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Foreword

The Geo-mapping for Energy and Minerals (GEM) program is laying the foundation for sustainable economic development in the North. The Program provides modern public geoscience that will set the stage for long-term decision making related to responsible land-use and resource development. Geoscience knowledge produced by GEM supports evidence-based exploration for new energy and mineral resources and enables northern communities to make informed decisions about their land, economy and society. Building upon the success of its first five-years, GEM has been renewed until 2020 to continue producing new, publically available, regional-scale geoscience knowledge in Canada's North.

During the 2017 field season, research scientists from the GEM program successfully carried out 27 research activities, 26 of which will produce an activity report and 12 of which included fieldwork. Each activity included geological, geochemical and geophysical surveying. These activities have been undertaken in collaboration with provincial and territorial governments, Northerners and their institutions, academia and the private sector. GEM will continue to work with these key partners as the program advances.

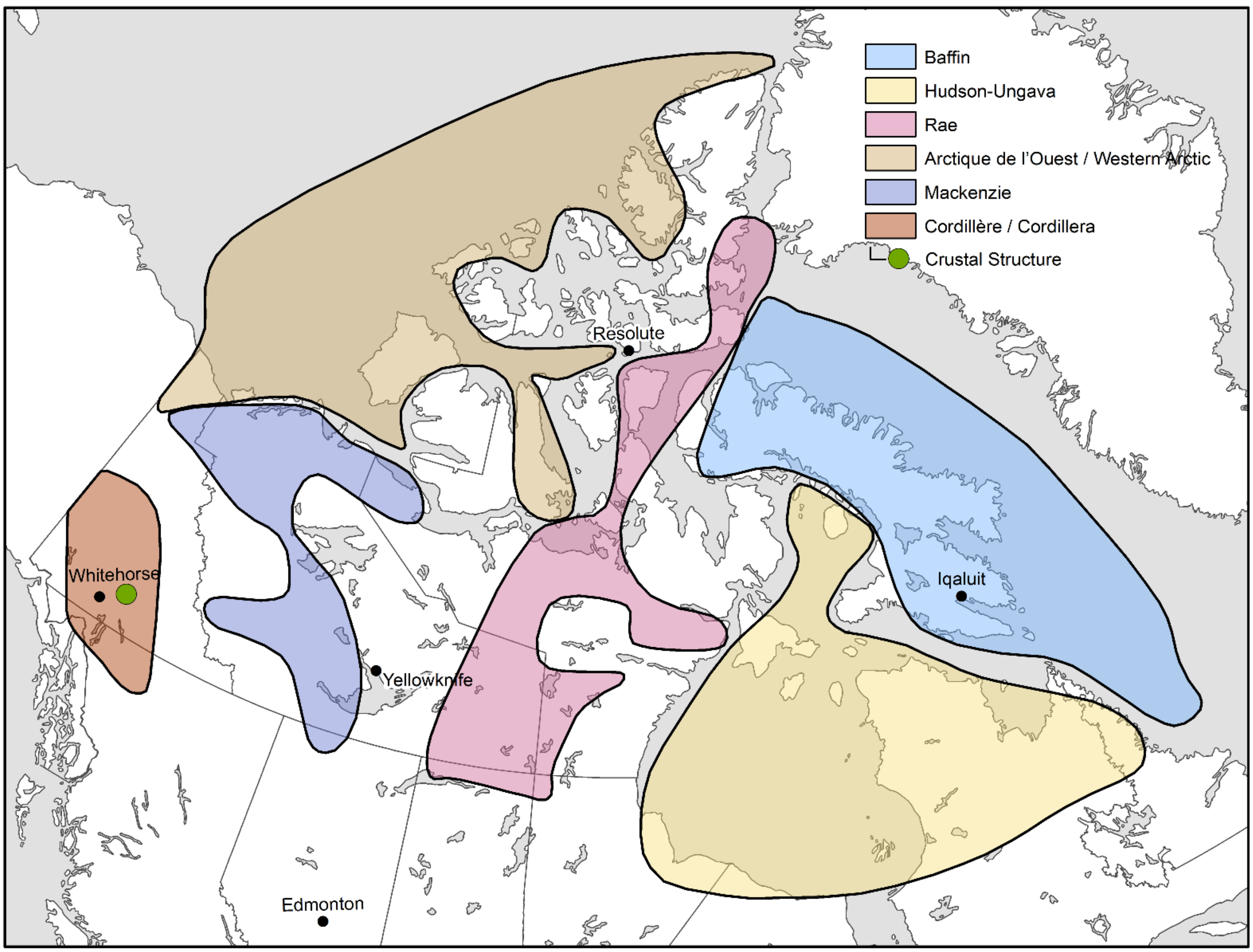

Figure 1. Overview map illustrating the footprints of all GEM-II projects, including the Cordillera project. Location of the Crustal Structure activity is indicated by green dot.

Project Summary

This open file report outlines the 2017 field activities conducted in the Dunite Peak area of the Big Salmon Range, south central Yukon (Figure 1), as part of the Geo-mapping for Energy and Minerals (GEM-2) program Cordillera project. Following from 2016 field activities in the same region, targeted bedrock geological mapping and sampling was conducted to test new hypotheses and gain better understanding of the deformation processes responsible for the tectonic assembly of the NW Cordillera and the timing of specific events during collision with and accretion to the North American craton.

