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Authors' addresses

C.F. Roots *(croots@gsc.nrcan.gc.ca)*
Yukon Geology Program
Canada–Yukon Geoscience Office
2099-2nd Avenue
Whitehorse, Yukon Y1A 1B5

M. de Keijzer *(de_keijzer@unb.ca)*
Department of Geology
University of New Brunswick
P.O. Box 4400
Fredericton, New Brunswick E3B 5A3

J.L. Nelson *(JoAnne.Nelson@gems1.gov.bc.ca)*
M.G. Mihalynuk *(Mitch.Mihalynuk@gems5.gov.bc.ca)*
Geological Survey Branch
British Columbia Ministry of Energy,
Mines and Petroleum Resources
1810 Blanshard Street
Victoria, British Columbia V8W 9N3

Revision mapping of the Yukon–Tanana and equivalent terranes in northern British Columbia and southern Yukon Territory between 131° and 132°W[1]

Charlie F. Roots, Martin de Keijzer, JoAnne L. Nelson, and Mitchell G. Mihalynuk

GSC Pacific, Vancouver

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Abstract: The northern half of the Jennings River (104-O) and southern half of the Wolf Lake (105 B) map areas include multiply deformed and metamorphosed rocks of the eastern Big Salmon Complex (Yukon–Tanana Terrane) and a succession of mostly Paleozoic rock assemblages whose terrane affinity is in question.

Hazel Ridge, on the west side of the area, reveals folded mafic metavolcanic rock, piedmontite chert, and marble in a series of overturned isoclinal folds. This consistent stratigraphic succession is overlain by metagreywacke on a possible unconformity.

In the northeast, siliceous gritty and mafic metavolcanic rocks of the Dorsey assemblage are intruded by orthogneiss. These are overlain on a probable detachment fault by thin mafic volcanic rock and limestone ((?)Klinkit assemblage) and by dark phyllitic rocks and quartzite (Swift River assemblage).

Both Hazel Ridge and the Dorsey assemblage contain several quartz±feldspar-phyric siliceous layers that suggest volcanogenic massive-sulphide potential.

Résumé : Dans la moitié nord de la région cartographique de Jennings River (SNRC 104-O) et la moitié sud de celle de Wolf Lake (SNRC 105 B), s'étendent les roches plusieurs fois déformées et métamorphisées du Complexe de Big Salmon oriental (terrane de Yukon-Tanana), ainsi que des assemblages de roches remontant principalement au Paléozoïque, dont l'appartenance à un terrane donné demeure incertaine.

Dans la partie ouest de la région, la crête Hazel laisse voir des métavolcanites mafiques, des cherts à piedmontite et des marbres qui sont déformés en une série de plis isoclinaux renversés. Cette séquence stratigraphique cohérente est surmontée par des métagrauwackes, dont elle est séparée probablement par un contact discordant.

Au nord-est, des roches siliceuses à granules et des roches métavolcaniques mafiques rapportées à l'assemblage de Dorsey sont recoupées par des orthogneiss. Cet assemblage, dont le sommet correspond probablement à une surface de décollement, est recouvert par une mince succession de roches volcaniques mafiques et de calcaires (assemblage de Klinkit?), ainsi que par des lithologies phylliteuses sombres et des quartzites (assemblage de Swift River).

La crête Hazel et l'assemblage de Dorsey renferment plusieurs horizons siliceux à phénocristaux de quartz±feldspath, ce qui laisse croire à la présence possible de sulfures massifs volcanogènes.

[1] Contribution to the Ancient Pacific NATMAP Project.

INTRODUCTION

The region east of Teslin Lake to the continental divide (Fig. 1) includes polydeformed medium- to high-grade metamorphic rocks. The western third is Big Salmon Complex (Mihalynuk et al., 1998); the eastern two thirds has previously been referred to as Dorsey Terrane (Monger et al., 1991). The study area is bounded to the east by the Cassiar Terrane and Cassiar batholith. Revision mapping began in 1999, building upon ongoing mapping by the British Columbia Geological Survey (Nelson et al., 1998; Mihalynuk et al., 1998).

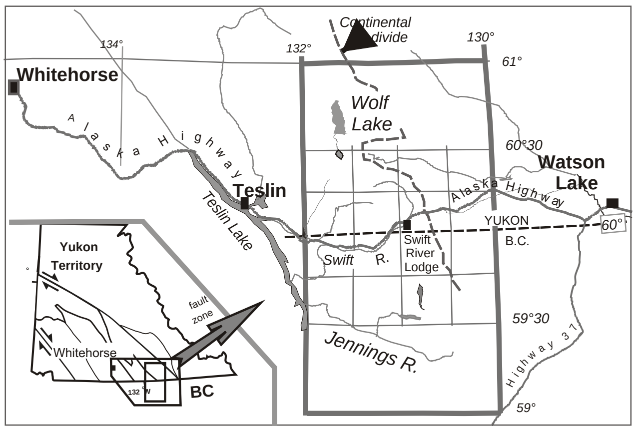

Figure 1. Wolf Lake and Jennings River map areas (thick outline) straddle the British Columbia–Yukon border. Thin lines delineate the 1:50 000 scale map areas to be addressed under the Ancient Pacific Margin NATMAP Project. This area is shown in Figure 2.

