Preliminary observations of the Mesoproterozoic Pinguicula Group in the Coal Creek inlier, Yukon (parts of NTS 116B/11, 14)

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Abstract

Proterozoic strata in central Yukon are exposed in the Coal Creek, Hart River and Wernecke inliers. The Paleoproterozoic and Neoproterozoic strata are well correlated across the inliers; however, correlation of the Mesoproterozoic units remains ambiguous. We present two stratigraphic logs of Mesoproterozoic units PP1 and PP2 (previously termed PR1 and PR2, respectively) in the Coal Creek inlier. PP1 is dominantly siltstone and sandstone, whereas PP2 is mostly dolostone. In one section where the contact is well exposed, PP2 gradationally overlies PP1, suggesting that these units, at least locally, are conformable. Based on similarities in the stratigraphy and contact relationships with underlying and overlying units, we suggest that PP1 and PP2 are correlative with the Pinguicula Group formally defined in the Hart River and Wernecke inliers. Resolving how PP1 and PP2 correlate with Proterozoic strata exposed in other inliers provides insight into basin development along northwest Laurentia during the Meso–Neoproterozoic.

Introduction

Proterozoic strata are exposed across central Yukon in a series of erosional inliers that are separated from each other by younger Phanerozoic rocks (Fig. 1). Mapping, stratigraphic analysis, and geochronology have been used to correlate strata between these inliers. Correlation of the late Paleoproterozoic Wernecke Supergroup in these inliers across the Yukon is well established (Delaney, 1981; Abbott, 1997; Thorkelson, 2000; Furlanetto et *al*., 2016). Analysis of the Neoproterozoic Fifteenmile Group in the Coal Creek inlier (Macdonald et *al*., 2011, 2012; Halverson et *al*., 2012) has provided convincing evidence for its correlation with the Hematite Creek Group (Mackenzie Mountains Supergroup) in the Wernecke inlier (Eisbacher, 1981; Thorkelson, 2000; Turner, 2011). However, compared to Paleoproterozoic and Neoproterozoic strata, correlation of Mesoproterozoic strata across the Yukon is less well understood. In particular, correlating units PP1 and PP2 in the Coal Creek inlier to the other inliers farther east has remained controversial (Fig. 2; Medig et *al*., 2010, 2014; Macdonald et *al*., 2012). Resolving the age and correlation of these units is necessary to understand the history of basin development along the northwestern margin of Laurentia (present-day coordinates) in the Proterozoic.

This paper presents two measured stratigraphic sections of PP1 and PP2 in the Coal Creek inlier (NTS 116B/11, 14). Section W2313 was measured through strata mapped as PR1 and PR2 by Thompson et *al*. (1994);

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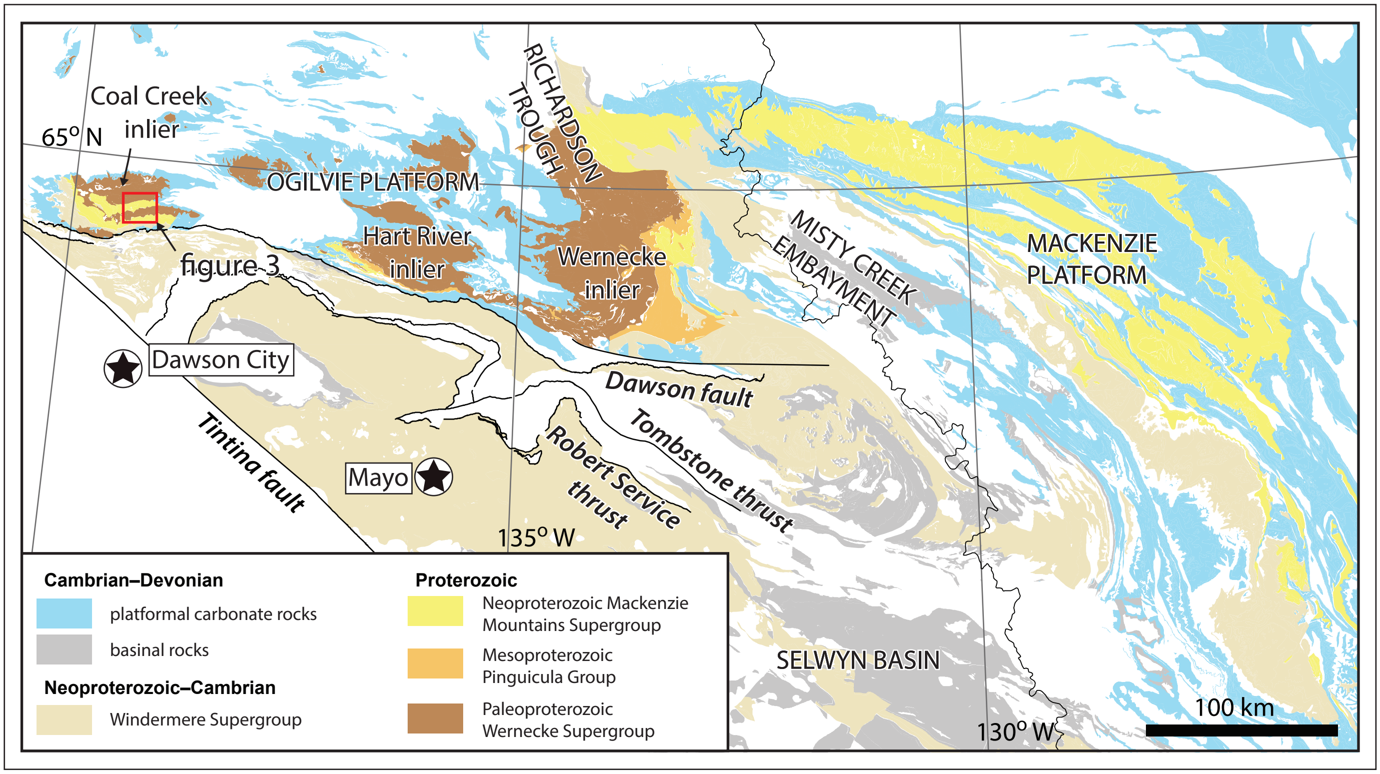

Figure 1. *Simplified geological map showing the distribution of Proterozoic strata in the Yukon and Northwest Territories (after Moynihan et al., 2019). The study area (outlined in red box) is located in the Coal Creek inlier. White areas are Devonian and younger strata. Geology is from Yukon Geological Survey (2022).*

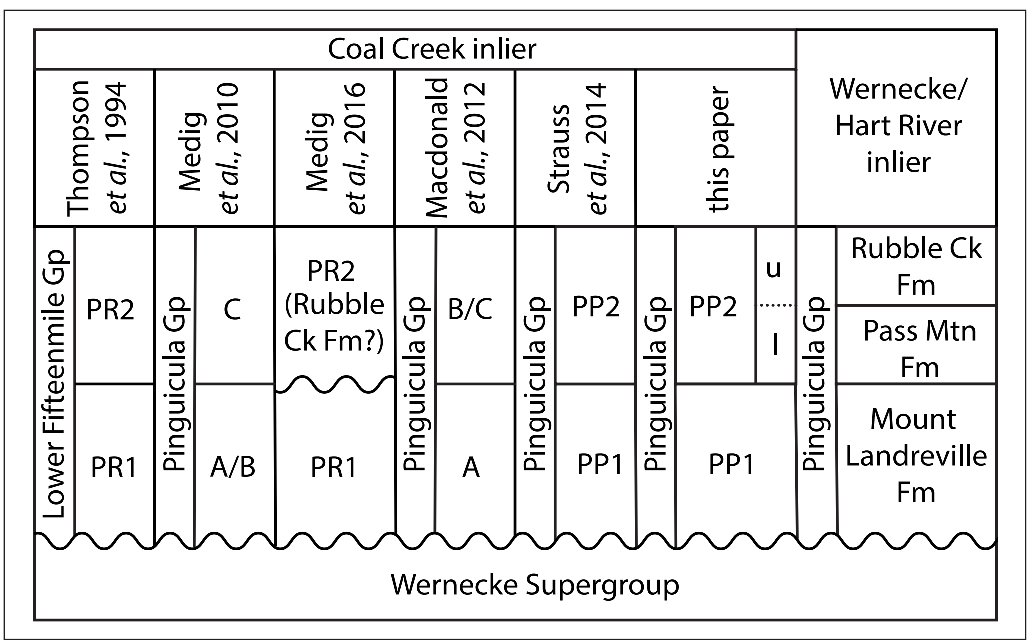

Figure 2. *Summary of terminology used and proposed correlations for units PR1/PP1 and PR2/PP2 by Thompson et al. (1994), Medig et al. (2010, 2016), Macdonald et al. (2012), Strauss et al. (2014), and this paper. Thompson et al. (1994) did not correlate these units to the Pinguicula Group. Medig et al. (2016) did not correlate PR1 with the Pinguicula Group and instead proposed that PR1 was deposited during an earlier basin-forming event based on the results of Medig et al. (2014).*

