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Geological setting of Paleozoic strata in the Mount Todd–Adams Lake region, south-central British Columbia[1]

Shannon L. Acton*[3], *Suzanne Paradis*, *Robert I. Thompson*[2], and *Stephen T. Johnston*[3]
Mineral Resources Division, Sidney

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[1] Contribution to the Ancient Pacific Margin NATMAP Project

[2] 9860 West Saanich Road,
Sidney, British Columbia
V8L 4B2

[3] School of Earth and Ocean Sciences, University of Victoria,
P.O. Box 3055, Station CSC,
Victoria, British Columbia
V8W 3P6

Abstract

The (?)Paleozoic Sicamous and Tsalkom formations overlie deformed metasedimentary rocks of the Proterozoic and/or Paleozoic Silver Creek Formation in the Adams Lake area. The contact between these units may be transitional, an unconformity, or a fault. The Sicamous Formation can be correlated with unit EBL of the Eagle Bay Assemblage in the Adams Lake–Clearwater region.

A sequence of carbonaceous phyllite and slate separates the Silver Creek Formation from the Upper Triassic Nicola Group in the Mount Tod area. These rocks may represent a previously unrecognized sequence, a Sicamous Formation equivalent, or metamorphosed sedimentary rocks at the base of the Nicola Group.

Calcareous rocks of the Sicamous Formation host the Steep skarn and Serpent massive sulphide deposits. The Silver Creek Formation exhibits sulphide mineralization adjacent to a quartz-vein stockwork system within the Chase Silica quarry. Previously unrecognized massive sulphide mineralization occurs within the Nicola Group.

Résumé

Les formations (?)paléozoïques de Sicamous et de Tsalkom surmontent des roches métasédimentaires déformées de la formation protérozoïque et/ou paléozoïque de Silver Creek dans la région d'Adams Lake. Le contact entre ces formations peut être une transition, une discordance ou une faille. La Formation de Sicamous peut être mise en corrélation avec l'unité EBL de l'Assemblage d'Eagle Bay dans la région du lac Adams et de Clearwater.

Une succession de phyllade et d'ardoise carbonatés sépare la Formation de Silver Creek du Groupe de Nicola (Trias supérieur) dans la région du mont Tod. Ces roches pourraient représenter une séquence jusqu'à maintenant non reconnue, un équivalent de la Formation de Sicamous, ou une séquence de roches sédimentaires métamorphisées à la base du Groupe de Nicola.

Les roches calcaires de la Formation de Sicamous encaissent le gisement skarnifère Steep et le gisement de sulfures massifs Serpent. La Formation de Silver Creek présente une minéralisation en sulfures près d'un réseau de filons de quartz anastomosés en stockwerk dans la carrière Chase Silica. Une zone minéralisée de sulfures auparavant non reconnue se rencontre dans le Groupe de Nicola.

INTRODUCTION

The correlation and western extent of pericratonic strata deposited on the distal margin of ancient North America in south-central British Columbia is problematic. Within the Thompson–Okanagan–Shuswap region, strata included within the pericratonic Kootenay Terrane are poorly exposed, obscured by intense deformation, and mapped only at reconnaissance scale (**Fig. 1;** Wheeler and McFeely, 1991). For example, the relationship of pericratonic strata in the Mount Tod–Adams Lake area to rocks of the Eagle Bay Assemblage to the north and the Sicamous, Tsalkom and Silver Creek assemblages to the east and south is uncertain (Jones, 1959; Okulitch, 1979; Schiarizza and Preto, 1987). Rocks in the Mount Tod–Adams Lake region 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 (**Fig. 2** and **3**). Particularly, detailed and reconnaissance field work focused on the following: 1) the relationship of rocks of the Lower Cambrian to Mississippian Eagle Bay Assemblage in the Adams Lake–Clearwater region and the Paleozoic Tsalkom and Sicamous formations mapped 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 fieldwork completed during the summer 2000 season.