The NW Cordillera is composed of multiple crustal blocks which formed volcanic islands (island arcs) west of the North American continent between the Devonian to Jurassic periods. Prior to their accretion, these islands were separated from the continent by an intervening ocean basin; Slide Mountain Ocean (SMO) (Fig. 2). During the Triassic – Cretaceous, these blocks or 'terranes' collided with the North American continent craton to produce the NW Cordilleran mountain system. In the Dunite Peak area, remnants of oceanic rocks belonging to the SMO are preserved structurally on top of the Yukon-Tanana terrane (YTT). The aim of this study is to characterize the structural relationships between the Slide Mountain and Yukon-Tanana terranes to better understand the early formation of the SMO and the deformation processes that occurred during closure of this ocean, and terrane accretion to the North American continent. The results of 2017 field activities provide a clearer picture of the petrogenesis of the Dunite Peak ophiolite and allow for completion of a geological map for the area.

1. Introduction

The NW Cordillera (Figure 2) is composed of multiple terranes that record a complex and protracted geological history spanning 1.8 Ga, prior to and during accretion to the North American continent (Nelson *et al.* 2013). Determination of the timing and kinematics of terrane accretion is fundamental to our understanding of the NW Cordillera and of accretionary orogens in general.

Such understanding can be gained through targeted, integrated geochronological, thermobarometric and mapping followed up with detailed PTtD (Pressure, Temperature, time, Deformation) studies of terrane interactions (e.g. Berman *et al.* 2007). Here, we present preliminary findings from field activities in 2017 that build on fieldwork conducted in the same area in 2016.

The Slide Mountain terrane (SMT) is an oceanic terrane comprised of chert, mid-ocean ridge basalt (MORB), gabbro, serpentinized mantle peridotite and associated marine sedimentary rocks, with its type section described at Sliding Mountain, northern British Columbia (BC) (Orchard & Struik 1985; Struik & Orchard 1985; Nelson *et al.* 2013).

The SMT has been mapped in SE and north-central BC and south-central Yukon (Figure 2) and typically forms either isolated klippen *overlying* peri-Laurentian / parautochthonous terranes, or thrust-bound enclaves juxtaposed *between* peri-Laurentian / parautochthonous terranes (e.g. Tempelman-Kluit 1979; Erdmer 1985; Struik & Orchard 1985; Nelson, 1993; de Keijzer *et al.* 1999; Fallas *et al.* 1999; Colpron *et al.* 2006; Nelson *et al.* 2013; Petrie *et al.* 2015; Colpron *et al.* 2016; Isard *et al.* 2016).

