Geologic Setting of Paleozoic Strata and Mineral Occurrences in the Mount Tod Region, South-Central British Columbia

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KEYWORDS: Kootenay Terrane, Quesnel Terrane, Silver Creek Formation, Eagle Bay Assemblage, Nicola Group, skarn alteration, massive sulphide deposits, disseminated sulphide mineral occurrences, Steep, Serpent, Chase Silica.

INTRODUCTION

The correlation and extent of pericratonic strata deposited on the western distal margin of ancient North America in south-central British Columbia is problematic. Within the Thompson-Okanagan-Shuswap and Adams Lake regions, strata included within the pericratonic Kootenay Terrane are poorly exposed, obscured by intense deformation, and mapped only at reconnaissance scale (Figure 1; Wheeler and McFeely, 1991). As a result, the boundary between pericratonic rocks of the Kootenay Terrane and rocks of the allochthonous Quesnel Terrane is a subject of debate. This boundary has been interpreted as a large scale, complex thrust zone (Monger *et al*., 1972, 1982; Wheeler and McFeely 1991). Alternatively, Mesozoic volcanic and volcaniclastic rocks of Quesnel Terrane may stratigraphically overlie and be linked to pericratonic strata of the Kootenay Terrane (Thompson and Daughtry, 1997).

Rocks of the Eagle Bay Assemblage in the Adams Plateau – Clearwater – Vavenby area, and the Sicamous, Tsalkom and Silver Creek formations in the Thompson – Okanagan – Shuswap region are included within the pericratonic Kootenay Terrane (Jones, 1959; Okulitch, 1979; Schiarizza and Preto, 1987). Volcanic and volcaniclastic rocks of the Late Triassic Nicola Group and arc-related rocks of the Devonian to Late Permian Harper Ranch Group characterize Quesnel Terrane in the Thompson – Okanagan – Shuswap area (Monger *et al*., 1982; Wheeler and McFeely 1991). The relationship of strata in the Mount Tod – Adams Lake area to assemblages of the Kootenay and Quesnel terranes is uncertain. These rocks are of significant economic interest since they are host to several polymetallic massive sulphide deposits. However, the distribution, setting, and age of most of these deposits is not well established (Höy, 1999).

Mapping of the area west of Adams Lake to Mount Tod was undertaken as part of the Ancient Pacific Margin NATMAP Project in an attempt to address these problems (Figures 2, 3 and 4). Particularly, reconnaissance and de-

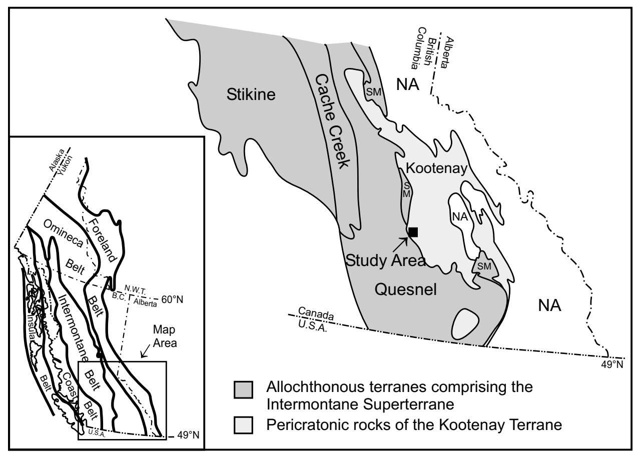

Figure 1. Location of the study area and the pericratonic Kootenay Terrane in southern British Columbia. SM = Slide Mountain Terrane, NA = North America.

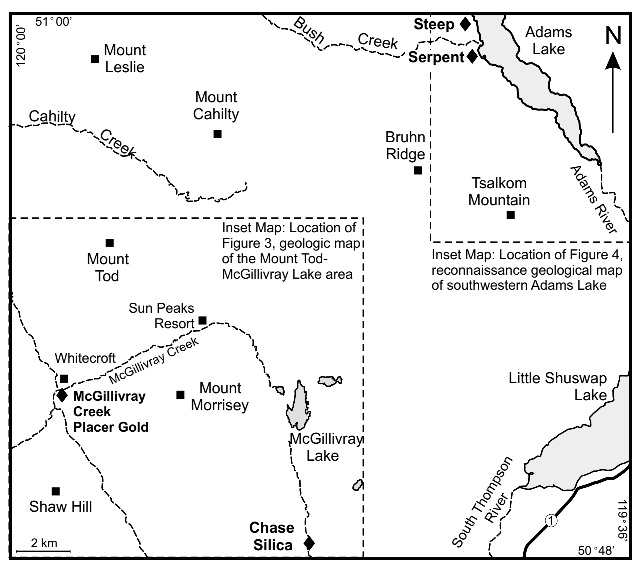

Figure 2. Location of the Mount Tod and Adams Lake study areas and limit of preliminary mapping.

