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Stratigraphic linkage of carbonate-rich units across east-central Vernon map area, British Columbia: are Kingfisher (Colby) and Big Ledge zinc-lead occurrences part of the same regional marker succession?[1]

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Abstract: A calcareous quartzite and calc-silicate marker succession can be mapped across east-central Vernon map area (82 L/7). Both the lithologies present and the trend of the succession suggest it correlates with host strata to the Kingfisher (Colby) and Big Ledge base-metal occurrences. This model expands potential exploration targets by defining a large region of potential host rocks that appear to extend from the eastern shores of Upper Arrow Lake west to the town of Chase, a distance of more than 100 km.

Résumé : Une succession repère de quartzite calcareux et de roches calco-silicatées peut être suivie à travers la partie centre est de la région cartographique de Vernon (SNRC 82 L/7). Aussi bien les lithologies que l'orientation de la succession laissent croire à une corrélation avec les roches encaissantes des indices de métaux communs de Kingfisher (Colby) et de Big Ledge. Ceci accroît le nombre de cibles d'exploration potentielles en délimitant une vaste région de lithologies favorables qui semblent s'étendre vers l'ouest depuis la rive est du lac Arrow supérieur jusqu'à la ville de Chase, soit sur une distance de plus de 100 km.

[1] Contribution to the Ancient Pacific Margin NATMAP Project

INTRODUCTION

Fieldwork in 1999 focused on east-central Vernon map area (82 L/7) between Trinity Valley on the west, Sugar Lake on the east, Blue Springs Valley and Shuswap River on the south, and Trinity Hills and Park Range on the north (Fig. 1). The purpose of this work was to search out and map marker units in the high-grade Neoproterozoic and Paleozoic schist and gneiss succession, and to map the east-west extent of overlying Triassic Slocan Group strata.

Relevance of the work bears directly on an assessment of the zinc-lead and lead potential of the high-grade metamorphic assemblages. Carbonate-hosted zinc occurrences called Big Ledge and Kingfisher (Fig. 1) occur within specific, carbonate-dominated portions of the schist, paragneiss, quartzite, marble, and calc-silicate gneiss succession that underlies nearly all of east-central Vernon map area (Hoy, 1976a, b). In this paper we pursue the idea that the successions that host these two zinc-lead occurrences are physically linked; and that the exploration potential of the intervening area, in this case map area 82 L/7, is significant.

SUMMARY OF STRATIGRAPHIC RELATIONS

The area between the Okanagan Valley and the peaks that form the Monashee Mountains is underlain by a high-grade metamorphic succession dominated by quartzofeldspathic biotite schist and paragneiss with lesser amounts of quartzite, marble, and amphibolitic schist, which, until now, have not

