

Preliminary report on the bedrock geology of the Rackla River area, southern Wernecke Mountains, Yukon (parts of NTS 106C/4, 5 and 106D/1, 8)

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Abstract

The Rackla River area is underlain by normal faulted and gently folded sedimentary strata of the Paleoproterozoic Wernecke Supergroup, Mesoproterozoic Pinguicula Group, Neoproterozoic Hematite Creek Group and Windermere Supergroup, and Paleozoic Bouvette Formation. Gabbro dikes and sills that are likely age equivalent to the ca. 1380 Ma Hart River Sills cut the Wernecke Supergroup rocks. The presence of a mafic volcanoclastic horizon within the Bouvette allows its informal subdivision into a lower and upper member. These volcanoclastic rocks may be the distal equivalent to volcanic rocks near the Tiger deposit, located ~20 km to the southwest. Three major angular unconformities are documented in the map area: at the base of the Rapitan Group, the base of the lower Bouvette, and the base of the upper Bouvette Formation.

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Introduction

This paper presents preliminary results from 1:50 000-scale geological mapping conducted during 2019 in the Rackla River area, southern Wernecke Mountains, east-central Yukon. The mapped area covers ~300 km² and includes parts of NTS map sheets 106C/4 (Mount Mervyn), 106C/5 (Rusty Mountain), 106D/1 (Mount Westman) and 106D/8 (Mount Good). Prior to this study, most of the area was mapped at the 1:250 000 reconnaissance scale (Blusson, 1974). The area is host to significant mineralization, including the Val (Yukon MINFILE 106C 085, 116, 117) and Vera (Yukon MINFILE 106C 083, 114) occurrences, that justifies more detailed mapping.

Previous work

Aside from the westernmost part, Blusson (1974) previously mapped the area as part of a series of four

1:250 000-scale maps of the northern Selwyn basin. Delaney (1981) described and subdivided the Wernecke Supergroup into the Fairchild Lake, Quartet, and Gillespie Lake groups. Eisbacher (1981) described the Pinguicula Group and divided it into units A–F. Roots (1990) mapped the adjacent 1:50 000-scale sheets to the west (eastern half of 106D/7 and 106D/8). Abbott (1997) and Thorkelson (2000) mapped similar Proterozoic stratigraphy in the Hart River (116A/10, 11) and northern Wernecke (106D/16, 106C/13, 14) inliers, respectively. Based on the interpretation of an unconformity between Pinguicula C and D of Eisbacher (1981), Thorkelson (2000) reassigned Pinguicula Group units D–F into the newly defined Hematite Creek Group. Morrow (1999) formalized and described the type section of the Bouvette Formation. Turner (2011) formalized the Hematite Creek Group and assigned it to the lowermost Mackenzie Mountains Supergroup. To the south of the map area, in the Rackla belt,

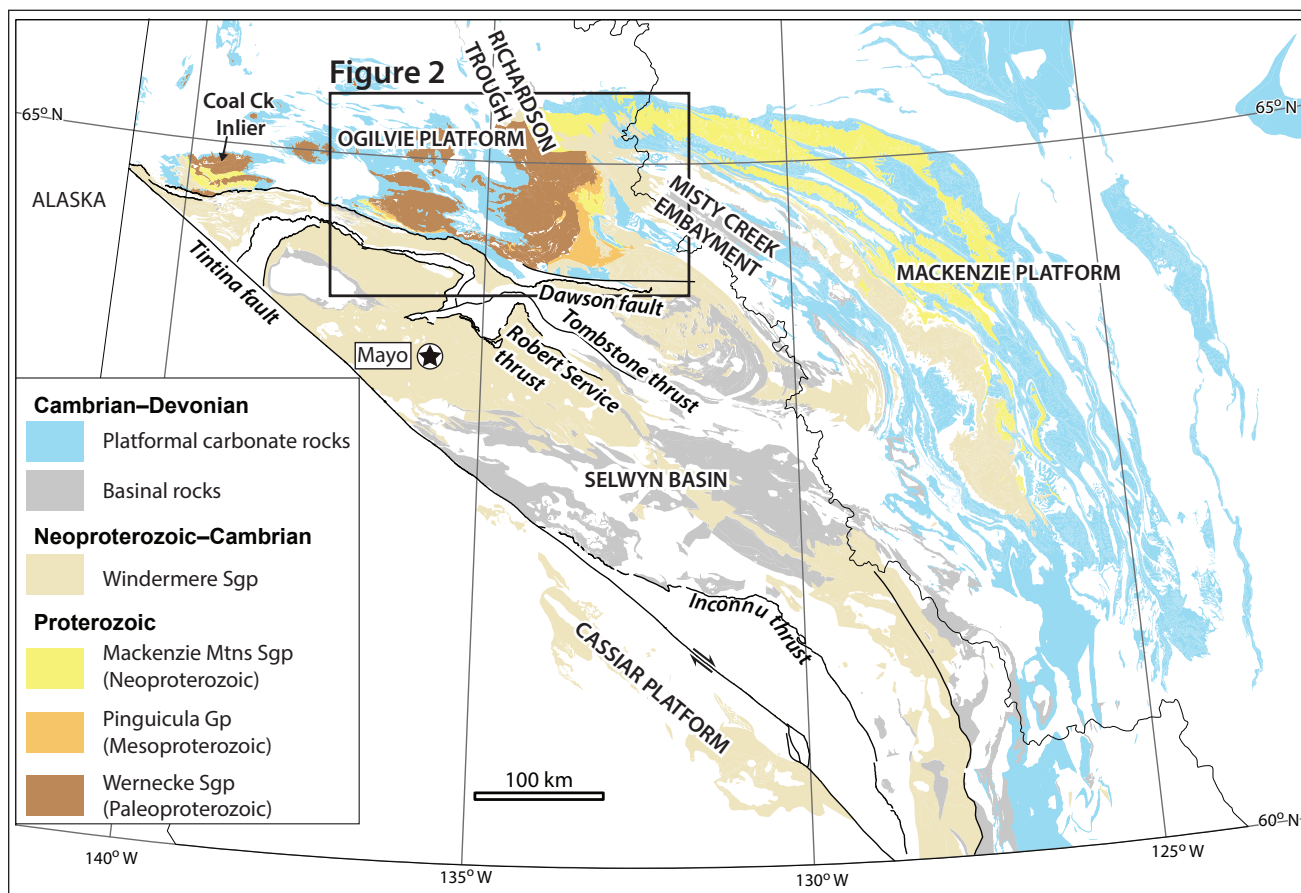


Figure 1. Simplified geological map of eastern Yukon and western Northwest Territories illustrating the distribution of Proterozoic through to Devonian assemblages (after Moynihan et al., 2019). The study area is located within the Wernecke Inlier, the farthest east, and largest of several erosional windows that expose Paleoproterozoic and Mesoproterozoic rocks.

Colpron et al. (2013) mapped five 1:50 000-scale map sheets (106C/1–4 and D/1), and Moynihan (2014) mapped 106B/4. Medig et al. (2016) described and formalized type sections for the Pinguicula Group in the Wernecke Inlier. Moynihan et al. (2019) defined the Rackla Group of the Windermere Supergroup. Property-scale mapping, conducted by Sivertz (1980), W.G. Timmins Exploration & Development Ltd. (1983), Waugh (1989) and Eaton (1999), focused on the Val and Vera mineral occurrences.

Location and geological setting

The mapped area is located in the southern Wernecke Mountains, ~120 km NE of Mayo (Figs. 1 and 2). Access is by a fixed-wing flight from Mayo to Rackla airstrip (64.22°N 133.21°W) followed by a helicopter flight to the field area. The map area is located along the southern margin of the Wernecke Inlier (Figs. 1 and 2). Along with the Coal Creek and Hart River inliers to the west, the Wernecke Inlier is an erosional window through the Phanerozoic cover of Ancestral North

America into the underlying Proterozoic stratigraphy. The Proterozoic rocks exposed in these inliers include the oldest non-crystalline rocks exposed in the Cordillera and provide clues to the Proterozoic evolution of northwestern Canada. The inliers are located north of the Dawson fault on the relatively thick lithosphere of the Yukon stable block (Lenz, 1972). The Dawson fault marks the northern boundary of the Selwyn basin, a Paleozoic feature that developed on comparatively thin lithosphere.

The map area exposes Proterozoic through Paleozoic rocks (Fig. 3). The southern margin of the map is the Kathleen Lakes fault, which is nearly coincident with the East Rackla River. The Rackla River flows south through the central part of the map. The oldest rocks exposed in the Wernecke Inlier are Paleoproterozoic rocks of the Wernecke Supergroup and Mesoproterozoic Rocks of the Pinguicula Group. Overlying these successions are the Neoproterozoic Hematite Creek Group, the Neoproterozoic to earliest Cambrian Windermere Supergroup, and the Cambrian to Devonian Bouvette Formation (Fig. 4).