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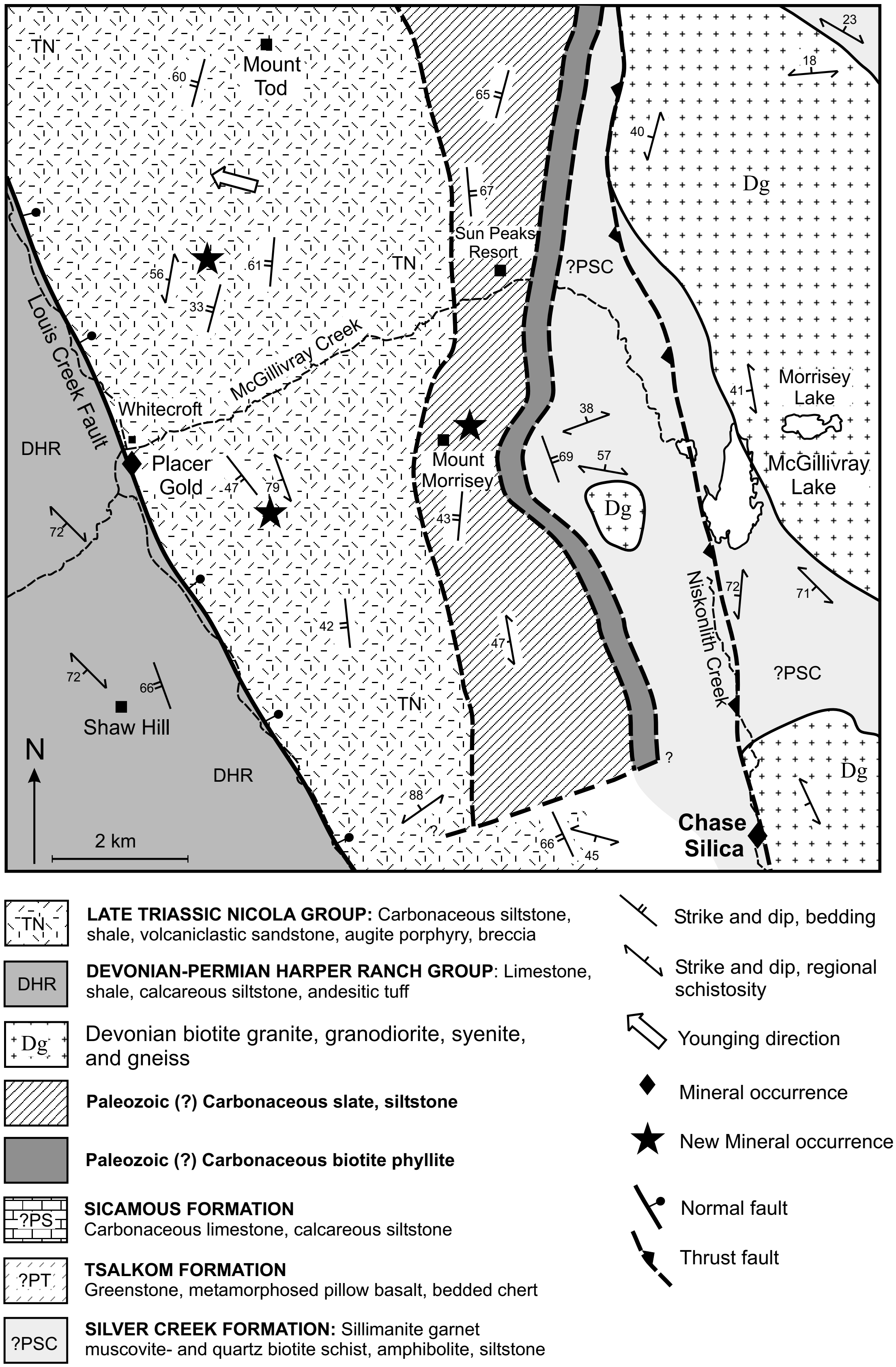

Figure 3. Simplified geologic map of the Mount Tod – McGillivray Lake area.