This work is the central component of the Ancient Pacific Margin NATMAP Project, which will investigate the ages, structural relationships, tectonic evolution, and metallogeny of rock units that lie immediately west of the ancestral continental margin in Canada. The central component will produce a new map at 1:250 000 scale of northern Jennings River (British Columbia) and southern Wolf Lake (Yukon) map areas, and maps at 1:50 000 scale of selected areas over the next five years (Fig. 2).

Reconnaissance bedrock mapping from the early 1950s and early 1960s (Aitken, 1959; Green et al., 1960; Mulligan, 1963a, b; Gabrielse, 1969) defined the major lithological units with limited paleontological and geochronological control. Mineral exploration in pursuit of carbonate-hosted zinc-lead deposits (e.g. Midway, now called Silvertip) and skarn-related tin-tungsten and gold (e.g. Logtung) led to updated regional coverage (Abbott, 1981; Lowey and Lowey, 1986; Murphy, 1986; Nelson and Bradford, 1993). A framework of four assemblages, Ram Creek, Dorsey, Swift River, and Klinkit, each with distinctive lithological and structural characteristics, was established by Stevens and Harms (1995) and Harms and Stevens (1996; Fig. 3).

In 1999, mapping focussed primarily on small, relatively well exposed key areas to investigate the deformational history of, and the nature of the contact between, the previously defined assemblages. Field observations and implications for mineral exploration are presented here from two areas: Hazel

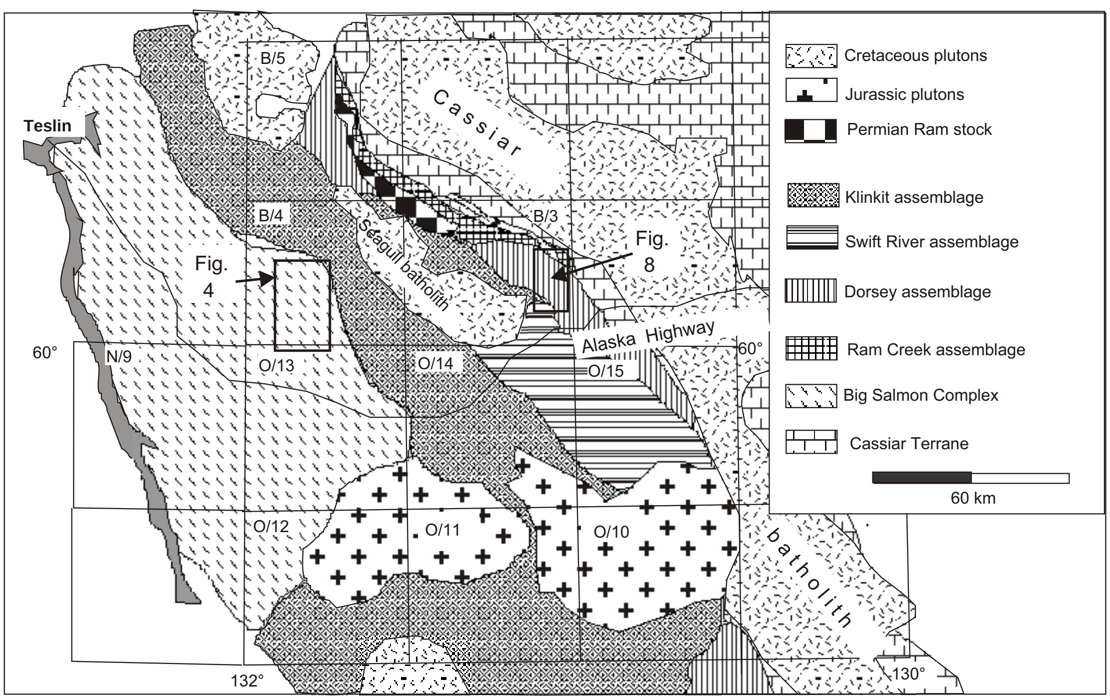

Figure 2. Tectonic units of southern Yukon and northern British Columbia, modified from Nelson et al. (1998) and unpublished data.