PR1 and PR2 were later termed PP1 and PP2, respectively, by Strauss et *al*. (2014). Section W2316 was measured through strata mapped as the Quartet and Gillespie Lake groups (Wernecke Supergroup) by Thompson et *al*. (1994) but are interpreted here as PP1 and PP2 based on field observations made during summer 2023. In this paper we suggest that PP1 and PP2 are correlative with the Pinguicula Group in the Wernecke and Hart River inliers to the east, in agreement with some previous work (Medig et *al*., 2010; Halverson et *al*., 2012; Macdonald et *al*., 2012; Strauss et *al*., 2014). Field observations reported here do not support the hypothesis that PP1 was deposited in a separate, earlier, basin-forming event (Medig et *al*., 2014, 2023).

Previous work

The Coal Creek inlier was first mapped at a reconnaissance scale of 1:250 000 by Green (1972). Building on this initial work, Thompson et *al*. (1994) mapped the Coal Creek inlier at a more detailed 1:50 000 scale and divided the Proterozoic strata into the Wernecke Supergroup, the lower Fifteenmile Group (PR1–PR5), the upper Fifteenmile Group and the Mount Harper Group. As in the Hart River and Wernecke inliers (Delaney, 1981), the Wernecke Supergroup in the Coal Creek inlier is divided, from oldest to youngest, into the Fairchild Lake, Quartet and Gillespie Lake groups (Thompson et *al*., 1994). Here, we focus on the sedimentary units PR1 and PR2 (termed PP1 and PP2 here, building on recent work), which unconformably overlie the Wernecke Supergroup and underlie units PR3–PR5.

Since Thompson et *al*. (1994), units PR1 and PR2 have been assigned and correlated to different groups (Fig. 2). Based on similar stratigraphy and contact relationships with the underlying Wernecke Supergroup and Wernecke Breccia, Medig et *al*. (2010) tentatively correlated PR1 and PR2 with the Pinguicula Group in the Wernecke and Hart River inliers (Fig. 2). Macdonald et *al*. (2011) measured section E1003 through PR1 and PR2 and referred to those units as 'Fifteenmile Group undifferentiated'. Macdonald et *al*. (2012) agreed with Medig et *al*. (2010) and correlated units PR1 and PR2, as well as PR3, with the Pinguicula Group, and assigned PR4 and PR5 to the newly defined and informal 'lower' assemblage of the Fifteenmile Group. Halverson et *al*. (2012) agreed that PR1 and PR2 are correlative with the Pinguicula Group and informally divided units PR3–5 in the lower Fifteenmile Group into the Gibben formation, equivalent to PR3, PR4 and PR5a, and the Chandindu Formation, equivalent to PR5 (formalized in Kunzmann et *al*., 2014).

The correlations between PR1 and the Pinguicula Group were challenged by Medig et *al*. (2014). Based on the presence of a near unimodal ca. 1499 Ma detrital zircon population from a sandstone within PR1, which is distinct from the Pinguicula Group in the Hart River and Wernecke inliers, Medig et *al*. (2014, 2023) proposed that PR1 records a separate, older basin-forming event and is not correlative with the Mount Landreville Formation of the Pinguicula Group. Furthermore, they proposed that the contact between PR1 and PR2 is unconformable and that PR2 is still possibly correlative to the Rubble Creek Formation of the Pinguicula Group.

In their updated compilation map of the Coal Creek inlier, Strauss et *al*. (2014) renamed PR1 and PR2 to PP1 and PP2, respectively, and this is the terminology that we will use here. Notably, throughout these changes in unit names and correlation schemes, the lithological descriptions of the units have remained consistent (Table 1). PP1 is described as a siltstone to shale-dominated unit with large dolostone blocks interpreted as olistoliths and siliciclastic conglomerates interpreted as debris flows. PP2 is a dolostone-dominated unit with dolostone grainstone, micrite and boundstone. PP2 is locally stromatolitic and has minor shale and siltstone intervals (Medig et *al*., 2014; Strauss et *al*., 2014).

Stratigraphy

Section W2313

Section W2313 was measured along the same ridge as section E1003, which was previously measured and described in Macdonald et *al*. (2011) as part of broader work to correlate all Neoproterozoic strata in the Coal Creek inlier (Figs. 3, 4). The purpose of remeasuring and describing this section here is to 1) focus on these units in light of new observations on the Pinguicula Group in the Hart River and Wernecke inliers (Medig et *al*., 2016, 2023); 2) collect samples for isotopic, geochemical and geochronological analyses; and 3) provide a comparison with section W2316 (described below).

Table 1. *Description of units PR1–PR5 from Thompson et al. (1994) and updated terminology and descriptions from Strauss et al. (2014).*

Thompson et *al.* (1994)			Strauss et *al.* (2014)
PR5	shale; pebbly mudstone; gritty mudstone; stromatolitic limestone; quartz sandstone	Chandindu Fm	basal maroon shale and siltstone with abundant mud cracks; transitions upward into cyclic shale, siltstone, and dolostone intervals with grainstone, stromatolites, or microbialaminite; local stromatolitic bioherms and poorly sorted, massive coarse-grained sandstone beds; upper part contains large carbonate olistoliths (possibly correlative with Katherine and Hematite Creek groups; Halverson et *al*., 2012; Long and Turner, 2012; Macdonald et *al*., 2012; Kunzmann et *al*., 2014)
PR4	medium grey dolostone breccia, oolitic packstone, uncommon stromatolitic dolostone	Gibben Fm	grey ribbon-bedded dolostone, oolitic grainstone, stromatolitic dolostone, and microbialaminite with tepee structures; thickens northward into several hundred metres of grey to black shale that transition up-section into pink ribbon-bedded limestone (possibly correlative with Katherine and Hematite Creek groups; Halverson et *al*., 2012 ; Long and Turner, 2012; Macdonald et *al*., 2012)
PR3	recessive weathering grey medium-bedded dolomite with mudstone interbeds		
PR2	medium to thick-bedded dolomitic mudstone; dolostone breccia; massive, medium crystalline dolostone	PP2	orange to light blue weathering dolostone grainstone, micrite, and boundstone; locally stromatolitic with morphospecies *Minjaria* and *Conophyton*; locally upper black shale and minor dolomicrite with green weathering, planar-laminated siltstone and minor coarse-grained quartz arenite (equivalent to PR2 of Medig et *al*. [2014])
PR1	shale, silty dolomite with common dolostone olistoliths	PP1	weakly foliated, brown to grey-coloured siltstone, shale, and phyllite with irregularly dispersed large dolostone blocks and conglomerate interpreted as olistoliths and debris flows (Macdonald et *al*., 2012; equivalent to PR1 of Medig et *al*. [2014[)

The base of section W2313 is placed at a minor fault that separates orange-weathering dolostone to the north and dark grey siltstone to the south (Figs. 4, 5a, b and 6a). The dolostone below the fault consists of alternating beds of finely laminated, micritic dolostone, and dolostone with granule to pebble-sized, micritic dolomite intraclasts (Fig. 5a). Stromatolites and tepee structures are also present. Consistent with previous mapping of this area, we interpret this dolostone as part of the Gillespie Lake Group.

Above the faulted contact, the basal 280 m of section W2313 is composed of heavily cleaved siltstone (Fig. 6b) and sandstone. Aside from current ripple cross-lamination in sandstone (Fig. 6c), sedimentary structures are limited. Thin beds of very coarse sandstone are present but rare in the first 275 m of the section. The interval from 280 to 310 m is dominantly medium to very coarse grained sandstone (Fig. 6d). From 310 to 370 m, the exposure is poor and is mostly recessive subcrop interpreted as siltstone. At approximately 340 m, an orange-weathering dolostone olistolith, several metres wide and several metres tall with conical stromatolites, is present (Fig. 6e, f). Additional olistoliths, up to several tens of metres in size, were observed in this same siltstone interval along ridges to the east and southeast.