Interpretations based on current understandings of the SMT propose that the SMO formed as a back-arc basin between the peri-Laurentian and parautochthonous terranes between Devonian-Mississipian times (Tempelman-Kluit 1976; Tempelman-Kluit 1979; Orchard & Struik 1985; Nelson 1993; Roback *et al.* 1994; de Keijzer *et al.* 2000; Murphy *et al.* 2006; Colpron *et al.* 2007). Closure of SMO is proposed to have occurred between Mid Permian – Mid Triassic times during accretion of the YTT and the Quesnellia terrane (QT) to the North American continent (NAC). Final closure of SMO is thought to have completed by the Late Triassic, followed by deposition of a sedimentary cover sequence that overlaps SMT, YTT, QT and NAC (de Keijzer *et al.* 2000; Colpron *et al.* 2006; Baranek and Mortensen 2011).

2. The Dunite Peak ophiolite

The Dunite Peak ophiolite in the Big Salmon range, South-Central Yukon (Figure 2) comprises mafic-ultramafic klippen assigned to SMT, overlying metasedimentary rocks belonging to YTT (de Keijzer *et al.*, 1999; Parsons *et al.*, 2017). The mafic-ultramafic unit consists of an upper layer of ultramafic klippen overlying klippen of mafic to intermediate greenstone and gabbro (Parsons *et al.*, 2017).