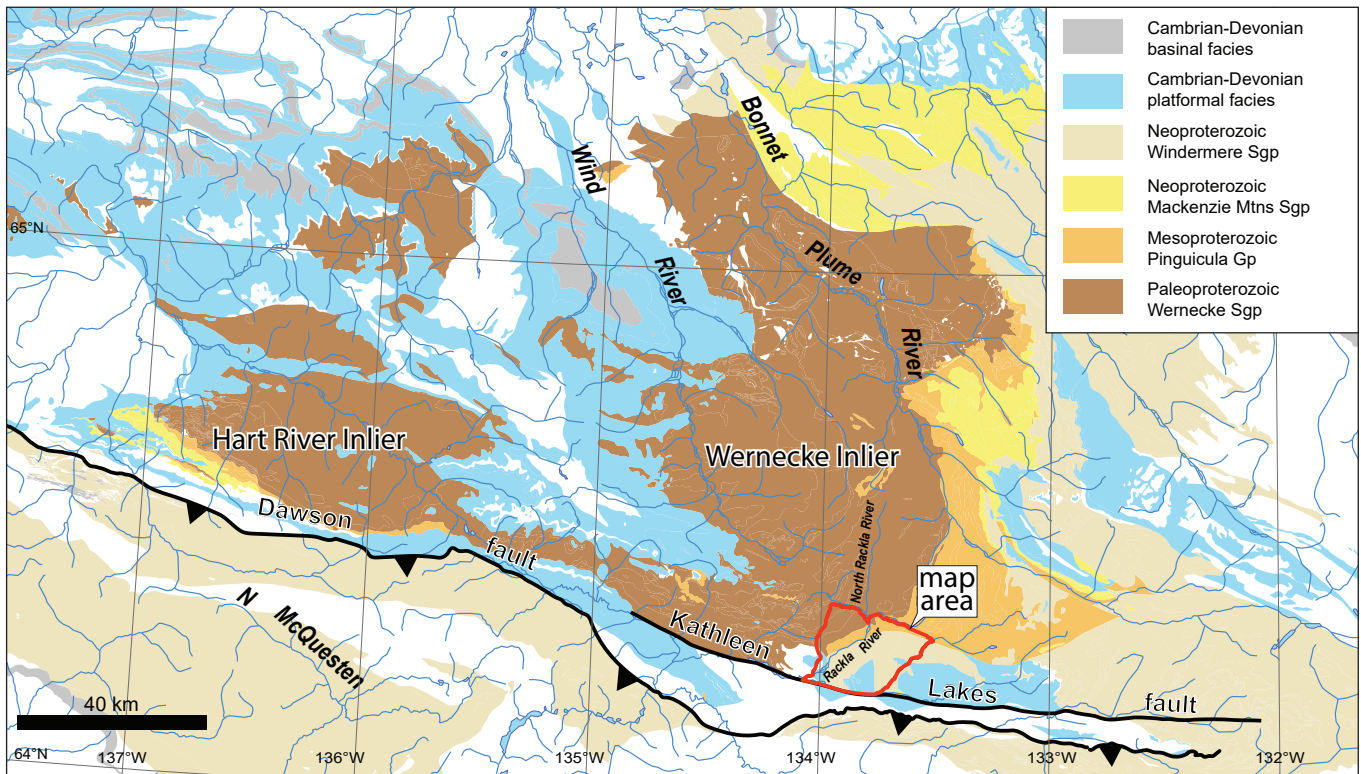
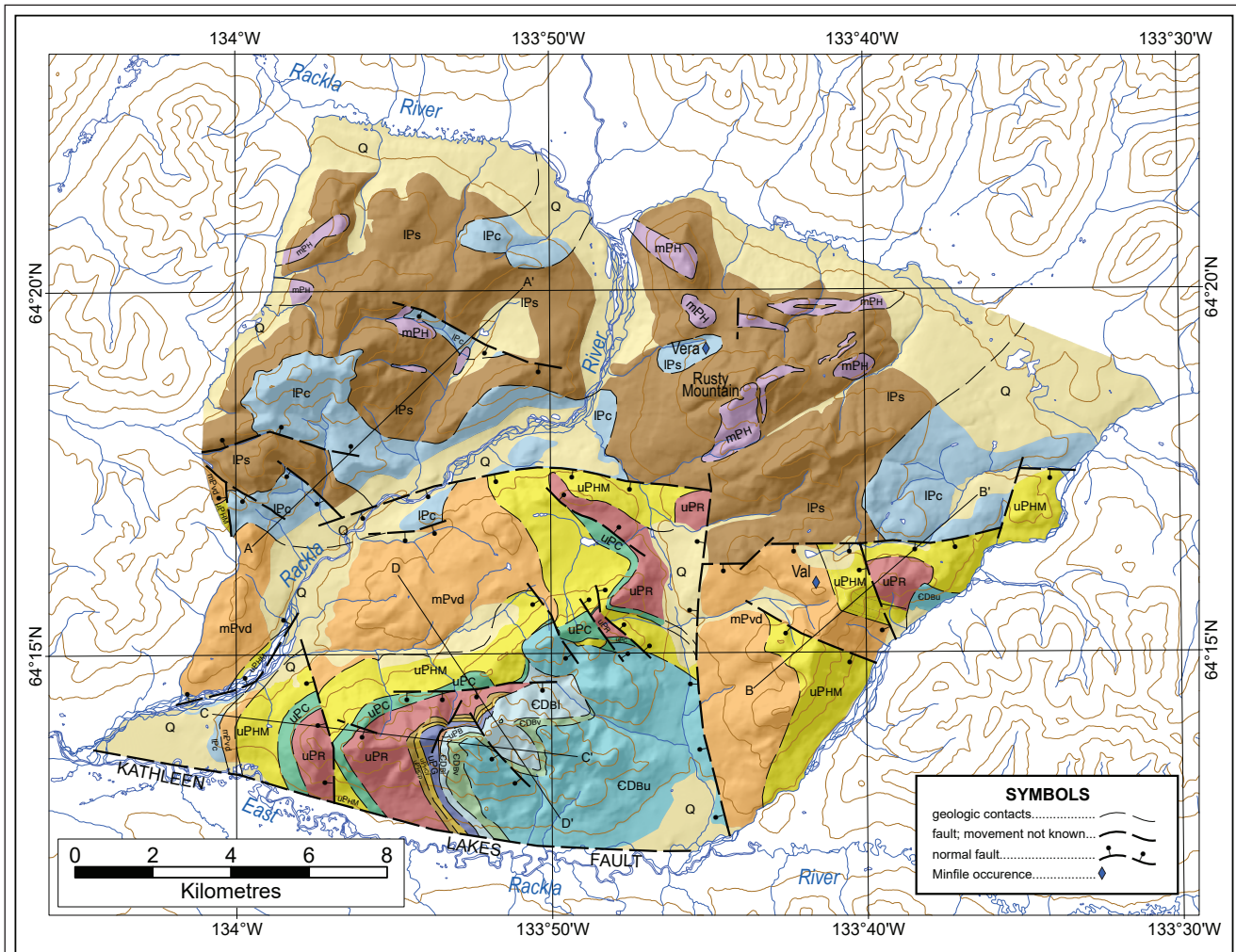


Figure 2. Simplified geological map of the Wernecke and Hart River inliers. Location is shown in Figure 1. The map area (outlined in red) is located north of the Dawson and Kathleen Lakes faults, and across the southern margin of the Wernecke Inlier. Geology from Colpron et al. (2016).



QUATERNARY

Q unconsolidated alluvial, colluvial, fluvial, and glacial deposits

CAMBRIAN TO DEVONIAN

BOUVETTE FORMATION

CDBu UPPER MEMBER: light to medium grey weathering dolostone; commonly thickly bedded; locally fossiliferous

CDbv VOLCANICLASTIC MEMBER: grey, green and orange weathering volcaniclastic sandstone and conglomerate; locally fossiliferous

CDbl LOWER MEMBER: light to medium grey weathering sugary dolostone

EDIACARAN

RACKLA GROUP

uPB BLUEFLOWER FORMATION: brown weathering shale and siltstone

uPG GAMETRAIL FORMATION: Well bedded and laminated grey, buff, maroon, yellow-orange, and green weathering silty lime- and dolo-mudstone

CRYOGENIAN-EDIACARAN

HAY CREEK GROUP

uPHCr RAVENSTHROAT FORMATION: grey and cream weathering dolostone, gray and black chert; local chaotic bedding and tepee structures

uPHCp MOUNT PROFEIT DOLOSTONE/ICE BROOK FORMATION: grey and cream weathering dolostone; light-grey weathered carbonate-clast diamictite

CRYOGENIAN

RAPITAN GROUP

uPR orange, maroon, and brown weathering clast- to matrix-supported diamictite; maroon and green shale, siltstone and sandstone intervals

TONIAN

CALLISON LAKE FORMATION

uPC light to medium grey weathering dolostone with irregular chert layers; commonly laminated; locally silica replaced oolitic grainstone; locally hematite-cement conglomerate

NEOPROTEROZOIC

HEMATITE CREEK GROUP

uPHM laminated, medium to very thickly bedded grey, purple, and orange weathering quartz sandstone, with subordinate shale, siltstone, limestone, red-weathering stromatolitic dolostone, and orange-weathering dolostone and dolomitic siltstone

MESOPROTEROZOIC (?)

"VAL DOLOSTONE"

mPvd dark and light grey laminated dolostone with local zebra textures

MESOPROTEROZOIC

HART RIVER SILLS

mPH medium-grey weathering fine- to medium-grained greenish-grey gabbro sills and dikes

PALEOPROTEROZOIC(?)

