Updated definition and correlation of the lower Fifteenmile Group in the central and eastern Ogilvie Mountains

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ABSTRACT

Ongoing mapping, chemostratigraphy, geochronology, and stratigraphic analysis of Neoproterozoic successions in the Ogilvie Mountains requires redefinition and correlation of the Fifteenmile Group across the Proterozoic inliers in Yukon. Here we present new stratigraphic logs through the lower Fifteenmile Group in the Coal Creek and Hart River inliers. Based on these data and new observations, we propose redefinition of the lower Fifteenmile Group. A succession dominated by sandstone, mapped as unit PPD1 in the Hart River inlier, is now recognized at the base of the Fifteenmile Group in the Coal Creek inlier. These strata unconformably overlie the Pinguicula Group and transition upward into a distinctive carbonate interval; together, these comprise the informally defined Gibben formation. The shallowing-upward carbonate sequence contains abundant oolitic grainstone and packstone and microbial laminated dolostone. It is capped by a distinct interval of mud-cracked maroon mudstone, siltstone, and fine-grained sandstone that forms the base of what we informally define as the Chandindu formation. The mud-cracked shale transitions upwards into interbedded shale, coarse-grained sandstone, and minor carbonate. The overlying informally defined Reefal assemblage consists of up to 1 km of complexly interbedded carbonate and shale, with variable truncation beneath the major angular unconformity at the base of the Callison Lake Dolostone. The lower Fifteenmile Group (now informally PPD1 through the Chandindu formation) likely correlates with the Hematite Creek Group in the Wernecke Mountains.

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INTRODUCTION

Proterozoic strata in Yukon are preserved in mountainous inliers that stretch between Alaska and Northwest Territories, north of the Dawson thrust (Fig. 1). Geologists have worked for decades to determine the age and correlation of these rocks in Yukon (*e.g.*, Abbott, 1997; Thorkelson *et al.*, 2005) and across the rest of northern Canada (*e.g.*, Gabrielse, 1972; Young, 1979; Rainbird *et al.*, 1996). Cryogenian–Ediacaran-aged strata of the Windermere Supergroup and the Mount Harper Group and its equivalents in the Ogilvie Mountains comprise the so-called 'Sequence C' in northwestern Canada, the base of which is the major unconformity below the Rapitan and Mount Harper groups. Early and mid-Neoproterozoic (Tonian) strata comprise 'Sequence B', which includes the Shaler Supergroup on Victoria Island, the Mackenzie Mountains Supergroup and Coates Lake Group in the Mackenzie and Wernecke mountains, and the Fifteenmile Group in the Ogilvie Mountains (Fig. 1)(Eisbacher, 1981; Young, 1981; Rainbird *et al.*, 1996; Long *et al.*, 2008; Macdonald and Roots, 2010). In the Coal Creek, Hart River, and Wernecke inliers, the enigmatic Pinguicula Group occurs between the significantly older Wernecke Supergroup (late Paleoproterozoic–early Mesoproterozoic) and Sequence B strata (Young, 1979; Eisbacher, 1981; Thorkelson *et al.*, 2005; Medig *et al.*, 2010; Turner, 2011). Its placement within the tectonostratigraphic framework of the Proterozoic successions of northwestern Canada is a subject of ongoing debate.

While the broad correlation of Neoproterozoic strata between Victoria Island and the Mackenzie Mountains is relatively straightforward and uncontroversial, the poor accessibility and greater degree of Cordilleran deformation in Yukon have hindered detailed correlation of the Neoproterozoic stratigraphy with regions to the east. However, recent mapping coupled with application of high precision U-Pb zircon dating and chemostratigraphy (Macdonald *et al.*, 2010a,b) have significantly improved correlations and clearly established that the Neoproterozoic successions in the Tatonduk,

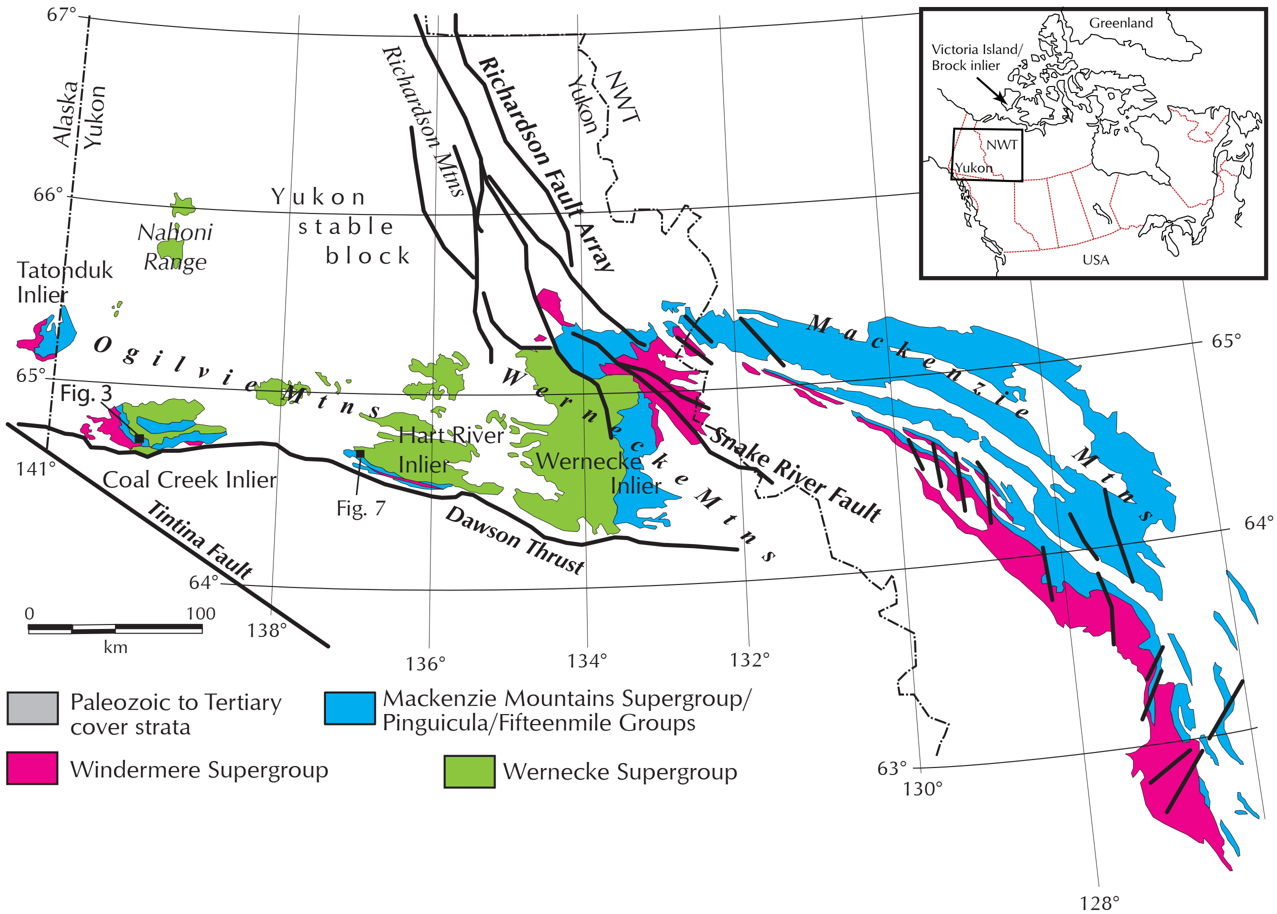

Figure 1. *Location and simplified geological map showing the Proterozoic inliers of the western Northwest Territories and Yukon and the distribution of Proterozoic strata. Black boxes in the Coal Creek and Hart River inliers show locations of maps and measured sections in subsequent figures. Modified from Macdonald et al. (2010).*

Coal Creek, and Hart River inliers (Fig. 1) are equivalent to Sequences B and C in the Mackenzie Mountains, albeit with a patchy and typically thin Cryogenian-Ediacaran succession. Macdonald and Roots (2010) and Macdonald *et al.* (2011) presented new correlations between the Tatonduk, Coal Creek, and Hart River inliers and preliminary revisions to the nomenclature in order to normalize stratigraphic names between these three regions. Our ongoing fieldwork in the inliers and complementary research by other groups (*e.g.*, Turner *et al.*, 2011; Medig *et al.*, 2010) continue to fill in remaining gaps in the Neoproterozoic stratigraphic framework for Yukon.

