Wolf Lake project: Revision mapping of Dorsey Terrane assemblages in the upper Swift River area, southern Yukon and northern B.C.[1]

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Roots, C.F., de Keijzer, M. and Nelson, J.L., 2000. Wolf Lake project: Revision mapping of Dorsey Terrane assemblages in the upper Swift River area, southern Yukon and northern B.C. *In:* Yukon Exploration and Geology 1999, D.S. Emond and L.H. Weston (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 115-125.

ABSTRACT

The northern half of the Jennings River (104O) and southern half of the Wolf Lake (105B) map areas include polydeformed and metamorphosed rocks of the eastern Big Salmon Complex (Yukon-Tanana Terrane) and a succession of mostly Paleozoic rock assemblages currently grouped in Dorsey Terrane.

On the northeast side of Dorsey Terrane, siliceous grits and mafic metavolcanic rocks of the Dorsey assemblage are thrust over the Ram Creek assemblage. Dorsey assemblage is in turn structurally overlain by thin mafic volcanic rocks and limestone (Klinkit (?) assemblage), and by dark phyllitic rocks and quartzites of the Swift River assemblage.

Extensive stratabound pyrrhotite-sphalerite mineralization occurs along a 6.5 km structural trend in calc-silicate rocks and rhyolite of the Ram Creek assemblage. Similar mineralization also occurs several kilometres southwest of that trend, within or adjacent to the Dorsey assemblage. Both assemblages contain quartz +/- feldspar -phyric layers with potential for volcanogenic massive sulphide showings.

RÉSUMÉ

La moitié nord de la région cartographique de Jennings River (SNRC 104-O) et la moitiée sud de celle de Wolf Lake (SNRC 105-B) sont sous-tendues par les roches métamorphiques de tectonisme polyphasé de la partie orientale du Complexe de Big Salmon (Terrane de Yukon-Tanana) ansi que par une succession de roches principalement Paléozöiques présentement attribuées au Terrane de Dorsey.

Au nord-est du Terrane de Dorsey, les roches siliceuses à granules et des roches métavolcaniques mafiques rapportées à l'assemblage de Dorsey chevauchent l'assemblage de Ram Creek. L'Assemblage de Dorsey est à son tour superposé tectoniquement par une mince succession de roches volcaniques mafiques et de calcaires (assemblages de Klinkit (?)), ainsi que par des lithologies phylliteuses sombres et des quartzites (assemblage de Swift River).

Les roches calco-silicatées et les rhyolites de l'assemblage de Ram Creek renferment de nombreux indices stratiformes minéralisés en phyrrotine et sphalérite. La minéralisation est répartie sur une distance de 6,5 km le long d'un axe tectonique. À quelques kilomètres au sud-ouest de cet axe, le mème type de minéralisation est retrouvé en bordure et dans l'assemblage de Dorsey. Les assemblages de Dorsey et Ram Creek renferment plusiers horizons siliceux à phénocristaux de quartz ± feldspath, ce qui suggère un potentiel pour la présence de sulfures massifs volcanogènes.

[1]Contribution to the Ancient Pacific Margin NATMAP project. Geological Survey of Canada Contribution 199212.

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INTRODUCTION

The region east of Teslin Lake to the continental divide (Fig. 1) includes poly-deformed, medium- to high-grade metamorphic rocks which range from older than Devonian to Triassic in age. The western third comprises the Big Salmon Complex which has similar lithostratigraphy to Yukon-Tanana Terrane; the eastern two thirds has been referred to as Dorsey Terrane (this term may become obsolete as the component rock units are attributed to other, better established, terranes). The study area is bounded to the east and northeast by the Cassiar Platform and intruded by Early Cretaceous Cassiar batholith. Revision mapping of the Swift River area by the Geological Survey of Canada (GSC) began in 1999, in concert with on-going projects of the British Columbia Geological Survey (BCGS; Nelson et al., 1998; Mihalynuk et al., 2000).

This work is part of the central component of the Ancient Pacific Margin NATMAP, a Cordillera-length forum for understanding the tectonic evolution, paleogeography and metallogeny of rock units that form the late Paleozoic and early Mesozoic western margin of ancestral North America. In addition to accelerated mapping and metallogenic studies by the GSC, the initiative involves programs of the BCGS and the Glenlyon and Finlayson projects of the Yukon Geology Program. The rock units, sometimes known as pericratonic terranes, are structurally complex and metamorphosed because they have taken the brunt of deformation and high-pressure metamorphism during collision of North America with arcs, oceanic crust and outboard terranes. The long-term NATMAP objective in the Swift River area is to produce a revised map covering northern Jennings River, B.C. (104O) and southern Wolf Lake, Yukon (105B) at 1:250 000 scale, in addition to open-file maps at 1:50 000 scale of selected areas.

Existing bedrock maps date from reconnaissance fieldwork in the fifties and early sixties (Mulligan, 1963; Poole et al., 1960; Aitken, 1959; and Gabrielse, 1969); these authors defined the major lithologic units with limited paleontological and geochronological control. Discovery of carbonate-hosted zinc-lead deposits (e.g., Midway, now called Silvertip) and intrusive-related tin tungsten and gold deposits (e.g., Logtung) led to mineral exploration booms and subsequent geological mapping (e.g., Abbott, 1981; Lowey and Lowey, 1986; Murphy, 1986; Nelson and Bradford, 1993), but the regional coverage has not been updated to reflect these advances. During a synthesis of tectonic assemblages of the Canadian Cordillera, the name 'Dorsey Terrane' was given to rocks that lay outboard of the Cassiar Platform but did not resemble the Yukon-Tanana or Slide Mountain terranes (Monger et al., 1991). Field mapping aimed at defining the Dorsey Terrane established a framework of five assemblages, Hazel, Ram Creek, Dorsey, Swift River and Klinkit, each with distinctive lithologic and structural characteristics (Harms and Stevens, 1996; Fig. 2).