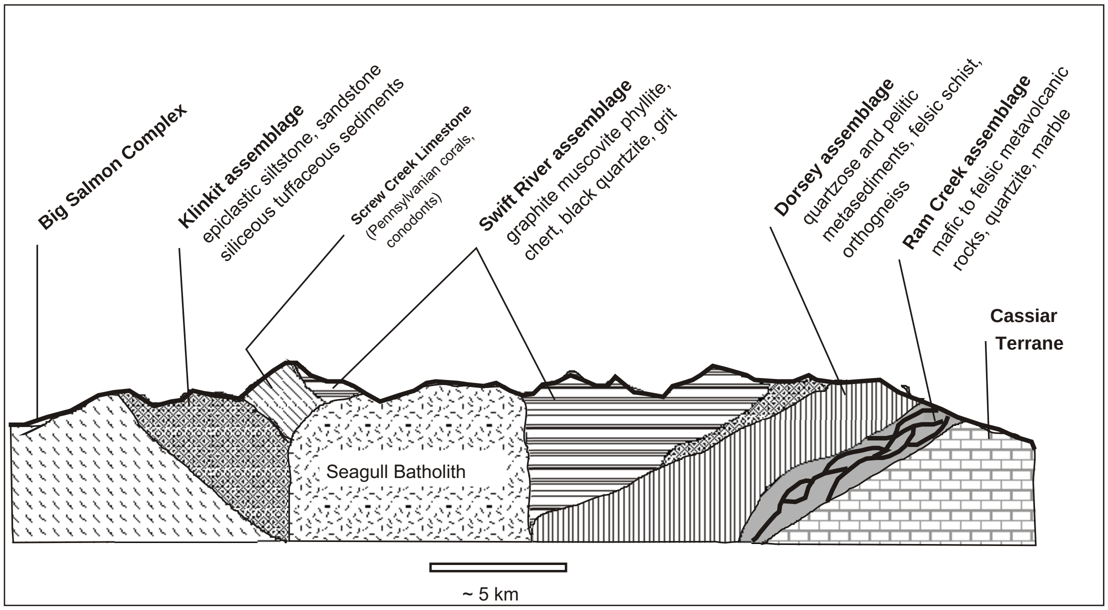

Figure 3. *Schematic section of Dorsey Terrane units between Big Salmon Complex (southwest) and Cassiar Terrane (northeast). The assemblage descriptions are abbreviated from Stevens and Harms (1995) and Harms and Stevens (1996).*

Ridge in the southwest part of 105 B/4, and the Swift River headwaters south of the Dan Ag-Pb-Zn showing in eastern105 B/3.

HAZEL RIDGE

Regional context

This rolling upland was mapped by Green et al. (1960) as Sylvester Group and by Stevens and Harms (1995) as Hazel assemblage. Harms and Stevens (1996) pointed out close parallels between Hazel assemblage and Yukon–Tanana Terrane, but did not map a detailed stratigraphy. These rocks extend to the south into the Big Salmon Complex in British Columbia as documented by Mihalynuk et al. (1998). Since this publication, new U-Pb dates suggest the stratigraphic order of the units should be reversed, as follows (upward from the oldest):

1. Greenstone (600–1800 m);
2. 'Crinkled chert' (25–60 m); piedmontite and hematite locally prominent;
3. buff-weathering white carbonate (70–300 m);
4. mixed metavolcanic/metasedimentary rocks, including graphitic metaconglomerate and meta-tuff layers (>135 m); meta-tuff was dated at ~325 Ma (R.M. Friedman, pers. comm., 1999);
5. Immature clastic metasediments (>150 m).

The present work shows that these units extend north to Hazel Ridge (Fig. 4) as follows:

Metavolcanic unit

Dark green- and grey-weathering layered metavolcanic rocks overlie and underlie the chert unit on the south half of the ridge. The most common rock is medium to dark green hornblende-chlorite schist with common decimetre-scale compositional bands defined by variations in abundance of plagioclase, biotite, or magnetite porphyroblasts. These rocks were likely andesitic or basaltic flows. Layers with millimetre-scale banding were interpreted as meta-tuffs.

Metachert unit

Grey to pink recrystallized siliceous schist ((?)metachert) is exposed on a broad saddle of the ridge and between the metavolcanic and limestone units to the north and northwest. Typically the chert laminae are crenulated (Fig. 5) and exhibit red to pink hues from hematite and piedmontite (Mn-epidote).

Marble unit

Buff-weathering calcareous and dolomitic marble contains thin layers of quartzite on the British Columbia–Yukon boundary, 3 km west of Hazel Ridge. The equivalent unit on Hazel Ridge comprises sandy calcareous marble intercalated with grey marble boudins (Fig. 6), and also forms a recumbent fold hinge near the midpoint of Hazel Ridge. Unspecified Devono-Mississippian fossils were found at the third (ridge) locality by Green et al. (1960).

