Geology of the Kutcho Assemblage between the Kehlechoa and Tucho Rivers, Northern British Columbia (NTS 104I/01, 02)

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KEYWORDS: Kutcho assemblage, Cache Creek complex, Sinwa Formation, Inklin Formation, Whitehorse trough, King Salmon fault, Nahlin fault, Kutcho Creek volcanogenic massive sulphide deposit

INTRODUCTION

The Kutcho project is a two-year bedrock mapping program initiated by the British Columbia Geological Survey Branch in 2010. The main goals of the project are to gain a better understanding of, and provide more detailed geological maps for, the Permo-Triassic Kutcho assemblage, which hosts the Kutcho Creek volcanogenic massive sulphide deposit. This study is a component of the Natural Resources Canada-led Edges (Multiple Metals-Northwest Canadian Cordillera (Yukon, British Columbia)) project, which is a contribution to the GEM (Geomapping for Energy and Minerals) program. The GEM program was initiated by the Federal Government in 2008 to enhance public geoscience knowledge in northern Canada, in order to stimulate economic activity in the energy and mineral sectors.

The 2010 mapping program covered about 200 square kilometres east of upper Kutcho Creek (Schiarizza, 2011a, b). Fieldwork in July and August 2011 covered an additional 200 square kilometres west of the creek, but also included some fill-in traverses within the 2010 map area. The 2011 field program was carried out by a single traverse team comprising the author and student assistant Matthew Newman (Simon Fraser University). Work was conducted from Kutcho Copper Corporation's exploration camp on Kutcho Creek. Operating funds were provided by the British Columbia Geological Survey Branch, a private-public partnership agreement with Kutcho Copper Corporation (a subsidiary of Capstone Mining Corporation) and the Geological Survey of Canada (Edges project).

The Kutcho project area is located in the southeast corner of NTS map sheet 104I (Cry Lake), and encompasses the transition between the Stikine Ranges of the Cassiar Mountains to the north and the Spatsizi Plateau to the south. The nearest community is Dease Lake, located on Highway 37, 100 km west-northwest of the Kutcho Creek deposit. A poor tote road connects the map area to Dease Lake, but the most efficient access is by air, facilitated by a gravel airstrip at the exploration camp on the west side of Kutcho Creek.

The geological interpretation presented here builds on studies carried out by the Geological Survey of Canada in the Cry Lake and Dease Lake map areas from 1956 to 1991 (summarized by Gabrielse, 1998), including regional studies of the Kutcho assemblage by Monger (1977), Monger and Thorstad (1978), Thorstad (1979, 1984) and Thorstad and Gabrielse (1986). It also incorporates work carried out in the vicinity of Kutcho Creek deposit by provincial government geologists from 1974 to 1977 (Panteleyev, 1975, 1978; Pearson and Panteleyev, 1976; Panteleyev and Pearson, 1977a, b), and detailed studies of the deposit and surrounding rocks by Bridge *et al.* (1986), Barrett *et al.* (1996) and Childe and Thompson (1997).

This report summarizes the geology of the entire project area, because the 2011 mapping program has prompted revisions to several aspects of the geology presented by Schiarizza (2011a) for the area east of Kutcho Creek. Those map units and structures for which the interpretation remains unchanged will be briefly summarized, with reference to the earlier report.

REGIONAL GEOLOGICAL SETTING

The geological setting of the Kutcho project area is shown on Figure 1. The map area is located at the east end of the King Salmon allochthon, a relatively narrow structural/stratigraphic belt that has been traced several hundred kilometres to the west-northwest, and separates the main exposures of the oceanic Cache Creek terrane to the north from those of the Stikine arc terrane to the south. The allochthon itself consists mainly of Early to Middle Jurassic clastic sedimentary rocks of the Inklin Formation, which forms the main exposure belt of the Whitehorse trough in northern British Columbia. The allochthon is bounded by the King Salmon and Nahlin faults, which are interpreted as northerly dipping thrust faults that were active in early Middle Jurassic time.

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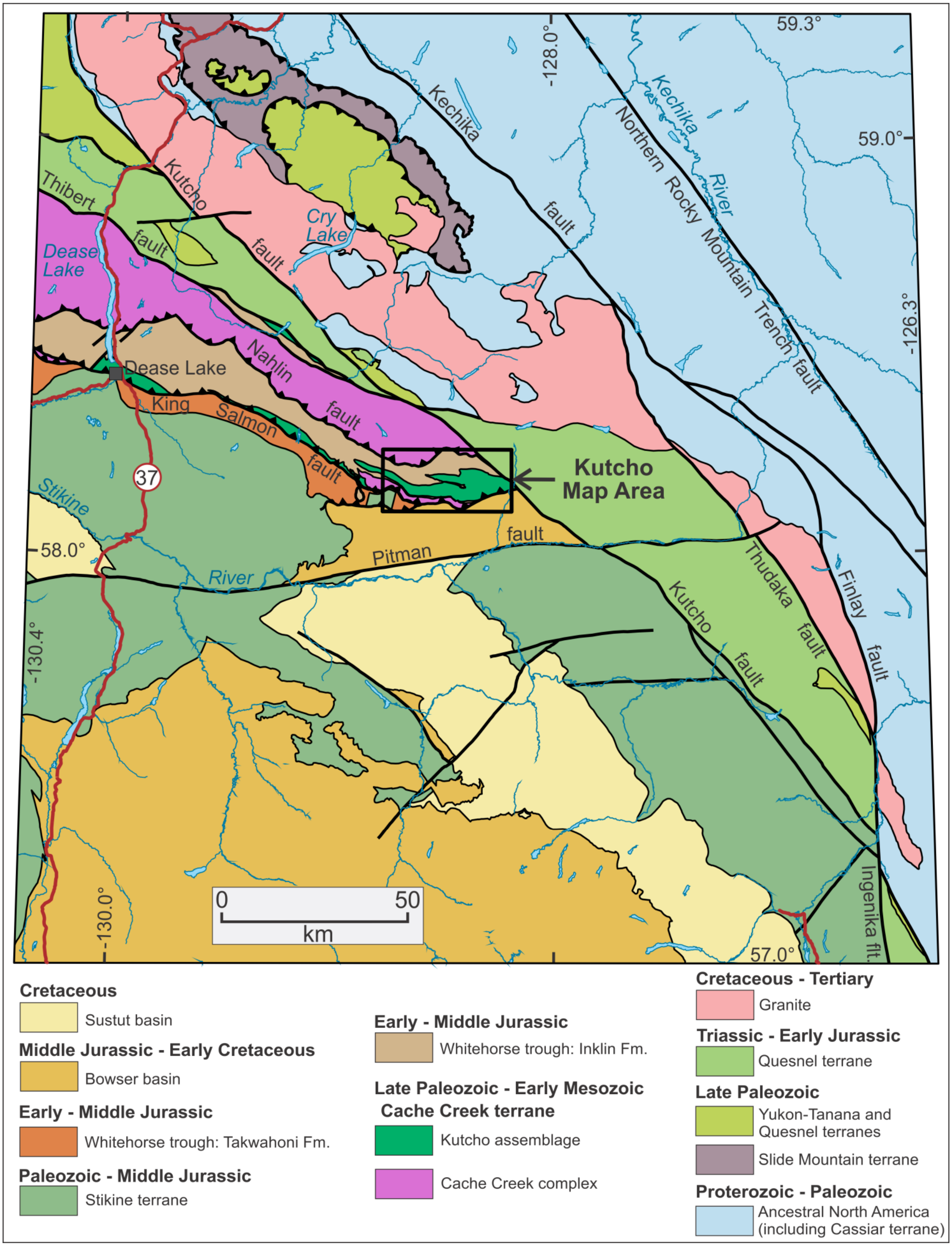


Figure 1. Regional geological setting of the Kutcho map area, after Massey *et al.* (2005).

The Cache Creek terrane is represented mainly by the Cache Creek complex, which includes structurally interleaved slices of chert, argillite, basalt, carbonate, wacke, gabbro and alpine ultramafic rocks, collectively ranging from Early Mississippian to Early Jurassic in age (Monger, 1975; Cordey *et al.*, 1991; Gabrielse, 1998; Mihalynuk *et al.*, 2004). Although the main belt of Cache Creek exposures is northeast of the Nahlin fault, slivers of the Cache Creek complex also occur within the eastern part of the King Salmon allochthon, where they are spatially associated with Permo-Triassic bimodal volcanic and volcaniclastic rocks of the Kutcho assemblage, which may represent a primitive oceanic arc sequence within Cache Creek terrane. The Kutcho assemblage and Cache Creek complex within the King Salmon allochthon are stratigraphically overlain by the Inklin Formation, indicating that they form part of the basement to the Whitehorse trough.

The Stikine terrane comprises a stacked succession of arc-derived volcanic, sedimentary and plutonic rocks that includes the Paleozoic Stikine assemblage, the Upper Triassic Stuhini Group and the Lower to Middle Jurassic Hazelton Group (Anderson, 1993). The Takwahoni Formation, exposed along the northeastern edge of Stikine terrane, comprises Lower to Middle Jurassic conglomerate and sandstone that are coeval with the finer grained clastic rocks of the Inklin Formation within the adjacent King Salmon allochthon. The two formations are interpreted as proximal and distal facies, respectively, of the Whitehorse trough, which may represent a forearc basin that formed along the margin of Stikine terrane (Johannson *et al.*, 1997; English *et al.*, 2005). A well-studied section of the Takwahoni Formation at Lisadele Lake in the Tulsequah map area records progressive unroofing of Stikine terrane in the Lower Jurassic section and a profound provenance shift marked by Cache Creek-derived chert pebble conglomerate in Middle Jurassic (Bajocian) rocks at the top of the section (Mihalynuk *et al.*, 2004; Shirmohammad *et al.*, 2007). The chert-rich Bajocian rocks may correlate with the basal part of the Middle Jurassic to Lower Cretaceous Bowser Basin, a successor basin that overlies large areas of Stikine terrane, but received a significant clastic input from Cache Creek terrane and other non-Stikine sources (Tipper and Richards, 1976; Evenchick *et al.*, 2007). Late Cretaceous clastic rocks of the Sustut Basin crop out mainly along the eastern margin of the Bowser Basin, where they were deposited during deformation of Bowser Basin strata in the Skeena fold belt (Evenchick, 1991; Evenchick *et al.*, 2007).

The King Salmon allochthon, together with adjacent Cache Creek and Stikine terranes, is truncated to the northeast by a system of northwest-striking faults that record significant dextral strike-slip displacement of Cretaceous and Tertiary age (Gabrielse, 1985, 1998; Gabrielse *et al.*, 2006). This fault system offsets the King Salmon allochthon from correlative rocks of the Sitlika assemblage, which crop out 300 km to the south in the Takla Lake area of central British Columbia (Monger *et al.*, 1978; Gabrielse, 1985; Schiarizza and Massey, 2010). The fault panels directly northeast of the Cache Creek – King Salmon – Stikine belts include mid-Paleozoic, late Paleozoic and Mesozoic arc sequences that are part of Yukon-Tanana and Quesnel terranes (Gabrielse, 1991; Nelson and Friedman, 2004). Farther northeast, these rocks are faulted against, and intruded by, a major belt of granitic rocks that includes the Cretaceous Cassiar Batholith. The rocks northeast of this granitic belt consist mainly of Proterozoic through Paleozoic sedimentary rocks of North American affinity, locally overlain by thrust slices of oceanic Slide Mountain terrane, Quesnel terrane and Yukon-Tanana terrane, which together comprise the Sylvester allochthon (Gabrielse, 1991; Nelson and Friedman, 2004).

GEOLOGICAL UNITS

The distribution of the main geological units within the Kutcho map area is shown on Figure 2. Figure 3 provides a more detailed map of the central part of the area, and shows subdivisions of the Kutcho assemblage and Whitehorse trough that are not indicated on Figure 2. Figure 4 presents schematic vertical cross-sections through the area, along lines that are indicated on figures 2 and 3.

The map area is underlain mainly by rocks within the King Salmon allochthon, including the Cache Creek complex, the Kutcho assemblage, and overlying Triassic-Jurassic metasedimentary rocks of the Whitehorse trough. All of these rocks, and a thick gabbroic sill that cuts the northern part of the Kutcho assemblage, are penetratively deformed and characterized by a cleavage or schistosity defined by greenschist facies mineral assemblages. South-verging folds and north dipping thrust faults that deform the main map units are broadly contemporaneous with the metamorphism and probably formed in early Middle Jurassic time. The allochthon is bounded to the south by the north dipping King Salmon thrust fault, and to the north by the Nahlin fault. Clastic sedimentary rocks of the Takwahoni Formation and Bowser Lake Group occur in the footwall of the King Salmon fault, and rocks of the Cache Creek complex crop out on the north side of the Nahlin fault. The northwest striking Kutcho fault truncates the King Salmon allochthon near the northeast edge of the map area, and juxtaposes it against undated plutonic rocks, mainly granodiorite and quartz diorite, which are part of the Quesnel terrane. The youngest rocks mapped in the area comprise small post-metamorphic plugs of diorite that cut the Kutcho assemblage. These plugs, and abundant sills and dikes of hornblende-pyroxene-plagioclase porphyry that are associated with them, are probably Eocene in age. Other post-metamorphic dikes, including lamprophyre and hornblende porphyry, are of unknown age.