Approximately 665 m of grey-weathering dolostone is present above the basal 370 m of siltstone and sandstone. The lower 170 m of dolostone consists of alternating beds of dolomite intraclast conglomerate and planar-laminated micritic dolostone (Fig. 7a). The dolomite intraclast conglomerate contains granule to cobble-sized clasts. Above the lower 170 m, intraclast conglomerate beds are absent and the grey-weathering

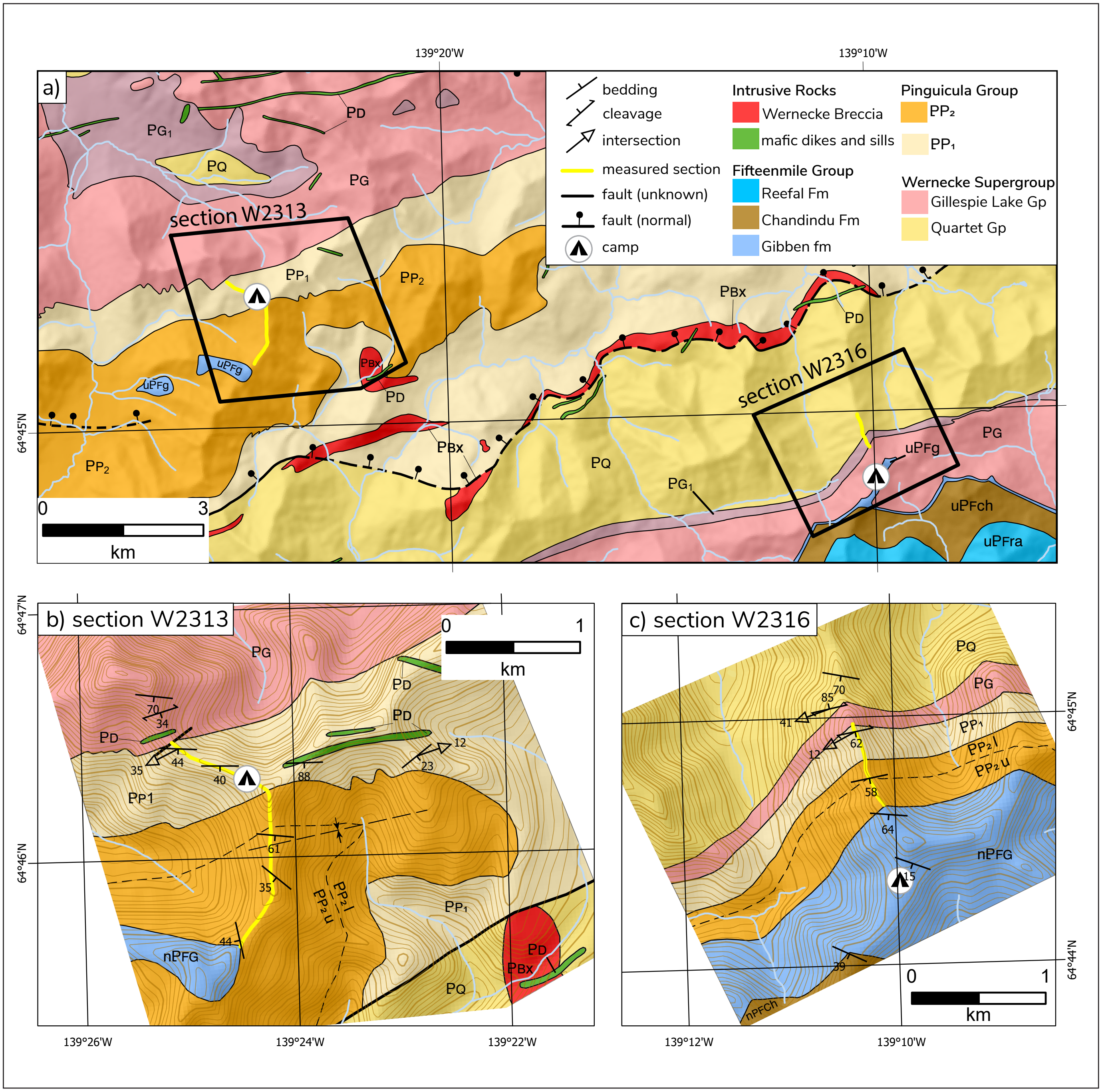

Figure 3. ***a)*** *Geological map of the study area showing the location (yellow lines) of the two stratigraphic sections we present in this paper (geology from Strauss et al. [2014] and Thompson et al. [1994]).* ***b)*** *Geology of the area at section W2313 modified from Strauss et al. (2014). The original map of Thompson et al. (1994) and subsequent update by Strauss et al. (2014) mapped the Wernecke Breccia (PBx) in the southeastern part of the area as cross-cutting PP1/PR1; however, the Wernecke Breccia has since been dated at ca. 1.6 Ga (Thorkelson et al., 2001), indicating that the host rocks are the older ca. 1.65 Ga Wernecke Supergroup (Furlanetto et al., 2016). Given that these rocks are siliciclastic, they most likely belong to the Quartet Group and the contact with PP1 is now interpreted as a fault.* ***c)*** *Geology of the area at section W2316. As seen in panel a), the rocks transected by this section were originally mapped as the Quartet and Gillespie Lake groups. However, as discussed in the text, we interpret only a thin interval of Gillespie Lake Group near the base of our section that is underlain by the Quartet Group and is overlain by PP1, PP2 and the Fifteenmile Group. In panels b) and c), the contact between our upper (PP2u) and lower (PP2l) is indicated by a dashed line.*

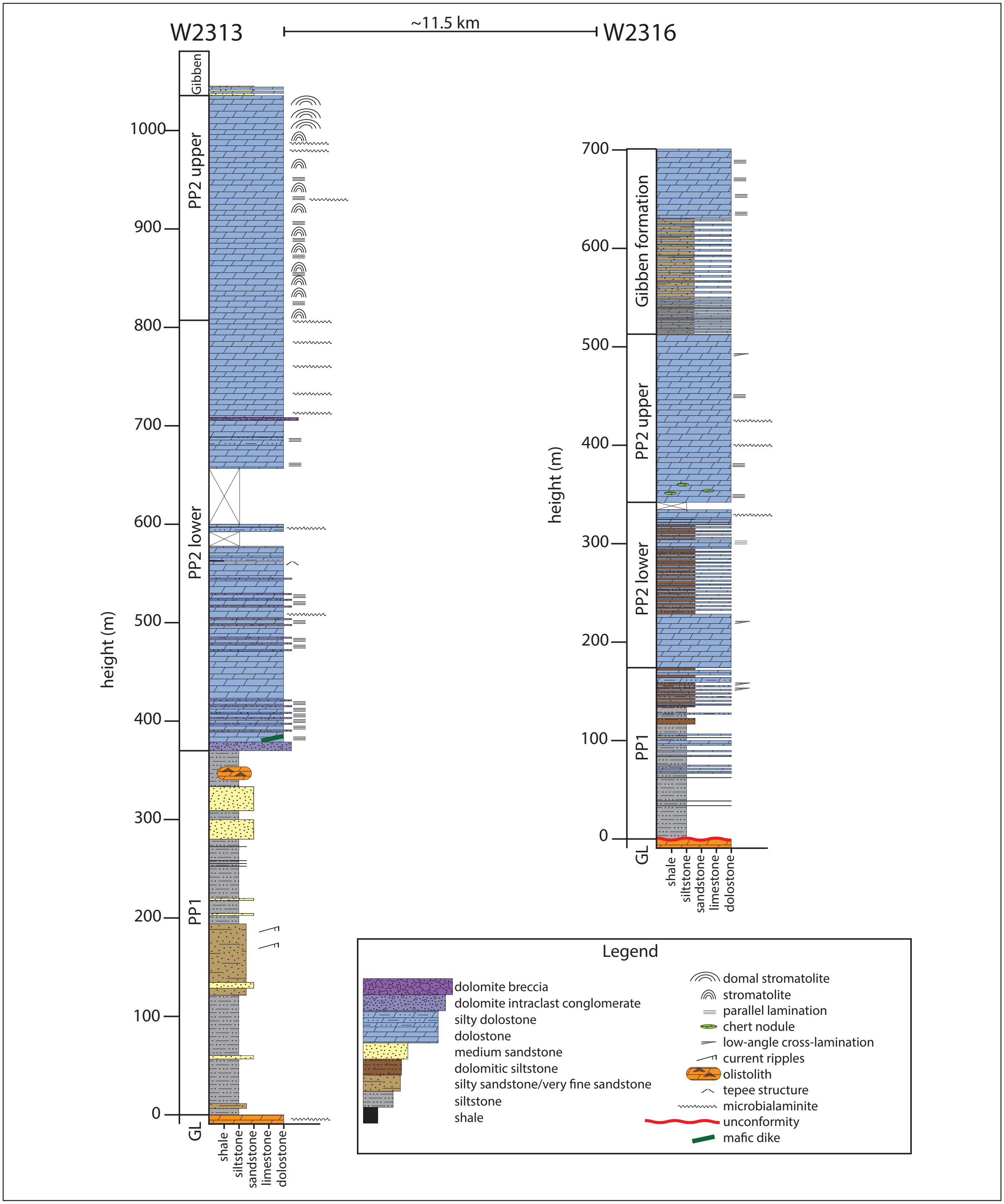

Figure 4. *Stratigraphic logs of sections W2313 and W2316 measured through PP1 and PP2. GL: Gillespie Lake Group. The base of section W2313 is located at 64.774502°N, 139.417783°W and section W2316 is approximately 11.5 km away at 64.749551°N, 139.172991°W.*

