrix-supported brecciated limestone with varying amounts of brown, sandy matrix. This paleokarst horizon variably possesses characteristic *terra rosa* coloration, dissolution surfaces, and sand-filled grikes that are indicative of subaerial exposure (Moynihan, 2014; Moynihan et *al.*, accepted). At the type section near the little Nahanni River (NTS 105O/15), the Narchilla Formation is divided into three members (Gordey and Anderson, 1993); Cecile (2000) later defined two members in the Narchilla Formation in the Niddery Lake map area (NTS 105O). The ~400 m thick lower Senoah Member is composed of brown to tan siltstone and shale with thick interbeds of resistant quartzite. The upper Arrowhead Lake Member (~120 m thick) consists of maroon and olive-green siltstone and

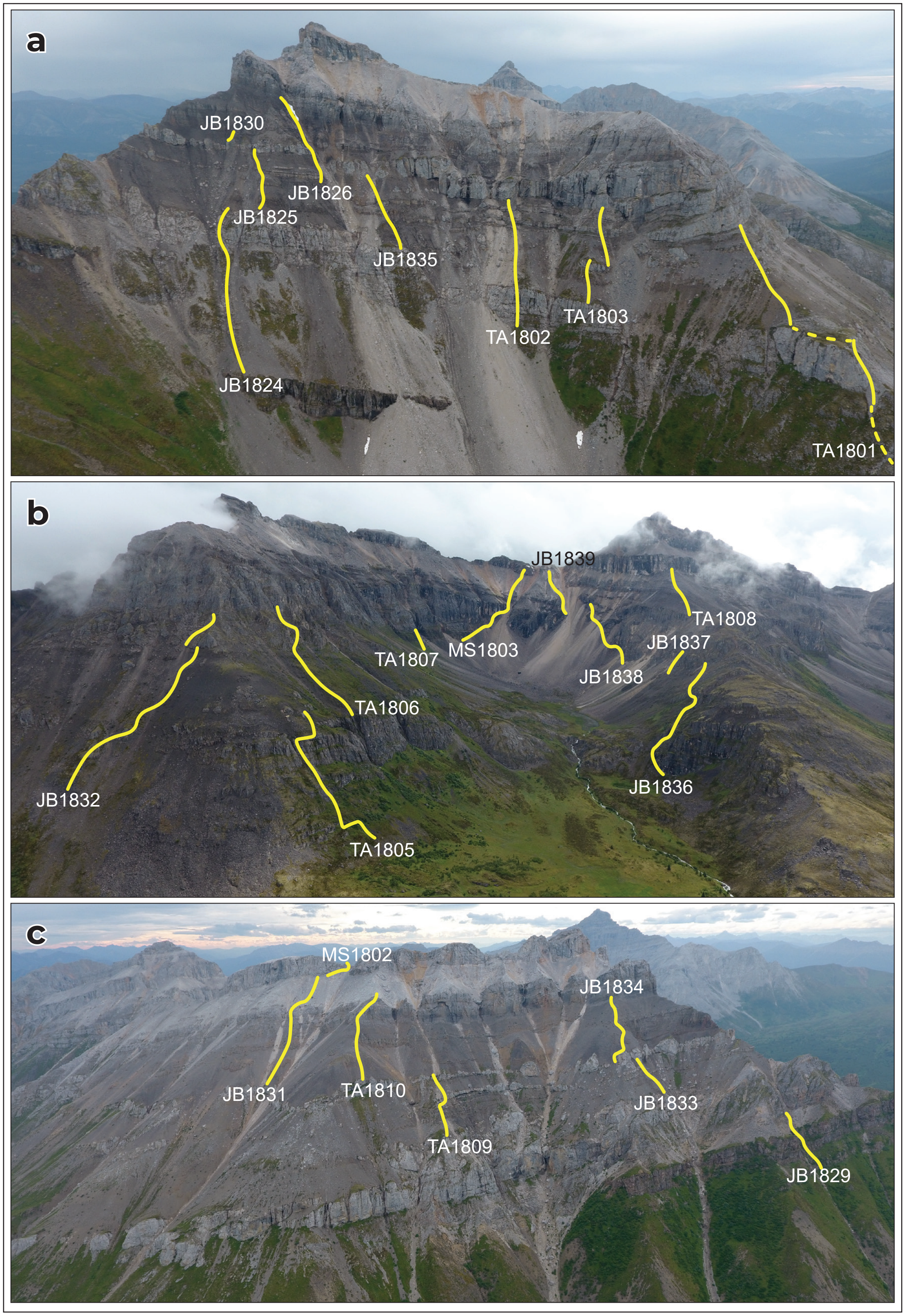


***Figure 5.*** *Locations of measured sections in the study area, southeast of Nadaleen Mountain. Colored lines show routes of the measured sections.*

shale with minor quartzite interbeds. In the Nadaleen Mountain area, the Narchilla Formation is undivided and comprises a basal lithologically variable interval that includes thickly laminated hematite-cemented quartz arenite, dark grey calcite-cemented sandstone and siltstone, and carbonate clast rudstone. This thin basal unit is overlain by a maroon and green siltstone and shale unit that locally contains a penetrative cleavage that obscures primary sedimentary structures. The presence of simple horizontal trace fossils preserved on the soles of sandstone beds within this unit, including *Oldhamia*, likely indicate deposition during the Terreneuvian to Cambrian Stages 2–3 (Hofmann et al., 1994; Moynihan, 2014; MacNaughton *et al.*, 2016; Moynihan *et al.*, *accepted*).

## Cambrian-Devonian

### *Gull Lake Formation* (lCG)

The Gull Lake Formation (Gordey and Anderson, 1993) predominantly comprises fine-grained siliciclastic rocks in the Nadaleen Mountain area. The basal strata consist of dark brown poorly sorted matrix-supported conglomerate with granule to boulder-sized clasts of calcite-cemented sandstone, chert, recrystallized limestone, and archeocyathid-bearing boundstone (Moynihan, 2014). This basal unit is overlain by a package of thin to medium-bedded medium to coarse-grained quartz arenite, quartz wacke, and sublitharenite with local carbonate matrix. This unit is pervasively bioturbated and contains minor carbonate rudstone and a variety of different Bouma subdivisions, which broadly suggest deposition by suspension sedimentation and turbidity and sediment-gravity flows. A distinctive 4 to 10 m thick medium to thick-bedded quartz arenite marks the top of the Gull Lake Formation in the Nadaleen Mountain area. The archeocyathid-bearing limestone clasts in the basal unit provide an approximate maximum age constraint of Cambrian Series 2 for the Gull Lake Formation (Moynihan, 2014; Moynihan *et al.*, *accepted*), which is consistent with Abbott's (1997) report of *Bonnia-Ollenelus* Zone trilobites within the Gull Lake Formation in the Hart River area. Occurrences of *Oldhamia* trace fossils in the upper part of the Gull Lake Formation provide a minimum age constraint of Cambrian Stage 5, as *Oldhamia* does not occur above middle Cambrian strata worldwide (Herbosch and Verniers, 2011; Moynihan, 2014; MacNaughton *et al.*, 2016).

