Geology and Mineral Occurrences of the Murphy Lake Area, South-Central British Columbia (NTS 093A/03)

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KEYWORDS: Quesnel terrane, Nicola Group, Takomkane batholith, Spout Lake pluton, Kamloops Group, Chilcotin Group, copper, molybdenum, gold

INTRODUCTION

The Takomkane Project is a multiyear bedrock mapping program initiated by the British Columbia Geological Survey in 2005. This program is focused on Mesozoic arc volcanic and plutonic rocks of the Quesnel terrane in the vicinity of the Takomkane batholith, which crops out in the northern Bonaparte Lake (NTS 092P) and southern Quesnel Lake (NTS 093A) map areas. Mapping during the 2005 through 2007 field seasons covered the Canim Lake, Hendrix Lake and Timothy Lake map areas, and is summarized by Schiarizza and Boulton (2006a, b), Schiarizza and Macauley (2007a, b), Schiarizza and Bligh (2008) and Schiarizza et al. (2008). Here, we present preliminary results from the fourth and final year of mapping for the Takomkane Project, which was carried out by a four-person crew from mid-June to the end of August 2008. This work covers 950 km^2 of generally subdued topography encompassing parts of the Fraser Plateau and Quesnel Highland physiographic provinces, including NTS map area 093A/03 and a small part of adjoining area 093A/06 (Figure 1). This area is within the traditional territories of the Northern Secwepemc te Qelmucw and Esketemc First Nations. Access to most parts of the map area is easily achieved via extensive networks of logging and forest service roads that connect to Highway 97 at 100 Mile House, Lac La Hache and 150 Mile House.

The Takomkane Project builds on the geological framework established by the reconnaissance-scale mapping of Campbell and Tipper (1971) and Campbell (1978), the metallogenic studies of Fox (1975) and Barr et al. (1976), and, more recently, relatively detailed mapping programs by Panteleyev et al. (1996), Schiarizza and Israel (2001) and Schiarizza et al. (2002a–c). Our geological interpretation of the Murphy Lake area also incorporates data found in assessment reports available through the BC Geological Survey's Assessment Report Indexing System (ARIS), and airborne magnetic and radiometric data from a number of recent surveys funded by the Geological Survey of Canada, Geoscience BC and various industry partners (Carson et al., 2006a, b; Dumont et al., 2007).

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REGIONAL GEOLOGICAL SETTING

The Takomkane Project area is underlain mainly by rocks of the Quesnel terrane, which is characterized by a Late Triassic to Early Jurassic magmatic arc complex but also includes late Paleozoic arc sequences and, in southernmost BC, late Paleozoic rocks of more oceanic aspect (Monger et al., 1991). The Quesnel terrane occurs along most of the length of the Canadian Cordillera. It is flanked to the east by assemblages of Proterozoic to Paleozoic siliciclastic, carbonate and local volcanic rocks of ancestral North American affinity, but is commonly separated from these rocks by an intervening assemblage of late Paleozoic oceanic basalt and chert assigned to the Slide Mountain terrane. The Cache Creek terrane, dominated by late Paleozoic and early Mesozoic oceanic basalt, chert and limestone, occurs to the west of the Quesnel terrane and is generally interpreted as part of the accretion-subduction complex that was responsible for generating the Quesnel magmatic arc (Travers, 1978; Struik et al., 2001). Although some tectonic models depict the Quesnel terrane as part of an allochthonous crustal fragment that was accreted to the North American continental margin in Early Jurassic time (e.g., Monger et al., 1982), numerous studies have demonstrated older stratigraphic, provenance and geochemical linkages between North American rocks and those of the Slide Mountain and Quesnel terranes (Campbell, 1971; Klepacki and Wheeler, 1985; Schiarizza, 1989; McMullin et al., 1990; Roback and Walker, 1995; Ferri, 1997; Erdmer et al., 2001; Unterschutz et al., 2002; Thompson et al., 2006). One set of tectonic models formulated to explain these linkages, as well as evidence for regional Permo–Triassic deformation, has the Late Paleozoic arc of the Quesnel terrane forming on a crustal fragment that separated from ancestral North America during back-arc extension that produced the Slide Mountain marginal ocean basin. This fragment then returned to proximity with the continental margin during Permo–Triassic collapse of the Slide Mountain basin, prior to formation of the Mesozoic arc that characterizes the Quesnel terrane (Smith, 1979; Schiarizza, 1989; Roback and Walker, 1995; Ferri, 1997; Dostal et al., 2001). Thompson et al. (2006) suggested that, in parts of southern BC, there was little or no separation of this western crustal fragment from the continental margin, and that both the late Paleozoic and Mesozoic arc sequences of the Quesnel terrane are therefore autochthonous and were deposited above North American continental crust.

In southern and central BC, the early Mesozoic arc of the Quesnel terrane is represented mainly by Middle to Upper Triassic volcanic and sedimentary rocks of the Nicola Group, together with abundant Late Triassic to Early Jurassic calcalkaline and alkaline intrusions (Schau, 1970; Preto, 1977, 1979; Mortimer, 1987; Panteleyev et al.,

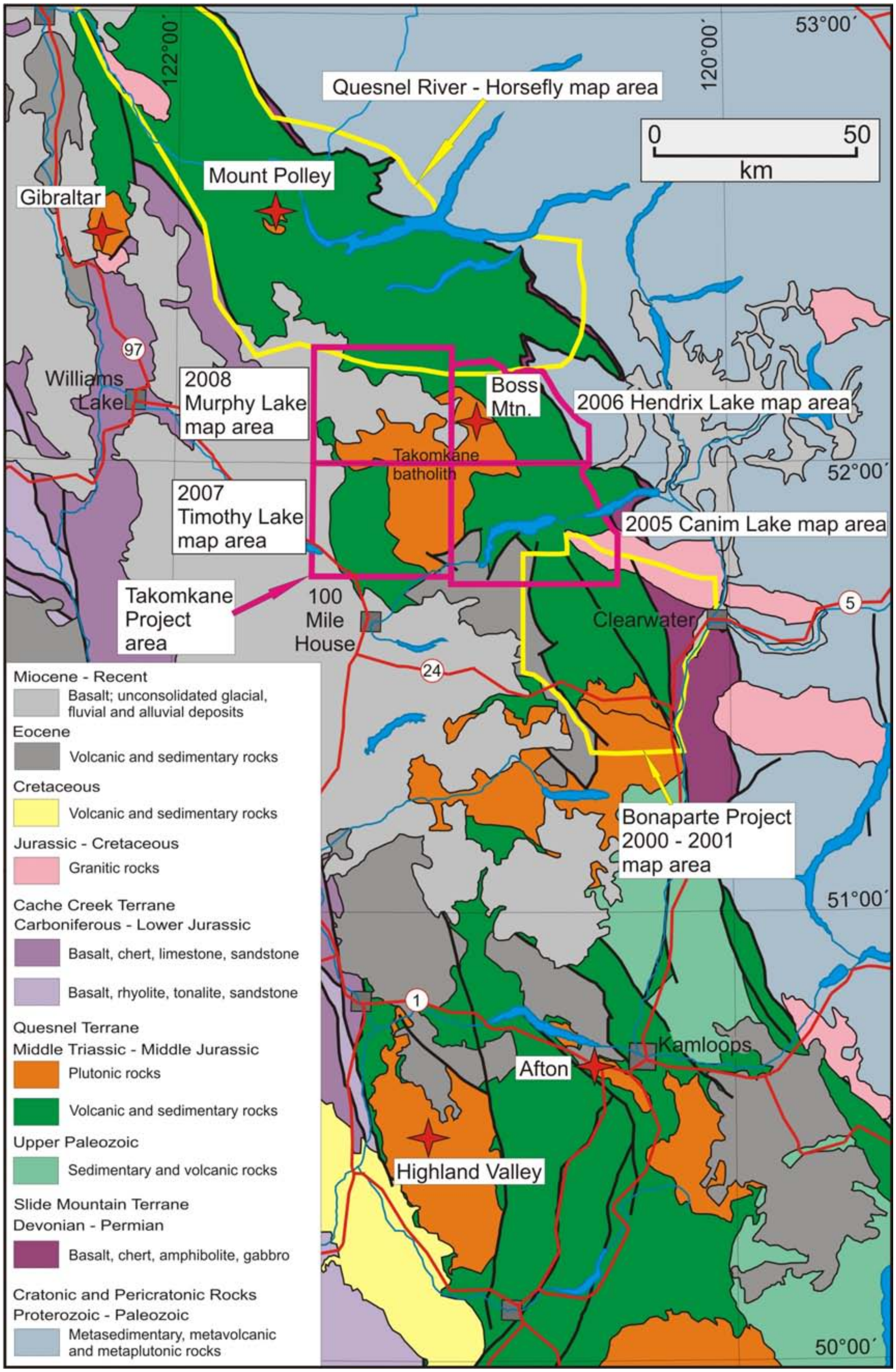

Figure 1. Regional geological setting of the Takomkane Project area, showing the areas mapped in 2005, 2006, 2007 and 2008, as well as the area mapped during the 2000–2001 Bonaparte Project, and the Quesnel River–Horsefly map area of Panteleyev et al. (1996). Stars denote locations of selected major mineral deposits.

1996). The Nicola Group is characterized by volcanic and volcanic-derived sedimentary rocks but also includes an eastern sedimentary facies of dark grey siltstone and slate intercalated with quartzite and quartz sandstone (Bloodgood, 1990; Schiarizza et al., 2002a). The volcanic rocks consist mainly of augite-phyric basalt and andesite that belong to a high-potassium to shoshonitic rock series, but low-potassium calcalkaline volcanic rocks form a distinctive western belt in southern BC (Preto, 1977; Mortimer, 1987). Lower to Middle Jurassic sandstone and conglomerate rest unconformably above the Triassic successions at scattered localities within the belt (Travers, 1978; Monger and McMillan, 1989; Schiarizza et al., 2002a; Logan and Mihalynuk, 2005a), and an assemblage of Lower Jurassic shoshonitic to calcalkaline arc volcanic rocks, assigned to the Rossland Group, is a prominent component of the southeastern part of the terrane (Höy and Dunne, 1997). These Lower Jurassic volcanic rocks occur well east of the axis of Triassic arc magmatism, but rest above Triassic sedimentary rocks that are correlated with the eastern sedimentary facies of the Nicola Group.