In this contribution we present new stratigraphic logs, mapping, and other field observations from the lower Fifteenmile Group in the Coal Creek and Hart River inliers. These results motivate a substantial revision to the definition of this heretofore poorly documented part of the Neoproterozoic stratigraphy in Yukon and its relationship to the Pinguicula Group in this region.

FIFTEENMILE GROUP

The Fifteenmile Group is named after Fifteenmile River, which drains the south-central Coal Creek inlier, between Mount Harper and Mount Gibben. As originally defined, the Fifteenmile Group comprises the strata between the late Paleoproterozoic Wernecke Supergroup below and the Mount Harper Group above (Thompson *et al.,* 1994; Mustard, 1991; Mustard and Roots, 1997), and hence represents Sequence B (Young *et al.*, 1979; Rainbird *et al.*, 1996) in the central Ogilvie Mountains. Thompson *et al.* (1994) subdivided the Fifteenmile Group into informal lower and upper subgroups, comprising five (PR1–PR5) lower map units and three (PF1–PF3) upper map units. Abbott (1993) extended the upper Fifteenmile Group nomenclature to the Hart River inlier and assigned an additional unit (PF4). Subsequently, Abbott (1997) renamed PF4 the Callison Lake Dolostone and reassigned all strata between the Wernecke Supergroup and Callison Lake Dolostone to the Pinguicula Group, which had previously been defined in the Wernecke Mountains as a distinct, mixed carbonate-siliciclastic succession overlying the Wernecke Supergroup (Eisbacher, 1981; Thorkelson *et al.*, 2005). The relationship between the Fifteenmile and Pinguicula groups remained vague.

Recent mapping, stratigraphy, chemostratigraphy, and U-Pb zircon dating of volcanic units and tuffs in the Coal Creek inlier have revealed major discrepancies in previous mapping and resulted in progressive revision to nomenclature and correlation of Fifteenmile Group strata both within the Coal Creek inlier and with neighboring inliers. A new U-Pb zircon age of 717.43 ± 0.14 Ma on a rhyolitic flow in the Mount Harper volcanic complex (Macdonald *et al.*, 2010a) places a firm minimum age constraint on the Fifteenmile Group. An 811.51 ± 0.25 Ma U-Pb zircon age on a tuff in the middle Fifteenmile Group is the first direct age on this succession (Macdonald *et al.*, 2010a). In combination with chemostratigraphy, these new ages provide a basis for correlation of the Fifteenmile Group with the lower Tindir Group in the Tatonduk inlier and refined correlation with the Hart River inlier (Macdonald and Roots, 2010). In an attempt to reconcile the stratigraphy of the Fifteenmile Group with major revisions to the mapping in the Coal Creek inlier, including elimination of many inferred thrust faults in the lower Fifteenmile Group, Macdonald *et al.* (2011) proposed a new subdivision of the Fifteenmile Group into an informal "Lower Assemblage" of mixed shale and variably stromatolitic dolostone, overlain by the informal "Craggy Dolostone." This thick and heavily recrystallized dolostone is unconformably overlain by the Callison Lake Dolostone in the Coal Creek inlier.

In this subdivision, Macdonald *et al.* (2011) ascribed what had previously been mapped as the lower Fifteenmile Group (PR1-PR4) to the Pinguicula Group, consistent with recent observations described by Medig *et al.* (2010). The latter authors observed that Pinguicula unit A (PPA) in the Hart River inlier post-dates the 1.38 Ga Hart River sills and highlighted similarities between units PR1 and PR2 in the Coal Creek inlier and Pinguicula units A–C.

NEW SECTIONS THROUGH THE LOWER FIFTEENMILE GROUP

In 2010 and 2011 we measured a series of new stratigraphic sections spanning the lower Fifteenmile Group in the central Coal Creek inlier and eastern Hart River inlier (Table 1). Based on these new sections and our correlations with the Hart River inlier, we define three new informal formations in what we regard as the lower Fifteenmile Group and revise a fourth map unit (PPD1 in the Hart River inlier; Abbott, 1997) to the Fifteenmile Group. Here we describe two key sections that underpin these new definitions and our proposed correlations.

Table 1. *Section names and locations of new stratigraphic logs in the Coal Creek (CC) and Hart River (HR) inliers that form the base of our proposed new nomenclature and correlation scheme for the lower Fifteenmile Group is this region.*

Measured Section	Inlier	Units measured	Latitude	Longitude	Comments
GO130	CC	Gibben fm (including lower sandstone), lower Chandindu fm	N64°44′36.1″	W139°48′34.8″	Proposed type section for the Gibben fm, which is superbly exposed
GO131	CC	Chandindu fm, lower Reefal ssemblage	N64°44′18.4″	W139°49′59.4″	Good exposure of siltstones in Chandindu fm; little exposure of overlying lower Reefal assemblage
GO133	CC	middle Reefal assemblage	N64°43′52.5″	W139°50′08.4″	Overall poor exposure, but some excellent exposure of silty black shale in creek
GO134	CC	middle Reefal assemblage	N64°43′46.1″	W139°50′18.5″	Intervals of no exposure, but some excellent exposures of black shales and carbonates
GO132	CC	middle Reefal assemblage	N64°43′15.4″	W139°49′52.8″	Top of section=base of F833 section; poorly exposed and tectonically thickened
GO137	HR	lower Gibben fm	N64°38′8.2″	W136°53′26.1″	Base of section in fault contact with PPD1; top of section folded
GO138	HR	Lower Gibben fm, Chandindu fm	N64°37′52.9″	W136°53′52.7″	Continuation of GO137; excellent exposure through upper Chandindu fm

COAL CREEK INLIER

We measured a series of new sections spanning the lower Fifteenmile Group, including a composite stratigraphic section starting from the Pinguicula-Fifteenmile contact through the base of the extraordinarily well-exposed section (F833; Figures 3 and 4 in Macdonald and Roots, 2010) that contains the 811 Ma ash bed (Macdonald *et al.*, 2010a) just north of the Mount Harper volcanic edifice (Figs. 2–4). Mapping of this lower Fifteenmile Group outcrop belt demonstrated that a series of minor thrust faults mapped by Thompson *et al.* (1994) as placing PR4 dolostone on PR5 shale are in fact conformable contacts, with each of the dolostone deposits representing distinct stratigraphic units interbedded with shale. Although the section is clearly affected by minor folding and tectonic thickening, in particular in the substantial intervals of shale, it represents a continuous stratigraphic section.