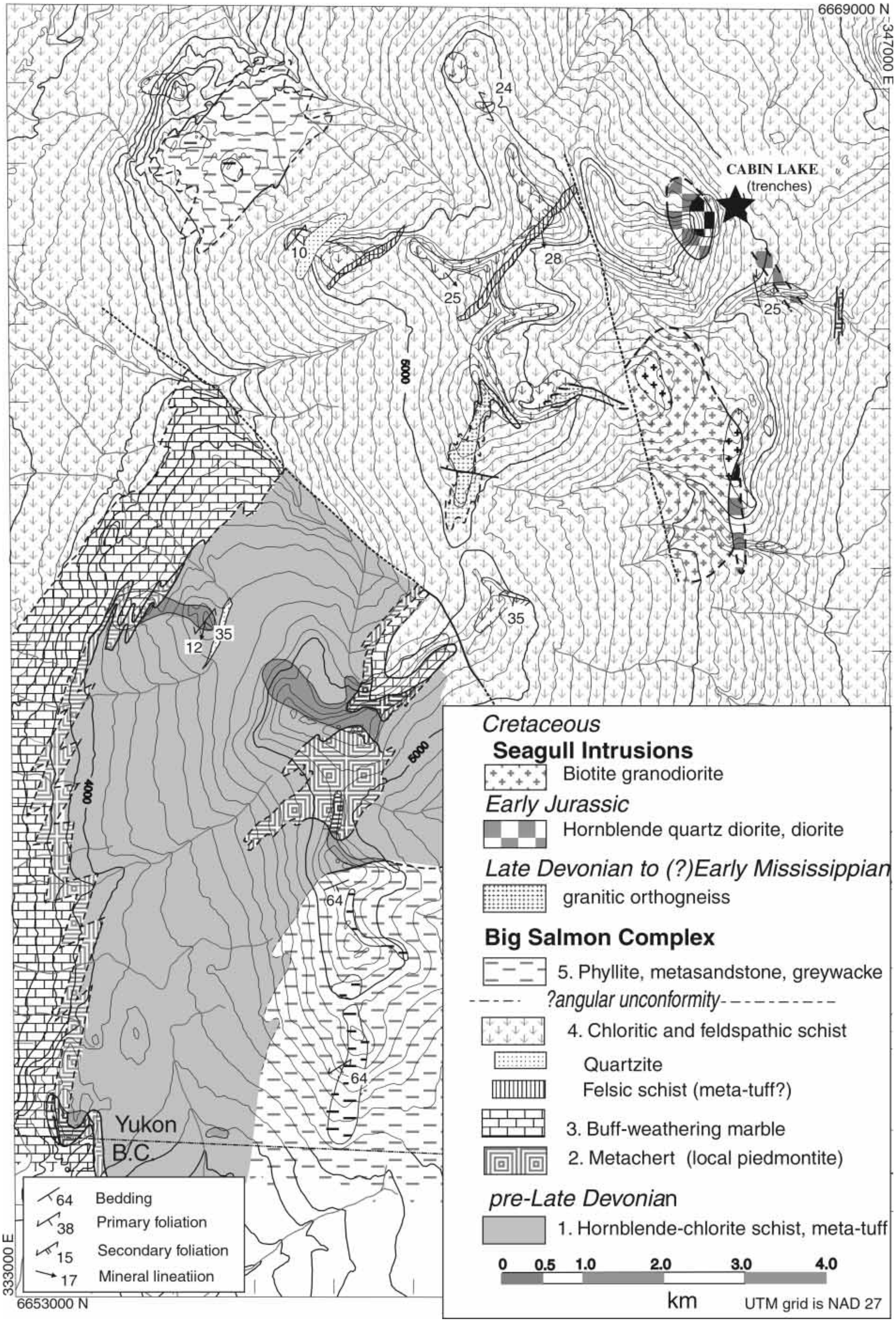

Figure 4. *Bedrock geology of Hazel Ridge, based upon fieldwork in 1999. Areas of outcrop are shown by dark patterns.*

Mixed greenstone–metaclastic rock unit

This unit, on the north half of Hazel Ridge, consists mostly of layered chlorite-feldspar schist. We interpret these as meta-tuffs, but unlike the metavolcanic unit 1, these include bands of white quartzite, grey marble, and at least two felsic schist layers (marked on Fig. 4). The western layer is quartz-muscovite phyllite containing abundant recrystallized quartz grains or phenocrysts, 2–6 mm in diameter (rarely to 1 cm). The eastern layer is a rusty-weathering, grey-green muscovite-quartz±chloritic phyllite with abundant pyrite and jarosite alteration. Similar possible felsic horizons were noted by Mihalynuk et al. (1998) in their mixed volcanic/clastic-succession (here called unit 4).

Metaclastic unit

This unit overlies metavolcanic rocks on the south end of Hazel Ridge, as indicated by sedimentary top indicators within a few metres of the contact. Its base is dark grey phyllite with lighter sandy lamination and quartz wisps from 2 mm to several centimetres thick. Most of the unit is carbonaceous muscovite-quartz metasandstone to metagreywacke with layers of dark grey metasiltstone-phyllite, rare limy metasandstone, and a single metre-thick pebble metaconglomerate bed. Planar lamination and visible detrital quartz grains are characteristic of the sandstone. The metaconglomerate contains subequal amounts of dark grey phyllite and white quartzite clasts. Metaconglomerate containing strongly deformed clasts occurs above the contact with greenstone several kilometres to the southeast, where Mihalynuk et al. (1998) suggested an erosional unconformity.

On the northwest spur of Hazel Ridge, light coloured muscovite-quartz-plagioclase schist with detrital quartz and limy layers topographically overlies unit 4.

