GEOLOGY OF SEVERAL TALC OCCURRENCES IN MIDDLE CAMBRIAN DOLOMITES, SOUTHERN ROCKY MOUNTAINS, BRITISH COLUMBIA (82N/1E, 820/4W)

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KEYWORDS: Industrial minerals, talc, Cambrian dolomite, stratabound, Red Mountain, Gold Dollar, Silver Moon, Cathedral escarpment.

INTRODUCTION

The basal Middle Cambrian dolomites of the Southern Canadian Rocky Mountains host significant occurrences of *stratabound microcrystalline talc varying from black and* chloritic to white and nearly pure. The two groups of occurrences examined are at Talc Lake and nearby Mount Whymper in Kootenay National Park in British Columbia. The occurrences include the Red Mountain, Gold Dollar and Silver Moon. This preliminary study presents descriptions of the occurrences and guides to exploration, in the hope that they will encourage exploration for similar deposits outside the park.

All talc used in British Columbia is imported. As much as 2.3 tonnes of talc per day are consumed by 25 pulp and paper mills for pitch control and as a filler for paper coating (MacLean, 1988). Most is imported from southwestern Montana, where it is mined from conformable, commonly chloritic replacement lenses in Precambrian dolomitic marble.

The talc at Talc Lake and Mount Whymper, like that of the Montana deposits, is massive and microcrystalline to cryptocrystalline (steatite grade), but strongly fractured. It is either white or, more commonly, a darker coloured "soft platy talc" variety with minor chlorite. This study indicates that the white talc replaced dolomite and approaches pure talc in composition (ideally $Mg_6[Si_8O_{20}](OH)_4$), but contains minor pyrite. The black and grey chloritic talc replaced variably argillaceous, carbonaceous dolomite.

Numerous authors suggest talc formed by the replacement of dolomite, following Winkler's (1974) reaction:

3 dolomite + 4 quartz + H_2O = talc + 3 calcite + $3CO_2$.

This requires the addition of 32 volume per cent quartz to pure dolomite, which is rarely documented.

The Mount Whymper (NTS 82N/1E) and Talc Lake (NTS 82O/4W) talc occurrences are 20 kilometres apart and 35 and 25 kilometres west and southwest, respectively, of Banff, Alberta (Figures 3-1-1 and 3-1-2). They are 1 to 2.5 kilometres southwest of the border between British Columbia and Alberta, which follows the Continental Divide.

In the decade after the initial staking in 1915 to 1917, four adits were driven 10 to 15 metres into the talc bodies. In 1930, 150 metres of diamond drilling was done at Red Mountain, the main occurrence at Talc Lake. The last geologic report on the occurrences was based on a 1937 visit by Spence (1940; *see* also Wilson, 1926).

The locations of the talc occurrences at Stanley Creek and near Shadow Lake (Figure 3-1-2) are described in a letter (Scruggs, 1970) to the Research Council of Alberta. Talc talus in Stanley Creek valley could not be located; the Shadow Lake occurrence was not examined

The descriptions that follow are based on field mapping, examination of 18 thin sections, x-ray fluorescence (XRF), x-ray diffraction (XRD) and inductively coupled argon plasma (ICP) analyses of 12 rock samples collected during mapping. In addition, two silt and two soil samples were collected at Talc Lake and Mount Whymper, respectively.

GEOLOGIC SETTING

The talc occurrences are in the Foreland tectonostratigraphic belt of the southern Canadian Rocky Mountains, at and just east of the boundary between the eastern and western Main Ranges (Figure 3-1-1). All are along or near northwest-trending normal faults and major Cambro-Ordovician facies boundaries.

STRATIGRAPHY

The boundary between the eastern and western Main Ranges is marked by the abrupt, generally discordant facies change from the Middle and Upper Cambrian carbonate-