NEW MEASURED SECTION (GO130-131-132-133-134)

The base of the section (G0130; Fig. 3) is an unconformable contact with a wedge of large, domal, locally brecciated, and heavily cemented gold and grey dolomitic stromatolites below. The stromatolite unit is 10.2 m thick, but it thins to the east, where the Fifteenmile Group rests directly on cleaved shale and siltstone of the Gillespie Lake Group. To the west, the stromatolite unit thickens dramatically: approximately 3 km to the west, it is over 600 m thick. Above this contact, the basal Fifteenmile Group is composed of medium-grained, moderately sorted sandstone with abundant lithic fragments (carbonate and slate) and wavy, medium-bedding. In this section, the poorly exposed sandstone is only 13.5 m thick and transitions upwards into carbonate (Fig. 4a); to the west, the sandstone thickens and an unmeasured interval of shale separates the sandstone from the overlying carbonate unit.

This carbonate unit (Figs. 3 and 4) comprises 217 m of predominantly blue-grey, medium bedded dolostone with abundant ooid and intraclast grainstone and packstone, wavy laminated, dark grey ribbonites with molar tooth structures, microbial laminite, and associated rudites arranged in an overall shallowing-upward sequence. Rounded quartz grains are abundant in the lower part of the unit, indicating that the base of the carbonate is transitional from the sandstone below. Three recognizable but minor subaerial exposure surfaces occur within this interval (Fig. 3). The top of the dolostone unit consists of ~24 m of distinct, cream-coloured microbial laminite with minor grainstone capped by a prominent exposure surface.

This exposure surface marks a sharp transition into a prominent mud-cracked maroon shale and siltstone facies that is approximately 35 m thick. Interbedded silt and shale form flaser-like couples and couplets, and some beds are slightly dolomitic. The mud-cracked facies gives way to shoaling-upwards, 1 to 10 m-scale cycles consisting of shale and siltstone passing upward into dolomitic grainstone, stromatolites, and stromatolitic breccias. The stromatolites are columnar to biohermal (up to 3 m thick) grey dolomite, commonly with egg-carton morphology in plan view, and in places canted and displaying significant inherited relief (Fig. 5).

The interval of carbonate-capped cycles passes upward into maroon and olive-coloured silty shale within interbedded fine-quartz wackestone and thin, fine-grained quartz arenite beds. This section eventually gives way to a dipslope on the ridge and non-exposure. The composite section was continued in a drainage 1 km to the west using the exposure at the top of the carbonate unit (Fig. 4b) as a correlation datum. Featureless siltstone and dolomitic wackestone with minor interbedded fine quartz arenite continue to a stratigraphic height of 171 m above the base of the carbonate, marked by a distinct shift to monotonous shale. A long interval of poor exposure follows, although where exposed, the lithology is exclusively dark grey to black shale with minor siltstone beds. Mapping of the unit indicates no apparent lithological variation. Where decent exposure resumes in a ravine, the lithology comprises black shale with minor black marl, transitioning upward to muddy carbonate. The carbonate begins as black limestone rhythmites with fine grey turbidites and grades upwards into a 12.7 m-thick rhythmite plus stromatolite breccia that marks the first major, resistant carbonate bed above the thick shale-dominated section. Flaggy marls with distinct wavy black limestone concretions occur above the breccia and continue upward into marl, black limestone rhythmite, and black rhythmite breccia. The breccias become silicified and dolomitic, in places forming clearly distinct coarse breccia sheets separated by lenses of black marl and rhythmite. This heavily altered, dolomitic breccia forms a prominent resistant cap to the ridge on which it occurs.

This dolomitic unit is separated from the next major carbonate buildup, the base of which is the lower part of section F833 (Fig. 2; Figure 4 in Macdonald and Roots, 2010; Macdonald *et al.*, 2010a,b). Exposure along the continuation of the measured section (through a saddle) was limited, but float consisted entirely of dark grey to black siltstone and shale. Steep gullies on either side of the saddle afford excellent exposures of black shale. This shale interval is likely several hundred metres thick, but due to local folding and potential repetition, an accurate stratigraphic thickness cannot be determined.

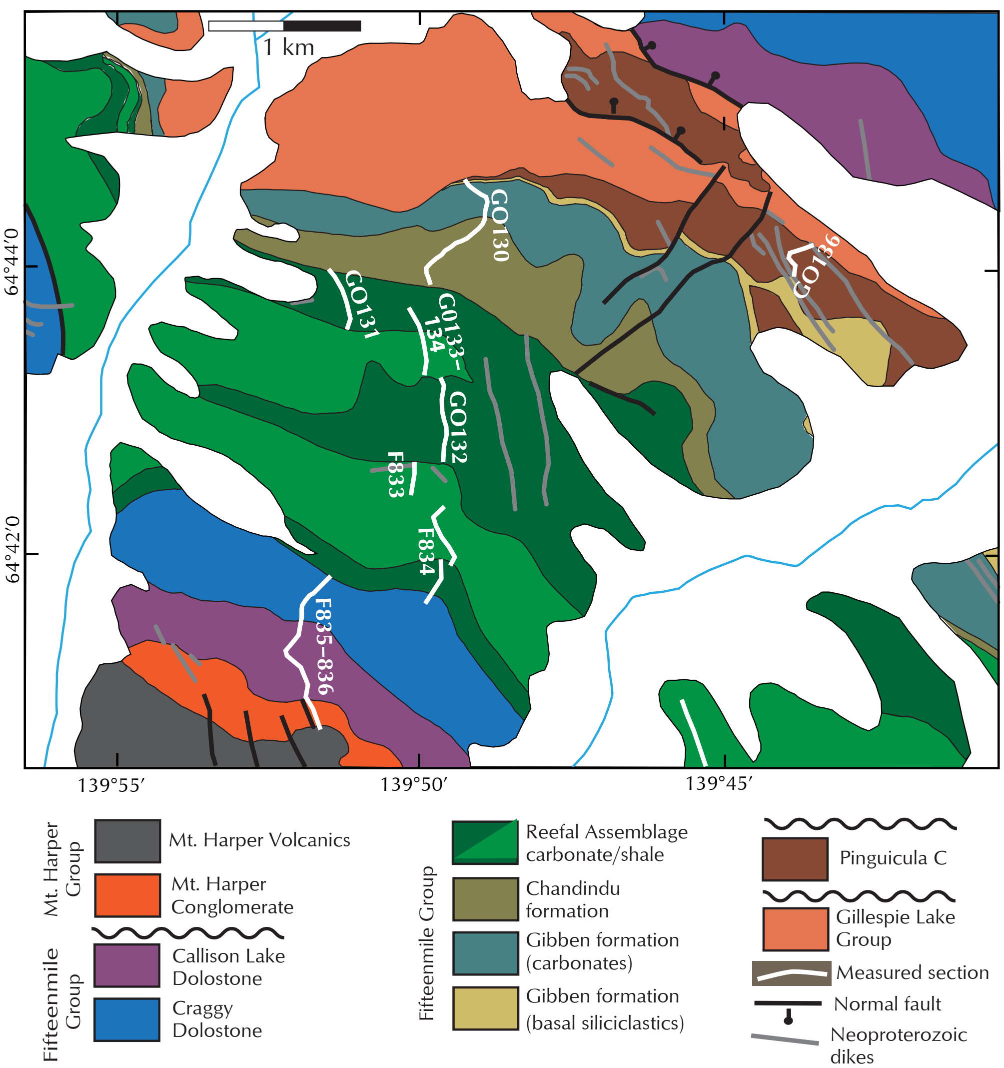

Figure 2. *Geological map for the NE flank of Mount Harper in the southwestern Coal Creek inlier (Fig. 1) showing the location of a key composite stratigraphic section through the Fifteenmile Group (see Figure 3). Based on our own mapping and previous mapping by Thompson et al. (1994).*