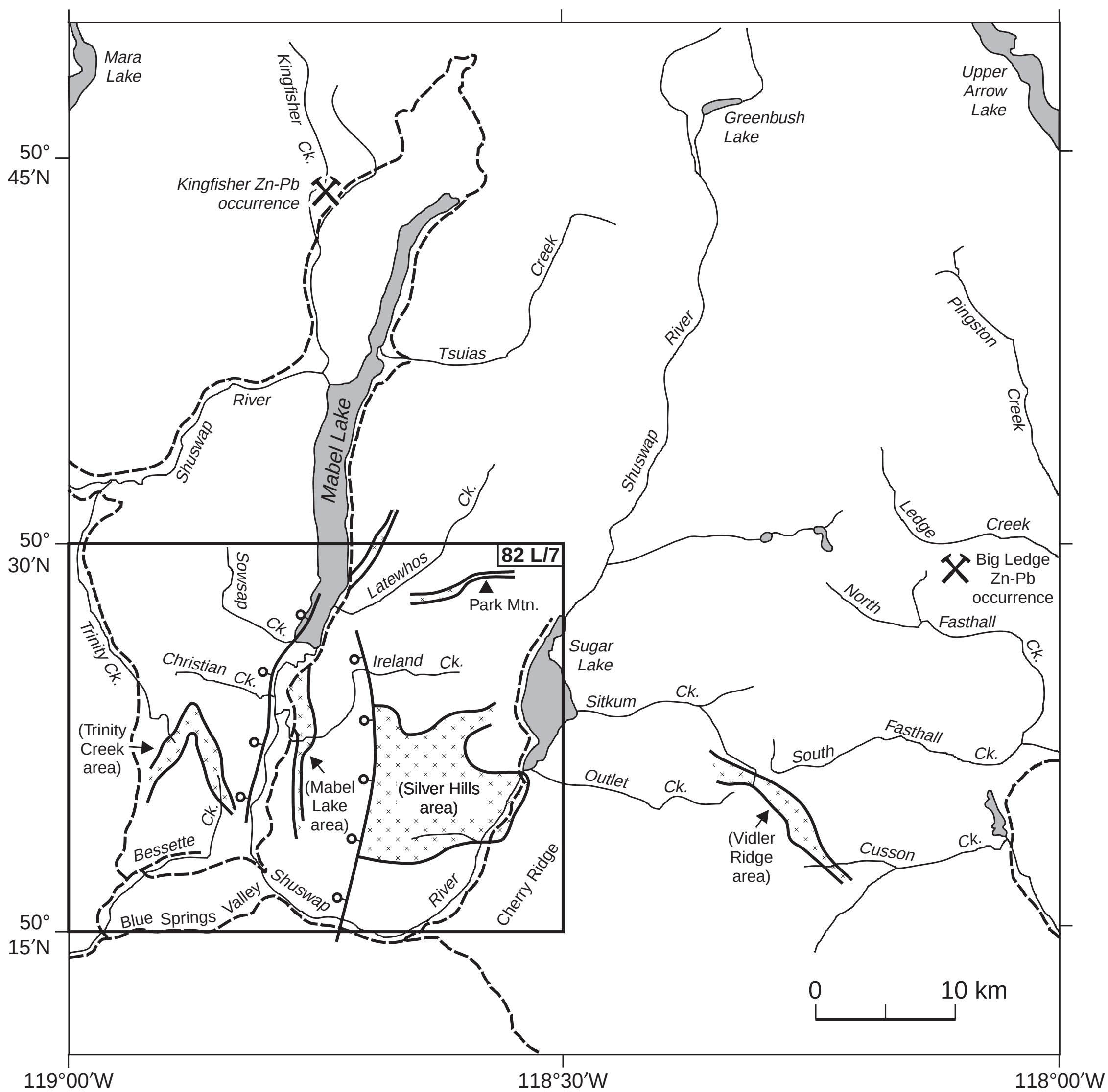

Figure 1. Generalized map of eastern Vernon map area (82 L) showing locations of the Big Ledge and Kingfisher zinc-lead occurrences. Inset map area (82 L/7) shows distribution of the calcareous quartzite marker unit highlighted by a stippled pattern; distribution of the marker unit in the Vidler Ridge area is taken from Carr (1990).

been systematically subdivided into mappable subunits, save rare carbonate markers recognized by Jones (1959). A separate, mappable overlying unit belonging to the Upper Triassic Slocan Group consists of carbonaceous mudstone and limestone, siltstone, incidental sandstone, and volcanic rocks including both pyroclastic and epiclastic varieties. Neither Permian volcanic and carbonate rocks belonging to the Harper Ranch Group, nor (?)older carbonaceous schist, marble, and conglomerate belonging to the Spa Creek assemblage were recognized in the region mapped (82 L/7), possible evidence that the base of the Triassic Slocan Group cuts stratigraphically down to the east and north.

In the Monashee Mountains, where exposure is exceptional, high-grade schist and gneiss units have been subdivided into two fundamental and tectonically separate successions: 1) the Monashee Complex or 'core zone', a window of paragneiss (layered biotite-quartz-feldspar gneiss) and orthogneiss (gneissic biotite granodiorite, quartz monzonite, and veined hornblende-biotite granodiorite); and 2) a mantling zone of paragneiss and schist interpreted as an east-verging allochthon (Brown et al., 1992) that contains a plethora of map units (Reesor and Moore, 1971; Read, 1979; Carr, 1990) consisting for the most part of quartzite, marble, amphibolite, and varieties of schist and paragneiss. It is reasonable to expect that some of these marker units extend westward into the region of dense vegetation that mantles the map area reported on here.

Of particular importance is a calcareous quartzite/calc-silicate gneiss/marble marker unit that hosts the Big Ledge zinc and lead mineralization (Hoy, 1976b; Fig. 1). Similarities between it and a calcareous quartzite marker unit having extensive distribution in map area 82 L/7 suggest there may be considerable additional exploration potential concealed beneath the vegetated slopes and highlands.