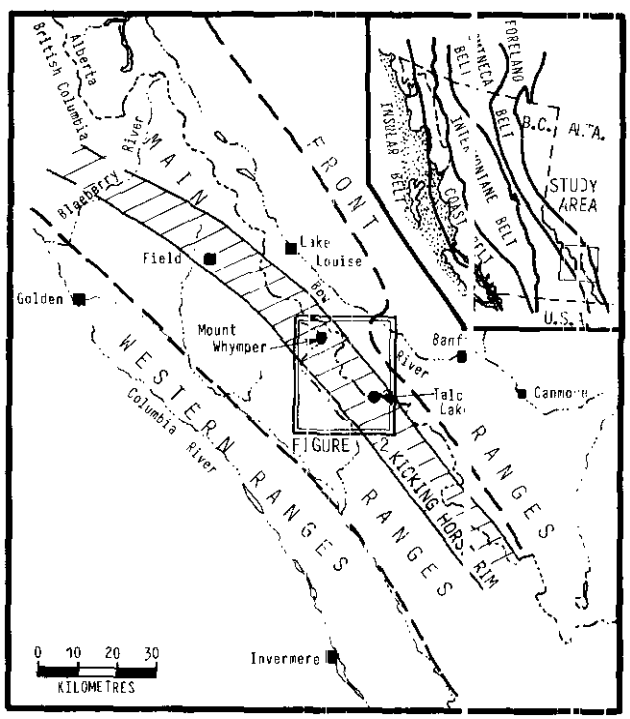

Figure 3-1-1. Location of the Talc Lake and Mount Whymper talc occurrences in the Southern Canadian Rocky Mountains on maps of the tectonostratigraphic belts of the Canadian Cordillera in British Columbia and of the Kicking Horse rim of the western Main Ranges (after Aitken, 1971).

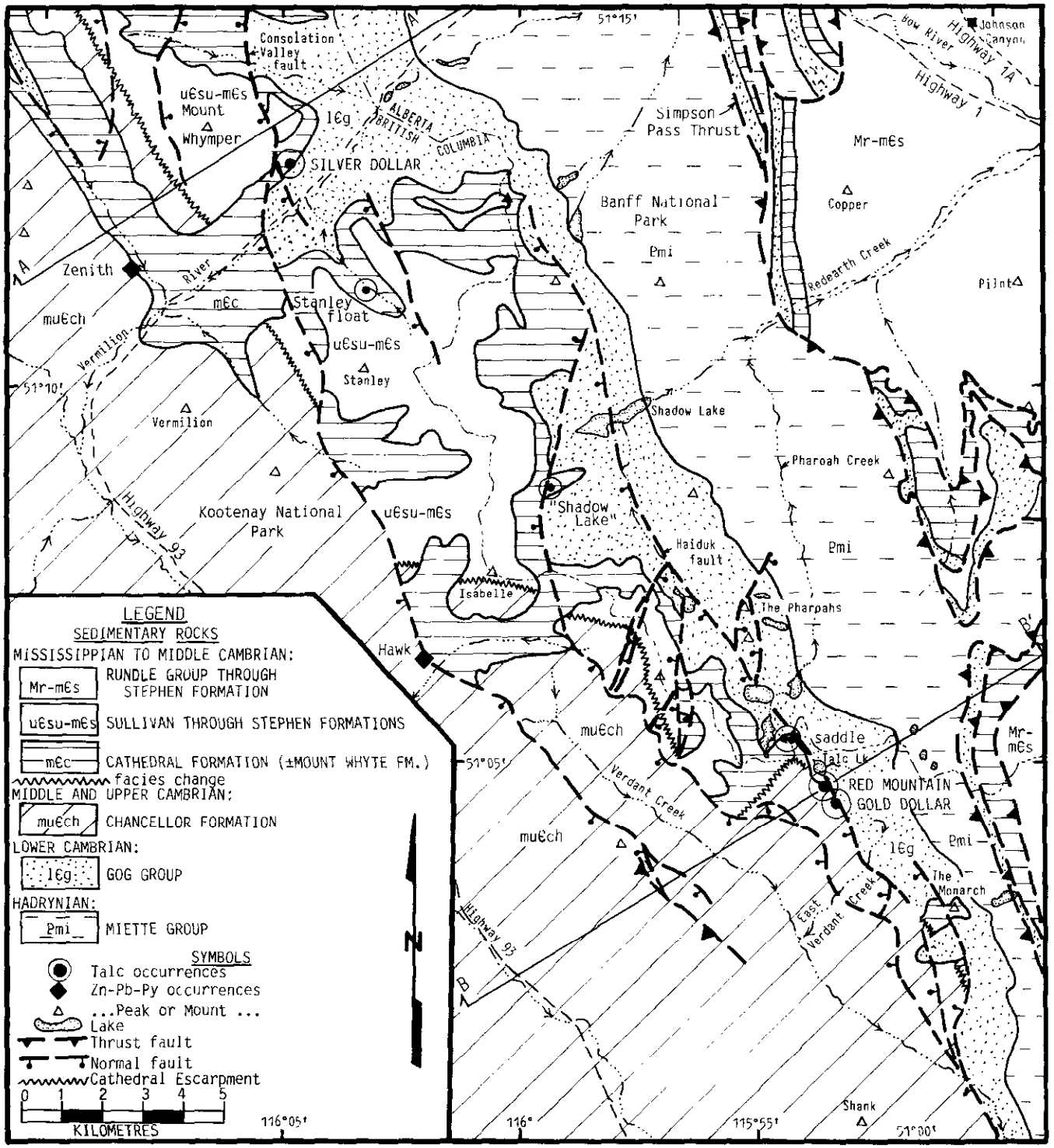

Figure 3-1-2. General geology of the area of the Talc Lake and Mount Whymper talc occurrences (after Price and Mountjoy, 1972; Price *et al.*, 1978).