The structural geology of the Quesnel terrane includes generally poorly understood faults that exerted controls on Late Triassic volcanic-sedimentary facies distributions and the localization of plutons and associated mineralization and alteration systems (Preto, 1977, 1979; Nelson and Bellefontaine, 1996; Logan and Mihalynuk, 2005b; Schiarizza and Tan, 2005). In central and southern BC, east-directed thrust faults and associated folds, of Permo–Triassic and/or Early Jurassic age, are documented within the eastern part of the Quesnel terrane and the structurally underlying rocks of the Slide Mountain terrane (Rees, 1987; Struik, 1988a–c; Schiarizza, 1989; Ferri, 1997). Younger structures include west- to southwest-verging folds, in part of early Middle Jurassic age, that deform the east-directed thrust faults (Ross et al., 1985; Brown et al., 1986; Rees, 1987; Schiarizza and Preto, 1987), and prominent systems of Eocene dextral strike-slip and extensional faults (Ewing, 1980; Panteleyev et al., 1996; Schiarizza and Israel, 2001).

The Quesnel terrane is an important metallogenic province, particularly for porphyry deposits containing copper, gold and molybdenum. The world-class Highland Valley copper-molybdenum porphyry deposits occur in calcalkaline plutonic rocks of the Late Triassic Guichon Creek batholith (Casselman et al., 1995), which is hosted in the western calcalkaline belt of the Nicola Group (Figure 1). Copper-gold porphyry deposits, such as the Mount Polley and Afton mines, are associated with slightly younger, latest Triassic alkaline plutons that are hosted by the main belt of shoshonitic volcanic and volcaniclastic rocks of the Nicola Group (Mortensen et al., 1995; Logan and Mihalynuk, 2005a, b). Cospatial with these latest Triassic alkaline plutons is a belt of large, Early Jurassic calcalkaline plutons that includes the Takomkane, Thuya, Wild Horse, Pennask and Bromley batholiths. These plutons locally host copper-molybdenum±gold porphyry deposits, such as the past-producing Brenda mine (Weeks et al., 1995) and the Southeast zone of the Woodjam property (this report). Much younger calcalkaline plutons of mid-Cretaceous age intrude the Quesnel and adjacent terranes, and host porphyry molybdenum deposits, including the past-producing Boss Mountain mine (Soregaroli and Nelson, 1976; Macdonald et al., 1995).

GEOLOGICAL UNITS

The distribution of the main geological units within the Murphy Lake map area is shown on Figure 2, and schematic vertical cross-sections are presented on Figure 3. The bedrock geology is dominated by Late Triassic to Early Jurassic volcanic, volcaniclastic and plutonic rocks of the Quesnel terrane, but also includes two substantial accumulations of Eocene volcanic and sedimentary rocks assigned to the Kamloops Group. Basalt of the Miocene to Pliocene Chilcotin Group is represented by a few exposures in the northwestern part of the map area, and two outliers of Quaternary basalt are mapped in the southeastern part of the area.

The oldest rocks of the Quesnel terrane comprise volcanic and sedimentary rocks of the Late Triassic Nicola Group, which crop out mainly in the western part of the map area but also occur in two small areas near Tisdall Lake in the northeast. The most areally extensive units of the Quesnel terrane are plutonic rocks, represented mainly by the alkaline Spout Lake pluton and the calcalkaline Takomkane batholith. Smaller intrusive units include an ultramafic-mafic complex located north of Tisdall Lake, two stocks of coarse plagioclase porphyry west of Woodjam Creek and a small monzonite plug south of the McIntosh Lakes.

Nicola Group

The Nicola Group, originally named for exposures on the south side of Nicola Lake (Dawson, 1879), comprises a diverse assemblage of Middle and Upper Triassic volcanic, volcaniclastic and sedimentary rocks that crop out over a broad area in south-central BC. The name is applied to Triassic rocks in the Takomkane Project area following Campbell and Tipper (1971) and Panteleyev et al. (1996), although the Triassic rocks in the Quesnel Lake map area have also been referred to as Quesnel River Group (Campbell, 1978) or Takla Group (Rees, 1987). The former term has generally been superseded by Nicola Group, and the latter continues to be applied to Triassic rocks in central and northern BC that correlate with the Nicola Group (e.g., Nelson and Bellefontaine, 1996; Schiarizza and Tan, 2005).

On Figure 4, the Nicola Group in the Takomkane Project area is subdivided into four general map units. The easternmost rocks of the group, assigned to the Lemieux Creek succession, comprise dark grey slate and siltstone with local intercalations of limestone and quartz sandstone. These rocks pass westward and structurally upward into a broad belt of pyroxene- and feldspar-rich sedimentary and volcanic rocks referred to as the volcaniclastic succession. The volcaniclastic succession includes several internal units of coarse volcanic breccia and pyroxene-phyric basalt. One of these, at the top of the succession, is separated out on Figure 4 and referred to as the basalt-breccia unit. This unit crops out mainly as a continuous belt along the eastern margin of the Takomkane batholith, but also occurs west of the batholith, where it forms the uppermost part of the volcaniclastic succession between Spout Lake and the McIntosh Lakes. There, it is overlain by the fourth map unit, which is referred to as the polylithic breccia succession. This succession consists mainly of polylithic breccia and conglomerate with intercalated feldspathic sandstone, and is the uppermost unit of the Nicola Group exposed in the Takomkane Project area.

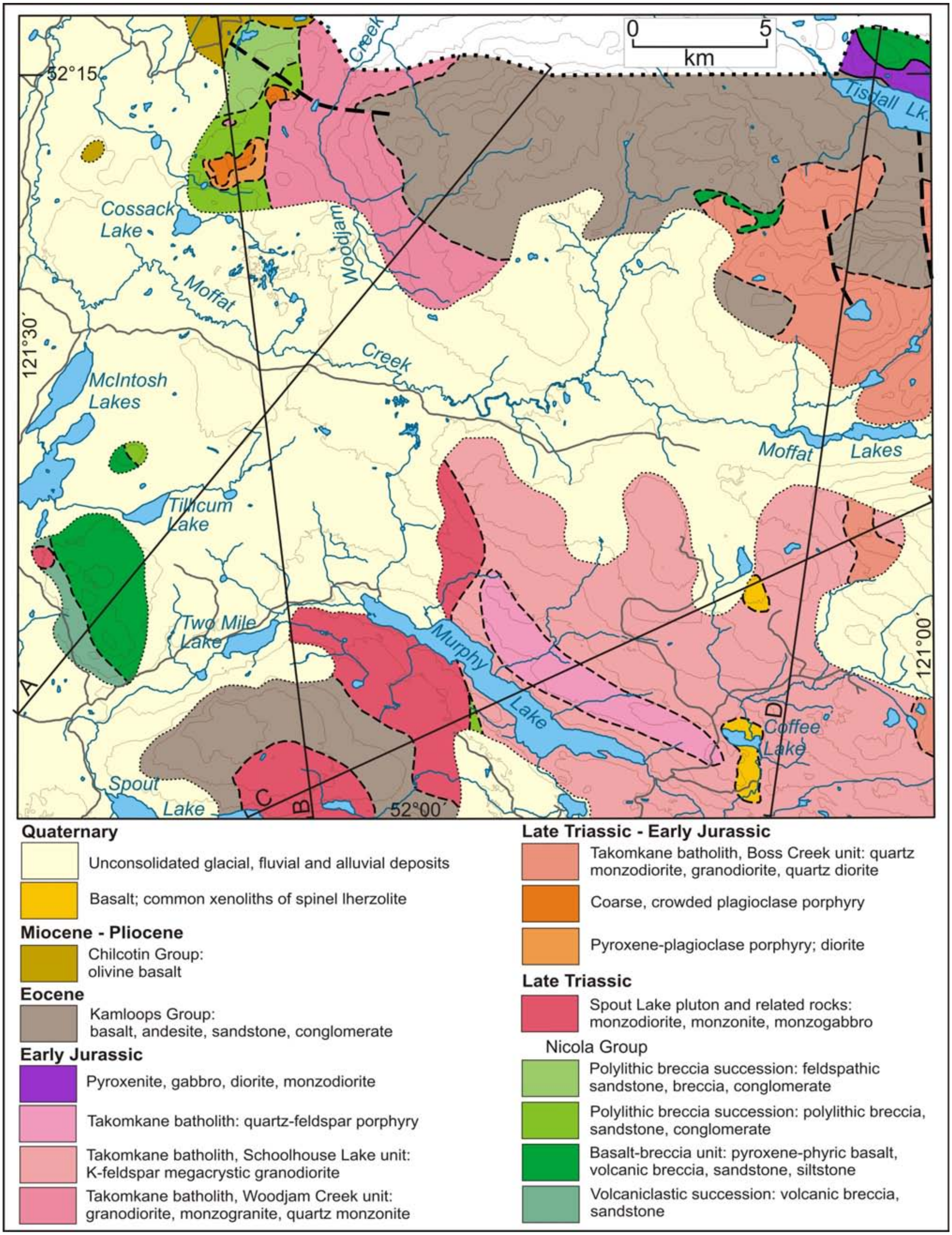

Figure 2. Generalized geology of the Murphy Lake map area, based mainly on 2008 fieldwork.