LOWER CARBONATE UNIT

IPc well-bedded, laminated, grey and orange weathering dolostone and limestone that is commonly cross-laminated; dolomitic/calcareous shale, siltstone, sandstone and intraclast rudstone

LOWER CLASTIC UNIT

IPs grey, brown, black, terracotta, green and blue weathering shale, siltstone and sandstone; locally phyllitic and slaty; locally conglomerate;

Figure 3. Simplified geological map of the Rackla River area.

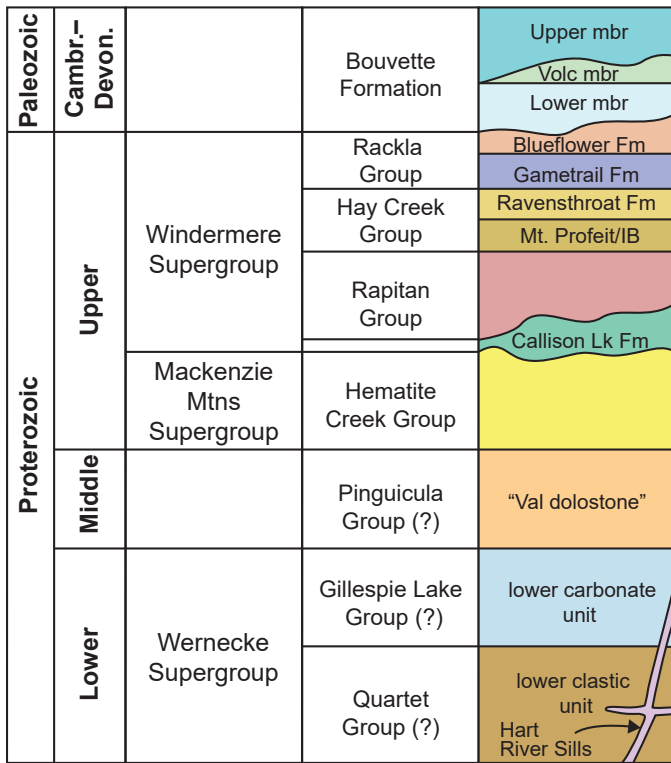


Figure 4. Stratigraphy and tentative correlations of the Rackla River area.

Stratigraphy

Lower clastic unit

The oldest unit (lower clastic unit) is exposed in the northern and central part of the map area and consists of brown, blue, green, black, terracotta and grey weathering laminated shale, siltstone, and sandstone (Figs. 3–5). Planar parallel laminations are common (Fig. 5a,b) and wavy laminations are locally observed. An interval of sandstone interbedded with matrix to clast-supported conglomerate containing clasts of limestone, siltstone, and chert is present at one locality west of Rusty Mountain. Siltstone and sandstone beds are locally cross-laminated (Fig. 5c,d). A pencil cleavage is commonly well-developed (Fig. 5e) and a slaty to phyllitic cleavage is locally developed. At one locality, on a ridge ~3 km NNW of Rusty Mountain, dark and light grey finely crystalline limestone with 5 mm-thick dark-grey chert nodules is present. At this same locality, chert also occurs as interbeds and nodules within orange-weathering dolostone.

Lower carbonate unit

The lower carbonate unit gradationally overlies the lower clastic unit and consists primarily of well-bedded and commonly cross-laminated, grey and orange weathering limestone and dolostone (Fig. 6a–c) and relatively minor shale, siltstone, dolomitic and calcareous siltstone, and silty dolostone (Fig. 6d). The contact between the lower carbonate unit and the underlying lower clastic unit is particularly well exposed in the western part of the map area (Fig. 7). Here, the upper most ~10 m of the lower clastic unit becomes slaty and phyllitic, and the overlying basal ~10 m of the lower carbonate unit comprises tan weathering dolomitic shale and platy silty dolostone that passes up section into orange weathering dolostone and limestone more typical of the unit. A distinct lithology that consists of very thickly bedded, commonly intensely calcite-veined, dark-grey, micritic limestone occurs at various stratigraphic levels within this unit (Figs. 6e and 8). An interval, a few metres thick, of intraclast conglomerate–breccia containing clasts of limestone in an orange weathering dolomitic matrix occurs locally in the northwest quadrant of the map area (Fig. 6f).

Outcrop-scale evidence for tectonic deformation is not common in the lower carbonate unit. A cleavage is developed in siliciclastic intervals and minor (10s of cm in scale) folds are rarely observed in carbonate beds.

Hart River Sills

The lower clastic and lower carbonate units are cut by medium-grey weathering, fine to medium-grained, greenish-grey gabbro sills and dikes (Figs. 3, 4, 9 and 10). These intrusions are most likely equivalent to the Mesoproterozoic (ca. 1.38 Ga) Hart River Sills that have been described elsewhere in the Wernecke Inlier (e.g., Abbott 1997; Thorkelson, 2000; Verbaas et al., 2018). The distribution of the intrusions is variable, being most abundant near Rusty Mountain, yet absent to the southeast despite similar host rocks. Whereas intrusions are locally abundant in the lower clastic unit, there is only one locality, in the northwestern part of the map area, where metamorphism of the lower carbonate unit indicates that it was also intruded (Fig. 3). Although this relationship is not directly observed, gabbro is exposed within a hundred metres of hornfelsed siliciclastic rocks and marble.



Figure 5. Select field photographs of the lower clastic unit. **(a–c)** Laminated shale and siltstone. Dark lenses in **(c)** are cross-laminated. **(d)** Cross-bedded sandstone with dewatering/soft-sediment deformation structure. **(e)** Pencil cleaved siltstone. **(f)** Minor fold in slaty siltstone and fine-grained sandstone.



Figure 6. Representative field photographs of the lower carbonate unit. **(a–c)** Typical orange and grey weathering laminated dolostone and limestone. **(d)** Siltstone interbedded with orange weathering dolostone. **(e)** Dark grey micritic limestone containing abundant calcite veins. **(f)** Carbonate-intraclast conglomerate with orange dolomitic matrix.

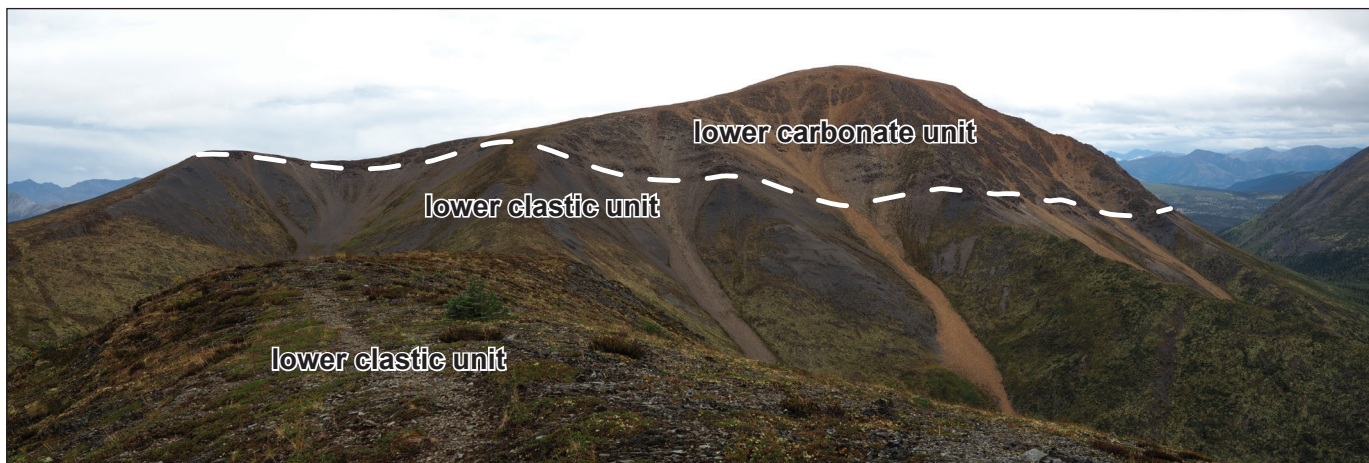


Figure 7. Panoramic field photograph of the resistant orange weathering lower carbonate unit underlying recessive shale and siltstone of the lower clastic unit.

