Cache Creek terrane, Stikinia, and overlap assemblages of eastern Whitehorse (NTS 105D) and western Teslin (NTS 105C) map areas

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ABSTRACT

Bedrock mapping of parts of the Whitehorse and Teslin map areas in the summer of 2012 has improved upon existing knowledge of the local geology from previous 1:250 000 scale mapping in the respective map sheets. Our mapping characterizes the nature of the Cache Creek terrane in Yukon, including the identification of a previously unknown siliciclastic package, informally named the Michie formation, a gabbroic intrusive complex, and the Marsh Lake intrusive complex, in addition to more typical oceanic lithologies. This mapping helps refine the structural history of the area and define the relationships between Cache Creek terrane and rocks of Stikinia and Whitehorse trough. Two main phases of compressional deformation have been identified: 1) an initial phase of west-verging thrusting, emplacing Cache Creek terrane rocks above rocks of Stikinia and the Whitehorse trough along the Judas Mountain thrust, a northern equivalent to the Nahlin fault; and 2) a subsequent, second phase of thrusting which reshuffles Stikinia and Whitehorse trough rocks onto the Cache Creek terrane along the east-verging Mount Michie thrust. Three main styles of mineralization were observed, associated with either ultramafic bodies or Cretaceous intrusions in the region.

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INTRODUCTION

The Cache Creek terrane is one of the most enigmatic terranes in the Canadian Cordillera. It consists of an accretionary complex made up of a mixture of oceanic and arc volcanic rocks, pelagic sedimentary rocks, ultramafic bodies, and exotic limestone containing Early Permian Tethyan fauna (e.g., Monger and Ross, 1971; Paterson and Harakal, 1974; Gabrielse, 1991; Struik *et al.*, 2001; Orchard *et al.*, 2001). The character of the Cache Creek terrane is known mainly from studies in British Columbia; less is known about the terrane in southern Yukon. To address this gap in knowledge bedrock mapping of an area roughly 680 km^2 in size, and straddling the Michie Creek (NTS 105D/9), Tagish (NTS 105D/8), and Squanga Lake (NTS 105C/5) map areas, was completed in the 2012 summer field season. The area is located approximately 75 km southeast of Whitehorse (Fig. 1) and can largely be accessed from the Alaska Highway along the eastern shore of Marsh Lake. The area lies at the northern termination of the Cache Creek terrane in the Cordillera. The most recent published bedrock maps for this area include parts of the 1:250 000-scale maps of the Whitehorse (NTS 105D; Wheeler, 1961) and Teslin areas (NTS 105C; Gordey and Stevens, 1994). This report summarizes preliminary observations about the nature of the Cache Creek terrane in Yukon, and its relationships with adjacent rocks of Stikinia and Whitehorse trough.

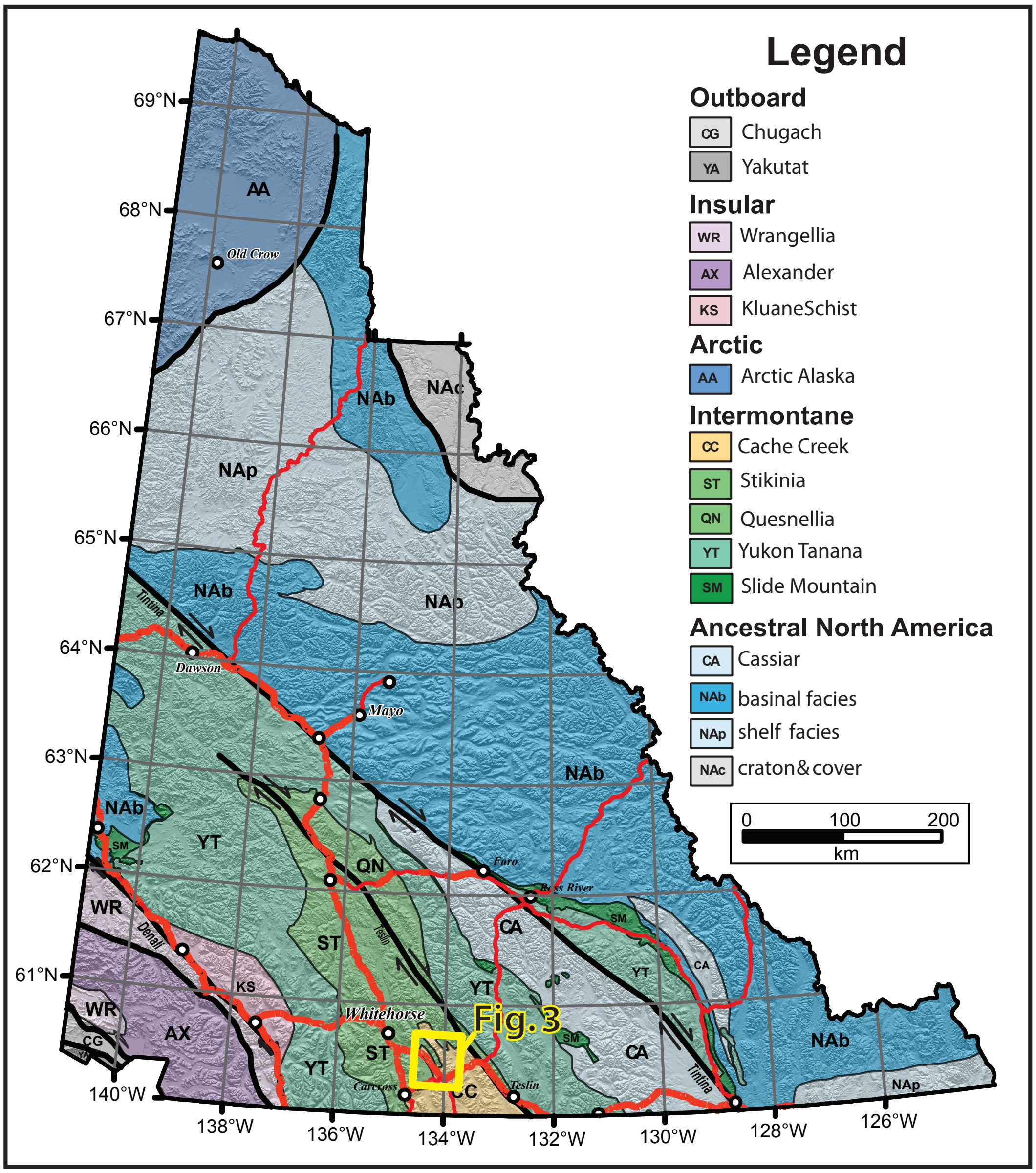

Figure 1. Regional context of field area, shown on the Yukon terrane map (modified after Colpron and Nelson, 2011). The yellow box outlines the field area and bedrock geology map of Figure 3 centered over the northern termination of the Cache Creek terrane.

REGIONAL SETTING

South-central Yukon contains multiple segments of terranes accreted to the Laurentian margin in the Cordilleran orogeny. In map-view, the late Paleozoic to early Mesozoic island arc terranes Stikina and Quesnellia, together with the affiliated peri-Laurentian Yukon-Tanana terrane, enclose at the northwestern end pelagic sedimentary rocks, oceanic seamount and ophiolite assemblages, as well as massive carbonate of the exotic Cache Creek terrane (Fig. 1). The thick, regionally extensive limestone of the Cache Creek terrane locally contains distinctive Early Permian fauna of Tethyan affinity (Monger and Ross, 1971). This fauna contrasts with the less exotic McCloud fauna found in limestone of Quesnellia and Stikinia. The presence of limestone with exotic fauna, coupled with local occurrences of Triassic to Lower Jurassic blueschist within mélange in the eastern part of Cache Creek terrane in British Columbia (Paterson and Harakal, 1974; Gabrielse, 1991; Struik *et al.*, 2001; Mihalynuk *et al.*, 2004), has been inferred to indicate a significant amount of Panthalassa lithosphere subducted beneath the Quesnellia-Stikinia arc from Permian to Jurassic time. The contributing factors of exotic Cache Creek *vs.* less exotic Stikinia/Quesnellia fauna, significant subduction beneath these arcs, and the final enclosing geometry, led to the oroclinal entrapment model of Mihalynuk *et al.* (1994).