***Figure 5.** Metachert on the crest of Hazel Ridge (ULM 340200E 66590000N). Dark laminae are hematite and entire outcrop is coloured pink by piedmontite (Mn-epidote).*

Plutonic rocks

Orthogneiss

Strongly foliated orthogneiss forms an irregular body underlying the northern part of Hazel Ridge. It is locally rusty weathering and contains specularite. This rock clearly truncates carbonate-rich layers in the metavolcanic unit. It resembles the Hazel orthogneiss (Mihalynuk et al., 1998) which intrudes the greenstone unit and yielded a Late Devonian age (R.M. Friedman, pers. comm., 1999).

Diorite

Unfoliated medium-grained hornblende diorite forms a plug up to 1 km^2 on the east side of Hazel Ridge and acicular hornblende-bearing dykes from 0.5 to 2 m wide cut all the foliated units. Both are likely related to the many small elongated north- and northwest-trending bodies and dike swarms throughout the Dorsey Range (Abbott, 1981) that may be coeval with large Jurassic plutons in Jennings River map area (Simpson Peak and Nome Lake batholiths; Mihalynuk et al., 1998).

***Figure 6.** Boudins in buff-weathering marble, on the west side of Hazel Ridge (ULM 337350E 6661550N).*

Granodiorite

A hornblende-biotite granodiorite plug, located on the east side of Hazel Ridge, has pegmatite veinlets with molybdenite and siderite along its western margin and is probably of the same suite as the younger Logtung stock (Stewart and Evensen, 1983) of mid-Cretaceous age.

Structural notes

Field observations suggest four generations of deformation in the Hazel Ridge rocks. Both mesoscopic F_1 and F_2 folds are tight to isoclinal. F_3 folds are southwesterly verging isoclines: a kilometre-scale recumbent F_3 fold is outlined by unit 3 carbonate within the chert and metavolcanic units. Broad antiformal and synformal warps (F_4) disperse earlier fold axes. These are indicated by map-scale variations in orientation (e.g. axes of F_2 folds plunge towards 150E on the west side and towards 175Eon the east side of the northern part of Hazel Ridge).

The (millimetre-scale) penetrative S_1 foliation, defined primarily by a preferred orientation of muscovite and chlorite, parallels compositional layering (S_0), apart from in F_1 hinges, where it is at a high angle. S_0 and S_1 are overprinted by a 5 mm spaced cleavage (S_2), which is defined by thin feldspar bands and veinlets, and are folded by mesoscopic F_2 folds (Fig. 7). F_2 folds are associated with a southerly plunging L_2 mineral lineation.

With three generations of isoclinal folds and transposition we cannot be certain of stratigraphy except at the kilometre scale. However, the apparent inversion of the stratigraphic order of Big Salmon Complex units documented in northern British Columbia (Mihalynuk et al., 1998) on the west side of Hazel Ridge, indicates much of the area is overturned. However, we know that unit 5 on southern Hazel Ridge is right side up, and it overlies units 1 and 4. Therefore Unit 5 may have been deposited after a major deformation of the previous four units, above an angular unconformity.

Figure 7. *View south of folded metachert and phyllite exhibiting top-to-the-southwest verging F_2/F_3 folds, north end of Hazel Ridge (ULM 3403500E 6665700N). Hammer in centre for scale.*

Discussion

Hazel Ridge is part of the Big Salmon Complex, with the chert quartzite horizon being a regional marker. Unit 1 is probably overturned where it is in contact with the chert unit, and is disconformably overlain by clastic rocks of unit 5. The four generations of structures described in this study are consistent with those described by Mihalynuk et al. (1998). Their study showed that the peak of regional metamorphism was attained during F_2, with the growth of garnet, biotite, actinolite, staurolite, and andalusite; F_3 folding was accompanied by retrograde growth of chlorite, muscovite, calcite, and epidote.

Mineralization

Malachite staining and pockets of chalcopyrite and arsenopyrite are found along the margins of limy layers and pods in the metavolcanic rocks of unit 4. Pyrite and marcasite are disseminated in the light beige- or rusty-weathering (jarosite) felsic schist horizons. The quartz-eye phyllite resembles the ‘Arsenault dacite’, found 16 km to the southeast on Mount Francis, where it is spatially associated with Cu-Pb stream anomalies and Fe-Cu mineralization (Mihalynuk et al., 1998).

Two mineral properties are located in the metavolcanic rocks nearby. The Cabin Lake prospect (Fairfield Minerals), on the eastern slope of Hazel Ridge, 4.5 km southwest of Cabin Lake, has disseminated pyrite and chalcopyrite in siliceous schist, including a layer with up to 5% blue quartz eyes. The quartz-eye schist on the crest of Hazel Ridge has a similar width and northeast strike. About 25 km northwest of Hazel Ridge is another polymetallic sulphide prospect, the Caribou Creek (Fairfield Minerals, currently optioned to Brett Resources). On the property is a 5 m thick layer of phyllic-altered quartz-augen sericite schist. Felsic schist is also exposed near a copper, lead, zinc, and barium stream-silt anomaly about 300 m north.