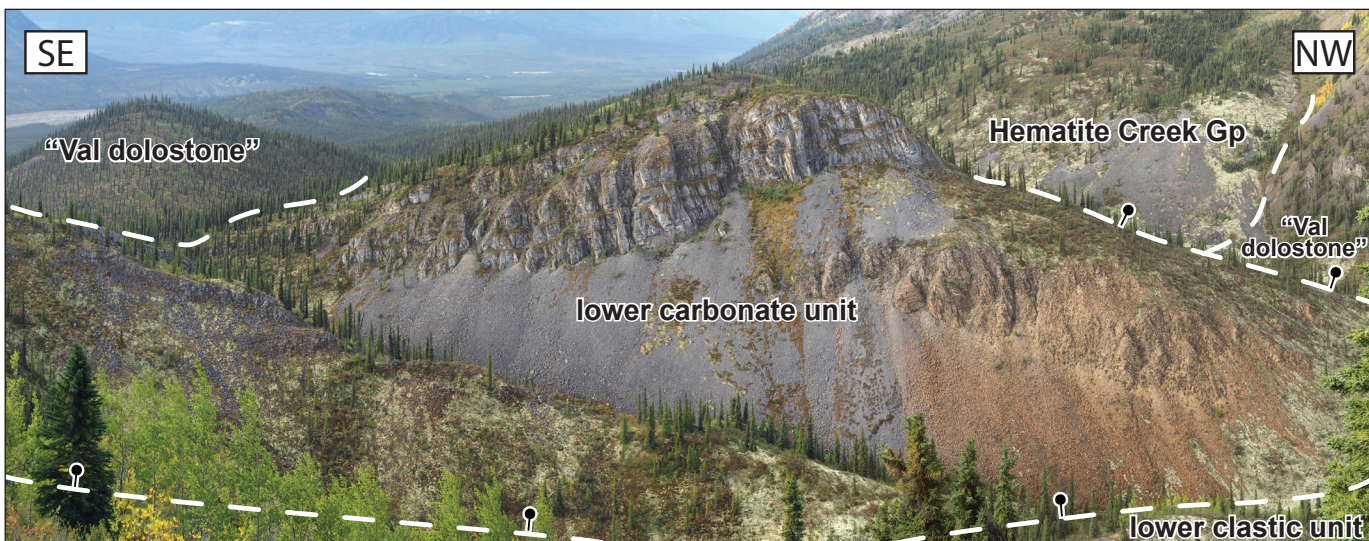


Figure 8. Panoramic field photograph from the westernmost extent of the map area illustrating the relationship between laminated dolostone of the “Val dolostone” and very thickly bedded carbonate of the underlying lower carbonate unit. In the top right of the frame, quartz arenite of the Hematite Creek Group, and underlying “Val dolostone”, are both in fault contact with the lower carbonate unit. Photo is taken from shale and siltstone of the lower clastic unit.

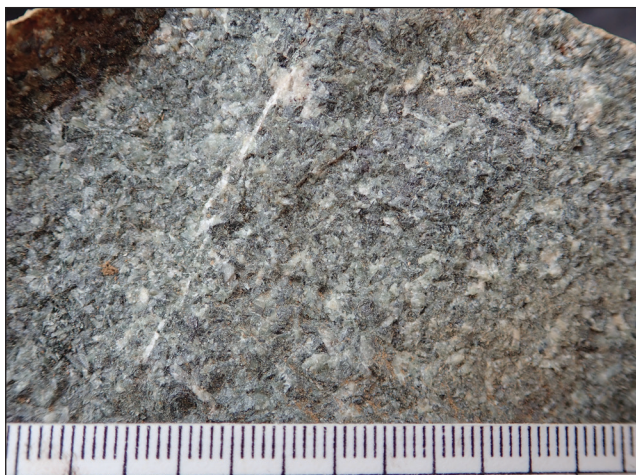


Figure 9. Hand sample photograph of greenish altered gabbro. Scale bar is in mm.



Figure 10. Field photograph of a gabbro dike, cutting fine-grained clastic rocks of the lower clastic unit on Rusty Mountain.

“Val dolostone”

The “Val dolostone” is informally named after the host lithology at the Val occurrence (MINFILE 106C 085). It consists of dark and light grey laminated dolostone (Fig. 11a). Laminations are typically planar parallel and, in places, wavy and discontinuous. The “Val dolostone” is in fault contact with the lower clastic unit north of the Val occurrence (Fig. 3). On the western edge of the map area, the “Val dolostone” apparently overlies thickly bedded limestone of the lower carbonate unit (Fig. 8). The orientation of bedding in both units is consistent, but the exact nature of the contact is uncertain as it occurs undercover in a small gully and, as elsewhere in the map area, may be a fault.

The “Val dolostone” is commonly replaced by mm to cm-scale bands of orange and white sparry dolomite that commonly occur as en échelon arrays, a feature commonly described as zebra texture (Fig. 11b,c). This texture is common in hydrothermal dolomite associated with base metal deposits (e.g., Wallace et al., 1994). Occurrences of zebra textures are typically associated with brecciation and disruption of layers (Fig. 11d–f). The degree of dolomitization and brecciation is variable. Weakly brecciated zones locally preserve tepee-like structures (Fig. 11d).

In the southeastern part of the map area (near the Val occurrence), the top ~100 m of the “Val dolostone” becomes progressively more quartzose and eventually grades into overlying siliciclastic rocks of the Hematite Creek Group. At this same locality, east of the Val occurrence, the “Val dolostone” contains a several tens-of-metres thick horizon of orange weathering dolostone. Neither the increasing quartz content nor the orange-weathering dolostone were observed in other regions of the map area.

Hematite Creek Group

The “Val dolostone” is gradationally overlain by a heterolithic succession dominated by thickly bedded quartz arenite of the Tonian Hematite Creek Group (Figs. 12 and 13; Thorkelson 2000; Turner, 2011; Gibson et al., 2019). The quartz arenite typically weathers light to medium grey, less commonly purple and, when iron oxides are present, orange (Fig. 13b). The Hematite Creek Group also contains interbedded limestone, grey, orange, and maroon shale and siltstone, orange weathering dolostone and silty dolostone, and red weathering stromatolitic dolostone (Fig. 13). These carbonate and shale intervals are similar to parts of the lower carbonate unit, although they are always associated with quartz arenite in the Hematite Creek Group. Planar parallel laminations, and less commonly cross-laminations, occur in quartz arenite, limestone and siltstone of the Hematite Creek Group.

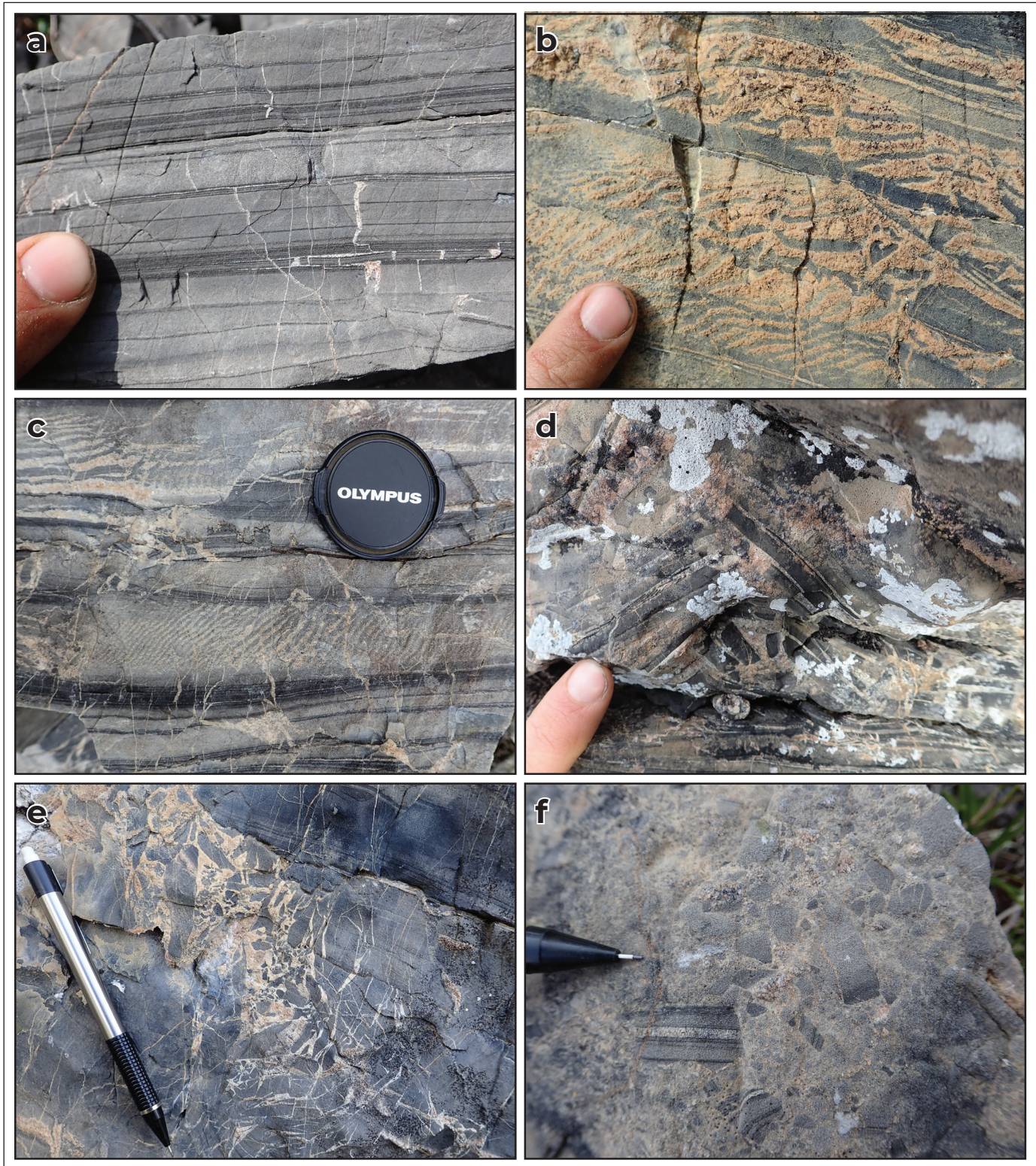


Figure 11. Representative field photographs of the “Val dolostone”. **(a)** Typical pin-stripe laminated dolostone. **(b–c)** Zebra dolostone, characterized by orange and white sparry dolomite that occurs as en échelon bands. **(d)** Tepee structure in brecciated “Val dolostone”. **(e)** Brecciated fluid pathway in laminated dolostone. **(f)** Breccia with angular clasts of laminated dolostone.