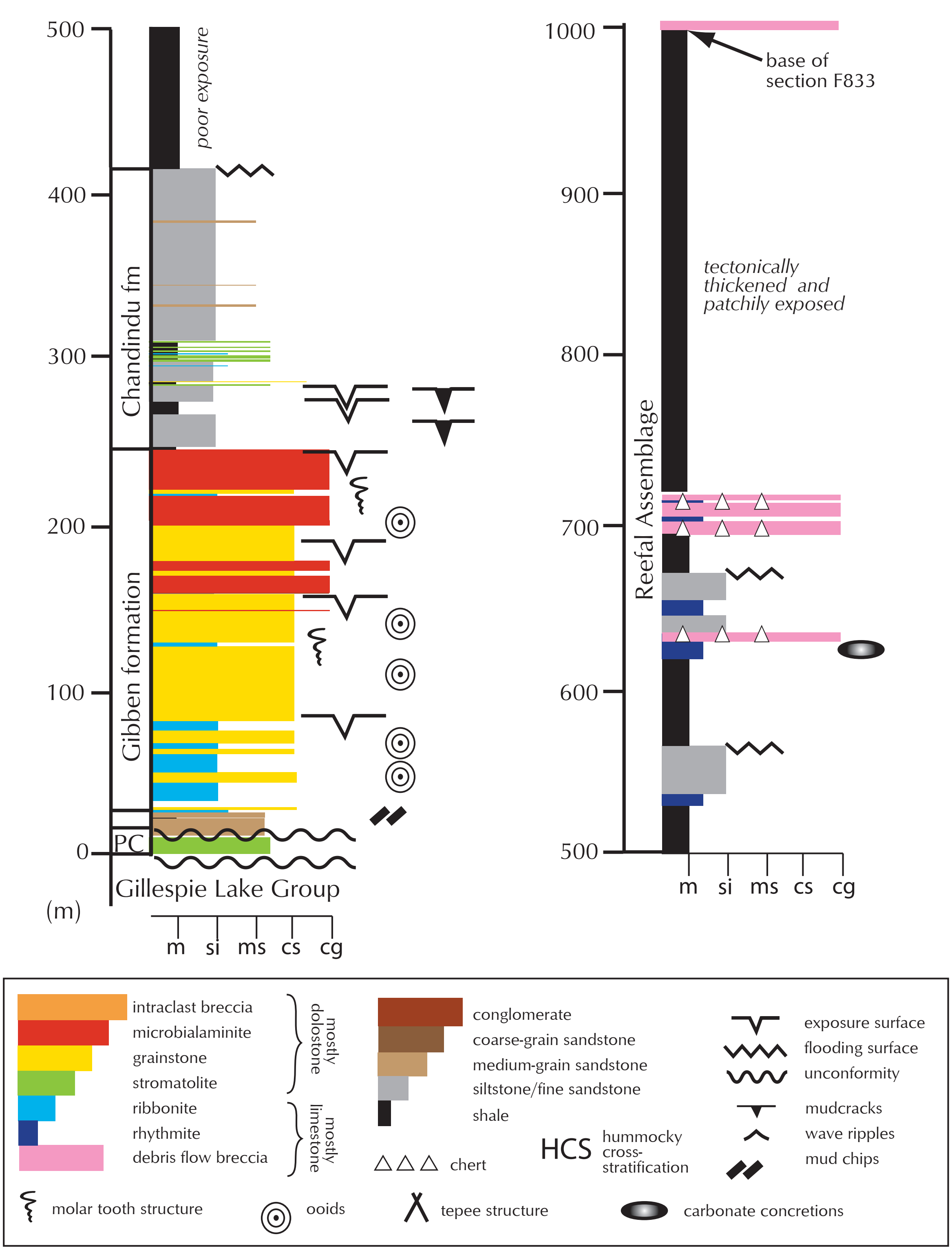

Figure 3. *Composite stratigraphic log (GO130/GO131/GO133-134/GO132) through the lower Fifteenmile Group NE of Mount Harper. Note the log ends at the base of section F833, which is the continuation of this composite Fifteenmile Group plotted in Macdonald and Roots (2010). Grain size scale: m = mud; si = silt; ms = medium sand; cs = coarse sand; cg = coarse gravel.*

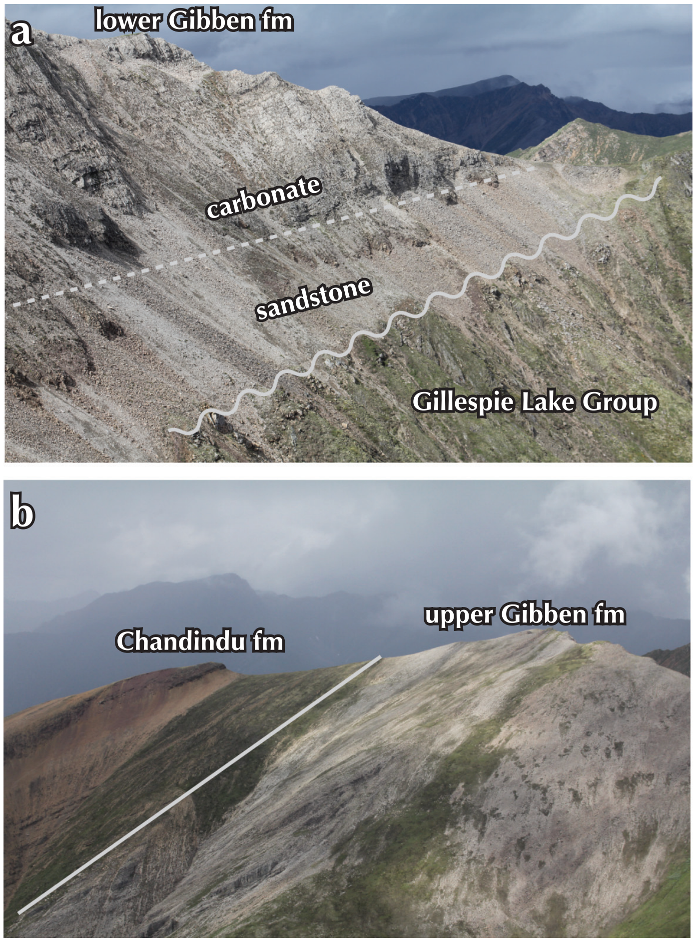

Figure 4. *Views of the lower Fifteenmile Group at section GO131, north of Mount Harper (Fig. 3).* ***(a)*** *Poorly exposed, northward-tapering sandstone interval here assigned to the basal Gibben formation unconformably overlies the Gillespie Lake Group and grades upward into ribbonite and grainstone of the lower Gibben formation.* ***(b)*** *Contact between dolomitic grainstone and microbial laminite of the upper Gibben formation and distinctive mud-cracked siltstone of the lower Chandindu formation.*

Figure 5. *Distinct, pseudo-columnar, canted grey limestone stromatolites in the middle Chandindu formation of the Coal Creek inlier and capping a shale-carbonate parasequence. Hammer, for scale, is 37 cm tall.*

HART RIVER INLIER

We measured stratigraphic sections through the lower Fifteenmile Group in the Hart River inlier (Figs. 6–8) in 2009, 2010, and 2011, building upon the detailed mapping of Abbott (1997) in the western part of the inlier and complementary work focused on the Pinguicula Group (e.g., Medig *et al.*, 2010). The Fifteenmile Group is relatively incomplete in the Hart River inlier due to major erosional unconformities beneath both the Callison Lake Dolostone and the Cambrian–Devonian Bouvette Formation (Fig. 8). However, there are well-exposed sections of what has variably been included in the Fifteenmile (Abbott, 1993) and Pinguicula (Abbott, 1997) groups and what we regard here as lower Fifteenmile Group. Here we describe a key new section measured in 2011 (Fig. 7) that permits confident correlation of the upper Pinguicula and Fifteenmile groups between the Hart River and Coal Creek inliers.