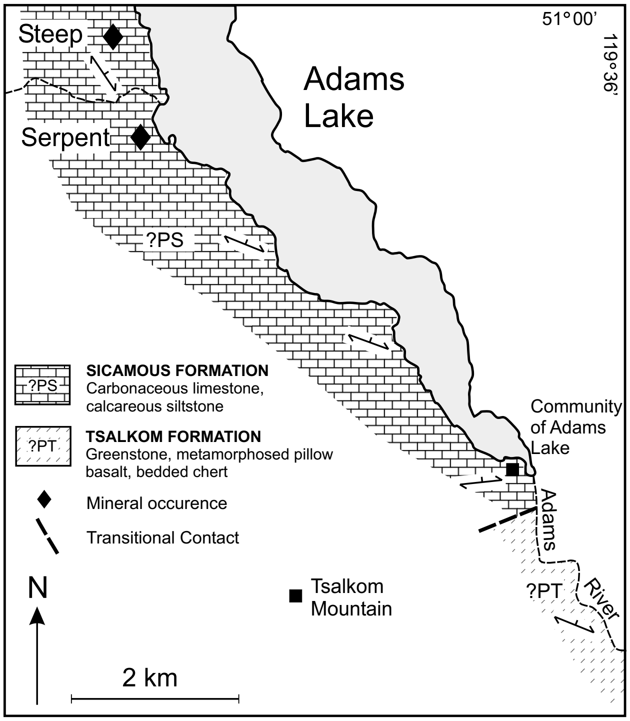

Figure 4. Reconnaissance geologic map of the shore of southwestern Adams Lake. Refer to Figure 3 for complete legend.

tailed field work focused on the following: 1) the relationship of rocks of the Early Cambrian to Mississippian Eagle Bay Assemblage in the Adams Lake-Clearwater region, and the Paleozoic Tsalkom and Sicamous formations mapped to the west and south of Adams Lake to rocks in the Mount Tod area; 2) the structural and tectonic relationships of pericratonic rocks in the Adams Lake – Mount Tod region; and 3) the distribution and setting of mineral deposits within the Mount Tod-Adams Lake region. This paper summarizes the initial findings of 9 weeks of fieldwork completed during the summer 2000 season.

REGIONAL GEOLOGY

Volcanic and clastic sedimentary rocks comprising the Devonian to Permian Fennell Formation of the oceanic Slide Mountain Terrane structurally overlie the Early Cambrian to Mississippian Eagle Bay Assemblage in the Adams Plateau – Clearwater – Vavenby area (Schiarizza and Preto, 1987; Roback *et al*. 1995). The Eagle Bay Assemblage consists of a complex succession of metasedimentary and metavolcanic rocks that are intruded by Late Devonian orthogneiss (Jones, 1959; Okulitch, 1979, 1989; Schiarizza and Preto, 1987). The basal part of the Eagle Bay Assemblage consists of quartzite and schist (Units EBQ and EBH) overlain by mafic metavolcanic rocks (Unit EBG) intercalated with Early Cambrian Tshinakin limestone. These lithologies are overlain by undated phyllite, carbonate, and metavolcanics (Unit EGS), metamorphosed basalt, chert and quartzite (Unit EBM), and carbonaceous phyllite and limestone (Unit EBL). The upper part of the Eagle Bay Assemblage consists of felsic to intermediate metavolcanic and metasedimentary rocks (Units EBA and EBP; Schiarizza and Preto, 1987).

Phyllite and limestone of the Sicamous Formation overlie mafic metavolcanic rocks of the Tsalkom Formation and quartzite, schist and marble of the Silver Creek Formation in the Thompson – Okanagan – Shuswap region (Jones, 1959; Okulitch, 1979, 1989; Roback *et al*., 1995). The ages of these formations are unknown due to a lack of microfossils and minerals suitable for radiometric age analysis. Jones (1959) proposed that the Silver Creek, Tsalkom, and Sicamous formations were "Archean or younger". Okulitch (1979) revised the geology of the Shuswap region, and assigned a Late Triassic age to the Sicamous Formation based on similarities to the Slocan Group in the Kootenay Arc. Okulitch (1989) modified this interpretation, and suggested that the Tsalkom and Sicamous formations may correlate with the Cambrian to Ordovician Jowett and Index formations within the Kootenay Arc based on lithological comparisons.