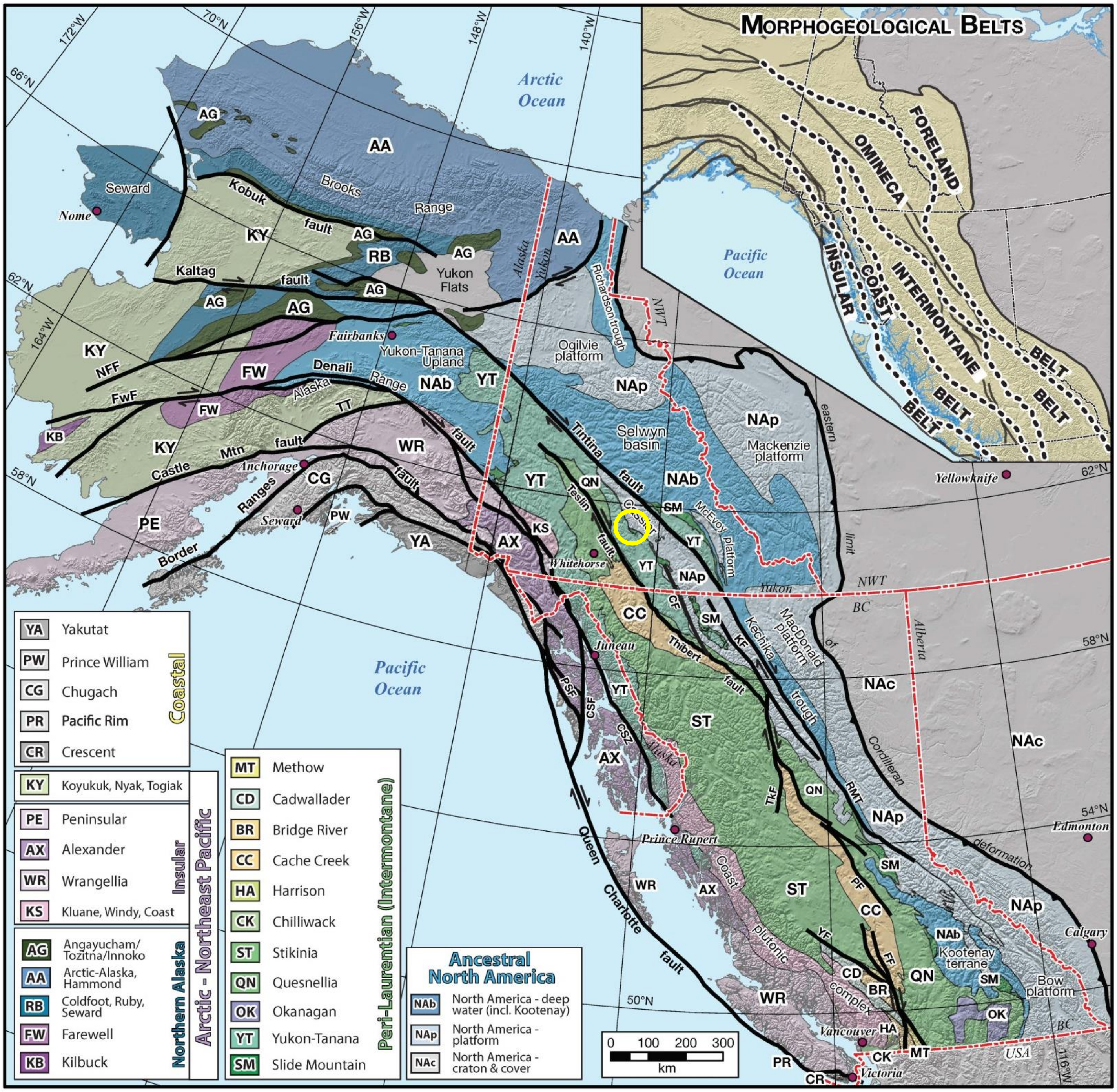

Figure 2. Terrane map of the NW Cordillera (from Nelson et al. 2013). Dunite Peak area highlighted by yellow circle.

U-Pb zircon geochronometry of a plagiogranite in the mafic section yielded an igneous age of 269 ± 10 Ma (de Keijzer *et al.*, 2000).

The underlying metasedimentary rocks contain a lower portion of amphibolite-facies marble with subordinate garnet-kyanite-bearing metapelitic layers. This sequence is overlain by an upper portion of carbonaceous quartzite, marble and quartz-rich semi-pelite and pelite (Parsons *et al.*, 2017).

All units are strongly sheared and commonly mylonitic. Shear zones are identified between the base of the Dunite Peak ophiolite and underlying metasedimentary rocks and between the mafic and ultramafic rocks within the Dunite Peak Ophiolite (Parsons *et al.* 2017). A cryptic shear zone may also exist between the amphibolite-facies marble and overlying carbonaceous metasedimentary rocks based on differences in metamorphic mineral assemblages, although the contact is not observed. (Parsons *et al.* 2017). Across the region, transpositional foliation is sub-parallel to compositional layers. This foliation and associated mineral stretching lineations are folded into a regional synform with a NE-SW trending axial trace. The ultramafic klippen form the core of this synform (Parsons *et al.*, 2017).