NEW MEASURED SECTION (GO137-138)

This section lies along Abbott's (1997) Section 1 and follows a north-south ridge ~1.5 km east of Marc Creek in the eastern Hart River inlier (Figs. 6–8). Our section starts in maroon to purple shale that Abbott (1997) included as the upper member (above medium-grained quartz arenite) in map unit PPD1. The contact between the quartz arenite and shale is disturbed by a pair of north-dipping normal

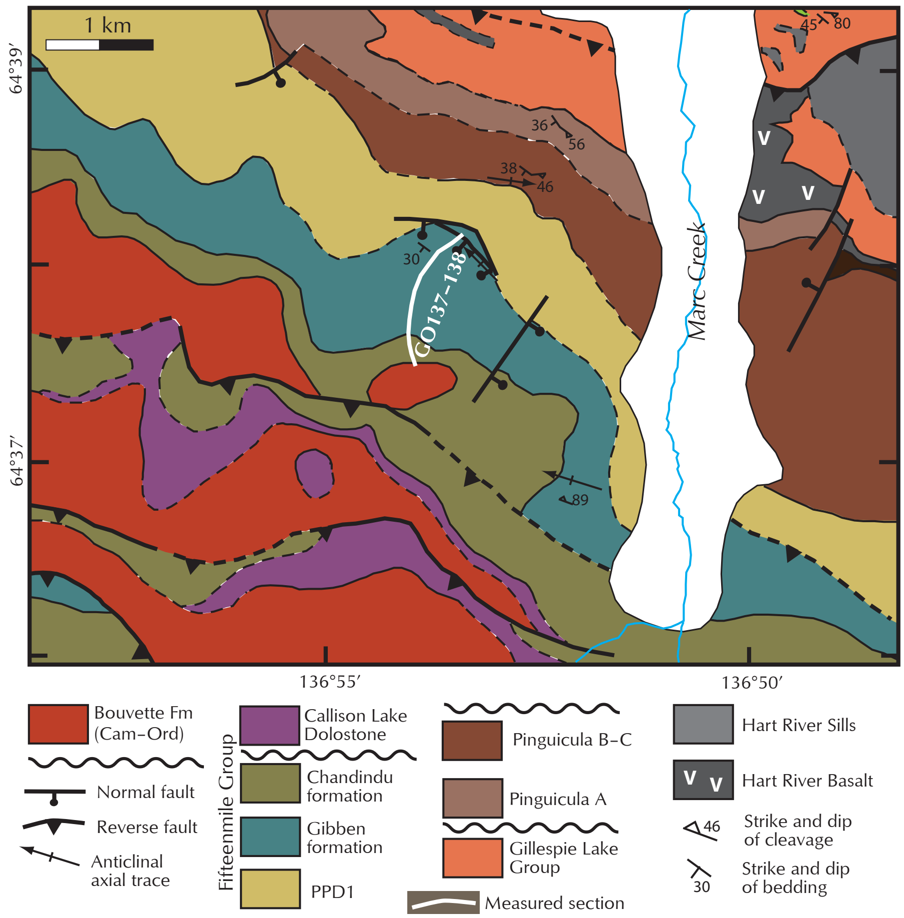

Figure 6. *Geological map in the eastern Hart River inlier (Fig. 1), showing the location of our new stratigraphic log through the Fifteenmile Group (Section 1 in Abbott, 1997) shown in Figure 7. Map is modified from Abbott (1997).*

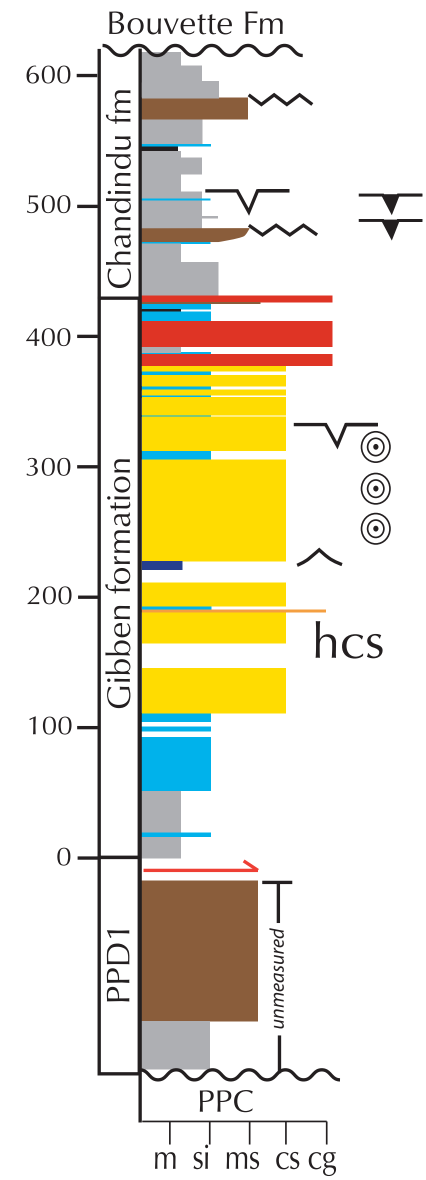

Figure 7. *Stratigraphic log in the lower Fifteenmile Group (PPD1, Gibben formation, and Chandindu formation) in the eastern Hart River inlier (Fig. 6). Grain size scale: m = mud; si = silt; ms = medium sand; cs = coarse sand; cg = coarse gravel. See Figure 3 for legend.*

faults and folds in the basal shale. However, along strike, it is clear that the quartz arenite transitions upwards into the shale, even if the transition is rather abrupt. These lower purple shales contain abundant lenses and thin beds of pink limestone through at least 55 m of section. They transition gradationally into flaggy to wavy pink and white limestone with minor hummocky cross-stratification (HCS) and abundant purple shale partings. The limestone-dominated interval is ~35 m thick, but because it is heavily folded and becomes poorly exposed upsection, its exact thickness is impossible to determine.

Whereas the contact with the much thicker, blue-grey carbonate unit above (Fig. 8) is somewhat obscured by cover, it appears gradational and likely reflects upward shoaling of the depositional sequence. This blue-grey dolomite unit measures 335 m thick and consists predominantly of grainstone and packstone, with abundant ooids, coated grains, and flat pebble intraclasts, arranged in mainly tabular, medium beds (Fig. 9a). Coarser-grained intraclast conglomerates also occur, and parallel to ribbony-laminated dark grey dolostones with minor HCS and molar tooth structures are also common (Fig. 9b). Rare exposure, flooding, and obviously scoured surfaces occur, and through most of the interval, there is no apparent cyclicity. However, in the upper 50 m of

Figure 8. *East-facing view of the measured section spanning the lower Fifteenmile Group in the Hart River inlier (equivalent to Abbott's [1997] section 1). Note that the section is top-truncated here by the Cambrian–Devonian Bouvette Formation. Elsewhere, the upper contact with the Chandindu formation is an angular unconformity beneath the Callison Lake Dolostone.*

the section, microbial laminite with tepee structures (Fig. 9c) becomes the dominant carbonate facies and occurs in beds separated variably by shale, marl, and dolomite ribbons, giving rise to apparent metre-scale cyclicity. The abundance of mud within this part of the section is noticeably diminished in outcrops approximately 2 km to the southeast, where the microbial laminite facies (Fig. 9c) is conversely more pronounced.