The Nicola Group is not a major component of the Murphy Lake map area, but substantial exposures occur in two localities in the western part of the area, south of the McIntosh Lakes and west of Woodjam Creek (Figure 2). The exposures south of the McIntosh Lakes comprise rocks of the volcaniclastic succession overlain to the east-northeast by the basalt-breccia unit. The basalt-breccia unit is in turn overlain by the polylithic breccia succession in an isolated set of exposures on a low hill east of the southern lake. The northwest-dipping interval west of Woodjam Creek comprises rocks of the polylithic breccia succession, which is subdivided into a lower unit of mainly coarse breccia and conglomerate, and an upper unit dominated by feldspathic sandstone. Nicola Group rocks elsewhere in the Murphy Lake map area include exposures near Tisdall Lake that are assigned to the basalt-breccia unit, and an exposure south of Murphy Lake, between the Spout Lake pluton and the Takomkane batholith, that is included in the polylithic breccia succession.

VOLCANICLASTIC SUCCESSION

The volcaniclastic succession is represented by a narrow belt of exposures south of the McIntosh Lakes. Here, the succession consists mainly of volcanic breccia (Figure 5), with local intercalations of massive to thin-bedded sandstone. The breccia is mainly medium to dark green or greyish green, and weathers rusty brown to greenish brown; locally, however, the fragments weather to a variety of colours, mainly in shades of green, grey and maroon, imparting a mottled colour to the rock. Fragments are mainly feldspar- and feldspar-pyroxene–phyric basalt, but the clast population also includes aphyric volcanic rock, feldspar-hornblende-pyroxene–phyric basalt or andesite, and limestone. The fragments commonly range from a few millimetres to a few centimetres in size, but locally are more than 10 cm across. They are typically angular to subrounded, poorly sorted and matrix supported. The matrix consists of sand-size grains of feldspar, accompanied by a smaller proportion of mafic minerals and dark volcanic-lithic grains.

The breccia of the volcaniclastic succession is massive to vaguely stratified, and was probably derived from mass-flow deposits. Locally, thick breccia units are separated by narrow intervals, only a few tens of centimetres wide, of thin-bedded feldspathic sandstone and siltstone. The succession also includes thicker units of massive sandstone, as represented by a single isolated exposure of dark green,

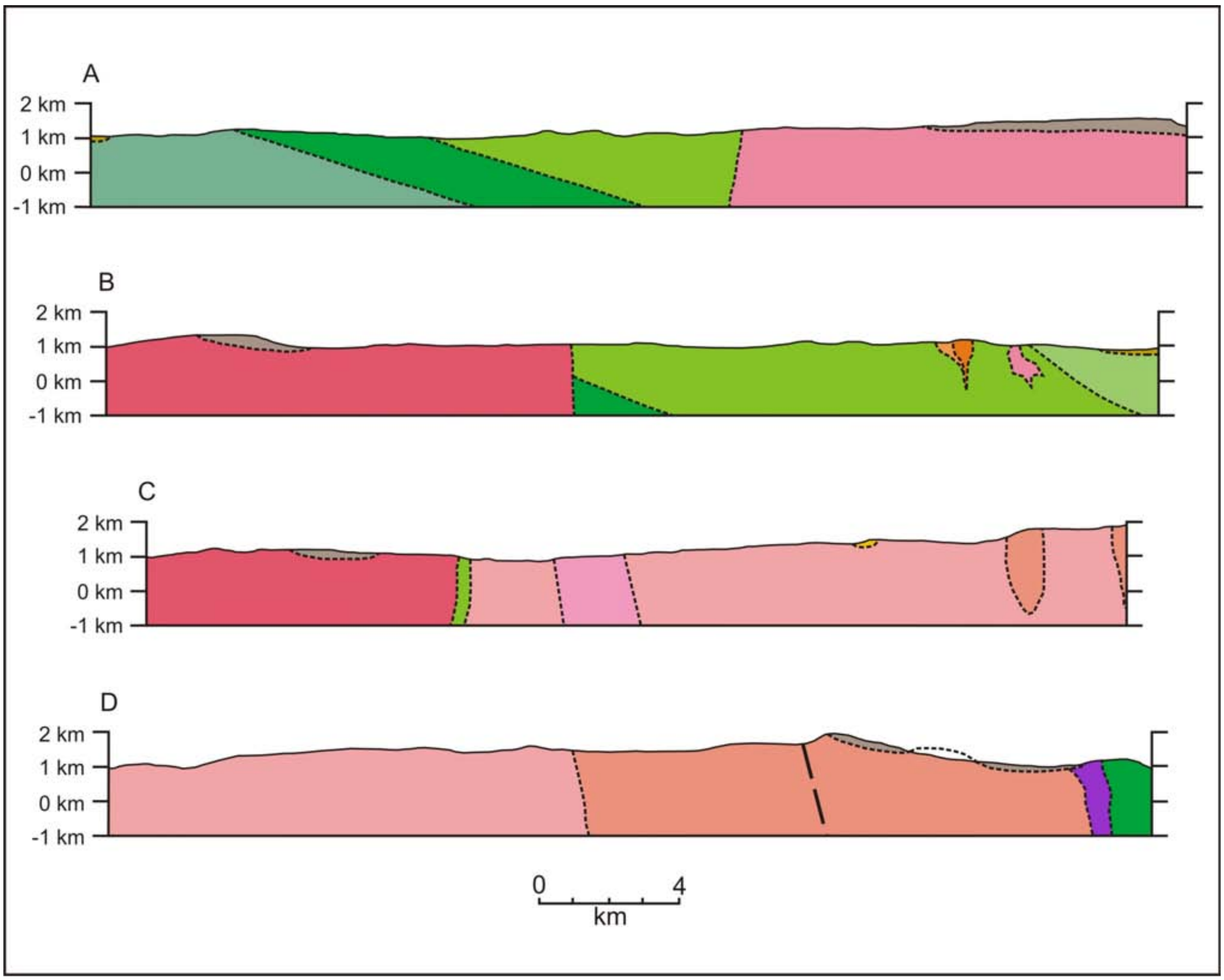

Figure 3. Schematic vertical cross-sections along the lines shown in Figure 2. See Figure 2 for legend.

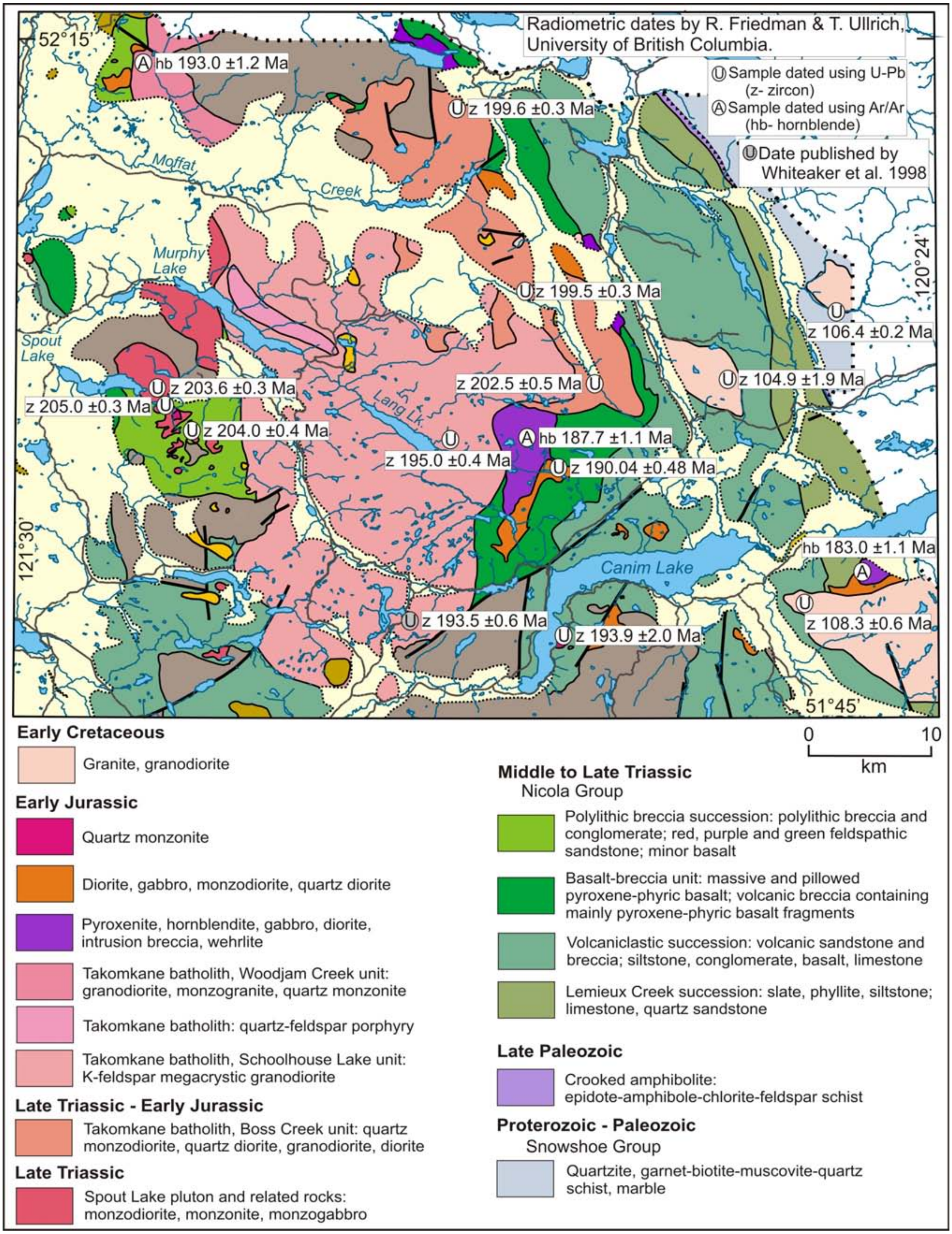

Figure 4. Simplified geology of the entire 2005–2008 Takomkane Project area, showing major subdivisions of the Nicola Group and locations of isotopically dated samples of plutonic rocks. Legend for Tertiary and Quaternary units shown in Figure 2.

rusty-brown–weathered, coarse-grained feldspathic sandstone in its upper part, west of Tillicum Lake.

The volcaniclastic succession is not dated within the Murphy Lake map area. Correlative rocks to the south include a prominent lens of limestone, 10 km southeast of Lac La Hache, that has yielded fossils of Late Triassic, probably Norian age (Campbell and Tipper, 1971).

