Bedrock geology of the Teslin Mountain and east Lake Laberge areas, south-central Yukon

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ABSTRACT

Mafic volcanic and clastic strata of the Middle Triassic Joe Mountain Formation, east of Lake Laberge, Yukon, represent a juvenile volcanic arc sequence. Mafic volcanic rocks of the Upper Triassic Lewes River Group were formed in the spatial and temporal continuity of Joe Mountain volcanism. Carbonate sedimentation took place in shallow oceanic subbasins adjacent to the arc from the Carnian to Rhaetian; these subbasins were separated by physiographic boundaries inherent to the arc, resulting in lateral stratigraphic variations. Polymictic conglomerate and turbiditic sequences of the Lower-Middle Jurassic Laberge Group unconformably overlie Triassic rocks. Two north-northwest strike-slip faults, the Laurier Creek and the Goddard, control the distribution of units. Joe Mountain Formation rocks are characterized by an east-west structural trend, whereas the Upper Triassic and Jurassic sequences are characterized by north-northwest trending tight folds and thrust faults. At least five post-accretion igneous suites intrude or overlie older stratigraphy, including the Late Cretaceous Open Creek volcanic complex.

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INTRODUCTION

The area located northeast of Whitehorse, east of Lake Laberge, in south-central Yukon, is underlain by arc-related, volcano-sedimentary rocks that are part of Stikinia (Fig. 1), and post-accretion sedimentary rocks and plutons. The Middle Triassic Joe Mountain Formation (Hart, 1997) and Upper Triassic Lewes River Group (Bostock and Lees, 1938; Lees, 1934; Tempelman-Kluit, 1984, 2009; Tozer, 1958; Wheeler, 1961) are unconformably overlain by the Early-Middle Jurassic Laberge Group, which defines the Whitehorse trough (Fig. 1; Wheeler, 1961; White *et al.*, 2012). Several post-accretion, Early to Late Cretaceous plutons intrude older stratigraphy and are locally associated with mineral occurrences.

This paper presents field observations gathered from 2015 to 2017 as part of a 1:50 000-scale bedrock mapping project covering parts of the Teslin Mountain (NTS 105E/2), Lake Laberge (NTS 105E/3) and Lower Laberge (NTS 105E/6) map areas. The project area also includes part the Joe Mountain map sheet (105D/15). Rock units in the Joe Mountain area were reviewed, but no modification was made to the mapping conducted by Hart and Hunt (1994, 2003). Preliminary observations and interpretations from the Teslin Mountain area were presented in Bordet (2016a). Data collected the following year along the east shore of Lake Laberge (NTS 105E/3 and 6) provide a detailed framework for the internal stratigraphy and structure of the Lewes River Group (Bordet, 2017a). This paper provides the latest interpretation of the stratigraphy and relationships between the Joe Mountain Formation, the Lewes River Group and the Laberge Group, as well as new data from samples collected from Early to Late Cretaceous plutons, dikes and volcanic strata.

This paper addresses the following points:

- Five volcanic, volcaniclastic and sedimentary units are defined as part of the Joe Mountain Formation. The units exposed north and northwest of Teslin Mountain were revisited during the summer of 2017. The area displays complex deformation and geology, combined with a lack of exposure along the valley where contacts should be exposed. In particular, a sequence of fine-grained clastic sedimentary rocks underlies the mafic volcanic rocks, suggesting the existence of a basin prior to Joe Mountain volcanism. This clastic sequence also underlies coarse volcanic conglomerate, volcanic sandstone and minor basalt that were originally attributed to the Late Triassic Lewes River Group. Recent reinterpretation of stratigraphic and structural relationships in this area suggests that the coarse volcaniclastic package must be part of the Middle Triassic Joe Mountain Formation. While rock descriptions remain the same as in the previous years, the interpretation presented in this paper supersedes those found in previous work by Bordet (2016a,b and 2017a).
- Nine units are interpreted as part of the Lewes River Group, including by a basal volcanic mafic sequence, and a younger laterally variable carbonate sequence. The internal stratigraphy of the group is now supported by detailed mapping, combined with fossil analyses and detrital zircon geochronology. Lateral variations within the carbonate sequence may result from synchronous sedimentation in isolated subbasins, controlled by the physiography of a central volcanic arc highland.
- Individual dikes with a range of compositions and textures were mapped over the course of three summers. Preliminary investigations of these dikes include petrography, geochemistry and geochronology work. While detailed analyses are not presented here, field descriptions and preliminary results highlight the lithological, compositional and temporal diversity of this discrete, but pervasive igneous system. Results suggest at least three distinct episodes of igneous activity took place in the Early, middle and Late Cretaceous. Some of these intrusions are suspected to be related to mineralizing events.
- The Late Cretaceous Open Creek volcanic complex located north of Teslin Mountain was mapped in detail for the first time. At least four volcanic map units were identified, and samples were collected for petrography, geochemistry and geochronology to better constrain the nature of the volcanic rocks and their relationship with other Late Cretaceous magmatic suites in Yukon. This dominantly silicic pyroclastic volcanic sequence is spatially and temporally associated with the Late Cretaceous Teslin Mountain pluton.

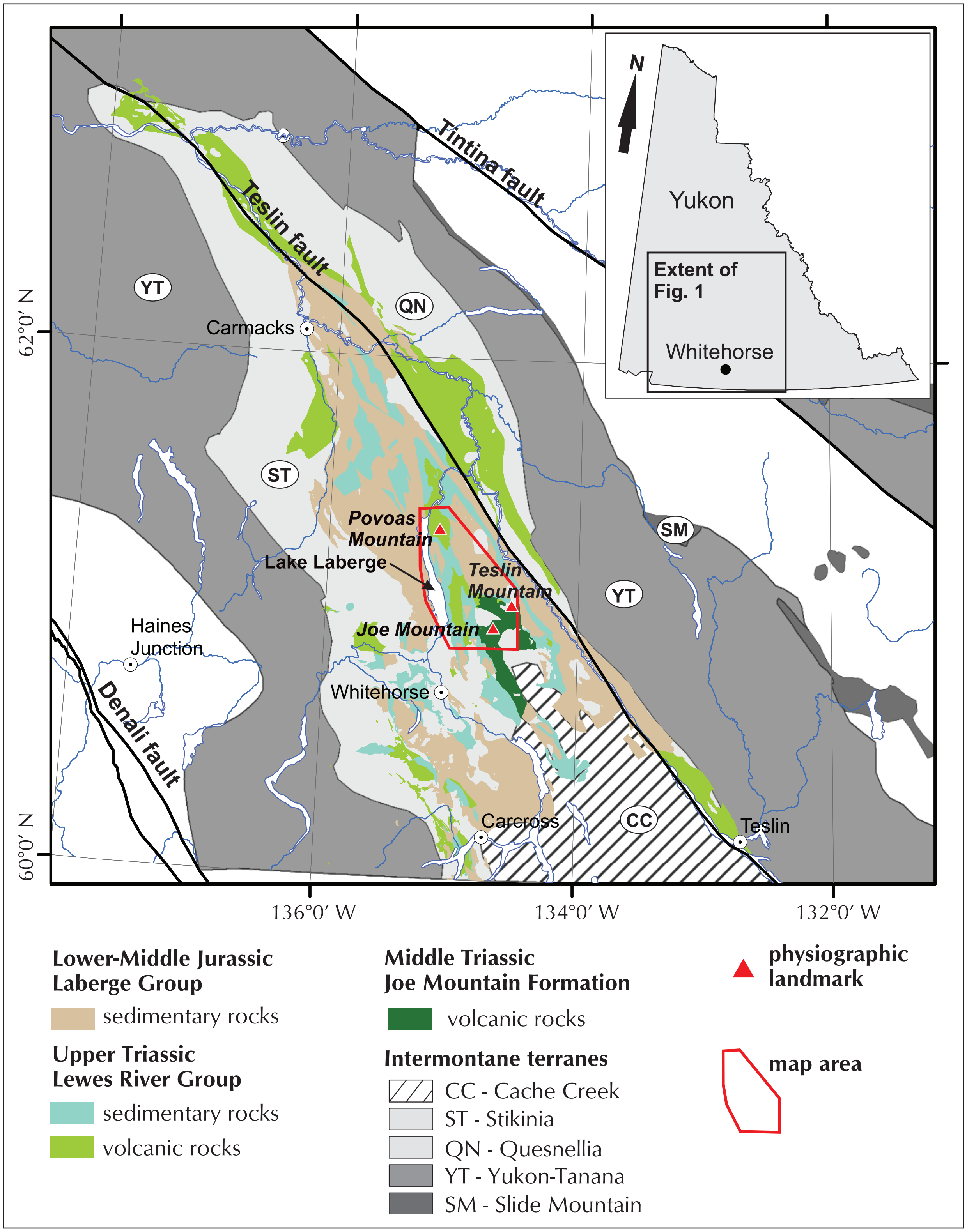


Figure 1. *Terrane map of south-central Yukon showing the distribution of Intermontane terranes and Triassic to Middle Jurassic geology of the Whitehorse trough. Red polygon on figure delineates the mapped area, and includes parts of Teslin Mountain (105E/2), Lake Laberge (105E/3) and Lower Laberge (105E/06) map sheets. Physiographic landmarks referred to in text are indicated. Terrane boundaries after Colpron and Nelson (2011). Laberge Group rocks extent correspond to the Whitehorse trough (after Hutchison, pers. comm., 2015).*

TECTONIC SETTING

The Intermontane terranes underlie most of south-central Yukon and British Columbia southwest of the Tintina fault (Fig. 1). They represent the largest amalgamation of crustal fragments that accreted to the North American margin during the Mesozoic (Coney *et al.*, 1980). In Yukon, the outer margin of the Intermontane terranes is defined by middle Paleozoic (and older) metasedimentary and metavolcanic rocks of the Yukon-Tanana terrane (Fig. 1; Mortensen and Jilson, 1985; Mortensen, 1992). The core and bulk of the Intermontane terranes comprise Mesozoic volcanic arc rocks of Stikinia and Quesnellia (Fig. 1; Colpron and Nelson, 2011; Wheeler *et al.*, 1991), which are juxtaposed along the Teslin fault north of Whitehorse (Fig. 1). Upper Paleozoic to lower Mesozoic accretionary complex rocks of the Cache Creek terrane (*e.g.*, Monger *et al.*, 1991; Struik *et al.*, 2001) are surrounded by Stikinia and Quesnellia (Fig. 1) and extend south of Whitehorse to northern British Columbia. To date, Cache Creek rocks have not been identified north of Whitehorse (Bickerton *et al.*, 2013).

Subduction of the Panthalassa Ocean along the North American margin during the Mesozoic produced volcanic arcs of Stikinia and Quesnellia (Mihalynuk *et al.,* 1994). In south-central Yukon, arc volcanism and arc-related basinal sedimentation are recorded by Middle and Upper Triassic volcanic and sedimentary rocks of Stikinia, namely the Joe Mountain Formation and Lewes River Group (Wheeler, 1961; Hart, 1997).

Erosion of Stikinia and Quesnellia arcs and their plutonic roots from the Early to Middle Jurassic resulted in the deposition of up to 3000 m of sediments of the Lower to Middle Jurassic Laberge Group in the Whitehorse trough (*e.g.*, Wheeler, 1961; White *et al.*, 2012). The Whitehorse trough extends approximately 650 km, from Dease Lake, British Columbia to north of Carmacks in central Yukon. The Whitehorse trough originally developed as a forearc basin and evolved into a northwest-trending, synorogenic, intermontane piggy-back transpressional basin by Middle Jurassic (Colpron *et al.*, 2015; White *et al.*, 2012).

Ongoing eastward subduction of Pacific plates beneath North America during the Cretaceous led to progressive thickening and shortening of the crust, associated with orogen-parallel dextral displacements (Nelson *et al.*, 2013). In this dominantly transpressional and transtensional orogen, corridors of deformation provided pathways for post-accretionary arc-activity and the emplacement of a number of mineral occurrences (Nelson *et al.*, 2013).