### *Unnamed Cambrian Limestone* (Cl)

An unnamed fine-grained carbonate unit conformably overlies the dominantly siliciclastic Gull Lake Formation in the Nadaleen Mountain area (Colpron *et al.*, 2013). This unit was identified by Colpron *et al.* (2013) with its base marked by the first carbonate that overlies siliciclastic rocks of the Gull Lake Formation. The Cambrian limestone unit is approximately 150 m thick and composed predominantly of recessive, thin-bedded and locally fossiliferous grey-brown platy lime mudstone and calcareous shale. Some intervals from this unit contain distinct Bouma CDE alternations with subtle grain-size differences, thin beds of lime mudstone with localized coarse-grained fossiliferous or sandy lags, and zones of soft-sediment deformation and slump folds. There are several 1 to 2 m thick interbeds of dark grey-brown rudstone and orange to dark grey limestone clasts, some of which are fossiliferous. The top of the unit is marked by a sharp contact with either intraclast rudstone or volcaniclastic conglomerate of the overlying unnamed conglomerate map unit.

### *Unnamed Cambrian Conglomerate* (Cc)

In the Nadaleen Mountain area, an unnamed, approximately 200 m thick conglomerate unit disconformably overlies the unnamed limestone unit identified by Moynihan (2016). The contact is marked by a sharp to irregular surface filled with light grey to tan-weathering thick-bedded and poorly sorted conglomerate with pebble to boulder-sized clasts composed of silty lime grainstone, recrystallized limestone, and calcite-cemented sandstone supported by a calcitic quartz sand matrix. Where measured (JB1829; Fig. 5c), there is a lower interval of volcanic detritus in the informal conglomerate unit that is approximately 70 m thick and composed of a basal succession dominated by dark green to light grey volcaniclastic conglomerate. The interval begins with a polymict conglomerate composed of well-rounded to subrounded clasts of recrystallized limestone, sandy dolograinstone, and mafic volcanic rocks in a poorly sorted, medium to coarse subrounded litharenite matrix with subordinate quartz sand and minor green silt. Above the basal interval, the clasts become exclusively composed of pebble to boulder-sized dark green mafic volcanic rocks that are variably amygdaloidal with void-filling chalcedony. The matrix is dominated by sand and silt-size particles of the same composition and has rare interbeds of volcaniclastic litharenite and siltstone. The lower volcaniclastic strata pass laterally to the northwest and southeast of the study area and vertically into carbonate-clast rudstone, which is locally up to approximately 160 m thick. The carbonate rudstone is very thick bedded to massive and is locally interbedded with matrix and clast-supported rudstone and grainstone (Fig. 6a) dominated by granule to pebble-sized tabular and subrounded clasts of finely crystalline limestone with variable silicification and a sandy/silty lime matrix. Some clasts contain silicified, well-rounded, granule-sized coated grains as well as

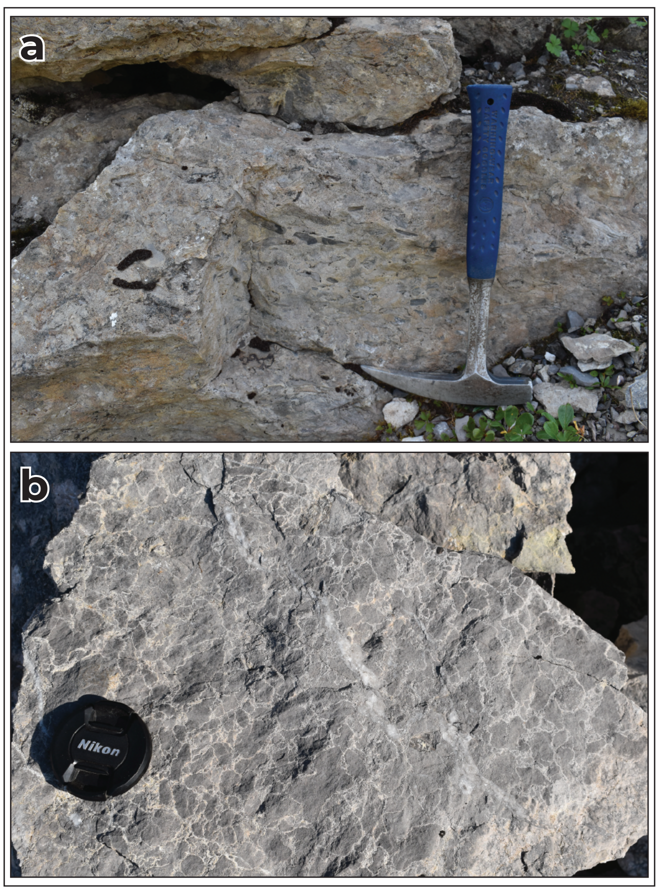


**Figure 6. (a)** *Medium to thick-bedded rudstone that composes most of the Unnamed Conglomerate; and* **(b)** *peculiar altered, brecciated, or microbial limestone facies near the top of the Unnamed Conglomerate.*

beautifully preserved trilobites. The basal, approximately 120 m thick rudstone interval is succeeded by a dark grey limestone interval with subangular to subrounded clasts and no observable matrix (Fig. 6b). The upper ~5 m of the unnamed conglomerate unit is fossiliferous in places having abundant tabulate and rugose corals and stromatolites, but it also contains discontinuous lenses and vertical pipes of brecciated limestone with a tan sandy/silty matrix tentatively interpreted as paleokarst breccia. The upper surface of the unnamed conglomerate is highly irregular with up to ~5 m of relief (*see* Fig. 7a,c); the upper fossiliferous interval is only preserved in the southeastern part of the study area.

The Cambrian volcaniclastic conglomerate map unit, approximately 3 km to the west (Colpron, 2012a), yielded a chemical abrasion-isotope dilution-thermal ionization mass spectrometry (CA-ID-TIMS) U-Pb zircon age of 499.82 ± 0.19 Ma (YGS Geochronology Database, 2018). This map unit shares many lithological similarities to the reworked mafic volcanic detritus interval identified at the base of the unnamed conglomerate unit here. Additionally, Old Cabin Formation mafic volcanic rocks of the northeastern Selwyn basin have been dated to *ca.* 499 Ma (MacNaughton *et al.*, 2016). This could be a likely source of the mafic volcanic detritus given its proximity to the Nadaleen Mountain area, but as the volcanic material in the unnamed conglomerate is reworked, it only suggests a maximum depositional age for the unit.

### *Bouvette Formation* (CDB)

In this preliminary study, 24 closely spaced stratigraphic sections of the Bouvette Formation were measured utilizing a Jacob staff at cm-resolution (Fig. 5). Based on the variation in lithology, sedimentary structures, and fossil assemblages, we identified six distinct stratigraphic units. The thickness of these units varies along depositional dip and is schematically shown in Figure 4, along with a composite stratigraphic column for the Nadaleen Mountain area. Several high-resolution UAV images accompany the measured sections and illustrate the stratigraphic expression of the six units distinguished within the Bouvette Formation (Fig. 7).