The top of the carbonate unit is marked by an abrupt shift to dominantly fine-grained siliciclastic rocks. The succeeding 186 m form 20 m-scale cycles that consist mainly of dark shale gradationally transitioning into grey to white siltstone or fine-grained quartz arenite. The cycles are separated by flooding and exposure surfaces. The cycles become somewhat coarser-grained upsection and the uppermost fine-grained sandstones below the Bouvette unconformity contain low angle cross-beds. Mud-cracks are also common in the upper part of the lower cycles (Fig. 9d). Tan to orange, flaggy dolomitic interbeds occur in the middle of several of the cycles and are more prominent upsection. In exposures ~2 km to the southeast, some of these thin and laminated dolomitic intervals are replaced by poorly developed, stromatolite beds (Fig. 9e).

CORRELATIONS AND UPDATED NOMENCLATURE FOR THE FIFTEENMILE GROUP

Two key observations in the Coal Creek inlier underlie the major revision to the correlation and nomenclature of the lower Fifteenmile Group (previously referred to as the "Lower assemblage"; e.g., Macdonald *et al.*, 2011) that we propose here. First, the lowermost Fifteenmile Group is highly variable in thickness and appears to fill small fault-bounded sub-basins, resulting in wedge-shaped stratal geometries (Fig. 10). Second, a series of south-directed

Figure 9. *Lithofacies characteristic of the Gibben and Chandindu formations in the Hart River inlier.* ***(a)*** *Coated grain packstone in the middle Gibben formation.* ***(b)*** *Ribbon facies dolostone in the middle Gibben formation.* ***(c)*** *Microbial laminite with small tepee structures in the upper Gibben formation.* ***(d)*** *Mud-cracks in the lower Chandindu formation siltstone and shale.* ***(e)*** *Stromatolites in the upper Chandindu formation.*

thrust faults mapped as duplicating sections of carbonate-shale in the upper part of the lower Fifteenmile Group (Thompson *et al.* 1994) appear instead to be conformable stratigraphic contacts. Resolution of these problems paints a new picture of the stratigraphic evolution of the lower Fifteenmile Group and motivates new formation names that can be extended to the Hart River inlier. We propose below an informal tripartite division of the lower Fifteenmile Group comprising the Gibben formation (including unit PPD1), the Chandindu formation, and the Reefal assemblage.

THE GIBBEN FORMATION (INCLUDING UNIT PPD1)

The base of the Fifteenmile Group in Section 3 (Fig. 10) consists of hundreds of metres of shale, grading upward into pink limestone ribbonites. This distinct interval of the lower Fifteenmile Group tapers out laterally over a distance of kilometres; it is entirely absent in nearby Section 4 (Fig. 10). To the north (Sections 1 and 2), the Pinguicula Group is unconformably overlain by <10 m of coarse sandstone on paleo-highs and hundreds of metres of shale to siltstone in the axes of newly formed grabens. In Section 2, the sandstone is succeeded by the distinct pink limestone ribbons, which grade upward into ooid grainstones then microbial laminites with tepees, reflecting subaerial exposure. Hence this succession comprises a characteristic shoaling-upward sequence. It is overlain by distinct, maroon, mud-cracked shale and siltstone. In our new section north of Mount Harper (Fig. 4 and Section 2 in Fig. 10), an analogous shoaling-upward sequence occurs, albeit with a relatively condensed interval of ribbonites and a thicker interval of ooid-rich grainstone (Fig. 5). This sequence is similarly bound above by an exposure surface and overlain by mud-cracked maroon shale and siltstone at Section 2 and everywhere else we have mapped it (Fig. 10). We propose to name this succession, which includes the basal siltstone-sandstone and the carbonate sequence, the Gibben formation (informal) after Mount Gibben (Section 5), in the south-central Coal Creek inlier, but recommend that Section 2 be the reference section because the base of the section near Mount Gibben is truncated, lacking the lower ribbonites. Based on this definition, the base of the Gibben formation is a sandstone in unconformable contact with underlying Pinguicula or Gillespie Lake Group (Fig. 4A). The nature of this contact and the significance of the sandstone will be discussed further below. The Gibben formation varies in thickness from <20 to >600 m in the Coal Creek inlier. As defined, it is broadly equivalent to units PR3, PR4, and PR5a in Thompson *et al.* (1994).

THE CHANDINDU FORMATION

The top of the Gibben formation is an exposure surface developed on top of an interval of interbedded microbial laminites and grainstones (Fig. 4b). This contact marks an abrupt transition to fine-grained, mud-cracked, maroon shale and siltstone that form the base of what we have named the Chandindu formation, after the Chandindu River which drains the region east and south of Mount Gibben. This distinctive mud-cracked facies is more widespread than the underlying Gibben formation and has been recognized in all of our measured sections in the lowermost Fifteenmile Group (Fig. 10). The remainder of what we have identified as the Chandindu formation is rather variable between sections, but is typically dominated by shale or siltstone, in places arranged in cycles capped by carbonates (grainstone, stromatolite, or interclast breccia). In some sections, stromatolites are relatively abundant (Fig. 6), forming distinct bioherms surrounded by shale. Poorly-sorted, thin, granular sandstone beds also occur in some sections. We have placed the upper boundary of the Chandindu formation as the first major flooding surface above the mud-cracked shale and siltstone, which effectively separates this heterogeneous sequence from the overlying shale and dolomite-dominated informal “Reefal assemblage” described below. As defined, the Chandindu formation is approximately equivalent to Thompson *et al.* (1994) map unit PR5 and varies in thickness from ~150–400 m where we have mapped it in the Coal Creek inlier.

THE REEFAL ASSEMBLAGE

The removal of many of the minor thrust faults from the unpublished maps of the lower Fifteenmile Group in the Coal Creek inlier has important implications for understanding the stratigraphic evolution of the sedimentary basin in which the Fifteenmile Group was deposited. For example, we interpret the contact between heavily silicified, coarse breccia and shale (at approximately the 1300 m level in composite Section 2 in Fig. 10) previously mapped as a north-directed thrust fault that places “PR4” on “PR5” (Thompson *et al.*, 1994) to record instead a transition from deepwater rhythmites to talus breccias at the toe of a prograding carbonate platform. This and similar revisions to the mapping portray the upper part of the lower Fifteenmile Group as a thick (>1000 metres in our composite Section 1; Fig. 10) complex framework of interwoven carbonate and shale (Figs. 3 and 10). We interpret this stratigraphy to reflect a series of northwest-prograding stromatolite-cored reef tracts that grade distally into grey and black-shale dominated deep basinal deposits. Sections from within the carbonate platform are dominated by stromatolitic bioherms (Section 4) and shallow intertidal to supratidal facies (Section 5). To the northwest, stromatolites are rare and the succession is dominated by shale and gravitationally redeposited carbonate sediments (Section 2 in Fig. 10). In recognition of the importance of stromatolite reefs throughout this interval, we propose to name it the “Reefal assemblage,” which is roughly equivalent to