BASALT-BRECCIA UNIT

The basalt-breccia unit consists of pillowed to massive basalt and basalt breccia, characterized by abundant, coarse pyroxene phenocrysts. It is well exposed on the hills and ridges south of the McIntosh Lakes, where it is underlain by the volcaniclastic succession and overlain by the polylithic breccia succession (Figure 3, section A). It also occurs northeast of Tisdall Lake and as a thin screen beneath Eocene cover on the margin of the Takomkane batholith, southwest of the lake.

The basalt-breccia unit south of the McIntosh Lakes is dominated by dark green, brownish-weathered, massive to pillowed basalt. The basalt typically comprises 10–30% pyroxene phenocrysts, 2–8 mm in size, and smaller but equally or more abundant feldspar phenocrysts, in a fine-grained, variably epidote-calcite-chlorite–altered groundmass. Amygdules of epidote and/or calcite are common locally, and varioles were noted rarely in some exposures of pillowed basalt. Irregular veins and patches of calcite-epidote are a common feature, particularly in pillowed units.

Medium to dark green, greenish-brown to rusty-brown weathered volcanic breccia is a subordinate but significant component of the basalt-breccia unit south of the McIntosh Lakes, and makes up most of the unit in the two exposure belts near Tisdall Lake. Fragments are angular to subrounded, and commonly range from less than 1 cm to 8 cm in size, although some exposures include fragments that are more than 20 cm across. The fragments consist mainly of pyroxene- and pyroxene-feldspar–phyric basalt, although clasts of limestone, pyroxenite and volcanic sandstone occur locally. There may be considerable textural variation among basalt fragments, mainly with respect to size, abundance and proportion of phenocrysts, but most are characterized by coarse pyroxene phenocrysts that commonly range up to 8 mm in size (Figure 6). The fragments are typically supported in a matrix made up of sand- to granule-size grains of mainly pyroxene and feldspar.

Pyroxene-feldspar sandstone and gritty sandstone is a relatively minor component of the basalt-breccia unit in the Tisdall Lake area. It either forms massive units that have indistinct contacts with enclosing breccia, or narrow thin-bedded intervals up to a few metres thick. Dark grey, rusty-weathered, laminated to thin-bedded siltstone forms an interval at least 10 m thick that was traced for 1.3 km within the basalt-breccia unit south of the McIntosh Lakes.

POLYLITHIC BRECCIA SUCCESSION

The polylithic breccia succession crops out mainly in the northwest corner of the map area, where it forms a north-northwest-dipping panel that is subdivided into a lower unit of mainly coarse breccia and an upper unit of mainly feldspathic sandstone with local intercalations of breccia and conglomerate (Figure 2). A few exposures of polylithic breccia also occur east of the McIntosh Lakes, and demonstrate the stratigraphic position of the polylithic breccia succession, above the basalt-breccia unit. A single exposure of hornfelsed, thin-bedded sandstone, siltstone and skarn, located between the Spout Lake pluton and Takomkane batholith south of Murphy Lake, is also included in the polylithic breccia succession. These rocks resemble thin-bedded intervals within the polylithic breccia succession near the Nemrud skarn occurrence, along the margin of the Takomkane batholith just south of the Murphy Lake map area (Schiarizza and Bligh, 2008).

The breccias of the polylithic breccia unit have an overall light to dark green or greenish grey colour, and commonly weather to light shades of brown, greenish brown or beige. They are typically matrix supported and poorly sorted, with angular to subrounded clasts that commonly range from a few millimetres to 6 cm in size, and are locally as large as 12 cm. The clast population is dominated by fine-grained, equigranular to weakly porphyritic feldspathic rocks but also includes porphyritic volcanic clasts containing variable proportions of feldspar, pyroxene and hornblende phenocrysts, and clasts of medium-grained gabbro/diorite and monzodiorite (Figure 7). The matrix consists mainly of feldspar with scattered mafic mineral grains. The feldspar is mainly plagioclase, but commonly includes a substantial proportion of pinkish

Figure 5. Volcanic breccia of the Nicola Group volcaniclastic succession, south of the McIntosh Lakes.

Figure 6. Volcanic breccia with coarse pyroxene porphyry basalt fragments, Nicola Group basalt-breccia unit, north of Tisdall Lake.

grains that may be K-feldspar and/or hematite-altered plagioclase. The polylithic breccias are typically massive, but some exposures display weak stratification. Locally, this stratification is accented by the intercalation of narrow intervals of thin-bedded feldspathic sandstone, gritty sandstone and siltstone.

The upper unit of the polylithic breccia succession consists mainly of medium- to coarse-grained, locally gritty, feldspathic sandstone. It is mostly medium green to grey-green and weathers rusty brown to light greenish brown, but in some exposures is red to purple on weathered and fresh surfaces. The clastic feldspar grains are mainly plagioclase, but commonly include pinkish K-feldspar and/or hematitic plagioclase, which are at least in part the products of alteration. Bedding is evident mainly as a planar platy to flaggy parting, but thin to medium beds are locally well defined by distinct units of contrasting grain size, ranging from siltstone to gritty sandstone. Matrix-supported pebble to cobble conglomerate and conglomeratic sandstone occur locally as thicker beds, and contain clasts that are similar in composition and texture to those in the underlying breccia unit.

Volcanic rocks were not positively identified within either the upper or lower unit of the polylithic breccia succession, but both units include exposures of fine-grained feldspathic rock, locally with scattered coarser grains of feldspar and/or mafic minerals, of uncertain origin. It is suspected that most of these are feldspathic sandstone and gritty sandstone with textures obscured by hornfels development and/or alteration. However, some might be volcanic rocks and/or high-level dioritic to monzodioritic intrusions.

Rocks assigned to the polylithic breccia succession in the Murphy Lake map area are readily correlated with similar rocks mapped to the south between Spout Lake and Mount Timothy (‘polylithic breccia’ and ‘red sandstone-conglomerate’ units of Schiarizza and Bligh, 2008). The succession is inferred to be Late Triassic because it sits stratigraphically higher than the volcaniclastic succession, which is dated regionally as Late Triassic, and is cut by the Late Triassic Peach Lake stocks southeast of Spout Lake (Figure 4).

Plutonic Rocks of the Quesnel Terrane

SPOUT LAKE PLUTON

The Spout Lake pluton, of mainly monzodiorite to monzonite composition, crops out in the southwestern part of the Murphy Lake map area. It measures at least 16 km north-south by 9 km east-west, but the western and northern limits are obscured by Quaternary drift. The pluton apparently intrudes the basalt-breccia unit and polylithic breccia succession of the Nicola Group along its south and southeast margins, and is cut by the Schoolhouse Lake unit of the Takomkane batholith to the northeast, but none of these contacts are exposed. The southern part of the pluton is locally overlapped by Eocene volcanic rocks of the Kamloops Group.

Most exposures of the Spout Lake pluton consist of light-grey–weathered, medium- to coarse-grained, equigranular monzodiorite to monzonite. Mafic minerals commonly constitute 15–20% of the rock. The mafic component is typically clinopyroxene with lesser biotite, but some rocks contain hornblende and biotite. Quartz is locally present as a minor constituent, and apatite is conspicuous in thin sections. Planar dikes of fine- to medium-grained, equigranular to porphyritic monzonite, monzodiorite, syenite and diorite are common, as are veins and irregular patches of pegmatite, ranging from monzonite to granite in composition (Figure 8).

Darker grey, coarse-grained, equigranular monzogabbro forms a distinctive unit within the eastern part of the Spout Lake pluton south of Murphy Lake. Mafic minerals typically form about 30% of the rock and consist mainly of clinopyroxene, with minor amounts of altered olivine evident in thin section. Clinopyroxenite locally forms irregular patches and lenses, up to 20 cm across, within the monzogabbro, and dikes of monzodiorite, monzonite, syenite and pegmatite, similar to those found elsewhere in the pluton, are common (Figure 9). Where observed, contacts between monzogabbro and the more typical monzodiorite are highly irregular, with no clear indication of the relative ages of the two units, although xenoliths of melanocratic gabbro that might be related to the monzo-

Figure 7. Breccia of the Nicola Group polylithic breccia unit, east of the McIntosh Lakes.

Figure 8. Monzodiorite of the Spout Lake pluton containing a xenolith of melanocratic gabbro and cut by a pegmatite dike and a younger fine-grained monzonite dike, 3 km south of the west end of Murphy Lake.

gabbro unit occur locally within the monzodiorite, as shown in Figure 8.

A sample of fairly typical monzodiorite collected from the southern part of the Spout Lake pluton in 2007 yielded a Late Triassic U-Pb zircon date of 203.6 ±0.3 Ma (Figure 4). A sample of monzogabbro collected from the eastern part of the pluton in 2008 has also been submitted for U-Pb dating, but the results are not yet available.

MONZONITE PLUG SOUTH OF THE MCINTOSH LAKES

A small intrusive plug, less than 1 km in diameter, cuts the volcaniclastic succession of the Nicola Group south of the McIntosh Lakes. It consists of pinkish-brown–weathered, medium-grained, equigranular monzonite, containing about 25% clinopyroxene and traces of hornblende and biotite. Fine-grained monzodiorite forms part of the southeastern margin of the plug, and narrow dikes of fine-grained syenite locally cut the main monzonite and monzodiorite phases. The plug is undated but may be related to the Spout Lake pluton and the monzodiorite to monzonite stocks south of Peach Lake, two of which have yielded Late Triassic U-Pb zircon dates of 204.0 ±0.4 Ma and 205.0 ±0.3 Ma (Figure 4; Schiarizza and Bligh, 2008).