REGIONAL GEOLOGY

In south-central Yukon, the Middle Triassic Joe Mountain Formation and Upper Triassic Lewes River Group of Stikinia comprise coherent, massive to flow-banded or pillowed, subalkaline tholeiitic to calc-alkaline basalt and basaltic andesite, as well as a range of volcaniclastic units (Hart, 1997). In addition, the Lewes River Group comprises a thick sedimentary and volcaniclastic sequence, including thick-bedded limestone, calcareous conglomerate, calcareous sandstone/mudstone, and volcaniclastic sandstone, mudstone and conglomerate (Aksala formation; Wheeler, 1961; Hart, 1997; Tempelman-Kluit, 1984, 2009). A summary of regional mapping work and original stratigraphic descriptions of the Joe Mountain Formation and Lewes River Group are provided in Bordet (2016a, 2017a).

The Lower to Middle Jurassic Laberge Group includes shallow marine to fluvial and coal-bearing sandstone, conglomerate and shale of the Tanglefoot formation exposed in the northern part of the Whitehorse trough (Hart, 1997; Lowey, 2005, 2008; Tempelman-Kluit, 1984, 2009). To the south, deep-marine turbidite and mass-flow conglomerate of the Richthofen formation are partly coeval and laterally equivalent to the Tanglefoot formation (*e.g.*, Lowey, 2005; Tempelman-Kluit, 1984, 2009). The Nordenskiöld facies, a distinct crystal-lithic tuff (Tempelman-Kluit, 1984, 2009), occurs at multiple stratigraphic levels in both the Richthofen and Tanglefoot formations, and represents at least three distinct volcanic events between 188 and 186 Ma (Colpron and Friedman, 2008).

The Middle Jurassic Teslin Crossing pluton intrudes the Laberge Group sedimentary strata (Tempelman-Kluit, 1984). Other overlap assemblages include intrusive bodies related to the Whitehorse, Teslin and Rancheria plutonic suites (Colpron *et al.*, 2016; and discussion below). Finally, a few occurrences of the middle Cretaceous Byng Creek volcanic rocks are reported south of Joe Mountain (Hart and Hunt, 1994, 2003; Hart, 1997), and the Upper Cretaceous Open Creek volcanic rocks (Tempelman-Kluit, 1984, 2009) are exposed north of Teslin Mountain.

TRIASSIC STRATIGRAPHY

JOE MOUNTAIN FORMATION (MIDDLE TRIASSIC)

The southeastern part of the map area, east of the Laurier Creek fault, is dominated by coherent pillowed basalt of the Joe Mountain Formation (mŦJMb) centered on Joe Mountain and Teslin Mountain, overlain by mafic volcaniclastic deposits (mŦJMvc) west of Teslin Mountain (Fig. 2a,b). North of Teslin Mountain, Joe Mountain Formation basalt and fragmental rocks are underlain by clastic, locally thin-bedded and laminated strata (mŦJMms). To the north, this clastic sequence is also underlying, or locally thrusted over a volcanic and volcaniclastic assemblage (mŦJMbx; Fig. 2a,b). In addition, dark, massive, coarse-grained and locally pegmatitic, pyroxene gabbro and diorite (mŦJMg) are reported at Joe Mountain (105D/14; Hart, 1997; Hart and Hunt, 1994, 2003; Fig. 2a,b).

The thickness of the Joe Mountain Formation is estimated at ~3500 m, including an ~1000 m-thick basal sedimentary sequence north of Teslin Mountain, a cumulative thickness of 2000-2300 m for the basalt and volcaniclastic sequence (Bordet, 2016a), and a thickness of at least 500 m for the younger volcaniclastic sequence. Previous thickness estimates indicate at least 3200 m for the Joe Mountain Formation type section at Joe Mountain (Hart and Hunt, 1994, 2003; Hart, 1997).

The Joe Mountain Formation is folded along a consistent E-W structural trend (Fig. 2a). It is locally intruded by middle and Late Cretaceous plutons.

*Coherent basalt (*mŦJMb)

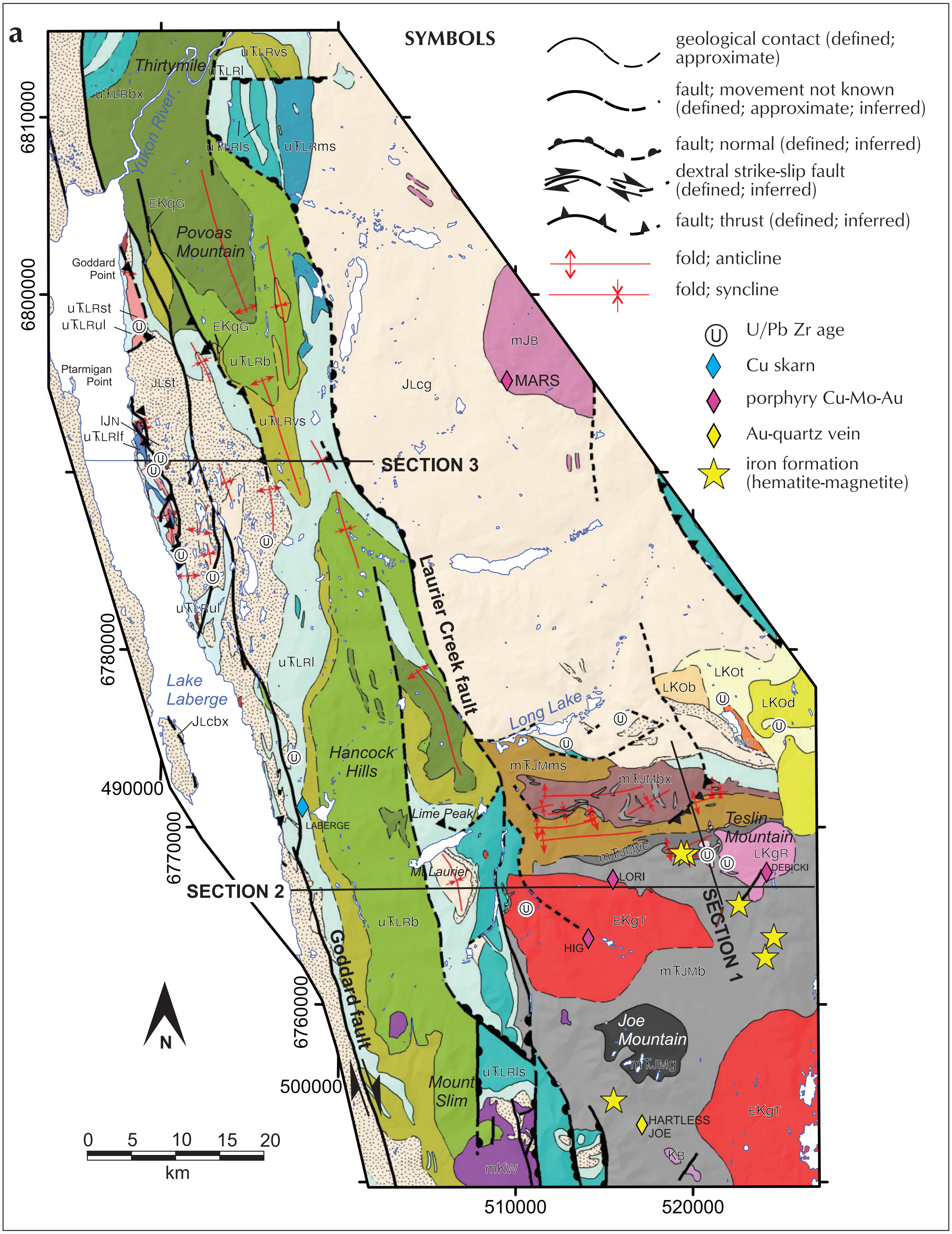
The dominant lithology of the Joe Mountain Formation comprises dark grey, grey-green aphyric to microcrystalline coherent basalt and basalt andesite exposed throughout the area between Joe Mountain and Teslin Mountain (Fig. 2a). Coherent mafic rocks overlie thin-bedded clastic strata exposed north of Teslin Mountain, and are overlain by volcaniclastic strata along the western ridge of Teslin Mountain (Fig. 3a, section 1; Bordet, 2016a). The Laurier Creek fault marks the western boundary of the Joe Mountain Formation basalt (Figs. 2a,b and 3b). East of this boundary, the contact between Joe Mountain Formation basalt and the overlying Lewes River Group carbonate sequence is folded (Bordet, 2017a), and is likely a stratigraphic disconformity.

Coherent mafic strata of the Joe Mountain Formation include grey to rusty-brown weathering, dark grey-green, fine to medium-crystalline, locally finely amygdaloidal or vesicular aphyric basalt and basaltic andesite forming thick-bedded (up to 1-2 m), blocky, massive to pillowed lava flows (Bordet, 2016a). The lava is locally plagioclase-phyric (up to 5%), or displays minor pyroxene cumulates. Locally, layers of volcanic breccia and volcaniclastic sandstone are found interbedded with the basalt. Joe Mountain Formation basalt is intruded by several plutons (Fig. 2a), including monzonite and monzodiorite of the middle Cretaceous Laurier Creek pluton (EKgT) and granodiorite of the Late Cretaceous Teslin Mountain pluton (LKgR).

Chlorite alteration is pervasive amongst coherent basalt of the Joe Mountain Formation, and is accompanied by quartz or carbonate veinlets and disseminated pyrite. The unit is magnetite-rich, and the highest magnetic values are measured in layers and clasts of hematite-magnetite iron formation (Figs. 2 and 4; Piercey, 2005).