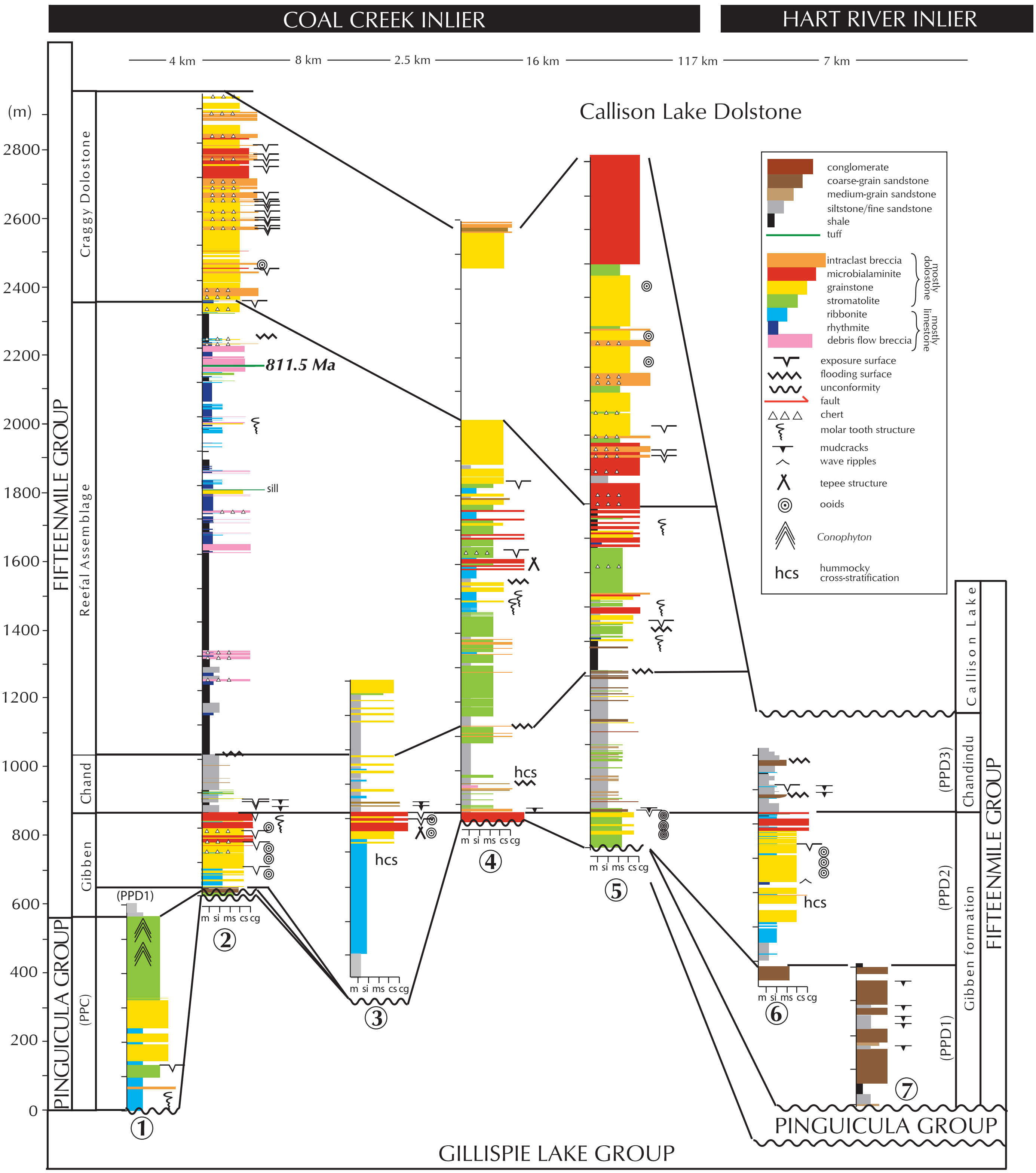

Figure 10. *Selected stratigraphic columns through the upper Pinguicula Group and lower Fifteenmile Group in the Coal Creek and Hart River inliers with suggested correlations and updated nomenclature. Note that the equivalent of map unit PPD1 in the Hart River inlier is included within the Gibben formation in the Coal Creek inlier. Grain size scale: m = mud; si = silt; ms = medium sand; cs = coarse sand; cg = coarse gravel.*

map unit "PF1a" of Thompson *et al.* (1994). The top of the Reefal assemblage is recorded by a distinct subaerial exposure surface overlain by the heavily silicified Craggy Dolostone ("PF1"), which comprises mainly shallow-water dolostone facies and appears to mark the progradation of a broad carbonate platform over the basin.

PPD1 AND CORRELATION WITH THE HART RIVER INLIER

In our proposed reference section (Fig. 3), the basal Gibben formation comprises several metres of medium-grained, moderately-sorted sandstone with rounded quartz grains and variable lithic clasts. This sandstone pinches out to the west and significantly thickens to the east (Fig. 2), where a dark grey siltstone is exposed beneath the sandstone. The contact between this siltstone-sandstone unit and the recrystallized stromatolitic dolostone below (previously mapped as "PR2"; Thompson and Roots, 1994) is an unconformity (Fig. 10). This overall sequence of siltstone grading up into sandstone and capped by a thick, shoaling-upward, medium-bedded, bluish-grey carbonate sequence replete with ooids and overlain by mud-cracked muddy siltstone is nearly identical to our measured section in the Hart River inlier (Figs. 7 and 8). Abbott (1997) referred to the siltstone–sandstone unit, along with the overlying maroon-purple shale as "PPD1", the carbonate sequence as "PPD2", and the upper interval of shale and siltstone with minor dolostone as unit "PPD3". We correlate PPD2 and PPD3 with the Gibben and Chandindu formations, respectively and interpret the siltstone-sandstone sequence at the base of the Fifteenmile Group in the Coal Creek inlier to be equivalent to PPD1 (Fig. 10). Because the equivalent of PPD1 is relatively poorly preserved in the Coal Creek inlier and transitional with overlying carbonates of the Gibben formation, we include PPD1 in the Gibben formation. However, pending identification of an appropriate reference section, PPD1 as a whole, or the lower shale-siltstone interval, should be separated as a distinct formation comprising the base of the Fifteenmile Group.

Abbott (1997) placed PPD1, PPD2, and PPD3 in the Pinguicula Group. However, we have recognized a prominent unconformity beneath PPD1 elsewhere in the Hart River inlier (Section 7; Fig. 10), consistent with Abbott (1993) and our observations in the Coal Creek inlier. Consequently, as originally proposed by Abbott (1993) and in agreement with Medig *et al.* (2010), we suggest including these units within the lower Fifteenmile Group. Correlation between the Coal Creek and Hart River inliers implies that a large portion of the Fifteenmile Group (upper Chandindu formation through the Craggy Dolostone) is missing in the Hart River inlier (Fig. 10). This conclusion is consistent with the documentation of a prominent angular unconformity beneath the Callison Lake Dolostone in the Hart River inlier (Abbott, 1997; Macdonald and Roots, 2010).

CONTACT WITH THE PINGUICULA GROUP

In Abbott's (1997) Section 1 in the Hart River inlier (Figs. 7 and 8), what we recognize as the base of the Fifteenmile Group unconformably overlies orange-weathering muddy dolostone and green shale of unit B of the Pinguicula Group (PPB). Further east in the inlier, the uppermost Pinguicula Group is composed of a cream-coloured, massive to thick-bedded dolostone (PPC; Abbott, 1997), which conformably overlies PPB (Medig *et al.*, 2010) and is intensely brecciated and karstified beneath PPD1. In our reference section for the Gibben formation (Fig. 3), PPD1 rests unconformably atop a unit of cream-coloured dolomitic stromatolites, this is truncated beneath the contact to the west. To the east, this dolostone thickens to over 600 m, the upper part of which is composed of a spectacular exposure (Fig. 10) of large, reef-forming *Minjaria* and *Conophyton* stromatolites (Fig. 11) and stromatolite breccias. We correlate this thick stromatolitic dolostone unit with PPC in the Hart River inlier. Notably, just as PPC appears to have been rotated and eroded beneath PPD1 in the Hart River inlier (Abbott, 1997), our upper Pinguicula Group stromatolites form a wedge-shaped map unit beneath the Fifteenmile Group (Fig. 2), implying rotation and truncation. This observation is consistent with mapping of the Gibben formation, which indicates that the onset of Fifteenmile Group deposition resulted from an extensional episode post-dating the Pinguicula Group but significantly earlier than 811 Ma.