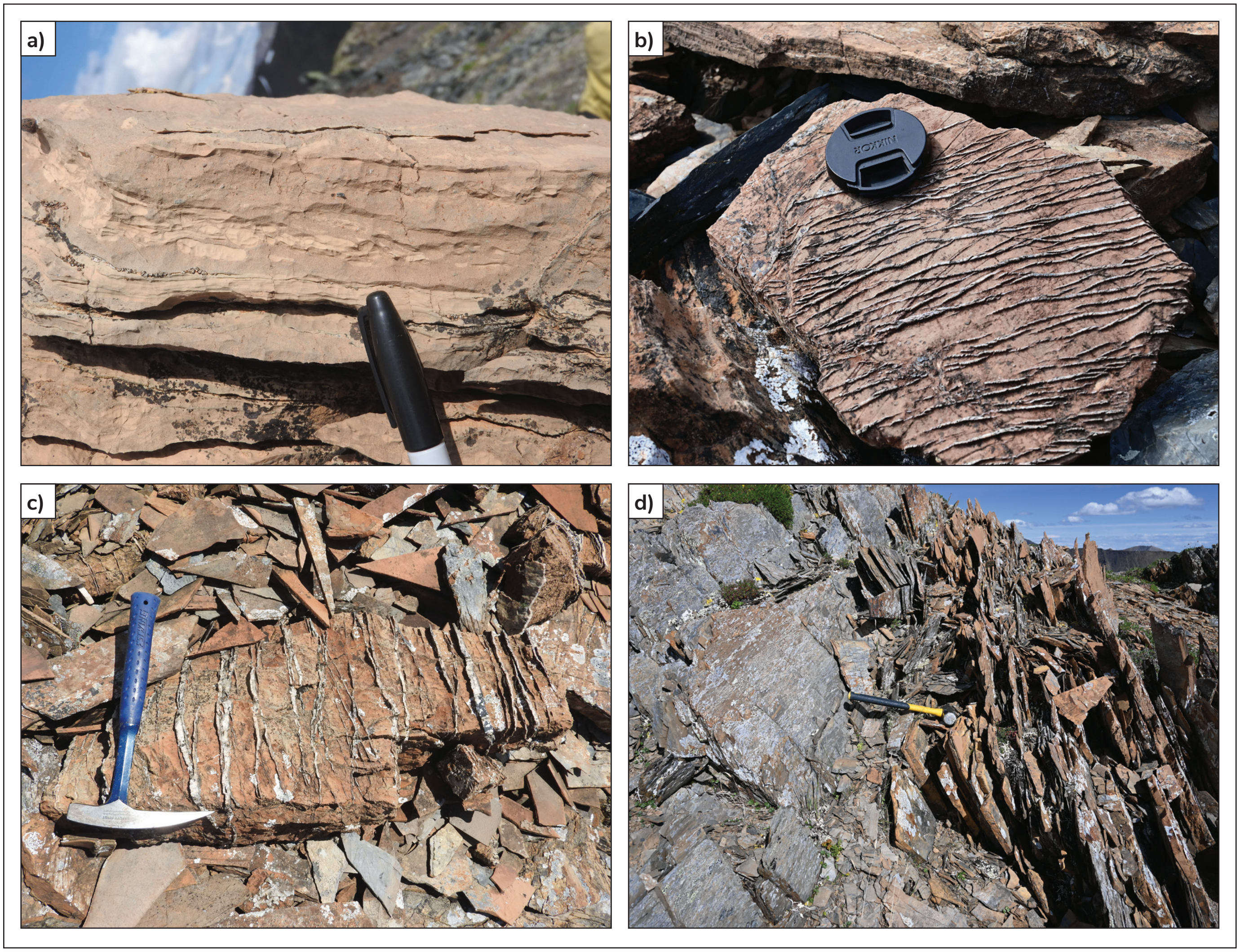

Figure 5. *Field photographs of the Gillespie Lake Group at sections W2313 (**a, b**) and W2316 (**c, d**): **a)** dolostone with micritic intraclasts immediately below the base of W2313; **b)** and **c)** silicified veins in dolostone blocks from float below the base of **b)** W2313 and **c)** W2316. Typically, veins in PP2 dolostone are carbonate rather than the silica common in the Gillespie Lake Group shown here; **d)** siltstone and thinly bedded orange-weathering dolostone immediately below the base of W2316 (stratigraphic up is to the right).*

dolostone is dominantly thinly laminated and wavy bedded with occasional teepee structures (Fig. 7b, c). Within this dolostone interval, crinkly lamination interpreted as microbialaminite is common, with more microbialaminite observed as stratigraphic height increases.

At approximately 810 m of total stratigraphic height, the dolostone becomes stromatolitic (Fig. 7d–f). Stromatolitic dolostone alternates with planar, finely laminated dolostone. The stromatolitic beds contain columnar stromatolites that are a few centimetres in width and up to tens of centimetres in height (Fig. 7d, e). The stromatolitic and laminated dolostone alternate in approximately 5 to 10 m intervals. Columnar stromatolites are the dominant form for the first 200 m of the stromatolitic interval, and large, domal stromatolitic buildups approximately 30 cm wide and 1 m tall dominate the remaining 40 m (Fig. 7f).

Interbedded orange-weathering carbonate (mostly dolostone but limestone in places) and blue-weathering sandstone overlies the large domal stromatolites (Fig. 8a, b). The contact between the stromatolites and the interbedded siltstone and carbonate is poorly exposed. Approximately 50 m of the interbedded sandstone and dolostone is exposed between the basal contact and the top of the hill.