*Mafic tuff and volcanic breccia (*mŦJMvc*)*

To the west and north of Teslin Mountain, an ~100 m thick volcaniclastic sequence includes poorly sorted volcanic conglomerate, volcanic sandstone, and mafic tuff interbedded with minor lenses of calcareous mudstone/sandstone (Figs. 2a and 3a; Bordet, 2016a). This unit overlies the Joe Mountain Formation basalt. Thick-bedded, polymictic, chaotic volcaniclastic conglomerate displays boulder-size clasts (30-50 cm) of quartz-plagioclase-phyric diorite, cherty, glassy, basaltic ash tuff, dark green, finely crystalline basalt, and blocks of red-brick oxidized iron formation (Fig. 4b; Piercey, 2005). The conglomerate is interbedded with orange-brown-grey to tan weathering, pale grey-green, and medium-bedded volcaniclastic sandstone, with angular, dark basalt clasts (2%), and quartz eyes (up to 3%) in a pale grey-green very fine matrix. North of Teslin Mountain, this unit is dominated by south-dipping, pale green weathering, dark green to grey, silicified, laminated, mafic ash tuff (Bordet, 2016a). Mafic ash tuff is interbedded with lenses of pale grey weathered, thin-bedded calcareous mudstone and sandstone. Disseminated pyrite is observed locally.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SYMBOLS
geological contact (defined; approximate)
fault; movement not known (defined; approximate; inferred)
fault; normal (defined; inferred)
dextral strike-slip fault (defined; inferred)
fault; thrust (defined; inferred)
fold; anticline
fold; syncline
U/Pb Zr age
Cu skarn
porphyry Cu-Mo-Au
Au-quartz vein
iron formation (hematite-magnetite)
Thirtymile
uTLRvs
uTLRl
uTLRbx
Yukon River
uTLRls
uTLRms
EKqG
Povoas Mountain
Goddard Point
uTLRst
uTLRul
EKqG
uTLRb
Ptarmigan Point
JLst
JLcg
mJB
MARS
lJN
uTLRlf
uTLRvs
SECTION 3
Laurier Creek fault
uTLRul
uTLRl
Lake Laberge
JLcbx
Long Lake
LKot
LKob
LKod
Hancock Hills
mTJMms
mTJMbx
Lime Peak
LABERGE
Teslin Mountain
LKgR
mTJMvc
DEBICKI
Mt Laurier
LORI
SECTION 2
SECTION 1
uTLRb
EKgT
HIG
mTJMb
Joe Mountain
mTJMg
Goddard fault
Mount Slim
uTLRls
HARTLESS JOE
EKgT
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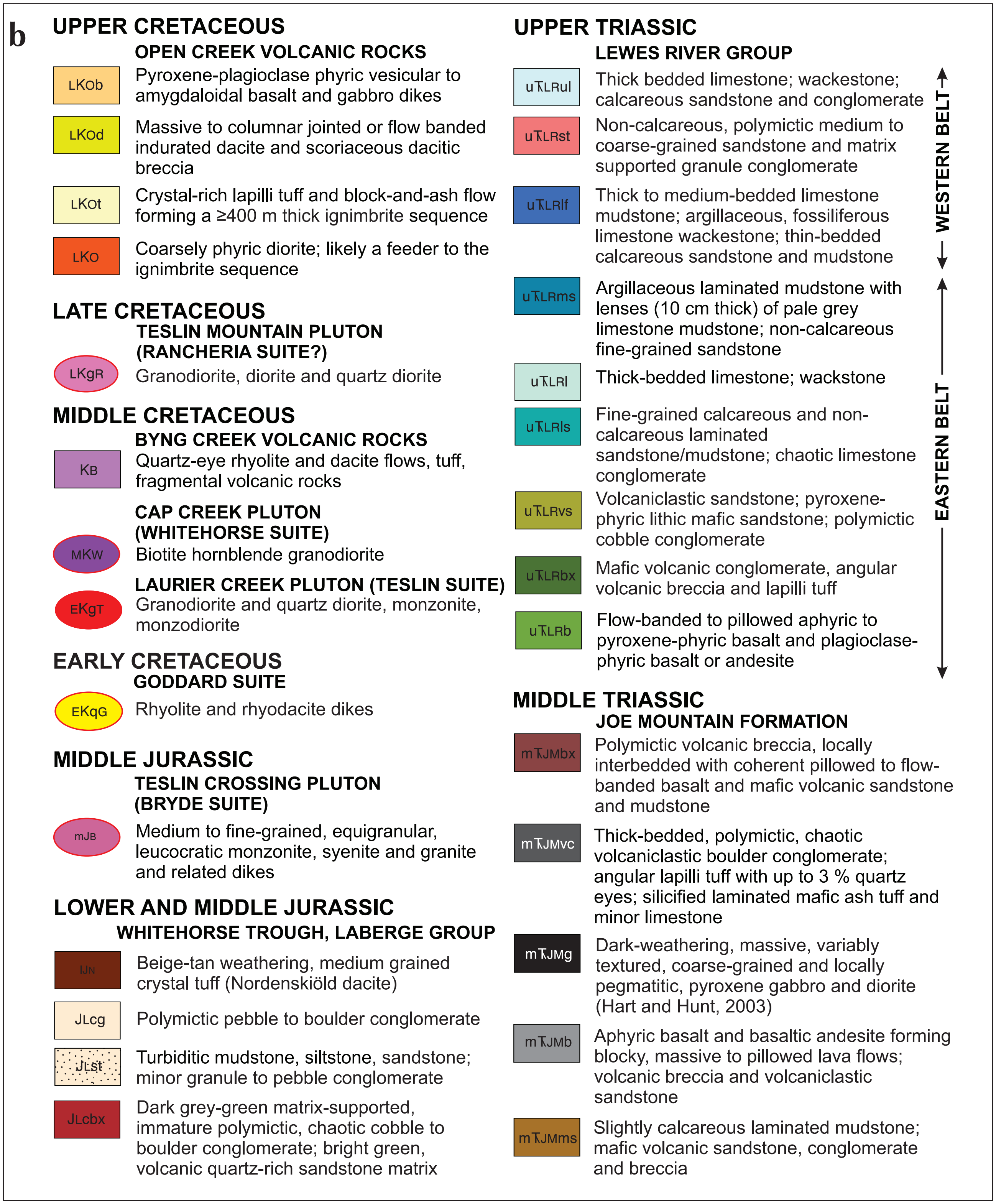

Figure 2. *Geology of parts of the Teslin Mountain (105E/2), Lake Laberge (105E/3) and Lower Laberge (105E/6) areas based on 1:50 000-scale mapping conducted during the summers of 2015-2017. Mineral occurrences from Yukon MINFILE (2015). Grid in UTM zone 8, NAD 83.* ***(a)*** *Bedrock geology map; and* ***(b)*** *legend. Sections are on Figure 3.*

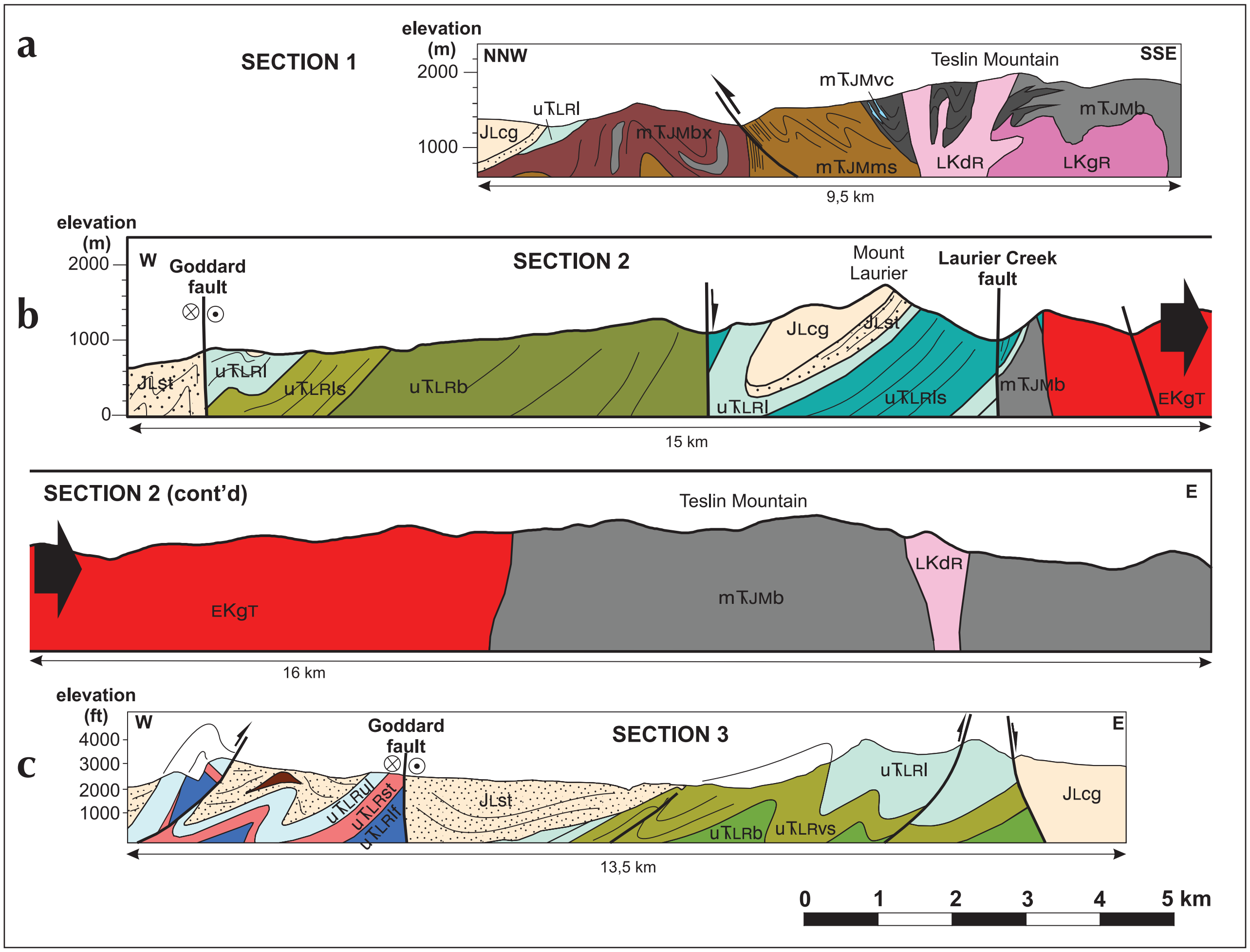

Figure 3. *Schematic geological cross sections illustrating stratigraphic and structural relationships in the map area;* ***(a)*** *section 1 is located across the Joe Mountain Formation at Teslin Mountain (NNW-SSE);* ***(b)*** *section 2 (W-E) is along the Mount Laurier-Teslin Mountain axis (6766440 N); and* ***(c)*** *section 3 (W-E) is located north of the Hancock Hills (6790660 N). See Figure 2a for section lines.*

Clastic sedimentary sequence (mŦJMms)

A newly defined, dominantly clastic sedimentary sequence underlies mafic and volcaniclastic strata of the Joe Mountain Formation north of Teslin Mountain (Fig. 2a). North of Teslin Mountain, the clastic sedimentary strata display a consistent southern dip. Contact with mafic volcaniclastic rocks (mŦJMvc) to the south is interpreted as conformable, whereas the contact to the north with volcanic conglomerate and breccia (mŦJMbx) is interpreted as a thrust fault (Fig. 3a). The sequence is continuously exposed along the northern flank of Teslin Mountain's westernmost ridge, and presumably underlies an east-west trending valley covered by vegetation and thick glacial fluvial terraces. The sequence outcrops again south of Long Lake (Fig. 2a). The Laurier Creek fault marks the westernmost boundary of this sequence, and it is not exposed past Long Lake to the north.

The sequence comprises slightly calcareous, laminated mudstone/sandstone, mafic volcanic sandstone, conglomerate and breccia. A south dipping sequence of rusty-brown weathering, dark grey to pale grey-green, thin to medium-bedded, fine-grained, slightly calcareous laminated mudstone/sandstone is exposed north of Teslin Mountain and is up to 100 m thick. The same thin-bedded, laminated mudstone lithology is exposed along steeply dipping beds south of Long Lake. This lithology contains less than 1% disseminated sulphides. Coarse, matrix-supported, angular volcanic conglomerate made of volcanic clasts and dark brown, very fine mudstone clasts in a sandstone rich matrix, contains thick interbeds of

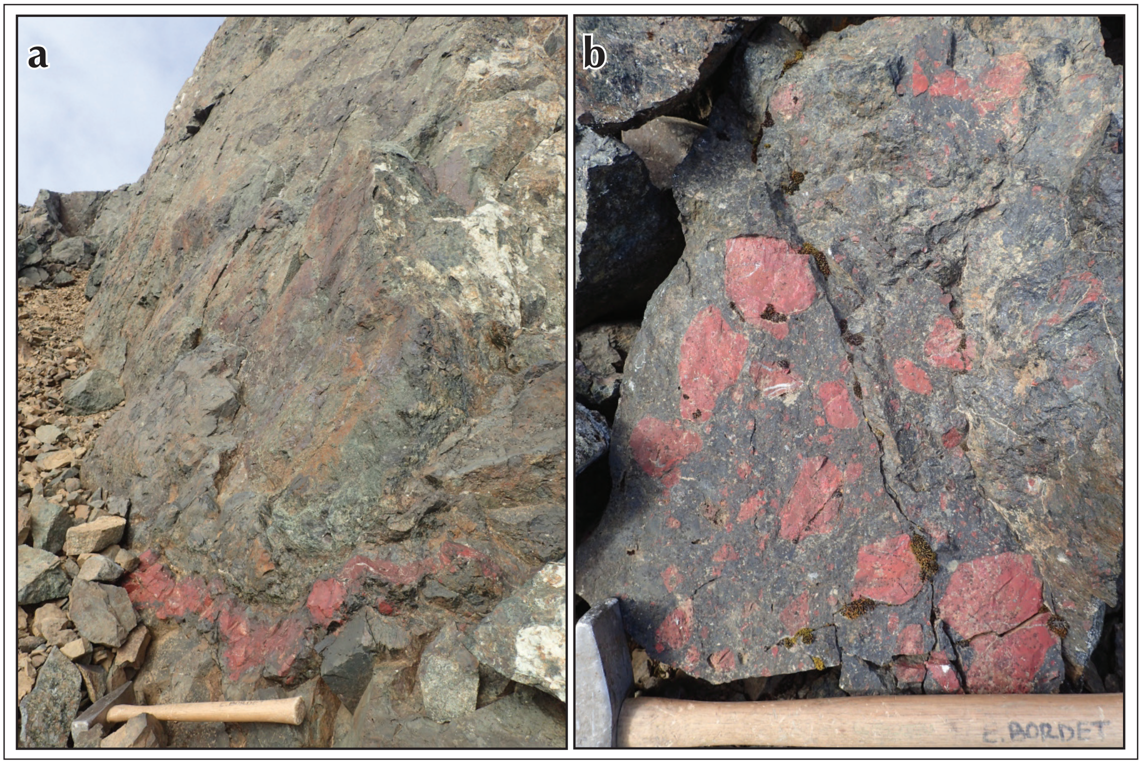

Figure 4. *Iron formation within the Joe Mountain Formation basalt at Teslin Mountain,* ***(a)*** *layer of hematite-magnetite with a coherent basalt sequence; and* ***(b)*** *clasts of the iron formation within the volcaniclastic unit (mŦJMvc) at Teslin Mountain.*

laminated sandstone. Brown-grey weathering, calcareous sandstone to pebble conglomerate are found immediately north of the contact with Joe Mountain Formation basalt at Teslin Mountain, and contains rounded to subangular clasts of limestone, shell fragments, and fine-grained, dark grey, aphyric or plagioclase-phyric volcanic rock.