In 1999, a joint BCGS-GSC one-month camp was established on Morley Lake with a shared contract helicopter to assist continued fieldwork in the Big Salmon Complex (Mihalynuk et al., 1998, in press) and southeast Dorsey Terrane (Nelson et al., 1998, this volume), as well as to permit traverses across key geological exposures of the above-mentioned assemblages in southern Yukon. Mapping in 1999 showed that Hazel Ridge, a broad upland east of Morley Lake, is a direct continuation of the Big Salmon Complex (Roots et al., 2000), hence the term 'Hazel assemblage' should be retired. The remainder of this paper describes exposures in the Swift River headwaters area which are among the most accessible in Dorsey Terrane. The authors focus upon the relationships between the component assemblages, and intend to date these rocks and perform provenance studies, which will likely modify their interpretation.

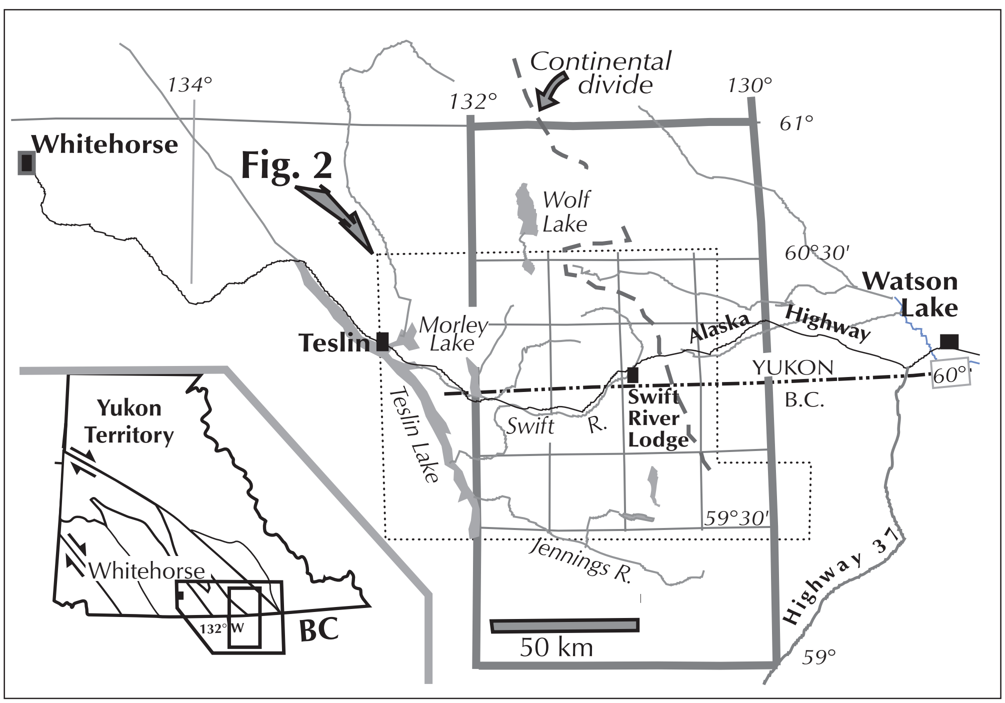

Figure 1. *Wolf Lake and Jennings River map areas (thick outline) straddle the BC-Yukon border. Thin lines delineate the 1:50 000-scale map areas.*

GEOLOGY OF THE UPPER SWIFT RIVER AREA

Four-wheel drive exploration roads and bulldozer trails extend about 30 km northwest from the Pine Lake airstrip near the continental divide, and require fording the river about 10 km from the Alaska Highway. The Bar mineral occurrence (generally known as the Dan showing; Yukon Minfile, 1997, 105B 027) is located below treeline (Fig. 3) and is owned by First Yukon Silver Resources. The showing includes a 200-m-long trenched and washed exposure with abundant stratabound sphalerite, magnetite-pyrrhotite and galena known locally as 'the Window.' Mineralization is discontinuously exposed along structural grain to the northwest for 6.5 km, principally at the Lucy, Gossan and Crescent (Yukon Minfile, 1997, 105B 026) showings. The area was under option to Cominco in 1993 (Indian and Northern Affairs Canada, 1994, p. 4) and Birch Mountain Resources in 1997 (Burke, 1999). Numerous assessment and other reports describe the geology;

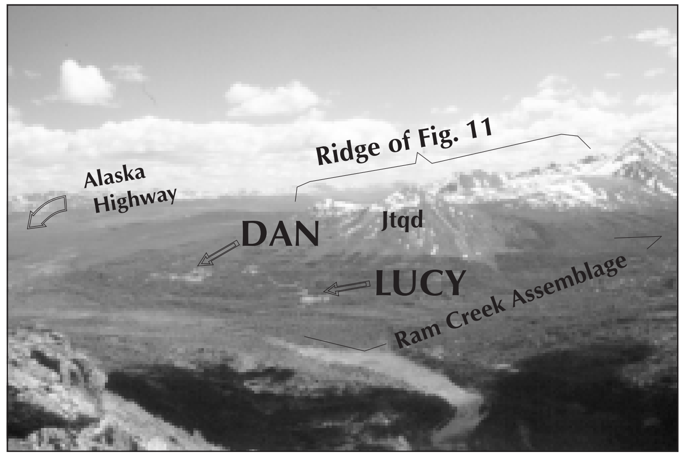

Figure 3. *View southeast of upper Swift River valley, showing some mineral occurrences and units mentioned in text.*