Volcanic and volcaniclastic rocks of the Late Triassic Nicola Group unconformably overlie unmetamorphosed sedimentary and volcanic rocks of the Devonian to Late Permian Harper Ranch Group in the Thompson – Okanagan – Shuswap area (Monger *et al*., 1982; Wheeler and McFeely 1991; Roback *et al*., 1995). The Nicola and Harper Ranch groups are the main stratigraphic elements of the island-arc Quesnel Terrane in this region.

GEOLOGY OF THE MOUNT TOD REGION

Silver Creek Formation

The Silver Creek Formation is a deformed and metamorphosed assemblage of pelitic schist, gneiss, amphibolite, siltstone, carbonaceous phyllite, aplite and pegmatite. These rocks have been metamorphosed to sillimanite grade and deformed into a series of tight polydeformed folds. The age of the Silver Creek Formation is unknown, but may be Late Proterozoic, to as young as Middle to Late Paleozoic (Okulitch, 1979, 1989; Thompson and Daughtry, 1997; Thompson, pers. comm. 2000). The upper contact of the Silver Creek Formation may be transitional with the basal portion of the Tsalkom and / or Sicamous Formation in the Okanagan-Shuswap region (Thompson and Daughtry, 1997).

The Silver Creek Formation is characterized by sillimanite-garnet-muscovite and quartz- plagioclase-biotite schist in the region immediately east of McGillivray Lake (Figure 3). Almandine garnet porphyroblasts are 0.5-2.0 cm in diameter, and are rotated relative to the enclosing fabric. Fine-grained crystals of pink-brown, fibrous sillimanite overprint and crosscut fine- to medium-grained metamorphic biotite. Schistosity is defined by the parallel alignment of coarse-grained flakes of biotite and muscovite up to 3 cm in diameter. Thin layers of dark grey-green actinolite-biotite schist and amphibolite occur locally in the McGillivray Lake area. These strata represent metamorphosed rocks of the Silver Creek Formation within the contact aureole of a Devonian (?) granitic body. West of McGillivray Lake, tightly folded, thinly bedded medium grey quartzite and siltstone metamorphosed to biotite grade are the dominant lithologies.

The metamorphic grade of the Silver Creek Formation decreases from sillimanite grade to chlorite-biotite grade eastwards from McGillivray Lake to the Tsalkom Mountain area (Figure 3). In the Tsalkom Mountain area, beds of rusty to brown weathering carbonaceous phyllite, slate and siltstone are interbedded with fine-grained quartz-biotite schist.

Sills of orthogneiss and sills and dikes of leucogranitic aplite and pegmatite are present throughout the Silver Creek Formation. The aplite and pegmatite sills and dikes are undeformed to weakly strained and 1-10 m in thickness. These sills and dikes may be intrusions related to the Devonian (?) granitic body near McGillivray Lake.

Carbonaceous Phyllite-Slate-Siltstone

A package of rocks consisting predominantly of carbonaceous phyllite and slate can be distinguished between the Silver Creek Formation and Nicola Group in the Mount Morrisey - McGillivray Creek area (Figure 3). Rusty weathering carbonaceous phyllites and slate are highly recessive, strongly deformed and metamorphosed to biotite-garnet grade near the peak of Mount Morrisey. Porphyroblasts of biotite are pervasive and occur as resistant-weathering books 2-4 mm in diameter. Biotite porphyroblasts are preferentially aligned along phyllitic surfaces that crosscut an older bedding-parallel foliation. Phyllites and slate are interbedded with thin beds of carbonaceous siltstone 0.5 to 1.5 m thick. Carbonaceous siltstones are rusty weathering, poorly indurated, and contain minor amounts of disseminated pyrite.

The carbonaceous phyllite-slate-siltstone unit may correlate with an assemblage of schist, marble, and quartzite separating the Silver Creek Formation from Triassic rocks correlative with the Nicola Group in the Vernon area (Thompson and Daughtry, 1997, 1998; Underschutz *et al*., 1999). This assemblage is interpreted as a stratigraphic transition zone, implying that rocks assigned to Quesnel Terrane are stratigraphically linked with pericratonic rocks of the Kootenay Terrane. Alternatively, these rocks may be metamorphosed sediments at the base of the Nicola Group, or a Sicamous Formation equivalent (Jones, 1959; Okulitch, 1979).