TAKOMKANE BATHOLITH

The Takomkane batholith is a large, composite pluton that measures 56 km north-south by 20–33 km east-west (Figure 4). It cuts the Spout Lake pluton and several different units of the Nicola Group, and is itself cut by several Early Jurassic ultramafic-mafic plutons and the Early Cretaceous Boss Mountain Mine stock. Locally it is nonconformably overlain by volcanic successions of Eocene, Miocene and Quaternary age. The Takomkane batholith consists of two major subdivisions: the Late Triassic to Early Jurassic Boss Creek unit and the Early Jurassic Schoolhouse Lake unit (Figure 4; Schiarizza and Boulton, 2006a). Both of these units are present in the Murphy Lake map area, as are two additional mappable units: a quartz-feldspar porphyry that is within the Schoolhouse Lake unit; and the Woodjam Creek unit, which is texturally distinct but compositionally similar to the Schoolhouse Lake unit, and forms the northwestern part of the batholith.

Boss Creek Unit

The Boss Creek unit forms the northeastern part of the Takomkane batholith, and underlies a belt about 35 km long that extends southeastward from the eastern part of the Murphy Lake area into the Canim Lake map area. Within the Murphy Lake map area, it is well exposed along several sets of ridges north of the Moffat Lakes. It consists mainly of light grey, medium- to coarse-grained, equigranular quartz monzodiorite to granodiorite, locally grading to quartz diorite and diorite. Mafic minerals typically form 15–25% of the rock. These commonly consist of hornblende with lesser amounts of biotite, but locally include clinopyroxene, biotite and hornblende. Rounded xenoliths of fine-grained dioritic rock are scattered sparsely through some exposures and, in one isolated exposure south of the east end of the Moffat Lakes, medium-grained diorite hosts numerous xenoliths of coarse-grained gabbro, diorite and hornblendite.

Samples of biotite-pyroxene-hornblende quartz monzodiorite from near the southern and northern limits of the Boss Creek unit have yielded U-Pb zircon dates of 202.5 ±0.5 Ma and 199.6 ±0.3 Ma, respectively (Figure 4). A sample of hornblende-biotite granodiorite collected between these two sites has yielded a U-Pb zircon date of 199.5 ±0.3 Ma. These dates indicate crystallization of the Boss Creek unit at about the Triassic–Jurassic boundary, which has been placed at 199.6 ±0.7 Ma by Pálfy et al. (2000).

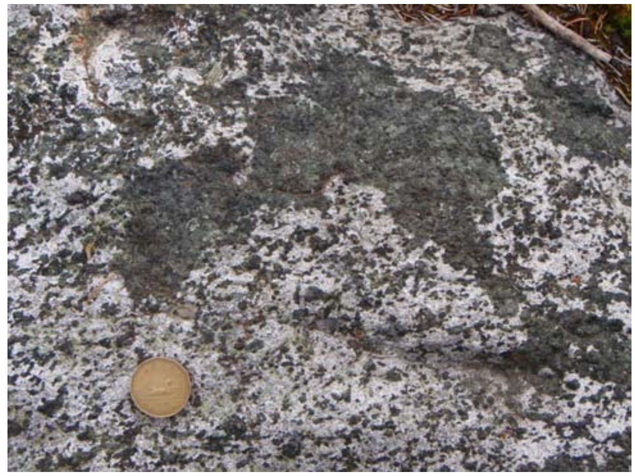

Figure 9. Monzogabbro containing irregular patches of pyroxenite, Spout Lake pluton, southwest of Murphy Lake.

Schoolhouse Lake and Quartz-Feldspar Porphyry Units

The Schoolhouse Lake unit is the main component of the Takomkane batholith, with exposures extending from Moffat Creek southward 40 km to the southern margin of the batholith at Bridge Creek (Figure 4). It is remarkably homogeneous throughout this area, comprising light grey to pinkish grey, coarse- to medium-grained, hornblende-biotite granodiorite to monzogranite characterized by K-feldspar megacrysts up to 5 cm in size and, commonly, quartz grains and aggregates up to 1 cm in size. Mafic minerals typically make up 10–20% of the rock, with hornblende predominating over biotite. Variations in composition and texture occur mainly along the margins of the unit, where equigranular granodiorite and tonalite have been noted locally.

Pegmatite and aplite dikes, generally less than 1 m wide, are a widespread but relatively minor component of the Schoolhouse Lake unit. Thicker dikes of grey to pink quartz porphyry and quartz-feldspar porphyry also occur; in the Timothy Lake map area, these dikes were noted in both the Schoolhouse Lake unit and the adjacent Nicola Group (Schiarizza and Bligh, 2008). In the Murphy Lake map area, a northwest-trending unit of quartz-feldspar porphyry, up to 1800 m wide, has been traced for 11 km within the Schoolhouse Lake unit on the northeast side of Murphy Lake. It consists of quartz and K-feldspar phenocrysts in a fine-grained sugary groundmass of feldspar and quartz, accompanied by relatively minor amounts of biotite and hornblende. The phenocrysts are typically 4–10 mm in size, but K-feldspar megacrysts are locally as large as 3 cm. We suspect that this unit is broadly related to the enclosing Schoolhouse Lake unit, and of similar Early Jurassic age. This interpretation will be tested with U-Pb dating of zircons from a sample collected during the 2008 field season.

Outcrop distribution within the Murphy Lake and Hendrix Lake map areas suggests that the contact between the Schoolhouse Lake and Boss Creek units is irregular and complex (Figure 4). The contact is not well exposed, however, and the relative ages of the two units have been established through isotopic dating. The Schoolhouse Lake unit has yielded U-Pb zircon crystallization ages of 193.5 ±0.6 Ma from a sample near Ruth Lake (Whiteaker et al., 1998), and 195.0 ±0.4 Ma from a sample near Lang Lake (Figure 4). These dates indicate that the Schoolhouse Lake unit is younger than the Boss Creek unit by about 5 Ma.

Woodjam Creek Unit

The Woodjam Creek unit makes up the northwestern part of the Takomkane batholith, where it is represented by good exposures on both sides of Woodjam Creek. It cuts the polylithic breccia succession of the Nicola Group to the west, and is overlain by Eocene volcanic and sedimentary rocks to the east. It is also in contact with undated plugs of feldspar porphyry and feldspar-pyroxene porphyry along its western margin, but relative ages have not been established. The contacts between the Woodjam Creek unit and the Boss Creek and Schoolhouse Lake units are obscured by large areas of Eocene and Quaternary cover.

The Woodjam Creek unit consists mainly of light grey, light pinkish-grey to white weathered, hornblende-biotite granodiorite, monzogranite, quartz monzonite and quartz monzodiorite. This range in rock names does not reflect a wide compositional range for the unit, but rather a fairly restricted range of compositions that plot near the mutual contact point of these four fields on a QAP diagram. Texturally, the rocks are isotropic, medium to coarse grained and generally equigranular, although some exposures feature K-feldspar and hornblende grains, up to 1 cm long, that are coarser than other mineral grains. Mafic minerals, mainly hornblende with relatively minor amounts of biotite, commonly form 10–15% of the rock. Dikes of aplite, pegmatite and quartz-feldspar porphyry are a widespread but volumetrically minor component of the unit.

The Woodjam Creek unit resembles the Schoolhouse Lake unit, but generally has less quartz and does not contain the large K-feldspar megacrysts that characterize the latter unit. Logan et al. (2007) reported that hornblende from a sample collected on the west side of Woodjam Creek yielded a well-defined Ar/Ar cooling age of 193.0 ±1.2 Ma, which they interpreted as an approximate crystallization age. This date suggests a temporal relationship between the Woodjam Creek and Schoolhouse Lake units. A sample collected from the east side of Woodjam Creek during the 2008 field season has been submitted for U-Pb dating of zircons to further evaluate the crystallization age of the unit.

TISDALL LAKE ULTRAMAFIC-MAFIC COMPLEX

The Tisdall Lake complex comprises ultramafic and mafic plutonic rocks that crop out on the northeast side of Tisdall Lake. These rocks intrude the Nicola Group basalt-breccia unit to the northeast, and are overlain be Eocene volcanic rocks to the south. They are inferred to intrude the Boss Creek unit of the Takomkane batholith beneath the Eocene cover (Figure 3, section D).

Eastern exposures of the Tisdall Lake complex comprise complex mixtures of dark green, coarse-grained hornblende clinopyroxenite; medium- to coarse-grained melanocratic gabbro; grey, medium-grained diorite; and light grey, fine- to medium-grained leucodiorite. The hornblende clinopyroxenite, which contains accessory biotite and magnetite, is the oldest phase present and forms irregular patches ranging from less than 1 m to more than 10 m across. Melanocratic gabbro forms smaller patches that have sharp to gradational contacts with the clinopyroxenite. Mafic minerals make up 40–80% of the gabbro and include clinopyroxene, hornblende and minor biotite. Variations in modal composition are typically complex and irregular, but rare patches display modal layering. Grey diorite dominates large areas of outcrop, and also occurs as dikes cutting clinopyroxenite and gabbro. Leucodiorite occurs as narrow dikes and irregular veins cutting all other rock types, and locally forms the matrix of intrusion breccia that contains xenoliths of clinopyroxenite, gabbro and diorite (Figure 10).

Western exposures of the Tisdall Lake complex consist mainly of grey, medium- to coarse-grained, equigranular diorite. The diorite locally encompasses patches of less homogeneous, varitextured diorite to gabbro, and locally contains xenoliths of clinopyroxenite and melanocratic gabbro. Pegmatitic quartz monzodiorite forms dikes and irregular patches within the dioritic rocks, and dominates some areas along the north contact of the complex.

The Tisdall Lake complex correlates with two similar ultramafic-mafic plutonic complexes that crop out along the eastern margin of the Takomkane batholith farther south (Figure 4). These are referred to as the Hendrix Lake complex (Schiarizza and Macauley, 2007a) and the Iron Lake complex (Schiarizza and Boulton, 2006a). These ultramafic-mafic plutons are assigned Early Jurassic ages based on isotopic dating of the Iron Lake complex (Figure 4).