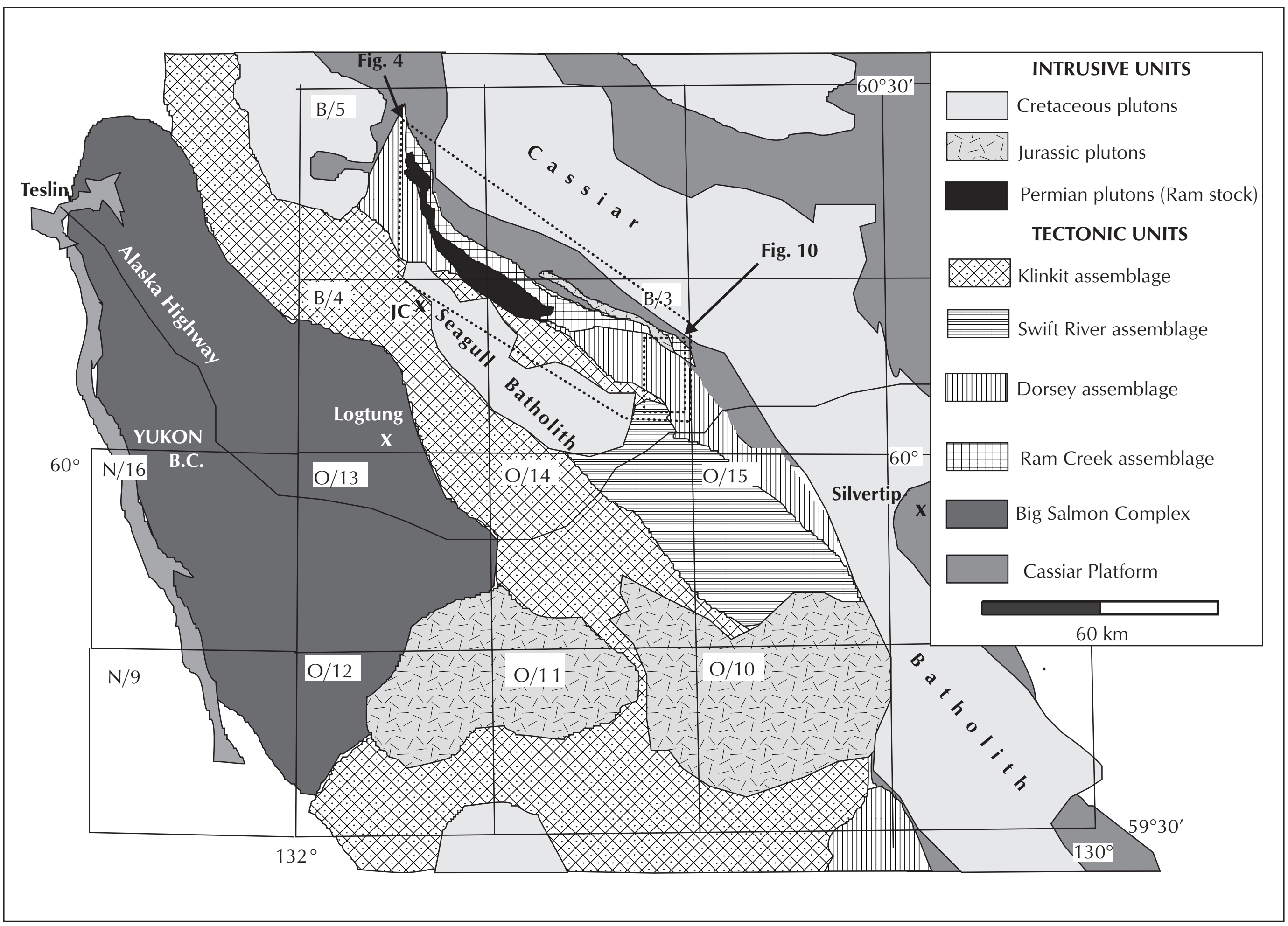

Figure 2. *Tectonic units of southern Yukon and northern British Columbia, modified from Nelson et al. (1998) and unpublished data.*

this work is summarized in Indian and Northern Affairs Canada, (1981, p. 144; 1993, p. 2) and by Bremner and Liverton (1991, a, b). These showings will likely be the focus of a metallogenic study by Suzanne Paradis (Mineral Deposits Division, GSC) and detailed structure by Luis José Homen D'el-Rey Silva (Instituto de Geosciencias, Universidade de Brasilia, Brasil) under the aegis of the Ancient Pacific Margins NATMAP.

The above-mentioned showings lie within a mixed lithologic package called the Ram Creek assemblage. This narrow belt trends 45 km in a northwesterly direction between the Cassiar Platform to the northeast, and the Dorsey assemblage to the southwest (Fig. 4).