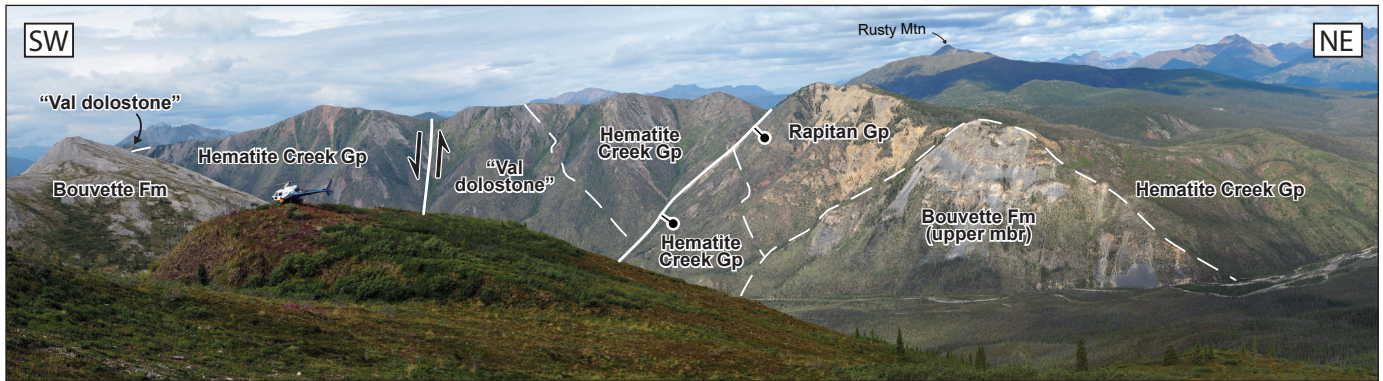


Figure 12. Panoramic field photograph illustrating field relationships along the ridge at the eastern margin of the map area. Two unconformities are visible, one at the base of the Bouvette Formation, and another at the base of the Rapitan Group. The peak of Rusty Mountain is visible in the background.

Windermere Supergroup

Callison Lake Formation

The Tonian Callison Lake Formation (Abbott, 1997; Strauss et al., 2015) constitutes the base of the Windermere Supergroup in the area (Fig. 4). In the Coal Creek and Hart River inliers, the Callison Lake Formation rests with angular unconformity on older strata (Abbott, 1997; Strauss et al., 2015). In the map area, however, it always overlies the Hematite Creek Group and thus evidence for an angular unconformity is lacking (Figs. 3 and 14). The Callison Lake Formation consists of light to medium-grey weathering, thin to thickly bedded, cliff-forming dolostone with irregular mm to few-cm-thick chert layers (Fig. 15). It is commonly laminated (Fig. 15b) and includes discontinuous intervals of grey to black chert (Fig. 15c) and silicified oolitic grainstone (Fig. 15d). A several metre-thick interval of matrix to clast-supported hematite-cemented conglomerate containing clasts of carbonate, chert and jasper is present at the easternmost exposure of the unit (Fig. 15e). Locally, the Callison Lake Formation also contains a matrix to clast-supported conglomerate with intraformational clasts of chert, carbonate and silicified oolitic grainstone (Fig. 15f). The identification of the Callison Lake Formation in the map area extends its geographic range significantly farther east than has previously been recognized.

Rapitan Group

The Cryogenian Rapitan Group (Yeo, 1981) consists of orange, maroon and brown weathering, very poorly sorted, clast to matrix-supported conglomerate and diamictite, and maroon, orange and green shale, siltstone and fine-grained sandstone (Fig. 16). The base of the Rapitan Group is an unconformity that cuts the stratigraphic section from the Callison Lake Formation in the west (Fig. 14) to as deep as the Hematite Creek Group in the east (Fig. 12). Sandstone and siltstone are commonly laminated (Fig. 16f), and all rock types locally exhibit a well-developed tectonic foliation (Fig. 16e,f). Clasts within the conglomerate are angular to rounded and include chert, jasper, siltstone, dolostone, limestone, and mafic volcanic rocks. The upper contact of the Rapitan Group is observed at two localities: at the southern edge of the map sheet where it underlies the Mount Profeit dolostone, and along the eastern margin of the map area, where it unconformably underlies the upper member of the Bouvette Formation. A fine-grained mafic dike cutting maroon siltstone and sandstone is present at one locality near the southern extent of the map area.



Figure 13. Representative field photographs of the Hematite Creek Group. **(a)** Thickly bedded light grey weathering quartz arenite. **(b)** Iron-oxides in quartz arenite that cause red to orange weathering. **(c)** Interbedded calcareous shale-siltstone and limestone. **(d)** Red weathering stromatolitic dolostone. **(e)** Interbedded orange weathering dolostone, dolomitic siltstone and quartz arenite. **(f)** Interbedded dolomitic siltstone-sandstone, dolomitic quartzite and quartzite.

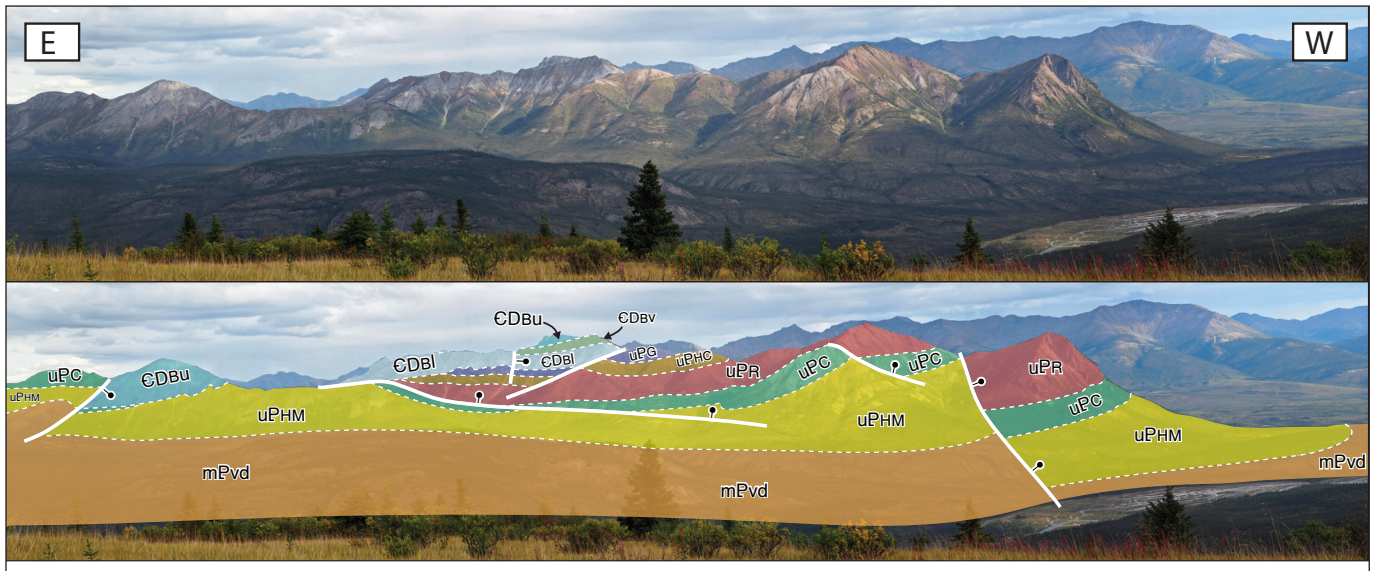


Figure 14. Panoramic field photograph of an east-west trending ridge in the southwestern part of the map area that illustrates the stratigraphic relationship between Mesoproterozoic and younger units. Rackla River is in the valley bottom. See Figure 3 for legend.

Hay Creek Group

In the map area, the Hay Creek Group (Yeo, 1978) comprises the Cryogenian Mount Profeit dolostone and Ice Brook Formation, and the Ediacaran Ravensthorpe formation (Figs. 3, 4 and 17a–d). An ~200 m-thick section of the Hay Creek Group is exposed along a ridge in the southern part of the map area (Figs. 3 and 14). The Mount Profeit dolostone, which constitutes the base of the Hay Creek Group in the area and overlies the Rapitan Group, consists of grey and cream weathering dolostone with irregular chert intervals (Fig. 17a). The Mount Profeit dolostone is overlain by a several metre thick interval of light grey weathering, carbonate-clast diamictite of the Stelfox member of the Ice Brook Formation (Fig. 17b). The Ice Brook Formation is overlain by the Ravensthorpe formation, which consists of grey and cream weathering dolostone containing chert layers that highlight chaotic layering, tepee-shaped structures and sheet-cracks (Fig. 17c,d).