dominated platformal margin sequence in nine formations to the east, to thicker, slope then predominantly basinal shales of the Chancellor Formation to the west. Cambrian and Precambrian strata of the eastern Main Ranges form massifs with spectacular castellated peaks. The facies change occurs along the Kicking Horse rim, a northwest-trending, narrow (1 km) positive paleotopographic feature first active in Early Cambrian time (Figures 3-1-1 and 3-1-4). Lower Cambrian strata were bevelled by erosion and weathered along the crest of the rim. The rim may have continued to act as a hinge between more rapid subsidence on the west and less rapid on the east throughout the Middle and Late Cambrian and into the Ordovician (Aitken, 1971).

A regolith is formed at the top of the Lower Cambrian quartz arenites and interbedded varicoloured pelites of the Gog Group, with local significant relief. The Gog Group is overlain unconformably, locally with angularity, by Middle Cambrian strata (Aitken, 1971). It is unconformably underlain by Upper Proterozoic slates and pebble conglomerates of the Miette Group of the Windermere Supergroup.

At the crest of the rim, shales and interbedded limestones of the basal Middle Cambrian Mount Whyte Formation pinch out to the west (Figure 3-1-3). Farther to the west, coeval mudstones and shale with gravity-slump structures and a local basal limestone form the westward-thickening wedge of the Naiset Formation (Aitken, 1971, 1981; Stewart, 1989). At Mount Whymper, both formations appear to be absent. At Talc Lake, the black argillites sharply overlying the Gog Group could be the Naiset Formation (W.D. Stewart, personal communication, 1992).

In the Middle Cambrian, platformal growth of the Cathedral Formation of variably dolomitized peritidal carbonates was initiated on the crest of the Kicking Horse rim and prograded basinward. The lower two-thirds (240 m) of the Cathedral Formation grades westward into the Takakkaw tongue of the lower Chancellor succession. It comprises sooty limestones with debris flows and slide surfaces – the deposits of a deep water ramp-like slope (Aitken, 1989). The upper third of the Cathedral Formation terminates westward (seaward) in the almost vertical Cathedral escarpment (Figure 3-1-3). Near Field, British Columbia, 33 kilometres north of Mount Whymper (Figure 3-1-1), the escarpment is the edge of a constructional organic reef up to 200 metres high that controlled the platform margin. The reef is altered to coarsely crystalline dolomite (Aitken and McIlreath, 1984). A pyritic halo up to 2 kilometres wide and 1.2 kilometres high surrounds the escarpment, but has not been mapped in detail (J.D. Aitken, personal communication, 1992).

Just west of Talc Lake, a cliff shows the escarpment was destructive in this area rather than constructive. Large-scale collapse of the outer platform during late Cathedral time created an embayment about 2.5 kilometres to the east (Figure 3-1-2). Dolomitized blocks up to 90 metres across fell from an escarpment 250 metres high and were deposited on the lower Cathedral carbonates then covered by strata of the upper Takakkaw tongue (Figure 3-1-5; Stewart, 1991).

Structure

The Cambro-Ordovician facies change and nearby talc occurrences are entirely within the gently west-dipping Simpson Pass thrust sheet of the mid-Jurassic to Eocene Cordilleran orogeny (Figures 3-1-2 and 3-1-4). The compe-