Throughout the northern Canadian Cordillera, the Cache Creek terrane is typically bounded by major structures that separate it from the adjacent assemblages. In northern British Columbia, the Cache Creek terrane is bound on the east by the Thibert-Kutcho strike-slip fault system (*e.g.*, Gabrielse, 1985, 1991; Evenchick *et al.*, 2005; Gabrielse *et al.*, 2006). The Teslin fault is interpreted to be the northern extension of the Thibert fault in southern Yukon (*e.g.*, Gabrielse *et al.*, 2006; White *et al.*, 2012); it separates the combined Quesnellia and Yukon-Tanana terranes from the Cache Creek terrane. In northern British Columbia, the western boundary of the Cache Creek terrane is the Nahlin fault, which juxtaposes Cache Creek over strata of Whitehorse trough (Gabrielse, 1991, 1998; Mihalynuk, 1999; Mihalynuk *et al.*, 2004; Evenchick *et al.*, 2005). Hart and Radloff (1990) have traced the Nahlin fault into southern Yukon as far north as Carcross where it is cut by a Late Cretaceous pluton and apparently offset by the northeast-trending Crag Lake fault. The nature of the western boundary of the Cache Creek terrane north of the Crag Lake fault is less clear; it has been inferred to be a southwest-verging thrust fault (Gordey and Makepeace, 2001; Colpron, 2011). In northern British Columbia and south-central Yukon, Quesnellia, Cache Creek, Stikinia and Whitehorse trough are imbricated by a series of southwest-verging folds and thrust faults that are dissected by northwest-striking strike-slip faults (Mihalynuk *et al.*, 2004; English and Johnston, 2005; Colpron, 2011; White *et al.*, 2012).

In Yukon, rocks of Stikinia include the Upper Triassic Lewes River Group, which consists of a lower volcanic sequence, the Povoas formation, conformably overlain by a sedimentary sequence, the Aksala formation (Fig. 2; Wheeler, 1961; Tempelman-Kluit, 1984, 2009; Hart, 1997). The Aksala formation comprises a mixed clastic-carbonate assemblage, divisible into three dominant facies: calcareous lithic sandstone (Casca member); locally thick carbonate (Hancock member); and maroon clastic rocks (Mandanna member; Fig. 2; Tempelman-Kluit, 1984, 2009; Long, 2005). The Lewes River Group is unconformably overlain by sandstone, shale, and conglomerate of the Lower to Middle Jurassic Laberge Group of the Whitehorse trough (Wheeler, 1961; Hart, 1997; Lowey *et al.*, 2009). The Whitehorse trough is interpreted as a record of deposition in a forearc setting which evolved into a synorogenic, intermontane piggy-back basin by Middle Jurassic (Mihalynuk *et al.*, 1994, 2004; White *et al.*, 2012). The influx of chert detritus in Middle Jurassic strata of the Laberge Group and in the overlying Middle Jurassic to Lower Cretaceous Tantalus Formation provides evidence for imbrication of the Cache Creek terrane with Stikinia and Whitehorse trough by early Bajocian (*ca.* 171-175 Ma; Mihalynuk *et al.*, 2004; Fig. 2).

The Cache Creek terrane has been extensively studied throughout British Columbia, particularly in northern British Columbia where river incisions of the central Cordilleran plateau have exposed thick sections of Cache Creek terrane rocks. The rock types recognized include tectonized and serpentinized harzburgitic mantle rocks, mafic intrusive and volcanic rocks, hemipelagic chert and shale, and limestone (*e.g.*, Mihalynuk, 1999; Mihalynuk *et al.*, 2003; English *et al.*, 2010; Fig. 2). The age of mantle harzburgite is relatively unconstrained aside from an Early Triassic U-Pb zircon age of 245.4 ± 0.8 Ma from an isolated peridotite body in the Teslin map area, east of the study area (Gordey *et al.*, 1998). In the Atlin area, intrusive rocks include pyroxene gabbro, hornblende diorite, and minor plagiogranite which occur both as lozenges in mélange and as undeformed bodies. The plagiogranite has been dated by U-Pb zircon at *ca.* 261.4 ± 0.3 Ma (Mihalynuk *et al.*, 2003), a Late Permian age which correlates with

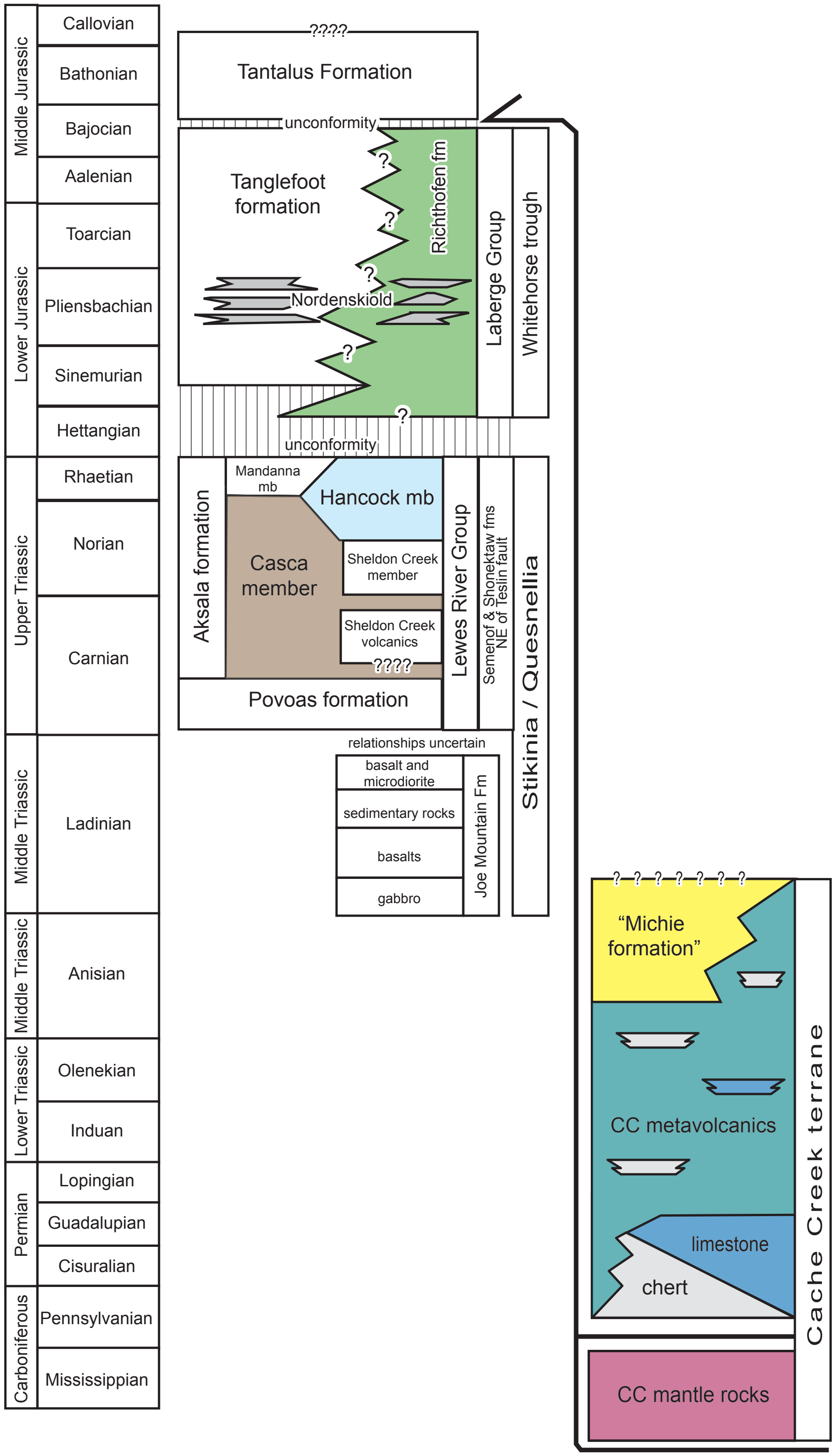

Figure 2. *Composite stratigraphic chart for the Cache Creek terrane, Stikinia, and Whitehorse trough in Yukon (modified after Hart, 1997; Lowey, 2004; White et al., 2012). Note the coloured units are those observed in the mapping area. It should also be noted that many of the stratigraphic units in use for Stikinia and Whitehorse trough are informal. Accordingly, unit terms are not capitalized for informal units here and in the text.*

a U-Pb zircon 263+1/-1.4 Ma age determination of a rhyodacite tuff deposited within the Cache Creek terrane in the French Range, Dease Lake area (Mihalynuk *et al.*, 1999). Mafic volcanic rocks belonging to the Nakina formation in British Columbia comprise fine-grained, massive black basaltic flows, and mint green basaltic tuff and flows (Mihalynuk, 1999). The Nakina formation is thought to have developed during the Late Mississippian to Permian, based on fossil collections from a section of limestone in the Nakina River area (Monger, 1975, 1977). Siliciclastic rocks included in the Cache Creek terrane are called the Kedahda Formation in British Columbia; this formation consists of chert, argillite and fine-grained wacke (*e.g.*, Mihalynuk, 1999) originally thought to range in age from Permian to Upper Triassic (Monger, 1975; Gabrielse, 1994), however, Lower Jurassic radiolarians were also collected from chert mapped as Kedahda Formation in northern British Columbia (Cordey *et al.*, 1991). Carbonate of the Cache Creek terrane is called the Horsefeed Formation in northern British Columbia and occurs as regionally extensive massive pale grey to tan limestone (*e.g.*, Mihalynuk, 1999). This formation hosts Tethyan fusulinid fauna of the family *Verbeekinidae* which range in age from Early Pennsylvanian to Late Permian (Monger, 1975). Southeast of the Nahlin fault, in the Dease Lake area, the King Salmon allochthon contains a sliver of Cache Creek terrane as a structural base, where it is spatially associated with Permo-Triassic bimodal volcanic and volcaniclastic rocks of the Kutcho Assemblage; these rocks are thought to represent a primitive oceanic arc sequence within the Cache Creek terrane and currently represent a partial basement to strata of the Whitehorse trough (Schiarizza, 2011).