Rackla Group

In the map area, the Ediacaran Rackla Group (Moynihan et al., 2019) comprises the Gametrail and Blueflower formations (Figs. 3, 4 and 14). As with the Hay Creek Group, the Rackla Group is only exposed in a small area near the southern extent of the map area (Fig. 3). The Gametrail Formation consists of grey, buff, maroon, yellow-orange, and green weathering, well-bedded and laminated, silty lime and dolo-mudstone (Fig. 17e,f). The Blueflower Formation unconformably underlies the lower member of the Bouvette Formation and consists of brown shale and siltstone containing Ediacaran trace fossils (Fig. 17e).



Figure 15. Field photographs presenting key characteristics of the Callison Lake Formation. **(a)** Thickly-bedded dolostone. **(b)** Lamination in dolostone. **(c)** Discontinuous black chert layering in light grey dolostone. **(d)** Silicified oolitic grainstone. **(e)** Hematite cemented conglomerate. **(f)** Conglomerate containing dolostone matrix and clasts of light grey dolostone, black chert and silicified oolitic grainstone.



Figure 16. Field photographs of the Rapitan Group. **(a)** Cliff of maroon weathering diamictite. Arrow points to geologist for scale. **(b–d)** Orange and maroon weathering diamictite. **(e)** Orange weathering, matrix supported, well-foliated conglomerate. **(f)** Maroon-weathering siltstone exhibiting shallow laminations and a steeply dipping cleavage.

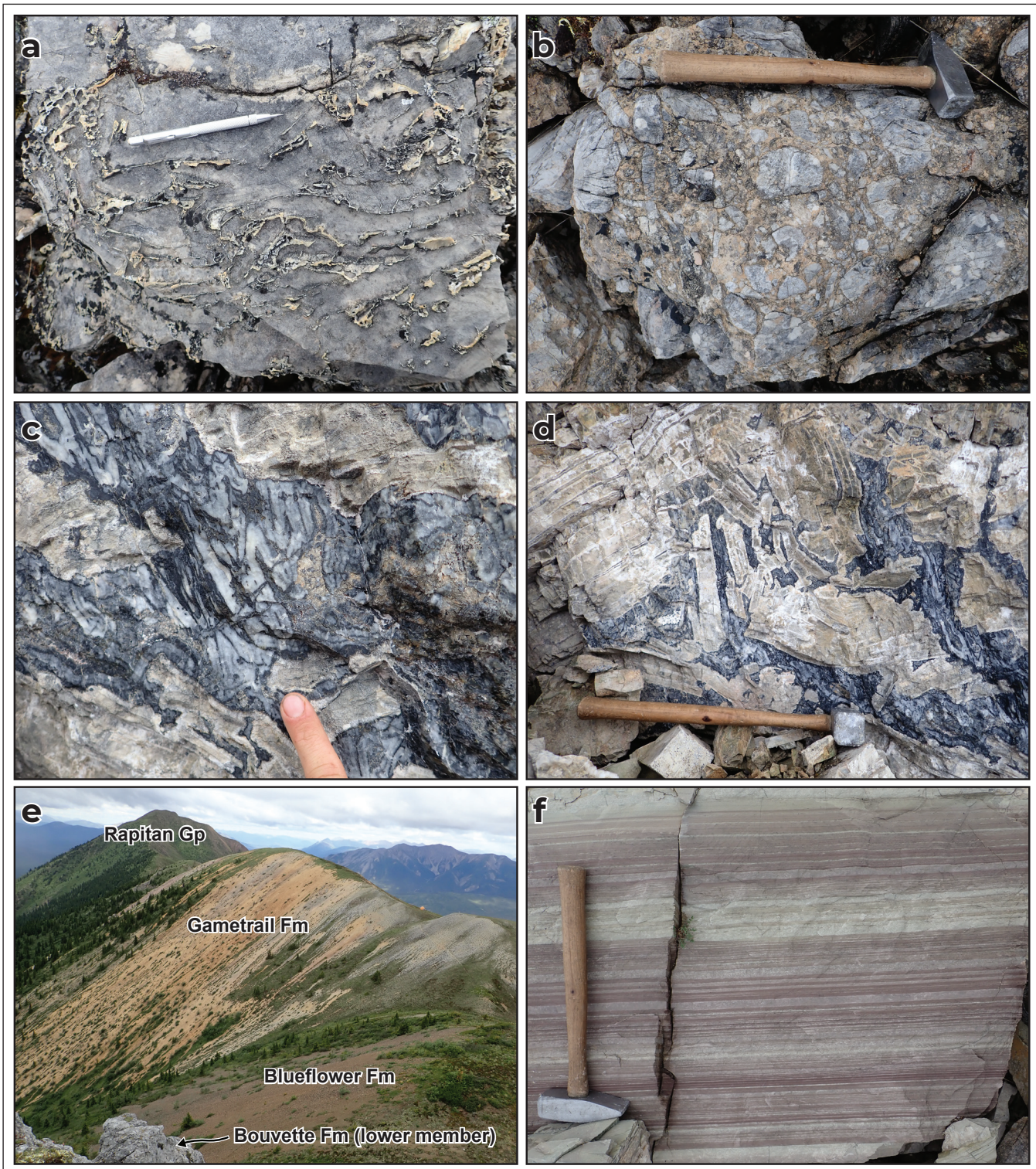


Figure 17. Select field photographs of the Hay Creek Group (a–d) and Rackla Group (e–f). **(a)** Dolostone containing irregular cream-coloured chert layers of the Mount Profeit dolostone. **(b)** Carbonate-clast diamictite, Stelfox Member of the Ice Brook Formation. **(c–d)** Chaotic bedding, sheet crack and tepee-shaped structures in the Ravensthorpe formation. **(e)** View from Bouvette Formation (grey dolostone at very base of photo) of brown shale of the Blueflower Formation and underlying yellow-orange, silty lime mudstone of the Gametrail Formation. Peak at end of ridge is Rapitan Group. Hay Creek Group is hidden from view. Looking west. **(f)** Laminated maroon and grey silty lime mudstone in the Gametrail Formation.

Bouvette Formation

The Cambrian to Devonian Bouvette Formation (Morrow, 1999) overlies older successions along an unconformity that cuts stratigraphy from as young as the Blueflower Formation to as old as Hematite Creek Group (Figs. 3, 4, and 18a). We informally divide the Bouvette Formation into a lower, volcanoclastic, and upper member. The lower member consists of light grey weathering, saccharoidal dolostone with minor grey chert (Fig. 18a). The volcanoclastic member consists of thin to medium-bedded grey, green, and orange weathering volcanoclastic sandstone and conglomerate (Fig. 18). Clasts and grains include fragments of mafic volcanic rocks, fossils, and limestone in a predominantly carbonate matrix (Fig. 18b,c,e). Intervals of the volcanoclastic member are extensively bioturbated (Fig. 18f). Fossils are locally abundant and include graptolites, brachiopods, trilobites, sponges, crinoids, bryozoans and echinoids. The volcanoclastic member may be a more distal equivalent of the mafic volcanic rocks exposed ~20 km WSW at the Tiger deposit.

The upper member of the Bouvette Formation consists of light to medium grey weathering dolostone (Figs. 12 and 14). Unlike the lower member, the upper member is commonly bedded and locally fossiliferous, with corals being most common. The base of the upper Bouvette is an unconformity that, in the field area, cuts from the volcanoclastic member in the west, down through the stratigraphy to the Hematite Creek Group in the east (Figs. 3, 12 and 14). A preliminary assessment of the fossil assemblages indicates a late Ordovician to earliest Silurian age for the volcanoclastic member, and a Silurian age for the upper member of the Bouvette (R.B. Blodgett, pers. comm., 2019).

Structure

In the map area the strata are inclined and gently folded (Fig. 19). Outcrop-scale minor folds are rare and are best developed in the lower clastic unit, lower carbonate unit, and “Val dolostone”. An axial planar cleavage is commonly well developed in the lower clastic unit and Rapitan Group, and in fine-grained clastic intervals in the lower carbonate unit. The relatively incompetent

shale and siltstone of the lower clastic unit exhibit the most deformation and, in places, may be overturned on the short limbs of asymmetric folds (see cross section A-A' in Fig. 19). Normal faults are the dominant structure in the map area (Figs. 3 and 19). A major normal fault runs east-west for ~20 km across the centre of the map area and separates old, Paleoproterozoic strata to the north from Mesoproterozoic and younger rocks to the south. Another major fault runs north-south through the centre of the map area and down-drops strata to the west. A series of shorter, generally NNW–WNW striking, normal faults were also identified.

Correlation of older units

The lithology and stratigraphic relationships of the lower clastic unit, lower carbonate unit, and “Val dolostone” indicate that they may be correlative with the Mount Landreville (formerly Pinguicula A of Eisbacher, 1981), Pass Mountain (formerly Pinguicula B of Eisbacher, 1981), and Rubble Creek (formerly Pinguicula C of Eisbacher, 1981) formations of the Pinguicula Group (Medig et al., 2016). However, as discussed above, the lower clastic and the lower carbonate units are cut by mafic dikes that are likely equivalent to the ca. 1380 Ma Hart River Sills (e.g., Abbott, 1997; Thorkelson, 2000; Verbaas et al., 2018). Based on contact relationships observed elsewhere in the Wernecke Mountains, Medig et al. (2010) interpreted the Hart River Sills to have intruded the Wernecke Supergroup prior to the deposition of the overlying Pinguicula Group. This suggests that the lower clastic and carbonate units are more likely correlative with the Quartet and Gillespie Lake groups of the Wernecke Supergroup, a plausibility also supported by their lithological characteristics.