STOCKS EAST OF WOODJAM CREEK

Two separate stocks that cut the Nicola Group polylithic breccia succession along the western margin of the Takomkane batholith, in the northwest corner of the map area, consist of coarse plagioclase porphyry, partially enveloped by finer grained feldspar-pyroxene porphyry and, locally, fine-grained hornblende-phyric diorite. The coarse porphyry units are characterized by 30–40% plagioclase

Figure 10. Hornblende clinopyroxenite, grey diorite and leucodiorite of the Tisdall Lake ultramafic-mafic complex, north of Tisdall Lake.

phenocrysts, commonly 6–10 mm long and locally up to 2 cm long, within an aphanitic groundmass of randomly oriented plagioclase microlites and fine opaque material (Figure 11). Ovoid to irregularly shaped green alteration patches, from a few millimetres to 3 cm in size, are also a common feature. They consist mainly of actinolite and epidote, locally accompanied by feldspar and specularite. Some of these look like amygdules, whereas others appear to represent alteration of feldspar and mafic phenocrysts. The finer grained porphyry along the margins of the stocks comprises 50% feldspar and mafic phenocrysts, 1–6 mm in size, within an aphanitic groundmass. The mafic phenocrysts have a pyroxene habit, but are seen in thin section to be pale green amphibole, possibly an alteration product. Irregular patches and lenses of green, grey and red sandstone occur locally within the finer grained porphyry near the margin of the southern stock, and are inferred to be screens of hematite-altered country rock.

The plagioclase porphyry stocks cut the polylithic breccia succession of the Nicola Group, so are Late Triassic or younger. They may also be in contact with the Woodjam Creek unit of the Takomkane batholith, but contact relationships were not observed. The stocks resemble some coarse plagioclase-phyric flows within the Eocene Kamloops Group (Schiarizza and Bligh, 2008), but are suspected to be Mesozoic, in part because they display significant epidote-chlorite-hematite alteration, typical of Mesozoic rocks in the area.

Kamloops Group

Eocene volcanic and sedimentary rocks in the Quesnel Lake map area were assigned to the Kamloops Group by Campbell (1978). The group underlies substantial areas in the northern and southwestern parts of the Murphy Lake map area (Figure 2), where it consists of mafic volcanic flows and subordinate amounts of volcanic breccia, conglomerate and sandstone. These gently dipping rocks rest unconformably above a number of different Mesozoic units, including the Nicola Group, the Spout Lake pluton, the Takomkane batholith, and the Tisdall Lake ultramafic-mafic complex (Figure 3).

The Kamloops Group in the Murphy Lake map area is represented in large part by dark grey, grey-brown to rusty-brown weathered, pyroxene-plagioclase–phyric basalt or andesite flows and related flow breccia. Flows are typically massive to weakly columnar-jointed, but are friable in places due to pervasive platy fractures. Olivine-pyroxene–phyric basalt flows are also present, and fine-grained, aphyric andesite forms a significant part of the succession near Tisdall Lake. Vesicles within the volcanic rocks are commonly filled with chalcedonic quartz, calcite or zeolite minerals (Figure 12).

Sedimentary intervals scattered throughout the volcanic succession consist mainly of friable, yellow-brown to red weathered pebble conglomerate, with local intercalations of lithic wacke (Figure 13). The conglomerate contains mafic to intermediate volcanic-lithic clasts, probably derived from the Eocene succession, and local chips of woody material. Conglomerate near the base of the Eocene section in the northern outcrop belt also includes granitic clasts derived from the underlying Takomkane batholith, and is intercalated with quartz-feldspar sandstone and gritty sandstone.

Chilcotin Group

The Chilcotin Group comprises flat-lying basalt flows and related rocks, of Early Miocene to Early Pleistocene age, that are distributed over much of the Interior Plateau of south-central BC (Bevier, 1983; Mathews, 1989; Andrews and Russell, 2007). The group is represented by a few scattered exposures in the northwest corner of the Murphy Lake map area, where it is inferred to rest unconformably above the Nicola Group and the Woodjam Creek unit of the Takomkane batholith. These exposures comprise medium to dark grey, grey-brown to rusty-brown weathered, variably vesicular, fine-grained basalt. A thin section from one of the exposures consists mainly of plagioclase, clinopyroxene, olivine and opaque minerals, arranged in a subophitic texture. A Chilcotin basalt sample collected from an exposure just west of the Murphy Lake map area, near the south end of the McIntosh Lakes, yielded a Late Miocene K-Ar whole-rock date of 8.7 ±0.4 Ma (Mathews, 1989).

Quaternary Basalt

Flat-lying basalt flows of probable Quaternary age overlie the Schoolhouse Lake unit of the Takomkane

Figure 11. Coarse plagioclase porphyry from stock west of Woodjam Creek.

Figure 12. Andesite with amygdules of chalcedonic quartz, Eocene Kamloops Group, west of Tisdall Lake.

batholith in two separate areas in the southeastern part of the map area (Figure 2). The southern outlier is locally well exposed along the creek that drains the southeast end of Coffee Lake, where it is represented by columnar-jointed flows with a combined thickness of several tens of metres. Exposure is poor elsewhere, although sufficient to confirm that it is these flows that generate pronounced positive anomalies on aeromagnetic maps of the area. The basalt is dark grey, aphanitic and, in part, weakly vesicular. It contains xenocrysts (±phenocrysts) of olivine and numerous mantle and crustal xenoliths, generally less than 5 cm across but locally ranging up to 12 cm in size. The mantle xenoliths are mainly lherzolite. The crustal xenoliths show a wide range of textures and compositions, and include quartzofeldspathic gneiss, quartz diorite, diorite and layered gabbro.

Exposures of similar xenolith-bearing basalt occur just to the east of the Murphy Lake map area, on Takomkane Mountain (Schiarizza and Macauley, 2007a), as well as to the south, on and around Mount Timothy (Schiarizza and Bligh, 2008). They are assigned a Quaternary age because, on Takomkane Mountain, the basalt rests on a glaciated surface, but the associated cinder cone has been sculpted by subsequent glacial action (Sutherland Brown, 1958). These basalt outliers are probably related to the Quaternary Wells Gray volcanic field to the east (Hickson and Souther, 1984).

STRUCTURE

Outcrop-scale structures within the Murphy Lake map area consist mainly of brittle faults and fractures that are more common in Mesozoic rocks than in Eocene rocks of the Kamloops Group. Rocks of the Nicola Group basalt-breccia unit north of Tisdall Lake commonly display a steeply dipping, northwest-striking schistosity, but penetrative foliations elsewhere are restricted to rare, narrow, local shear zones.

Nicola Group rocks south of the McIntosh Lakes apparently form a homoclinal succession that dips at moderate angles to the northeast (Figure 3, section A), whereas the panel of Nicola rocks exposed west of Woodjam Creek dips at moderate angles to the north-northwest (Figure 3, section B). The regional significance of these orientations is difficult to evaluate because the exposures are isolated from other Nicola rocks by tens of kilometres of plutonic rock to the east, and extensive Quaternary and Miocene cover to the west. Rocks of the basalt-breccia unit north of Tisdall Lake dip steeply to the southwest, which is consistent with their position along the west edge of a thick panel of Nicola rocks that generally dips and faces to the southwest above a basal contact with the Crooked amphibolite (Figure 4; Schiarizza and Macauley, 2007a, b).

Eocene rocks are flat lying to gently dipping wherever bedding orientations were observed. Two northerly-trending faults are inferred to the south of Tisdall Lake from abrupt juxtapositions of flat-lying Eocene rocks against rocks of the Takomkane batholith. The Eocene rocks are apparently down-dropped between the faults in a small graben structure. A northwest-trending fault in the northwestern corner of the map area is likewise inferred from an apparent offset, down-dropped to the north, of the basal Eocene contact above the Takomkane batholith. This fault may also be partly responsible for a pronounced jog in the contact between the batholith and the Nicola Group (Figure 2). Relief on the basal Eocene contact elsewhere is inferred to be due mainly to Eocene paleotopography.

Figure 13. Conglomerate and conglomeratic sandstone, Eocene Kamloops Group, east of Woodjam Creek.

Although Eocene or younger faults are clearly present, many of the outcrop-scale faults observed within Mesozoic units are inferred to be pre-Eocene because these structures are much more prevalent in the older rocks. Steeply dipping faults with northwest, north and northeast strikes are most common. Topographic lineaments with these orientations are also common but, with the exception of the mapped Eocene or younger faults, none have been proven to be controlled by major faults.

MINERAL OCCURRENCES

Metallic mineral occurrences are found mainly in the southwest and northwest parts of the Murphy Lake map area (Figure 14). Those in the southwest are copper showings within the Spout Lake pluton. Those in the northwest include porphyry-style copper-molybdenum-gold mineralization within the Woodjam Creek unit of the Takomkane batholith, as well as copper-gold mineralization within the adjacent Nicola Group. Occurrences elsewhere in the map area include two showings southwest of Tisdall Lake that are associated with the Boss Creek unit of the Takomkane batholith, and a copper occurrence within the Schoolhouse Lake unit of the batholith southwest of the Moffat Lakes.

Occurrences in the Spout Lake Pluton

CLEO (MINFILE 093A 044) AND BORY (MINFILE 093A 063)

The Cleo and Bory showings comprise minor amounts of chalcopyrite disseminated in monzonite of the Spout Lake pluton. The Cleo showing is located about 1.5 km south of the west end of Murphy Lake and was discovered in 1971 during exploration on the Cleo claim group by Nitro Development Inc. (Kirwin, 1971). The Bory showings are located north and northeast of the east end of Two Mile Lake (Aulis, 1993). They are named after the Bory claim group, which covered this area in the early 1970s (Sutherland and Brown, 1971).