Devonian – Permian Harper Ranch Group

Limestone, slate, and calcareous and carbonaceous siltstone of the Harper Ranch Group are exposed in a northwest trending belt west of Louis Creek (Figure 3). These units are intercalated with thin layers of crystal-lithic andesitic tuff and ash tuff. Rocks of the Harper Ranch Group have been folded during chlorite- biotite-grade metamorphism, resulting in the development of a penetrative slatey cleavage. Mississippian to Permian limestones in the Shaw Hill area can be correlated with similar carbonaceous and calcareous siltstones to the northwest (Ray and Webster, 2000).

Carbonaceous siltstones of the Harper Ranch Group are brown to rusty weathering, silty and recessive. Two penetrative, intersecting cleavages are present. Beds of carbonaceous siltstone grade into thinly bedded light to medium grey calcareous siltstone up-section. Thin interbeds of limestone and veinlets of calcite (1-5 mm thick) are present throughout the siltstone unit. These rocks are overlain by dark brown weathering, massive, dark grey argillaceous limestone. Beds of argillaceous limestone are foliated and 5 to 20 m thick. The contact between these lithologies is poorly exposed, and is interpreted as being transitional. Carbonaceous siltstones and argillaceous limestones of the Harper Ranch Group are metamorphosed to chlorite grade.

Sedimentary rocks of the Harper Ranch Group are intercalated with layers of light to medium grey-green augite crystal-lithic andesitic tuff and chlorite ankerite ash tuff. These rocks are brown to rusty weathering, massive and friable. Contacts between tuffaceous and sedimentary units are sharp.

Triassic Nicola Group

Carbonaceous siltstone and slate, volcaniclastic sandstone and siltstone, augite crystal tuff, and augite porphyry flows and breccia characterize the Late Triassic Nicola Group in the area surrounding Mount Tod. These lithologies are well exposed, and deformed and metamorphosed to chlorite-biotite grade. Proximal to Louis Creek, west of Mount Tod, slate, siltstone and volcanic rocks of the Nicola Group are well-cleaved and metamorphosed to chlorite-biotite grade (Figure 3).

Carbonaceous siltstone and slate of the Nicola Group are rusty weathering and recessive, and consist of mud to silt-sized grains of quartz, feldspar, carbonaceous material and minor disseminated pyrite. Beds of slate and siltstone are 0.1 to 1.5 m thick and exhibit a phyllitic sheen on some bedding surfaces.

Massive beds of tuff and volcaniclastic sandstone are intercalated with carbonaceous siltstone and slate. Layers of medium grey, homogenous augite crystal and crystal-lithic tuff are 0.2 to 2.0 m thick with sharp basal contacts. Sandstone beds are rusty weathering, medium grey, fine to medium-grained, finely laminated and competent. Contacts between the sandstone and finer-grained units are undulating and sharp. Clasts of undeformed shale and siltstone (0.2-2.5 cm in diameter), cross-bedding, scours and graded bedding occur within the volcaniclastic sandstone. Facing directions are consistently up to the west and south, indicating that the units are upright.

Augite porphyry and augite porphyry breccia form resistant ridges and knobs throughout the study area. Ridges of augite porphyry comprise Mount Tod, which is the highest topographical feature in the region. Phenocrysts of euhedral black and pale green augite 2-4 mm in diameter are dispersed within an aphanitic matrix of andesitic composition. Breccia consists of sub-rounded to sub-angular clasts of augite porphyry 5 to 40 cm in diameter within a matrix of augite crystal-lithic tuff. All flows are 10 to 40 m in thickness, and 10 to 100 m in length along strike.

INTRUSIVE ROCKS

A poorly exposed body of massive biotite granite, granodiorite, syenite and gneiss intrudes metasedimentary rocks of the Silver Creek Formation in the McGillivray-Morrisey Lakes area (Figure 3). Equigranular, medium to coarse-grained granites and granodiorites consist of quartz, plagioclase, potassium feldspar, biotite and muscovite. These rocks are undeformed except in rare zones of intense deformation and strain in which biotite gneiss is developed.

Biotite granite and granodiorite in the McGillivray lake region has been previously interpreted to be Jurassic-Cretaceous in age (Jones, 1959). However, based on lithologic similarities to granitic intrusions such as the Ordovician (?) Little Shuswap Gneiss in the Thompson-Okanagan-Shuswap region and unit "Dgn" near Adams Lake, this granitoid may be of Ordovician to Devonian age (Okulitch, 1979, 1989; Schiarizza and Preto, 1987).