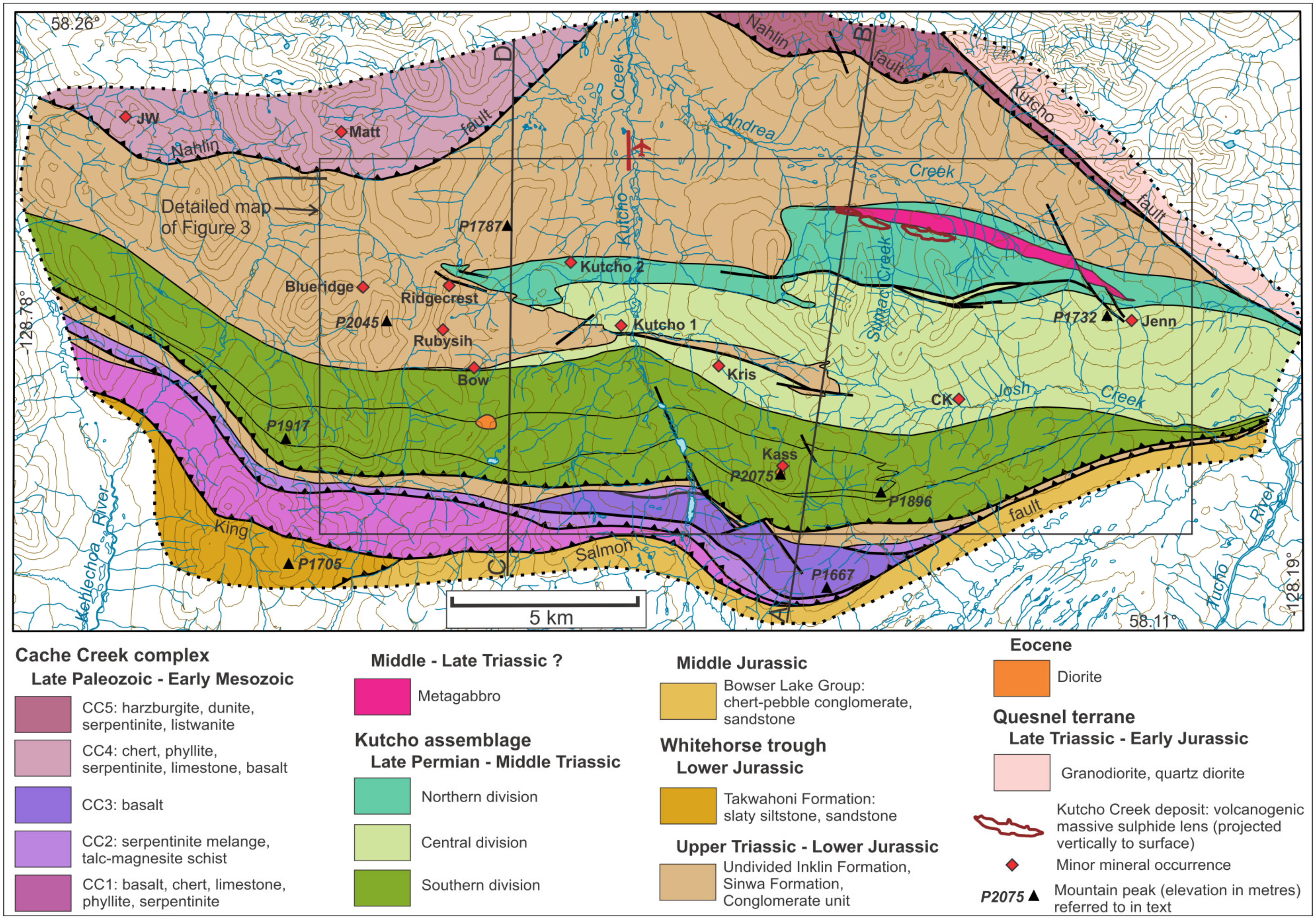
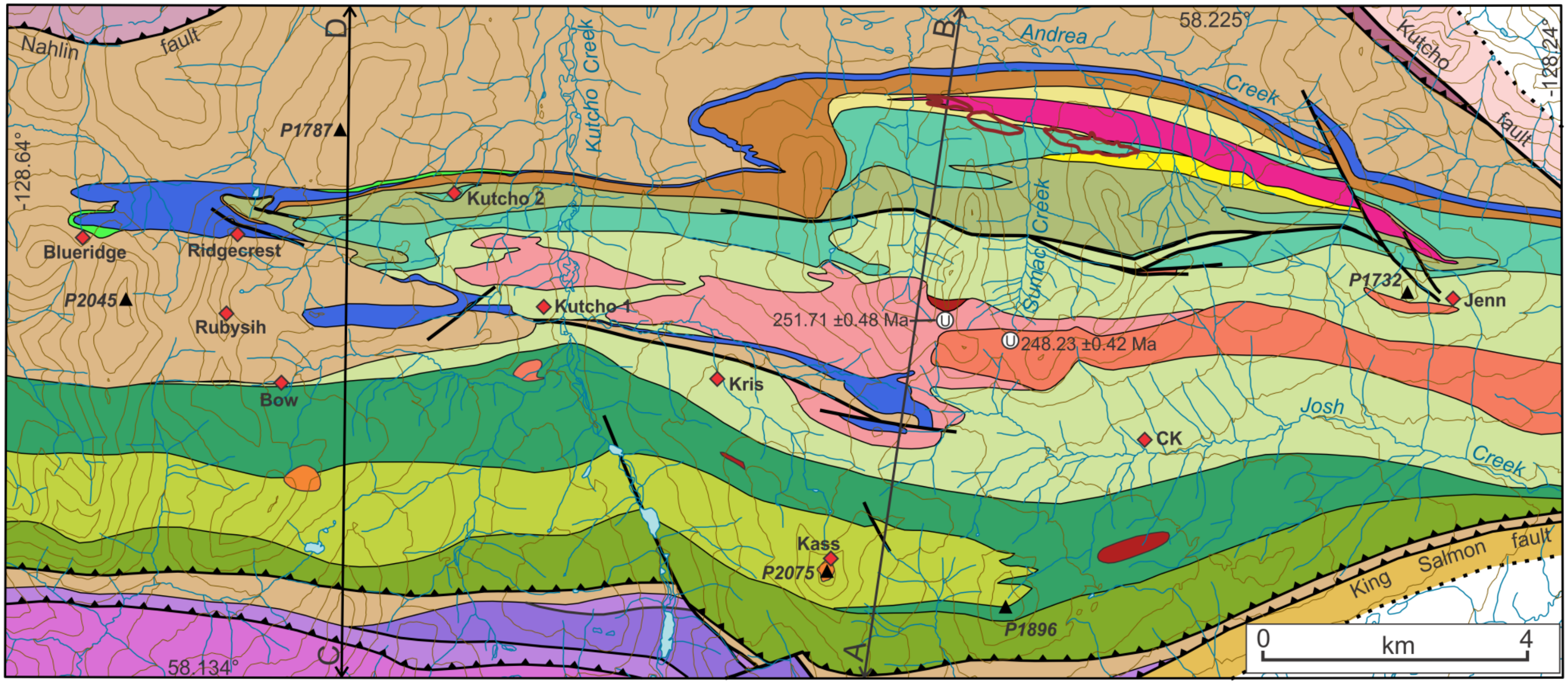


Figure 2. Generalized geology of the Kutcho map area, based mainly on 2010 and 2011 fieldwork.



Kutcho assemblage
Southern division

- KS3: epidote-chlorite schist derived from mafic volcanic rocks
- KS2: felsic fragmental schist, metarhyolite, epidote-chlorite schist, sandstone, phyllite
- KS1: feldspathic schist; felsic fragmental schist

Kutcho assemblage
Intrusive rocks

- Tonalite
- Diorite

Central division

- Metarhyolite; epidote-chlorite schist; felsic fragmental schist; sandstone, phyllite, chert
- Metarhyolite

Ⓤ U/Pb zircon date (sample collected in 2010; dated by R. Friedman, UBC)

Kutcho assemblage
Northern division

- KNs: phyllite, siltstone, sandstone; gabbro
- KNa: pyritic quartz-sericite schist
- KNf: feldspathic sericite-chlorite schist; breccia, metarhyolite
- KNq: coarse quartz-eye chlorite-sericite schist; breccia

Whitehorse Trough
Early - Middle Jurassic

- Inklin Formation: slate, siltstone, sandstone, conglomerate, limestone
- Gritty feldspathic sandstone

Late Triassic

- Sinwa Formation: limestone, marble

Late Triassic ?

- Conglomerate; clasts derived from Kutcho assemblage

Figure 3. Geology of the central part of the Kutcho map area, showing detailed subdivisions of the Kutcho assemblage and Whitehorse trough.

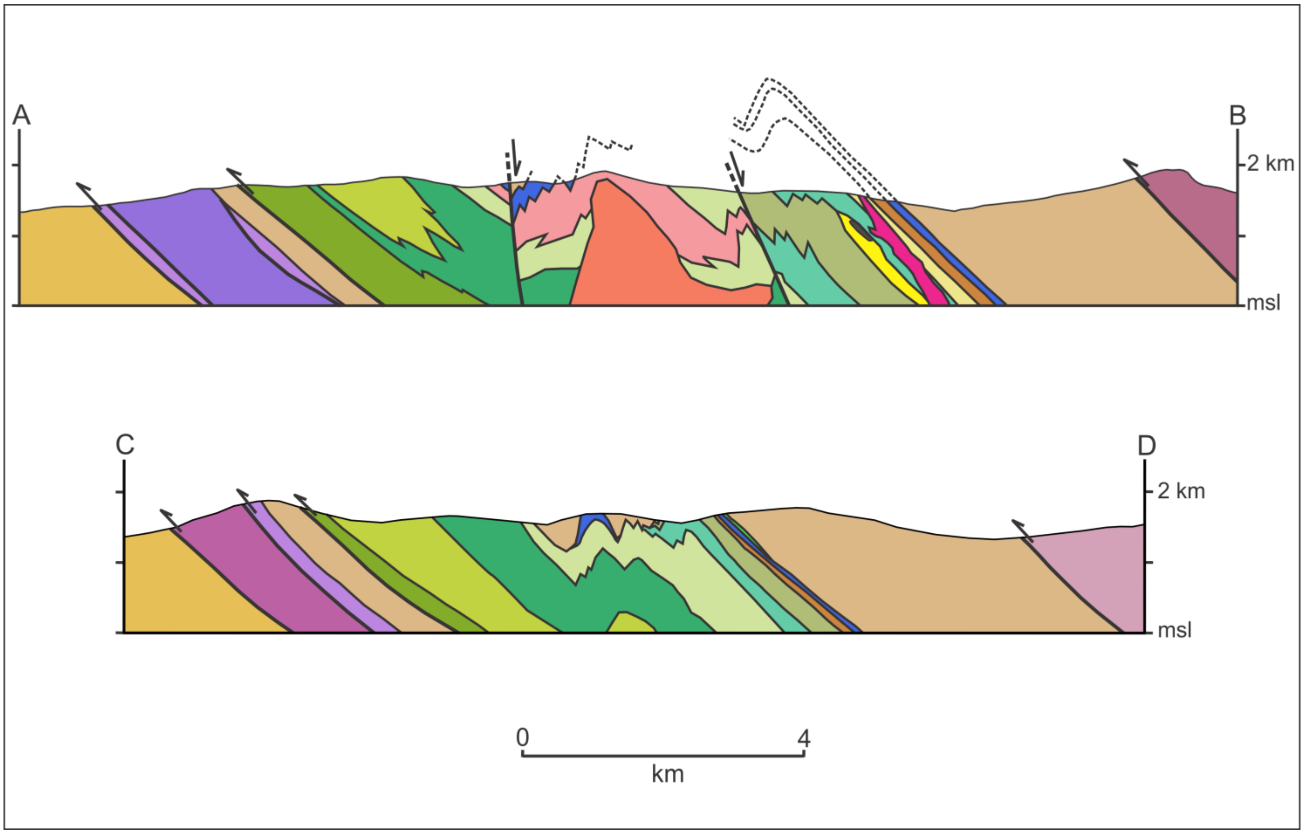


Figure 4. Schematic vertical cross-sections along lines A-B and C-D, shown in figures 2 and 3. See figures 2 and 3 for legend.