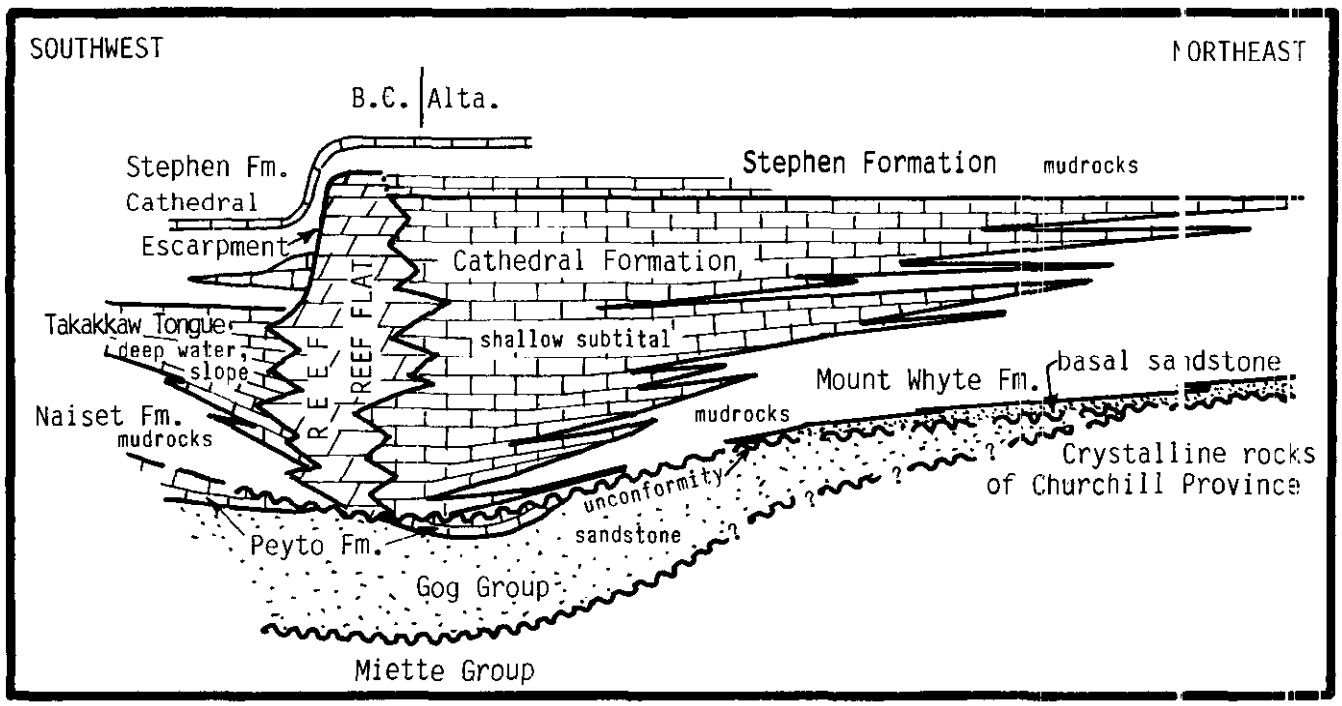

Figure 3-1-3. Schematic stratigraphic cross-section of the facies change at the Cathedral escarpment between the platformal Middle Cambrian Cathedral and Mount Whyte formations to the basinal Takakkaw tongue (slope facies of the Cathedral Formation) and Naiset Formation to the west (after Figure 4a of Aitken, 1989). Horizontal length of section is about 475 kilometres.