STRUCTURE

Deformation of the Silver Creek Formation and "carbonaceous phyllite-slate" unit in the Mount Tod region is dominated by a series of broad, northwest trending, west verging folds. Associated with the folds is a penetrative cleavage defined by the parallel alignment of micaceous minerals within slatey and pelitic rocks of the Nicola Group and Silver Creek Formation. This style of deformation is similar to the folding of strata of the Eagle Bay Assemblage in the Adams Lake-Johnson Lake region. Folds in the Johnson Lake region are northwest trending, shallowly dipping, and approximately parallel to a series of northwest trending thrust faults (Schiarizza and Preto, 1987; Bailey *et al*., 2000).

Rocks in the Mount Tod-Adams Lake region record at least two phases of folding. Two intersecting cleavage surfaces are evident within incompetent shale and slate sequences of the Harper Ranch and Nicola Groups. In these examples, a bedding-parallel cleavage is intersected by a second cleavage at an acute angle. Also, parasitic folds on limbs of tightly folded siltstones and quartzites of the Silver Creek Formation are common.

Volcanic and volcaniclastic rocks of the Nicola Group near Mount Tod are separated from rocks of the Harper Ranch Group in the Shaw Hill area by the Louis Creek Fault (Figure 3). Displacement across the Louis Creek Fault, a northwest-southeast trending, east-dipping normal fault, is estimated at 1 to 2 km. A west-dipping, north-south trending thrust fault separates rocks of the Silver Creek Formation from unit "Dg" in the Chase Silica quarry region (Figure 3). Rocks of the Silver Creek Formation are present in both the hangingwall and footwall north of the Chase Silica quarry, suggesting that displacement along the fault is minor. However, the original extent of the Silver Creek Formation is unknown, and the displacement across this fault is uncertain.

STRATIGRAPHY SOUTHWEST OF ADAMS LAKE

Tsalkom and Sicamous Formations

Exposures of the Tsalkom and Sicamous formations were examined during reconnaissance field trips along the western perimeter of Adams Lake (Figure 4). The Tsalkom Formation consists of laterally discontinuous massive greenstone, metamorphosed pillow basalt and bedded chert along the Adams Lake West Road south of the community of Adams Lake (Figure 4). The greenstones consist of massive, olive green, and foliated chlorite biotite schist. Altered chilled margins of remnant pillows can be identified within the metamorphosed basalts. Layers of well-bedded chert are intercalated with the greenstones and pillow basalts. Individual chert beds are white to light grey and 0.2 to 2.0 cm thick; each intercalated package of bedded chert is 1 to 10 m thick.

Massive outcrops of carbonaceous limestone and calcareous siltstone of the Sicamous Formation are present along the Adams Lake West Road proximal to the town of Adams Lake. Randomly oriented white calcite veins 2-6 cm thick crosscut the medium to dark grey limestone and siltstone. These rocks have been correlated with limestone and calcareous phyllite (unit EBL of Schiarizza and Preto, 1987) of the Eagle Bay Assemblage mapped in the Adams Lake-Clearwater region (Schiarizza and Preto, 1987; Schiarizza, pers. comm. 2000).

The contact between the Tsalkom and overlying Sicamous formation has been interpreted as gradational in the Adams Lake – Shuswap region (Thompson and Daughtry, 1997, 1998). Within the contact zone, which is 10 to 40 m thick, massive foliated greenstone of the Tsalkom Formation is interlayered with calcareous siltstone of the Sicamous Formation (Figure 4). The Sicamous Formation directly overlies rocks of the Silver Creek Formation in the area northeast of Adams Lake where the Tsalkom Formation is absent due to either non-deposition or structural disruption.

MINERALIZATION

Paleozoic rocks in the Mount Tod – Adams Lake region are host to several polymetallic massive sulphide, disseminated sulphide and silica deposits. The Steep / Eve (BC Minfile 082LNW052), Serpent / Eve (BC Minfile 082LNW051), and Chase Silica (BC Minfile 082LNW031) prospects were examined during the summer 2000 field season (Figures 2 and 4). As well, previously unrecognized and undescribed sulphide mineralization within the Nicola Group and carbonaceous phyllite-slate map unit near Mount Morrisey and the village of Whitecroft was investigated.