Similarly we speculate that the calcareous quartzite marker unit mapped throughout map area 82 L/7 is the same succession that hosts the Kingfisher zinc-lead deposit, which is contained in marble, quartzite, and calc-silicate gneiss (Hoy, 1976a). This occurrence is located near the northwest terminus of Mabel Lake, roughly 30 km beyond the area reported on herein (Fig. 1).

DETAILED STRATIGRAPHY OF THE CALCAREOUS QUARTZITE MARKER UNIT

The most distinctive map unit encountered in map area 82 L/7 is a white- to light-grey-weathering calcareous quartzite succession tens to hundreds of metres thick. Its most characteristic feature, best observed on weathered surfaces, is a coarse granular texture caused by rounded quartz crystals standing in relief within rinds of recessively weathering calcite. Feldspar, muscovite, and diopside are common accessory minerals. Map-unit lithologies are invariably calcareous, with some layers more akin to quartzose carbonate. Layering is difficult to discern on fresh surfaces; however, weathered surfaces provide ample evidence of a systematic variation in carbonate content at centimetre to decimetre scale. At a distance, outcrops of this unit may be visible among the trees as massive, white- to light-grey-weathering cliffs that are often difficult to distinguish from white-weathering granite.

There are three main outcrop areas of the calcareous quartzite marker unit (Fig. 1): one in the highland area between Trinity Valley and Shuswap River south of Christian Creek, referred to as the Trinity Creek area; another that parallels the east margin of Mabel Lake and the Shuswap River, referred to as the Mabel Lake area; and a third constitutes much of the Silver Hills region, referred to as the Silver Hills area. The unit has been traced into cliffs south of Sugar Lake that bound the northwestern margin of Cherry Ridge, but its extent there has not been determined.

In the Trinity Creek area, the calcareous quartzite marker unit forms a shallow east-dipping homocline beneath Upper Triassic Slocan Group siltstone, argillite, and volcaniclastic rocks. Basal contact of the marker with underlying quartzofeldspathic biotite schist was not observed. Contact relations are partly obscured by a foliated granodiorite intrusion thought to be Jurassic. There is little lithological variation within the unit, save the uppermost 10 to 20 m, which consists of flaggy, muscovite-bearing, tan quartzite. Contact with the overlying carbonaceous siltstone and volcaniclastic rocks of the Slocan Group is sharp to within a few metres; however, the actual contact surface was not observed.

Exposures in the Trinity Creek area are separated from those in the Mabel Lake area by a steeply dipping, west-side-down normal fault having displacement on the order of 1 km or less. In the Mabel Lake area, the marker unit is broadly folded about east-west-trending axes such that shallowly dipping fold limbs are discontinuously exposed along west-facing slopes (Fig. 1). A prominent north-dipping rib can be traced from Bigg Creek south toward Christian Lake. Unlike the Trinity Creek area, the calcareous quartzite marker unit here contains at least one unit of noncalcareous micaceous quartzite roughly 10 to 15 m thick. The marker unit is underlain by micaceous quartzite containing local siliceous marble layers; systematic, foliation-parallel variations in biotite content impart a colour banding or gneissosity. The marker unit is overlain (contact relationships were not observed) by a medium to dark grey, fine crystalline, calcareous, biotite-rich quartzite with abundant disseminated pyrite; samples are magnetic, indicating magnetite and or pyrrhotite are present as well. Biotite content determines colour, imparting a distinctive striped appearance on fresh surfaces. Metamorphic grade is consistent with that of the calcareous quartzite marker unit. Fresh surfaces are very difficult to break. We have not yet established whether this unit of calcareous quartzite belongs with the marker unit, or with the overlying Upper Triassic Slocan Group. It passes upward through a thin grey marble into black meta-argillite, metasiltstone, and metavolcaniclastic rocks of the Slocan Group.

Between Mabel Lake and the outlet of Ireland Creek is an east-dipping panel of the calcareous quartzite marker unit estimated at 350 m in thickness. A series of cliff faces affords decent exposure. A feature typical of all exposures, but especially well developed here, is the presence of coarse-grained leucocratic sills presumed to be Eocene that make up about

40% of the unit by volume. In many places, contacts between host and sill are gradational, or at best difficult to define. Sill thickness can vary from a few centimetres to more than 10 m. Chalky white calc-silicate gneiss in layers 1 m to several metres in thickness, composed primarily of quartz and diopside, represent a minor constituent of the marker unit here. Micaceous quartzite underlies the marker unit, and it is overlain by platy, phyllitic, dark grey, carbonaceous limestone containing layers of light- to medium-green-weathering volcaniclastic rocks of the Slocan Group. This basal unit gives way, upsection, to chlorite-biotite quartzose schist and hornblende-biotite schist. At one locality near the upper contact with the marker unit, an outcrop of fine crystalline, calcareous quartzite with centimetre-scale stripes and abundant disseminated pyrite was observed. This is a presumed extension of the same lithology seen near Christian Lake.