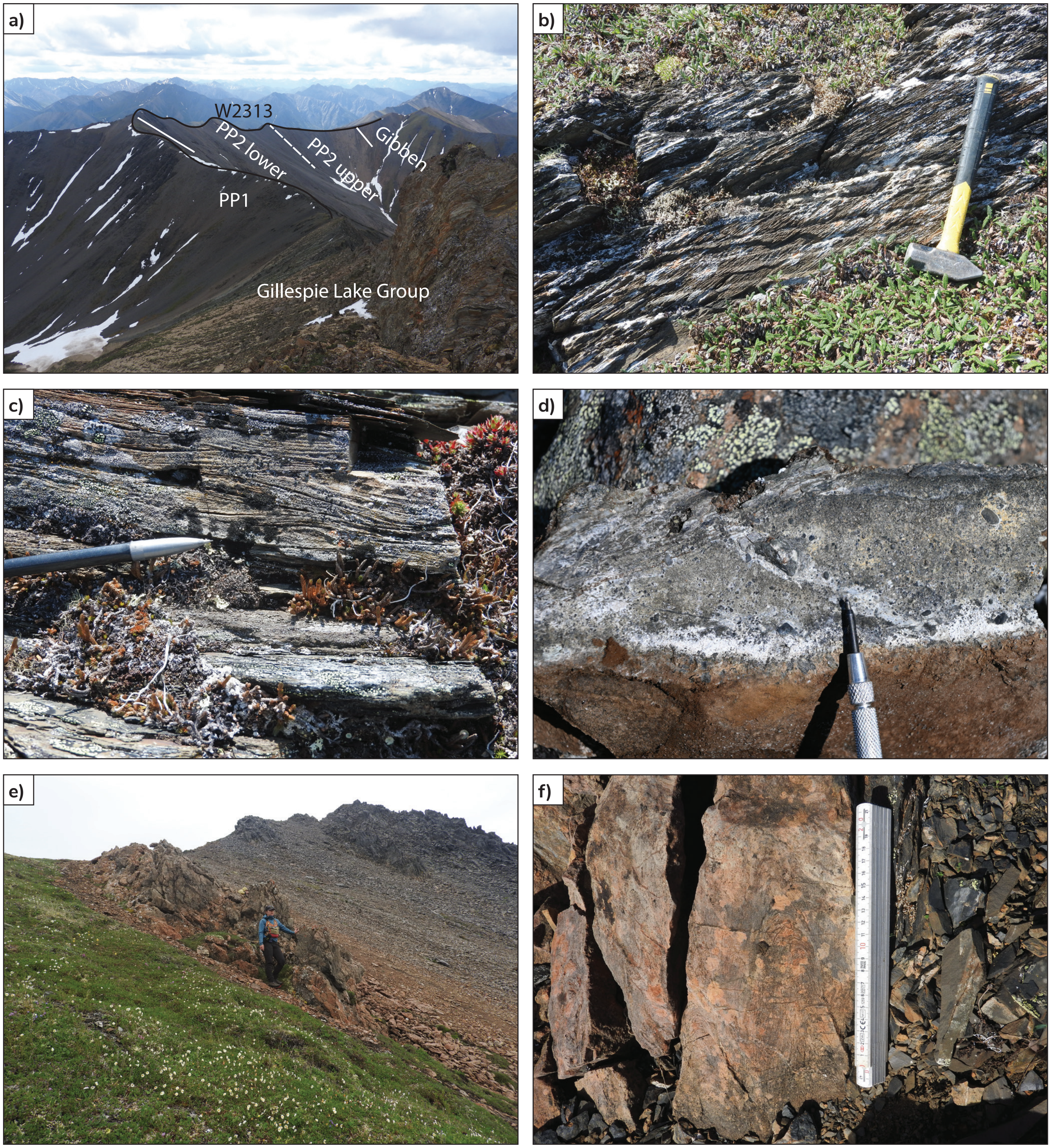

Figure 6. Field photographs of PP1 from section W2313: ***a)*** *ridge that W2313 was measured along with proposed contacts identified with white lines. In section W2313, PP1 is exposed along a ridge that is nearly parallel to strike;* ***b)*** *cleaved siltstone within PP1;* ***c)*** *current ripple cross-lamination in sandstone at 172 m of stratigraphic height,* ***d)*** *very coarse, gritty sandstone from sandstone interval between 280 and 330 m;* ***e)*** *orange-weathering dolostone olistolith in siltstone subcrop near the top of PP1 (person for scale);* ***f)*** *conical stromatolite from within a dolostone olistolith in PP1 (oriented in the same direction as ruler). This photograph is from an olistolith within PP1 along the ridge to the east of section W2313. Collapsible metre stick with cm markings for scale.*

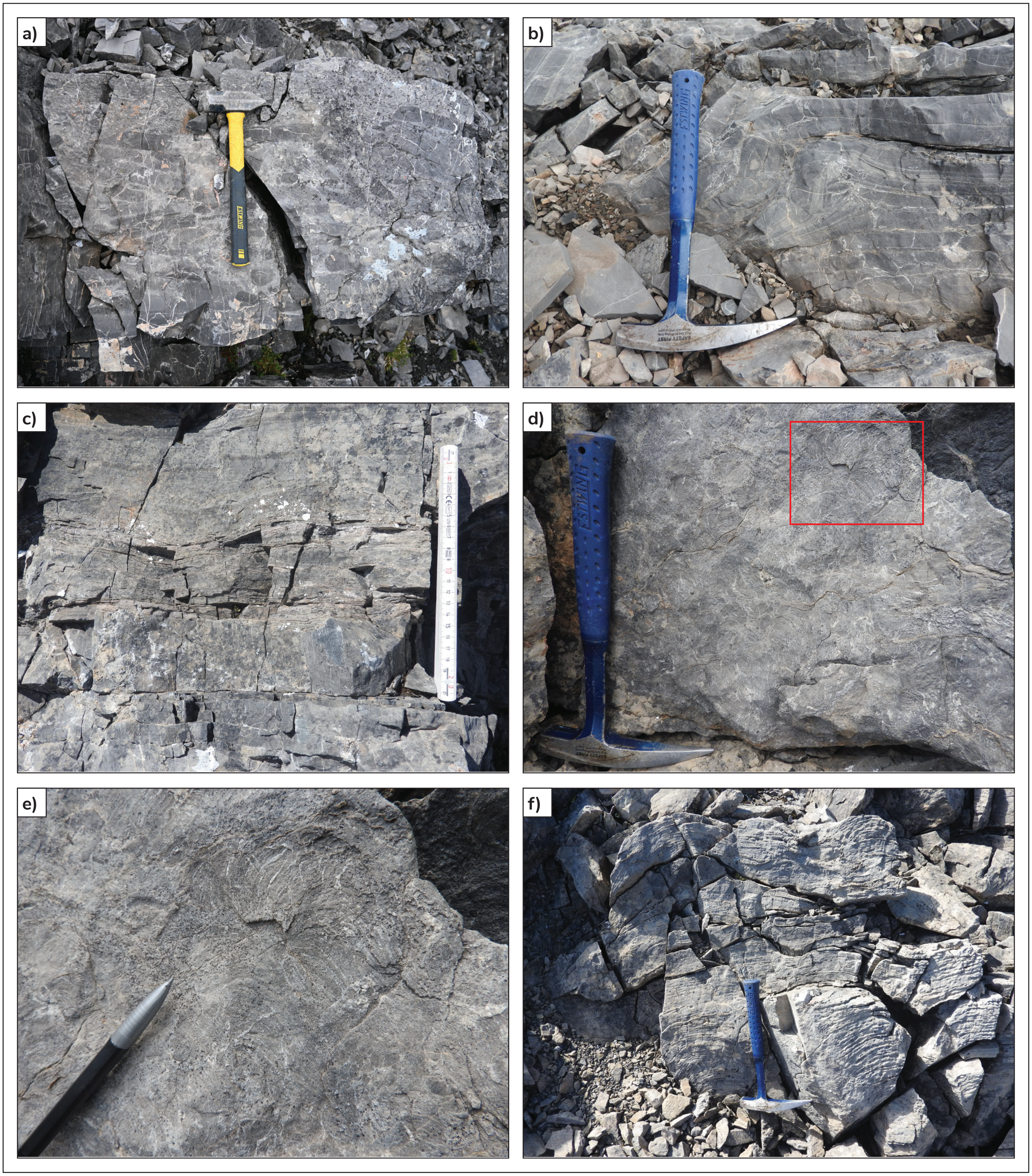

Figure 7. *Field photographs of PP2 from section W2313:* ***a)*** *dolostone intraclast conglomerate. This facies is more common in the base of PP2 lower;* ***b)*** *tepee structure in dolostone from PP2 lower;* ***c)*** *thinly bedded to thinly laminated dolostone with wavy bedding from PP2 lower;* ***d)*** *columnar stromatolites in dolostone from PP2 upper. Red box marks the area shown in part* ***e)****;* ***e)*** *columnar stromatolite that is 3–5 cm wide;* ***f)*** *larger, domal stromatolites from the top of PP2 upper near the contact with the Gibben formation.*