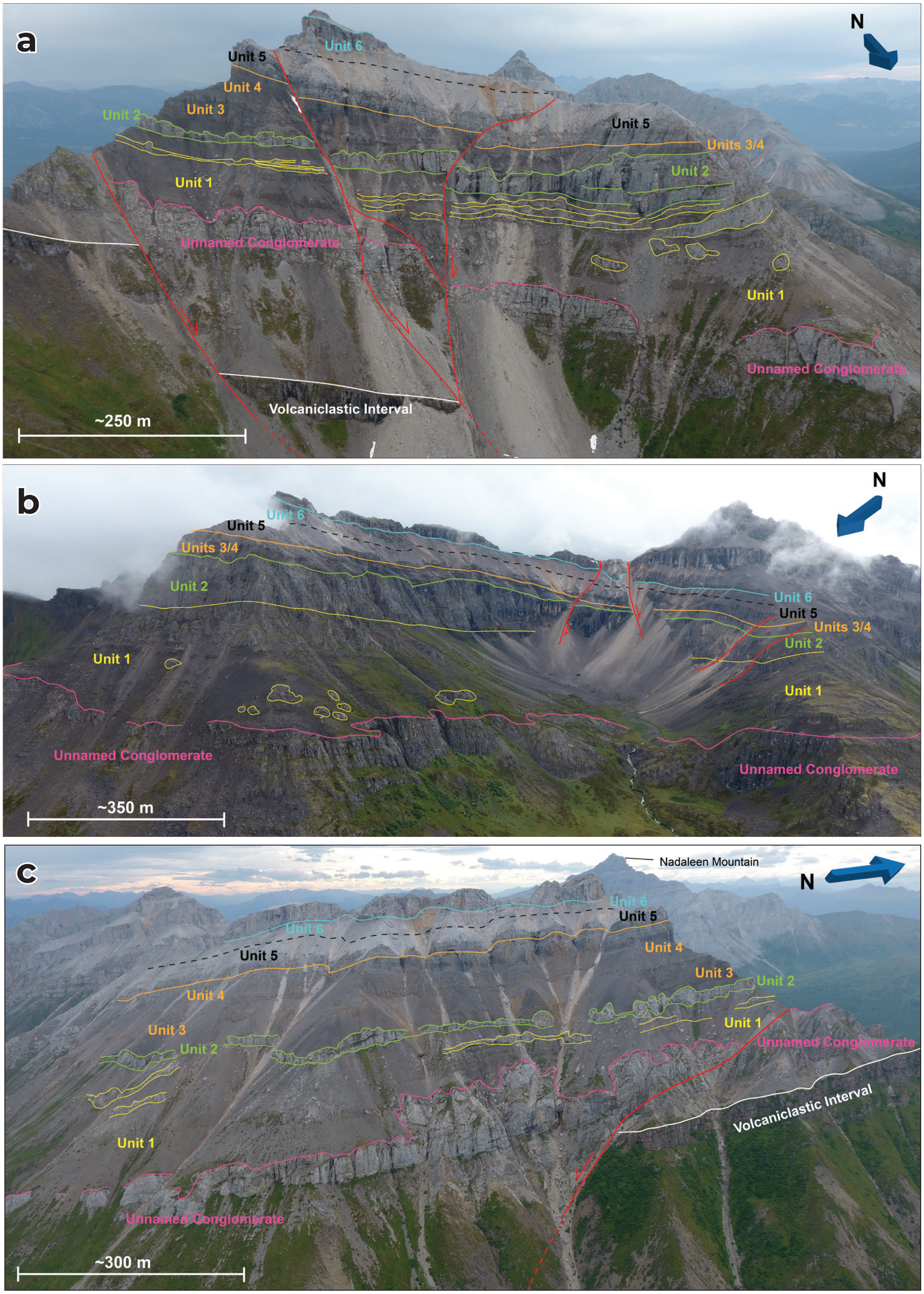


***Figure 7.*** *Interpreted drone photographs illustrating the expression of the six distinct units in the Bouvette Formation across the study area. Unit contacts are drawn based on observations within measured sections and while on traverse (see Fig. 5).*

Unit 1: This approximately 50 to 175 m thick unit consists of fossiliferous lime wackestone and lime mudstone (Fig. 8a) containing trilobites, crinoids, bivalves and brachiopods. Towards the top of the lime mudstone interval at the northwestern end of the study area, there are isolated, recrystallized and fossiliferous limestone bodies (ranging from 5 to 13 m wide by 4 to 11 m tall) containing fragments of stromatolitic boundstone and silicified rugose and tabulate coral. These fossiliferous bodies of limestone are onlapped by the overlying thin-bedded fossiliferous lime packstone (Fig. 8b) and may represent patch reefs due to the lack of evidence for subaerial exposure, no observable deformation in the underlying beds, and the abundance of coral fossils. Alternatively, they could represent allochthonous blocks shed from the edge of the carbonate platform. These limestone bodies are overlain by thin and wavy-bedded fossiliferous echinodermal lime packstone (Fig. 8c) that form more resistant outcrops and comprise resistant wedges that thicken to the northwest from approximately 50 to 175 m in distinct clinoformal geometries (Fig. 7a). This unit is followed by a recessive fossiliferous lime mudstone/wackestone package that contains trilobites and brachiopods.

Unit 2: This unit is approximately 25 to 100 m thick and has an erosive base with several metres of relief that contain ripped-up cobbles of the underlying lime mudstone/wackestone facies and boulders of fossiliferous lime packstone containing abundant coral and reef fossil material. The basal rudstone passes upwards into massive fossiliferous lime packstone containing abundant trilobite, rugose coral, tabulate coral, crinoids, brachiopods, gastropods and nautiloids (Fig. 9a,b). At the top is a highly irregular mound-shaped surface with up to 10 m of relief (Fig. 9d). There are abundant *in situ* rugose and tabulate corals, suggestive of an isolated reefal buildup with no evidence of subaerial exposure (Fig. 9c). This upper reef/mound interval is onlapped by fine-grained facies of Unit 3. Unit 2 thickens to the northwest from ~25 to 100 m where it becomes difficult to discern from the underlying Unit 1 and forms a massive cliff-forming unit composed of fossiliferous lime packstone (Fig. 7a,b).