Cache Creek complex

The Cache Creek complex forms a narrow lens along the structural base of the King Salmon allochthon, in the central and western parts of the map area, where it is subdivided into 3 informal units, designated CC1, CC2 and CC3. The complex is also represented by two units that crop out north of the Nahlin fault; unit CC4 west of Kutcho Creek and unit CC5 east of the creek. There are no paleontologic or radiometric dates available for any of the Cache Creek rocks in the Kutcho map area.

UNIT CC1

Unit CC1 forms the structural base of the Cache Creek complex within the King Salmon allochthon. It is a heterogeneous unit dominated by three main components: chlorite schist and semischist derived from mafic volcanic rocks; siliceous phyllite and chert; and limestone. These components are structurally interleaved on a scale of metres to hundreds of metres. Individual units are lenticular and are typically separated from adjacent units by contacts that are parallel to the strong north-dipping schistosity.

Mafic volcanic rocks comprise light to dark green, typically rusty brown weathered chloritic schists and semischists that commonly contain abundant calcite and epidote as veins and/or disseminations. There is little indication of original mineralogy or texture at the outcrop scale, but a thin section shows a relict volcanic texture of intergrown plagioclase and clinopyroxene, partially overprinted by metamorphic chlorite, epidote and actinolite. Coarser grained epidote-chlorite-plagioclase schists occur locally, and were probably derived from diabasic or gabbroic intrusive phases. Narrow units of serpentinite were also noted within, or along the margins of, some of the mafic metavolcanic lenses.

Siliceous metasedimentary units consist mainly of light to dark grey or greenish grey platy quartz phyllites that comprise narrow lenses of very fine grained quartzose rock, typically less than 1 cm thick, separated by phyllitic partings containing sericite and chlorite. Grey or green chert is also common, and occurs as lenticular beds, 1 to 5 cm thick, separated by phyllitic partings. Narrow units of relatively homogeneous medium to dark grey phyllite or calcareous phyllite occur locally, but are not common.

Medium to dark grey, light grey weathered limestone occurs as units ranging from less than 1 m to more than 50 m thick. Some of the thick limestone units can be traced for several km. None of the limestone lenses are conspicuously fossiliferous, but samples collected during the 2011 field season are being processed for conodonts.

UNIT CC2

Unit CC2 is a serpentinite melange unit that comprises serpentinite and talc-magnesite schist which enclose blocks and lenses of a variety of other Cache Creek lithologies. It forms a narrow unit that has been traced for about 20 kilometres within the King Salmon allochthon, where it structurally overlies unit CC1 or, near the western edge of the map area, an intervening lens of metasedimentary rocks assigned to the Inklin Formation. This belt of serpentinite melange forms the structurally highest unit of the Cache Creek complex in the west, but in the south-central part of the map area it is structurally overlain by a metabasalt unit that is assigned to unit CC3. Discontinuous lenses of serpentinite melange occur structurally above the metabasalt unit, and these are also assigned to unit CC2.

Irregularly-foliated green to black serpentinite is the dominant lithology within unit CC2. The mineralogy of the ultramafic protolith is generally not apparent, although a lens of harzburgite occurs within serpentinite at one locality near the west edge of the map area. Rusty weathered talc-magnesite schist is also common, and typically displays gradational, interfingering contacts with serpentinite. The largest knockers, ranging up to several hundred metres in size, comprise mafic intrusive complexes that are dominated by gabbro, but also include pyroxenite, feldspar pyroxenite, diabase and, rarely, diorite or quartz diorite. Mafic volcanic rocks, including chlorite schist, chloritic semischist and massive, silicified greenstone, are also very common, and occur as blocks ranging up to several tens of metres in size. Metasedimentary rocks are rare within the serpentinite melange, but metre-scale knockers of chert and cherty argillite occur locally.

UNIT CC3

Unit CC3 consists of metabasalt, with rare thin lenses of bedded chert and limestone, which forms a belt about 10 km long and up to 1.5 km wide near the east end of the Cache Creek exposures within the King Salmon allochthon. The medium to pale green, weakly to moderately schistose metabasalt forms monotonous greenish brown to rusty brown weathered exposures, as described by Schiarizza (2011a). Unit CC3 is structurally underlain by the main serpentinite melange belt assigned to unit CC2, but it is also overlain by apparently discontinuous lenses of similar serpentinite melange, also assigned to unit CC2. This arrangement, and the lithologic similarity between unit CC3 and basalt knockers that are common within unit CC2, suggests that unit CC3 is essentially a large lens within the serpentinite melange belt.

UNIT CC4

Cache Creek rocks north of the Nahlin fault in the northwestern part of the map area, which were examined only briefly during the 2011 field season, are assigned to unit CC4. Rocks in the central part of this belt, near the Matt showing, are dominated by a light to dark grey siliceous metasedimentary assemblage that includes thin-bedded chert, siliceous phyllite, cherty argillite and phyllite. Discontinuous layers of light grey weathered limestone, up to 10 m thick, are fairly common, and lenses of metabasalt and serpentinite occur locally. Similar rocks also occur in the flanking areas to the east and west, but here the assemblage includes a higher proportion of metabasalt, and also contains large amounts of serpentinite and talc-magnesite schist.

UNIT CC5

Unit CC5 consists of variably serpentinized ultramafic rocks, including harzburgite and dunite, which crop out on the north side of the Nahlin fault in the northeast part of the map area. These rocks are briefly described by Schiarizza (2011a). They are part of a widespread ophiolitic assemblage that forms a major part of the Cache Creek terrane of northern British Columbia (Monger, 1975; Terry, 1977; Ash, 2001; English *et al.*, 2010).

Kutcho assemblage

The Kutcho assemblage is a heterogeneous package of schists derived from felsic and mafic volcanic and volcaniclastic rocks and associated felsic and mafic intrusions. The widest belt of exposures, and the informal type area for the assemblage, is within the current map area (Thorstad and Gabrielse, 1986), but the Kutcho assemblage also occurs as several smaller lenses that have been mapped within the King Salmon allochthon as far west as Dease Lake (Gabrielse, 1998).

The history of nomenclature, age assignments and correlations for rocks now included in the Kutcho assemblage is summarized by Schiarizza (2011a). The assemblage is assigned a Permo-Triassic age based on U-Pb zircon dates presented by Childe and Thompson (1997), and new dates obtained during the current study. Childe and Thompson (1997) obtained primitive Nd isotopic signatures from Kutcho volcanic rocks and primitive Pb isotopic signatures from the syngenetic mineralization of the Kutcho Creek volcanogenic massive sulphide deposit. These data, together with geochemical data presented by Barrett *et al.* (1996), showing that mafic and felsic volcanic rocks from the northern part of the Kutcho assemblage have an arc tholeiite affinity, suggest that the Kutcho assemblage represents part of a primitive intra-oceanic arc.

Schiarizza (2011a) subdivided the Kutcho assemblage into three main divisions referred to as southern, central and northern. This same three-fold scheme is applied here, although nomenclature and definitions of some of the internal units within the northern and southern divisions have been modified. Although there are local fold repetitions, rocks within the assemblage generally dip and face to the north. Available dates, shown on Figure 5, indicate that the northern division is, at least in part, younger than the central division, consistent with a younger above older stratigraphic relationship. There are no dates yet available for the southern division; it appears to rest

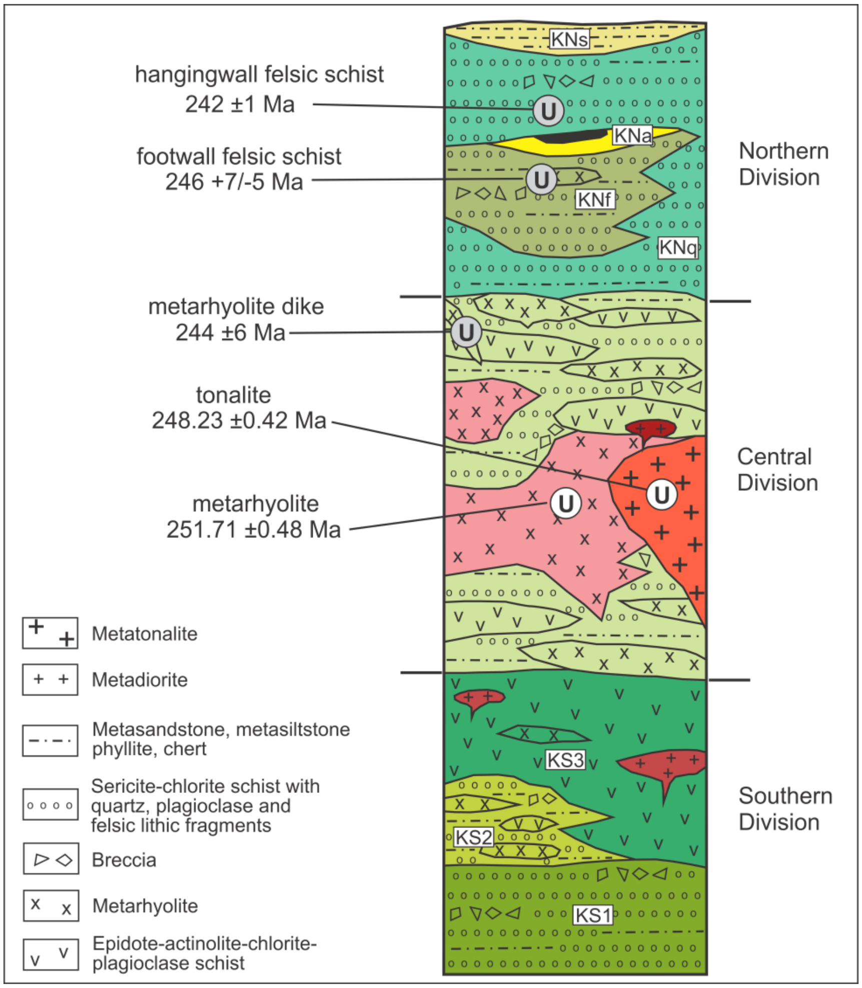


Figure 5. Schematic stratigraphic column through the Kutcho assemblage, showing main lithologic components and available age constraints. See Figure 3 for colour legend.

stratigraphically beneath the central division, but it might be a lateral equivalent, separated from the overlying rocks by a cryptic fault.

SOUTHERN DIVISION

Schiarizza (2011a) subdivided the southern division of the Kutcho assemblage into two units, a basal clastic and volcaniclastic unit referred to as KS1 and an overlying unit of mafic schists referred to as KS2. This scheme was modified by Schiarizza (2011b), who split the lower unit into two parts, KS1 and KS2, and assigned the upper mafic schists to unit KS3. This latter scheme is followed here, with an additional modification whereby clastic rocks that were included in the basal part of unit KS1 are taken out of the unit and assigned to the Inklin Formation. The basal contact of the Kutcho assemblage is an inferred north dipping thrust fault that places unit KS1 above these Inklin rocks.

Unit KS1

Unit KS1 comprises gritty and fragmental schists that were derived mainly from felsic epiclastic rocks. They are typically medium to dark green, and weather to a pale brownish green colour. Gritty varieties consist of plagioclase grains, 1-4 mm in size, within a well-foliated matrix that contains variable proportions of chlorite, sericite, quartz, plagioclase, calcite and epidote, and locally actinolite or stilpnomelane. The clastic plagioclase grains are commonly accompanied by smaller and less abundant quartz grains, and in some narrow intervals quartz predominates over plagioclase. Fragmental schists are similar, but include flattened, commonly epidote-altered lithic fragments (Figure 6). The lithic fragments are typically a few millimetres to a few centimetres in size, but coarser units, with lithic clasts up to 10 cm in longest dimension, occur locally. The fragments are dominated by aphanitic to very fine-grained felsite, locally with small feldspar and/or quartz phenocrysts. Fragments composed of fine grained, equigranular intergrowths of feldspar and quartz are also present, and one exposure, 1.5 km east of peak 1896, includes a substantial number of medium grained quartz monzonite clasts. The schists of unit KS1 locally display a crude stratification, and rarely occur as distinct thin to thick beds, some of which are graded (Schiarizza 2011a). The well-bedded intervals may include thin interbeds of fine to medium grained schisty quartz-feldspar metasandstone

Figure 6. Felsic fragmental schist, unit KS1, 4 km south-southeast of peak 2045.