The Steep Pb-Zn skarn showing is located within altered and mineralized argillaceous limestone and calcareous phyllite of the Sicamous Formation. These rocks are overlain by quartz-sericite schist of the Eagle Bay Assemblage (Unit EBK), which are intruded by Late Devonian orthogneiss (Unit Dgn; Schiarizza and Preto, 1987). A concordant zone of skarn alteration is traceable for at least 10 km along strike and includes phyllitic calc-silicate and massive garnet-rich skarn (Ettlinger and Ray, 1989; Miller, 1989). The calc-silicate skarn is 50 to 140 m thick and includes actinolite, plagioclase, chlorite, epidote, pyroxene and quartz, whereas the garnet-rich skarn is greater than 50 m thick and comprises garnet, calcite, epidote, actinolite, chlorite, quartz, potassium feldspar, plagioclase and apatite. Mineralization is dominated by disseminated (5% average) to massive pyrrhotite, with lesser disseminated and massive pyrite, chalcopyrite, magnetite and rare sphalerite and galena. Trace amounts of gold associated with bismuth occurs with the pyrrhotite in some samples. Maximum assay values from drillhole intersections range from 1.68 to 5.8 grams per tonne gold, 4.6 ppm silver, 694 to 3830 ppm copper, 256 to 6910 ppm lead, and 400 ppm zinc (Ettlinger and Ray, 1989; Miller, 1989). It is uncertain whether the Steep property is an intrusion-related, epigenetic skarn deposit, or a syngenetic, exhalitive stratiform skarn deposit (Ettlinger and Ray, 1989).

The Serpent Cu-Pb-Zn massive sulphide showing occurs within the transitional contact zone between limestone and calcareous phyllite of the Sicamous Formation and quartz-sericite schist of the overlying Eagle Bay Assemblage (unit EBK of Schiarizza and Preto, 1987). The Serpent showing is located 2-3 km south of the Steep showing along the western shoreline of Adams Lake, proximal to a Devonian orthogneiss intrusion (Dgn of Schiarizza and Preto, 1987). Fine-grained and massive to disseminated pyrite, sphalerite, galena and chalcopyrite occurs within siliceous phyllite, graphitic schist, calcareous slate and limestone of both formations. The origin of the mineralization may be similar to the Steep property skarn deposit, yet remains uncertain.

Deposits in metasedimentary rocks of the Silver Creek Formation are located within altered and strained zones proximal to intrusive contacts. For example, the Chase Silica quarry is characterized by the occurrence of a 7 to 15 m thick white quartz vein located near the contact between pelitic schist and amphibolite of the Silver Creek Formation and Devonian (?) granite (Minfile 082LNW031). Within the quarry, located on Niskonlith Creek south of McGillivray Lake, the Silver Creek Formation is host to an extensive quartz vein stockwork system and exhibits pervasive quartz- sericite-fuchsite-pyrite alteration (Figure 3). Mineralization includes disseminated pyrite (2 to 7%), chalcopyrite (2 to 6%), pyrrhotite (2 to 5%), sphalerite, galena, scheelite and tungstenite.

Volcanic and volcaniclastic rocks of the Nicola Group and the carbonaceous phyllite-slate map unit are host to previously unrecognized showings of sulphide mineralization. Disseminated pyrite (2 to 8%), chalcopyrite (2 to 5%), and minor galena (< 2%) occur within metamorphosed augite crystal-lithic andesitic tuff and volcaniclastic sandstone and siltstone of the Triassic Nicola Group. Mineralized zones are 5 to 10 m thick and laterally discontinuous. The two main zones of mineralization are located west of Mount Morrisey and north of McGillivray Creek on the western flank of Mount Tod (Figure 3).

The carbonaceous-phyllite-slate unit is host to abundant disseminated sulphides. Fine-grained disseminated pyrite and chalcopyrite (2 to 5%) occurs within thin (0.5 to 1.5 m thick), rusty weathering beds of carbonaceous siltstone interbedded with phyllite and slate. Mineralized zones are laterally discontinuous, and extend 5 to 20 m along strike. Mineralization is constrained to the Mount Morrisey area. The age and origin of mineralization within rocks of the Nicola Group and carbonaceous phyllite-slate map unit is unknown.

SUMMARY

Preliminary mapping has resulted in two important observations pertaining to the the Mount Tod – Adams Lake area.