The chert unit may also be of economic interest. The chert is highly anomalous in barium and manganese, has several minor occurrences of chalcocite, chalcopyrite, and copper stain, and is a readily recognized regional marker (Mihalynuk et al., 1998). Nelson (1997) suggested an exhalative origin. It may be analogous to the iron-formation found directly above stratabound mineralization at the Wolverine deposit in Yukon–Tanana Terrane near Finlayson Lake (Tucker et al., 1997).

RIDGE SOUTH OF SWIFT RIVER HEADWATERS

Dorsey assemblage

A transposed section of mixed intermediate to felsic tuff and silicic and calcareous metasedimentary rocks with sills of orthogneiss constitutes the southwestern extent of the Dorsey assemblage (Fig. 8). The most common rock type is chlorite-mmuscovite-feldspar-quartz schist. Some compositional layers contain relict quartz granules. Yellowish calc-silicate

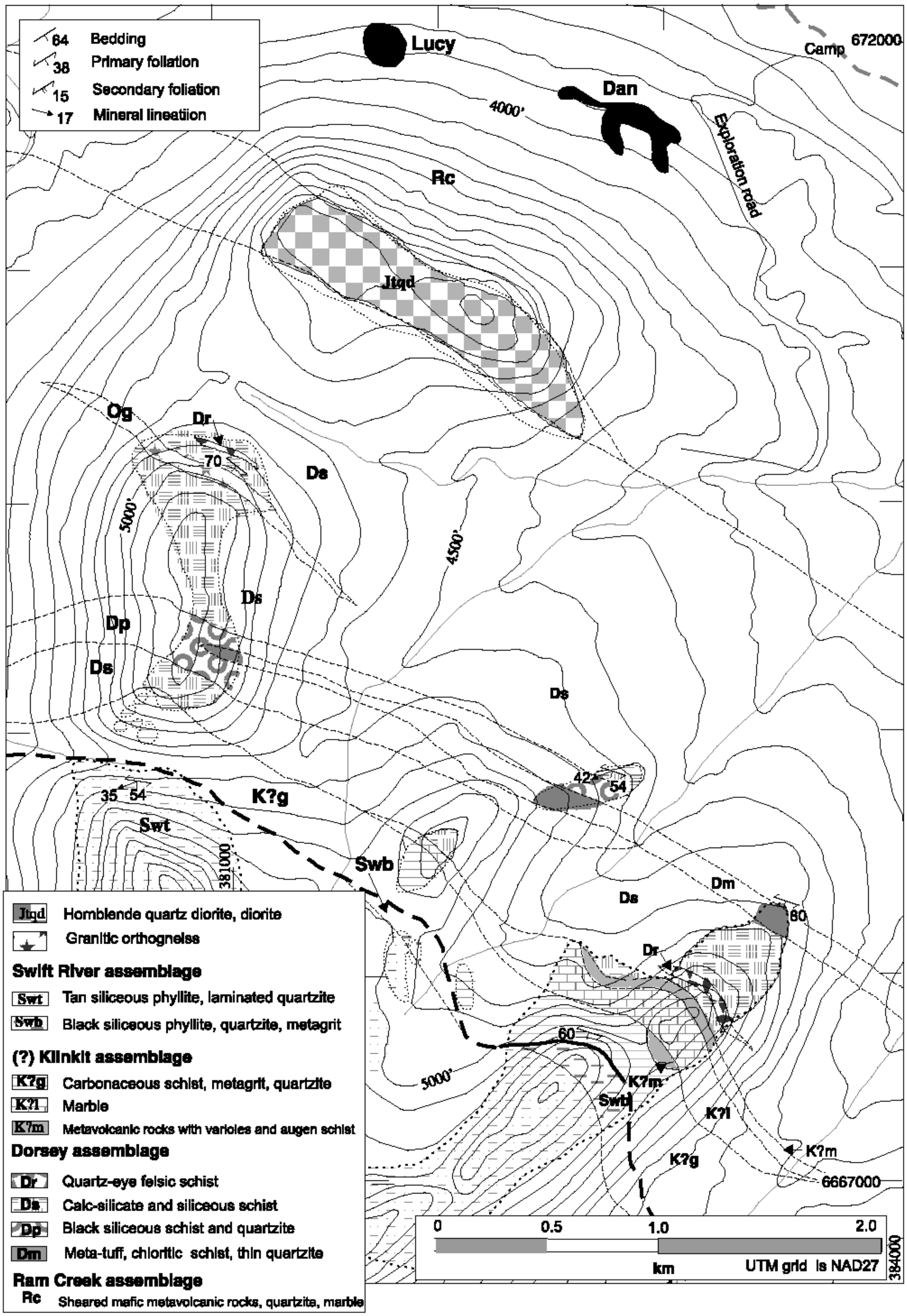

Figure 8. *Bedrock geology of the Swift River headwaters area discussed in text. Area of Jtqd is modified from Stevens and Harms (1995).*

layers reveal brown retrograde garnets about 1 mm across. At least three quartz-feldspar-phyric, white to pale yellow, metarhyolite layers were noted on the spurs at approximately the same distance below the top of the Dorsey assemblage.