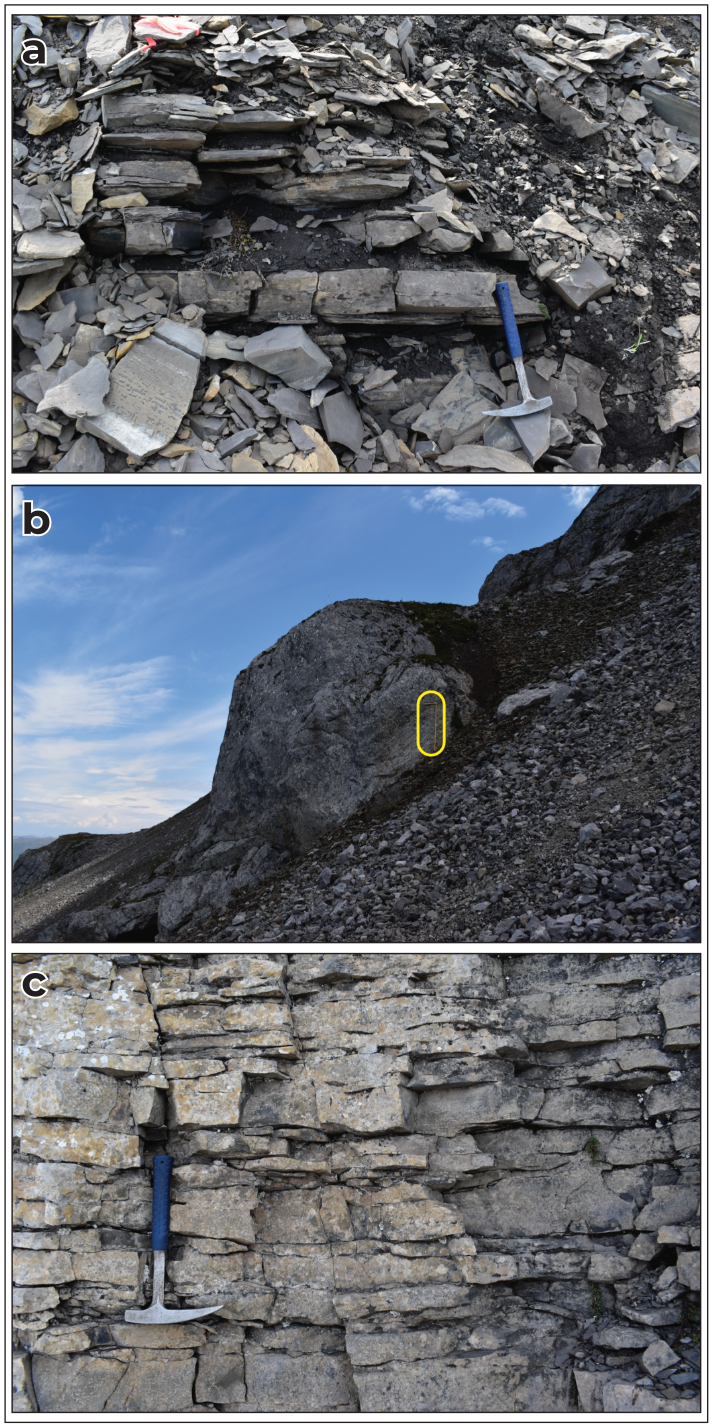


**Figure 8. (a)** *Thin and planar-bedded fossiliferous lime mudstone at the base of Unit 1;* **(b)** *isolated block in Unit 1 composed of recrystallized fossiliferous lime packstone surrounded and overlain by fossiliferous lime wackestone (m stick circled for scale); and* **(c)** *thin and wavy-bedded fossiliferous echinodermal lime packstone that comprises one of the clinoformal wedges in Unit 1 (see Fig. 7a).*


***Figure 9.*** ***(a)*** *gastropods and a possible stromatoporoid in a massive outcrop of fossiliferous lime packstone that comprises Unit 2;* ***(b)*** *nautiloid fossils found within the massive fossiliferous lime packstone of Unit 2;* ***(c)*** *in situ corals, including halysitid and favositid tabulate and rugosan corals, found on the uppermost surface of a Unit 2 reef shown in panel (d); and* ***(d)*** *dome-shaped reef buildup with ~10 m of stratigraphic relief and in situ corals at the top of Unit 2, which is onlapped by dark grey fossiliferous lime mudstone of Unit 3.*

Unit 3: This unit is approximately 10 to 75 m thick and comprises dark brown-grey thin to wavy-bedded fossiliferous lime wackestone, packstone, and mudstone that onlaps the top of Unit 2 and transitions laterally into microbial and stromatolitic boundstone. Fossil material includes crinoids, brachiopods, rugose corals and tabulate corals. Fossiliferous packstone intervals are often composed almost entirely of echinodermal debris with minor rugose or tabulate corals. Within intervals of stromatolitic and microbial boundstone, there are approximately 3 to 5 m wide dome-shaped features where bedding changes to nearly vertical (Fig. 10). Strata overlying these dome-shaped features are undeformed, suggesting they could represent large bioherms rather than structural deformation. Unit 3 is thickest in the southeastern part of the study area and thins notably towards the northwest.

***Figure 10.*** *Biohermal buildup (geologist for scale) near the base of Unit 3 within a thin to medium-bedded stromatolitic boundstone facies.*

Unit 4: This approximately 10 to 50 m thick unit consists of light to dark grey thin to wavy-bedded fossiliferous lime wackestone/packstone and boundstone with *in situ* tabulate and less abundant rugose corals (Fig. 11). The tabulate corals are silicified and are upright and in-place, rather than transported and overturned. The Unit 4–5 boundary is marked by an abrupt transition in fossil content from tabulate and rugose corals to disarticulated and whole brachiopods. The first appearance of brachiopods occurs as minor, thin, interbeds of relatively small shells. Within several metres, the corals disappear

***Figure 11.*** *In situ favositid tabulate coral at the base of Unit 4 within a thin and wavy-bedded fossiliferous wackestone.*

entirely, and the brachiopods occur in medium to thick, tabular, cross-stratified beds (Fig. 12a). Similar to Unit 3, it is thickest in the southeastern part of the study area and thins towards the northwest.

Unit 5: This approximately 50 to 100 m thick unit consists of light grey and thick-bedded brachiopod packstone and grainstone containing rare corals (Fig. 12a,b). Beds have tabular geometries and are cross-stratified. At the base, the brachiopod shells are small and grow larger and more abundant up-section. Farther up-section, these strata become entirely recrystallized and dolomitized with vuggy replacement of bioclasts. The brachiopod fossils disappear at the top of the unit, which is poorly exposed. This unit also is thickest in the southeastern part of the of the study area and thins towards the northwest.

Unit 6: This approximately 25 m thick unit consists of light grey and highly recrystallized sucrosic dolostone and limestone. The unit weathers massive and outcrops poorly until its top, where it transitions into a cliff-forming limestone containing no visible fossils (Fig. 7). This unit was not examined in detail due to its general inaccessibility.

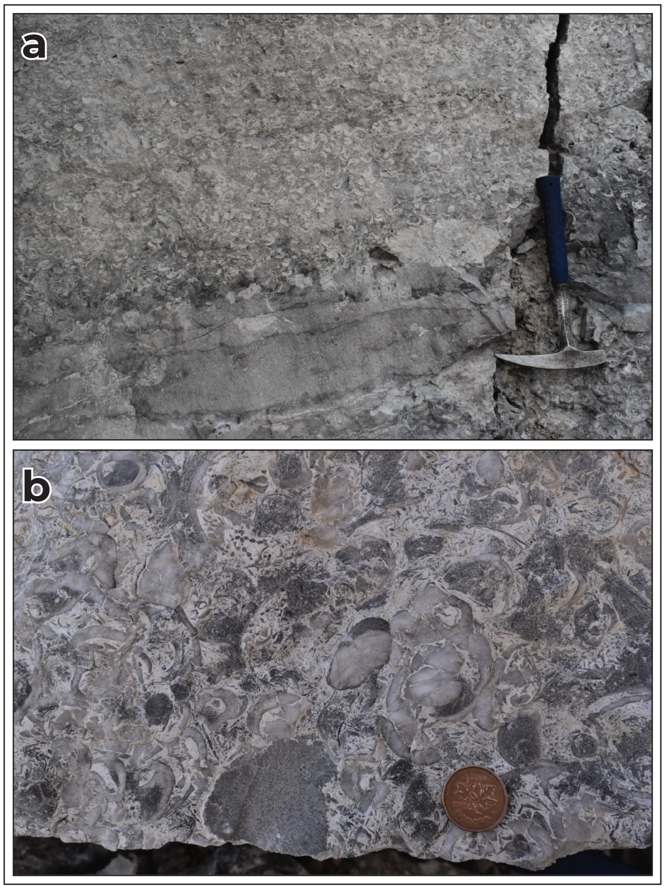


**Figure 12. *(a)*** *Medium to thick-bedded fossiliferous lime packstone composed mostly of brachiopod shells within Unit 5; and* ***(b)*** *fossiliferous lime packstone at the base of Unit 5 composed mostly of brachiopod shells with some clasts of halysitid and favositid tabulate corals.*

## Fossil Collections

The only previous age constraint on the Bouvette Formation in the Nadaleen Mountain map area was defined by an Early Ordovician gastropod collected approximately 15 km west of the study area (Colpron, 2012a). In 2018, a number of fossils were collected from measured sections south of Nadaleen Mountain (see Fig. 2; fossil locations 3, 4, 5) and preliminary identifications of coral fossils have been made. In 2017, a reconnaissance section was measured at the base of Nadaleen Mountain (J1721; Fig. 2) where several fossils were collected from the unnamed Cambrian limestone unit and the Bouvette Formation (see Fig. 2; fossil locations 1, 2). These fossil collections were recovered approximately 3 km from the detailed measured sections described herein, so future fieldwork in the area will focus on linking these strata more precisely to the units described above.