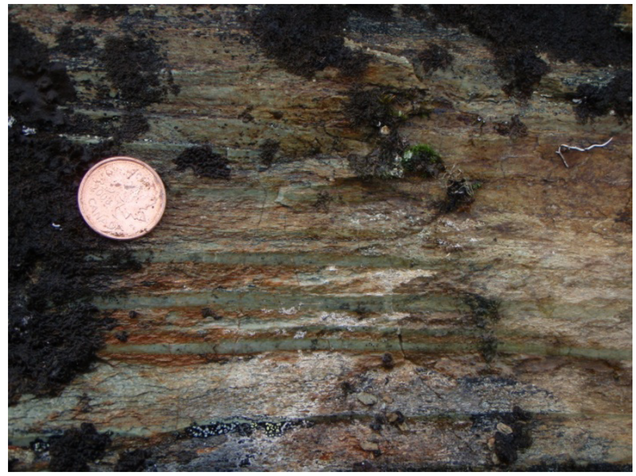


Figure 7. Thin-bedded metasandstone and metasiltstone, unit KS2, 4 km southwest of peak 2045.

and/or laminated phyllite and metasiltstone.

Unit KS2

Unit KS2 is a discontinuous map unit that extends from the slopes north of peak 1896, where it interfingers with unit KS3, westward to the area of peak 1917 (Figure 2). It apparently pinches out west of the latter area, as it was not recognized on traverses conducted between the two forks of the Kehlechoa River, along the western edge of the map area.

Unit KS2 includes gritty plagioclase-rich schists and felsic fragmental schists similar to those of unit KS1, but it also includes metarhyolite, chlorite schist derived from mafic volcanic rocks, and significant amounts of well-bedded metasedimentary rock. Metarhyolite forms light grey, weakly to strongly schistose units, from a few metres to a few tens of metres thick, which were probably derived from flows and/or sills. Relict plagioclase phenocrysts, generally less than 2 mm across, occur within a groundmass of very fine-grained quartz and feldspar, accompanied by flakes of chlorite and sericite, and, in some cases, minor amounts of epidote and biotite. Medium to dark green mafic volcanic units, up to several tens of metres thick, comprise thoroughly recrystallized calcite-epidote-actinolite-chlorite-plagioclase schists. Metasedimentary intervals range from a few metres to more than a hundred metres thick. Some are dominated by thin to thick beds of schistose metasandstone, containing detrital grains of mainly plagioclase and quartz, interbedded with green or grey, commonly laminated, phyllitic metasiltstone (Figure 7). Other intervals comprise vaguely laminated, fine grained epidote-chlorite-sericite-plagioclase-quartz schists, locally with relict silt to sand-size grains of quartz and plagioclase, which were probably derived from siltstones or fine tuffs. Conglomerate or breccia units occur locally, and form layers 10 to 20 m thick within metasandstone-dominated intervals. They consist of variably flattened fragments, up to 20 cm across, within a chlorite-sericite-plagioclase-quartz schist matrix. Fragments are mainly fine-grained felsite and sericite-quartz schist, but the clast population locally includes quartz-phyric metarhyolite, medium-grained tonalite, plagioclase porphyry, and minor amounts of dark grey phyllite and limestone.

Unit KS3

Unit KS3 consists mainly of chlorite schist derived from mafic volcanic rocks, but also includes narrow intervals of metarhyolite and felsic volcaniclastic rock. It forms the uppermost unit of the southern division and has been traced across the entire width of the Kutcho map area. It overlies unit KS1 in the eastern and far western parts of the map area, but interfingers with and overlies unit KS2 in the intervening area. Unit KS3 is overlain by the central division of the Kutcho assemblage through much of the map area, but is directly overlain by the Inklin Formation in the west, where the central division has apparently been removed beneath the unconformity at the base of the Whitehorse trough.

The predominant rock type of unit KS3 is medium to dark green, greenish brown weathered, variably calcareous actinolite-epidote-chlorite-plagioclase schist. The schist appears uniform and homogeneous in some exposures, but more commonly has an irregular mottled appearance resulting from patches and veins of pale green calcite-epidote cutting dark green schist. Elsewhere, the schist displays a thin, lenticular layering defined by the segregation of metamorphic minerals into alternating layers rich in chlorite±actinolite and calcite-epidote, respectively. Protolith textures are generally not evident on either the outcrop or thin section scale, although relict plagioclase phenocrysts occur in some thin sections, and small vesicles were observed in an exposure 500 m north of peak 1896. Fragmental schist, with epidote-altered fragments several centimetres in size, occurs locally, but it is not clear if the fragments were derived from autoclastic, pyroclastic or epiclastic processes.

Plagioclase-phyric metarhyolite, similar to metarhyolite bodies within unit KS2, is scattered throughout unit KS3, but is a relatively minor component and typically forms narrow units less than 10 m wide. Felsic volcaniclastic rocks are also present, but are even less common. They comprise narrow units of sericite-plagioclase-quartz schist that contain quartz and plagioclase grains as well as small felsic lithic fragments.

CENTRAL DIVISION

The central division of the Kutcho assemblage is a heterogeneous succession of felsic and mafic volcanic, volcaniclastic and intrusive rocks that is exposed mainly east of Kutcho Creek, and is described by Schiarizza (2011a). This division is characterized by large amounts of coherent metarhyolite, but also includes a significant proportion of actinolite-epidote-chlorite-plagioclase schist derived from mafic volcanic rocks. The felsic and mafic metavolcanic units are intercalated with fragmental schists derived from felsic volcaniclastic rocks, bedded metasedimentary intervals that include metasandstone, metasiltstone, phyllite and chert, and local units of massive to vaguely laminated, commonly pyritic chert that may represent siliceous exhalites. This division also hosts substantial amounts of tonalite and diorite. Most components are intercalated on too fine a scale to be mapped separately, but a large rhyolite unit, and several intrusive units that crop out east of Kutcho Creek are shown on Figure 3.

Exposures of the central division west of Kutcho Creek comprise the same rocks types, in about the same proportions, that are present east of the creek. Metarhyolite predominates, and in part forms a large mappable body that straddles Kutcho Creek (Figure 3). Typical metarhyolites are light grey, weakly foliated rocks comprising distinct phenocrysts of quartz and plagioclase, 1-4 mm in size, within a very fine grained groundmass that includes quartz, plagioclase and scattered flakes of sericite (Figure 8). Calcareous actinolite-epidote-chlorite-plagioclase schist underlies a substantial area north and northeast of the Kutcho 1 mineral showing, and occurs as isolated exposures elsewhere (Figure 9). Light grey, massive to weakly foliated pyritic chert, probably derived from a siliceous exhalite, is intercalated with metarhyolite at the Kutcho 1 occurrence. Isolated exposures representing other components of the central division include chlorite-sericite schist with quartz, plagioclase and felsic lithic fragments, and feldspathic chlorite schist possibly derived from a feldspathic sandstone.

NORTHERN DIVISION

The northern division of the Kutcho assemblage is derived mainly from felsic volcaniclastic rocks, and consists of chlorite-sericite schists that contain variable proportions of quartz and feldspar crystals and felsic lithic fragments. Schiarizza (2011a), following previous workers (Bridge *et al.*, 1986; Barrett *et al.*, 1996; Childe and Thompson, 1997), subdivided this division into 4 units, KN1 through KN4, which comprise a north dipping and north-facing succession in the area of the Kutcho

Figure 8. Quartz-plagioclase-phyric metarhyolite, central division of the Kutcho assemblage, west of Kutcho Creek, 4 km south of the airstrip.

Figure 9. Epidote-chlorite schist, central division of the Kutcho assemblage, west of Kutcho Creek, 4 km south of the airstrip.

Creek VMS deposit. However, it was noted that coarse quartz-eye schists similar to those of unit KN3, which form the hangingwall of the deposit, also crop out along the southern margin of the northern division. The stratigraphic relationships of this southern belt of coarse quartz-eye schists was not established, but it was speculated that it might be a fault-bounded repetition of the hangingwall belt (Schiarizza, 2011a).

The 2011 mapping program demonstrates that the southern belt of coarse quartz-eye schists forms the stratigraphic base of the northern division, and overlies rocks of the central division on the slopes west and east of Kutcho Creek. These schists are here assigned to unit KNq, which is the most voluminous component of the northern division, and occurs at the base of the division, as well as at higher stratigraphic levels. Finer grained feldspathic schists that were formerly assigned to unit KN1 are here assigned to unit KNf, and appear to form a thick unit that is within unit KNq. Pyritic quartz-sericite schists (part of unit KN2 of Schiarizza, 2011a) that occur locally at the top of unit KNf, as part of the footwall alteration zone beneath the Kutcho Creek VMS deposit, are assigned to unit KNa. Sedimentary rocks that form the uppermost unit of the Kutcho assemblage (unit KN4 of Schiarizza, 2011a) are now referred to as unit KNs.

Unit KNq

Unit KNq comprises schists, derived mainly from felsic volcaniclastic deposits, which characteristically contain very large quartz grains. These schists occur at the base of the northern division, and overlie rocks of the central division in apparently unfaulted sections on either side of Kutcho Creek, as well as to the northwest and northeast of peak 1732 in the eastern part of the map area. Unit KNq also occurs at higher stratigraphic levels within the northern division, where it overlies the Kutcho Creek massive sulphide lenses and is referred to as hangingwall quartz-feldspar crystal tuff (QFCT) by Bridge *et al.* (1986), and QFCT rhyolite by Barrett *et al.* (1996). The upper and lower belts of KNq schists apparently merge to form a single belt northeast of peak 1732, where intervening rocks, mainly unit KNf, have pinched out.

Unit KNq consists primarily of medium to pale green or silvery green, well foliated chlorite-sericite-plagioclase-quartz schists that contain abundant glassy quartz eyes, typically 2-10 mm in size, but locally to 1.5 cm (Figure 10). The quartz grains are highly strained and some have embayed margins. They are invariably accompanied by smaller plagioclase grains, typically 1-5 mm in size, which are variably altered to sericite and/or epidote, and commonly have subhedral or euhedral outlines. In many exposures the quartz and feldspar crystal grains are accompanied by scattered lithic fragments, typically less than 1 cm across but locally up to 3 cm in size. These lithic fragments include fine to medium-grained tonalite, very fine grained felsite, and quartz±plagioclase-phyric rhyolite. Most exposures of unit KNq are not apparently stratified, or display only vague hints of stratification, indicated by variations in the size, abundance and proportions of crystal grains. However, typical schists in the lower part of the unit on the ridges 4 km east of Kutcho Creek occur, in part, as distinct thin to thick beds intercalated with grey to green phyllitic siltstone. The lower part of unit KNq in this area also includes thin to medium beds of quartz-feldspar sandstone, and thin chert beds intercalated with siliceous phyllite. Thick graded beds also occur in the upper part of unit KNq, where they were intersected in diamond drill holes in the vicinity of the western sulphide lens (Esso lens) of the Kutcho Creek deposit (Bridge *et al.*, 1986).

A lens of coarse matrix-supported breccia, at least several tens of metres wide, is exposed within the upper part of unit KNq west of Sumac Creek. The matrix consists of coarse quartz-eye schist typical of the unit, and the vast majority of the clasts, which range up to 30 cm in size, are the same rock type. The clast population also includes a minor proportion of fine to medium grained equigranular quartzofeldspathic rock, and rare mafic clasts of calcareous epidote-chlorite schist. Parts of the breccia unit display hints of a crude stratification, and lenses of laminated coarse grained quartz-feldspar sandstone are intercalated with coarse breccia units locally (Barrett *et al.*, 1996)

Unit KNf

Unit KNf comprises feldspar and quartz-bearing schists derived from felsic volcaniclastic rocks, and also includes minor amounts of coherent metarhyolite. It forms a substantial unit that interfingers with, and is both underlain and overlain by, unit KNq. Unit KNf is mostly equivalent to unit KN1 of Schiarizza (2011a), but also includes some rocks that were assigned to unit KN2.

Typical schists of unit KNf are medium green on fresh surfaces and weather to a grey-green or brownish green colour. They are characterized by conspicuous grains of plagioclase, typically 1-4 mm in size, which are invariably accompanied by quartz grains of similar or smaller size, and commonly by felsic lithic fragments, mostly 2-10 mm in size but locally up to 3cm (Figure 11). The plagioclase typically forms whole or broken crystals

Figure 10. Coarse quartz-eye schist, unit KNq, 1800 m southeast of peak 1787.