This sequence is deformed, as indicated by frequent changes of strike and dip, interpreted as successive, parallel E-W trending folds (Figs. 2a and 3).

Volcanic breccia and conglomerate (mŦJMbx)

A newly defined unit of volcanic conglomerate/breccia, locally interbedded with coherent pillowed to flow-banded basalt and mafic volcanic sandstone/mudstone covers an area ~12 by 4 km on the high alpine ridges between Teslin Mountain and Long Lake (Fig. 2a). This sequence is dominated by thick-bedded (1-5 m), orange-brown-grey weathering, dark green, matrix-supported volcanic breccia and conglomerate. Clasts are subangular to subrounded, range from lapilli to block size, and are poorly sorted. Clast composition is volcanic, but displays textural variability or various degrees of oxidation. They include red oxidized pyroxene or plagioclase-phyric basalt/andesite, vesicular to massive andesite, and lapilli size angular fragments of grey, grey-green to red aphanitic volcanic rock. The conglomerate matrix is a fine-grained, grey to green volcaniclastic sandstone, with ash to lapilli size fragments and disseminated plagioclase and pyroxene crystals. Petrographic observations of the breccia matrix indicate a relatively homogeneous clast composition. Fragmental rocks are locally interbedded with coherent pillowed to flow-banded basalt and mafic volcanic sandstone/mudstone. Frequent changes of dip and a generally consistent east-west bedding strike suggest that this unit is deformed by east-west trending folds similar to those affecting the underlying sedimentary sequence (Figs. 2a and 3).

Gabbro and diorite (mT̄JMg)

Dark-weathering, massive, variably textured, coarse-grained and locally pegmatitic, pyroxene gabbro and diorite (Fig. 2a) underlies the highest peaks of Joe Mountain (105D/15), where the Joe Mountain Formation was originally defined (Hart and Hunt, 1994, 2003; Hart, 1997). This unit underlies and intrudes microdiorite and basalt flows that form the bulk of the formation (Hart, 1997).

Age and interpretation of the Joe Mountain Formation

Coherent, massive aphyric microcrystalline basalt appears to be underlain by a series of fine-grained, thin-bedded, laminated mudstone/sandstone north of Teslin Mountain. This suggests the existence of a sedimentary basin prior to, or coeval with, Joe Mountain basaltic volcanism. Basalt is generally pillowed, with subaerial, flow-banded, vesicular lava locally observed. Regular lamination within the mafic tuff sequence, interbedded limestone lenses, and the presence of pillows suggests deposition under water for at least part of the formation. A reaction rind surrounds the limestone lenses at the contact with the mafic tuff, suggesting that limestone was incorporated as the tuff was still hot (Bordet, 2016a). The chaotic organization of the volcanic conglomerate and dominant volcanic clast composition indicate that only a minimum amount of reworking took place.

The youngest part of the Joe Mountain Formation is characterized by volcaniclastic conglomerate and breccia, interbedded locally with coherent pillow basalt and volcaniclastic sandstone. Because of similarities to volcaniclastic conglomerate of the Lewes River Group, this unit was originally inferred to be Late Triassic. However, the east-west structural grain reflects deformation observed in the rest of the Joe Mountain Formation, and contrasts with the north-south trend measured in rocks of the younger Lewes River Group. The combined structural relationship, as well as stratigraphic ties, implies that this unit is more likely to represent a volcaniclastic facies of the Joe Mountain Formation.

The Joe Mountain Formation volcanic rocks are dominated by basalt and basaltic andesite. Geochemical signatures are characterized by MORB/BABB and IAT (Bordet, 2017b). Pegmatitic and pyroxene-gabbro and diorite exposed at Joe Mountain likely represent a juvenile subvolcanic intrusion that developed just beneath a volcanic arc centre and was later exposed by erosion.

A preliminary U/Pb zircon age of ~245 Ma (J. Crowley, *pers. comm.,* 2016) was obtained from the laminated mafic tuff of the Joe Mountain Formation volcaniclastic sequence (mT̄JMvc) at Teslin Mountain. The outcrop comprises brown to grey weathering, fine to coarse-grained, laminated volcanic sandstone/mudstone. This date confirms a Middle Triassic age for the Joe Mountain Formation. It is compatible with Ladinian conodont ages collected at Joe Mountain, about 15 km south of the present study area (Hart and Orchard, 1996; Hart 1997).

LEWES RIVER GROUP (UPPER TRIASSIC)

The Upper Triassic Lewes River Group is exposed along a north-northwest trending belt between Laurier Creek fault and the east shore of Lake Laberge (Fig. 2a). A basal mafic volcanic sequence (~1000 m thick) is overlain by a laterally variable succession of carbonate and clastic sedimentary rocks (~1000-1500 m thick). Nine map units comprising clastic sedimentary, calcareous, volcaniclastic and mafic volcanic strata are defined based on lithology, stratigraphic associations and geographic distribution. Minor adjustment was made to units, but descriptions and the stratigraphic framework for the Lewes River Group remain the same as the one presented in Bordet (2017a).

Limestone strata of the Lewes River Group overlie basalt of the Joe Mountain Formation along Laurier Creek, and volcaniclastic strata of the Joe Mountain Formation south of Long Lake and north of Teslin Mountain (Fig. 2a). The contact between the Lewes River Group and the overlying Laberge Group is marked by an angular unconformity south of Long Lake (Fig. 2a). The overall structural trend in the Upper Triassic sequence is north to north-northwest (Fig. 2a).

The total thickness of the group is >3000 m based on field estimates and map measurements. Previous thickness estimates for the Lewes River Group are from 2100 m (Tozer, 1958) to greater than 3000 m (Hart, 1997).

Mafic volcanic sequence

The volcanic sequence of the Lewes River Group is exposed in the central part of the map area, along a north-south-trending belt extending more than 60 km from

Mount Slim to Povoas Mountain (Fig. 2a). It continues north beyond the limit of the map area past the mouth of the Yukon River. The belt is characterized by a subdued, rolling topography, with extensive and thick tree cover in valleys and rare exposed hill tops in the Hancock Hills. The volcanic sequence is bounded to the east by the Laurier Creek fault and to the west by the Goddard fault. No occurrences of the Lewes River Group volcanic sequence were observed west of the Goddard fault, except for a sliver of coherent, plagioclase-pyroxene-phyric, basalt-andesite in a valley bottom that parallels the inferred trace of the Goddard fault (Bordet, 2017a).

Coherent basalt (uŦLRb)

Between the Laurier Creek and Goddard faults, in the Hancock Hills, coherent, flow-banded and pillowed basalt dominate (Bordet, 2016a). The unit comprises coherent, dark green-grey to rusty brown weathering, dark green, flow-banded to pillowed aphyric to pyroxene-phyric basalt and plagioclase-phyric basalt or andesite. Basalt comprises very fine (< 1 mm) plagioclase crystals (1-5%), small brown pyroxene crystals (1%) and minor olivine (<1%) in a finely crystalline aphyric groundmass. Amygdules or sparse small rounded (1-2 mm) to larger irregularly shaped (1-2 cm) vesicles are visible locally. Petrographic observations (Bordet, 2016a) display a porphyritic texture of the basalt, with plagioclase, clinopyroxene and olivine phenocrysts in a microcrystalline, equigranular, plagioclase rich groundmass. Mafic crystals are locally strongly altered to chlorite. Carbonate alteration is pervasive.

*Fragmental facies (*uŦLRbx *and* uŦLRvs*)*

Coherent basalt is interbedded with various volcanic breccia, volcaniclastic sandstone and conglomerate units. Descriptions of the various volcanic fragmental facies mapped in the Hancock Hills are provided in Bordet (2016a). One distinctive pale green, matrix-supported volcanic breccia with subrounded, pyroxene-phyric basalt blocks forms beds up to 10-20 m thick (Bordet, 2016a). At Povoas Mountain and in the Thirtymile area, angular volcanic breccia and volcaniclastic sandstone dominate (Fig. 5a-c). Brown weathering, red-green, matrix-supported volcanic breccia contains angular, dark green clasts of microcrystalline basalt, in a dark brown, fine-grained plagioclase-rich groundmass.

Carbonate sequence

The region between the Hancock Hills and the east shore of Lake Laberge is underlain by a succession of deformed sedimentary rocks that overlie the basal mafic volcanic sequence. In particular, north to northwest-trending ridges of pale grey weathering, micritic limestone constitute visibly prominent stratigraphic marker beds and structural features. Detailed mapping in 2016 and 2017 allowed the breakdown of a single carbonate sedimentary unit of the Lewes River Group (Hancock member of Tempelman-Kluit, 1984) into six distinct units, distributed in two belts with distinct stratigraphy (Fig. 2a; Bordet, 2017a).

*Eastern carbonate sequence (*uŦLRls, uŦLRl *and* uŦLRlms*)*

A carbonate sequence is exposed on either side of the Lewes River Group mafic volcanic belt (Fig. 2a). The stratigraphic framework includes prominent north to northwest-trending ridges of pale grey micritic limestone east of Mount Laurier, at Lime Peak, and east of Thirtymile (Fig. 2a).

Thin to medium-bedded calcareous mudstone and sandstone (uŦLRls) is exposed along the Laurier Creek fault and overlies the Joe Mountain Formation basalt (Bordet, 2017a). Massive to thick-bedded, pale grey weathering, micritic and fossiliferous limestone is particularly well exposed at Lime Peak (uŦLRl; Yarnell *et al.,* 1999), as well as along a north-trending belt that extends north and west of the Hancock Hills. It overlies Middle and Upper Triassic volcanic rocks, or is interfingered with other thin-bedded calcareous units. In the centre of the map area, massive limestone is interbedded with tan-grey weathering, clast-supported (locally matrix-supported), non-sorted, pebble to cobble calcareous conglomerate, which also includes lenses of tan-orange weathering, fine-grained calcareous sandstone. The conglomerate comprises subrounded to subangular limestone mudstone clasts in a pale yellow weathering, medium-grained calcareous sandstone matrix. Finally, east of the mouth of the Yukon River at Thirtymile, an east dipping sequence of argillaceous laminated mudstone and fine-grained sandstone is exposed (uŦLRms; Fig. 5d-f). It comprises at least three levels of thick–bedded, massive micritic limestone, interbedded with intervals of medium to thin-bedded, brown weathered argillaceous mudstone and fine-grained sandstone.