The character of the Cache Creek terrane is well documented in British Columbia. Correlative lithologies in Yukon, however, have been less extensively studied. The purpose of this study is to improve our understanding of the Cache Creek terrane in Yukon through bedrock mapping of parts of the Michie Creek/Tagish/Squanga Lake area (Fig. 3).

GEOLOGY OF THE MICHIE CREEK/ TAGISH AREA

CACHE CREEK TERRANE

The Cache Creek terrane in the map area comprises mainly mafic to intermediate metavolcanic rocks with lesser chert and minor limestone throughout the stratigraphy, and extensive metavolcanic rocks grading into a newly recognized siliciclastic unit (informally the Michie formation; Fig 2). Also affiliated with the Cache Creek terrane are ultramafic rocks of variable character, which typically occur as faulted segments, and a mafic intrusive complex. Metamorphism in these rocks reaches predominantly greenschist facies, typically recognized within the extensively chloritized volcanic rocks.

METAVOLCANIC ROCKS

Metavolcanic rocks are the most widespread unit in the Cache Creek terrane in the study area. They are primarily found in the eastern and south-central part of the Michie Creek map area, as well as the eastern and north-central parts of the Tagish map area, near Jakes Corner (Fig. 3). Metavolcanic rocks in the area are mainly composed of plagioclase and clinopyroxene within a chloritic matrix. They locally show pillowed and hyaloclastic textures. The basaltic rocks are typically massive and extensively chloritic. These rocks range from dark grey, medium-grained to aphanitic basalt to light grey, fine-grained andesite. They are commonly thoroughly fractured and silicified, and locally contain amygdules filled with both calcite and silica. The flows exposed in the Marsh Lake and Judas Creek areas typically dip to the southeast. In the eastern part of the Michie Creek map area andesite and basalt are intercalated with green-grey volcaniclastic rocks containing a significant amount of sedimentary lithic clasts, particularly in proximity to the newly described Michie formation (see below).

Sedimentary rocks are locally intercalated with the volcanic rocks, becoming more common near the contact with the Michie formation. These include metre to decimetre-scale lenses of limestone and chert, as well as upwardly increasing amounts of volcaniclastic and siliciclastic rocks in the transition to the Michie formation (Fig. 2).

CHERT

Chert is one of the more distinctive lithologies of the Cache Creek terrane throughout the Cordillera, but is less extensive in the Yukon part of this terrane. Massive chert is locally exposed directly east of Marsh Lake in the north-central part of the Tagish map area and near Jakes Corner where it is intercalated with metavolcanic rocks (Fig. 3). Apart from the more massive occurrences, chert also appears as subordinate lenses within the metavolcanic rocks and as clasts in volcanic breccia of the Cache Creek terrane throughout the map area (Figs. 2 and 4a). Chert units also commonly crop out as ribbon-banded sections, grey-red-brown in colour, and are locally contorted by soft-sediment deformation (Fig. 4b). Chert beds are normally 5 to 10 cm thick with fine-grained argillite interbeds, but thinner bedding is seen in the ribbon-banded outcrops (2-5 cm).

LIMESTONE

In the study area, limestone occurs primarily as lenses within heavily to moderately chloritic basalt and only locally as thickly bedded, massive crystalline limestone to dolostone. Extensive exposures of thickly bedded white limestone, such as found southeast of the Crag Lake fault, do not occur in the study area.

MICHIE FORMATION (INFORMAL; NEW UNIT)

The Michie formation is a previously undocumented stratigraphic unit referring to clastic rocks which overlie mafic metavolcanic rocks in the eastern part of the map area, from east of Mount Michie, extending northwest to the area southwest of Fox Lake (Fig. 3). This formation is composed of a variety of lithologies: beige, coarse-grained sandstone to wacke; clast-supported pebble conglomerate; and dark grey siltstone; (Fig. 5a,b,c). Medium to coarse-grained sandstone to wacke of the Michie formation is typically in sharp contact with the siltstone (Fig. 5c). The sandstone is immature with sub-rounded to angular carbonate and volcanic-lithic clasts. Pebble conglomerate of the Michie formation is found east of Mount Michie, as well as southwest of Fox Lake (Fig. 3). The subrounded to angular clasts in the conglomerate include both mafic and felsic volcanic clasts, limestone, chert, and very fine-grained siltstone clasts (Fig. 5b). Locally, sequences of

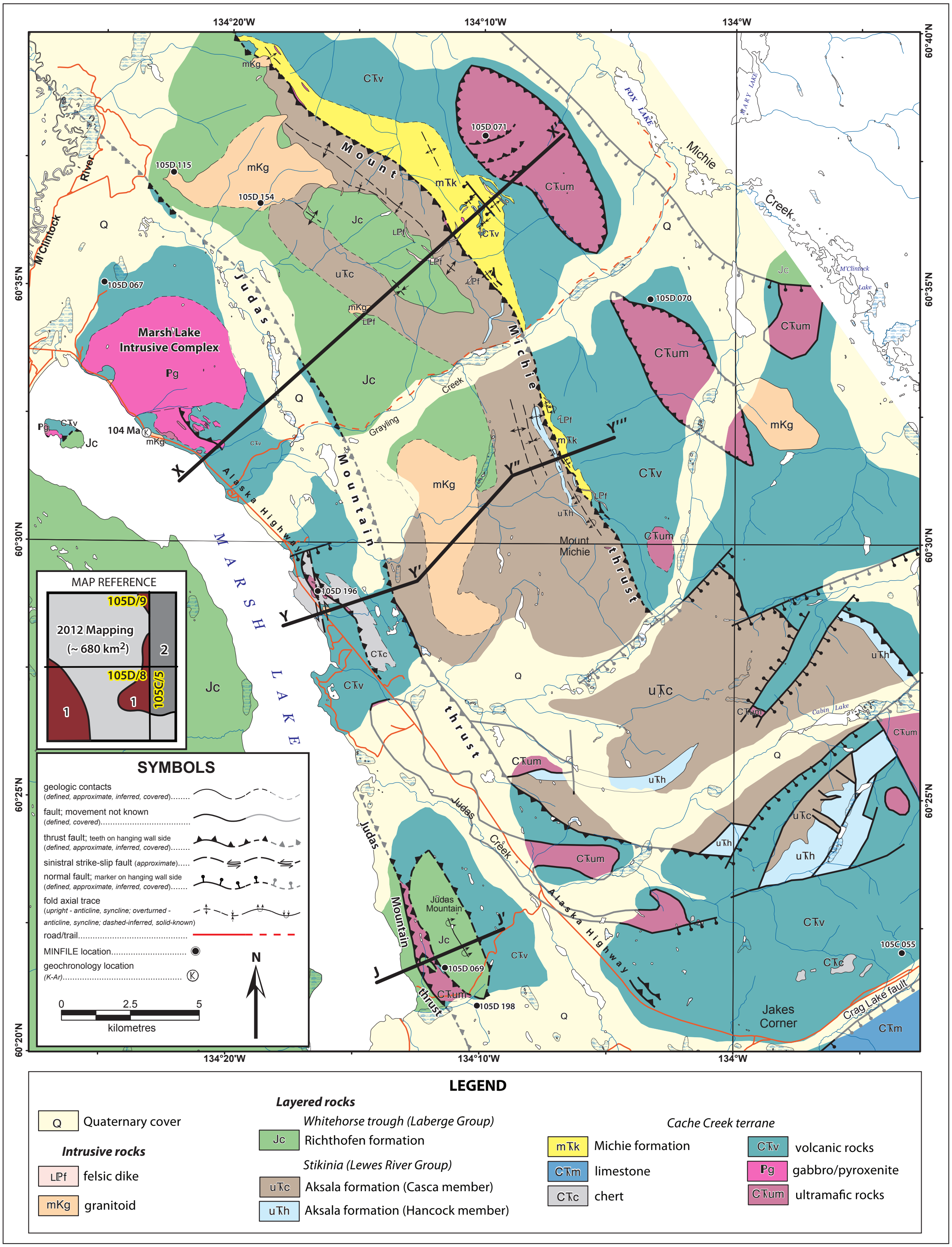

Figure 3. *Simplified bedrock geology map of the study area. Map reference inset shows parts of the map area compiled from 1) Wheeler (1961); and 2) Gordey and Stevens (1994); the author's detailed mapping of an area ~680 km², straddling the Michie Creek (105D/9), Tagish (105D/8), and Squanga Lake (105C/5) map areas is also indicated.*

conglomerate-sandstone-siltstone in conformable contact can be seen with minor normal grading in the sandstone-siltstone transition (Fig. 5c). Siltstone is commonly found coupled with sandstone beds but locally forms massive sections up to 250 m thick. The siltstone is carbonaceous, giving the bed surfaces an iridescent sheen, and is locally interbedded with buff-weathering limestone beds that are 10 to 15 cm in thickness. Southwest of Fox Lake (Fig. 3), a carbonate-rich debris flow unit occurs near an occurrence of limestone interbedded with siltstone. This unit locally includes a limestone olistolith approximately 60 m wide and 250 m long.