Two other explanations can account for the geological relationships observed: (1) the intrusions may be younger than the Hart River Sills and thus it would be permissible that the section is all part of the Pinguicula Group. (2) Another less likely explanation is that the Hart River Sills intruded the Pinguicula Group, up to, at minimum, the Pass Mountain Formation. Thorkelson (2000) and Thorkelson et al. (2005) reported that the base of the Mount Landreville Formation was cut by a diorite dike correlative with the Hart River Sills.

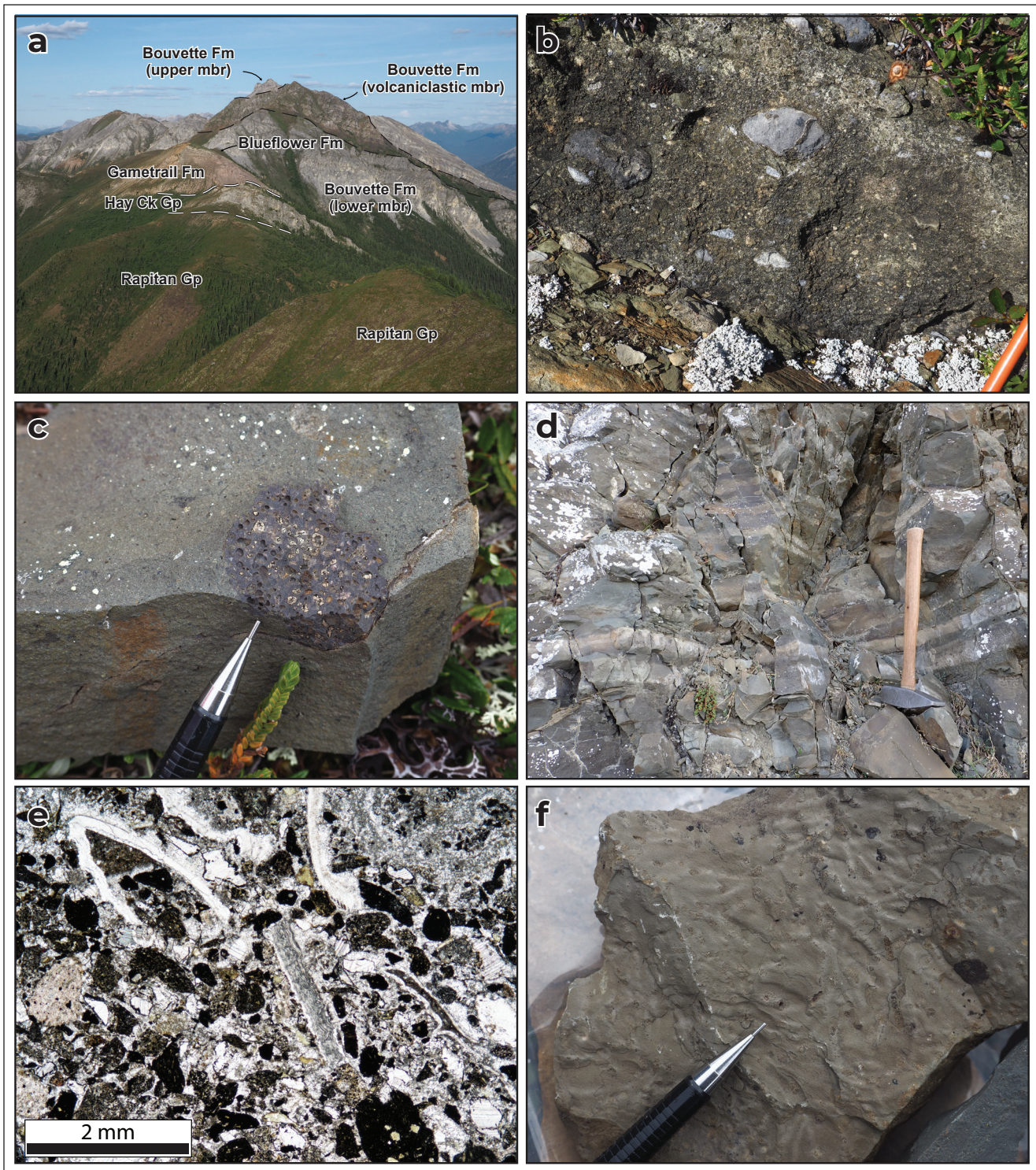


Figure 18. Select field photographs of the lower, volcaniclastic and upper members of the Bouvette Formation. **(a)** Field photograph illustrating the stratigraphy of the Windermere Supergroup overlain by the Bouvette Formation along a ridge at the southern extent of the map area. **(b)** Conglomerate from the volcaniclastic member with grey limestone clasts and a green-weathering sandy matrix. Pencil for scale in bottom right if frame. **(c)** Scoria clast in green weathering volcaniclastic sandstone. **(d)** Well-bedded, green-weathering volcaniclastic sandstone. **(e)** Photomicrograph (PPL) of sandstone from the volcaniclastic member, comprising fragments of mafic volcanic rocks (dark clasts) and fossils in a carbonate matrix. **(f)** Burrows in green-weathering sandstone from the volcaniclastic member.

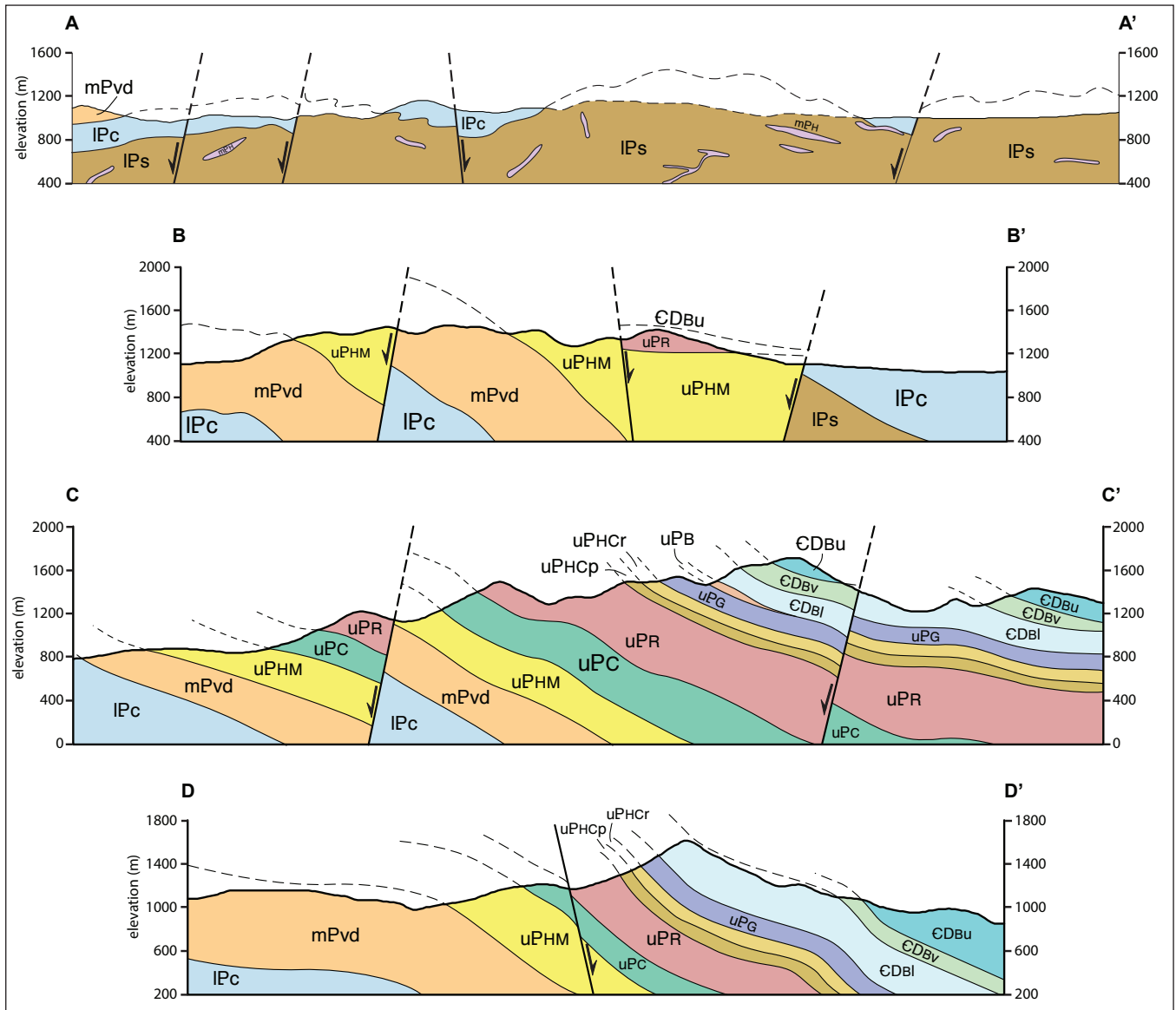


Figure 19. Cross sections illustrating the geological and stratigraphic relationships. Locations are indicated in Figure 3. See Figure 3 for legend.