STRATIGRAPHY

Silver Creek Formation

The Silver Creek Formation is a highly 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 Upper Proterozoic, or as young as Middle to Upper Paleozoic (Okulitch, 1979, 1989; Thompson and Daughtry, 1997; R.I. Thompson, pers. comm., 2000).

The Silver Creek Formation is characterized by sillimanite-garnet-muscovite and quartz-plagioclase-biotite schist in the region immediately east of McGillivray Lake (**Fig. 3**). Almandine garnet porphyroblasts are 0.5 to 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 adjacent to intrusive contact(s) 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 are the dominant rock types. The Silver Creek Formation decreases from sillimanite grade to chlorite-biotite grade eastward from McGillivray Lake to the Tsalkom Mountain area (Fig. 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 dykes of leucogranitic aplite and pegmatite are present throughout the Silver Creek Formation. The aplite and pegmatite sills are undeformed to weakly strained, 1 to 10 m thick, and have been interpreted to represent melted and redistributed sediments of the Silver Creek Formation (K.L. Daughtry, pers. comm., 2000). Alternatively, sills and dykes may be intrusions related to the (?)Devonian granitic body near McGillivray Lake.

The upper contact of the Silver Creek Formation may be transitional with the basal portion of the Tsalkom Formation and/or Sicamous Formation in the Okanagan–Shuswap region (Thompson and Daughtry, 1997). This contact was examined during reconnaissance field trips in the Adams Lake area, and will be investigated during future field seasons.

Tsalkom and Sicamous formations

Exposures of the Tsalkom and Sicamous formations were examined during reconnaissance field trips along the western perimeter of Adams Lake (Fig. 2). 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 to 6 cm thick crosscut the medium to dark grey limestone and siltstone. These rocks can be 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; P. Schiarizza, pers. comm., 2000).

The Tsalkom Formation consists of laterally discontinuous massive greenstone, metamorphosed pillow basalt, and bedded chert along the Adams Lake West road south of the town of Adams Lake. The greenstone consists of massive, olive-green, 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 greenstone and pillow basalt. 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.

The contact between the Tsalkom and overlying Sicamous formations 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, calcareous siltstone beds of the Sicamous Formation are interlayered with massive foliated greenstone. The Sicamous Formation directly overlies rocks of the Silver Creek Formation in the area northeast of Adams Lake where the Tsalkom Formation is absent because of either nondeposition or structural disruption.

Carbonaceous phyllite-slate-siltstone

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

On the basis of lithological similarities to rocks mapped in the Vernon region and previous mapping in the Shuswap–Okanagan region, this unit is assumed to be equivalent in age to the Sicamous Formation (Jones, 1959; Okulitch, 1979; Thompson and Daughtry, 1997, 1998). Alternatively, these rocks may be metamorphosed sedimentary rocks at the base of the Nicola Group. Petrographic and geochemical analyses are being undertaken to assist in the interpretation of this unit.

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 (Fig. 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

(Ray and Webster, 2000). Limestone samples were collected from the Shaw Hill area for conodont analysis to verify the classification of these rocks as Mississippian to Permian (Ray and Webster, 2000) and to assist in correlation with similar carbonaceous and calcareous siltstone to the northwest.

Carbonaceous siltstone of the Harper Ranch Group weathers brown to rusty and is silty and recessive. Two penetrative, intersecting cleavages are present. Beds of carbonaceous siltstone grade upsection into thinly bedded, light to medium grey, calcareous siltstone. Thin interbeds and veinlets of limestone and 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 rock types is poorly exposed and is interpreted as being transitional.

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 weather brown to rusty and are 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 Upper Triassic Nicola Group in the area surrounding Mount Tod. These units are well exposed, undeformed, and unmetamorphosed. 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 (**Fig. 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 each other and with beds of 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), crossbedding, 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 make up Mount Tod, the highest topographic feature in the region. Phenocrysts of euhedral black and pale green augite 2 to 4 mm in diameter are dispersed within an aphanitic matrix of andesitic composition. Breccia consists of subrounded to subangular 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 thick and discontinuous 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 (**Fig. 3**). Granite and granodiorite are equigranular, medium- to coarse-grained, and 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 as Jurassic–Cretaceous (Jones, 1959). However, on the basis of lithological 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 Ordovician to Devonian (Okulitch, 1979, 1989; Schiarizza and Preto, 1987). Samples of granite and granodiorite collected for the purpose of radiometric age dating are being processed to test this interpretation.