The Michie formation is apparently bound by the Mount Michie thrust to the west. The unit terminates to the northwest, east of the M'Clintock River, and to the southeast, near Mount Michie. Thickness estimations from cross sections indicate an apparent thickness of ~100 m where the unit is tapered east of Mount Michie, and a thickness of ~670 m in the area southwest of Fox Lake (Fig. 3).

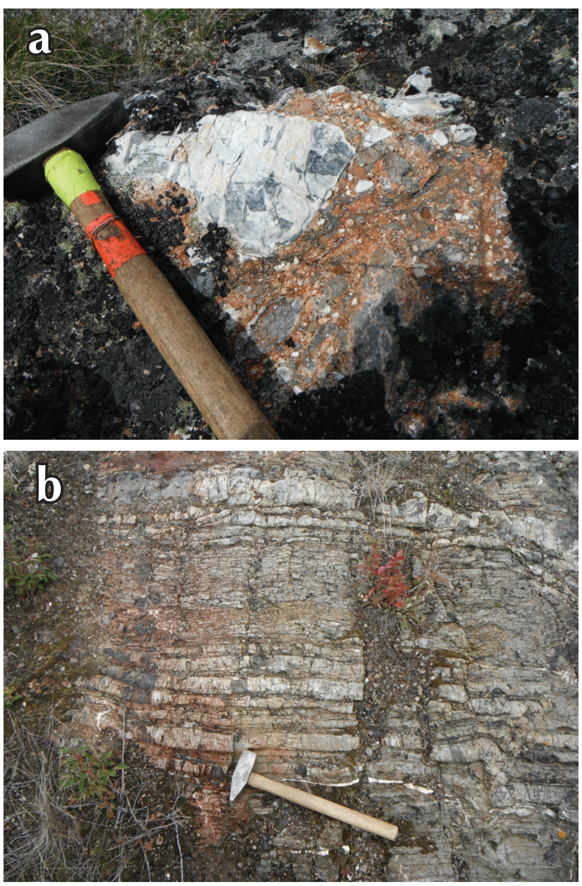

Figure 4. Outcrop photos of Cache Creek terrane rocks; a) chert clasts within a volcaniclastic matrix, east of Mount Michie; and b) ribbon-banded chert in the Marsh Lake area.

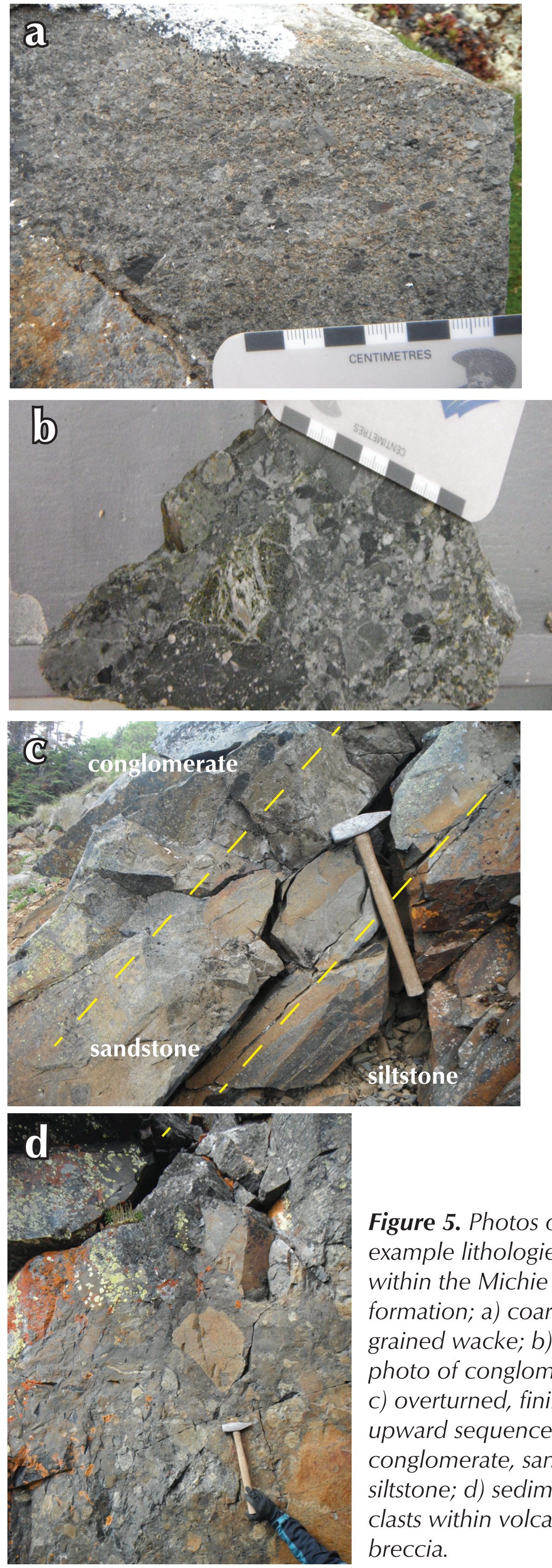

Figure 5. *Photos of example lithologies within the Michie formation; a) coarse-grained wacke; b) slab photo of conglomerate; c) overturned, fining-upward sequence of conglomerate, sandstone, siltstone; d) sedimentary clasts within volcanic breccia.*

ULTRAMAFIC ROCKS

Ultramafic rocks in the Cache Creek terrane are characterized by two main compositions. The ultramafic rocks exposed in the western part of the study area are typically pyroxenite, ranging to serpentinite when in faulted contact with volcanic rocks and chert, or with rocks of the Whitehorse trough in the Judas Mountain and Judas Creek area (Fig. 3). The ultramafic bodies in the eastern part of the map area have the composition of harzburgite to dunite and are typically larger exposures, the most extensive outcrop being ~14 km^2 found to the southwest of Fox Lake.

The typical western ultramafic rocks are exposed near fault contacts and are commonly altered to listwaenite (quartz-carbonate-fuschite). Serpentinite is also commonly found near these fault boundaries where it is locally brecciated (Fig. 6a). Pyroxenite in the western part of the map area is typically non-magnetic, medium grained and dominantly composed of clinopyroxene. These rocks show extensive chlorite and epidote alteration.

The large harzburgite-dunite bodies in the eastern part of the Michie Creek map area are coarse grained and contain abundant magnetite. Locally, harzburgite shows a subtle cumulate texture of olivine with interstitial orthopyroxene; elsewhere, these rocks are sections of rounded blocks in a sheared matrix of heavily altered ultramafic. Veins of antigorite and serpentinite occur throughout theses bodies and also in some areas that are intruded by pegmatite. Typically, olivine crystals are completely replaced by serpentine. The large ultramafic bodies are in fault contact with volcanic rocks of the Cache Creek terrane, but listwaenite alteration is not a prominent feature near these contacts.

MARSH LAKE INTRUSIVE COMPLEX

A gabbroic complex crops out extensively in the south-central part of the Michie Creek map area, near the north end of Marsh Lake. The complex lies between the M'Clintock River and Grayling Creek (Fig. 3), and intrudes exclusively mafic metavolcanic rocks of the Cache Creek terrane. These rocks have extensive chlorite alteration and, locally, are intensely foliated.

Compositions range from hornblende diorite to gabbro to pyroxenite (Fig. 6b). The diorite phases range from microdiorite to hornblende-porphyritic intrusive rocks. Olivine-porphyritic diabase crosscuts the diorite/gabbro throughout the intrusive complex. Plagioclase, clinopyroxene and less commonly olivine-bearing gabbroic intrusive rocks locally grade to clinopyroxene-dominant pyroxenite. The pyroxenite phases are similar in character to the larger bodies of pyroxenite elsewhere in the Cache Creek terrane.