RAM CREEK ASSEMBLAGE

This assemblage comprises mafic to intermediate metavolcanic rocks with discontinuous bodies of quartzite, marble and meta-plutonic rocks (Harms and Stevens, 1996). We observed these rocks in the vicinity of the Dan showing, and south of Ram Creek at the northwest end of the belt. At the former, bulldozer scraping and trenching have exposed predominantly calc-silicate rock with interfolded metavolcanic and marble layers (Fig. 5). The calc-silicate unit comprises metamorphosed clastic and volcanic sediments, chloritic schist and amphibolite. Visible minerals include diopside, plagioclase, garnet and calcite; in places pyroxene and garnet are replaced by actinolite and chlorite. The retrograde metamorphic assemblage is spatially associated with the massive sphalerite and pyrrhotite-magnetite (Bremner and Liverton, 1990b).

The calc-silicate unit includes meta-rhyolite, a greenish, finely banded rock with visible quartz and rare plagioclase phenocrysts (Fig. 6). Intense shearing and stretching has obliterated most primary structures. In pockets, however, evidence of igneous origin remains and includes beta-quartz phenocryst morphology and rare primary flow textures. The millimetre scale layering which can be traced several tens of metres at the Window is the product of very localized strain.

The origin of the mineralization is debatable. The stratabound nature of mineralization and presence of rhyolite imply nearby volcanism. The mineralogy is clearly that of a hydrothermal skarn deposit, and it postdates metamorphic layering. It has been argued that the sulphides have been remobilized from a pre-existing syngenetic deposit, but the coincidence that mineralization is concentrated within the superimposed thermal aureoles of three plutonic bodies, is unlikely.

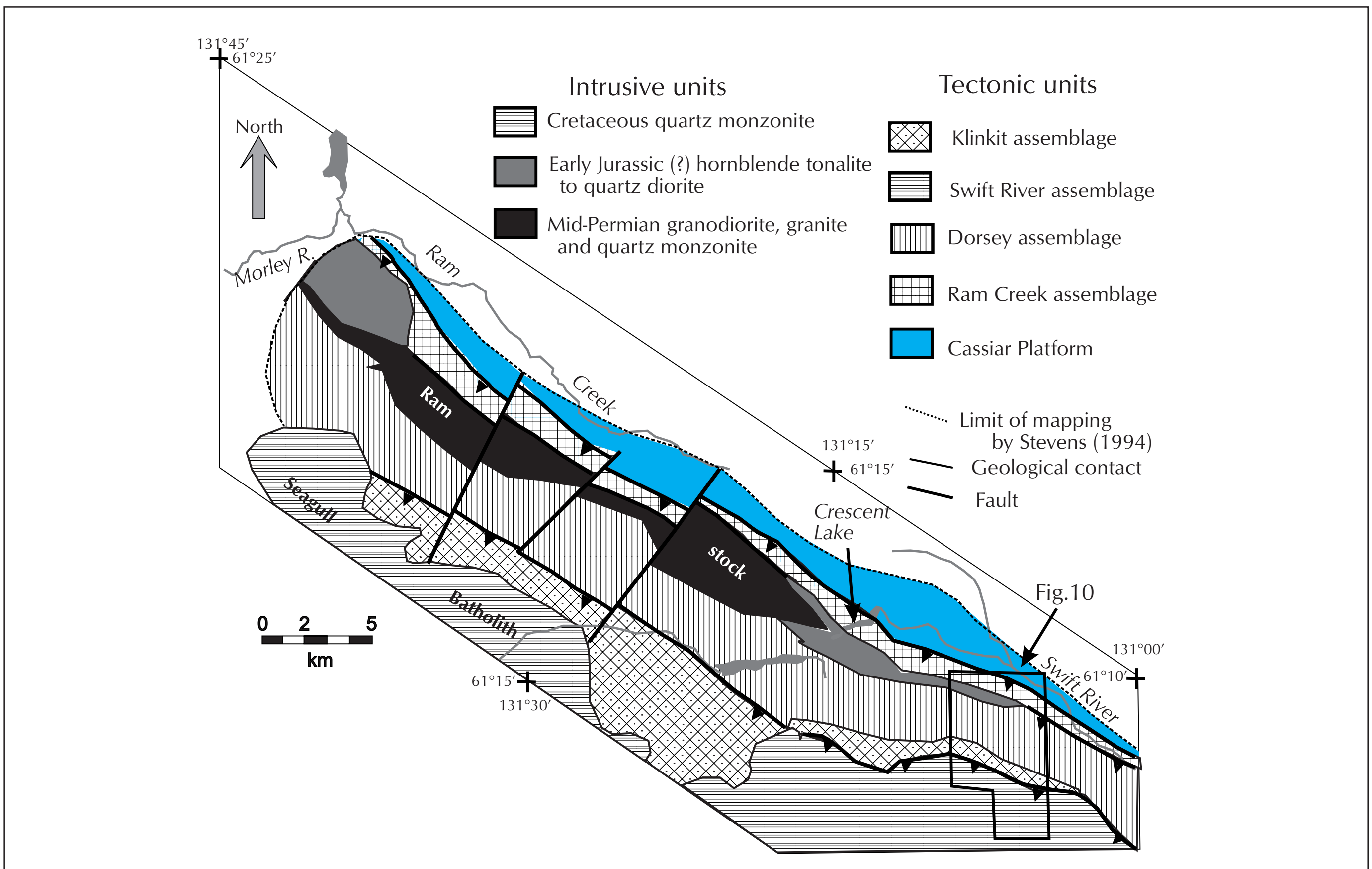

__Figure 4.__ Map of northern Dorsey assemblage, modified from Stevens (1996).

The authors also examined the Ram Creek assemblage at the northwest end of the belt. There it consists of chloritic metavolcanic schist interbedded (at metre scale) with black phyllitic argillite. Locally, the green rock reveals compositional layering (Fig. 7); the authors interpret it to represent mafic flows. The calc-silicate rock and mineralization are absent from the three spur ridges examined at the northwest end of the Ram Creek assemblage.