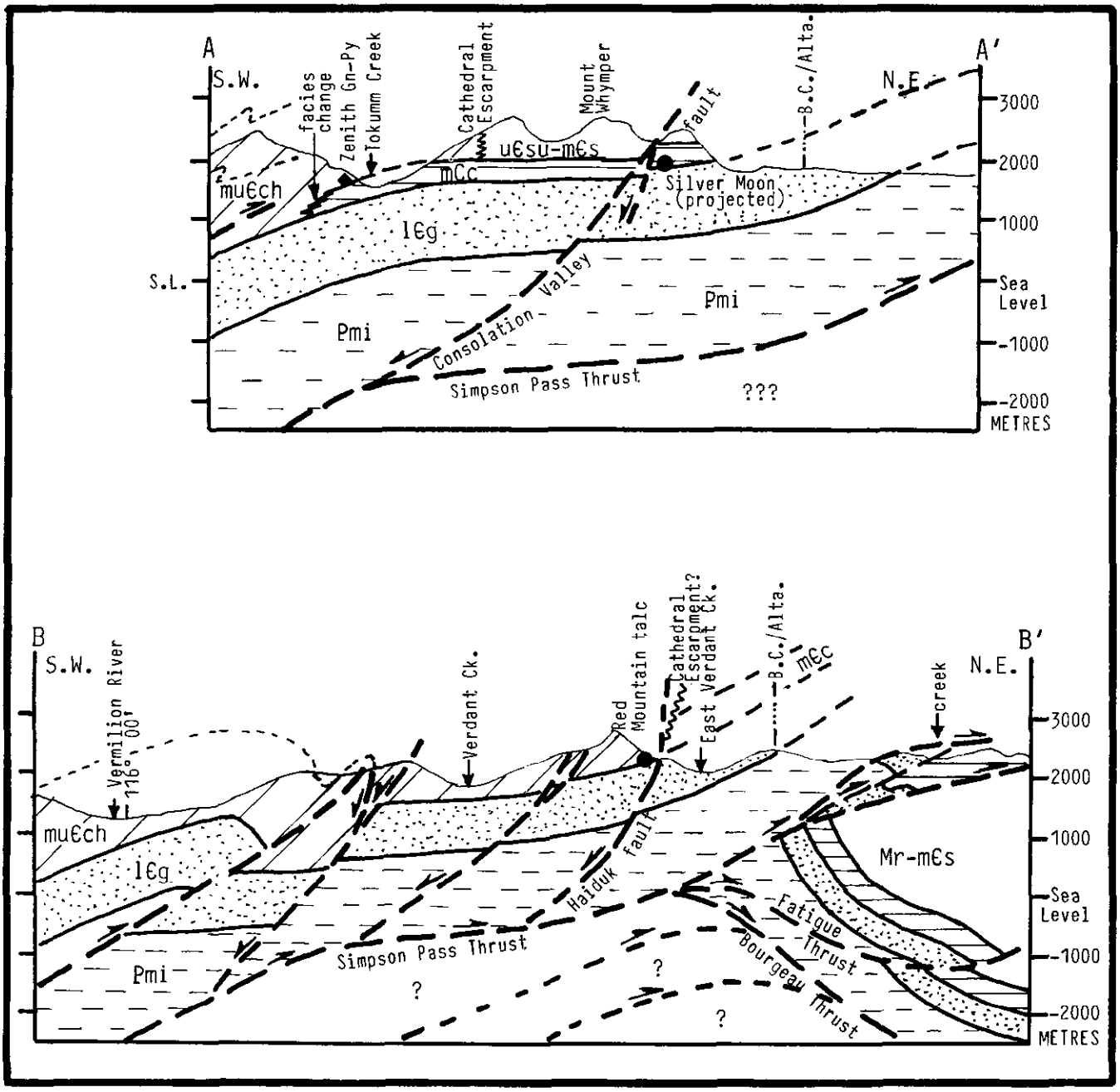

Figure 3-1-4. Geologic cross-sections through the area of the Silver Moon and Red Mountain talc occurrences (after Price and Mountjoy, 1972; Price *et al.*, 1978). *See* Figure 3-1-2 for location of the section lines.

tent sequence east of the facies boundary is broadly and concentrically folded and cut by normal faults.

The normal faults trend northwest to north, obliquely across the more west-northwest regional structural grain (Figure 3-1-2). They form a system of subparallel, branching and en echelon faults. Their map pattern suggests they formed in a regime of transtension, with components of northeast extension and northwest right-lateral strike-slip displacement. The normal offset was followed by minor subhorizontal displacement. The faults truncate and offset secondary thrusts, but apparently not the basal Simpson Pass thrust (Cook, 1975). Concordant wedges of dolomitization locally extend away from the normal faults into adjoining carbonates (Westervelt, 1979).

Economic Geology

The Cathedral escarpment played an important role in localizing lead-zinc-silver mineralization at the Monarch and Kicking Horse mines and magnesite at the Mount Brussilof mine. The mines are 33 kilometres north and 37 kilometres south of the talc occurrences, respectively. Mineralization replaced and filled dolomitized and brecci-

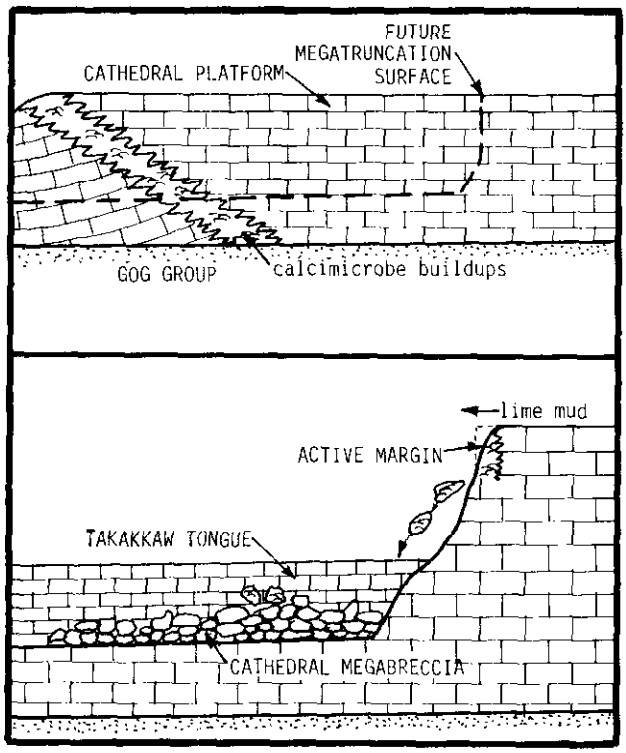

Figure 3-1-5. Model for the development of the Cathedral escarpment at Talc Lake (from Stewart, 1991, Figure 54: a, c).

ated Cathedral carbonates adjacent to the escarpment and near normal faults. The geologic setting of these deposits is analogous to that of the talc occurrences.