STIKINIA

Only the upper part of Stikinia is exposed in the Michie Creek/Tagish map area comprising two members of the Aksala formation of the Lewes River Group, the Casca and Hancock members (Fig. 2), both of which only reach sub-greenschist facies. Stikinia rocks dominantly crop out along the ridge extending northwest from Mount Michie to east

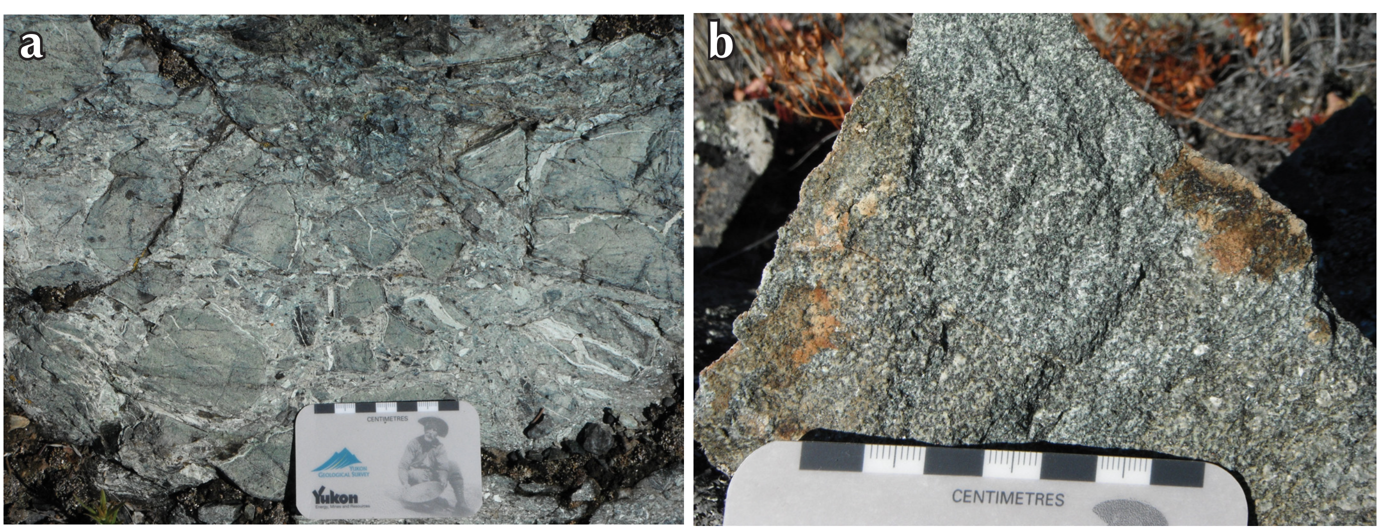

Figure 6. *Outcrop photos of Cache Creek terrane rocks; a) brecciated serpentinite found near Judas Mountain; and b) pyroxene gabbro of the Marsh Lake intrusive complex.*

of the M'Clintock River in the northern part of the Michie Creek map area (Fig. 3). The Aksala formation is ~1000 m thick at its thickest exposure; however, the complete stratigraphic thickness is unknown in the area.

CASCA MEMBER

The Casca member is composed of clastic sedimentary strata varying from coarse-grained, black-grey sandstone to fine-grained, thinly laminated, dark grey argillaceous siltstone. Siltstone units occur as thick, monotonous sections with grey and tan-coloured, very fine-grained sandstone interlaminations. The siltstone beds are commonly graded (Fig. 7a) and contain scour marks, flame structures, rip-up clasts, and locally, trace fossils (Fig. 7b); all indicate that the section is upright. The medium to coarse-grained quartz sandstone of the Casca member has relatively immature grains which are angular to subangular and dominantly poorly sorted. The sandstone is commonly calcareous and occurs as 10 to 20 cm-thick beds among the more dominant argillaceous siltstone.

HANCOCK MEMBER

Carbonate rocks of the Hancock member of the Aksala formation are dominantly found north of Jakes Corner (Fig. 3) as massive, crystalline, locally fossiliferous limestone. These rocks were recognized through the mapping of Gordey and Stevens (1994). Carbonate rocks similar to the Hancock member also appear as locally contiguous, coarsely crystalline limestone to limestone breccia interlayered with siliciclastic rocks at different stratigraphic levels within the Casca member. Limestone clasts within the brecciated sections of the carbonate vary in size from 5 mm to 20 cm and are dominantly subrounded to subangular.

WHITEHORSE TROUGH

Whitehorse trough, in the map area, is represented by the Richthofen formation of the regionally extensive Laberge Group. These rocks are dominantly sub-greenschist facies, and have similar characteristics to the siliciclastic rocks of the Casca member of Stikinia.

RICHTHOFEN FORMATION

The Richthofen formation in the map area comprises dominantly black siltstone and less common greenish-grey sandstone and thick matrix-supported polymictic conglomerate (Fig. 8a,b). The conglomerate within this formation locally reaches an apparent thickness of ~250 m. Rocks typical of the Richthofen formation are found on the Marsh Lake shoreline, to the west of Judas Mountain, and trending parallel to the Mount Michie ridgeline in the north-central part of the area (Fig. 3). The medium to coarse-grained sandstone typically forms beds 5 to 15 cm thick and is coupled with fine-grained green-brown mudstone. Sandstone composition varies from quartz-dominant to micaceous with a strong volcanic-lithic

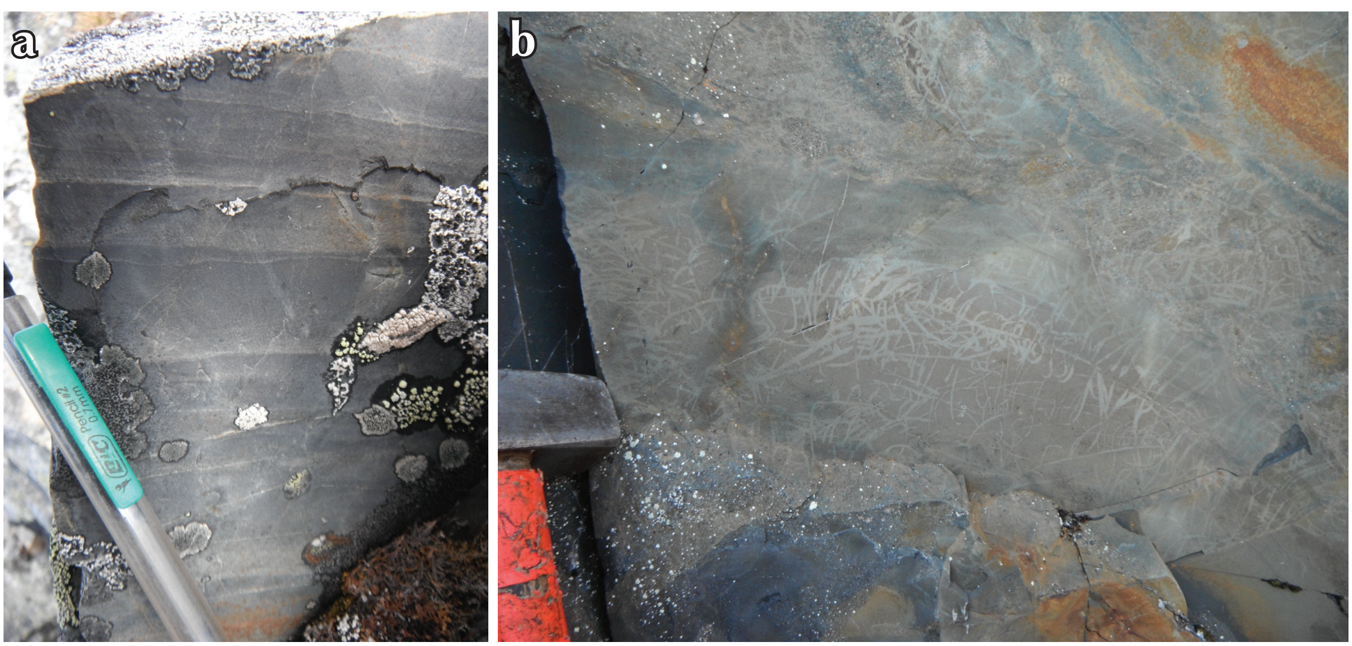

Figure 7. *Layered rocks of Stikinia; a) graded siltstone of the Casca member in the Aksala formation; and b) trace fossils (Chondrites) found within the Casca member of the Aksala formation.*

component. The black siltstone locally forms monotonous strata up to an estimated 1200 m in thickness, locally showing partial Bouma sequences, ranging from C-D to A-D (Fig. 8b). The Richthofen conglomerate is matrix-supported (Fig. 8a) and characterized by polymictic clasts, including grey, very fine-grained siltstone clasts, limestone, felsic plutonic, and less commonly, felsic volcanic clasts which vary from pebble to boulder-sized. The conglomerate rarely crops out as sections thicker than 200-250 m.