STRUCTURE

Deformation of the Silver Creek Formation and 'carbonaceous phyllite-slate' unit in the Mount Tod–Adams Lake 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 is similar to deformed strata of the Eagle Bay Assemblage in the Adams Lake–Johnson Lake region. Folds in this area 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 of the Silver Creek Formation, carbonaceous phyllite-slate unit, and Nicola Group in the Mount Tod–Adams Lake area 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 siltstone and quartzite 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 (**Fig. 3**). Displacement across the Louis Creek Fault, a northwest-trending, east-dipping normal fault, is minor. A west-dipping, north-trending thrust fault separates rocks of the Silver Creek Formation from unit Dg in the Chase Silica quarry region (Fig. 3). Rocks of the Silver Creek Formation are present in both the hanging wall and footwall north of the Chase Silica quarry, suggesting that displacement along the fault is minor.

MINERALIZATION

Paleozoic rocks in the Mount Tod–Adams Lake region are host to several polymetallic massive-sulphide and silica deposits. Several occurrences have been previously described in detail and include the Steep 3/Eve (Minfile 082LNW052), Serpent/Eve (Minfile 082LNW051), and Chase Silica (Minfile 082LNW031) prospects (**Fig. 2**). The Steep 3 Pb-Zn skarn showing is located within altered and mineralized argillaceous limestone, phyllitic calcsilicate skarn, garnet skarn, and quartz-sericite phyllite of the Sicamous Formation. Mineralization includes disseminated and massive galena, pyrite, and chalcopyrite. The Serpent Cu-Pb-Zn massive-sulphide showing occurs within the transitional contact zone between the Sicamous Formation and the overlying unit EBK of the Eagle Bay Assemblage (Schiarizza and Preto, 1987). Massive to disseminated pyrite, sphalerite, galena, and chalcopyrite occur within siliceous phyllite, graphitic schist, calcareous slate, and limestone of both formations.

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 thick (7–15 m) white quartz vein located near the contact between pelitic schist and amphibolite of the Silver Creek Formation and (?)Devonian granite. 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 (Fig. 1). Mineralization includes disseminated pyrite, chalcopyrite, pyrrhotite, sphalerite, galena, scheelite, and tungstenite.

Volcanic and volcaniclastic rocks within the Nicola Group and the carbonaceous phyllite-slate map unit are host to previously unrecognized showings of massive sulphides. Disseminated to massive pyrite, chalcopyrite, and galena occur within metamorphosed augite crystal-lithic andesitic tuff and volcaniclastic sandstone and siltstone of the Triassic Nicola Group near Mount Morrisey. Within the carbonaceous phyllite-slate unit, fine-grained disseminated pyrite and chalcopyrite are abundant.

SUMMARY AND DISCUSSION

Preliminary mapping has resulted in three important observations pertaining to the setting and significance of pericratonic strata in the Mount Tod–Adams Lake area. 1) Highly deformed metasedimentary rocks of the Silver Creek Formation are overlain by the (?)Paleozoic Sicamous and Tsalkom formations in the Adams Lake area. The nature of this contact remains a matter of conjecture — it may be transitional, an unconformity, or a fault. 2) A sequence of carbonaceous phyllite and slate separates 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 sedimentary rocks at the base of the Nicola Group. 3) Calcareous siltstone and limestone of the Paleozoic Sicamous Formation can be correlated with limestone and calcareous phyllite (unit EBL of Schiarizza and Preto, 1987) of the Eagle Bay Assemblage in the Adams Lake–Clearwater region. Also, massive greenstone of the Tsalkom Formation may be equivalent to greenstone and metamorphosed pillow basalt (unit EBM of Schiarizza and Preto, 1987) of the Eagle Bay Assemblage. Pelitic schist and quartzite of the Silver Creek Formation may also be correlative with units EBQ and EBH of the Eagle Bay Assemblage (Schiarizza and Preto, 1987). Further fieldwork and petrographic, geochemical, and geochronological analyses are required to better define these relationships.