Figure 11. Fragmental feldspathic schist, unit KNf, 1100 m southeast of peak 1787.

with subhedral shapes. The quartz crystals commonly display embayed margins, and locally include granophyric intergrowths of plagioclase. Lithic fragments are variably epidote altered and include aphanitic felsite, quartz-feldspar-phyric rhyolite, fine-grained diorite and tonalite. The relict mineral and lithic grains are enclosed in a fine grained, well-foliated matrix of chlorite, sericite, quartz and plagioclase, locally with significant amounts of epidote and carbonate. Typical feldspathic schist in one exposure west of Sumac Creek is intercalated with several narrow intervals of thin-bedded schist of similar composition but finer grain size. For the most part, however, the schists are not conspicuously bedded, although they commonly display hints of a crude stratification defined by variations in the size, abundance and proportions of crystal and lithic grains, as well as colour variations which reflect the sericite versus chlorite content of the foliated matrix. At one end of this spectrum are uncommon layers of coarse quartz-eye schist similar to those that characterize unit KNq, and at the other end are rare thin units of dark green chloritic schist without conspicuous mineral grains. Although the latter units are suspected to be uncommonly fine grained and mafic layers within the volcaniclastic succession, they might, alternatively, be derived from mafic flows or sills.

Coarse fragmental rocks occur within the upper part of unit KNf over a 1 km strike length southeast of peak 1787. Here, an interval about 20 m thick contains abundant moderately flattened lithic fragments, mainly <1-6 cm in size, but locally up to 15 cm in longest dimension. The fragments are of uniform composition, comprising fine to finely medium grained leucocratic diorite to quartz diorite. The fragmental rocks pass down-section into typical feldspathic schists that locally host sparsely scattered clasts, up to 40 cm across, of mainly aphanitic felsite and quartz porphyry.

Dark grey phyllite and laminated phyllitic siltstone occur as rare intercalations within the volcaniclastic schists of unit KNf, forming layers that rarely exceed a few metres in thickness. A distinctive unit that is exposed at the very top of the succession, directly beneath conglomerate of the Whitehorse trough, south of peak 1787, comprises green phyllite intercalated with thin beds and laminae of purplish brown-weathered silty phyllite, locally grading to a mottled green/purplish grey phyllite containing patches and veins of reddish calcite.

Narrow units of metarhyolite were noted within unit KNf at several localities, but are relatively rare. They typically comprise 10-25% quartz and plagioclase phenocrysts, 1-4 mm in size, within a very fine grained, weakly foliated groundmass of mainly quartz, plagioclase and sericite.

Unit KNa

Unit KNa is a narrow lens of rusty weathered schists that occur in the upper part of unit KNf, and comprise part of the hydrothermally altered footwall to the Kutcho Creek massive sulphide deposit (Figure 3). This unit consists mainly of pale grey to greenish grey, very fissile quartz-sericite schist that weathers rusty due to the presence of disseminated pyrite and flattened porphyroblasts of Fe-Mg carbonate. Small grains of quartz are common, as are flattened lithic fragments, up to a few centimetres long, of pale grey siliceous felsite, with or without small phenocrysts of quartz (Schiarizza, 2011a).

Unit KNs

Metasiltstone, metasandstone and phyllite that occur stratigraphically above coarse quartz-eye schists of unit KNq in the Andrea Creek area are assigned to unit KNs, which is the uppermost unit of the Kutcho assemblage within the map area. Unit KNs is cut by the large mappable metagabbro sill, as well as by thinner sills and dikes of similar metagabbro, and is stratigraphically overlain by the conglomerate unit of the Whitehorse trough. Unit KNs is described by Schiarizza (2011a) as unit KN4, and was not revisited in the 2011 field season.

INTRUSIVE ROCKS OF THE KUTCHO ASSEMBLAGE

Metatonalite forms three mappable bodies within unit KC east of Kutcho Creek, the largest of which is up to 1 km wide and more than 10 km long (Schiarizza, 2011a). Similar metatonalite forms a small plug within the upper part of unit KS3, about 500 m west of Kutcho Creek.

Small sill-like bodies of metadiorite, comprising relict plagioclase grains interspersed with a metamorphic assemblage of mainly epidote, actinolite, chlorite and calcite, are fairly common within units KS3 and KC, and were also noted within unit KS1. Only three of these bodies, two within unit KS3 and one within unit KC, are sufficiently large to be shown on Figure 3.

AGE OF THE KUTCHO ASSEMBLAGE

U-Pb zircon radiometric dates that constrain the age of the Kutcho assemblage are shown on Figure 5. Childe and Thompson (1997) present an Early to Middle Triassic date of 246 +7/-5 Ma for northern division rocks in the footwall of the Kutcho Creek VMS deposit, and a Middle Triassic date of 242 ±1 Ma for rocks directly above the deposit. They also provide a date of 244 ±6 Ma for a quartz-plagioclase porphyry dike to the south of the deposit, probably within the central division. Two additional ages from the central division are provided by samples collected during the 2010 field season, which were dated by Richard Friedman at the University of British Columbia. One sample was collected from the large rhyolite unit that is mapped within the division (Figure 3), and it provides a latest Permian date of 251.71 ±0.48 Ma. The other sample was collected from the large tonalite intrusion that cuts the rhyolite unit and other rocks of central division. It yields an Early Triassic date of 248.23 ±0.42 Ma.

Metarhyolite samples collected from the southern and northern divisions of the Kutcho assemblage during the 2011 field program have been submitted for U-Pb zircon dating, but the results are not yet available.

Metagabbro cutting northern division of the Kutcho assemblage

Metagabbro, described by Schiarizza (2011a), forms a thick transgressive sill that has been traced for about 8 km within the northern division of the Kutcho assemblage, cutting up-section from east to west. Similar metagabbro is common as narrow dikes and sills within unit KNs, and has also been reported as dikes in felsic schists lower in the section (Childe and Thompson, 1997). The metagabbro cuts metasedimentary rocks of unit KNs, which overlie the youngest known volcanic rocks within the Kutcho assemblage, and it has a shoshonitic chemical signature that is distinct from the tholeiitic signature of mafic metavolcanic rocks of the Kutcho assemblage (Barrett *et al.*, 1996; Childe and Thompson, 1997). It may, therefore, be unrelated to the volcanic and plutonic rocks of the Kutcho assemblage. However, Childe and Thompson (1997) suggest that the gabbro is not significantly younger, because some gabbro units display peperitic textures where they contact metasedimentary rocks of unit KNs, and interaction zones where they contact underlying felsic metavolcanic rocks, suggesting that these units had not been completely lithified when they were intruded by the gabbro.

Whitehorse Trough

The Whitehorse trough within the Kutcho map area is represented by three units: a discontinuous conglomerate unit; an overlying limestone unit which is also discontinuous; and an extensive package of clastic metasedimentary rocks consisting mainly of metasandstone, metasiltstone and slate. The latter package is assigned to the Inklin Formation and forms the east end of a belt that has been traced westward through the Cry Lake and Dease Lake map areas (Gabrielse, 1998) into the type area of the Inklin Formation in the Tulsequah map area (Souther, 1971). The formation is not well dated anywhere along this belt (Gabrielse, 1998), but fossil data from contiguous strata farther to the northwest indicate a Lower to Middle Jurassic age (Pálfy and Hart, 1995; Johannson *et al.*, 1997; Mihalynuk, 1999).

The limestone unit within the Kutcho map area is correlated with the Upper Triassic Sinwa Formation. The Sinwa is also named for exposures in the Tulsequah map area, where it comprises late Upper Triassic (Norian) limestone that occurs in the hangingwall of the King Salmon thrust fault, and is stratigraphically overlain by the Inklin Formation (Souther, 1971). Exposures of Sinwa Formation are intermittent between the type area and the current map area (Gabrielse, 1998), but the correlation is reasonable, given the commonality of stratigraphic position directly beneath the Inklin Formation and structural setting within the King Salmon allochthon.

The conglomerate unit has been recognized by previous workers in the Kutcho area, but some have included it in the Kutcho assemblage (Bridge *et al.*, 1986; Thorstad and Gabrielse, 1986) and others have interpreted it as part of the stratigraphic succession that overlies the Kutcho assemblage (Panteleyev and Pearson, 1977b; Childe and Thompson, 1997). Here, it is included in the Whitehorse trough succession that overlies the Kutcho assemblage, probably across a significant unconformity. This interpretation is based on the abrupt lower contact of the conglomerate unit and the truncation of map units within the Kutcho assemblage against this basal contact (Figure 3), a provenance that is dominated by a variety of lithologic units within the underlying Kutcho assemblage, and a gradational contact with the overlying Sinwa Formation (Childe and Thompson, 1997; Schiarizza, 2011a).

A striking feature within the Kutcho map area is the southward truncation of the upper two divisions of the Kutcho assemblage across the basal contact of the Whitehorse trough. Farther south, at lower structural levels within the King Salmon allochthon, metasedimentary rocks of the Whitehorse trough rest, apparently stratigraphically, above the Cache Creek complex. These relationships attest to an unconformable relationship between the Whitehorse trough and underlying units, reflecting poorly understood pre-Jurassic deformation within the Cache Creek complex and Kutcho assemblage.

CONGLOMERATE UNIT

The conglomerate unit forms a single belt that has been traced for about 20 km, from the eastern part of the map area to the anticlinal fold closure southwest of peak 1787 (Figure 3). It occurs above the northern division of the Kutcho assemblage and below the Sinwa Formation along the entire length of this belt, but the basal contact truncates the upper units of the Kutcho northern division as it is traced from northeast to southwest. The conglomerate unit is commonly on the order of 100-200 m thick in the vicinity of the Kutcho Creek VMS deposit, but thins as it is traced westward from Kutcho Creek, and is only 10-20 m thick where it wraps around the fold closure southwest of peak 1787. It pinches out entirely a short distance southeast of the fold closure, and is generally absent south of that point, although conglomerate that might be correlative forms a narrow unit, less than 10 m thick, at the base of the Inklin Formation on the ridge west of the Bow mineral occurrence (Figure 3).

The conglomerate unit generally weathers to a light greenish grey to brownish grey colour, but locally is reddish brown. It consists of flattened pebbles and cobbles within a schistose matrix of sericite, chlorite and sand to silt-size grains of quartz and feldspar (Figure 12). The clast population is dominated by pale grey to greenish grey felsic rock types that include aphanitic felsite, quartz±plagioclase-phyric rhyolite, quartz-sericite

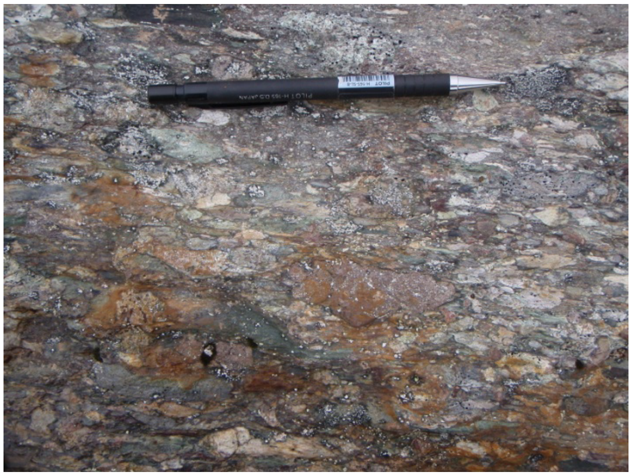


Figure 12. Conglomerate, base of the Whitehorse trough, 1300 m south-southwest of peak 1787.

schist and fine to coarse grained equigranular tonalite. Less common clast types include sericite-chlorite schist, chlorite schist, feldspathic chlorite schist and jasperoidal chert. All of these lithologic types are found within the underlying Kutcho assemblage. Foliation within the schistose clasts is parallel to, and continuous with, the matrix schistosity. The conglomerate is typically unstratified and poorly size-sorted, but a crude stratification is evident in some exposures, and locally the conglomerate is intercalated with thin to thick beds of schisty metasandstone, granule to small-pebble conglomerate, and sericite-quartz phyllite. Limestone is not common in the conglomerate unit west of Kutcho Creek, but in exposures east of the creek it occurs as occasional clasts, and as rare narrow lenses up to several tens of metres long. In a set of exposures northeast of the Kutcho Creek VMS deposit, conglomerate containing limestone clasts becomes common in the central part of the unit, and passes up section into conglomerate with a very limy matrix, which includes abundant clasts and rafts of limestone up to 1 m across (Schiarizza, 2011a).

SINWA FORMATION

The Sinwa Formation forms a continuous belt, between the conglomerate unit and the Inklin Formation, from the eastern part of the map area to the anticlinal fold closure southwest of peak 1787 (Figure 3). It is at least several tens of metres thick throughout most of the area east of Kutcho Creek, thins to only a few metres in some areas west of the creek, but forms a wide belt of exposures in the hinge zone of the anticline. The limestone pinches out on the south limb of the anticline, but forms a substantial belt of exposures 1 km farther south, in the core of another anticline, and is also exposed over a broad area in the hinge zone of a major syncline east of Kutcho Creek (Figure 3). In these latter areas, the conglomerate unit is absent, as is the northern division of the Kutcho assemblage, and the Sinwa Formation rests directly above rocks within the central division of the Kutcho assemblage. The coincidence of extensive limestone exposures with fold closures implies a significant component of structural thickening, but the exact mechanism by which this is achieved is not known.