POST-ACCRETIONARY INTRUSIVE ROCKS

GRANITOIDS

A number of post-accretionary intrusive rocks outcrop throughout the area and range in composition from granodiorite to quartz monzonite to syenite. These rocks are thought to be mid-Cretaceous in age based on a single K-Ar date of 104 ± 4 Ma (Hart, 1995) from a coarse-grained diorite stock cropping out near the eastern shore of Marsh Lake in the Michie Creek map area (Fig. 3). They are considered part of the Whitehorse plutonic suite (Gordey and Makepeace, 2001; Colpron, 2011).

The igneous body, ranging in composition from granodiorite to quartz monzonite, dominantly contains coarse-grained, equigranular alkali-feldspar and plagioclase, as well as minor quartz and biotite. The body is approximately 6 km wide, east to west, and 3.5 km long, north to south, and occurs in the northern part of the map area. It intrudes both Casca member and Laberge Group (Fig. 3). A small quartz monzonite pluton, located approximately 2 km north of the main granodiorite body, cuts the Mount Michie thrust which juxtaposes the Michie formation and sedimentary rocks of Stikinia and Whitehorse trough (Fig. 2).

A syenite intrusion of intermediate composition ranges from coarse-grained to pegmatitic, is alkali-feldspar dominant, and contains small (5 to 10 mm) books of coarse-grained biotite and muscovite that appear relatively unaltered by chlorite. The body occurs north of the Judas Creek area straddling the Michie Creek and Tagish map areas; it extends approximately 6.5 km north to south, and 1.5 km east to west. The pluton is poorly exposed and its contact is rarely exposed, but it does appear to only be in contact with sedimentary strata of the Laberge Group and the Casca member (Fig. 3); minor hornfels is observed at the contact.

RHYODACITE

Rhyodacitic dikes and plugs occur throughout the map area intruding all map units, making it the youngest unit observed in the map area. The rocks are typically medium to coarse-grained, spherulitic, quartz and feldspar-phyric rhyolite to dacite. The dikes show a well-developed flow-banded texture near their margins and typically have a massive texture and spherulitic feldspar closer to the cores.

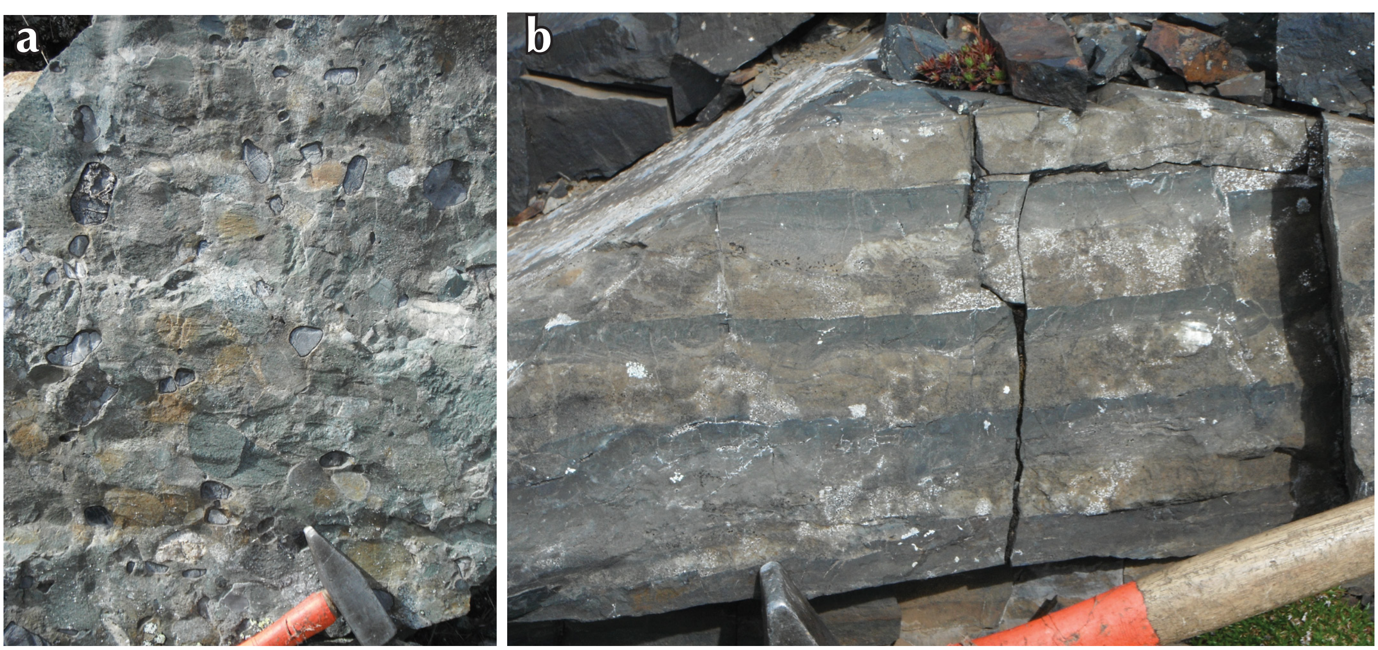

Figure 8. *Layered rocks of the Whitehorse trough; a) polymictic paraconglomerate of the Laberge Group; and b) fining-upwards bedding of sandstone and siltstone in the Laberge Group.*

These intrusive rocks occur as ring dikes, most commonly proximal to the peaks southwest of Fox Lake (Fig. 3). They are similar in character to those recognized in the Atsutla Range of northern British Columbia (Watson and Mathews, 1944; Mathews and Watson, 1953). Regionally, felsic to intermediate intrusive and volcanic rocks, which resemble those seen in the map area, include the early Tertiary Sifton Range volcanic rocks (*e.g.*, Miskovic and Francis, 2004), the Mount Skukum intrusive rocks (*e.g.,* Love *et al.*, 1998) and Eocene Sloko Group volcanic rocks (Souther, 1991; Mihalynuk, 1999) found in northwestern British Columbia and southern Yukon, west of the map area.

STRUCTURE

Due to poor to moderate exposures and the paucity of continuous outcrop, the main structural features in the area are inferred primarily through cleavage-bedding relationships and changes in foliation intensity at isolated outcrops. Offsets of lithology and the local presence of cataclasite and/or listwaenite are also used to determine the structural history of the area. The structural style of the Michie Creek and Tagish map areas is dominated by northwest-trending folds and north-northwest striking thrust faults (Fig. 3). In the southeast part of the map, north of Jakes Corner, Gordey and Stevens (1994) mapped a number of northeast-striking normal faults that delineate the contact between Stikinia/Whitehorse trough rocks to the north and Cache Creek terrane rocks to the south. These structures are similar in style and character to the Crag Lake fault mapped by Hart and Radloff (1990) southwest of the study area.

Two major thrust faults have been identified in the map area: 1) the Judas Mountain thrust, a north-northwest striking, steeply dipping thrust fault juxtaposing rocks of the Cache Creek terrane above sedimentary strata of the Whitehorse trough (Laberge Group), a structure almost entirely concealed at its leading edge by Marsh Lake; and 2) the Mount Michie thrust, a north-northwest striking, steeply west-dipping thrust fault which brings rocks of the Whitehorse trough (Laberge Group) and underlying Lewes River Group (Casca member) above the Cache Creek terrane in the centre of the map area (Fig. 9).