A presumed sill of medium- to coarse-grained granite to granodiorite orthogneiss is exposed on the north-facing slope. Its upper contact is slightly discordant with the overlying quartz-muscovite schist (Fig. 9), but its lower contact was not observed.

(?)Klinkit assemblage

Between the known Dorsey assemblage and the first layers of certain Swift River assemblage to the south, is an approximately 200 m thick section of mafic metavolcanic rocks, white marble, and dark epiclastic rocks. This section was included within Dorsey assemblage by Stevens and Harms (1995; middle of their section A1-A2) but these rocks lack the quartzofeldspathic 'sweats' and high-strain features that characterize the Dorsey (Stevens, 1997).

On the northeast spur, a dark-weathering metavolcanic layer a few metres wide structurally underlies the limestone. It is mottled green and maroon, with ovoid, light coloured patches several centimetres across which resemble varioles in altered basalt. The light-grey-weathering marble forms a prominent band 20–50 m wide across two spur ridges (Fig. 10). Its base consists of waxy green carbonate blocks in a darker weathering phyllitic matrix. Structurally above the limestone is brown, green, and black mottled mafic metavolcanic rock containing black quartzite with white streaks. Locally, the metavolcanic rock retains primary layering, with 1–3 cm separations of green and yellow chert, as well as epidotized and silicified layers. The rock is interpreted as mostly meta-tuff. Rippled, lumpy texture is caused by abundant quartz lenticles distributed on the foliation planes. One layer of medium- to coarse-grained greenish grit resembles a strongly sheared plutonic rock.

This carbonate-epiclastic succession is lithologically unlike rocks of the Dorsey assemblage and reminiscent of Klinkit assemblage. Layers containing quartz-feldspar augen are being tested for primary datable minerals.

Swift River assemblage

The base of the Swift River assemblage is defined at an abrupt change from dark coloured volcaniclastic rock below ((?)Klinkit assemblage), to brown-weathering metasiltstone with abundant black argillite partings above. The metasiltstone is about 50 m thick, structurally overlain by dark metasandstone with manganese oxide coating, interspersed with metre-thick streaky grey quartzite and mafic layers. The Swift River assemblage continues south at least 10 km to the Alaska Highway near the Swift River Lodge.

Structural notes

Transposition of compositional layering in these rocks is evident, and primary sedimentary features, such as way-up indicators, have been obliterated. Dorsey assemblage rocks display a moderately southwest-dipping penetrative foliation defined principally by oriented muscovite and biotite flakes. A mineral lineation plunges moderately towards 270–290E and is typically (nearly) parallel to hinges of tight to isoclinal folds.

In the structurally overlying Swift River assemblage, the amount of finite strain appears to be, at least locally, less than that experienced by the Dorsey assemblage rocks. Rarely, patches of fine metasedimentary laminae are preserved. Minor fold axes and crenulation lineations plunge moderately west, showing structural continuity and their common transposition history with the Dorsey rocks.

Figure 9. *Intrusive contact of light coloured orthogneiss into quartz-biotite plagioclase schist, Dorsey assemblage, on the north end of ridge (ULM 380950E 6670100N). Dimpled hammer handle in corner for scale.*

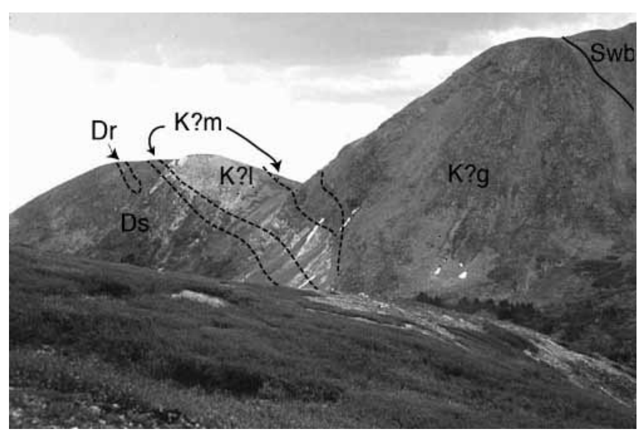

Figure 10. *View southeast of the northeast spur. The 40 m thick marble, with mafic metavolcanic ((?)Klinkit assemblage) on either side.* See *Figure 8 for unit abbreviations.*

No minor structures were observed to indicate the nature of the original contact between the Dorsey assemblage and the Swift River assemblage (e.g. a synorogenic (ductile or brittle) thrust, or a sedimentary contact). Mesoscopic top-to-the-south and -southwest ductile and brittle-ductile shear bands (Fig. 11), and brittle normal faults postdate the penetrative foliation. Normal faults, both mesoscopic and macroscopic, with probable normal displacements of up to 100 m, have been recognized throughout the area. In some cases, these faults occur at the contact of the two assemblages, thus obscuring original relationships (Fig. 12). In the northwestern Dorsey Range — about 34 km northwest of the area described here — the contact between the Dorsey Terrane and the Klinkit assemblage is also a late-stage, steeply south-dipping normal fault. The latter preserves abundant mesoscopic down-to-the-southwest normal faults.