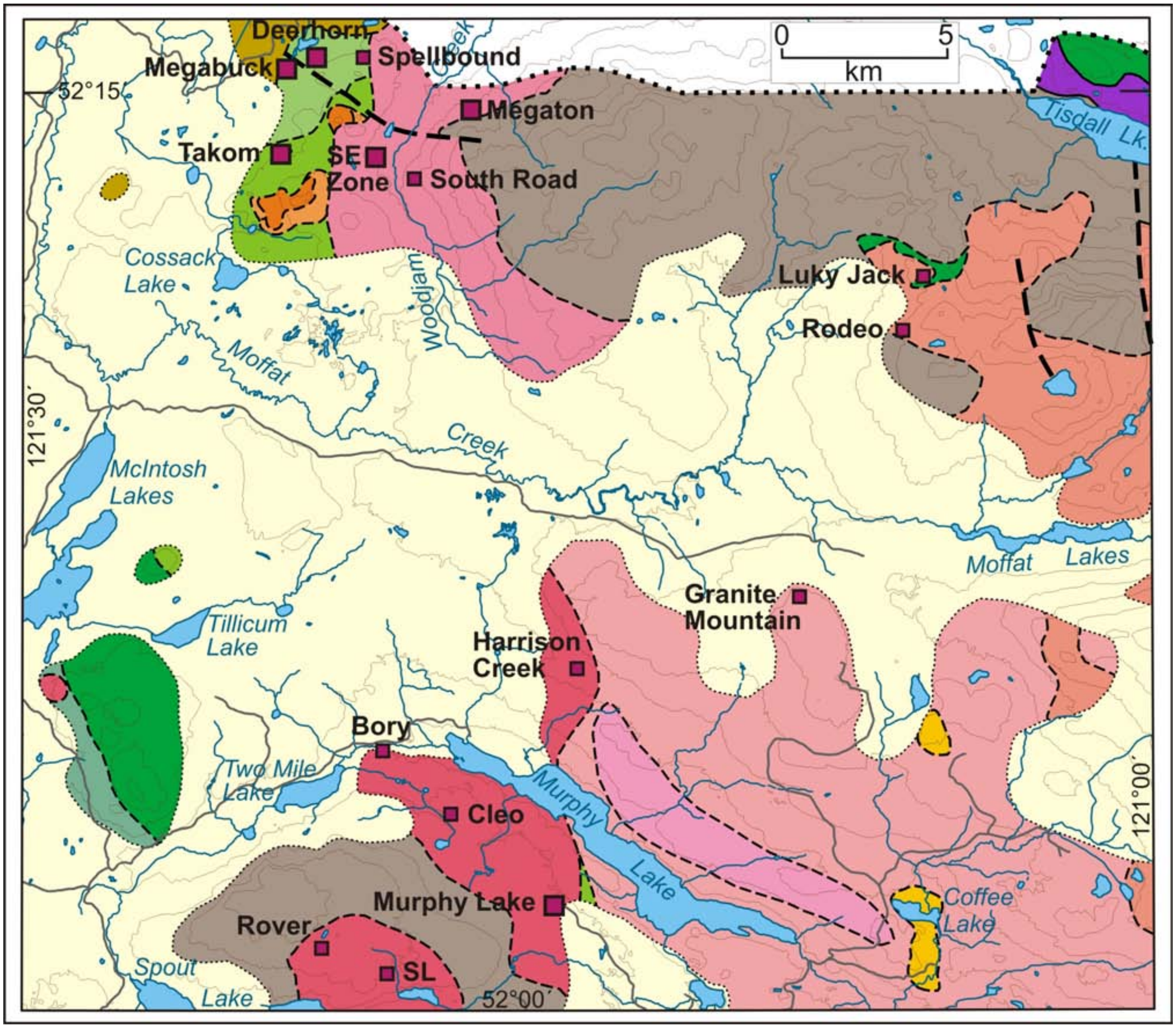

Figure 14. Mineral occurrences in the Murphy Lake map area. See Figure 2 for legend.

MURPHY LAKE (MINFILE 093A 073)

The Murphy Lake occurrence is located 2 km southwest of Murphy Lake, within an area of commingled monzodiorite, monzonite and monzogabbro of the Spout Lake pluton. Outcrops in this area contain scattered, minor occurrences of chalcopyrite and bornite (Aulis, 1993), but the most significant mineralization was discovered during a seven-hole diamond-drill program by Regional Resources Ltd. and GWR Resources Inc. in 1995 (von Guttenberg, 1996). Hole ML95-01 intersected 45 m of 0.20% Cu, and hole ML95-06, drilled 115 m to the north, intersected 53 m of 0.34% Cu and 0.04 g/t Au. These intersections were interpreted as part of a steeply dipping, north-striking mineralized zone, 30–35 m in true width and open to depth and along strike (von Guttenberg, 1996). Candorado Operating Company Ltd. drilled five additional holes in 2004 (Ostler, 2005) and two holes in 2007 (Koffyberg, 2008). These programs confirmed widespread, low-grade copper values, but did not define any continuous zones of major mineralization. One hole, ML04-1, was drilled between holes ML95-01 and ML95-06, but did not intersect the mineralized zone interpreted by von Guttenberg (Ostler, 2005).

Sulphide minerals at the Murphy Lake occurrence are mainly pyrite and chalcopyrite, but locally include minor amounts of bornite or molybdenite. The sulphides occur along fractures, in K-feldspar veins and as disseminations. Locally, in diamond-drill hole ML95-06, chalcopyrite occurs in veins, 10–15 cm thick, with chlorite and quartz (von Guttenberg, 1996).

SL (MINFILE 093A 113) AND ROVER

The SL and Rover occurrences comprise minor amounts of disseminated chalcopyrite and bornite within the southern part of the Spout Lake pluton. The SL showing (occurrence 2 of Janes, 1967) was discovered in 1966 during a prospecting program by Coranex Ltd. that followed the discovery of anomalous copper in silt samples during a reconnaissance geochemical survey. This initiated staking of the Rover claim group and follow-up exploration that led to the discovery of several additional minor occurrences.

The most significant of these, occurrences 4 and 9 of Janes (1967), are shown as the Rover showing on Figure 14. There has been little subsequent work on these showings, although the SL occurrence was briefly mentioned by Vollo (1973) in a report on geophysical and geochemical surveys over the SL claim group by Craigmont Mines Ltd., and Aulis (1993) noted disseminated chalcopyrite at the Rover showing in a report describing an exploration program on the Two Mile Lake claim group by Regional Resources Ltd.

HARRISON CREEK

The Harrison Creek occurrence, discovered during our 2008 mapping program, is located in the eastern part of the Spout Lake pluton, north of Murphy Lake. It comprises pyrite, chalcopyrite, magnetite and malachite within and along quartz–epidote–K-feldspar veins that cut monzodiorite. A grab sample of this mineralized vein material returned 1671 ppm Cu, 1432 ppb Ag and 105 ppb Au (Schiarizza et al., 2009, sample 08SBA-18).

Occurrences near Woodjam Creek

The area around Woodjam Creek has a protracted history of mineral exploration, dating from at least the mid-1960s, largely focused on the Megabuck and Takom (formerly WL) occurrences. Exposures of the polylithic breccia succession and the western part of the Takomkane batholith throughout this area display moderate to intense epidote alteration, locally accompanied by K-feldspar, tourmaline, magnetite and calcite. The known mineral occurrences are currently covered by two claim groups. The Woodjam property in the west was assembled by Wildrose Resources Ltd. in 1998 and currently is jointly owned by Cariboo Rose Resources Ltd. (40%) and Fjordland Exploration Inc. (60%). It encompasses the Megabuck, Takom and Spellbound occurrences, as well as the newly discovered Southeast and Deerhorn zones. The area east of the Woodjam property is covered by the Megaton claim group, which was staked by H. Wahl and J. Brown-John in 1996 and encompasses the Megaton and South Road occurrences (Figure 14).

MEGABUCK (MINFILE 093A 078)

The Megabuck zone is located near the northern boundary of the Murphy Lake map area, 2.5 km west of the Takomkane batholith. The few small outcrops observed during our 2008 fieldwork comprise grey-green gritty feldspathic sandstone cut by quartz veinlets that carry pyrite and chalcopyrite. A grab sample of mineralized rock returned 1431.92 ppm Cu, 29.27 ppm Mo and 1226 ppb Au (Schiarizza et al., 2009, sample 08PSC-260). The hostrocks are assigned to the upper unit of the Nicola Group polylithic breccia succession, as are good exposures of sandstone, conglomerate and breccia located about 1 km to the east and southeast. Small exposures of basalt, belonging to the Miocene–Pliocene Chilcotin Group, occur 500 m west of the mineralized outcrops.

The first drilling on the Megabuck occurrence comprised two diamond-drill holes by Exploram Minerals Ltd. in 1974 (Cruz, 1974a). Subsequent exploration has included diamond-drill programs by Placer Development Ltd. in 1983 and 1984, by Phelps Dodge Corp. in 1999, and by Fjordland Exploration Inc. from 2002 to 2007 (in part summarized by Peters, 2007). These programs have outlined a complex but approximately tabular mineralized zone about 175 m thick that trends northeast and dips about 45 to the southeast (Peters, 2005, 2007). Drill-tested mineralization has a 300 m strike length and extends 400 m down dip; it is truncated by mineralized faults to the northeast and east, but remains open to depth and to the southwest. Notable intersections from Fjordland's 2004 drilling program, designed mainly to test the mineralization at depth, include 0.81 g/t Au and 0.12% Cu over 378 m in hole 04-32, and 0.77 g/t Au and 0.13% Cu over 397.5 m in hole 04-37 (Peters, 2005).

Mineralization in the Megabuck zone consists of chalcopyrite, pyrite and minor amounts of bornite, which occur in several generations of quartz and quartz-calcite veins and stockworks, and also as disseminations and along fractures. Complex alteration assemblages include quartz, carbonate, epidote, K-feldspar, magnetite, hematite, chlorite and sericite (Campbell and Pentland, 1983; Peters, 2005). The hostrocks have been interpreted by some workers as a layered sequence of tuff, volcanic breccia and volcanic-derived sedimentary rocks (e.g., Campbell and Pentland, 1983), whereas others have indicated that the zone includes a significant proportion of premineralization dioritic to monzonitic intrusive rocks (e.g., Peters, 2005, 2007). The age of mineralization is partially constrained by an Ar/Ar cooling age of 163.67 ±0.84 Ma on biotite from a post-mineralization quartz-feldspar porphyry dike (Logan et al., 2007).