GEOLOGY OF THE TALC LAKE OCCURRENCES

A series of talc bodies is exposed at elevations of 2315 to 2375 metres on three spurs 1 kilometre to the southeast and northwest of Talc Lake (Figure 3-1-6). They may represent erosional remnants of once more continuous and extensive zones. The bodies are in the hangingwall, and 2 to 325 metres southwest of the northwest-trending informally named Haiduk normal fault. The fault cuts through saddles along the spurs, two of which mark the contact between the Gog Group and Takakkaw tongue. The talc bodies are also just southeast and north of the northeast corner of an embayment in the Cathedral escarpment (Figure 3-1-2). The Red Mountain and Gold Dollar occurrences are at the base of the Takakkaw tongue (or Naiset Formation), whereas the saddle occurrences are at the base of the Cathedral Formation.

Red Mountain Occurrence

LOCATION AND GEOLOGIC SETTING

The Red Mountain talc occurrence is on the north side of an easterly spur of Red Mountain and 250 to 300 metres south of Talc Lake (Figures 3-1-2, 3-1-4 and 3-1-6). The talc is exposed along steep, mostly inaccessible bluffs above

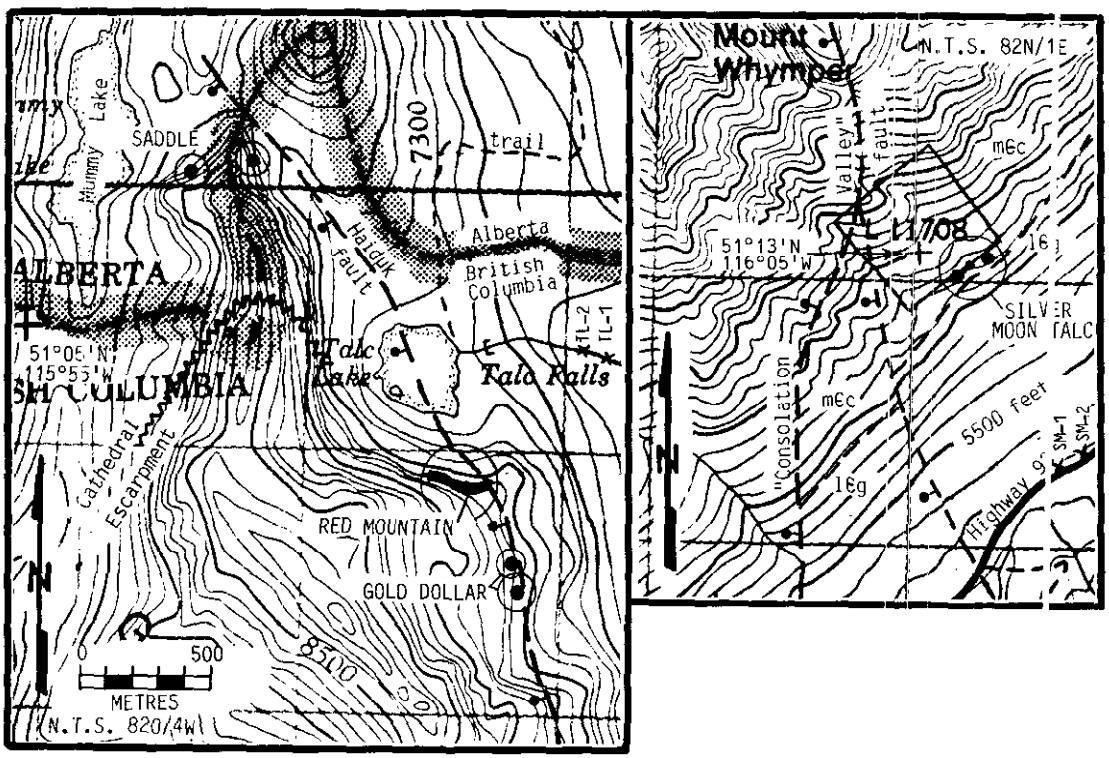

Figure 3-1-6. Locations of the Talc Lake (left) and Mount Whymper (right) talc occurrences on enlargements of 1:50 000 topographic maps with contour intervals of 100 feet (~30 m).

an extensive talus slope and below a cliff of the Takakkaw tongue and younger rocks (Figure 3-1-7). The cliff exposing the Cathedral escarpment is 550 metres to the north.

In 1927, ten years after the occurrence was first staked, two short (10 and 15 m) adits, 50 metres apart, were driven southerly into it by the National Talc Company (Figure 3-1-7). In 1930, Western Talc Holdings drilled five holes totalling 152 metres into the talc (Spence, 1940). The location of the core is unknown. In 1944, Wartime Metals Corporation developed a stope and raise at the end of the western adit.