Sampling of limestone conglomerate beds in the reconnaissance section from Nadaleen Mountain (J1721; Fig. 2) produced arthropod-dominated collections from seven different horizons, all of them Cambrian in age. Completed work has focused on two horizons in the section from which sizeable collections were recovered: one at 241 m, within the unnamed limestone map unit, and the other at 520 m, within the unnamed conglomerate map unit. The collection from 520 m is particularly diverse both taxonomically and morphologically (see Fig. 13), and contains *Irvingella,* a cosmopolitan and biostratigraphically useful Furongian trilobite genus that is known to occur only in Paibian and basal Jiangshanian strata (Hong *et al.*, 2003; Westrop and Adrain, 2016). Like the trilobites and agnostoid arthropods recovered from similar deep marine, gravity flow deposits in the Quebec and Humber Arm allochthons in eastern Canada (*e.g.* Rasetti, 1944, 1948; Ludvigsen *et al.*, 1989), those extracted from the Nadaleen Mountain rudstone are very well preserved. Although disarticulated, they display little or no evidence of diagenetic degradation or tectonic deformation. Most specimens are testate, and original cuticle and diagnostic surface textures are very well preserved. Although the taxonomic and biostratigraphic evaluation of the collections is at an early stage, identified fossils confirm that at least three distinct fauna (Fig. 13) are represented in the material from the two particularly productive horizons. Accessory components of the fauna include brachiopods (phosphatic and calcitic), hyoliths, and a few problematic taxa.

As is typical of gravity flow deposits, age determinations are complicated by the composite nature of the debrites, whose fossil content can include not only the remains of organisms that lived at the time of deposition, but also older fauna reworked from significantly older deposits exhumed by erosion higher on the slope. The fossils recovered from the limestone rudstone at 241 m (unnamed limestone map unit) illustrate this problem well. Two distinct fauna are present, a younger one (241-Y) in the matrix (and/or nearly syndepositional

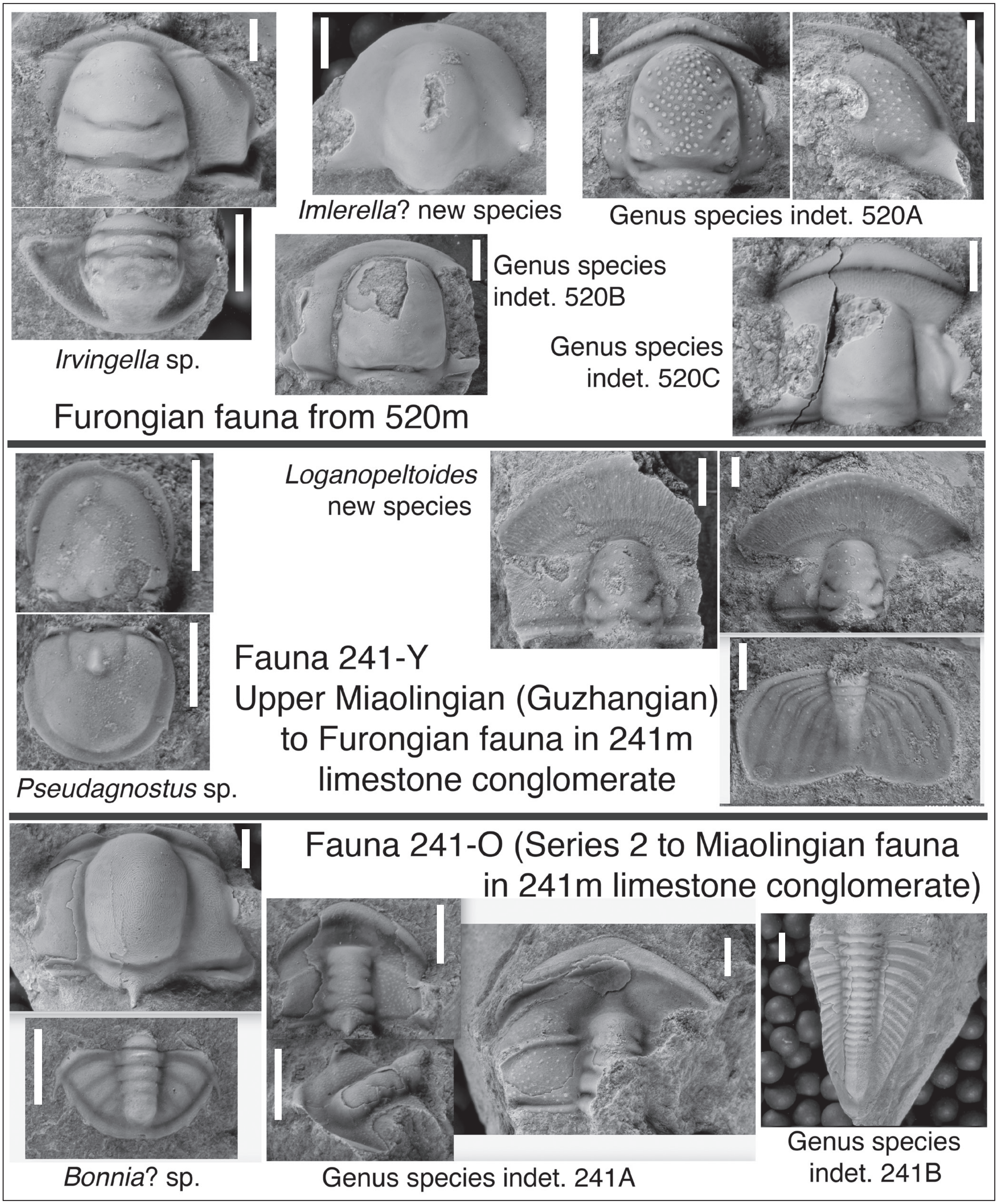


**Figure 13.** *Trilobites and agnostoid arthropods of the three Cambrian faunas recovered at fossil locality 1 (Fig. 2; section J1721) at Nadaleen Mountain from the unnamed limestone unit (Fauna 241-Y and 241-O) and Unit 1 of the Bouvette Formation (fauna from 520 m). White scale bar in each image is 2 mm long. Delineation of chronostratigraphic units (series and stages) follows Taylor et al. (2012).*

clasts) of light colored grainstone, and an older one (241-O) in well-indurated, darker grainstone clasts within the conglomerate (Fig. 13). These two fauna bracket the age of the unit. The presence of the agnostoid arthropod *Pseudagnostus* in the matrix fauna establishes the time of deposition as no older than late Miaolingian; the oldest documented occurrences of this genus, on multiple continents, lie within the uppermost stage of the Miaolingian, the Guzhangian Stage. The presence of *Loganopeltoides* in collection 241-Y would suggest that deposition occurred in the Jiangshanian, as all known species of that trilobite genus are from the Sunwaptan Stage of Laurentia (Ludvigsen *et al.*, 1989). However, the *Loganopeltoides* in 241-Y is a new species that is most similar to one previously reported from very low within the Sunwaptan. Consequently, a Paibian or even older age for the rudstone at 241 m in the unnamed Cambrian limestone unit is quite possible.

The older fauna (241-O) in the dark clasts is dominated by a species that represents one of several intergrading dorypigid trilobite genera that occur only in sub-Furongian strata (Fig. 13). It most closely resembles species that have been assigned to the "early Cambrian" (Series 2) genus *Bonnia*, but also is similar to many species of *Kootenia*, which occurs in both Series 2 and the "middle Cambrian" (Miaolingian Series). Two other distinctive genera associated with the dorypgid in fauna 241-O have not yet been identified precisely; hopefully when they are identified it will resolve whether that fauna is "early" or "middle" Cambrian in age. Similarly, the age of the 520 m collection (unnamed conglomerate map unit) is likely to be constrained more tightly as a number of distinctive trilobites are identified with greater precision (Fig. 13).