Contacts and comment

The northeast boundary of the Ram Creek assemblage is everywhere covered, but is likely a fault because the metamorphic grade and structural style differ markedly from the (structurally) underlying Cassiar Platform. The southwest side of the Ram Creek assemblage south of the Dan showing is a weakly deformed tonalite to diorite body parallel to the regional grain and is likely a sill of Jurassic age. The contact is reported to be slightly sheared.

At the northwest end of the Ram Creek assemblage, the southwest (structurally upper) contact is reported to be a mylonitic shear or strongly foliated zone 10-20 m wide, that grades upward into massive granodiorite of the Ram stock (Stevens and Harms, 1995). The nature of this contact should be regionally re-examined because at least one ridge spur exposes a sharp contact. Near this contact xenoliths of metavolcanic rock lie within the granite. Further fieldwork is also needed because the nature of the contact has important implications for timing of the deformation.

The Ram stock, elongated parallel to the northwest structural trend, has been dated by U-Pb zircon geochronology at

Figure 5. *The 'Window' exposure at the Dan occurrence. The white marble bodies lie within rusty-weathering calc-silicate rock; sphalerite-magnetite mineralization occurs near the contact (dark zone between T. Liverton and M. de Keijzer).*

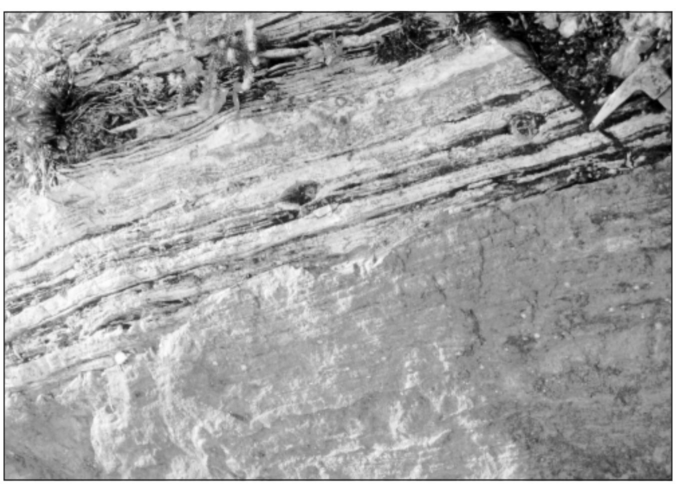

Figure 6. *Fine banding of chlorite-plagioclase-quartz in the calc silicate rock immediately south of the Dan mineralization. These layers are metamorphic and contacts between layers are entirely sheared (UTM 382650E, 6671550N).*

Figure 7. *Chloritic schist (mafic flow rock) of the Ram Creek assemblage near the northwest end of the belt (UTM 59250E, 6686750N).*

259 ± 2 Ma (J. Mortensen, pers comm., 1996; Stevens, 1996). If the contact with the Ram Creek assemblage is everywhere a shear zone, then its deformation may post-date the Permian intrusion, which could have later been thrust over the Ram Creek assemblage. The presence of mafic volcanic-looking clasts along the northeast side of the Ram stock, however, indicate that either the volcanic component of Ram Creek assemblage, or another volcanic unit, was adjacent to the intrusion in pre-Permian time.

Based upon initial observations, there is some doubt that the Ram Creek assemblage is a robust term. It does not appear to show lateral continuity in lithology, but appears to be structurally interleaved slices. Abbott (1981) interpreted this unit as fault-bounded slivers of Cassiar Platform strata and Yukon Cataclastic Complex (an obsolete term superseded by Yukon-Tanana Terrane in this region). Similarly, Stevens and Harms (1995) initially referred to the belt as the 'Imbricate assemblage.' We favour both Abbott's and Stevens' earlier interpretations, pending quantitative data on the age, or provenance of its constituents.

In east-central Jennings map area of northern B.C., a similarly situated belt (between Cassiar Platform and Dorsey assemblage) is also referred to as Ram Creek assemblage (Nelson et al., this volume). This belt is more cohesive, however, consisting of mafic to rhyolitic tuffs, with local limestone and chert. They are overthrust by the Dorsey assemblage on a mid-Permian thrust (Nelson et al., 1998). The rhyolitic tuffs are Mississippian in age, coeval with those in the Big Salmon Complex (Nelson et al., this volume). Given this evidence we suspect that 'Ram Creek assemblage' is a composite of rock units that are part of other terranes, including the Yukon-Tanana Terrane, and the term should eventually be retired.

DORSEY ASSEMBLAGE

In the Swift River area, mafic gneiss with interleaved siliceous schist and quartzite, is structurally overlain by muscovite ± biotite ± plagioclase ± tourmaline schist, quartzite and minor marble (Stevens, 1996). Where mapped south of the Dan showing, chlorite-muscovite-feldspar-quartz schist predominates (Fig. 8), but siliceous rock and orthogneiss are important constituents. Some compositional layers contain relict quartz granules and are probably metasedimentary. Yellowish calc-silicate layers reveal brown retrograde garnets about 1 mm across. At least three quartz-feldspar-phyric, white to pale yellow meta-rhyolitic layers (Fig. 9) were noted on spurs at approximately the same distance below the top of the Dorsey assemblage. On the north-facing slope, medium- to coarse-grained granitic orthogneiss is exposed. Its upper contact is slightly discordant with the overlying quartz-muscovite schist and is interpreted it as a sill. Orthogneiss of similar appearance is common in the Big Salmon Complex on Hazel Ridge and yielded a mid-Mississippian date (Mihalynuk et al., 1998). The orthogneiss on the ridge south of the Dan occurrence is expected to be of similar age.