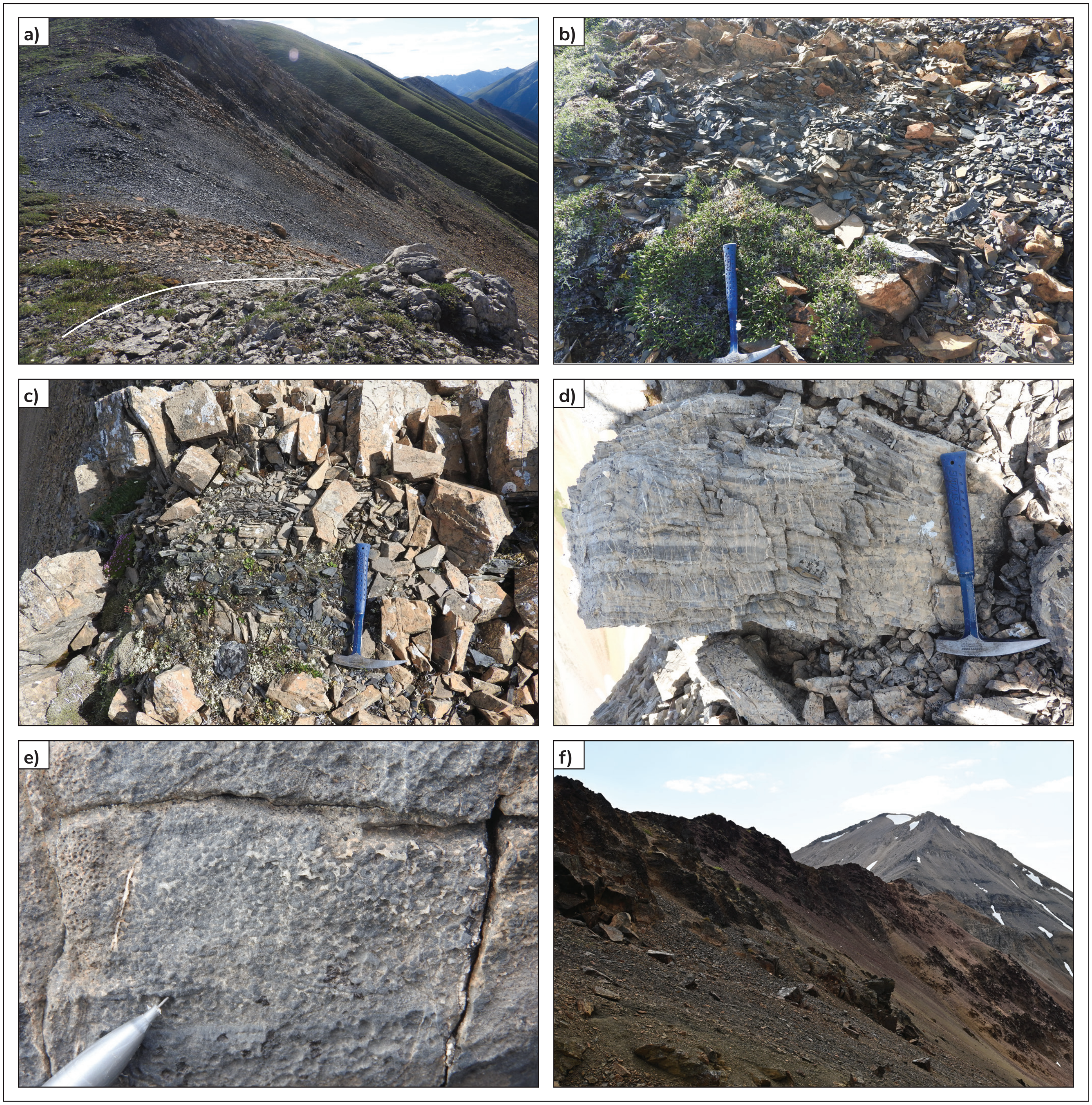

Figure 8. *Field photographs of stratigraphic units above PP1 and PP2 at section W2313* ***(a, b)*** *and W2316* ***(c, d, e, f)****:* **a)** approximately 50–100 m of alternating dark grey sandstone and orange-weathering dolostone above the *large domal stromatolites at the top of PP2 upper at section W2313. Above this, exposure of this unit is lost. This interbedded siliciclastic and dolostone unit is interpreted as the Gibben formation and the contact between it and PP2 upper is drawn as a white line;* ***b)*** *alternating sandstone and dolostone of the Gibben formation above PP2 upper at W2313;* ***c)*** *alternating siltstone and orange-weathering dolostone above the grey-weathering wispy laminated dolostone of PP2 upper at W2316. The alternating siltstone and dolostone is interpreted as the Gibben formation;* ***d)*** *thinly bedded dolostone with alternating darker and lighter beds. The centimetre-scale beds contain laminations stratigraphically above the interbedded siltstone and dolostone at section W2316;* ***e)*** *ooid and coated grain packstone stratigraphically above the thinly bedded dolostone;* ***f)*** *pebble to cobble conglomerate, coarse sandstone, and maroon-weathering siltstone stratigraphically above the oolitic dolostone. This is interpreted as the Chandindu Formation.*

Interpretation

We suggest that the contact between PP1 and PP2 is at the transition from dominantly siltstone to dominantly dolostone at 370 m of stratigraphic height. This is consistent with the descriptions of PP1 and PP2 from Thompson et *al*. (1994), Medig et *al*. (2010, 2014) and Strauss et *al*. (2014). We tentatively divide PP2 into lower and upper units with a contact at the transition from wavy bedded and thinly laminated dolostone to dominantly stromatolitic dolostone at 810 m of stratigraphic height. Macdonald et *al*. (2011) interpreted the shift to stromatolitic dolostone as a lateral facies change and, therefore, did not separate these units, referring to PP2 instead as Pinguicula B/C. Halverson et *al*. (2012) proposed that the stromatolitic dolostone, here termed 'PP2 upper', was correlative with the Rubble Creek Formation in the Hart River and Wernecke inliers. Whether PP2 lower and upper, as described here, can be separated as distinct mappable units will require additional sections.

Broadly, there is a shallowing upward trend within this section. We interpret PP1 as a relatively deep-water, mid to outer ramp environment. Although full Bouma sequences are absent from this section, the overall thickness of siltstone and sandstone in this section, current ripple cross-stratification, absence of features indicative of shallow-water conditions, and coarser event beds are consistent with a turbiditic environment below storm-weather wave base as suggested in Medig et *al*. (2014). The presence of olistoliths in the upper portion of PP1 is consistent with deposition along a slope and suggests that the basin was tectonically active during deposition. We interpret PP2 as a shallow, peritidal, inner ramp environment due to the presence of tepee structures and carbonate intraclast conglomerates in PP2 lower. Columnar and domal stromatolites in PP2 upper, typically found in subtidal to intertidal environments, also support the interpretation of a shallow, peritidal, inner ramp environment. This environmental interpretation is consistent with those presented in Macdonald et *al*. (2011) and Medig et *al*. (2014).

Section W2316

Section W2316 is located approximately 11 km to the southeast of section W2313 along a roughly north-trending ridge that is perpendicular to strike (Figs. 3, 4 and 9a). The base of section W2316 is at a sharp contact between orange-weathering dolostone and dark grey weathering siltstone. Immediately below the base of W2316, the laminated, orange-weathering dolostone is heavily silicified. We interpret the orange-weathering dolostone as the Gillespie Lake Group (Fig. 5c, d).

The first 30 m of section W2316 consists of siltstone (Fig. 9b) with occasional intervals of finer grained shale beds. Above 30 m, thin orange-weathering dolostone beds are present every 5 to 10 m. The interval from 50 to 130 m consists of interbedded siltstone and thinly bedded, parallel-laminated, orange-brown weathering dolostone (Fig. 9c). Above 130 m, the siltstone becomes dolomitic and is interbedded with laminated dolostone. At approximately 180 m, the interbedded dolostone and siltstone transitions to a 55 m thick interval of dominantly orange-brown weathering dolostone (Fig. 9d) before returning to interbedded dolomitic siltstone and dolostone for another approximately 110 m.

Above the relatively recessive siltstone and dolostone, at 342 m total stratigraphic thickness, there is a 173 m section of resistant, grey-weathering, microbialaminite and wispy-laminated dolostone with wavy bedding and low-angle cross-stratification (Fig. 9e). Chert occurs as bedding-parallel nodules, up to a few centimetres wide, at the base of this interval and as thin (<1 cm) layers within the dolostone farther up section (Fig. 9f).

Above this interval of dominantly dolostone, at 515 m of total stratigraphic thickness, there is 145 m of interbedded brown-orange weathering, laminated dolostone and dark grey-weathering, laminated, very fine sandstone to siltstone (Fig. 8c). At the start of this 145 m thick stratigraphic package, the siltstone intervals are 10 cm thick for every 0.5 to 1 m of dolostone. As stratigraphic height increases, the siltstone intervals thicken to approximately 1 m. A 40 m interval of grey-weathering, laminated, thin to medium-bedded dolostone (Fig. 8d) was measured above the interbedded siltstone and dolostone before stopping the log at a total thickness of 701 m. Stratigraphically above the end of the log, there is grey-weathering laminated dolostone and oolitic/coated grain packstone (Fig. 8e) that is overlain by maroon-weathering siltstone, pebble conglomerate, and sandstone (Fig. 8f).