In addition to these arthropod collections from the underlying unnamed limestone and conglomerate units, we also discovered Middle to Upper Ordovician coral and gastropod specimens of *Grewingkia* sp., *Septentrionites* sp., *Paleofavosites*, and *Maclurites* sp. (Fig. 14; identified by Robert Blodgett of Blodgett and Associates LLC) in the Bouvette Formation along the northern edge of Nadaleen Mountain (Fig. 2; fossil location 2). These strata are most likely correlative with Unit 1 described above. Fossils collected in 2018 are from the Bouvette Fromation in the area south of Nadaleen Mountain (Fig. 2; fossil locations 3, 4, 5) and include *in situ* specimens from the upper surface of Unit 2 (see Fig. 9c) and *in situ* specimens from within Unit 4 (see Fig. 11; identified by Robert J. Elias, University of Manitoba). The fossils identified from the top of Unit 2 (JB1825, JB1831, MS1803) include solitary rugose coral, *Streptelasmatine*; colonial rugose coral, *Palaeophyllum* sp., and halysitid tabulate corals, *Catenipora* sp. Fossils identified from within Unit 4 include a favositid tabulate coral, likely *Paleofavosites*. The corals identified above could range from Late Ordovician (Richmondian) to early Silurian (Llandovery).

## Discussion

Our preliminary observations from the Bouvette Formation near Nadaleen Mountain are presented as an initial geological map of the study area, biostratigraphic age data from collected fossil material, and sedimentological/stratigraphic data from measured sections and UAV imagery. Throughout the area adjacent to, and south of Nadaleen Mountain, the Guzhangian–Furongian unnamed Cambrian limestone map unit disconformably overlies the Cambrian Series 2–5 Gull Lake Formation (Fig. 2), which represents a significant depositional hiatus that may correlate with the Sauk II–III unconformity (Taylor *et al.*, 2012) and similar hiatal surfaces exposed throughout northwestern Canada (*e.g.*, Gordey and Anderson, 1993; Pigage *et al.*, 2015; Moynihan *et al.*, *accepted*).

Preliminary geological mapping in the Nadaleen Mountain area also facilitates the recognition of a poorly understood conglomeratic unit that was previously mapped as either belonging to the *ca.* 499 Ma Old Cabin volcanic rocks or part of the basal Bouvette Formation (Colpron, 2012a; Moynihan, 2016). The basal portion of the conglomerate unit transitions from carbonate-clast rudstone exposed at the base of Nadaleen Mountain (see 2017 camp location; Fig. 2) into volcaniclastic conglomerate south of Nadaleen Mountain (see 2018 camp location; Fig. 2), potentially highlighting a complex stratigraphic relationship between the unnamed Cambrian limestone unit and the basal Bouvette Formation. Additionally, the upper surface of the unnamed conglomerate is marked by an irregular interval of brecciated limestone with

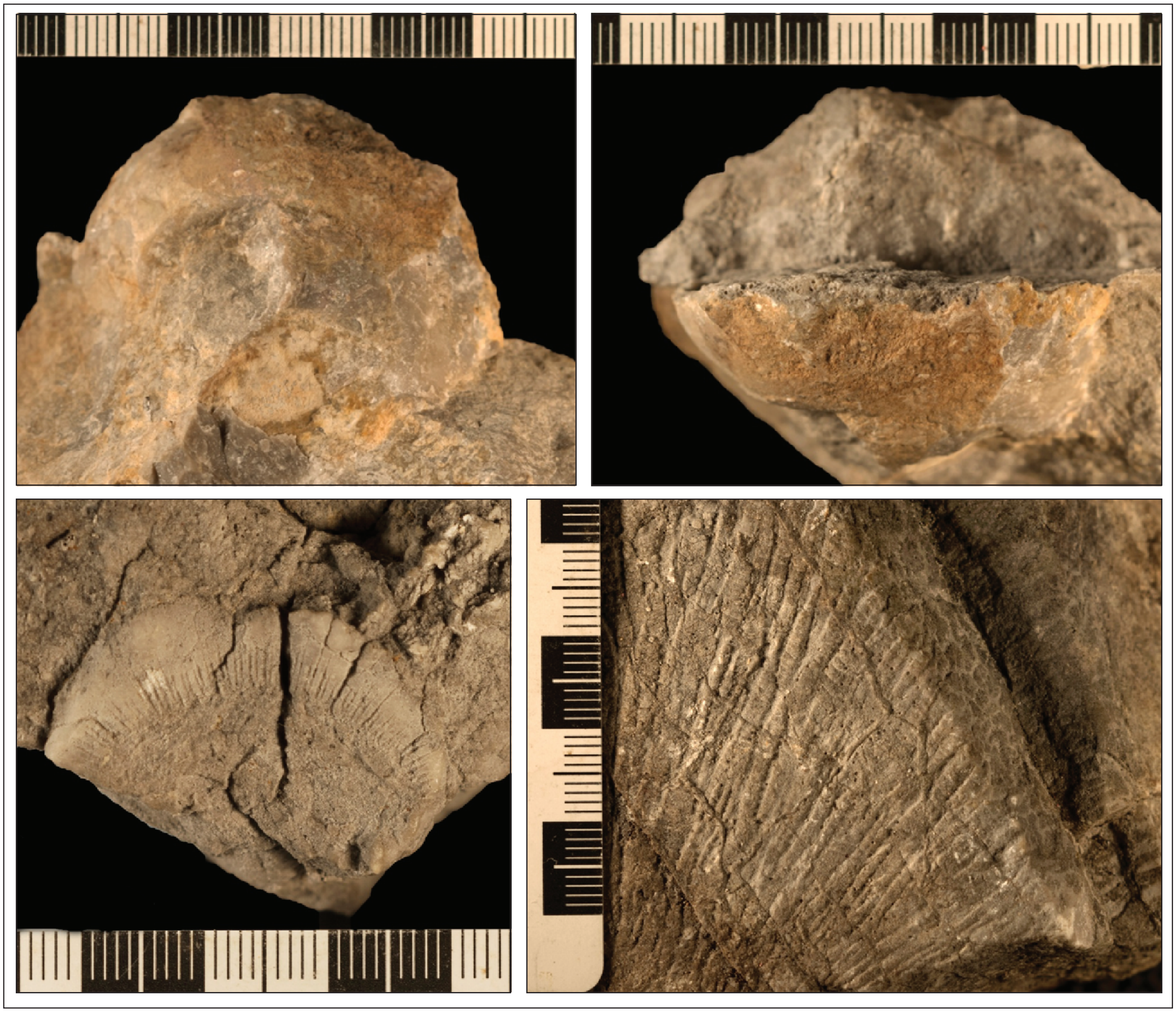

***Figure 14.** Fossils collected at locality 2 (Fig. 2): Maclurites sp. **(a)** basal view **(b)** side view; **(c)** Grewingkia sp. solitary rugose coral; and **(d)** Septentrionites(?) sp. tabulate coral. Scale bar increments are in mm.*

significant erosional relief and pervasive evidence of subaerial exposure (Figs. 4 and 7). Above this surface, our preliminary biostratigraphic data suggest Middle to Upper Ordovician tabulate and rugose corals and gastropods appear (Fig. 14), implying this unit boundary may represent a significant hiatus during which the platform was exposed to subaerial conditions. This exposure event is potentially correlative with the Sauk–Tippecanoe sequence boundary of Laurentia (Taylor *et al.*, 2012), although future biostratigraphic work is needed to explore this further.