The west-facing slope north of Latewhos Creek (Fig. 1) contains a somewhat thinner, southeast-dipping band of the calcareous quartzite marker unit approximately 200 m thick. Internally, it is identical to that described elsewhere. However, underlying it is a succession of quartzofeldspathic biotite-schist units containing a persistent grey, coarse crystalline marble unit about 5 m thick. The marker unit is overlain by quartzofeldspathic biotite-hornblende paragneiss and schist containing a coarse crystalline marble unit that parallels the upper contact with marker unit. There is insufficient detail to know whether repetition of the marble is a product of folding (overturned antiform?) or stratigraphic in origin. Unlike exposures of the marker unit farther south, there is no evidence of Slocan Group lithologies here.

A steep, west-dipping normal fault separates Mabel Lake area exposures from those that occupy much of the Silver Hills (Fig. 1). The fault can be traced from the Shuswap River north in a broad east-facing concave arc into Ireland Creek. The fault is well constrained in the south and poorly constrained in the north where outcrop is sparse. Dip-slip displacement on the order of 1 km or less is indicated.

The Silver Hills area contains excellent roadcut and cliff-face exposures of the calcareous quartzite marker unit, providing the best expression of compositional variation and layering characteristics in the region. The variation in calcite content is marked — in parts of the succession the dominant lithology is quartzite and feldspathic quartzite with slight carbonate content; in other parts calcite can make up 40% of the rock, which, on weathered surfaces, produces a coarse granular or saccharoidal texture due to calcite dissolution around quartz crystals; siliceous marble is not volumetrically important, but was observed as layers up to 2 m thick. Layers of rusty-weathering biotite-quartz-feldspar schist are common near the base of the succession, and calc-silicate layers composed of quartz, feldspar, and diopside (with or without garnet) are present and relatively minor.

Basal contact relations are obscured by a felsic intrusion (presumed to be Eocene); however, the nearest underlying layers exposed on the north-facing slope of Ireland Creek consist of deeply weathered, rust and yellow pyritic quartzite intruded by numerous felsic sills.

Contact with the overlying succession of Slocan Group metasedimentary rocks can be traced west, down the east-facing slopes of Sugar Lake and Shuswap River, and across the south end of the Sugar Lake Valley onto the lower slopes of northwestern Cherry Ridge. In the headwaters of Holstein Creek, the basal part of the Slocan Group consists of biotite schist, black carbonaceous phyllite, fine biotite schist, and black fine-crystalline pyritic limestone, and quartzite. Downslope, near the valley bottom, the basal succession consists of platy, micaceous quartzite; calcareous biotite quartzite having a distinctive striped appearance; and calcareous biotite-hornblende schist with interlayers of black, fine-grained metamudstone. The striped quartzite succession may equate with the pyritic calcareous quartzite seen at equivalent stratigraphic position in the Mabel Lake area.

In the Mount Park area, north of the Silver Hills proper, the marker unit is present as two mappable units 10 to 20 m thick within a succession dominated by hornblende schist and gneiss. Much of the area is laced with 50% or more coarse crystalline felsic sills and lenticular granite bodies which obscure contact relations, unit thicknesses, and structure. Association of the marker unit with amphibolite and amphibolitic schist was also observed at valley-bottom level on the east side of the Shuswap River where it is joined by Sawsap Creek; unfortunately exposure there is very limited. The Mount Park exposures of the marker unit are distinctive in that amphibolitic schist and gneiss are closely associated.