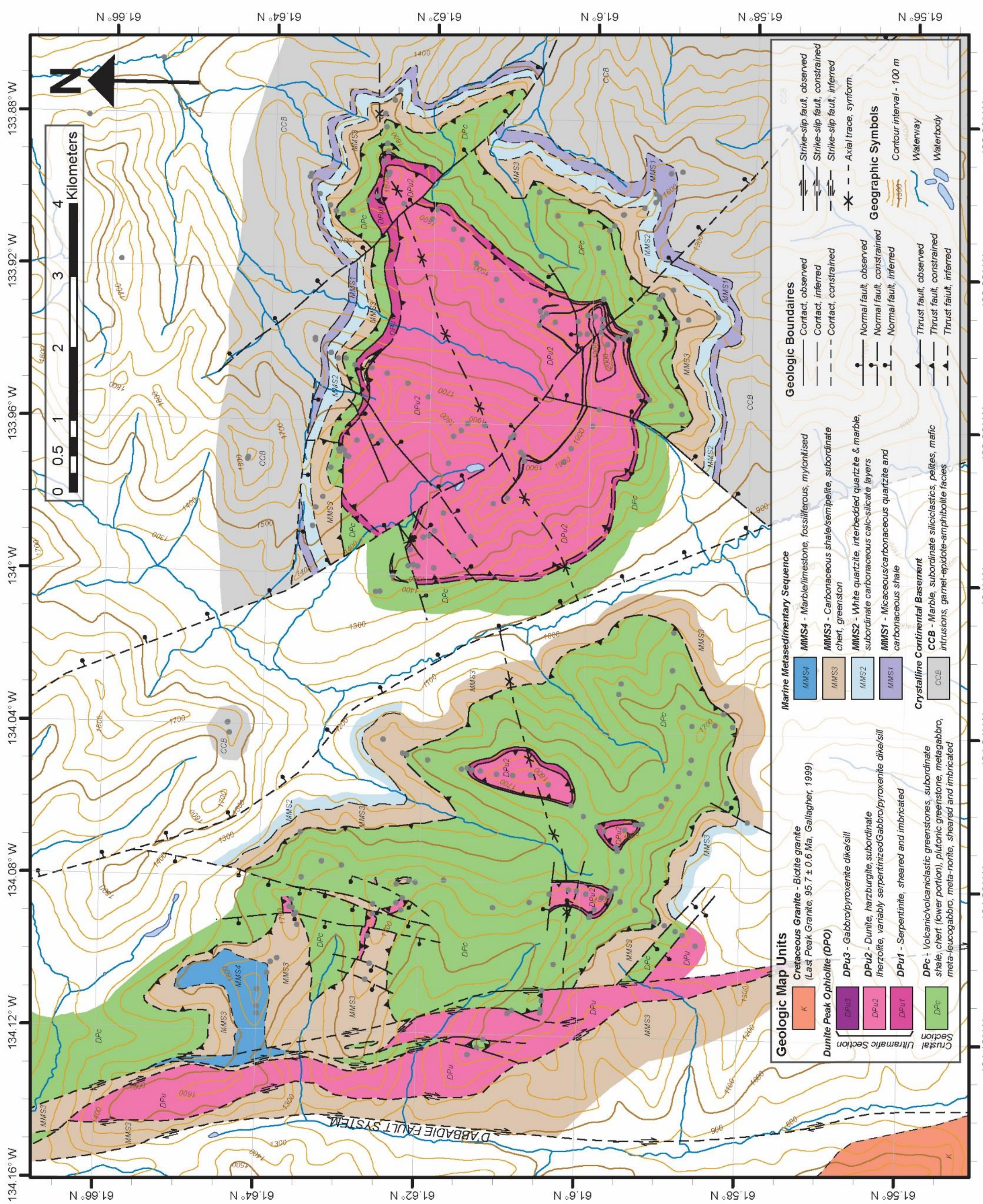

Figure 3. Geological map of the Dunite Peak area. Mapping of d'abbadie fault system compiled from de Keijzer et al. (1999)