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 the tectonic setting of the ancient distal margin of North America. Detailed and regional mapping of the Cahilty and Tsalkom Mountain regions and sampling for paleontological and geochronological analyses will commence during future field seasons to determine these relationships.

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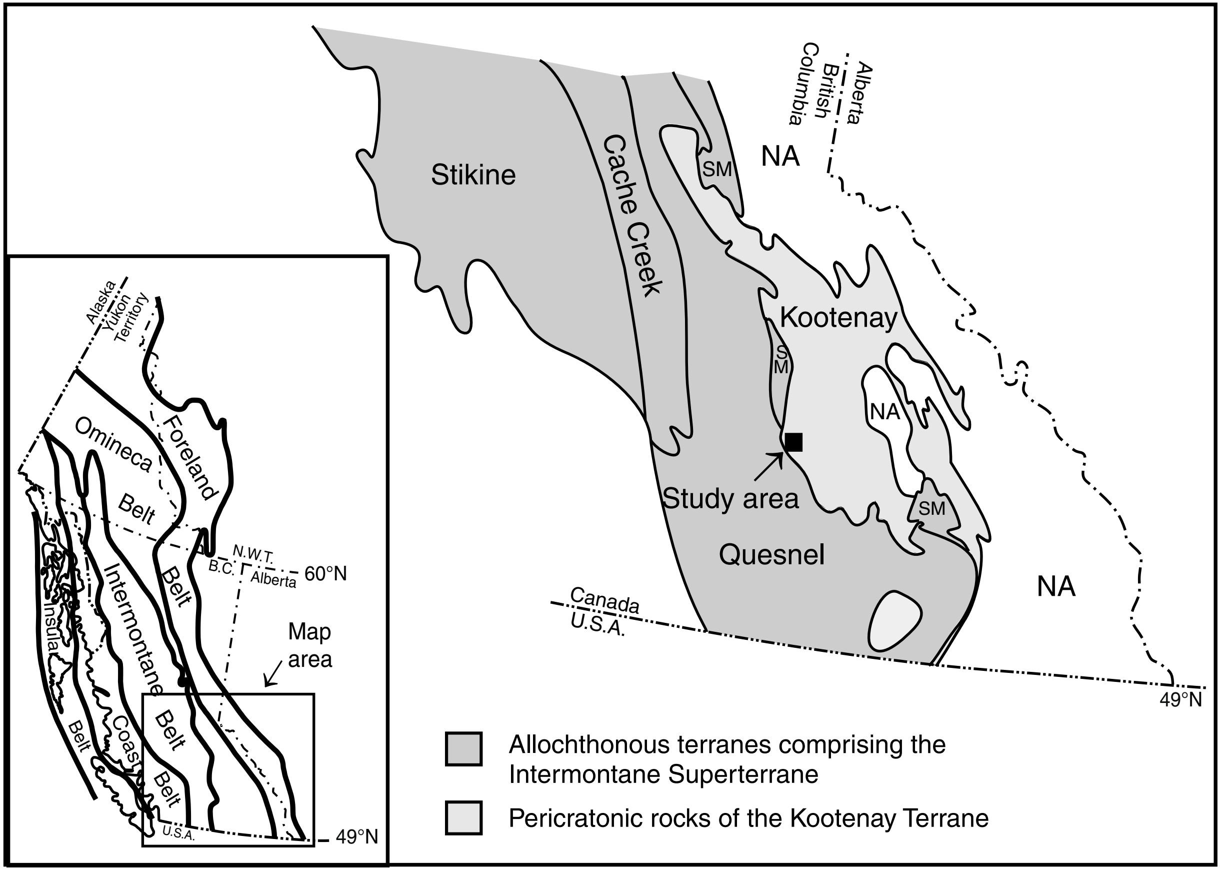