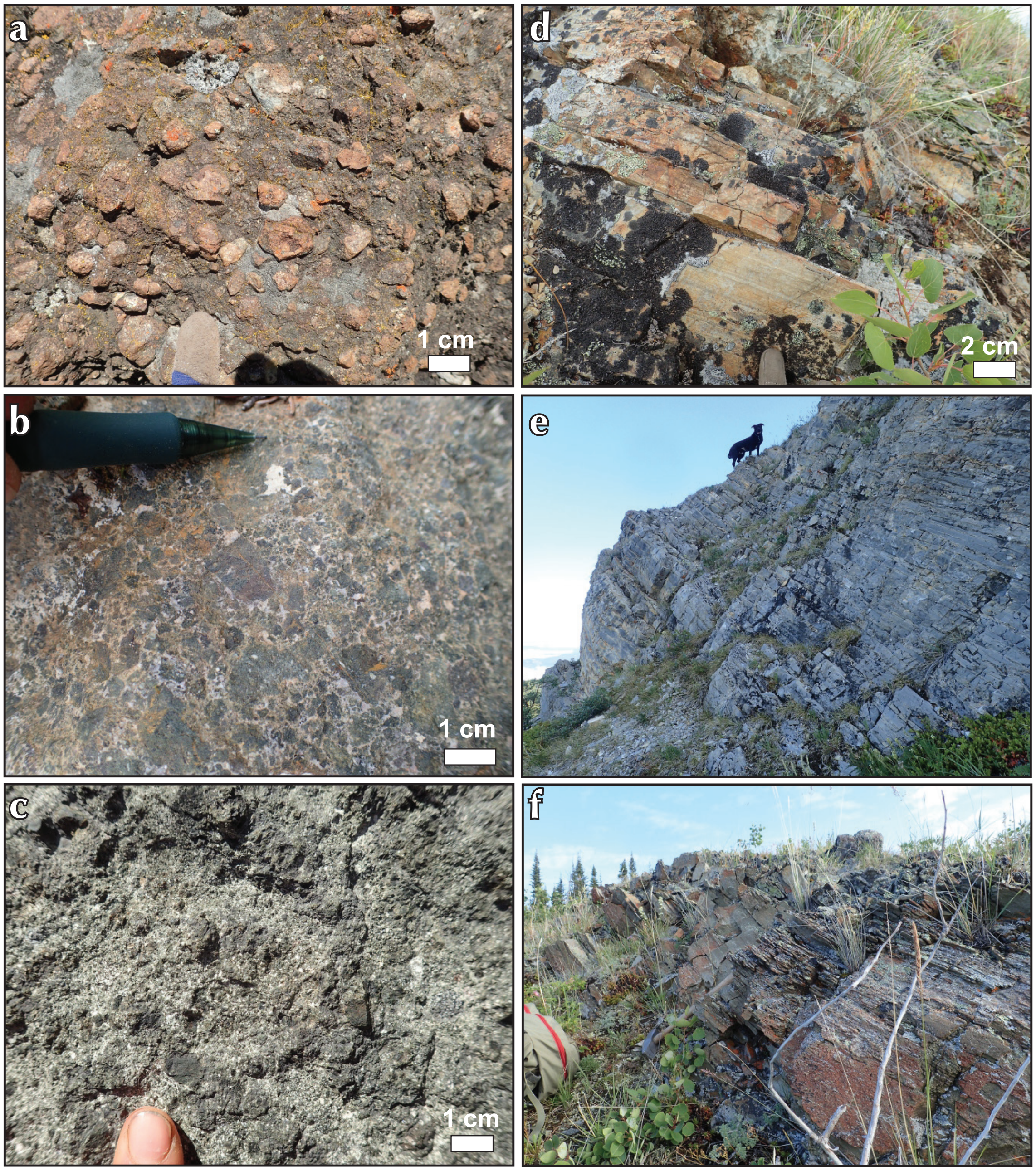

Figure 5. *Field photographs of the Lewes River Group in the Povoas Mountain and Thirtymile area. Fragmental volcanic sequence at Povoas Mountain and east of Thirtymile is illustrated in photos a, b, c. East dipping carbonate sequence east of Thirtymile is illustrated in photos d, e, f.* ***(a)*** *Matrix-supported pebble conglomerate east of Thirtymile. Formed of dark green, mafic matrix and clasts of plagioclase-phyric andesite, limestone mudstone, and red-oxidized volcanic clasts;* ***(b)*** *pale grey-green, matrix-supported, carbonate altered volcanic breccia, clasts are granule to boulder size, angular, made of dark green aphyric lava;* ***(c)*** *matrix-supported, grey-green angular volcanic breccia in the Povoas Mountain area. The matrix is plagioclase-rich and clasts are dark green aphyric to plagioclase-phyric basalt-andesite;* ***(d)*** *east-dipping thinly-bedded, laminated, non-calcareous mudstone;* ***(e)*** *east-dipping medium to thick-bedded, pale grey limestone-mudstone. Lighter colored intervals are very fine grained, argillaceous; and* ***(f)*** *East-dipping, very thin bedded slightly calcareous to non-calcareous mudstone and sandstone.*

*Western carbonate sequence (*uTLRlf, uTLRst, uTLRul*)*

The western part of the map area, exposed along the east shore of Lake Laberge, is characterized by a distinctive carbonate sequence (Fig. 2a,b; Bordet, 2017a). As in the rest of the map area, the stratigraphy includes prominent north to northwest-trending ridges of pale grey micritic limestone.

The following units form the core of an anticlinorium along the east shore of Lake Laberge: a medium-bedded (30-50 cm), argillaceous, fossiliferous (bivalve or brachiopod shells, corals and burrows) limestone wackestone; a thin-bedded, calcareous sandstone and mudstone; and a thick to medium-bedded, pale grey micritic limestone including lenses of rusty weathering, dark grey calcareous mudstone (uTLRlf). These rocks are overlain by 5-10 m of brown to orange weathering, dark grey-green, non-calcareous, medium to coarse-grained sandstone with polymictic, matrix-supported granule conglomerate (uTLRst). A characteristic of this clastic lithology is its high magnetic susceptibility (2-13 S.I.). Overlying this sequence is a very thick bedded, pale grey to orange weathering, dark grey, finely to coarsely crystalline, micritic limestone (uTLRul), which is interbedded with minor bioclastic wackestone (corals, bivalve shells/ brachiopods and crinoids), and minor calcareous sandstone and conglomerate.

Paleoenvironment interpretation

The Lewes River Group comprises a basal mafic volcanic sequence (Povoas formation of Tempelman-Kluit, 1984, 2009), and a carbonate and clastic sedimentary sequence (Aksala formation of Tempelman-Kluit, 1984, 2009). The mafic volcanic sequence is dominated by basalt and basaltic andesite compositions, as well as trachyandesite to tracydacite compositions. Geochemical signatures range from tholeiitic, transitional to calc-alkaline (Bordet, 2017b). This volcanic belt represents an arc sequence developed over and around Middle Triassic volcanic and sedimentary strata of the Joe Mountain Formation. This newer arc formed a significant topographic high, surrounded by a shallow oceanic basin in which carbonate sedimentation took place.

The thick (~2000-2500 m) carbonate sequence overlying mafic volcanic rocks can be divided into at least two belts displaying similar rock types, but spatially distinct stratigraphic successions. Lateral variation in the stratigraphy may result from carbonate sedimentation taking place simultaneously in subbasins separated by natural topographic boundaries controlled by the volcanic physiography. The eastern contact of the western carbonate belt extends to the Goddard fault (Figs. 2a and 3c), suggesting that the rocks originally formed in a shallow subbasin distal from the arc, and were later stacked over and against the eastern carbonate belt during Late Triassic or post Triassic deformation.

Massive micritic limestone strata represent reef buildup structures (Reid, 1980; Yarnell, 1999), whereas calcareous conglomerate likely represents a high-energy zone along the slope in front of the reef. Based on macrofossil analyses, environments of deposition for the carbonate sequence are interpreted as shallow marine (inner platform or shelf) to open marine, with normal salinity and a tropical climate (R. Blodgett, *pers. comm.,* 2017). Other fine-grained, thin-bedded, more argillaceous units are interpreted as forming in deeper parts of the basin, or in shallow lagoons located between the reef and the arc. Continuous erosion of the arc provided a steady supply of volcanic material throughout the Late Triassic.

Age of the Lewes River Group

A new macrofossil collection from the carbonate sequence of the Lewes River Group includes specimens of bivalve and brachiopod shells, gastropods, scleractinian corals, columnal crinoid ossicles, and various sponge and other biotic debris (R. Blodgett, *pers. comm*., 2017). Diagnostic fauna assemblages support a Late Triassic age, with some specimens restricted to the late Middle Norian (bivalves *Halobia* and *Monotis*). Five conodont samples also support a Late Triassic age for the carbonate sequence of the Lewes River Group. Identified specimens of *Mockina cf. englandi* restrict the age of deposition to the Norian-Rhaetian (Golding, 2017).

Two detrital zircon ages from a non-calcareous pebble conglomerate unit (uTLRst) underlying massive micritic limestone (uTLRul) returned a maximum deposition age between 212 and 211 Ma (J. Crowley, *pers. comm.* 2017).

Based on fossil and detrital zircon analyses, the age range for the Lewes River Group is constrained between the Carnian to Rhaetian. The carbonate sequence was deposited during the Late Triassic, dominantly in Norian time (Hoover, 1991; Senowbari-Daryan, 1990; Orchard, 1995; Orchard, *pers. comm.,* 2016; R. Blodgett, *pers. comm*., 2017; Golding, 2017).

OVERLAP ASSEMBLAGES

WHITEHORSE TROUGH – LABERGE GROUP

Early-Middle Jurassic strata of the Laberge Group are dominated by thick-bedded, polymictic pebble to boulder conglomerate (JLcg) in the northeastern part of the map area and along the rugged ridge of Mount Laurier (Figs. 2a and 3). The conglomerate unit is bounded to the west by the Laurier Creek fault, to the south by Long Lake, and to the east by the Teslin River. Fine-grained, thin-bedded clastic sedimentary rocks are exposed along the shore of Lake Laberge (JLst; Fig. 2a). Two additional minor units are reported: a dark green, matrix-supported conglomerate (JLcbx) and one occurrence of the Nordenskiöld dacite (lJN). The contact between Laberge Group and the underlying Lewes River Group is either a disconformity (Mount Laurier), or an angular unconformity (south of Long Lake; Fig. 2a). In fact, Laberge Group unconformably overlies various units of the Upper Triassic Lewes River Group, a relationship described in detail in van Drecht and Beranek (2018). The upper contact of the Laberge Group is not exposed in the Teslin Mountain area, therefore the estimated thickness of 2000 m for the Laberge Group is a minimum. Previous estimates report between 1000 and 3000 m (*e.g.*, Hart, 1997; White *et al.*, 2012) across the Whitehorse trough.

Polymictic conglomerate (JLcg)

Grey-brown-rusty to tan weathering, thick-bedded, clast to matrix-supported, poorly sorted, polymictic pebble to boulder conglomerate includes rounded to subrounded clasts of fine-grained mudstone, limestone mudstone or cherty limestone, a variety of intrusive clasts, and volcanic mafic clasts (Bordet, 2016a). Bedding thickness ranges from 10 to 30 cm to locally metre-scale. Matrix is a pale yellow weathering, dark grey-green calcareous sandstone rich in biotite, quartz, feldspar and hornblende. Lithic sandstone forms metre-scale interbeds or lenses within the conglomerate. In addition, an ~30 m thick sequence of brown weathering, thin-bedded sandstone and mudstone underlies the polymictic conglomerate and marks the base of the Laberge Group at Mount Laurier and north of Teslin Mountain (Bordet, 2016a).