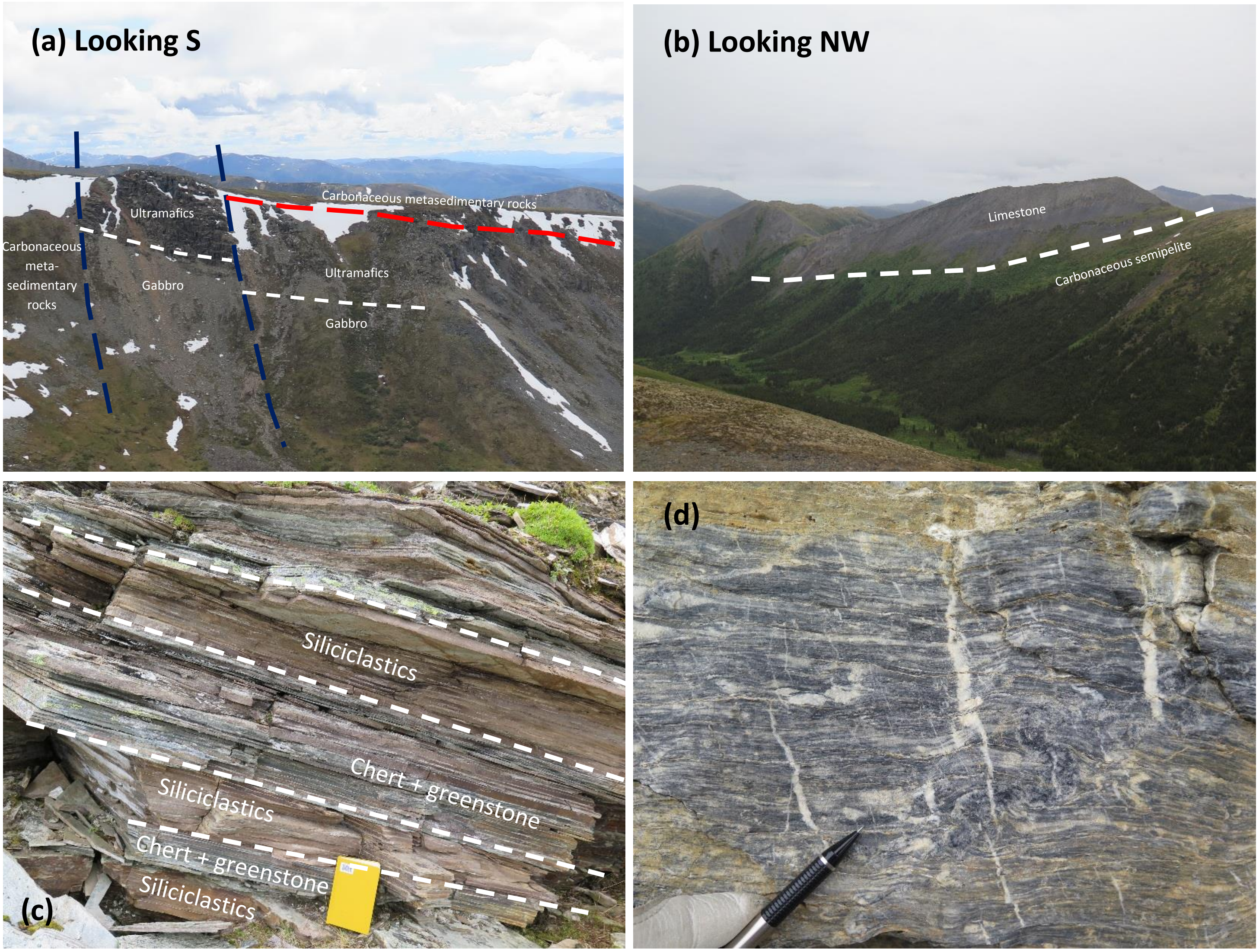

***Figure 4. (a) Faults in Dunite Peak area. White line = ultramafic-mafic structural contact. Red line = secondary thrust emplacing carbonaceous metasedimentary rock over Dunite Peak Ophiolite. Blue line = late steep faults. (b) Limestone ridge in NW corner of mapping area. White line = inferred basal contact. (c) Interbedded chert, greenstone and siliclastic rocks at top of carbonaceous semipelite unit, immediately below limestone ridge. (d) Mylonitized limestone from limestone ridge*.**

1. New observations from 2017 field activities

Fieldwork was conducted over 5 days in the western and southern regions of the mapped area. Key objectives were as follows: (*1*) extend mapping towards the west and northwest to complete geological mapping from 2016; (2) investigate the limestone ridge to the northwest of mapped region; (3) investigate possible stratigraphic relationships between different mafic-intermediate igneous lithologies identified in the Dunite Peak Ophiolite during 2016 field activities; (4) investigate the regional significance of the >400 m thick marble in the structurally lowest metasedimentary unit. The results of these investigations are as follows:

1.1. Completion of geological mapping

Geological mapping of the western and northwestern regions of the study area was conducted to extend and complete the preliminary geological map from the Dunite Peak area produced in 2016 (Figure 3).

Exposure is poor in the western edge of the study area. Isolated exposures of ultramafic rocks surrounded by metasedimentary rocks suggest that the area is heavily faulted. Steep N-S trending faults observed from a distance in the west-sloping ridges offset the ultramafic/mafic/metasedimentary rock sequence (Figure 4a). In some places, carbonaceous metasedimentary rocks structurally overly ultramafic and mafic rocks of the Dunite Peak Ophiolite (Figure 4a). Contacts between these rocks are inferred as thrust faults (Figure 3). In the northwestern corner of the study area the map was extended to include a large ridge of limestone (Figure 4b). The basal contact was not exposed but is inferred to be