DISCUSSION AND CONCLUSIONS

Figure 12 presents an updated but still incomplete revision of the informal nomenclature and stratigraphic framework for the Fifteenmile Group and its correlation between the Coal Creek and Hart River inliers. This new stratigraphic scheme builds upon recent revisions to the nomenclature in the Coal Creek and Tatonduk inliers (Macdonald and Roots, 2010; Macdonald *et al.*, 2011) and dispenses with the former PR and PF subdivision of the

Figure 11. *Stromatolites in the upper Pinguicula Group in the Coal Creek inlier (section GO136; Fig. 3). A thick stromatolitic succession in the upper part of PPC(?) comprises mainly Conophyton **(a)** and Minjaria **(b)**.*

Fifteenmile Group. Given the recognition of an angular unconformity separating the Callison Lake Dolostone from the underlying Fifteenmile Group in the Hart River inlier, we suggest that the Callison Lake Dolostone more appropriately belongs with the lower Mt. Harper Group (Fig. 11), or perhaps even separate from both the Fifteenmile and Mt. Harper groups. The Fifteenmile Group is now tentatively subdivided, from oldest to youngest, into PPD1 (in the Hart River inlier), the Gibben formation, the Chandindu formation, the Reefal assemblage, and the Craggy Dolostone (Fig. 11). PPD1 is a residual name from when it was assigned to the Pinguicula Group (Abbott, 1997) and should be replaced by a proper formation name pending identification of an appropriate reference section, most likely in the Hart River inlier where it is best developed.

PPD1 and the Gibben and Chandindu formations correlate unambiguously between the Coal Creek and Hart River inliers (Fig. 10). In the former, where we have measured more sections, all three are highly variably in thickness, reflecting the opening of small, fault-bound sub-basins during deposition of the lowermost Fifteenmile Group. This faulting, which appears to have been active at least until early Chandindu times, is evident in the significant lateral variations in thickness of PPD1 and the Gibben formation and in the lateral facies variations in the Chandindu formation (Fig. 10). In the Coal Creek inlier, the thickness of the lower Gibben formation is clearly linked to the extent of erosional truncation of the underlying stromatolite unit (Fig. 2), suggesting block rotation related to normal faulting.

Medig *et al.* (2010) had previously suggested that former map units PR1 and PR2 in the Coal Creek inlier belong to the Pinguicula Group and our mapping bears this interpretation out. Hence, the unconformity separating PPB and PPC from PPD1 in the Hart River inlier is the same unconformity we have mapped atop the rotated stromatolitic dolostone in the Coal Creek inlier. We further suggest that the stromatolitic unit in the upper Pinguicula Group in the Coal Creek inlier (Fig. 10) is most likely equivalent to unit PPC, as identified in the Hart River (Abbott, 1997) and Wernecke (Eisbacher, 1981; Thorkelson *et al.*, 2005; Medig *et al.*, 2010) inliers.

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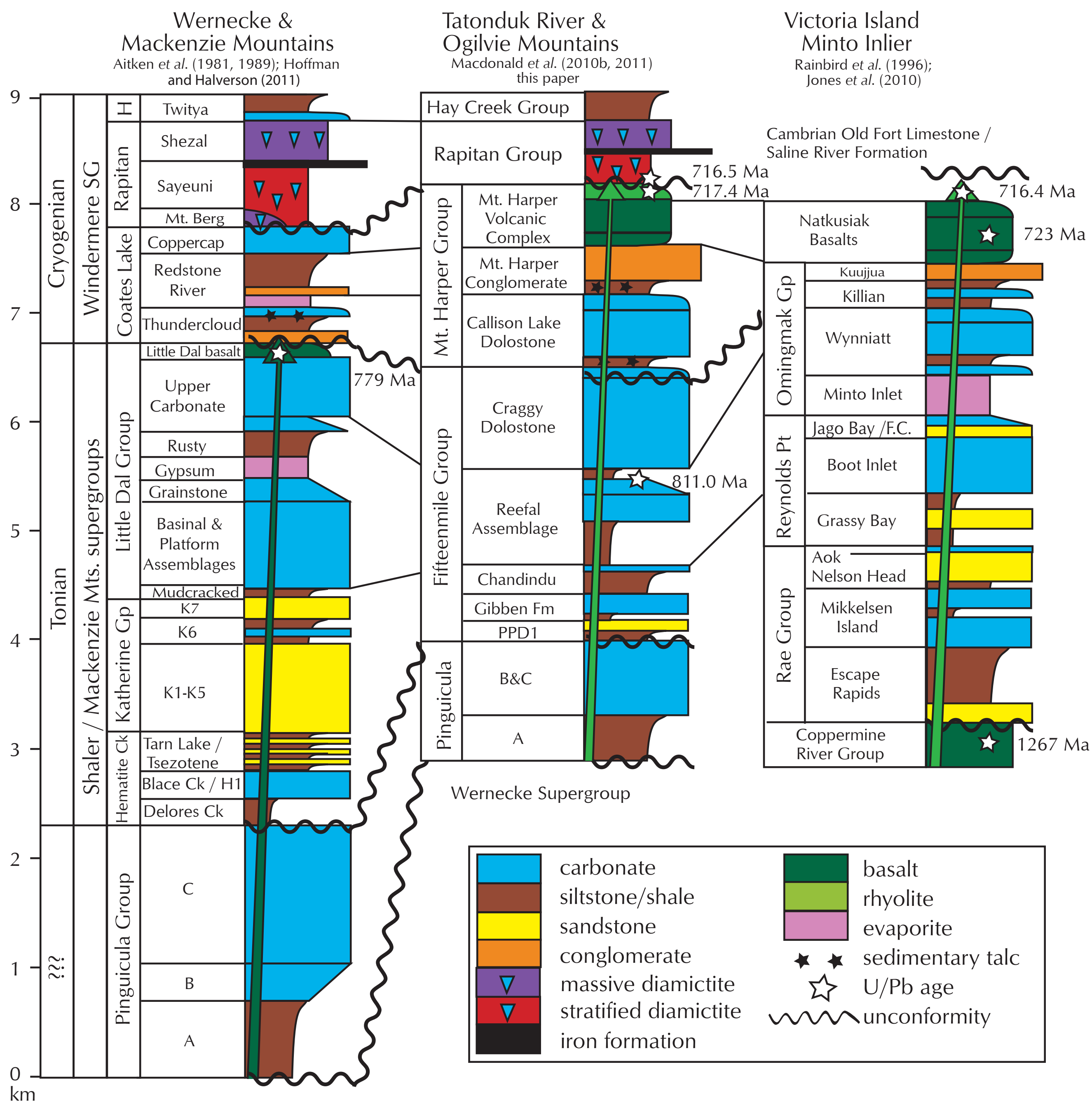

Figure 12. *Schematic columns of the Sequence B (plus Pinguicula) and lower Sequence C (Cryogenian) stratigraphy across northern Canada, showing available U-Pb zircon age constraints and our proposed correlations and new nomenclature for the lower Fifteenmile Group in the Ogilvie Mountains. U-Pb ages: 779 Ma (Harlan et al., 2003); 716.5, 717.4, 811.0, 716.4 Ma (Macdonald et al., 2010); 723 Ma (Heaman et al., 1992); 1267 Ma (LeCheminant and Heaman, 1989).*

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