SANDSTONE/MUDSTONE (JLST)

Fine-grained, thin-bedded clastic sedimentary rocks of the Early to Middle Jurassic Laberge Group are exposed along the west shore of Lake Laberge, on Richthofen Island, and as a discontinuous strip along the east shore of Lake Laberge (Bordet, 2017a). Unit JLst comprises dark grey to brown weathering, thin-bedded, slightly calcareous to non-calcareous, dark grey turbiditic mudstone and siltstone. Dark grey, thin-laminated mudstone displays interbeds of pale yellow weathering sandstone with angular mudstone intraclasts. Load structures are common between sandstone beds and underlying mudstone, and generally indicate a stratigraphic polarity to the west (Bordet, 2017a).

Dark green conglomerate (JLcbx)

A distinct dark green conglomerate unit is exposed east of Richthofen Island and at several locations on the east shore of Lake Laberge, north of Goddard Point, and at Ptarmigan Point (Bordet, 2017a; Fig. 2a). It is composed of dark grey-green weathering, bright green, thick to medium-bedded, matrix-supported, immature, polymictic, poorly sorted cobble to boulder conglomerate locally interbedded with thin-bedded, lenticular mudstone/ sandstone. The matrix is composed of pale green, fine-grained, non-calcareous volcanic sandstone with up to 3-4% quartz eyes. Subrounded clasts include pale grey micritic limestone, plagioclase-phyric rhyolite, andesite and dark grey mudstone.

Nordenskiöld dacite (lJN)

Beige-tan weathering, medium-crystalline, equigranular crystal tuff was mapped near the eastern shore of Lake Laberge. This unit is interbedded with pebble conglomerate and fine-grained sandstone and mudstone of the Laberge Group. The basal contact with thin-bedded mudstone-sandstone is irregular (Fig. 6a). The unit contains subrounded quartz crystals, hornblende and lithic fragments of plagioclase-phyric andesite in a microcrystalline plagioclase-phyric matrix (Fig. 6a,b). Small centimetre-scale lithic clasts of fine-grained grey mudstone are also reported (Fig. 6b). Magnetic susceptibility for this unit is high (~25 S.I.).

Petrographic observations (Fig. 6c) display a fragmental volcanic texture, with subrounded lithic fragments of plagioclase-phyric andesite (<1%). The matrix is plagioclase-rich. Crystals include quartz (1%), hornblende (3-5%), plagioclase (70%), opaque minerals (3%) and pyroxene (<1%).

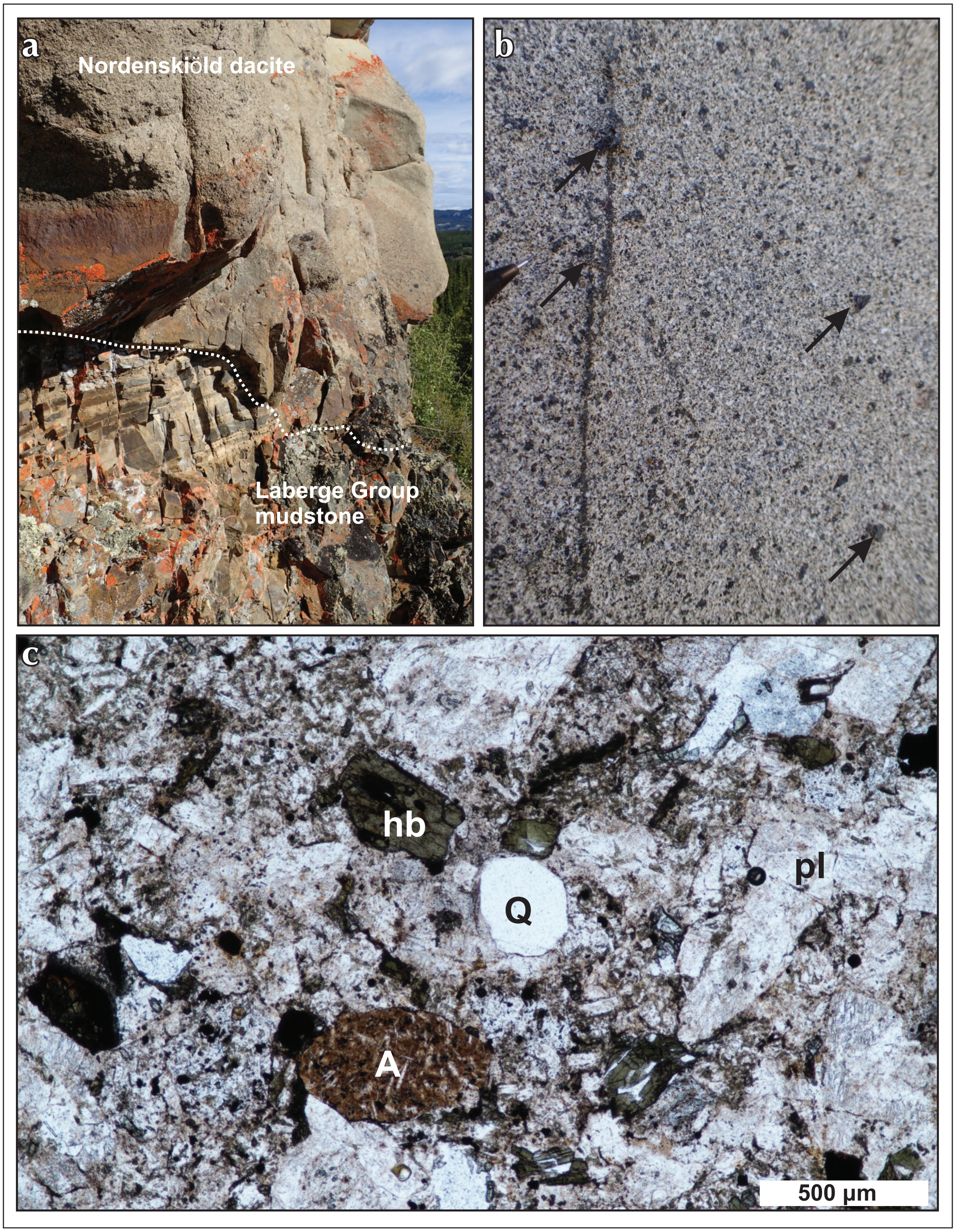

Figure 6. *Occurrence of the Nordenskiöld dacite east of Lake Laberge,* ***(a)*** *irregular basal contact (white dashed outline) of the Nordenskiöld dacite with underlying thin-bedded, laminated mudstone-sandstone of the Laberge Group;* ***(b)*** *macroscropic view of the outcrop of the Nordenskiöld dacite displaying tan weathering, medium crystalline, equigranular crystal tuff; pencil tip for scale. The matrix contains plagioclase and hornblende, and angular lithic clasts are visible (black arrows); and* ***(c)*** *petrographic view (plain light) of the Nordenskiöld dacite, characterized by a fragmental volcanic texture. Includes subrounded quartz crystals (Q), lithic fragments of plagioclase-phyric andesite (A), hornblende (hb), plagioclase (pl).*

Interpretation and age of the Laberge Group

Mapping suggests lateral facies changes within the Laberge Group from west to east. East of the Laurier Creek fault, Laberge Group is dominated by cobble to boulder polymictic conglomerate interpreted to represent submarine fan channel deposits (Dickie and Hein, 1995; Lowey, 2005, 2008). The lithology west of Laurier Creek fault, along Lake Laberge and on Richthofen Island, is dominated by fine-grained, thin-bedded turbiditic mudstone/sandstone, locally interbedded with granule to cobble polymictic conglomerate. This lithology is related to relatively deep-basin sedimentation. Limited conglomerate exposures within the turbiditic sequence to the west may be the result of localized channel activity. Detrital zircon ages within rocks of the Laberge Group range from the Late Triassic to Early Jurassic (~220-180 Ma; Colpron *et al.*, 2015).

The deposition of Laberge Group sediments in the Early Jurassic was likely controlled by pre-existing Triassic topography. Massive micritic limestone beds of the Lewes River Group (uTLRl) constitute present-day, prominent topographic features, and their reefal origin suggests that they were probably already shaping the landscape during the Late Triassic and Early Jurassic. These reefs formed buttresses, constraining the deposition of both Upper Triassic argillaceous sediments, and Laberge Group turbiditic or deltaic fan deposits (JLst).

The Nordenskiöld facies is a distinct crystal-lithic tuff (Tempelman-Kluit, 1984, 2009), occurring at multiple stratigraphic levels in both the Richthofen and Tanglefoot formations. It represents at least three distinct volcanic events between 188 and 186 Ma in the northern Whitehorse trough (Colpron and Friedman, 2008), but was also recognized and dated in the Lake Laberge area (184 ± 4 Ma; Hart, 1997). Samples collected east of Lake Laberge were compared to Nordenskiöld samples collected regionally, and compositional and textural similarity was established based on petrographic observations.

PLUTONIC ROCKS

Igneous rocks in the map area include the Middle Jurassic Teslin Crossing, middle Cretaceous Cap Creek (Hart and Hunt, 1994, 2003; Hart 1997) and Laurier Creek plutons, and Late Cretaceous Teslin Mountain pluton. In addition to these large plutonic bodies, more than 200 dikes were mapped over the course of three summers. Several of these igneous bodies are related to mineral occurrences.

Teslin Crossing pluton (mJB)

The Teslin Crossing pluton is an ~5 by 10 km body located in the northeastern part of the map area (Fig. 2a). Limited exposures of the pluton are visible along a north-south trending alpine ridge. Contact with Early-Middle Jurassic strata was mapped at the southern edge of the igneous body. The pluton is characterized by medium to coarse-grained monzonite, monzodiorite and syenite. Related dikes of dacite to andesite porphyry with euhedral andesine, hornblende and locally quartz in aphanitic greenish, or grey groundmass are also reported (Colpron, 2011). An age of *ca.* 172 Ma is reported for the Teslin Crossing pluton, and it is therefore interpreted to be part of the Bryde Plutonic suite (Sacks and Colpron, *pers. comm.* 2017). The Teslin Crossing pluton hosts the porphyry Cu-Mo-Au Mars prospect (Fig. 2a; Yukon MINFILE 105E 002).

Laurier Creek pluton (EKgT)

The Laurier Creek pluton is characterized by grey to tan weathering, white to pale pink, equigranular, medium to coarse-grained granodiorite, monzonite, monzodiorite and quartz diorite that forms an ~5 by 12 km intrusion to the southwest of Teslin Mountain (Figs. 2a and 3). It intrudes Joe Mountain Formation aphyric massive basalt, but also the Lewes River Group sedimentary succession to the west. Detailed descriptions based on recent observations along the northern and western contacts of the intrusion are provided in Bordet (2017a).

A preliminary U/Pb age of ~116 Ma was obtained from granodiorite of the Laurier Creek pluton (J. Crowley, *pers. comm.,* 2017). This is similar to a previous date of *ca.* 118 Ma (K/Ar biotite; Stevens *et al.*, 1982). Therefore, the Laurier Creek pluton is assigned to the middle Cretaceous Teslin Suite (123-115 Ma; Colpron *et al.*, 2016). The Laurier Creek pluton hosts the molybdenum porphyry Hig (Yukon MINFILE 105E 024) and Lori (Yukon MINFILE 105E 025) showings.

Teslin Mountain pluton (LKgR and LKdR)

The Teslin Mountain pluton is an ~4 by 3 km massive, blocky, medium-grained, grey weathering, pale grey to white monzodiorite (LKgR) that intrudes Joe Mountain Formation massive basalt at Teslin Mountain (Figs. 2a and 3b; Bordet, 2016a). It contains plagioclase (40-60%), K-feldspar (up to 15%), biotite (10-15%), hornblende (10-20%) and quartz (1-3%). Another phase (LKdR) comprises tan to grey weathering, massive, blocky, fine-grained, dark grey-green diorite (1-2% quartz) and quartz diorite (up to

5-10% quartz), which contain plagioclase (10-15% and locally up to 50%), biotite or hornblende (5-15%).