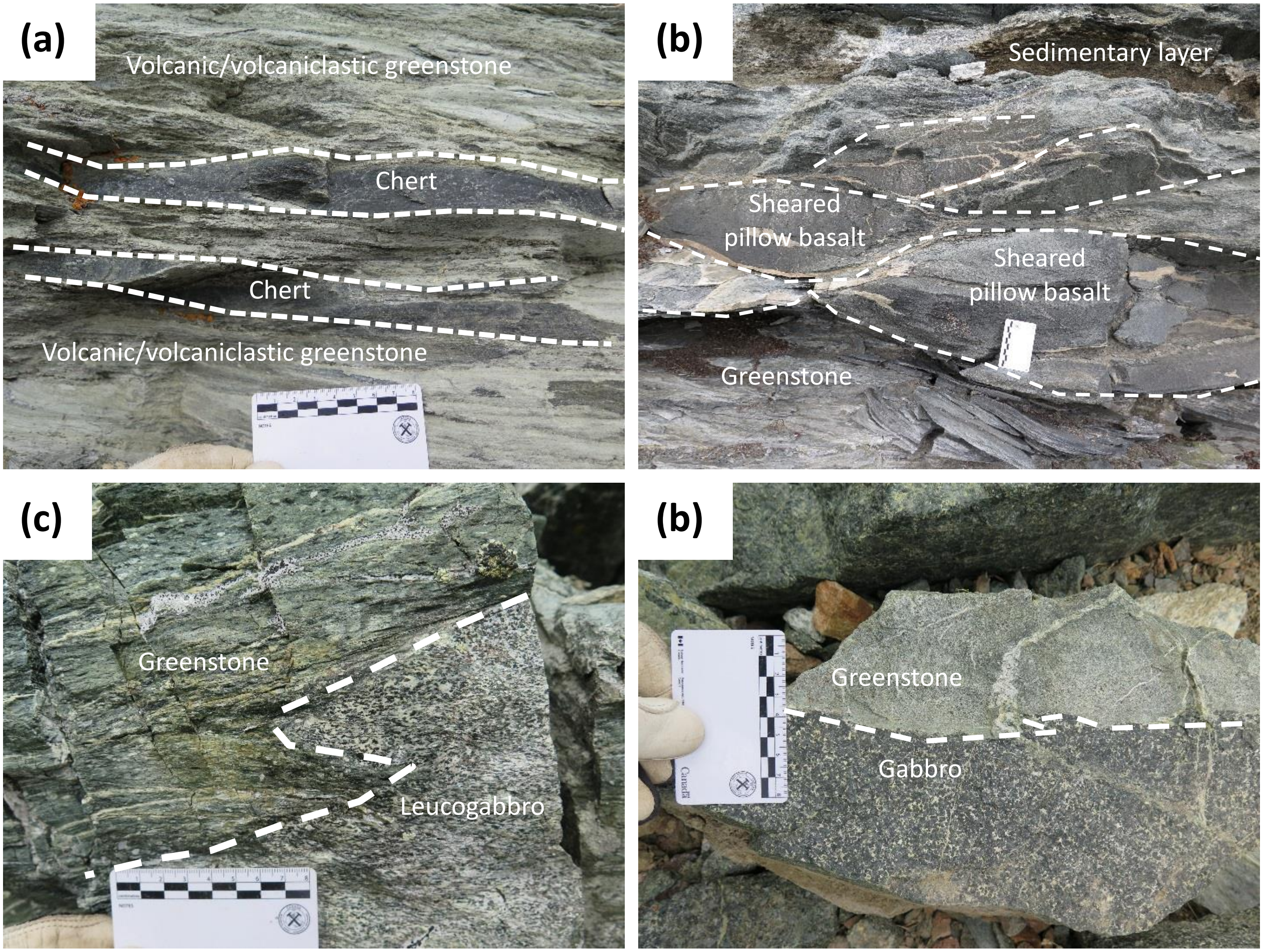

Figure 5. (a) Subordinate chert beds in greenstone. (b) Sheared pillow basalt amongst greenstone and subordinate metasedimentary layers. (c-d) Leucogabbro intruding greenstone.

parallel to local foliation (Figure 4b). Beneath this limestone, the carbonaceous metasedimentary rocks contain shale with subordinate siliciclastic, chert and greenstone interbeds (Figure 4c). These rocks were previously unrecognized during 2016 field activities. The greenstone interbeds are of similar appearance to greenstone within the Dunite Peak Ophiolite.

1.2. Investigation of limestone ridge

The limestone ridge in the northwest corner of the mapped area (Figures 3, 4b) is a dark grey, fine-grained micritic limestone that locally contains deformed shelly fauna, bryozoan and coral. This limestone is strongly deformed and commonly mylonitized (Figure 4d). It is visually distinct from the marble at the base of the metasedimentary sequence which is coarse grained, white to beige-yellow in colour and contains garnet bearing igneous and metasedimentary layers. As such it is mapped as a distinct unit (Figure 3).