Figure 1. Location of the study area and the pericratonic Kootenay Terrane in southern British Columbia. SM = Slide Mountain Terrane, NA = North America

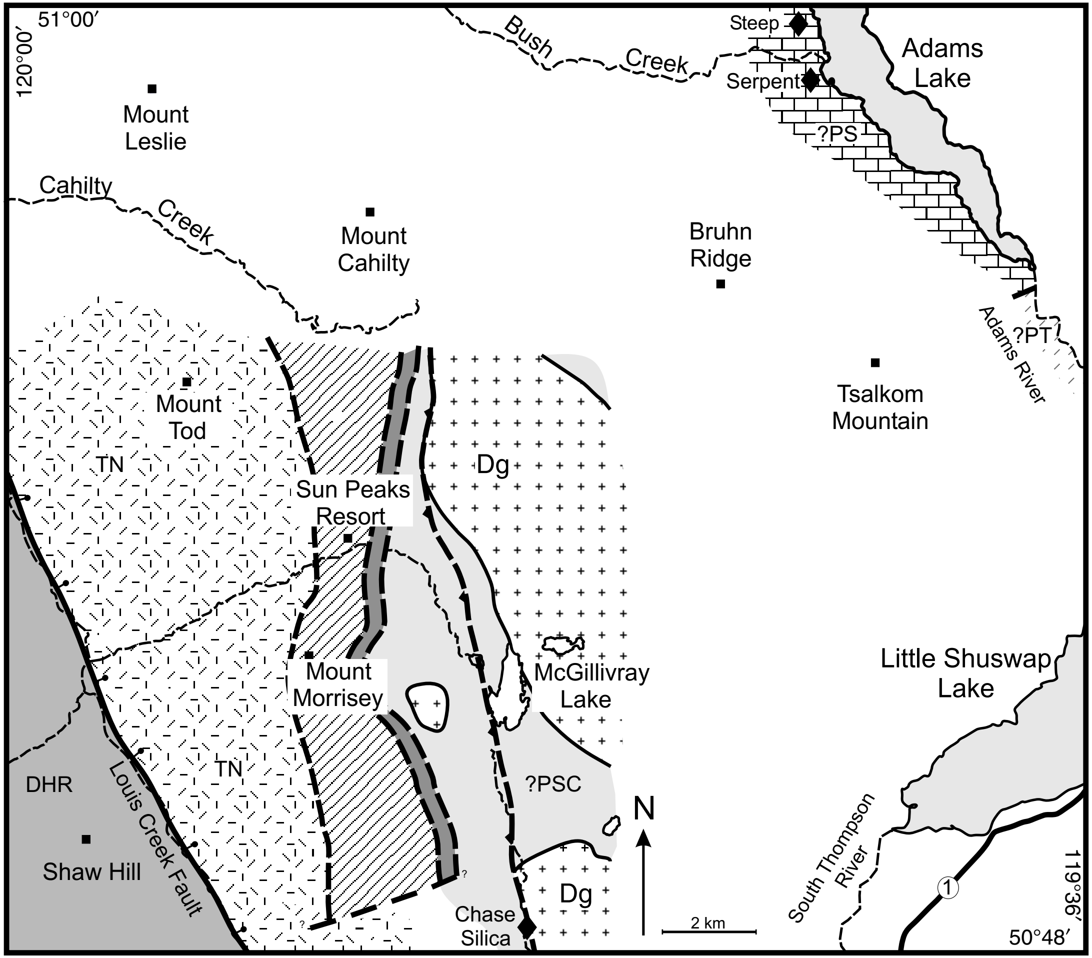

Figure 2. Location of the Mount Tod–Adams Lake study area and limit of preliminary mapping. Inset map: location of Figure 3, simplified geological map.