The preliminary measured stratigraphic sections and UAV imagery also reveal several important stratigraphic features, sedimentary facies and fossil assemblages within the Bouvette Formation that are unique to both platform reef margin and forereef depositional environments. Important depositional features in the Nadaleen Mountain area include two approximately 5 to 30 m thick stacked clinoformal wedges of fossiliferous packstone in Unit 1, which thicken to the northwest in the study area and are composed of crinoid, brachiopod and coral fossil debris (Figs. 7a and 8c).

A third massive approximately 15 to 100 m thick wedge in Unit 2 composed entirely of reef fossil debris and topped by domal tabulate and rugose coral reef buildups also thickens to the northwest in a clinoformal geometry (Figs. 7a and 9). The thinning of wedges of reef-derived material to the southeast in the study area, in clinoform-like geometries, strongly suggests a general deepening to the southeast towards the Selwyn basin and away from the Ogilvie platform interior.

Clinoformal wedges of platform reef talus composed of fossiliferous debris are common in fore-reef environments (*e.g.*, Enos and Moore, 1983). Furthermore, the interpreted clinoforms in units 1 and 2 require sufficient accommodation for the deposition of thick wedges of material with significant thickness changes along depositional dip. Collectively, these observations are more consistent with a forereef environment than a reef crest or deep-water basinal environment during the deposition of units 1 and 2. Additionally, the presence of possible allochthonous blocks within Unit 1 (Figs. 6 and 8b) are common in forereef and talus slope environments (Enos and Moore, 1983). The dome-shaped upper surface of Unit 2, containing *in situ* corals, is suggestive of a shallowing-upwards transition between Unit 1 and the top of Unit 2, from the wedge of peri-platform talus onto the lower reef crest. Further stratigraphic analysis is required to validate these initial interpretations of the Bouvette Formation depositional setting.

Another interesting observation within the Bouvette Formation at Nadaleen Mountain is the dramatic shift from coral-dominated fossiliferous packstone of Unit 4 to brachiopod-dominated fossiliferous packstone of Unit 5 (Fig. 12). This shift in the dominant fossil material between units having identical sedimentary facies happens rapidly, with the first appearance of brachiopod fossils being accompanied by complete dominance of this fossil type within several metres of strata. This shift in dominant fossil type within the same sedimentary facies may suggest an important palaeoceanographic or ecological shift at the boundary of units 4 and 5. The significance of this finding will be assessed through future field observations, collection of additional fossil specimens, and chemostratigraphic analyses.

In summary, this study describes, for the first time, the platform edge of the Bouvette Formation as it transitions into the Selwyn basin. The Bouvette Formation in the Nadaleen Mountain area is composed predominately of reef–forereef carbonate facies, making it perhaps the best place to describe the Bouvette Formation due to the excellent preservation of sedimentary facies, fossil material, and depositional features. The Bouvette Formation at Nadaleen Mountain shares similarities to the Royal Mountain area to the northeast (NTS 106E), where the Royal Mountain platform transitions into the Richardson trough, highlighting another area that could elucidate the depositional history of the Yukon block and different tectonic or oceanographic events that affected northwest Laurentia. Finally, there are few examples of well-exposed early Paleozoic reef–forereef successions elsewhere in the world. This study of the margin of the Ogilvie platform will be an excellent contribution to the understanding of early Paleozoic paleontology, sequence stratigraphy, paleogeography, and paleoenvironmental change. The extraordinary exposure afforded at Nadaleen Mountain will allow for a complete 3-D reconstruction of the depositional system at the margin of a large, shallow-water carbonate platform and will afford a view into this important, but rarely preserved sedimentary environment.

## Future Work

Future work on the Bouvette Formation in the Nadaleen Mountain area will include detailed geological mapping of the study area, additional measured sections of the strata that overlie Unit 6, collection of additional fossil material in the previously measured units 1 through 5, and further collection of UAV imagery. Importantly, the six units described from the Bouvette Formation south of Nadaleen Mountain will be traced to the north into the more massive platformal facies which occur adjacent to Nadaleen Mountain in order to better understand the transitional relationship between reef platform and reef margin facies. Carbonate samples collected for carbon isotope chemostratigraphy and conodont biostratigraphy will also be analyzed to develop a more rigorous chronology to support regional correlations of the Bouvette and underlying stratigraphy. These data will then be combined with three-dimensional elevation models generated from the UAV imagery to create a complete depositional model of the Bouvette Formation in the Nadaleen Mountain area.

## Acknowledgements

We acknowledge the Yukon Geological Survey (YGS) for their generous support of this project. This research was also partially funded by an American Association of Petroleum Geologists (AAPG) Richard W. Beardsley Grant awarded to JFB and a National Science Foundation Grant awarded to JVS (EAR-1624131). Erik Sperling and Tom Boag helped with fieldwork in 2017, and ATAC Resources provided logistical assistance and access to helicopter support with Horizon Helicopters during 2017 and 2018. We would like to thank Julia Lane at ATAC, Karl Marlowe at Barrick, and David Moynihan at the YGS for helpful discussions about the field area. David Moynihan at the YGS provided constructive feedback on a preliminary draft of this manuscript.

## References

Abbott, G., 1997. Geology of the upper Hart River area, eastern Ogilvie Mountains, Yukon Territory (116A/10, 116A/11). Whitehorse, Indian and Northern Affairs Canada, Exploration and Geological Services Division, Yukon Region, Bulletin 9, 92 p.

Blusson, S.L., 1974. Five geological maps of northern Selwyn Basin (Operation Stewart), Yukon Territory and District of Mackenzie (105N, O; 106A, B, C). Geological Survey of Canada, Open File 205, scale 1:250 000.

Blusson, S.L., 1968. Geology and Tungsten Deposits near the Headwaters of Flat River, Yukon Territory and southwestern District of Mackenzie, Canada. doi: 10.4095/102251.

Brabb, E.E., 1967. Stratigraphy of the Cambrian and Ordovician rocks of east-central Alaska. United States Geological Survey, Professional Paper 559-A, 30 p.

Cecile, M.P., 1982. The lower Paleozoic Misty Creek Embayment, Selwyn Basin, Yukon and Northwest Territories. Geological Survey of Canada, Bulletin 335, 78 p.

Cecile, M P., 2000. Geology of the northeastern Niddery Lake map area, east-central Yukon and adjacent Northwest Territories. Geological Survey of Canada, Bulletin 553, 120 p.

Cecile, M.P., Morrow, D.W. and Williams, G.K., 1997. Early Paleozoic (Cambrian to Early Devonian) tectonic framework, Canadian Cordillera. Bulletin of Canadian Petroleum Geology, vol. 45, p. 54–74.

Cohen, K.M., Finney, S.C., Gibbard, P.L. and Fan, J.X., 2013; updated. The ICS International Chronostratigraphic Chart. Episodes, vol. 36, p. 199–204.

Colpron, M., 2012a. Preliminary geological map of the Mount Ferrell area (106C/3), central Yukon. Yukon Geological Survey, Open File 2012-11, 1:50 000 scale.

Colpron, M., 2012b. Preliminary observations on the geology of the Rackla belt, Mount Ferrell map area (NTS 106C/3), central Yukon. *In*: Yukon Exploration and Geology 2011, K.E. MacFarlane and P.J. Sack (eds.), Yukon Geological Survey, p. 27–43.