A preliminary U/Pb zircon age of ~78 Ma was obtained for the Teslin Mountain pluton as part of this study (J. Crowley, *pers. comm.,* 2016). Based on geographic proximity and geological context, an association with the Rancheria plutonic suite exposed at Red Mountain (Yukon MINFILE 105C 009) east of the Teslin fault (81-79 Ma, Ar/Ar; Joyce *et al*., 2015) is proposed. The Open Creek volcanic complex (*see* below) constitutes likely volcanic equivalents of this intrusive suite.

The Teslin Mountain pluton hosts the Debicki occurrence (Yukon MINFILE 105E 050).

Dikes

More than 200 dikes crosscut the Triassic to Jurassic stratigraphy in the map area. Petrography and geochemical analyses identified a variety of textures and compositions (Bordet, 2016a, 2017a; Fig. 7). Dikes locally display a magmatic foliation and are generally oriented N-S. At least three different dike compositions are reported:

- Brown weathering, conchoidally fractured, dark grey-green gabbro dikes with pyroxene (1-2%) and plagioclase (5%) in a fine-crystalline, dark grey groundmass are less common (~8% of all dikes; Fig. 7a,b). They are spatially concentrated along the east shore of Lake Laberge, and crosscut massive micritic limestone of the Lewes River Group, as well as thin-bedded mudstone at the base of the Laberge Group (Bordet, 2017a). These gabbro dikes appear to be folded along with the Upper Triassic-Jurassic sequence.
- Grey to beige weathering, grey, porphyritic dacite and rhyodacite dikes are widespread (~36% of all the dikes; Fig. 7c,d). They display a grey-green, aphanitic to finely crystalline equigranular groundmass. Phenocrysts include plagioclase (5 mm to 2 cm; 10-15%, and up to 25%), hornblende (1-5%, and up to 10%; laths up to 1 cm) and quartz (<1%).
- Pale pink/orange/beige to tan weathering, massive to blocky or locally foliated rhyolite quartz-phyric dikes are most common (~56% of all the dikes; Fig. 7e,f). They display a fine to medium-crystalline, pale pink to grey groundmass, and contain up to 10-60% plagioclase. Phenocrysts include K-feldspar (5-25%), quartz (1-10%) and hornblende or biotite (1-5%).

Three dikes were selected for U/Pb zircon geochronology. Preliminary results returned one middle Cretaceous age for a gabbro dike (~106 Ma; J. Crowley, *pers. comm.* 2017) which can be related to magmatic activity of the Whitehorse plutonic suite (112-98 Ma; Colpron *et al.*, 2016).

Two Early Cretaceous ages were obtained for a quartz-phyric rhyolite and a rhyodacite dike (ca. 138-136 Ma; J. Crowley, *pers. comm*. 2017). Early Cretaceous igneous ages are rare in the Yukon, and no igneous suite is defined so far that includes 138-136 Ma ages (Colpron *et al.*, 2016). Considering the pervasive nature of felsic dikes such as those that were dated, and the increased frequency of these dikes along the Goddard fault zone, the Goddard plutonic suite (EKqG) is newly defined here (Fig. 2).

VOLCANIC ROCKS

Open Creek volcanic complex

Dark grey to brown weathering dacite lava and tephra and chaotic volcanic breccia are exposed northeast of Teslin Mountain and west of Open Creek (Fig. 2a). These rocks were previously described by Tempelman-Kluit (1984, 2009), and informally named "Open Creek volcanics". They cover an area of at least 5 by 10 km and are best exposed along the eastern flank of a north-south trending ridge, which also marks the boundary of a landslide scarp. Open Creek volcanic rocks are in unconformable contact with the underlying Laberge Group and Joe Mountain Formation, but contacts are not exposed.

Crystal-rich lapilli tuff and block and ash flow form a ≥400 m thick ignimbrite sequence (LKOt), overlain by indurated dacite lava and breccia (LKOd; Fig. 8a-c). Grey to rainbow weathering, beige-tan colored, lithic-crystal lapilli ash tuff (Fig. 8d) has up to 15% crystals (quartz, biotite, plagioclase), 5-10% angular and rounded lithic clasts (plagioclase phyric andesite or dacite), and 2-5% pumice lapilli (Fig. 8g). Elongated vesicles are visible in the upper part of the ignimbrite below the contact with overlying dacite lava. The block-and-ash flow (Fig. 8e) has a white-pale green silicic ash matrix containing crystals (biotite, plagioclase and hornblende) and lapilli size lithic fragments. Blocks are up to 1 m in size, subrounded, of intermediate-silicic composition. Composition of the ignimbrite sequence is rhyodacite to rhyolite.

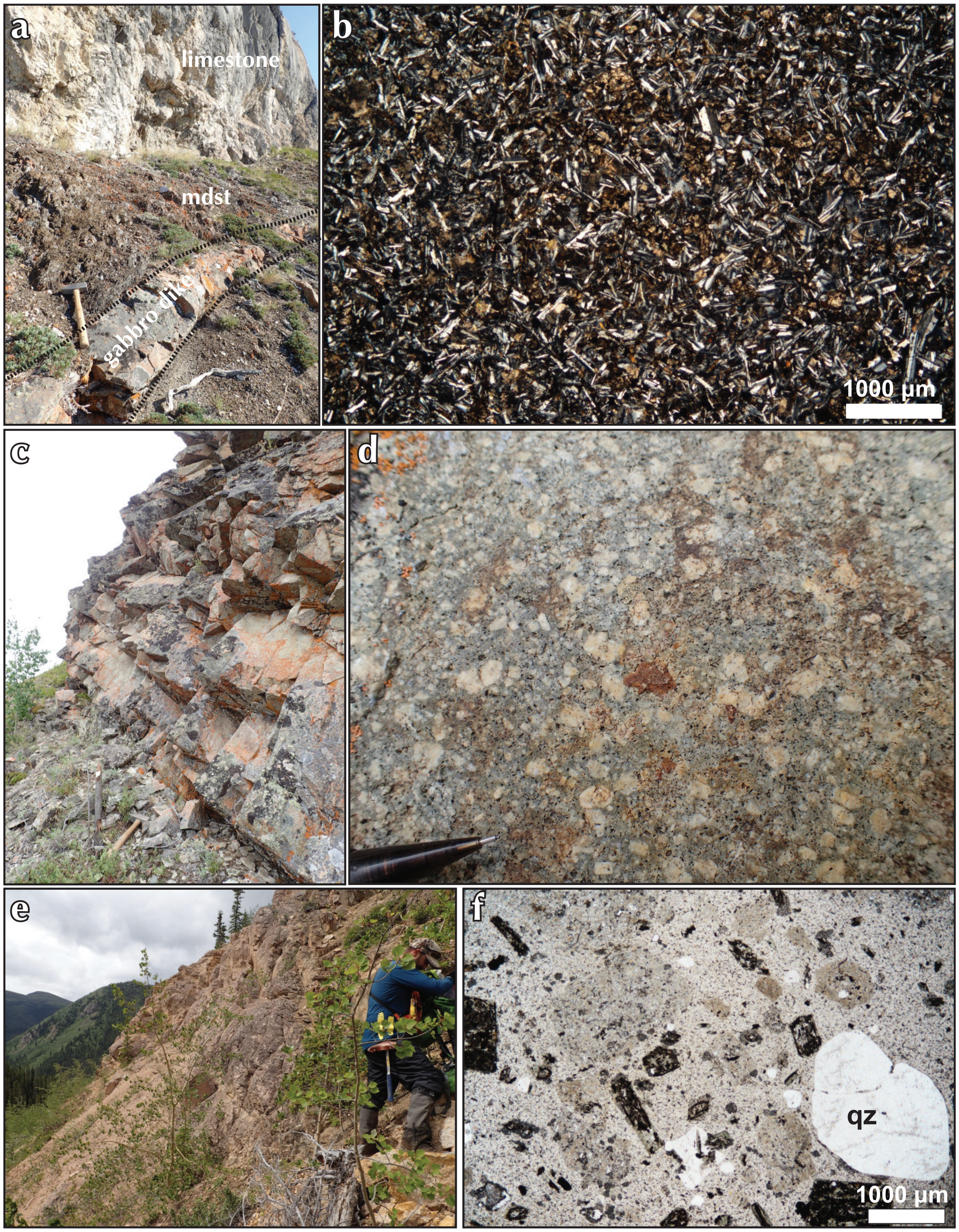

Figure 7. *Dikes textures and compositions,* ***(a)*** *outcrop photograph of an ~30 cm thick gabbro dike. At this location, Upper Triassic limestone is thrust over Early-Middle Jurassic mudstone of the Laberge Group. The dike intrudes the Jurassic sequence and is parallel to bedding;* ***(b)*** *petrographic view (cross-polar light) of the gabbro dike. Texture is equigranular, microcrystalline, essentially composed of plagioclase and pyroxene crystals;* ***(c)*** *outcrop photograph of an ~5 m wide rhyodacite dike intruding sedimentary strata of the Laberge Group;* ***(d)*** *macroscopic field photograph of the rhyodacite dike. Texture is porphyritic, with plagioclase phenocrysts, and biotite and hornblende microcrystals, in a pale grey aphanitic groundmass;* ***(e)*** *outcrop photograph of an ~10 m thick plagioclase-quartz-phyric rhyolite dike intruding mudstone of the Laberge Group; and* ***(f)*** *petrographic view (polarized light) of a quartz-plagioclase-biotite phyric rhyolite dike. The groundmass is pervasively carbonate altered.*