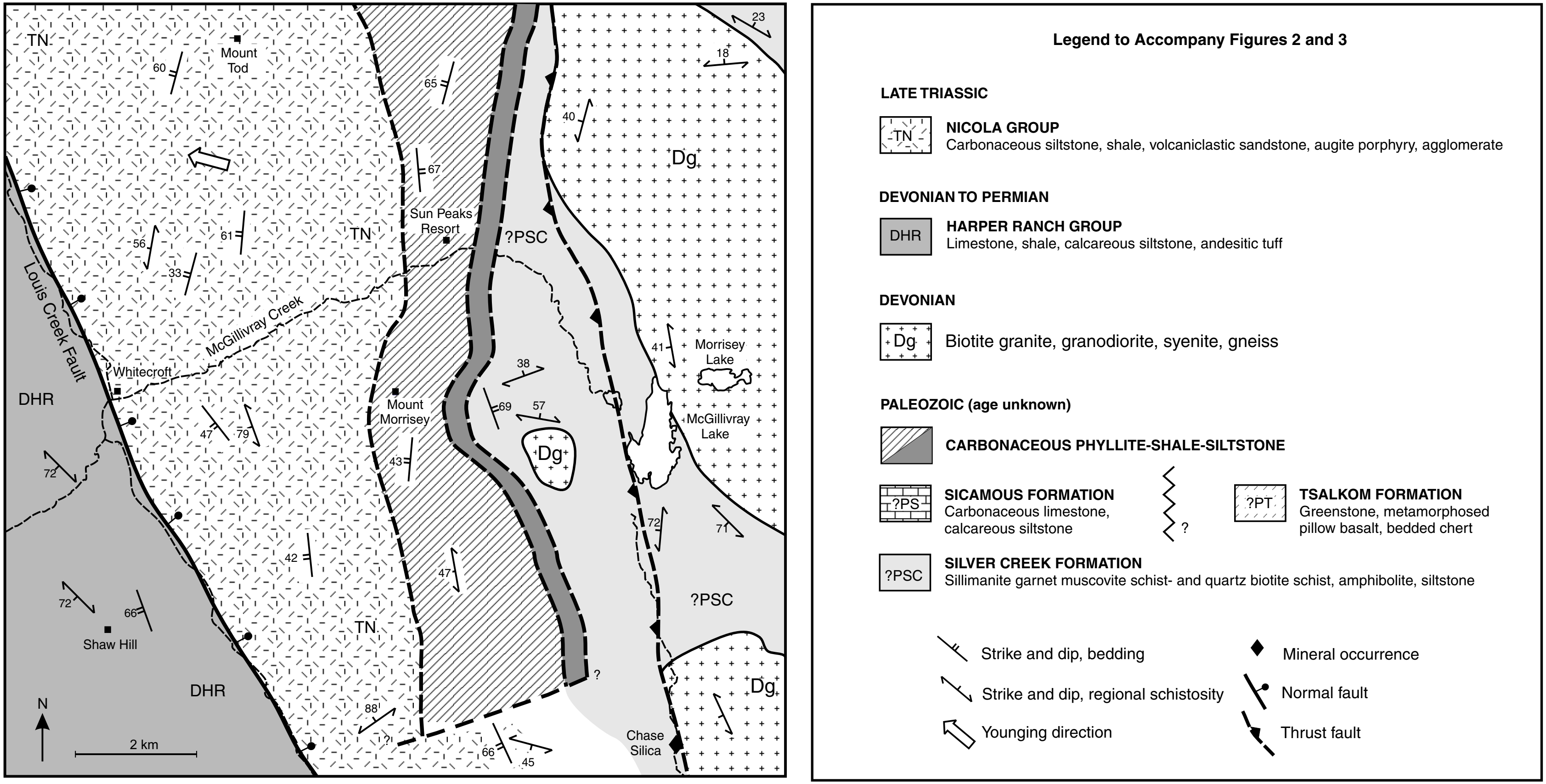

Figure 3. Simplified geological map of the Mount Tod–Adams Lake area showing the distribution of geological units and representative bedding and cleavage.