REGIONAL CORRELATIONS

Possible correlation with map units farther east in the Vidler Ridge area and the vicinity of the Big Ledge zinc-lead occurrence

In the Vidler Ridge area (Fig. 1) Reesor and Moore (1971), Read (1979), and Carr (1990) have mapped a calcareous quartzite marker unit which is perfectly matched to the description of the marker unit given above. Reesor and Moore (1971) also mapped this unit (misidentified in their text as map unit F4 instead of map unit F3) on the eastern shores of Arrow Lake, where it currently resides in the hanging wall of the Columbia River fault. Carr (1990) was successful in mapping the marker unit (her map unit 8) from Vidler Ridge southeast across the headwaters of Cusson Creek where it ‘diffuses’ into a region of undifferentiated metamorphic rocks intruded by leucocratic granite and pegmatite belonging to the Eocene Ladybird granite. Given the exposures of the marker unit on Arrow Lake, we suspect it persists east, beyond the limit of Carr’s mapping.

At the Big Ledge zinc-lead occurrence, Hoy (1976b) mapped calcareous quartzite as part of the zinc-lead-bearing succession, which includes dark, quartz-rich, biotite schist and calc-silicate gneiss. Thickness of the unit is undetermined because it forms the hinge of an overturned antiform with an apparent gentle plunge to the west. Projecting this structure west would have it line up with the marker unit at Park Mountain. We entertain the possibility that the “fringe zone” and “mantling zone” of Reesor and Moore (1971) are repetitions of the same rock units, the former having been intruded by copious quantities of leucogranite. Read's (1979) rendition of the geology supports our supposition.

Possible correlation with map units farther north in the vicinity of the Kingfisher zinc-lead occurrence

Hoy (1976a) described six map units at the Kingfisher (Colby) zinc-lead occurrence. Units 1, 2, and 6 (in descending order) are dominated by garnet-biotite (sillimanite) schist and paragneiss; unit 3 is a massive white marble (several hundreds of metres thick); unit 4 consists of calc-silicate gneiss, marble, and calcareous quartzite; and unit 5 is an interlayered composite of marble and quartzite. Of the five mineralized zones he described, two are associated with unit 4, two with unit 3, and the remaining one with units 3, 4, and 5 combined. Based on a preliminary survey of the area's lithologies, it is reasonable to suggest that units 3, 4 and 5 at Kingfisher are part of the calcareous quartzite marker unit mapped farther to the south and west in map area 82 L/7.

Correlative map units elsewhere in Vernon map area (82 L)

A calcareous quartzite marker unit that closely resembles the marker unit described in this report has been mapped within the Silver Creek assemblage along and east of Kalamalka Lake, south of the town of Vernon (Thompson and Daughtry, 1994, 1996; Erdmer et al., 1998; Glombick et al., 2000) and is presumed to be a westward extension of the marker unit. As well, the same marker has been mapped discontinuously northward along the east flank of the Okanagan Valley and in roadcut exposures north of the town of Grindrod (Thompson and Daughtry, 1994).

Daly (1915) named a succession of quartzite and calcareous quartzite the Chase Formation, after the town of that name on the South Thompson River. According to Jones (1959): "Nearly all the quartzites are at least slightly calcareous and most are conspicuously so"(and) "The weathered surface of the quartzites is generally coarsely granular or saccharoidal from the solution of calcite." (p.18). The range of lithologies and textures described by Jones and observed by the authors suggest that a correlation between the Chase Quartzite and the calcareous quartzite marker unit is warranted.

Given Reesor and Moore's (1971) recognition of marker-unit lithologies on the east shores of Arrow Lake and on Vidler Ridge, our recognition of the calcareous quartzite marker unit across the east-central Vernon map area over to the Okanagan Valley, and Jones' (1959) recognition of marker-unit lithologies near the town of Chase, we are led to the conclusion that the same succession of calcareous quartzite containing calc-silicate gneiss and minor schist extends more or less continuously across a 100 km width of Vernon map area and represents one of the linking units between it and adjacent Lardeau map area (NTS 82 K; Read and Wheeler, 1976) to the east. Such a correlation has significant structural implications in that any cross-section interpretation drawn along a line from Upper Arrow Lake to west of the Okanagan Valley would be geometrically constrained by a relatively thin and flat-lying lithostratigraphic succession that does not bear evidence of large-scale duplication across large-amplitude structures.

CONCLUSIONS

A distinctive marker succession called the calcareous quartzite marker unit presumed to be Neoproterozoic or lower Paleozoic, and consisting of calcareous quartzite, calc-silicate gneiss, and minor schist, can be mapped across most of Vernon map area. This succession also appears to contain the zinc-lead occurrences at Big Ledge and at Kingfisher. If these correlations are correct, they imply that the exploration potential for base-metal occurrences is significant within the east-central Vernon map area (82 L).

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