Mineralization

Several Zn-Pb-Ag showings lie near the Dorsey–Swift River boundary. To the north, within the Ram Creek assemblage, are the Dan (also known as Bar or Park) claims. Layers of black sphalerite, magnetite, and pyrrhotite have been traced over 315 m along the contact of a chlorite-actinolite±plagioclase ('meta-tuff') with calc-silicate and marble. About 1 km northwest is the Lucy prospect, where a 20 m width of actinolite and magnetite occurs in roughly the same structural setting.

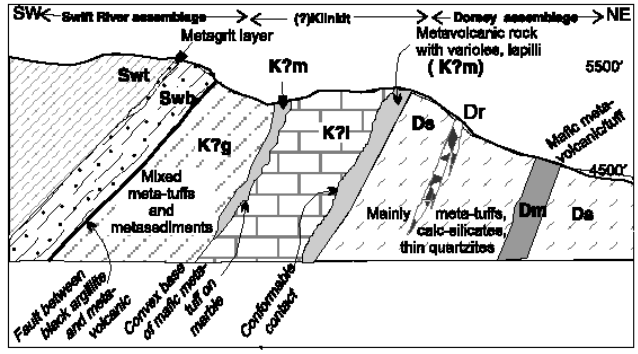

Figure 12. *Schematic section of the northeast spur with notes on contacts between Dorsey, (?)Klinkit and Swift River assemblages. Unit abbreviations correspond with those of Figure 8.*

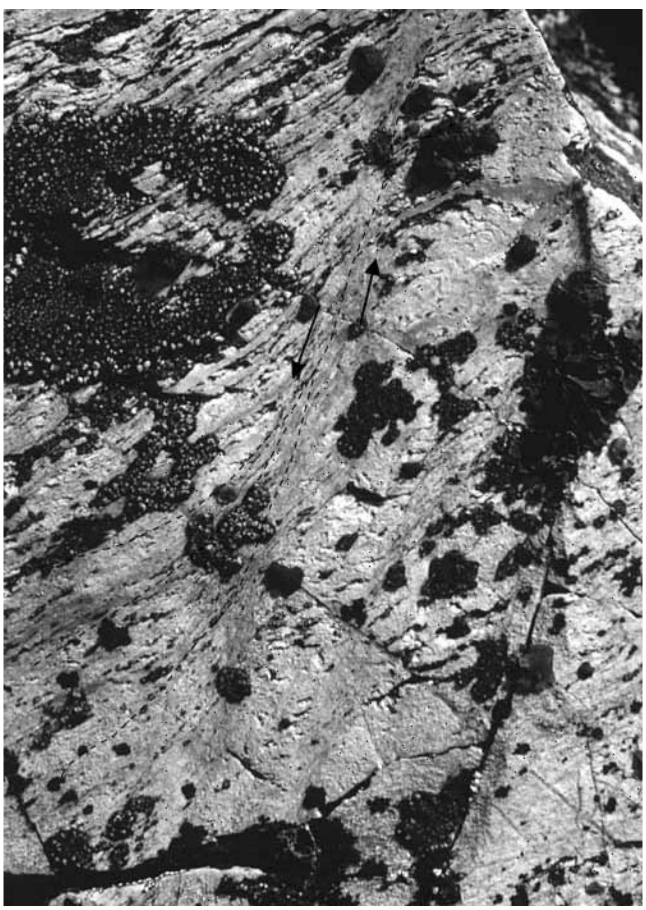

Figure 11. *View west at quartz-plagioclase-hornblende-muscovite schist near top of Dorsey assemblage (ULM 383120E 6687820N), showing down-to-the-southwest shear bands, implying a normal fault.*

Figure 13. *Quartz-eye felsic schist ((?)metarhyolite) in the Dorsey assemblage, 2 km south of Dan showing (ULM 381060E 6670240N).*

To the northwest (along the structural grain of the Dorsey-Swift River boundary) is the Mod and several other showings where magnetite-pyrrhotite, sphalerite, and galena with minor chalcopyrite and pyrite form bands 0.5 to 1 cm in thickness, and fill fractures. The host rock is hornfelsed argillite and at least three marble outcrops are exposed along strike, within the same structural grain as the 40 m wide marble described here as part of the (?)Klinkit assemblage.

Thirdly, three occurrences of quartz±feldspar-phyric rock were noted on the ridge spurs where we observed Dorsey and Swift River rocks (Fig. 13). These layers may be silicic dykes or felsic tuff horizons: if the latter, they are the best indication so far of the area's potential for volcanogenic massive-sulphide mineralization.

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