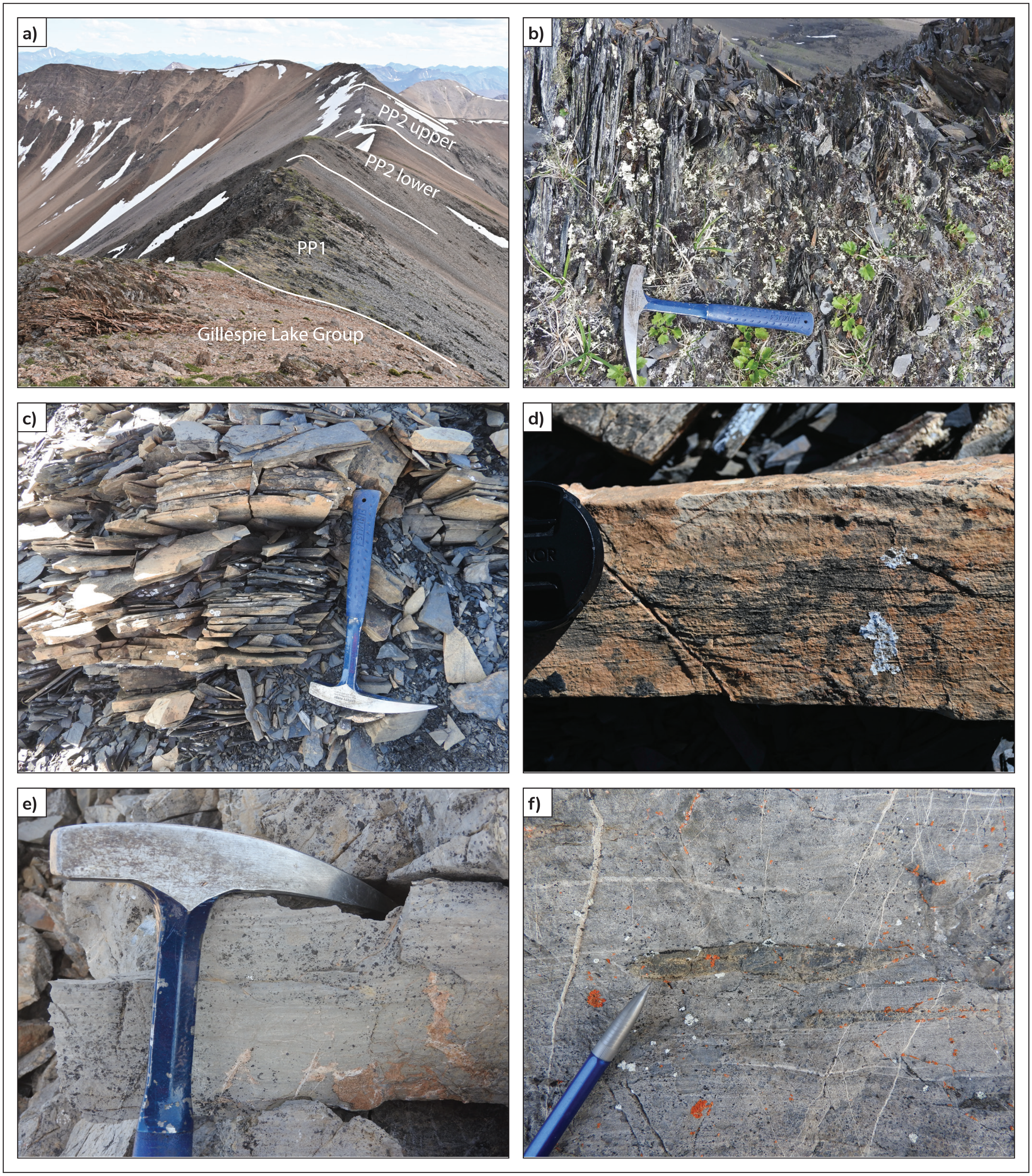

Figure 9. *Field photographs of PP1 and PP2 from section W2316:* ***a)*** *ridge that W2316 was measured along with proposed contacts identified with white lines;* ***b)*** *dark grey-weathering siltstone from the base of PP1 (stratigraphic up is to the right);* ***c)*** *interbedded siltstone and dolostone from the gradational contact between PP1 and PP2 lower;* ***d)*** *orange-brown weathering, laminated dolostone in PP2 lower;* ***e)*** *grey weathering, wispy and thinly laminated dolostone from PP2 upper;* ***f)*** *bedding-parallel chert nodule from the base of PP2 upper.*

Interpretation

Similar to section W2313, orange-weathering dolostone is overlain by an interval of dark grey-weathering, fine-grained siliciclastic rocks that pass up section to a laminated, grey-weathering dolostone. The units that overlie the dolostone at the top of W2316 are consistent with the descriptions of the Fifteenmile Group elsewhere in the Coal Creek inlier (Macdonald et *al*., 2011, 2012; Halverson et *al*., 2012; Kunzmann et *al*., 2014). Specifically, the laminated thin to medium-bedded dolostone and oolitic/coated grain packstone above the interbedded siltstone and dolostone is interpreted as the Gibben formation here, consistent with the descriptions of the middle of the Gibben formation in Halverson et *al*. (2012). The sharp contact between the dolostone above the oolitic/coated grain packstone and the maroon-weathering siltstone and granule to cobble conglomerate is interpreted here as the contact between the Gibben and Chandindu formations (Halverson et *al*., 2012; Kunzmann et *al*., 2014). Based on these similar stratigraphic relationships, we interpret our section as spanning PP1 and PP2, with the underlying orange dolostone as the Gillespie Lake Group and the overlying siliciclastic and carbonate strata as the Fifteenmile Group.

The contact between the Gillespie Lake Group and PP1 at the base of W2316 is unconformable. The contact between PP1 and PP2 is gradational and is placed at the transition from interbedded dolomitic siltstone and siltstone to dominantly dolostone at 180 m. The PP2 lower to PP2 upper contact within W2316 is at the base of a strongly resistant, grey-weathering dolostone above the interbedded dolostone and dolomitic siltstone at 342 m. We interpret the interbedded siltstone and dolostone as the base of the Gibben formation at 515 m. This contact with PP2 upper and the Gibben formation is gradational.

Our interpretation differs from Thompson et *al*. (1994), who mapped this ridge as Quartet Group overlain by Gillespie Lake Group. Thompson et *al*. (1994) and Strauss et *al*. (2014) did recognize Gibben formation (PR4) up section from the Gillespie Lake Group. However, they map it as unconformably overlying the Gillespie Lake Group. A section that was measured during the mapping reported in Thompson et *al*. (1994) but published in 2015 describes maroon siltstone and heterolithic conglomerate interpreted as the Gibben formation at a sharp, unconformable contact with the Gillespie Lake Group (Thompson and Roots, 2015).

Although our interpretations differ from the work by Thompson et *al*. (1994) and Thompson and Roots (2015), the interpretation of the Gibben and Chandindu formations here is consistent with more recent descriptions of these units elsewhere in the Coal Creek inlier (Halverson et *al*., 2012; Kunzmann et *al*., 2014). Additionally, the interpretation of the units PP1 and PP2 here is consistent with the overall description of PP1 and PP2 as a basal siliciclastic unit and overlying carbonate unit stratigraphically above the Wernecke Supergroup and below the Fifteenmile Group. Though our interpretation of the units as PP1, PP2 and Gibben formation differs from the interpretation of these units as the Gillespie Lake Group in Thompson and Roots (2015), we agree with Thompson and Roots (2015) that the contacts between units here are gradational.

Here, PP1 is identified and interpreted as a deep-water mid to outer-ramp environment due to the absence of cross-stratification or other sedimentary structures that would be consistent with a shallower environment. Unlike in section W2313, no olistoliths were identified in PP1 in section W2316. PP2 at section W2316 likely records a deeper environment than PP2 at W2313 because it is mostly wispy-laminated dolostone. Tepee structures, intraclast conglomerates, and stromatolites are absent.

Discussion

The two sections discussed here are separated by approximately 11 km and, though broadly similar, exhibit some key differences. Section W2313 is approximately 500 m thicker than section W2316. Numerous olistoliths are present near the top of PP1 in section W2313; however, they are absent in W2316. In section W2316, PP2 is relatively featureless and composed of microbialaminite and wispy-laminated dolostone. In contrast, PP2 in section W2313 contains tepee structures, intraclast conglomerates, wavy bedding and stromatolites. The olistoliths in W2313 are consistent with active tectonism during deposition. The lateral variation in sedimentary facies and stratigraphic thickness would be also expected in a tectonically active basin. Macdonald et *al*. (2012) noted that the overlying Fifteenmile Group is laterally variable in thickness as a result of small fault-bounded sub-basins and that the pattern of variance was similar to what they observed in PP1 and PP2. Additional sections are required to better understand the lateral variation in these units, and how the variation relates to tectonism in the basin at the time of deposition of PP1, PP2 and the overlying Fifteenmile Group.