However, these authors have since reinterpreted the host rock as being part of the Wernecke Supergroup, not the Pinguicula Group (Medig et al., 2010). Moreover, Thorkelson (2000) only ever interpreted the Hart River Sills to have intruded the lowest levels of the Mount Landreville Formation. The field relationships described herein would require that Hart River Sills intrude through the Mount Landreville Formation and into the Pass Mountain Formation. Based on this line of reasoning, the most likely explanation is that the lower clastic and carbonate units correlate to the Quartet and Gillespie Lake groups, respectively, of the Wernecke Supergroup.

Mineralization

The map area includes several mineral occurrences that are mostly located in the eastern half of the map area (see Eaton, 1999 and Kammerer and Eaton, 2010 for a summary). The most significant mineralization is centred at the Vera (Yukon MINFILE 106C 083 and 114) and Val (Yukon MINFILE 106C 085, 115, 116, and 117) occurrences (Fig. 3). The Vera occurrence, located on the north slope of Rusty Mountain, consists of Ag-Pb-Zn mineralization in brecciated orange weathering stromatolitic dolostone of the lower carbonate unit (Sinclair, 1981). The Val occurrence

consists of Ag-Pb-Zn mineralization in breccia zones and sparry dolomite veins in the 'Val dolostone' unit (Sivertz, 1980). Vera has a historical resource estimate of 392 667 t at 607.0 g/t Ag, 3.18% Pb and 3.47% Zn, and Val has a historic resource estimate of 19 964 t at 1029 g/t, 26.7% Pb and 7.3% Zn (Casselman, 2018). In addition to the Val and Vera occurrences, Ag-Pb-Zn mineralization also occurs across the eastern half of map area in veins and breccia in the lower clastic unit, Hart River Sills, and the Hematite Creek Group (e.g., Kammerer and Eaton, 2010).

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References

- Abbott, G., 1997. Geology of the upper Hart River area, eastern Ogilvie Mountains, Yukon Territory (116A/10, 116A/11). Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada 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.
- Casselman, S. (compiler), 2018. Yukon Mineral Deposits Summary 2018. Yukon Geological Survey, 30 p.
- 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. (2018 Update).
- Colpron, M., Israel, S., Murphy, D., Pigage, L. and Moynihan, D., 2016. Yukon bedrock geology map. Yukon Geological Survey, Open File 2016-1, scale 1:1 000 000.
- Delaney, G.D., 1981. The mid-Proterozoic Wernecke Supergroup, Wernecke Mountains, Yukon Territory. In: Proterozoic Basins of Canada, F.H.A. Campbell (eds.), Geological Survey of Canada, Paper 81-10, p. 1–23.
- Eaton, J., 1999. Geochemical, Geological and Geophysical Assessment Report for the Val, Vera, Rusty, KLA, Nad and Craig Claims, Manson Creek Resources Ltd., February 1999. Yukon Energy, Mines and Resources Assessment Report 093968.
- Eisbacher, G.H., 1981. Sedimentary tectonics and glacial record in the Windermere Supergroup, Mackenzie Mountains, northwestern Canada. Geological Survey of Canada, Paper 80–27, 40 p., <https://doi.org/10.4095/119453>.
- Gibson, T.M., Halverson, G., Macdonald, F., Cumming, V., Kunzmann, M., Wörndle, S., Lechte, M., Maloney, K., Millikin, A., Murphy, J. and Wallace, M., 2019. Tectono-stratigraphy and facies architecture of the Tonian Hematite Creek and Katherine groups, Wernecke Mountains, Yukon: In: Abstracts with Programs, GAC–MAC Conference 2019, Québec City, QC.
- Kammerer, M., and Eaton, W.D., 2010. Geological mapping, prospecting and geochemical sampling at the Rusty Property. Yukon Energy, Mines and Resources Assessment Report 95720.
- 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.
- Medig, K.P.R., Thorkelson, D.J. and Dunlop, R.L., 2010. The Proterozoic Pinguicula Group: Stratigraphy, contact relationships and possible correlations. In: Yukon Exploration and Geology 2009, K.E. MacFarlane, L.H. Weston and L.R. Blackburn (eds.), Yukon Geological Survey, p. 265–278.
- Medig, K.P.R., Turner, E.C., Thorkelson, D.J. and Rainbird, R.H., 2016. Rifting of Columbia to form a deep-water siliciclastic to carbonate succession: The Mesoproterozoic Pinguicula Group of northern Yukon, Canada. Precambrian Research, vol. 278, p. 179–206, <https://doi.org/10.1016/j.precamres.2016.03.021>.

- Morrow, D.W., 1999. Lower Paleozoic stratigraphy of northern Yukon Territory and northwestern District of Mackenzie. Geological Survey of Canada Bulletin 538, 202 p., <https://doi.org/10.4095/210998>.
- 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.P., Strauss, J.V., Nelson, L.L. and Padget, C.D., 2019. Upper Windermere Supergroup and the transition from rifting to continent-margin sedimentation, Nadaleen River area, northern Canadian Cordillera. GSA Bulletin, vol. 131, issue 9–10, <https://doi.org/10.1130/B32039.1>.
- Roots, C.F., 1990. New geological maps for the southern Wernecke Mountains, Yukon. In: Current Research Part E, Geological Survey of Canada, Paper 90-1E, p. 5–13.
- Sinclair, A.J., 1981. Report on the Vera, South Rusty Mountain and Siltstone mineral occurrences. Yukon Energy, Mines and Resources Assessment Report 062146.
- Sivertz, G.W., 1980. Assessment Report on Geology, Geochemistry and Drilling at Val 1-318 Claims 1980. Yukon Energy, Mines and Resources Assessment Report 090511.
- Strauss, J.V., MacDonald, F.A., Halverson, G.P., Tosca, N.J., Schrag, D.P. and Knoll, A.H., 2015. Stratigraphic evolution of the Neoproterozoic Callison Lake Formation: Linking the break-up of Rodinia to the Islay carbon isotope excursion. American Journal of Science, vol. 315, p. 881–944, <https://doi.org/10.2475/10.2015.01>.
- Thorkelson, D.J., 2000. Geology and mineral occurrences of the Slats Creek, Fairchild Lake and “Dolores Creek” areas, Wernecke Mountains, Yukon Territory (106D/16,106C/13, 106C/14). Exploration and Geological Division, Yukon Region, Indian and Northern Affairs Canada, Bulletin 10, 73 p.
- Thorkelson, D.J., Abbott, J.G., Mortensen, J.K., Creaser, R.A., Villeneuve, M.E., McNicoll, V.J. and Layer, P.W., 2005. Early and Middle Proterozoic evolution of Yukon, Canada. Canadian Journal of Earth Sciences, vol. 42, p. 1045–1071, <https://doi.org/10.1139/e04-075>.
- Turner, E.C., 2011. Stratigraphy of the Mackenzie Mountains supergroup in the Wernecke Mountains, Yukon. In: Yukon Exploration and Geology 2010, K.E. MacFarlane, L.H. Weston and C. Relf (eds.), Yukon Geological Survey, p. 207–231.
- Verbaas, J., Thorkelson, D.J., Milidragovic, D., Crowley, J.L., Foster, D., Daniel Gibson, H. and Marshall, D.D., 2018. Rifting of western Laurentia at 1.38 Ga: The Hart River sills of Yukon, Canada. Lithos, vol. 316–317, p. 243–260, <https://doi.org/10.1016/j.lithos.2018.06.018>.
- Wallace, M.W., Both, R.A., Ruano, S.M., Fenoll Hach-Ali, P. and Lees, T., 1994. Zebra textures from carbonate-hosted sulfide deposits; sheet cavity networks produced by fracture and solution enlargement. Economic Geology, vol. 89, p. 1183–1191, <https://doi.org/10.2113/gsecongeo.89.5.1183>.
- Wagh, D.H., 1989. A Preliminary Diamond Drilling and Trenching Report on the Val-Vera Quartz Claims (Rusty Mountain-Kathleen Lakes Area). Yukon Energy, Mines and Resources Assessment Report 092725.
- W. G. Timmins Exploration & Development Ltd., 1983. Summary Report on the Val-Vera Property: Kathleen Lakes, Yukon Territory. Yukon Energy, Mines and Resources Assessment Report 062185.
- Yeo, G.M., 1978. Iron-formation in the Rapitan Group, Mackenzie Mountains, Yukon and Northwest Territories. DIAND Mineral Industry Report, Economic Geology Series 1978-5, p. 170–175.
- Yeo, G.M., 1981. The Late Proterozoic glaciation in the northern Cordillera. In: Proterozoic basins of Canada, F.H.A. Campbell (ed.), Geological Survey of Canada, Paper 81-10, p. 25–46.
- Yukon MINFILE, 2019. Yukon MINFILE – A database of mineral occurrences. Yukon Geological Survey, <https://data.geology.gov.yk.ca>, [accessed November 2019].