The Dorsey assemblage to the northwest is intruded by the Ram stock, as indicated by abundant apophyses and inclusions. Because deformed clasts of the Dorsey assemblage are included within this Permian granite, the medium- to high-pressure metamorphism of that assemblage (Stevens, 1996) must be older than mid-Permian age.

KLINKIT (?) ASSEMBLAGE

Between the known Dorsey assemblage and the first layers of tan and black siliceous phyllite of the Swift River assemblage to the south (Fig. 10), is an approximately 250-m-thick section of mafic metavolcanic rocks, white marble and dark epiclastic

Figure 8. *Hinge of folded calc-silicate and quartz-feldspar augen schist of the Dorsey assemblage south of the Dan occurrence. This view is westerly, down moderately plunging stretching lineation parallel to the fold hinge (UTM 380850E, 6670240N).*

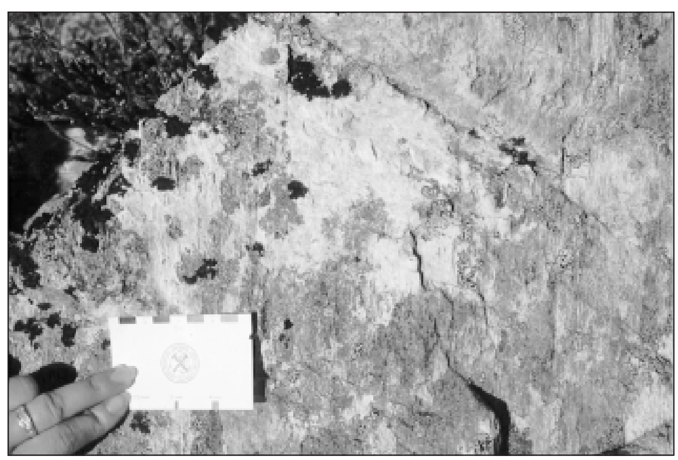

Figure 9. *Quartz-eye felsic schist (meta-rhyolite?) in the Dorsey assemblage, 2 km south of the Dan showing (UTM 381060E, 6670240N).*