Colpron, M., Moynihan, D., Israel, S. and Abbott, G., 2013. Geological map of the Rackla belt, east-central Yukon (NTS 106C/1-4, 106D/1). Yukon Geological Survey, Open File 2013-13, 1:50 000 scale, 5 maps and legend.

Enos, P. and Moore, C.H., 1983. Fore-reef Slope Environment. *In*: Carbonate Depositional Environments, P.A. Scholle, D.G. Bebout and C.H. Moore (eds.), AAPG Memoir Vol. 33, Chapter 10, p. 507–533.

Fritz, W.H., 1997. Cambrian (Chapter 5); *In*: The Geology, Mineral, and Hydrocarbon potential in Northern Yukon Territory and Northwestern District of Mackenzie, D.K. Norris (ed.), Geological Survey of Canada, Bulletin 422, p. 85–117.

Fritz, W.H., 1982. Report on Two Collections Of Cambrian Fossils From The Ogilvie Mountains, Yukon. Collected by R.I. Thompson, 1982 (NTS: 116C), Geological Survey of Canada, Paleontological Report C-4-WHF-1982, 1 p.

Gordey, S.P. and Anderson, R.G., 1993. Evolution of the Northern Cordilleran Miogeocline, Nahanni Map Area (105I), Yukon and Northwest Territories. Geological Survey of Canada, Memoir 428, 214 p.

Green, L.H., 1972. Geology of Nash Creek, Larsen Creek, and Dawson Map-Areas, Yukon Territory. Geological Survey of Canada, Memoir 364, 157 p.

Herbosch, A. and Verniers, J., 2011. What is the biostratigraphic value of the ichnofossil *Oldhamia* for the Cambrian: a review. Geologica Belgica, vol. 14, p. 229–248.

Hofmann, H. J., Cecile, M. P. and Lane, L. S. 1994. New occurrences of *Oldhamia* and other trace fossils in the Cambrian of the Yukon and Ellesmere Island, Arctic Canada. Canadian Journal of Earth Sciences, vol. 31, p. 767–782.

Hong, P.S., Choi, D.K. and Lee, J.G., 2003. Late Cambrian trilobite *Irvingella* from the Machari Formation, Korea: evolution and correlation. Special Papers in Palaeontology, vol. 70, p. 175–196.

Lenz, A.C., 1972. Ordovician to Devonian history of northern Yukon and adjacent District of Mackenzie. Bulletin of Canadian Petroleum Geology, vol. 20, p. 321–361.

Ludvigsen, R., Westrop, S.R. and Kindle, C.H., 1989. Sunwaptan (Upper Cambrian) trilobites of the Cow Head Group, western Newfoundland, Canada. Palaeontographica Canadiana, vol. 6, 175 p.

MacNaughton, R.B., Moynihan, D.P., Roots, C.F. and Crowley, J.L., 2016. New occurrences of *Oldhamia* in eastern Yukon, Canada: Stratigraphic context and implications for Cambrian deep-marine biostratigraphy. Ichnos, vol. 23, p. 33–52.

Morrow, D.W., 1999. Lower Paleozoic stratigraphy of northern Yukon Territory and northwestern District of Mackenzie. Geological Survey of Canada, Bulletin 538, 202 p.

Moynihan, D., 2014. Bedrock Geology of NTS 106B/04, Eastern Rackla Belt. In: Yukon Exploration and Geology 2013, K.E. MacFarlane, M.G. Nordling and P.J. Sack (eds.), Yukon Geological Survey, p. 147–167.

Moynihan, D., 2016. Bedrock geology compilation of the eastern Rackla belt, NTS 105N/15, 105N/16, 105O/13, 106B/4, 106C/1, 106C/2, east-central Yukon. Yukon Geological Survey, Open File 2016-2, scale 1:75 000, 2 sheets.

Moynihan D., Strauss, J.V., Padget, C.D., Nelson, L.L., *accepted* 2018. Upper part of the Windermere Supergroup in the Nadaleen River area, east-central Yukon: stratigraphy, regional correlations and implications for development of the western Laurentian continental margin. The Geological Society of America Bulletin.

Mustard, P.S., Donaldson, J.A. and Thompson, R.I., 1988. Trace fossils and stratigraphy of the Precambrian-Cambrian boundary sequence upper Harper group, Ogilvie Mountains, Yukon. *In*: Current Research, Part E, Geological Survey of Canada, Paper 88-1E, p. 197–203.

Norris, A.W., 1985. Stratigraphy of Devonian outcrop belts in northern Yukon Territory and northwestern District of Mackenzie (Operation Porcupine area). Geological Survey of Canada, Memoir 410, 81 p.

Norris, D.K., 1982. Geology: Ogilvie River, Yukon Territory. Geological Survey of Canada, Map 1526A, scale 1:250 000.

Pigage, L.C., 2004. Bedrock geology compilation of the Anvil District (parts of NTS 105K/2, 3,5, 7, and 11), Central Yukon. Yukon Geological Survey, Bulletin 15, 103 p.

Pigage, L.C., Abbott, J.G. and Roots, C.F., 2011. Bedrock geology of Coal River map area (NTS 95D), Yukon (1:250 000 scale). Yukon Geological Survey, Open File 2011-1.

Pigage, L.C., Roots, C.F. and Abbott, J.G., 2015. Regional bedrock geology for the Coal River map area (NTS 95D), southeast Yukon. Yukon Geological Survey, Bulletin 17, 155 p.

Pyle, L.J., 2012. Cambrian and Lower Ordovician Sauk megasequence of northwestern Canada, northern Rocky Mountains to the Beaufort Sea. *In*: The great American carbonate bank: The geology and economic resources of the Cambrian – Ordovician Sauk megasequence of Laurentia, J.R. Derby, R.D. Fritz, S.A. Longacre, W.A. Morgan and C.A. Sternbach (eds.), American Association of Petroleum Geologists, AAPG Memoir 98, p. 675–723.

Rasetti, F., 1944. Upper Cambrian trilobites from the Levis Conglomerate. Journal of Paleontology, vol. 18, p. 229–258.

Rasetti, F., 1948. Lower Cambrian trilobites from the conglomerates of Quebec. Journal of Paleontology, vol. 22, p. 1–24.

Taylor, J.F., Allen, T.J., Repetski, J.E., Strauss, J.V. and Irwin, S.J., 2015. Life on the edge in eastern Alaska: Basal Ordovician (Tremadocian), platform-margin faunas of the Jones Ridge Formation. Stratigraphy, vol. 12, p. 71–77.

Taylor, J.F., Repetski, J.E., Loch, J.D. and Leslie, S.A., 2012. Biostratigraphy and chronostratigraphy of the Cambrian – Ordovician great American carbonate bank. *In*: The great American carbonate bank: The geology and economic resources of the Cambrian – Ordovician Sauk megasequence of Laurentia, J.R. Derby, R.D. Fritz, S.A. Longacre, W.A. Morgan and C.A. Sternbach (eds.), American Association of Petroleum Geologists, AAPG Memoir 98, p. 15–35.

Westrop, S.R. and Adrain, J.M., 2016. Revision of *Irvingella tropica* Opik 1963 from Australia and related species from North America: implications for correlation of the base of the Jianghsanian Stage (Cambrian, Furongian). Australasian Palaeontological Memoirs, vol. 49, p. 395–432.

Yukon Geochronology, 2018. Yukon Geochronology – A database of Yukon geochronology sample locations, M. Colpron (compiler). Yukon Geological Survey, http://data.geology.gov.yk.ca/Compilation/22, [accessed November 13, 2018].