The Red Mountain occurrence is the most extensive of those examined, with a length of 260 metres and height of up to 30 metres. The gently southwest-dipping body appears stratabound and formed as replacement of dolomite in interbedded and intergradational thin-bedded dolomite, argillaceous dolomite and dolomitic carbonaceous argillites. In general, it is just above the lowermost occurrence of dolomite and 0 to 20 metres above the unconformity at the top of the Gog Group quartz arenites. However, scattered exposures of the footwall beds suggest the lower contact of the talc is complex in detail. This may in part result from rapid vertical and horizontal facies changes in the footwall.

The extreme eastern end of the talc body appears to be offset with a minimum dip-slip displacement of 10 metres along the Haiduk fault. The talc is also strongly deformed by steep to gently dipping shears and intersecting sets of fracture cleavage. The term "fracture cleavage" is used here to describe a series of non-pervasive subparallel fractures commonly spaced 0.5 to 15 centimetres apart.

TALC GEOLOGY

The talc body weathers a dark rusty brownish orange resulting from oxidized pyritic shears and fractures. Weathered rocks in the immediate footwall are surprisingly difficult to distinguish from talc. The talc, however, tends to form more rounded, hummocky but very rough weathered surfaces because of the well-developed fracture cleavages and shears.

Most of the talc is dark grey to near-black on fresh surfaces, with 2 to 10 per cent dirty white and up to 50 per cent very light grey patches, lenses, spots and specks (Plate 3-1-1). Thin sections and x-ray diffraction analyses indicate the near-black colour results from a carbon compound and a few per cent chlorite (Table 3-1-1). A distinct 18-metre interval of light grey talc with dirty white patches and lenses forms the hangingwall of the Haiduk fault. Locally the talc comprises a striking breccia with black angular fragments up to 10 centimetres in diameter floating in an off-white talc matrix. Thin sections indicate that spotted talc results from