The Sinwa Formation consists almost entirely of grey and white, weakly to moderately foliated, recrystallized limestone that typically forms monotonous exposures that weather to a uniform light grey to medium brownish grey colour. Medium to thick beds are displayed in a few exposures southwest of peak 1787 (Figure 13), and intervals of dark grey, fine-grained limestone and slaty limestone occur locally. The contact with the underlying conglomerate unit in the area east of Kutcho Creek is gradational (Schiarizza, 2011a), but the same contact west of the creek is sharp, as are basal contacts farther south, where the Sinwa Formation rests above the central division of the Kutcho assemblage.

Panteleyev and Pearson (1977b) and Monger (1977) report that fossils collected from the Sinwa Formation in the Kutcho map area include schleractinian corals, indicating a Middle Triassic or younger age. Macrofossils were not observed anywhere in the unit during the current study, and samples collected east of Kutcho Creek in 2010 did not yield conodonts. Additional samples, collected from Sinwa exposures west of the creek during the 2011 field season, are being processed for conodonts.

INKLIN FORMATION

The main exposures of the Inklin Formation form a wide belt that comprises the uppermost element of the King Salmon allochthon. These rocks are bounded to the north by the Nahlin fault, across which they are structurally overlain by rocks of the Cache Creek complex. This belt of Inklin rocks is folded through a series of west plunging, south-verging folds that are outlined by the basal contact of the formation, which rests above the Sinwa Formation in the northeast, but directly above the Kutcho assemblage to the southwest, where the Sinwa and conglomerate unit are missing. A narrow belt of Inklin rocks also occurs at lower structural levels within the King Salmon allochthon. These rocks rest

Figure 13. Bedded limestone, Sinwa Formation, 1500 m southwest of peak 1787.

stratigraphically (?) above the Cache Creek complex, and are structurally overlain by the basal part of the Kutcho assemblage across an inferred north dipping thrust fault. This belt of Inklin rocks forms the base of the King Salmon allochthon in the eastern part of the map area, where the Cache Creek complex has pinched out.

The Inklin Formation consists mainly of slate, metasiltstone and metasandstone. These rocks, together with minor amounts of limestone and conglomerate, are intercalated throughout the formation, but slate/metasiltstone intervals seem to be more common in the lower part, whereas metasandstone-dominated intervals become prevalent at higher stratigraphic levels and are, overall, the most abundant rock type present. Dark to medium grey slate typically contains small porphyroblasts of rusty Fe-Mg carbonate, and commonly displays laminations and thin interbeds of metasiltstone and slaty metasiltstone. Fine to coarse-grained metasandstone occurs as thin to thick, massive to graded beds intercalated with thinner interbeds of slate and metasiltstone (Figure 14). The metasandstones are typically schistose wackes containing plagioclase, quartz, and fine grained altered lithic clastic grains. One unusual sandstone unit, encountered in the southwestern part of the map area, in the upper part of the Inklin slice that overlies the Cache Creek complex, contains detrital grains of mainly plagioclase and hornblende.

Limestone is not common within the Inklin Formation, but occurs as narrow layers and lenses, typically only 1-2 m thick, that occur within both slate/siltstone and sandstone-dominated portions of the formation. Locally, limestone lenses occur within intervals of brown weathered calcareous sandstone. At one location, within the Inklin slice that overlies the Cache Creek complex, about 5 km west of Kutcho Creek, an interval of thin-bedded slate, siltstone and calcareous sandstone that includes thin limestone lenses also contains scattered calcareous concretions, up to 20 cm in diameter.

Conglomerate occurs locally within the main belt of Inklin rocks, but was not observed in the slice that overlies the Cache Creek complex. The conglomerate is mainly within metasandstone-dominated sections, but also occurs within slate/siltstone successions, and is commonly associated with units of limestone and/or calcareous metasandstone. It forms single or multiple thin to thick beds and may be the dominant rock type in sections up to several tens of metres thick. Conglomerate beds typically comprise a schistose metasandstone matrix that contains flattened pebbles of mainly felsic volcanic rock, accompanied by clasts of dark grey phyllite, laminated siltstone and limestone. At one locality, 1.5 km northeast of peak 2045, conglomerate occurs as a succession of several thick beds, each of which grades up into an interval of thin-bedded metasiltstone and metasandstone, capped by a layer, up to 40 cm thick, of laminated sandy limestone (Figure 15). The pebbles and cobbles in these conglomerate units consist of limestone and a variety of rounded felsic lithic clasts that include quartz-feldspar-phyric rhyolite, aphyric felsite, fine to medium-grained tonalite , sericite-quartz phyllite, and coarse quartz-eye volcaniclastic schist. These felsic clasts, and those in other conglomerate units, resemble rocks found in the underlying Kutcho assemblage.

The base of the Inklin Formation south and southeast of peak 1787, and on the opposite limb of the anticline north of peak 2045, comprises several tens of metres of grey-green gritty feldspathic sandstone and feldspathic sericite-chlorite schist that are very similar to the schists that characterize unit KNf of the Kutcho assemblage (Figure 3). These rocks have prompted some workers to infer that Kutcho-like volcanic activity continued, or was re-established, after deposition of the Sinwa Formation (Panteleyev, 1978; Troop, 1981; Alldrick and McLennan, 2010), and thus question the existence of a significant unconformity (Panteleyev, 1978) or the validity of the Sinwa correlation for the limestone unit (Alldrick and McLennan, 2010). The schists in question are clastic rocks that contain, in addition to abundant plagioclase, detrital quartz and fine grained altered lithic grains, not unlike other sandstone units within the Inklin Formation.

Figure 14. Thin to medium-bedded metasandstone, Inklin Formation, 1 km northwest of peak 2045.

Figure 15. Conglomerate unit within the Inklin Formation, 1.5 km northeast of peak 2045.

They are interbedded with narrow slate/siltstone intervals, and the unit south of peak 1787 passes along strike, to the west, into schistose conglomerate that contains pebbles of felsic volcanic rock and tonalite, as well as granules of quartz and feldspar. The feldspathic schists are here interpreted as clastic deposits derived from erosion of the older Kutcho assemblage, an interpretation that does not require a younger, post-Sinwa volcanic source.

Units south of the King Salmon fault

TAKWAHONI FORMATION

Rocks assigned to the Takwahoni Formation, following Gabrielse (1998), occur in the footwall of the King Salmon fault in the southwest corner of the Kutcho map area. The rocks in this area consist mainly of rusty weathered, dark to medium grey, moderately cleaved slaty siltstone. Medium grey to greenish grey, fine to coarse-grained sandstone occurs locally, and predominates in some sections up to several tens of metres thick. The sandstone commonly occurs as poorly defined medium to thick beds, but locally forms distinct thin to medium beds separated by thin interbeds of dark grey siltstone. Coarse-grained units locally contain scattered granules and small pebbles, 2-10 mm in size. The sandstones are mainly weakly foliated wackes, containing feldspar and volcanic-lithic grains that are heavily altered with sericite and calcite.

The Takwahoni Formation is not dated within the Kutcho map area, but according to Gabrielse (1998) these rocks are part of a greywacke-shale division that has yielded Lower Jurassic (Pliensbachian) fossils 20 km to the west (Tipper, 1978).

BOWSER LAKE GROUP

Clastic sedimentary rocks assigned to the Bowser Lake Group occur in the footwall of the King Salmon fault in the south-central and southeastern parts of the Kutcho map area. These rocks are separated from the Takwahoni Formation to the west by the inferred trace of a northerly dipping thrust fault, referred to as the Kehlechoa fault by Gabrielse (1998), that either merges with or is truncated by the King Salmon fault (Figure 1). East of Kutcho Creek, the Bowser Lake Group is represented mainly by chert-rich pebble conglomerate and chert-quartz sandstone, as described by Schiarizza (2011a). The few exposures examined west of the creek consist mainly of brown-weathered, bluish green, well-indurated coarse to medium-grained sandstone that contains plagioclase, clinopyroxene and volcanic-lithic grains. The sandstone commonly forms massive units, several metres to more than 10 m thick, that are interspersed with lesser amounts of medium to dark grey laminated siltstone that forms intervals up to 2 m thick. Locally, sandstone forms distinct thin to thick beds intercalated with laminated siltstone.

The Bowser Lake Group ranges from Middle Jurassic to Early Cretaceous in age (Evenchick *et al.*, 2007). The rocks are not dated within the current study area, but probably represent part of the lower, Middle Jurassic, portion of the group based on data outside the map area: The same panel of rocks has yielded Early Bajocian fossils about 25 km to the west, and is cut by a late Middle Jurassic pluton 15 km southeast of the map area (Gabrielse, 1998).

Quesnel terrane northeast of the Kutcho fault

Granitic rocks that crop out on the northeast side of the Kutcho fault are part of an unnamed and undated pluton, of suspected Early Jurassic age, within Quesnel terrane (Gabrielse, 1998). Those parts of the pluton examined by Schiarizza (2011a) include hornblende diorite to quartz diorite, hornblende-biotite tonalite and hornblende granodiorite.

Post-metamorphic intrusions

Small, intermediate to mafic, post-metamorphic intrusions are scattered sparsely through much of the map area, and are very common in the southern part of the King Salmon allochthon, for 6 to 8 km on either side of upper Kutcho Creek, where they cut rocks of the Kutcho assemblage, the Cache Creek complex and the Inklin Formation. The intrusions in this area are mainly porphyritic sills and dikes, ranging from a few metres to a few tens of metres wide, comprising phenocrysts of feldspar, hornblende and locally pyroxene, within a grey to brown, massive to platy, aphanitic to very fine grained feldspathic groundmass. Two small plugs that are mapped within this heavily diked area are probably part of the same suite. One comprises medium grained, equigranular diorite that cuts unit KS2 on peak 2075, 2.5 km east of the head of Kutcho Creek (Schiarizza, 2011a). The other plug consists of medium grained hornblende diorite, pyroxene hornblende porphyry and biotite hornblende porphyry, and cuts units KS2 and KS3 about 4.5 km west of upper Kutcho Creek (Figures 2 and 3). The post-metamorphic dikes, sills and stocks adjacent to upper Kutcho Creek are assigned an Eocene age, on the basis of a radiometric date obtained from a dike that crops out 1 km northeast of peak 2075. Stevens *et al.* (1982) report that a hornblende separate, containing about 10% biotite, from this dike yielded a K/Ar date of 55.4 ±3.0 Ma.

A dike of dark grey, brown-weathered, biotite-phyric lamprophyre cuts mafic schists of unit KS3 on a ridge crest about 2.7 km southeast of peak 2045. The dike is about 4 m wide and dips steeply to the north, roughly parallel with the schistosity of the enclosing schists. The lamprophyre contains scattered rounded xenoliths, <1-6 cm in size, of mainly diorite, gabbro and hornblendite.

A brownish grey hornblende porphyry dike, about 1 m wide, cuts feldspathic schists of unit KNf near the core of the major anticline, about 1.7 km southwest of peak 1787. The dike dips steeply to the southwest for part of its length, but when traced to the north displays an abrupt change in orientation, attaining a steep easterly dip. It comprises a very fine-grained groundmass that contains acicular hornblende phenocrysts up to 8 mm long, small magnetite grains, and quartz-filled vesicles. It is suspected that this dike is younger than the Eocene dikes described previously, in part because the hornblende phenocrysts are distinctly less altered.

Dikes of fine grained, equigranular hornblende biotite diorite, typically less than 1 m wide, are fairly common within the Takwahoni Formation in the southwest corner of the map area, and may correlate with the Eocene dikes that are common in the King Salmon allochthon to the northeast. At one locality, the Takwahoni Formation also hosts a creamy white weathered felsic dike, comprising phenocrysts of hornblende, plagioclase and quartz, 1-3 mm in size, within a beige aphanitic groundmass.

STRUCTURE

Structure of the King Salmon allochthon

The King Salmon allochthon comprises predominantly north dipping map units that are deformed by south-verging folds and north dipping thrust faults. The folds formed at the same time as the penetrative schistosity or cleavage that is displayed by all units within the allochthon. This foliation is defined by the preferred orientation of greenschist facies metamorphic mineral assemblages and, in coarse-grained units, variably flattened primary crystal and lithic fragments. The bounding King Salmon and Nahlin thrust faults, as well as the inferred north dipping thrust faults within the allochthon, probably formed during the same deformational event, but in detail may be slightly younger. Constraints beyond the current map area suggest that this deformation occurred in early Middle Jurassic time (Tipper, 1978; Mihalynuk *et al.*, 1992, 2004).