DEERHORN (MINFILE 093A 204)

The Deerhorn zone, located about 1 km northeast of the Megabuck zone, comprises mineralization that was encountered during a 2003 diamond-drilling program by Fjordland Exploration Inc., designed to test an area of anomalous copper in soils coincident with an IP anomaly that extends east-northeast from the Megabuck zone. The best mineralization came from hole DH-03-30, which intersected a breccia zone with quartz-carbonate veining and semimassive chalcopyrite, grading 0.90% Cu and 42.3 ppb Au over 15.4 m (Peters, 2004). Evaluation of this area is in its early stages, but diamond-drill hole WJ-06-70, 600 m northeast of hole DH-03-30, also encountered copper mineralization (Peters, 2007), as did two holes drilled on a separate IP anomaly in 2008, about 1 km north of DH-03-30 (Cariboo Rose Resources Ltd., 2008).

SPELLBOUND (MINFILE 093A 205)

The Spellbound showing is within hornfelsed sandstone of the polylithic breccia succession near the contact of the Takomkane batholith, about 2.3 km east of the Megabuck zone. It comprises minor amounts of chalcopyrite and pyrite in quartz stockworks within a broader area of tourmaline-epidote alteration. The mineralization was discovered by Noranda Exploration Company Ltd. in 1992, but has received little subsequent attention. A grab sample collected during an exploration program by Fjordland Minerals Ltd. in 2001 returned 1992 ppm Cu and 13 ppb Au (Peters, 2002, sample V-9).

TAKOM (MINFILE 093A 206)

The Takom zone is 2.5 km south of the Megabuck zone. Bedrock exposure is limited to a couple of old trenches and road scrapes, and consists of variably silicified and pyritic granodiorite to quartz monzodiorite that resembles the Woodjam Creek unit of the Takomkane batholith. Small exposures of pyrite-altered breccia occur a few hundred metres east of the granitic outcrops, and there are good exposures of epidote±tourmaline–altered breccia in a cut block about 700 m to the south. These breccia exposures are assigned to the polylithic breccia succession of the Nicola Group.

Exploram Minerals Ltd. tested the area with three diamond-drill holes in 1974 and another hole in 1977 (Cruz, 1974b, 1977). One of the holes, 74-3, intersected 1.3 g/t Au and 0.13% Cu over a 10.7 m interval that also included 1.5 m of 0.028% MoS_2 (Carne, 1984). Fjordland Exploration Inc. drilled eight reverse-circulation holes and one diamond-drill hole in 2005, to test coincident IP and copper-in-soils anomalies. The results were encouraging, and included an intersection grading 0.10 g/t Au and 0.12% Cu over the bottom 82.6 m of the diamond-drill hole (Peters, 2006, hole 05-48). A 526.4 m diamond-drill hole in 2006 intersected 0.033 g/t Au and 0.058% Cu over 464.0 m, and included several higher grade intersections (Peters, 2007, hole 06-71). The hostrocks intersected in Fjordland's drillholes are described mainly as feldspathic volcanics, volcaniclastics and breccias, cut by granitic intrusive rocks and hornblende porphyry. Mineralization consists of chalcopyrite, pyrite, magnetite and minor molybdenite, which occur in quartz stringers, as disseminations and along fractures.

SOUTHEAST ZONE

The Southeast zone is a porphyry-style copper-molybdenum-gold occurrence hosted by the Woodjam Creek unit of the Takomkane batholith. It is located on low, drift-covered ground a short distance west of Woodjam Creek, about 2.5 km east of the Takom occurrence. The mineralization was discovered in the late summer and fall of 2007, when Fjordland Exploration Inc. initiated a drilling program to test an IP chargeability anomaly identified by a geophysical survey conducted earlier that year. Three widely spaced vertical diamond-drill holes that were completed during the program were mineralized from top to bottom. The best grades came from hole WJ-07-79, which intersected 203.55 m grading 0.34% Cu and 0.014% Mo (Fjordland Exploration Inc., 2008a). Drilling began again in the spring of 2008 and, by the end of summer, a total of 15 vertical holes, totalling 6059 m, had been drilled in the Southeast zone; all were mineralized from the bedrock surface to the bottom of the hole (Fjordland Exploration Inc., 2008b). The deepest hole (WJ-08-82) extended to 700.4 m and intersected 570.9 m grading 0.24% Cu, 0.013% Mo and 0.028 g/t Au. The highest copper and gold grades so far recorded are from hole WJ-08-84, which intersected 226.77 m grading 0.93% Cu, 0.003% Mo and 0.40 g/t Au, including 51.00 m grading 1.61% Cu, 0.004% Mo and 0.84 g/t Au. Drilling has so far covered less than a third of the 1.5 km by 1.0 km IP anomaly, and mineralization remains open in all directions (Fjordland Exploration Inc., 2008b).

Mineralization in the Southeast zone consists of pyrite, chalcopyrite and molybdenite, which occur along fractures, in quartz veinlets and as disseminations. A core sample from diamond-drill hole WJ-07-79 was submitted to R. Creaser at the University of Alberta for Re-Os dating of molybdenum, and returned a model age of 196.9 ±0.9 Ma (J. Logan, pers comm, 2008). This Early Jurassic age demonstrates that mineralization was broadly synchronous with crystallization of the host Woodjam Creek unit of the Takomkane batholith.

MEGATON

The Megaton copper occurrence is hosted by the Woodjam Creek unit of the Takomkane batholith on the east side of Woodjam Creek, about 3 km northeast of Fjordland's Southeast zone. The initial discovery, made in the late summer of 1995 and followed up in the spring of 1996, comprised blocks of limonite- and malachite-stained granodiorite in a road bank within a new cut block. This led to staking of the Megaton claim group and several trenching programs, carried out from 1996 to 2006, that uncovered a significant area of copper mineralization (Wahl, 1996, 2002, 2006). The Megaton claims were subsequently optioned by Northern Rand Resource Corp., who carried out a major drilling program over the Megaton showing during the summer of 2008.

Trenches and drill roads on the Megaton showing expose highly fractured granodiorite, with fracture-controlled clay and limonite alteration, and abundant malachite and azurite, mainly along fractures and shears. Native copper is also reported, as are local occurrences of bornite, chalcopyrite and traces of molybdenite (Wahl, 2002, 2006). The sulphide minerals and their alteration products occur along fractures, in quartz veins and as disseminations.

The initial phase of diamond-drilling carried out by Northern Rand Resource Corp. consisted of 3186 m in 15 holes. Only a few preliminary results have been released, including intersections of 0.256% Cu over 13.9 m, 0.237% Cu over 7.1 m, and 0.340% Cu over 26 m, in hole MT 07a (Northern Rand Resource Corp., 2008).

SOUTH ROAD

The South Road showing is within the southern part of the Megaton claim group, on the slopes east of Woodjam Creek, about 1200 m southeast of Fjordland's Southeast zone. The mineralized outcrops were discovered in 1996, in the drainage ditch along a newly constructed logging road (Wahl, 1996). The mineralization consists of pyrite, chalcopyrite, malachite and local traces of molybdenite, which occur along fractures and shears cutting granodiorite of the Takomkane batholith (Woodjam Creek unit). Part of the original showing was re-exposed with a hand trench in 2002 (Wahl, 2002), but it has not received any subsequent attention.

Occurrences Associated with the Boss Creek and Schoolhouse Lake Units of the Takomkane Batholith

RODEO AND LUKY JACK OCCURRENCES

The Rodeo and Luky Jack occurrences are located 6–8 km southeast of Tisdall Lake. The TL claims, held by the Bethlehem Copper Corporation, were staked over this area in 1980 and were explored by Cominco Ltd. in 1981 with a program that included geological mapping, a soil geochemical survey and an induced-polarization geophysical survey (Rebic, 1981; Jackisch, 1981). Minor amounts of chalcopyrite and malachite, as disseminations and fracture-coatings, were identified at this time within quartz monzodiorite of the Takomkane batholith. Part of the area was re-staked as the Rodeo claims in 1998, to cover mineralization exposed in a pit excavated for road-fill during logging operations by Weldwood of Canada Ltd (Wahl, 1998). The adjoining Luky Jack claims were staked at the same time, to cover a zinc-in-soils geochemical anomaly and an adjacent IP geophysical anomaly, both identified by Cominco in 1981.

The Rodeo showing consists of chalcopyrite, locally with malachite and azurite, that occurs as disseminations, blebs and fracture-fillings associated with alteration and vein assemblages that include quartz, magnetite, epidote, K-feldspar and sericite. The hostrock is mainly quartz monzodiorite of the Takomkane batholith. A grab sample collected during the present study contained 6335.27 ppm Cu, 3824 ppb Ag and 212 ppb Au (Schiarizza et al., 2009, sample 08KBE-140). A short diamond-drill hole directed under the mineralized exposures in 2001 did not intersect any significant mineralization (Wahl, 2004).

The Luky Jack showing is located about 1800 m north-northeast of the Rodeo occurrence, and has been explored with trenches and two short diamond-drill holes (Wahl, 1998, 2004). It comprises quartz veins and stockworks that locally contain minor amounts of sphalerite and chalcopyrite, and are associated with alteration assemblages that include epidote, magnetite, K-feldspar and sericite. Hostrocks include the Boss Creek unit of the Takomkane batholith and adjacent breccias and flows of the Nicola Group.

GRANITE MOUNTAIN OCCURRENCE

The Granite Mountain copper occurrence is hosted by the Schoolhouse Lake unit of the Takomkane batholith, 5 km west-southwest of the Moffat Lakes. A group of claims covering this area was referred to as the Granite Mountain property by Bailey (2007), who described a small program of geological mapping and soil sampling. Mineralization consists of minor chalcopyrite and malachite marginal to shear-zone–hosted quartz veins, and minor malachite staining along joints within granodiorite to the south of the veins (Bailey, 2007).

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