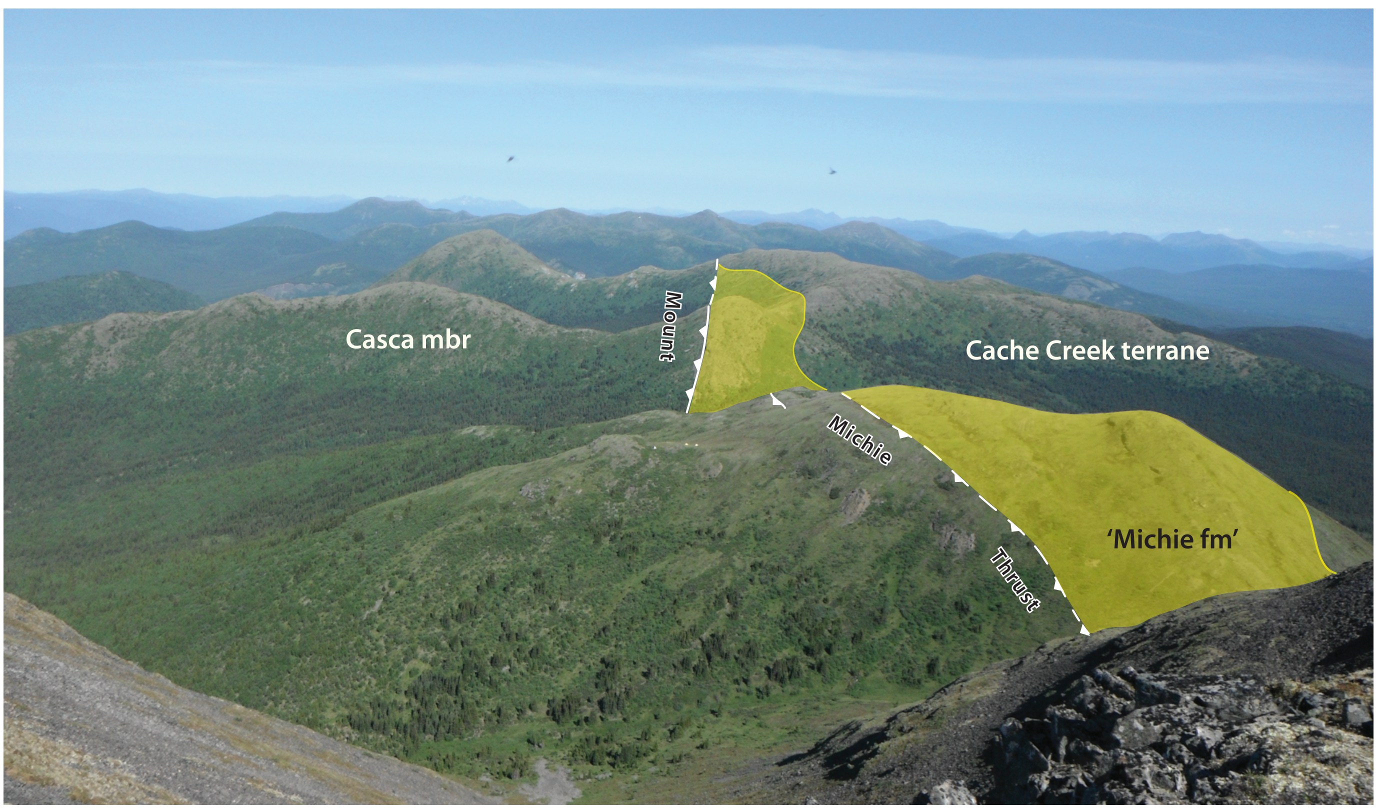

Figure 9. *View to north from Mount Michie; Cache Creek volcanic and ultramafic rocks on right (east), adjacent to exposures of Michie formation shaded in yellow; to the west are rocks of the Casca member (Aksala formation) found within the immediate hanging wall of the Mount Michie thrust, highlighted in white (teeth on hanging wall side).*

The Judas Mountain thrust marks the western structural boundary between the Cache Creek terrane and younger sedimentary strata. The thrust is exposed in the Judas Mountain area where rocks of the Whitehorse trough in the footwall show tight, overturned, southwest-verging folds. In the immediate hanging wall at this location, mafic and ultramafic rocks of the Cache Creek terrane are characterized by foliated listwaenite (e.g., Fig. 10a), serpentinite, and extensive hydrothermal veining. At Judas Mountain, directly east from the leading edge of the Judas Mountain thrust, rocks of the Laberge Group (Richthofen formation) are flanked by intensely foliated ultramafic rocks to the west and metavolcanic rocks of the Cache Creek terrane to the east (Fig. 3). This relationship is interpreted as a fenster of Laberge Group exposed in the footwall of the Judas Mountain thrust. We interpret that the fenster of Laberge Group was exposed through folding and erosion of the thrust contact (Fig. 11). This interpretation is based on the map pattern and structural observations such as steeply dipping foliation and extensive alteration of these rocks in the Judas Mountain area. A fault surface with similar characteristics as the Judas Mountain thrust is recognized to the east-northeast of the Alaska Highway as a northwest striking, steeply dipping structure juxtaposing Cache Creek terrane rocks to the west and sedimentary strata of Stikinia and Whitehorse trough to the east. This surface has little exposure, but is interpreted to be an eastern occurrence of the folded Judas Mountain thrust (Fig. 3). Folding of the Judas Mountain thrust is interpreted to result from a second phase of compression which led to the development of the Mount Michie thrust.

The Mount Michie thrust (Figs. 3 and 9) is characterized by intense foliation development (e.g., Fig. 10a), tight to isoclinal, northeast-verging folds in the immediate hanging wall (Fig. 10b), and the local occurrence of listwaenite and hydrothermally brecciated rocks in the immediate footwall of the boundary between the Cache Creek terrane to the east and Casca member rocks to the west (Fig. 10c). Open folds of sedimentary strata of the Casca member and Laberge Group that are typical in the central part of the

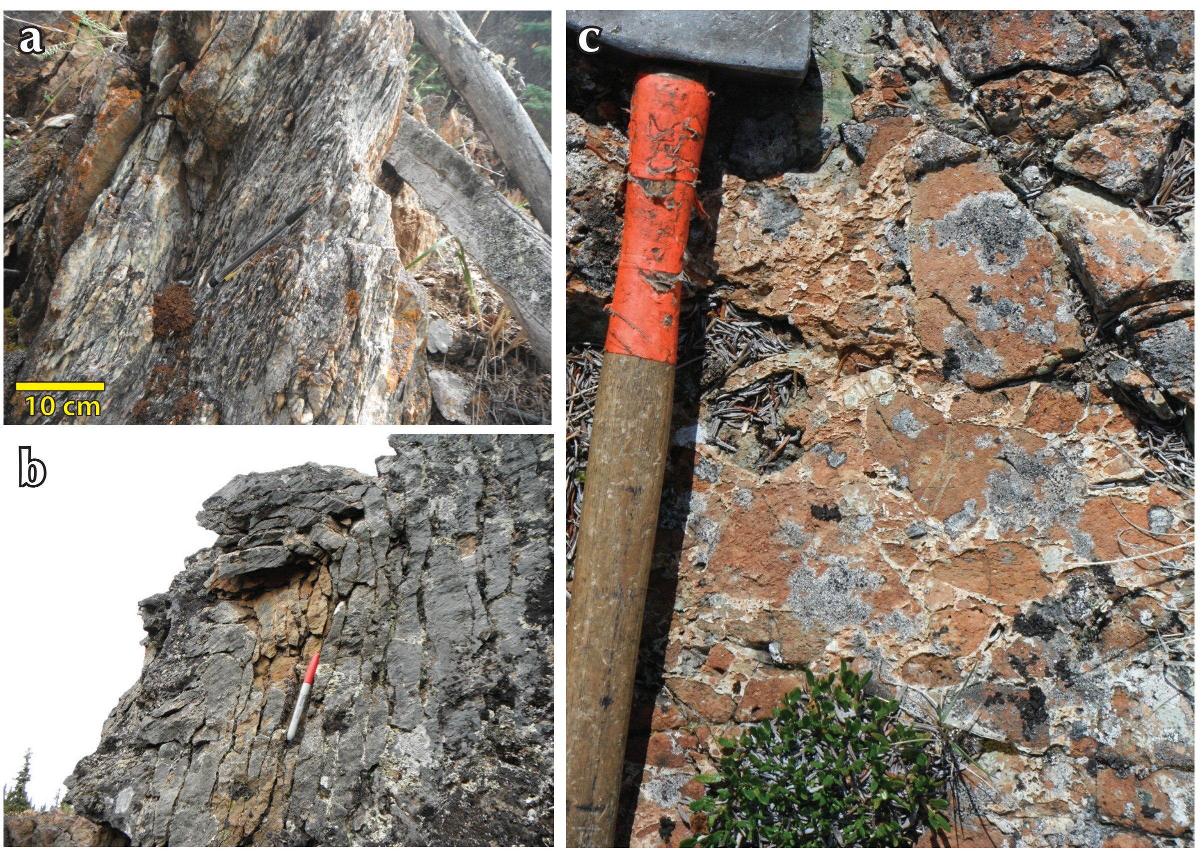

Figure 10. *Outcrop photos of structural features in the field; a) strongly foliated listwaenite of the Cache Creek terrane near a fault contact on Judas Mountain; b) tight northeast-verging chert and argillite of the Cache Creek terrane, Judas Creek area; and c) hydrothermally brecciated volcanic and volcaniclastic rocks of the Cache Creek terrane adjacent to the Mount Michie thrust.*

map area become progressively tight and overturned to the northeast near the Mount Michie thrust (Fig. 11). The hinge lines for these folds typically have a trend paralleling the strike of the Mount Michie thrust.

In summary, the structural evolution of the Michie Creek/Tagish area first involves a phase of southwest-verging folds and thrusts which emplaced rocks of the Cache Creek terrane over Stikinia and Whitehorse trough. This phase is represented by the Judas Mountain thrust, marking the westernmost extent of the Cache Creek terrane in the map area, and a probable northern equivalent of the Nahlin fault recognized in northern British Columbia and southern Yukon (Hart and Radloff, 1990; Mihalynuk, 1999). This phase may also correlate to the thrust faults which juxtapose the harzburgite/dunite bodies structurally above volcanic rocks within the Cache Creek terrane (Figs. 2 and 3). These bodies are interpreted as panels of ultramafic rocks which are thrust from deeper levels of the Cache Creek oceanic crust into contact with the relatively shallow level volcanic rocks.