The Kutcho assemblage and overlying sedimentary rocks of the Whitehorse trough underlie most of the allochthon, and comprise a predominantly north dipping and north-facing succession that is deformed by a series of west-plunging, south-verging folds that are well defined by the mapped contact between the two assemblages (Figures 3 and 4). The structural base of the Kutcho assemblage is not well exposed, but is inferred to be a north dipping thrust fault because north dipping and north-facing rocks of unit KS1 rest structurally above younger north dipping and north-facing rocks of the Inklin Formation. The narrow belt of Inklin rocks structurally beneath the Kutcho assemblage lies above units CC2 and CC3 of the Cache Creek complex through most of the area, but forms the immediate hangingwall to the King Salmon fault in the east, where Cache Creek rocks are absent. There is no indication of faulting in the few places where the Inklin/Cache Creek contact is well constrained, suggesting that the Inklin is in depositional contact with the Cache Creek. A post-Inklin fault is required at lower structural levels within the Cache Creek complex, where a thin sliver of Inklin rocks occurs between units CC1 and CC2 near the western edge of the map area. This structure in inferred to be a north dipping thrust fault, related to other Jurassic thrust faults of the King Salmon allochthon, at the structural base of unit CC2.

The penetrative schistosity that characterises the Jurassic and older rocks of the King Salmon allochthon dips steeply north and is axial planar to mesoscopic folds of bedding that are common within the Inklin Formation (Figure 16), and were observed locally within bedded units of the Kutcho assemblage. The axes of these mesoscopic folds, together with associated bedding/cleavage intersection lineations, plunge gently to the west-northwest or, less commonly, to the east-southeast. This folding (and the associated south-verging macroscopic folds) is reflected in a stereoplot of poles to bedding measured in the Kutcho assemblage and overlying Whitehorse trough sedimentary rocks (Figure 17), which define a great circle girdle, with a pole (280/06) that plots within the cluster of fold axes and intersection lineations. A younger generation of co-axial mesoscopic folds occurs rarely in the area east of Kutcho Creek (Schiarizza, 2011a), but these structures were not observed west of the creek. They comprise open folds of the main schistosity, with axes that plunge gently to the west-northwest, and an associated axial planar crenulation cleavage that dips 30 to 40 degrees to the north. The youngest mesoscopic structures observed in the map area

Figure 16. Synmetamorphic fold within the Inklin Formation, 1500 m east of peak 2045.

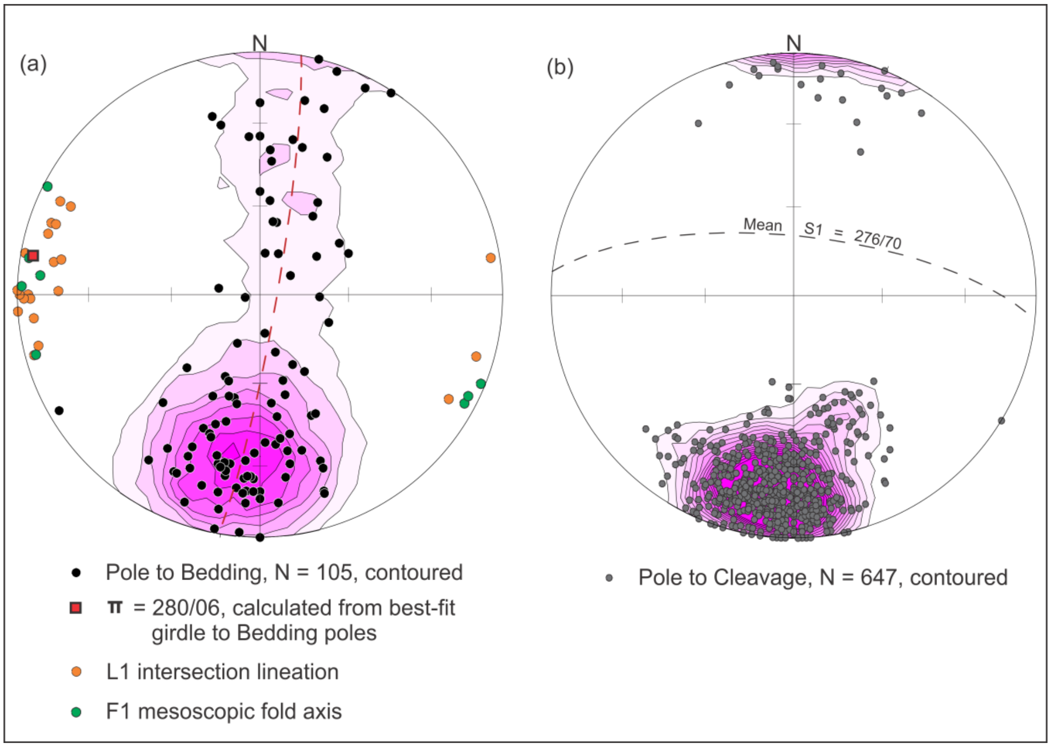


Figure 17. Lower hemisphere stereoplots of structural data from the Kutcho assemblage and overlying Whitehorse trough.

comprise post-metamorphic folds and kinks that warp the main schistosity across axes that plunge steeply to the northwest, north or northeast. Structures of this age have little apparent effect on the macroscopic geometry of the allochthon.

POST-METAMORPHIC FAULTS

Systems of west-trending faults occur along and near the contact between the central and northern divisions of the Kutcho assemblage south of the Kutcho Creek VMS deposit, and faults with a similar trend cut the south limb of the syncline north of peak 2075 (Figure 3). Stratigraphic separations across these faults suggests mainly north-side-down displacement. A small west-striking fault that is exposed in limestone cliffs northeast of peak 2045 has demonstrable north-side-down displacement where it drops a small lens of Inklin rocks into the Sinwa Formation (Figure 18)

Figure 18. View to the west at a steep north-side-down fault that juxtaposes dark grey slates of the Inklin Formation against limestone of the Sinwa Formation.

Northwest-striking faults are inferred in several places within the Kutcho map area, where they mark offsets of the predominantly east trending lithologic contacts and structures that formed during synmetamorphic deformation. Northeast-striking faults are likewise inferred in a couple areas, but are less common. These late structures display both dextral and sinistral apparent offsets, but the actual sense of movement was not established.

Pre-Jurassic deformation

Hints of pre-Jurassic deformation within the Cache Creek complex and Kutcho assemblage are provided by relationships at the base of Whitehorse trough. The narrow belt of Inklin rocks in the southern part of the King Salmon allochthon overlies the Cache Creek complex across what is suspected, but not proven, to be a stratigraphic contact. This contact truncates the fault that juxtaposes units CC2 and CC3, suggesting that structures relating to development of the melange belt are older than the Inklin Formation. Structures that accommodate the marked lenticularity of lithologic units within unit CC1 are likewise suspected to have an older history, but have been overprinted by significant Jurassic strain. Pre-Inklin structures have not been identified within the Kutcho assemblage, but the systematic southward truncation of the northern and central divisions beneath the Whitehorse trough suggests an older deformation that involved at least tilting of the succession.

Regional Faults

KING SALMON FAULT

The King Salmon fault is an important regional structure that forms the structural base of the King Salmon allochthon. It has been traced about 300 km west-northwest from the current map area, where it apparently merges with the long-lived, northwest trending Llewellyn fault zone (Mihalynuk, 1999). Where exposed, the King Salmon fault dips at low to moderate angles to the north, and displays deformation fabrics and map relationships consistent with south-directed thrust motion (Souther, 1971; Thorstad and Gabrielse, 1986; Gabrielse, 1998).

The King Salmon thrust fault crosses the southern part of the Kutcho map area, where it juxtaposes either the Cache Creek complex or the Inklin Formation above footwall rocks that include the Bowser Lake Group in the east and the Takwahoni Formation in the west. The trace of the fault is tightly constrained along Josh Creek, in the southeast corner of the map area, where it places Inklin Formation above the Bowser Lake Group. Here, south-directed thrusting is supported by mesoscopic structures near the contact, which include south-verging folds that deform the main synmetamorphic cleavage in hangingwall Inklin rocks, and north-dipping faults within footwall Bowser Lake Group (Schiarizza, 2011a). The trace of the King Salmon fault is also fairly well constrained in several places along the stretch that extends from peak 1667 to peak 1705 (Figure 2), but no structures or fabrics related to the fault were observed along this segment.

East of peak 1705, a northerly dipping thrust fault that places the Takwahoni Formation above the Bowser Lake Group is truncated by, or merges with, the King Salmon Fault (Figure 2). This structure, referred to as the Kehlechoa fault, has been traced about 30 km to the west (Figure 1; Gabrielse, 1998). The trace of the Kehlechoa fault is not well constrained in the current map area, but it marks a change in mesoscopic rock fabric, as rocks of the Takwahoni Formation are cleaved while those of the Bowser Lake Group are not (except in the immediate footwall of the King Salmon fault). Tipper (1978) noted a corresponding change in map-scale structural style in equivalent rocks to the west, where the Lower Jurassic rocks are involved in complex southwest-directed imbricate thrusting, whereas Middle Bajocian rocks display a less complex structural style involving mainly block faulting.

NAHLIN FAULT

The Nahlin fault has been traced from the current map area more than 350 km west-northwest to the Atlin Lake area (Souther, 1971; Mihalynuk *et al.*, 1992; Gabrielse, 1998). It forms the northeast boundary of the King Salmon allochthon, and juxtaposes the Inklin Formation, on the southwest side of the fault, with rocks of the Cache Creek complex to the northeast. The fault is generally interpreted as a northeast dipping thrust, although some segments dip steeply and may have a component of dextral strike-slip movement (Gabrielse, 1998).

The trace of the Nahlin fault is fairly well constrained on both the east and west sides of Kutcho Creek, but it was not studied in enough detail to establish its orientation or kinematic history. As noted by Schiarizza (2011a), the fault trace east of the creek is commonly marked by lenses of rock that may have been derived from the Sinwa Formation and Kutcho assemblage, consistent with the Nahlin fault being a thrust fault that ramped through these units into the overlying Inklin Formation.

KUTCHO FAULT

The Kutcho fault transects the northeast corner of the Kutcho map area, where it truncates the King Salmon allochthon and structurally overlying Cache Creek complex (unit CC5), and juxtaposes these map units against granitic rocks of Quesnel terrane. This structure is discussed by Schiarizza (2011a).

MINERAL OCCURRENCES

Mineral occurrences east of Kutcho Creek, including the important Kutcho Creek volcanogenic massive sulphide deposit, are described by Schiarizza (2011a). Occurrences west of the creek are described in this report. These include occurrences that are prospective for volcanogenic massive sulphide deposits, as well as younger vein deposits.

Kutcho 1

The Kutcho 1 occurrence is hosted by the central division of the Kutcho assemblage just to the west of Kutcho Creek, a little more than 4 km south of the airstrip. Mineralization comprises lenses of semimassive to massive sulphide within a pyritic cherty exhalite unit, which is intermittently exposed in an area measuring about 80 by 40 m (Belik, 1996).

Mineralization in the vicinity of the Kutcho 1 occurrence was encountered in a diamond drill hole cored by Noranda Exploration Company Limited in 1977. Chloritic schist intersected in hole NK-3 included a 3 m interval containing 2-5% pyrite with disseminated chalcopyrite, which contained 0.11% Cu (MacArthur, 1978). The area was re-staked and mapped by G. Belik in 1994, and optioned to Atna Resources Limited in 1996. Belik mapped the pyritic cherty exhalite unit in 1994, and during follow-up work for Atna Resources in 1996 excavated a pit where an angular float block of massive to semimassive pyrite-chalcopyrite was discovered within the unit. This pit exposed bedrock of highly siliceous rock with about 20% pyrite that locally displays primary sulphide layering. A sample of this bedrock material yielded 3282 ppm Cu, 1110 ppm Pb, 1097 ppm Zn, 7.0 ppm Ag and 7 ppb Au (Belik, 1996). Several mineralized float boulders were encountered during excavation of the pit, including a 5 kg subangular block of well banded, siliceous, semimassive to massive sulphide, which contained 10 592 ppm Cu, 2234 ppm Pb, 1816 ppm Zn, 17.6 ppm Ag and 30 ppb Au (Belik, 1996). An exploration program by Atna Resources Limited in 1997 included 9 diamond drill holes, several of which were cored in the area of the Kutcho 1 showing (Holbek *et al.*, 1998). However, none of these holes were filed for assessment.