1.3. Stratigraphic relationships within mafic-intermediate rocks of Dunite Peak Ophiolite

New stratigraphic relationships have been identified between different lithologies in the mafic-intermediate lower portion of the Dunite Peak Ophiolite. At the base of the mafic-intermediate section, subordinate chert and other sedimentary layers have been identified (Figure 5a) in close proximity to sheared pillow basalt (Figure 5b). The fissile, homogenous and very fine grained nature of the surrounding greenstones suggests that some may be volcaniclastic deposits (Figure 5a), possibly tuffs.

In the mid to upper portion of the greenstone and gabbro unit, coarse grained gabbro and leucogabbro are observed intruding greenstone, some of which are identified as fragmental volcaniclastic rocks (Figure 5c-d). Leucogabbro contains rare rafts of greenstone.

1.4. *Regional significance of marble at base of metasedimentary sequence*

The coarse-grained marble at the base of the metasedimentary sequence is >400 m in thickness (Parsons *et al.*, 2017). Such a thick sequence of marble is currently unreported from sedimentary units of the YTT (i.e. Snowcap assemblage) and this led Parsons *et al.* (2017) to speculate whether this amphibolite-facies basement was actually part of the parautochthonous Cassiar Terrane, North American Craton affinity, rather than YTT. Helicopter-assisted spot checks towards the south of the region conducted during 2017 field activities has revealed that this marble unit extends at least 10-20 km towards the south and maintains a thickness of >400 m. In some places, this unit appears to be as much as 600-800 m thick. Our reconnaissance to the south of the mapped area suggests that this marble unit correlates with the Scurvy Creek succession of Westberg *et al.* (2009), who mapped the Big Salmon range in the regions south of the Dunite Peak area.

2. Preliminary findings and implications for on-going investigations of the Dunite Peak Ophiolite, SMT and YTT

The preliminary findings and interpretations made from the 2017 field season in the Dunite Peak area are as follows:

- The completion of the geological map for the Dunite Peak area reveals details of the regional structural evolution. Obduction of the Dunite Peak Ophiolite was followed by a second phase of thrust faulting in which underlying carbonaceous metasedimentary rocks were emplaced over the Dunite Peak Ophiolite. In the west of the region, late vertical faulting is prevalent and deforms all other deformation structures and fabrics. This probably relates to deformation along the d'Abbadie fault (Figure 3), as described by de Keijzer *et al.* (1999).
- The limestone ridge to the northwest of the mapped region is a distinct unit, unrelated to the structurally lowest marble unit. Geochronological constraints are required to determine its relationship to other units in the Cordillera.
- Stratigraphic relationships observed in the Dunite Peak Ophiolite indicate that the basal portion of this unit comprises volcanic and volcaniclastic rocks with subordinate chert and other sedimentary horizons, indicative of a sub-aqueous environment. Towards the top of the greenstone and gabbro unit of the Dunite Peak Ophiolite, coarse-grained plutonic greenstone, gabbro and leucogabbro have intruded the finer-grained volcanic/volcaniclastic greenstone. Geochemical investigations of these different lithologies will aid in determining the relationships between these magmatic units and the petrogenesis of the Dunite Peak Ophiolite.
- The structurally lowest marble unit in the Dunite Peak area correlates with the Scurvy Creek succession of Westberg *et al.* (2009). Based on the presence of Mississippian granites, Westberg *et al.* (2009) correlated these rocks with the Snowcap assemblage of YTT. North of the Dunite Peak area, de Keijzer *et al.* (2000) also report the presence of Mississippian granites in amphibolite-facies metasedimentary rocks. We therefore interpret the amphibolite-facies marble and subordinate metapelitic and metaigneous layers as part of the Snowcap assemblage of YTT. Based on this interpretation we suggest that the carbonaceous metasedimentary rocks which overly the amphibolite-facies marble may correlate to the Swift River Group of the Finlayson assemblage (e.g. Colpron *et al.*, 2006). Geochronological investigations are required to investigate this hypothesis further.

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