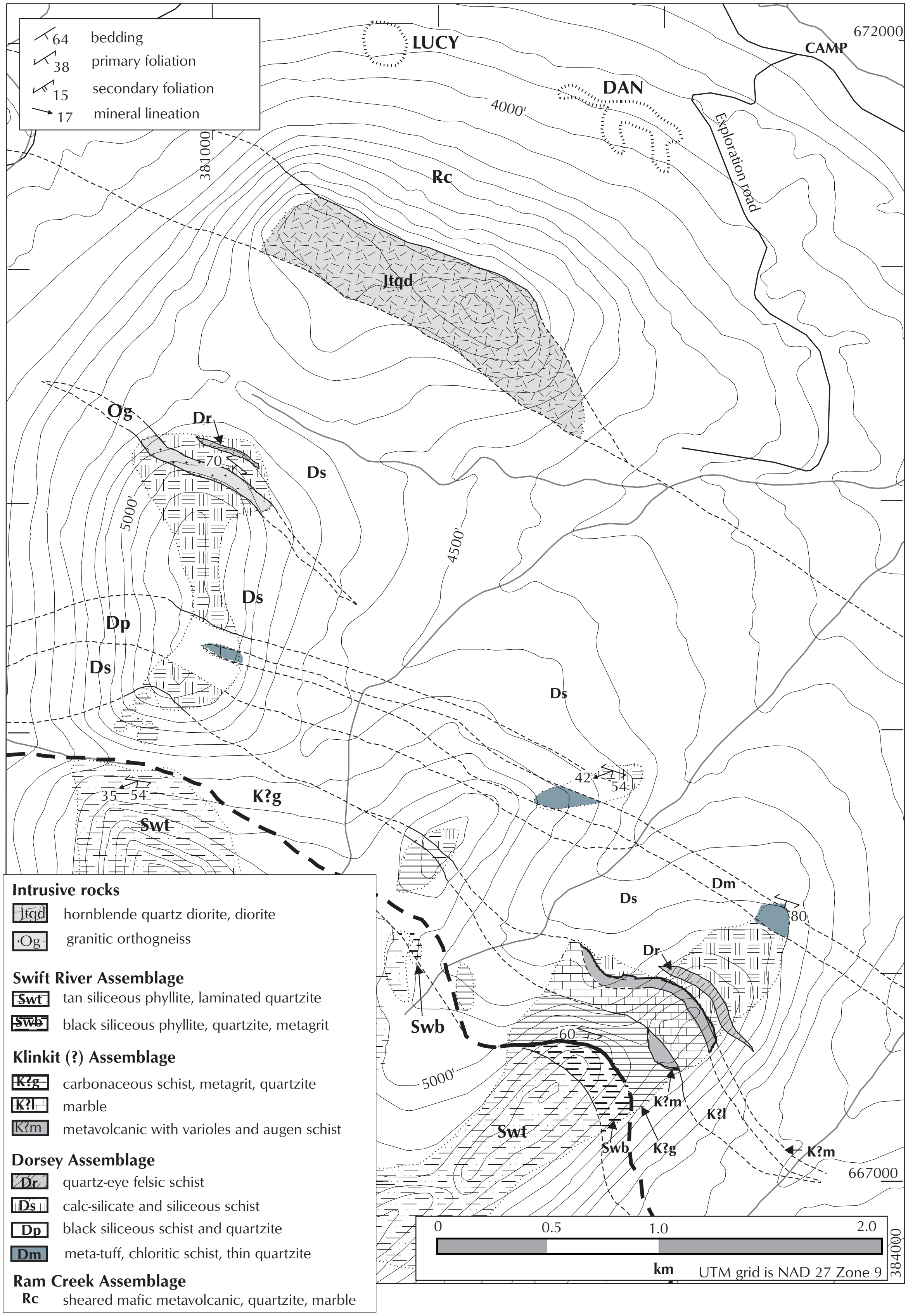

Figure 10. *Bedrock geology of the Swift River headwaters area. Contacts north of the Jurassic sill (unit Jtqd) are modified from Stevens and Harms (1995).*

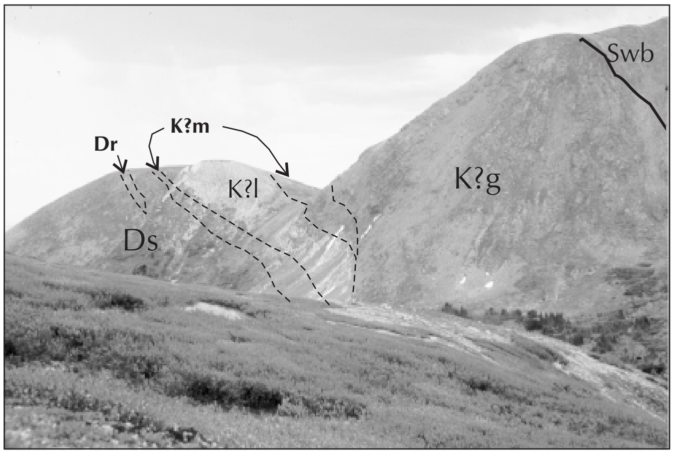

Figure 11. *View southeast of the northeast spur. Note the 40 m thick marble (K?l), with mafic metavolcanic (Klinkit (?) assemblage) on either side. See Figure 10 for unit abbreviations.*

Figure 13. *Dark, foliated metavolcanic rock conformably overlain by massive marble on the eastern-most spur ridge (see Fig. 10). View south at 381900E, 6667740N.*

rocks (Fig. 11). This section was included within the Dorsey assemblage by Stevens and Harms (1995; middle of their section A1-A2). The contacts are indicated on Figure 12.

On the northeast spur, a dark weathering metavolcanic layer a few metres wide structurally underlies the limestone (Fig. 13). The metavolcanic layer 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. 11). Its base consists of waxy green carbonate blocks in a darker weathering phyllitic matrix. Structurally above the limestone is about 150 m of brown, green and black mottled mafic metavolcanic rock containing black quartzite with white streaks. Locally, the metavolcanic rock has a rippled, lumpy texture caused by abundant quartz lenticles distributed on foliation planes. It is likely a meta-tuff since it shows compositional layering. The tuff beds are separated by 1-3 cm separations of green and yellow chert, as well as epidotized and silicified layers. One layer of medium to coarse greenish grit resembles a strongly sheared plutonic rock.

Comment

The rocks in this succession are lithologically unlike those of the neighbouring Dorsey and Swift River assemblages. The mafic volcanic and massive carbonate is reminiscent of Klinkit assemblage 25 km to the southwest in the Logtung area, however their age is unknown. Layers containing quartz-feldspar augen are being tested for primary datable minerals. Contacts are parallel to compositional layering and the foliation of enclosing units, with no discernible difference in structural character.

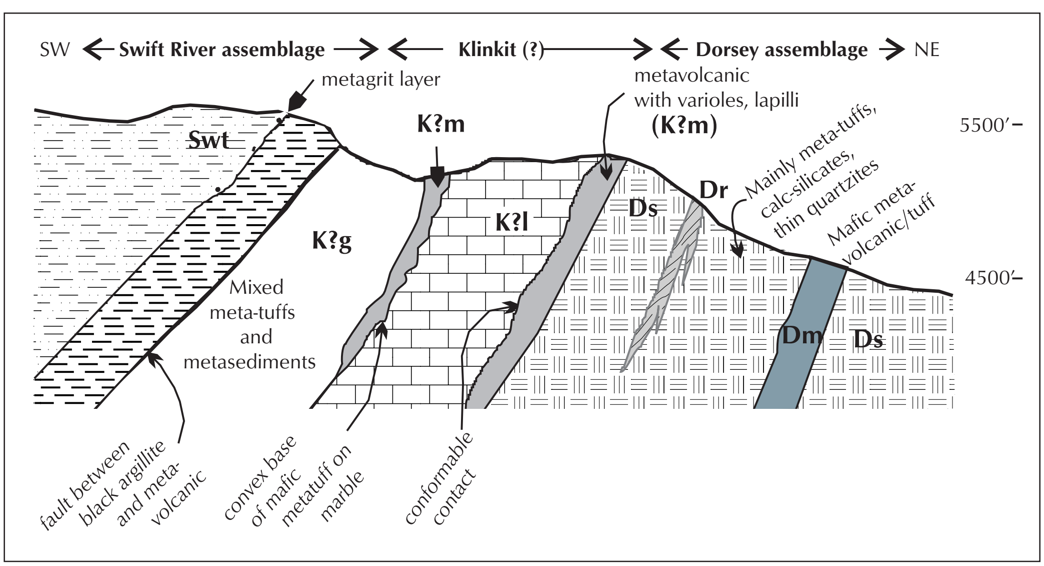

Figure 12. *Schematic section of the northeast spur with notes on contacts between Dorsey, Klinkit (?) and Swift River assemblages. Unit abbreviations correspond with those of Figure 10.*