The pit excavated within the pyritic cherty exhalite unit was located during the 2011 mapping program, but it is partially caved and bedrock is no longer exposed. The cherty exhalite exposed near the pit is a light to medium grey, very siliceous rock with several per cent disseminated pyrite, and local lenses and patches of heavily disseminated to semimassive pyrite. Rocks to the east and northeast of the exhalite unit are mainly epidote-chlorite schists derived from mafic volcanic rocks. Rocks to the south and southeast include coherent units of quartz-plagioclase-phyric metarhyolite intercalated with pyritic siliceous exhalite similar to that near the pit, and two narrow units of mottled red/grey chert that are probably also exhalites (iron chert units of Belik, 1996). These iron chert units (Figure 19) commonly have 1-2% disseminated pyrite, and local narrow lenses of more heavily disseminated pyrite. A sample collected from one of the iron chert units, located 80 m southeast of the pit, contains 652.5 ppm Cu, 33.3 ppm Pb, 669 ppm Zn and 1.2 ppm Ag (Table 1, sample 11PSC-438).

Kutcho 2 (MINFILE 104I 072)

The Kutcho 2 showing occurs within the northern division of the Kutcho assemblage, 1800 m west of Kutcho Creek and about 3 km southwest of the airstrip. It comprises several narrow lenses of heavily disseminated to semimassive sulphides, mainly pyrite, pyrrhotite and chalcopyrite, which occur within zones of quartz-sericite-chlorite-altered rock that are more or less concordant with the schistosity in the surrounding coarse quartz-eye schists. These schists are part of a small lens assigned to unit KNq, which occurs within a belt of mainly finer grained plagioclase-rich schists assigned to unit KNf (Figure 3).

The mineralization at the Kutcho 2 occurrence was located by geologists working for Noranda Exploration Company Limited in the mid to late 1970s (Troop, 1981). It was later covered by claims staked by Atna Resources Limited and the mineralization, which is exposed in several small pits that were excavated by Noranda, was described and sampled by Belik (1996). A south-plunging diamond-drill hole, which was collared in conglomerate of the Whitehorse trough to the north of the showings, tested this mineralized interval at depth, but encountered only weakly altered felsic volcaniclastic rocks (Holbek *et al.*, 1998, drill hole KU97-01).

Mineralization exposed in one of the old pits at the Kutcho 2 occurrence comprises a lens, 6-11 cm wide that consists of limonite altered and silicified rock with heavily disseminated to massive sulphides (Figure 20). A grab sample of this material returned >10 000 ppm Cu, 103.1 ppm Pb, 253 ppm Zn, 45 ppm Ag and 4549.2 ppb Au (Table 1, sample 11PSC-480). A different pit, about 30 m to the west, exposes a couple metres of variably silicified rock with patches of chlorite±sericite and veins of Fe-Mg carbonate. Sulphides occur mainly in two zones, the largest about 30 cm wide and comprising intermittent heavy disseminations with patches of semimassive sulphides. A grab sample of this material returned >10 000 ppm Cu, 78.8 ppm Pb, 159 ppm Zn, 11.4 ppm Ag and 8228.2 ppb Au (Table 1, sample 11PSC-481).

Figure 19. Iron chert, central division of the Kutcho assemblage, Kutcho 1 showing.

Figure 20. Lens of massive to heavily disseminated sulphides, Kutcho 2 occurrence.

Table 1. Selected elements from analyses of mineralized and altered rock samples collected during the 2011 field season.

				Mo	Cu	Pb	Zn	Ag	As	Au	Sb	Ba	W	Hg
				PPM	PPM	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPM	PPM
				0.1	0.1	0.1	1	0.1	0.5	0.5	0.1	1	0.1	0.01
Sample	Easting	Northing	Rock Type											
11PSC-46	524864	6446260	py-ser-qtz schist, unit KS2	6.8	20.8	2.3	21	<0.1	19.7	1.5	0.2	21	<0.1	0.02
11PSC-53	525669	6446669	py in Eocene hb-bio porphyry	2.6	93.7	4.2	31	0.1	1.5	2.1	0.2	91	5.4	<0.01
11PSC-56	525504	6446638	py in Eocene hb porphyry	3.2	71.8	7	49	0.2	4	3.5	0.2	73	0.4	<0.01
11PSC-64	534771	6451708	pyritic chert, unit KNq	3	13.9	5.8	11	0.1	3.8	3.2	0.5	18	<0.1	0.01
11PSC-79	524663	6447795	py-ser-qtz schist, unit KS3	0.2	38.4	1.2	39	<0.1	6.7	1.6	<0.1	6	<0.1	<0.01
11PSC-81	524594	6448059	py-qtz alt'n, unit KS3	0.2	4.9	1.2	35	<0.1	<0.5	3.6	<0.1	2	<0.1	<0.01
11PSC-140	524657	6450389	Ridgecrest; qtz vn; py, ch, ga, mal, az	1.1	>10000.0	7652.8	1239	>100.0	829.4	96.3	>2000.0	11	<0.1	1.55
11PSC-161	526455	6451070	py in feldspathic sst; Inklin Fm	0.4	17.4	4.6	97	0.5	7.2	0.6	1.9	36	0.1	<0.01
11PSC-240	522260	6445979	diss py in qtz-ep alt'n; unit KS2	1.5	74.5	27	76	2.2	2.7	0.7	13.1	8	<0.1	0.01
11PSC-265	522719	6447069	qtz-ser-py alt'n; unit KS3	0.5	26.1	1.6	41	<0.1	17.1	<0.5	0.3	11	<0.1	0.01
11PSC-314	515514	6448828	listwanite; unit CC2	<0.1	10.4	1.7	12	0.2	1.5	0.7	1.7	5	<0.1	0.01
11PSC-386	531923	6448398	Kris; qtz-ser schist; py, cpy, mal	0.1	380.3	3	80	<0.1	38.6	1.4	0.8	12	<0.1	0.02
11PSC-410	521721	6454512	Matt; pitted siliceous phyllite; mal	33.3	4468.9	29.1	71	1.3	45	1.4	1.7	2335	<0.1	0.08
11PSC-431	529289	6449215	Kutcho 1; iron chert; py	2.6	14.3	1.9	5	0.3	1.8	15.6	0.3	36	0.2	0.21
11PSC-438	529344	6449274	Kutcho 1; iron chert; py	3.7	652.5	33.3	669	1.2	5.3	1.2	0.9	67	<0.1	0.46
11PSC-440	529307	6449337	Kutcho 1; siliceous exhalite; py	6	25	3.9	17	0.1	9.7	2.2	0.2	41	<0.1	<0.01
11PSC-450	526646	6447718	qtz-ser-py alt'n; unit KS3	0.2	41.1	1.9	100	0.1	7.5	0.8	0.4	26	<0.1	0.01
11PSC-467	522321	6450317	Blueridge; qtz vn; py, ch, ga, mal, az	0.4	6222.8	>10000.0	806	>100.0	612	128.7	>2000.0	23	<0.1	0.96
11PSC-480	527964	6451029	Kutcho 2; sulphide lens	1.8	>10000.0	103.1	253	45	3	4549.2	13.6	47	0.2	0.46
11PSC-481	527925	6451029	Kutcho 2; sulphide lens	0.4	>10000.0	78.8	159	11.4	5.6	8228.2	10.9	14	0.2	0.34

Samples analysed at ACME Analytical Laboratories Ltd. , Vancouver BC, by ICP-MS following digestion of a 15 g sample split in hot Aqua Regia

Abbreviations: alt'n- alteration; az- azurite; bio- biotite; ch- chalcocite; cpy- chalcopyrite; ep- epidote; ga- galena; hb- hornblende; mal- malachite; py- pyrite; qtz- quartz; ser- sericite; vn- vein

Bow (MINFILE 104I 071)

The Bow occurrence, 4.5 km west of upper Kutcho Creek, refers to a mineralized quartz vein that was encountered in a diamond drill hole cored by Imperial Oil Ltd. in 1976. The hole, inclined 50º south, was collared in the Inklin Formation, but at 94 m entered a succession logged as quartz-sericite phyllite, quartzite and chlorite-calcite phyllite, which is probably part of the underlying Kutcho assemblage (unit KC). The mineralization is within this lower interval, and is described only as “minor bornite and chalcopyrite in one quartz vein” (Samoil, 1976).

Ridgecrest (MINFILE 104I 052)

The Ridgecrest showing comprises mineralized quartz veins that occur within the upper part of the Sinwa Formation, near the hinge of a major anticline, 5 km west of Kutcho Creek. The mineralized veins were mentioned by Gabrielse (1968), but there is no record indicating that there was any significant work performed on them. The Sinwa limestone in this area is host to numerous variably oriented quartz veins. Only a small percentage of the veins are mineralized, but small pods of mineralization are scattered over the entire 300 m strike length of good Sinwa exposures on the ridge top. Mineralization comprises small pockets of fine-grained sulphides, mainly pyrite, chalcocite and galena, accompanied by malachite and azurite. A grab sample from one of these mineralized pockets contains >10 000 ppm Cu, 7652.8 ppm Pb, 1239 ppm Zn, >100 ppm Ag, 96.3 ppb Au, 829.4 ppm As, >2000 ppm Sb and 1.55 ppm Hg (Table 1, sample 11PSC-140).

Blueridge

The Blueridge showing comprises small pockets of mineralization, identical to those at the Ridgecrest showing, scattered sparsely over several hundred metres on the ridge immediately to the west of the ridge containing the Ridgecrest mineralization. The intervening area probably hosts similar mineralization but bedrock is not exposed. Small pits and tunnels attest to past exploration of the Blueridge mineralization, but no work was ever filed for assessment purposes. Old claim posts in the vicinity of the workings are dated 1966. Although most of the mineralized veins are within the Sinwa Formation, as they are at the Ridgecrest occurrence, the largest pocket of mineralization observed is within quartz veins that are hosted by an isolated mass of coarse crystalline calcite that is apparently within the overlying Inklin Formation (indicated by the dot denoting the Blueridge showing on Figure 3). A grab sample of this mineralized material contains 6222.8 ppm Cu, >10 000 ppm Pb, 806 ppm Zn, >100 ppm Ag, 128.7 ppb Au, 612 ppm As, >2000 ppm Sb and 0.96 ppm Hg (Table 1, sample 11PSC-467).

Rubysih (MINFILE 104I 061)

The Rubysih showing is listed in MINFILE as quartz-siderite veins containing tetrahedrite and galena, hosted by the Inklin Formation about 1.5 km east of Peak 2045. This MINFILE listing is derived from a northern British Columbia mineral inventory assembled by Archer, Cathro and Associates. It states that the showing was examined in 1961 by the Cave Syndicate, and that a galena-rich sample yielded 30.3% Pb, 922 g/t Ag and

0.2 g/t Au, and another sample, containing abundant tetrahedrite, yielded 0.49% Cu, 0.7 g/t Ag and trace gold.

The Rubysih showing was not located during the present study, although veins of quartz and quartz-siderite are abundant in this area, and in many other parts of the Inklin Formation. However, none of those examined by the writer contain appreciable sulphide mineralization.

Matt

The Matt showing comprises a narrow mineralized layer that was encountered within Cache Creek metasedimentary rocks during the 2011 mapping program. It is located within unit CC4, 1 km north of the Nahlin fault and 7.8 km west of the Kutcho Creek airstrip (UTM grid coordinates 521721E, 6454512N). The mineralized unit is a layer of dark grey phyllite, 8 cm wide, which is stained with malachite and includes numerous small pits that may represent weathered-out sulphides. The host succession comprises siliceous phyllite, chert and cherty argillite, with local lenses of talc schist. A grab sample of malachite-stained rock from the pitted phyllite unit contains 4468.9 ppm Cu, 33.3 ppm Mo, 29.1 ppm Pb and 2335 ppm Ba (Table 1, sample 11PSC-410).

Eocene plug west of Kutcho Creek

The plug that cuts the KS2/KS3 contact 4.5 km west of upper Kutcho Creek commonly contains 1-3% pyrite, as disseminations, blebs and fracture coatings. A sample of pyritic rock from the central part of the plug yielded 93.7 ppm Cu, 2.6 ppm Mo and 5.4 ppm W (Table 1, sample 11PSC-53). A different sample, from near the west contact of the plug, contains 71.8 ppm Cu, 3.2 ppm Mo and 0.4 ppm W (Table 1, sample 11PSC-56).

JW (MINFILE 104I 066)

The Cache Creek complex in the hangingwall of the Nahlin fault, and particularly in the area between the Turnagain River and Kutcho Creek, hosts a large number of nephrite jade occurrences, including numerous producers and past-producers (Leaming, 1978; Simandl *et al.*, 2001). The JW occurrence, in the northwest corner of the Kutcho map area, is part of this domain. It comprises a number of nephrite occurrences, including boulders and in situ lenses, scattered over an area of several square kilometres within unit CC4, which here consists mainly of structurally interleaved serpentinite, metabasalt and limestone (Price, 1974). Twenty-five talus blocks from the JW occurrence were tested with a packsack drill in 1976, and found to comprise poor quality talcy nephrite (Price, 1976); no subsequent work has been recorded on the showing.

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