As discussed above, the correlation of PP1 and PP2 with other units farther east is ambiguous. Previous work has suggested that PP1 and PP2 are correlative with the Pinguicula Group in the Hart River and Wernecke inliers (Fig. 2; Medig et *al*., 2010; Macdonald et *al*., 2012; Strauss et *al*., 2014). However, Medig et *al*. (2014) challenged this correlation based on detrital zircon analyses from a sandstone in PP1, which suggest that PP1 recorded a separate, earlier basin-forming event possibly correlative with the Belt Supergroup. Medig et *al*. (2014) also suggested that PP2 unconformably overlies PP1 and could be correlative with the uppermost formation of the Pinguicula Group, the Rubble Creek Formation. Based on the field observations presented here, PP2 conformably overlies PP1 at section W2316 because the contact is gradational. This conformable relationship between PP1 and PP2 challenges the suggestion from Medig et *al*. (2014) that PP1 and PP2 record separate basin-forming events. Further, in section W2316, the contact between PP2 and the overlying Gibben formation appears to be gradational. This suggests that there is not much time missing between the deposition of these two units.

In the Hart River and Wernecke inliers, the Pinguicula Group is stratigraphically above the Wernecke Supergroup and below the Mackenzie Mountains Supergroup, and records deposition along a ramp (Medig et *al*., 2016). The base of the Pinguicula Group, the Mount Landreville Formation, is a dominantly siliciclastic unit with turbidites interpreted as being deposited in a deep-water environment, below storm-weather wave base (Medig et *al*., 2016, 2023). The overlying Pass Mountain Formation is dominantly carbonate and was deposited on the outer ramp near storm-weather wave base. The overlying Rubble Creek Formation is also carbonate dominated and was deposited above fair-weather wave base in places (Medig et *al*., 2016). In the sections described here from the Coal Creek inlier, PP1 is a dominantly siliciclastic unit deposited in a deep-water environment below storm-weather wave base. PP2 is composed of carbonates deposited in a shallow subtidal to peritidal environment in section W2313 and a deeper environment near storm-weather wave base in section W2316. The relative stratigraphic position and transition from a deep-water siliciclastic unit to shallower water carbonate unit support the proposed correlations between PP1 and PP2 and the Pinguicula Group, and that PP1 and PP2 were deposited during the same basin-forming event (Medig et *al*., 2010; Macdonald et *al*., 2012). The field observations and interpretations presented here do not agree with the hypothesis that PP1 records an earlier basin-forming event that is distinct from PP2 (Medig et *al*. 2014, 2023). Additional sections, mapping and geochronology are required to confidently establish these correlations and test tectonic models.

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References

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

Delaney, G.D., 1981. The mid-Proterozoic Wernecke Supergroup, Wernecke Mountains, Yukon Territory. *In*: Proterozoic Basins of Canada, F.H.A. Campbell (ed.), Geological Survey of Canada, Paper 81-10, p. 1–23. https://doi.org/10.4095/109384

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.

Furlanetto, F., Thorkelson, D.J., Rainbird, R.H., Davis, W.J., Gibson, H.D. and Marshall, D.D., 2016. The Paleoproterozoic Wernecke Supergroup of Yukon, Canada: Relationships to orogeny in northwestern Laurentia and basins in North America, East Australia, and China. Gondwana Research, vol. 39, p. 14–40. https://doi.org/10.1016/j.gr.2016.06.007

Green, L.H., 1972. Geology of Nash Creek, Larsen Creek, and Dawson map areas, Yukon Territory. Geological Survey of Canada, Memoir 364, p. 1–172. https://doi.org/10.4095/100697

Halverson, G.P., Macdonald, F.A., Strauss, J.V., Smith, E.F., Cox, G.M. and Hubert-Théou, L., 2012. Updated definition and correlation of the lower Fifteenmile Group in the central and eastern Ogilvie Mountains. *In*: Yukon Exploration and Geology 2011, K.E. MacFarlane and P.J. Sack (eds.), Yukon Geological Survey, p. 75–90.

Kunzmann, M., Halverson, G.P, Macdonald, F.A., Hodgskiss, M., Sansjofre, P.D., Schumann, D. and Rainbird, R.H., 2014. The early Neoproterozoic Chandindu Formation of the Fifteenmile Group in the Ogilvie Mountains. *In*: Yukon Exploration and Geology 2013, K.E. MacFarlane, M.G. Nordling and P.J. Sack (eds.), Yukon Geological Survey, p. 93–107.

Long, D.G.F and Turner, E.C., 2012. Formal definition of the Neoproterozoic Mackenzie Mountains Supergroup (Northwest Territories), and formal stratigraphic nomenclature for terrigenous clastic units of the Katherine Group. Geological Survey of Canada, Open File 7113, 40 p. https://doi.org/10.4095/292168

Macdonald, F.A., Halverson, G.P., Strauss, J.V., Smith, E.F., Cox, G., Sperling, E.A. and Roots, C.F., 2012. Early Neoproterozoic basin formation in Yukon, Canada: Implications for the make-up and break-up of Rodinia. Geoscience Canada, vol. 39, no. 2, p. 77–100.

Macdonald, F.A., Smith, E.F., Strauss, J.V., Cox, G.M., Halverson, G.P. and Roots, C.F., 2011. Neoproterozoic and early Paleozoic correlations in the western Ogilvie Mountains, Yukon. *In*: Yukon Exploration and Geology 2010, K.E. MacFarlane, L.H. Weston and C. Relf (eds.), Yukon Geological Survey, p. 161–182.

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., Thorkelson, D.J., Davis, W.J., Rainbird, R.H., Gibson, H.D., Turner, E.C. and Marshall, D.D., 2014. Pinning northeastern Australia to northwestern Laurentia in the Mesoproterozoic. Precambrian Research, vol. 249, p. 88–99. https://doi.org/10.1016/j.precamres.2014.04.018

Medig, K.P.R., Thorkelson, D.J., Turner, E.C., Rainbird, R.H., Gibson, H.D. and Marshall, D.D., 2023. Mesoproterozoic basins (Yukon, Canada) in the evolution of supercontinent Columbia. Canadian Journal of Earth Sciences, vol. 60, p. 912–973. https://doi.org/10.1139/cjes-2022-0055

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

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, no. 9–10, p. 1673–1701. https//doi.org/10.1130/B32039.1

Strauss, J.V., Roots, C.F., MacDonald, F.A., Halverson, G.P., Eyster, A. and Colpron, M., 2014. Geological map of the Coal Creek Inlier, Ogilvie Mountains (NTS 116B/10-15 and 116C/9, 16). Yukon Geological Survey, Open File 2014-15, scale 1:100 000.

Thompson, R.I., Roots, C.F. and Mustard, P.S., 1994. Geology of Dawson map area (116B,C) (northeast of Tintina Trench). Geological Survey of Canada, Open File 2849, scale 1: 50 000. https://doi.org/10.4095/194830

Thompson, R.I. and Roots, C.F., 2015. Twenty-six archival stratigraphic sections in Paleoproterozoic to Neoproterozoic strata from the Coal Creek inlier, southern Ogilvie Mountains, Yukon. Geological Survey of Canada, Open File 7925, 36 p. https://doi.org/10.4095/296977

Thorkelson, D.J., 2000. Geology and mineral occurrences of the Slats Creek, Fairchild Lake and "Dolores Creek" areas, Wernecke Mountains (106D/16, 106C/13, 106C/14), Yukon Territory. Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Bulletin 10, 73 p.

Thorkelson, D.J., Mortensen, J.K., Davidson, G.J., Creaser, R.A., Perez, W.A. and Abbott, J.G., 2001. Early Mesoproterozoic intrusive breccias in Yukon, Canada: The role of hydrothermal systems in reconstructions of North America and Australia. Precambrian Research, vol. 111, p. 31–55. https://doi.org/10.1016/S0301-9268(01)00155-3

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.

Yukon Geological Survey, 2022. Yukon Digital Bedrock Geology. Yukon Geological Survey, http://datatest.geology.gov.yk.ca/Compilation/3, [accessed November 2023].