The Mount Michie thrust is interpreted to be part of a 2nd compressional phase which brought rocks that were formerly in the footwall of the 1st phase Judas Mountain thrust (Stikinia and Whitehorse trough) over its hanging wall rocks (Cache Creek terrane). The second phase of compression also resulted in northeast-verging folds, including the folding of the Judas Mountain thrust, exposing a fenster of Laberge Group rocks (Figs. 3 and 11). A series of late, northeast-striking normal faults locally disrupts this sequence.

MINERAL OCCURRENCES

Three distinct styles of mineralization have been documented in the Michie Creek and parts of Tagish map area. Polymetallic Au-Cu-Ag veins and alteration zones occur in faulted, brecciated, and silicified metavolcanic rocks of the Cache Creek terrane (Yukon MINFILE 105C 055; 105D 067). This type of mineralization has the greatest potential near faults where ultramafic rocks become completely altered (*e.g.*, listwaenite-associated Au-Cu-Ag; Yukon MINFILE 105D 069; 105D 196; 105D 198). Similar to quartz-carbonate lode gold occurrences in northern British Columbia (Ash and Arksey, 1990), polymetallic Au-Cu-Ag veins are found in the southern and the northeastern parts of the map area, trending northwest along the strike of the Mount Michie thrust, where rocks of the Cache Creek terrane are in contact with Stikinia and Whitehorse trough (*e.g.,* Fig. 10a).

Mineralization spatially associated with the Cretaceous granodiorite pluton occurs at two locations in the northern part of the map area (Fig. 3). At one of these localities, lenses of galena with zones of disseminated pyrite and sphalerite are reported (Yukon MINFILE 105D 115). The other occurrence consists of visible gold-bearing veins (Yukon MINFILE 105D 154).

The third type of mineralization recognized in the region consists of base metals in large ultramafic bodies found in the eastern part of the map area. These bodies contain known occurrences of chromite (Yukon MINFILE 105D 070; 105D 071) and the mineralogy and locally unaltered character of the massive ultramafic rocks are prospective

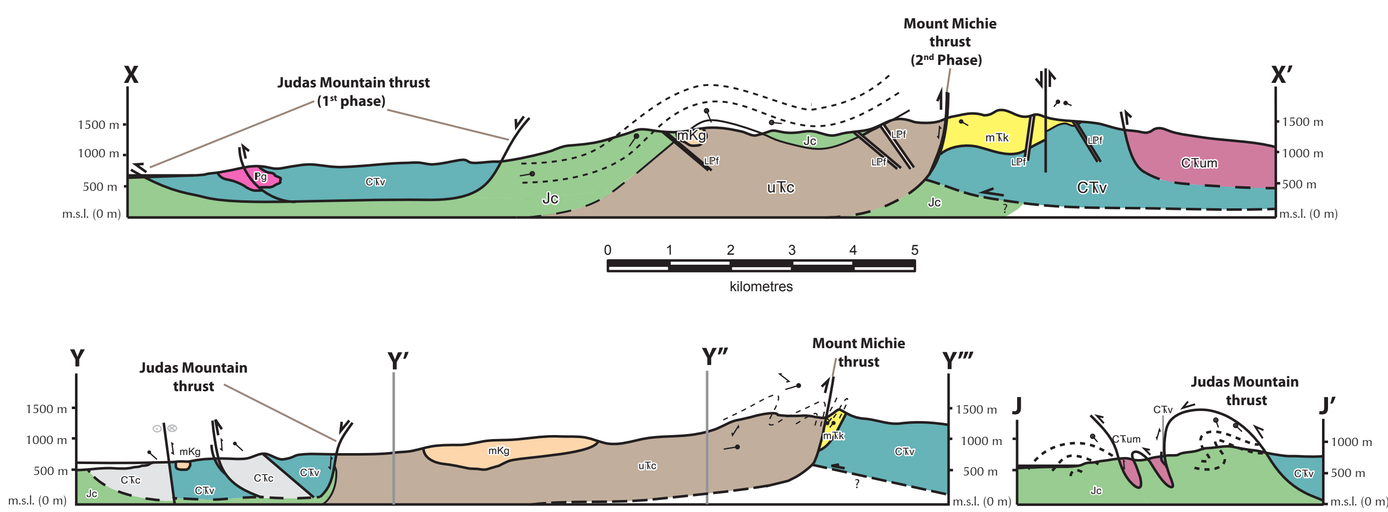

__Figure 11.__ Cross sections for section lines shown in Figure 3; the same legend applies in this figure as in Figure 3; no vertical exaggeration.

for nickel-iron alloys (awaruite) and platinum group elements; to date, nearby stream sediment geochemistry has indicated no trace of platinum (Yukon MINFILE 105D 070).

DISCUSSION

Detailed mapping in the Michie Creek and parts of Tagish map area refines and partially redefines the known bedrock geology. One significant new contribution from our mapping is the identification of a previously unrecognized siliciclastic unit, informally defined as the Michie formation, which is stratigraphically intercalated with volcanic and volcaniclastic rocks of the Cache Creek terrane. The Michie formation is a prominent unit within the footwall of the Mount Michie thrust. Preliminary detrital zircon work from this study (not presented here) has so far returned a uniform Early to Middle Triassic age suggesting a source similar to the Kutcho assemblage of northern British Columbia which contains latest Permian-earliest Triassic igneous rocks (Childe and Thompson, 1997; Schiarizza, 2011).

Secondly, we have documented a previously unrecognized mafic igneous intrusive complex emplaced into the Cache Creek terrane at the northern end of Marsh Lake (Fig. 3). The range in composition of this complex, from pyroxenite to diorite with crosscutting diabase, suggests it may have been derived from partial melting of a mantle source, leaving residual rocks with a composition similar to the other ultramafic rocks described in the field area. The harzburgite-dunite ultramafic rocks are inferred to represent the deeper levels of a Cache Creek terrane oceanic assemblage, whereas the igneous complex most likely represents intrusion into the shallow level volcanic rocks, but both may be derived from a similar magma source. Igneous complexes of this character are unusual in the Cache Creek terrane, but one similar occurrence is that of the gabbro-clinopyroxenite Rubyrock igneous complex in central British Columbia, which is interpreted to be part of an ophiolite suite that is upper Paleozoic to Triassic in age (Struik *et al.*, 1998, 2001; MacIntyre and Schiarizza, 1999).

Thirdly, our data suggest a new structural geometry and evolution that differs somewhat from what has been interpreted in northern British Columbia. We have documented two phases of thrust faulting with different kinematics. The first phase of major faulting is interpreted to have thrust rocks of the Cache Creek terrane southwestward over rocks of the Whitehorse trough. The leading thrust of this phase of faulting, the Judas Mountain thrust, has most of its trace covered by Marsh Lake, but is exposed directly west of Judas Mountain in the southern part of the map area and can be recognized on the island at the northern end of Marsh Lake (Fig. 3). A subsequent phase of compression folded the aforementioned thrust contact so that it appears as multiply repeating, steeply-dipping fault contacts (Fig. 11). The main structure associated with this second phase of deformation is the north-northwest-striking, east-verging Mount Michie thrust fault, which places rocks of the Whitehorse trough and Stikinia above those of the Cache Creek terrane (Figs. 9 and 11).

Regionally, the 1st phase Judas Mountain thrust is correlated to the Nahlin fault of northern British Columbia and southernmost Yukon (Hart and Radloff, 1990; Gabrielse, 1991, 1998; Mihalynuk, 1999; Mihalynuk *et al.*, 2004; Evenchick *et al.*, 2005). Faults of similar trend and vergence are also found throughout the Whitehorse trough north of the map area, including the Coghlan, Chain, and Hoochekoo faults (Colpron, 2011; White *et al.*, 2012). Structural features similar in character to the 2nd phase Mount Michie thrust are recorded in the Bowser Basin to the south where rocks which are similar to those of the Whitehorse trough (English and Johnston, 2005) were folded and thrust eastward as early as Oxfordian to Albian time (Skeena fold belt; Evenchick, 1991). The Mount Michie thrust, therefore, most likely developed following the accretionary emplacement of the Cache Creek terrane above strata of Stikinia and the Whitehorse trough, and possibly correlates to the structural features of the Skeena fold belt.

The newly described Michie formation, along with the reinterpreted structural history and presence of a mafic intrusive complex indicate that the northern termination of the Cache Creek terrane in south-central Yukon is more complex than what has been described in previous mapping (e.g., Wheeler, 1961). Future work will attempt to reconcile these complexities within the tectonic framework of the northern Cordillera, and examine the implications they have on previous tectonic models and regional mineral potential.

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