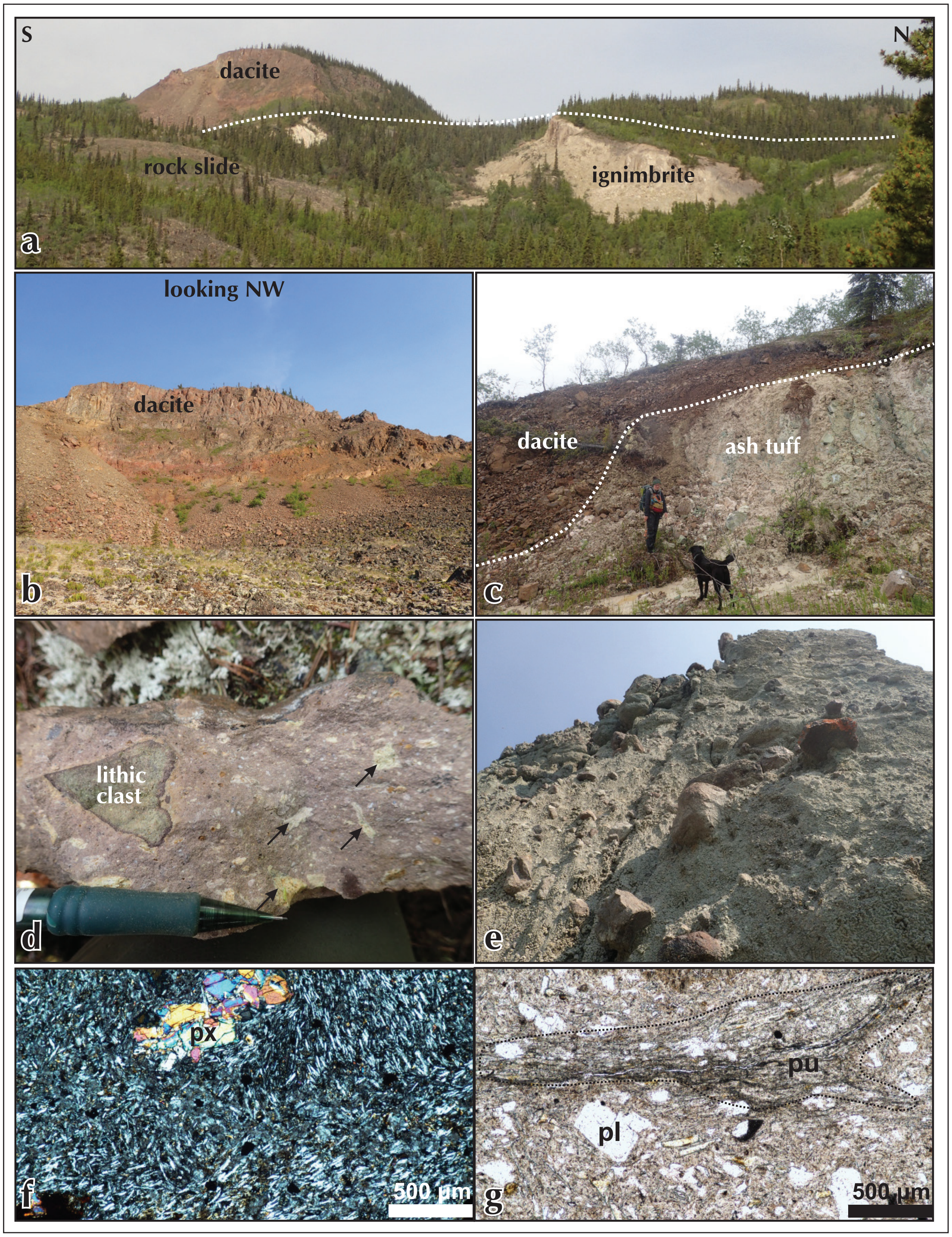

Figure 8. *Late Cretaceous Open Creek volcanic complex.* ***(a)*** *View looking west of the Open Creek volcanic complex. Indurated dacite lava and breccia cap an ~400 m thick ignimbrite sequence. Several landslides and rock slides occur in the area, due the ash tuff matrix of the ignimbrite forming a weak clay layer when altered;* ***(b)*** *a close up photograph of the indurated dacite cap, looking NW;* ***(c)*** *the contact between the basal clay-altered ignimbrite and overlying dacite lava;* ***(d)*** *a macroscopic view of the lapilli-ash tuff forming the ignimbrite. Pumice clasts indicated with black arrows;* ***(e)*** *block and ash flow sequence containing metre-sized blocks of dacitic lava in an ash-tuff matrix;* ***(f)*** *petrographic view of the dacite lava. The groundmass comprises microcrystalline plagioclase crystals, rare pyroxene phenocrysts are observed (px); and* ***(g)*** *petrographic view of the lapilli-ash tuff forming part of the ignimbrite sequence. Crystals include, plagioclase (pl), quartz. A pumice clast is outlined and labelled (pu).*

Brown-grey weathering, brown, aphyric to plagioclase (1-2%), pyroxene (2-3%), ±hornblende (1%) phyric, massive to columnar jointed or flow-banded indurated dacite (Fig. 8f) caps the ignimbrite sequence. It includes brown to rusty weathering, matrix-supported scoriaceous dacite breccia and autobreccia.

Isolated exposures of brown weathering, dark grey-brown, pyroxene-plagioclase phyric vesicular to amygdaloidal basalt and gabbro dikes (LKOb) are mapped to the west of the ignimbrite sequence, but their relationship with the rest of the stratigraphy is unclear. Grey-brown weathering, massive, grey, plagioclase (20%), biotite (1-3%), hornblende (7-10%) coarsely phyric diorite (LKO) sits at the base of the volcanic complex, and is likely a feeder to the volcanic sequence.

Interpretation and age of the Open Creek volcanic rocks

The nature of the Open Creek volcanic succession suggests a period of explosive volcanism, leading to the deposition of an ignimbrite sequence at least 400 m thick. The ignimbrite comprises block and ash flow deposits, as well as crystal-lithic rich lapilli-ash tuff. Metre-sized dacite blocks in the block and ash flow sequence, as well as very primary textures in the rest of the ignimbrite sequence, suggest that these deposits are relatively proximal to a volcanic centre (deposition within a few kilometres). The dacitic sequence capping the ignimbrite displays a range of textures from lava to monomictic breccia. Once again, the texture of the lava and breccia suggest they were emplaced proximally relative to a volcanic center.

The Open Creek volcanic rocks were originally dated at ~80 Ma (whole rock, K/Ar; Tempelman-Kluit, 2009). Two preliminary U/Pb dates conducted as part of this project returned similar ages of 79 Ma (J. Crowley, *pers. comm.*, 2017) for the ignimbrite sequence. The timing of volcanism is therefore coeval to the emplacement of the Teslin Mountain pluton, located just a few kilometres to the south. The felsic lithology, similar ages, and spatial proximity suggest that the Teslin Mountain pluton and Open Creek volcanic rocks are part of a same magmatic complex and probably share a common magmatic source.

The area where Open Creek volcanic rocks are exposed displays signs of active landslide and rockslide activity (Fig. 8a). In fact, the highly porous, ash matrix of the ignimbrite sequence is altered into clay-rich soil, creating an unstable slippery layer responsible for the collapse of the upper dacite lava.

STRUCTURE

A detailed structural review of the map area is provided in Bordet (2017a). In summary, two major north-northwest-trending strike-slip faults dissect the Triassic to Jurassic stratigraphy, the Goddard and Laurier Creek faults. Two dominant structural trends are identified in rocks exposed along these faults. North to northwest-striking thrust and normal faults, and east-verging tight folds dominate in the Lewes River Group, between the east shore of Lake Laberge and Laurier Creek fault (Fig. 2a). East of the Laurier Creek fault, bedding measurements consistently indicate an east-trending structural fabric and tight east-west folds within the Middle Triassic Joe Mountain Formation.

Deformation affects the entire Triassic to Jurassic sequence. Most of the thrusting, as well as strike-slip motion along the Goddard and Laurier Creek faults, must have at least a syn or post-Jurassic component. However, the contrasting east-west structural grain in rocks of the Joe Mountain Formation at Teslin Mountain, compared to the dominant north-northwest structural trends west of the Laurier Creek fault, suggest evidence for a pre-Late Triassic event that occurred prior to deposition of the Lewes River Group.

In addition, the structures in the map area contrast with those of the northern Whitehorse trough, characterized by northwest-striking, southwest-verging folds and thrust faults that are dissected by northwest and north-striking strike-slip faults (White *et al.*, 2012).

SUMMARY AND CONCLUSIONS

The Teslin Mountain and Lake Laberge areas in south-central Yukon were investigated from 2015 to 2017 as part of a 1:50 000 scale bedrock mapping project. The area is underlain by mafic volcanic, volcaniclastic and clastic sedimentary strata of the Middle Triassic Joe Mountain Formation, mafic volcanic and sedimentary strata of the Upper Triassic Lewes River Group, and polymictic conglomerate and thin-bedded turbiditic sequences of the Lower-Middle Jurassic Laberge Group. At least five post-accretion igneous suites are recognized, as well as one Late Cretaceous volcanic complex.

TRIASSIC STRATIGRAPHY

- Five volcanic, volcaniclastic and sedimentary units are now defined as part of the Middle Triassic Joe Mountain Formation, and nine units as part of the Upper Triassic Lewes River Group. Unit descriptions presented in this paper generally supersede previous subdivisions described by Bordet (2016a, 2017a).

- The nature of the northern contact of the Joe Mountain Formation basalt was revised in 2017, and the relationships with volcaniclastic and sedimentary units exposed northwest of Teslin Mountain were reinterpreted. In conclusion: 1) clastic sedimentary rocks (mŦJMms) underlying the Middle Triassic mafic sequence represent a basin that existed prior to Joe Mountain volcanism; 2) coarse volcanic conglomerate, volcanic sandstone and minor basalt (mŦJMbx) overlying the clastic sedimentary sequence must be part of the Middle Triassic Joe Mountain Formation in order explain structural and stratigraphic relationships with underlying strata.
- Joe Mountain volcanism is dated at ~245 Ma (J. Crowley, *pers. comm.*, 2016). The age range for the Lewes River Group is constrained between the Carnian and Rhaetian, based on combined fossil and U/Pb detrital zircon ages.
- The Joe Mountain Formation and Lewes River Group volcanic rocks are dominated by basalt and basaltic andesite compositions. The Joe Mountain Formation is characterized by MORB/BABB and IAT signatures, whereas Lewes River Group signatures range from tholeiitic, transitional to calc-alkaline. Geochemical analysis of the Triassic volcanic rocks indicates similar tectonic settings for both suites, with internal variations within each suite. However, the Joe Mountain Formation seems to represent a more juvenile end-member of the Triassic volcanic rocks sample suite. It is proposed that the Joe Mountain Formation represents the onset of arc magmatism in the Middle Triassic, and that the Lewes River group represents a temporal and spatial continuity of this arc throughout the Late Triassic.
- The Lewes River Group is interpreted to have developed on the margin of a volcanic arc forming a topographic highland. This arc constituted a natural break in a shallow oceanic basin, leading to synchronous but dissimilar carbonate sedimentation on either side of the arc. As a result, lateral stratigraphic variations occur throughout the Lewes River Group carbonate sequence.

OVERLAP ASSEMBLAGES

Interfingering between Triassic and Jurassic strata suggests that the deposition of Laberge Group sediments was controlled by pre-existing Triassic topography. This pattern was further emphasized by later deformation that thrusted sheets of Triassic rocks over younger Jurassic strata.

At least five distinct post-accretionary plutonic suites ranging from the Middle Jurassic to the Late Cretaceous are identified in the map area, as well as one Late Cretaceous volcanic complex. Igneous activity occurred at ~172 Ma (Teslin Crossing pluton), between 138 and 136 Ma (felsic dikes part of the newly defined Goddard Suite), between 116 and 106 Ma (Cap Creek pluton, Laurier Creek pluton, gabbro dike), and at ~79-78 Ma (Open Creek volcanic complex, Teslin Mountain pluton).

At least four map units were identified as part of the Late Cretaceous Open Creek volcanic complex. Field observations combined with preliminary analytical results suggest that a series of pyroclastic eruptions led to the deposition of a thick ignimbrite sequence around 79 Ma (J. Crowley, *pers. Comm.*, 2017), and subsequent dacitic lava flows capped the ignimbrite. The layered volcanic sequence is spatially and temporally associated with the nearby Late Cretaceous Teslin Mountain pluton.

A number of individual dikes showing a range of compositions and textures were mapped. Preliminary analytical results highlight the lithological, compositional and temporal diversity of this discrete, but pervasive igneous system. A new magmatic episode was identified with at least two of the dacite-rhyolite dikes returning ages between 138 and 136 Ma (J. Crowley, *pers. comm.,* 2017). This is newly defined as the Goddard suite, since most of the dikes occurrences are aligned with the Goddard fault zone.

The map area includes several styles of mineral occurrences: Cu or Mo porphyry associated with large middle Cretaceous plutons (*e.g.*, Hig showing, Yukon MINFILE 105E 024); quartz vein related gold and polymetallic veins (*e.g.*, Hartless Joe prospect, Yukon MINFILE 105D 051, Fig. 2a); and Cu or Mo skarn where the Upper Triassic carbonate sequence is intersected by numerous dikes (*e.g.*, Laberge prospect, Yukon MINFILE 105E 006). The middle Cretaceous Teslin Mountain pluton may be temporally and genetically related to the Red Mountain Cu-Mo-Au-porphyry deposit (Yukon MINFILE 105C 009) located about 45 km to the east. This relationship will be investigated during summer 2018.

STRUCTURE

Two north-northwest trending regional-scale faults crosscut the map area: the Goddard and Laurier Creek faults.

- The Goddard fault is regionally interpreted as a dextral strike-slip structure, but locally displays a thrust motion. Changes of strata strike and dip and an increased concentration of dikes occur in the vicinity of the fault.
- The Laurier Creek fault constitutes a major geological and structural boundary in the map area. The Middle Triassic Joe Mountain Formation is only exposed east of the fault, and characterized by an east-west structural grain. West of the fault, units of the Upper Triassic Lewes River group dominate, and they are characterized by north-northwest trending fold axes and thrust faults.

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