SWIFT RIVER ASSEMBLAGE

The base of the Swift River assemblage is defined by an abrupt change from dark coloured volcaniclastic rock below (Klinkit (?) assemblage), to brown-weathering phyllite (meta-siltstone) with abundant black argillite partings above (Fig. 14). The metasiltstone is about 50 m thick, structurally overlain by dark meta-sandstone with manganese oxide coating, and 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, although most primary sedimentary features, including 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°-290° and is typically sub-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.

No minor structures were observed that indicate the nature of the original contact between the Dorsey, Klinkit (?) and Swift River assemblages. Are they syn-orogenic (ductile or brittle) thrust, or sedimentary contacts? If the middle section is indeed a sliver of Klinkit assemblage, it is younger than the structurally overlying Swift River assemblage (see Nelson et al., this volume), thus the upper contact is a thrust. Nevertheless, the contact has undergone later shearing (Fig. 13) such that no small-scale motion indicators remain. Mesoscopic top-to-the-south and –southwest ductile and brittle–ductile shear bands (Fig. 15) 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 contact relationships. In the northwestern Dorsey Range, about 34 km northwest of the area described here, the contact between the Dorsey and Klinkit assemblages is also a late-stage, steeply south-dipping normal fault, and abundant mesoscopic down-to-the-southwest normal faults occur in Dorsey assemblage.

MINERALIZATION

About 2.5 km east along the structural grain from where the Dorsey-Swift River boundary was examined lies the Mod showing and several others where magnetite-pyrrhotite, sphalerite and galena, with minor chalcopyrite and pyrite form bands 0.5 cm to 1 cm in thickness. Although the ore and gangue mineralogy is similar to that of the Dan-Crescent trend, this mineralization is at least 1 km higher in the structural succession. Three marble outcrops are exposed within the same structural grain as the 40-m-wide marble described here as part of the Klinkit (?) assemblage. As with the Dan, it is unclear whether these are epigenetic skarns, or skarnified syngenetic (possibly volcanic-associated) occurrences. The presence of quartz ± feldspar-phyric rock layers within the Dorsey and possibly Klinkit assemblages strengthens the case for volcanogenic massive sulphide mineralization.

Figure 14. *Southeast view of discrete, strained contact between foliated metavolcanic rock (Klinkit (?) assemblage) and structurally overlying black clastic rock of the Swift River assemblage (UTM 382750E, 6667530N).*

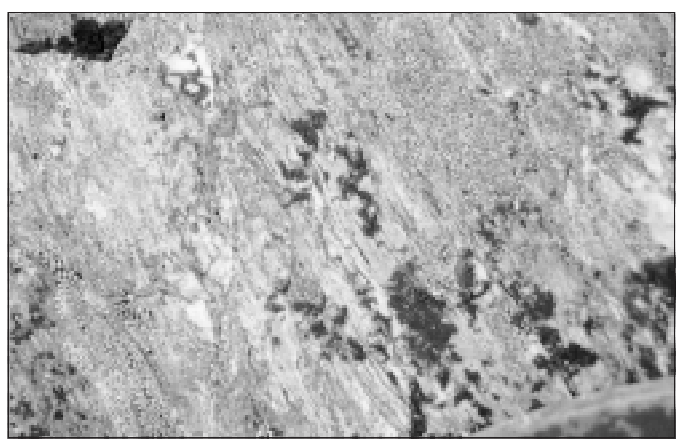

Figure 15. *View southeast of brittle-ductile shears, hammer head at lower right of photo. These small-scale structures are top-to-southwest shear bands common in northern Dorsey Terrane.*

ACKNOWLEDGEMENTS

This varied and wide-ranging field season would not have been possible without a strong show of support from the mineral industry and the cooperation of both the Yukon Geology Program and the BC Geological Survey. We benefited from astute observations by assistants Tom Gleeson and Kim Wahl, associates Steve Gordey (GSC), Rich Friedman (University of British Columbia) and Tekla Harms (Amherst College), as well as prompt, professional service by Andy Page (helicopter pilot) and Beth Hunt (cook). Dan Breeden and his family at Morley River Lodge cheerfully assisted with complicated logistics and communications. The H.S. Bostock Core Library, run by Mike Burke of Indian and Northern Affairs Canada graciously provided storage space. Dean Polard kindly assisted with camp construction. We thank Ed Balon and Wojtek Jakubowski (Fairfield Minerals), Geoff Bradshaw, James Smith and Terry Tucker (Brett Resources), as well as both Hardy Hibbing and Tim Liverton of Watson Lake for sharing geological information and permitting us to visit their mineral interests. This report includes maps originally drafted by Melanie Reinecke and editorial suggestions by Steve Gordey, Don Murphy and Grant Abbott.

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