1) A sequence of carbonaceous phyllite and slate separate the Silver Creek Formation and Nicola Group in the Mount Morrisey - McGillivray Creek area. This package of rocks may represent a previously unrecognized sequence, a Sicamous Formation equivalent, or a package of metamorphosed sediments at the base of the Nicola Group.
2) Previously unrecognized disseminated pyrite, chalcopyrite, and galena mineralization occurs within reworked tuff of the Nicola Group, and within the carbonaceous phyllite-slate-siltstone map unit near Mount Morrisey and Mount Tod. Two zones of mineralization within rocks of the Nicola Group are recognized near Mount Morrisey and McGillivray Creek. Disseminate pyrite and chalcopyrite within the carbonaceous phyllite-slate-siltstone map unit is restricted to the Mount Morrisey area.

Establishing the stratigraphic and structural relationships of the Paleozoic rocks in the Adams Lake region is important for understanding the genesis of massive sulphide deposits and tectonic setting of the ancient distal margin of North America. Additional fieldwork is planned in the Mount Tod region, including detailed and regional mapping near Cahilty and Tsalkom Mountain, and sampling for paleontological and geochronological analyses.

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REFERENCES

Bailey, S.L., Paradis, P., and Johnston, S.T. (2000): Geological setting of the Samatosum and Rea massive-sulphide deposits, Eagle Bay Assemblage, south-central British Columbia; *Geological Survey of Canada*, Current Research 2000-A15, 10 pages.

Ettlinger, A.D. and Ray, G.E. (1989): Precious Metal Enriched Skarns in British Columbia: An overview and geological study; *British Columbia Ministry of Energy and Mines,* Paper 1989-3, 120 pages.

Höy, T. (1999): Massive Sulphide deposits of the Eagle Bay Assemblage, Adams Plateau, South-Central British Columbia (082 M/3, 4); *in* Geological Fieldwork 1998, *British Columbia Ministry of Energy and Mines*, Paper 1999-1, pages 223-245.

Jones, A.G. (1959): Vernon map-area, British Columbia; *Geological Survey of Canada,* Memoir 296, 186 pages.

Miller, D.C. (1989): Geological and Geochemical Report: Steep 1, 3, 4 and 5 Claims; *Discovery Consultants*, Vernon / Kamloops, B.C., 14 pages.

Monger, J.W.H., Souther, J.G. and Gabrielse, H. (1972): Evolution of the Canadian Cordillera; a plate tectonic model; *American Journal of Science*, volume 272, pages 577-602.

Monger, J.W.H., Price, R.A. and Templeman-Kluit, D.J. (1982): Tectonic accretion and the origin of the two major metamorphic and plutonic welts in the Canadian Cordillera; *Geology*, volume 10, pages 70-75.

Okulitch, A.V. (1979): Lithology, stratigraphy, structure and mineral occurrences of the Thompson-Shuswap-Okanagan area, British Columbia; *Geological Survey of Canada*, Open File 637.

Okulitch, A.V. (1989): Revised stratigraphy and structure in the Thompson-Shuswap-Okanagan map area, southern British Columbia; in Current Research, Part E, *Geological Survey of Canada*, Paper 89-1E, pages 51-60.

Ray, G.E. and Webster, I.C.L. (2000): Geology of the Heffley Lake Area, South-central British Columbia; *British Columbia Ministry of Energy and Mines*, Open File 2000-10.

Roback, R.C., Schiarizza, P., Nelson, J., Fyles, J., Ferri, F., Höy, T., Ash, C. and Danner, W.R. (1995): Late Paleozoic Arc and Oceanic Terranes and their external relationships, southern Quesnellia; *GAC/MAC Annual General Meeting 1995*, Field Trip Guidebook B2, Victoria, British Columbia, 79 pages.

Schiarizza, P. and Preto, V.A. (1987): Geology of the Adams Plateau-Clearwater-Vavenby area; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1987-1, 88 pages.

Thompson, R.I. and Daughtry, K.L. (1997): Anatomy of the Neoproterozoic-Paleozoic continental margin, Vernon map area, British Columbia; in Current Research 1997-A; *Geological Survey of Canada*, pages 145-150.

Thompson, R.I. and Daughtry, K.L. (1998): Stratigraphic linkages across Vernon map area, British Columbia; in Current Research 1998-A; *Geological Survey of Canada*, pages 181-187.

Wheeler, J.O. and McFeely, P. (comp.) (1991): Tectonic Assemblage Map of the Canadian Cordillera and adjacent parts of the United States of America; *Geological Survey of Canada*, Map 1712A, scale 1:2 000 000.