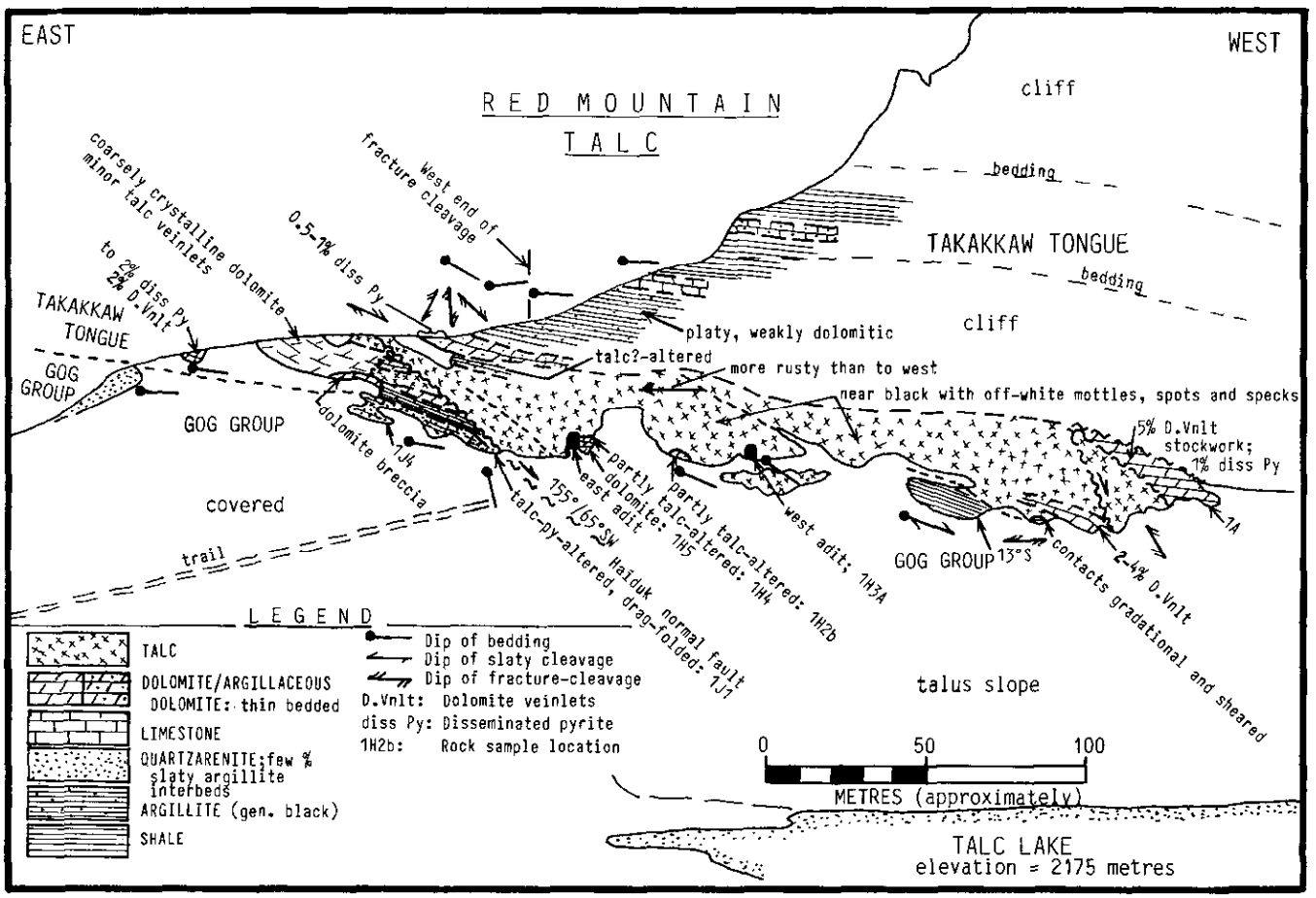

Figure 3-1-7. Geology of the Red Mountain talc occurrence at Talc Lake. The pseudosection is traced from a photograph looking south. The legend also applies to Figures 3-1-8 through 3-1-11 and 3-1-14.

Plate 3-1-1. Photomicrograph (crossed nichols) of pyritic white and light grey talc from east end of the Red Mountain talc body (sample 112). Coarser grained partial sprays of white talc are surrounded by a very fine grained mass of randomly oriented plates and fibres of talc.

alteration of a brecciated, variably carbonaceous argillaceous dolomite, and later shearing. However, unbrecciated talc with very delicate graded laminations resembling bedding is conspicuous on one polished shear surface.

Pyrite is very irregularly disseminated in the lighter coloured talc, commonly forming 0.5 to 1 per cent, to locally 3 per cent, fine to medium-grained disseminations. Very locally, sheared pyrite grains form up to 60 per cent of irregular zones of "rotten" talc to 5 centimetres or more thick. Thin sections indicate that the black talc does not contain pyrite.

An irregular, criss-crossing network of white talc veinlets, commonly 1 millimetre thick but locally to 1 to 2 centimetres, forms up to 4 per cent of the talc in several intervals. Rare(?) veins contain coarsely crystalline (to 3 by 10 cm) dolomite cut by minor veinlets of clear quartz, 1 millimetre thick. Vugs up to 3 by 12 centimetres occur very locally in the talc. They are lined with drusy to botryoidal dolomite(?) crystals and pyrite grains. The talc also contains a few sheared lenses of bedded dolomite to 20 by 50 centimetres, cut by dolomite veinlets.

The talc is generally moderately to strongly fractured and sheared. Intersecting fractures and fracture cleavages commonly result in a brecciated texture. An anastomotic sheared fracture cleavage with a spacing of 3 to 15 millimetres, is developed near and subparallel to moderately southwest-dipping normal faults. It intersects a shallow-dipping slaty cleavage subparallel to bedding in nearby beds, to yield an irregular pencil cleavage.

FOOTWALL ROCKS

The lithology of the rocks in the footwall of the talc varies along the spur from east to west, as follows.

East of the Haiduk Fault

Coarsely crystalline dolomite: In the footwall of the Haiduk fault, talc overlies a very distinct coarsely crystalline, weakly pyritic dolomite unit about 8 metres thick. Similar dolomite forms large (0.4 m diameter to 2 by 5 m) inclusions in the talc overlying and west of the main unit. The dolomite is described in detail because it may be related to talc alteration, although it is not exposed at the other Talc Lake occurrences. However, similar dolomite forms a 90 by 250 metre outcrop between the Red Mountain and saddle occurrences, about 380 metres northwest of Talc Lake. It contains rare talc veinlets to 2 millimetres thick, and a few per cent iron oxide nodules to 10 by 30 centimetres. The dolomite adjoins Cathedral dolomite and does not appear to have a simple relationship to the Cathedral escarpment. However, it is in the hangingwall (southwest) of the Haiduk fault, suggesting it may be related to the fault and the talc alteration event.

The recrystallized dolomite is opaque white to medium rusty orange on fresh surfaces. It contains 5 per cent or less, very irregular patches with 5 per cent fine graphite(?) grains surrounded by light grey to dirty white fine-grained (primary?) dolomite. Pyrite forms about 0.5 to 2 per cent, very fine to fine to locally medium-grained, irregularly distributed disseminations. The dolomite is strongly brecciated. It contains minor talc veinlets that are bright rusty orange, irregular, discontinuous and commonly up to 1 millimetre thick. Their origin and relationship to the overlying talc body are uncertain.

An east-dipping covered fault(?) separates the coarse dolomite from a succession to the west that is the most complete, although poorly accessible exposure of the footwall rocks. It is also in the immediate footwall of the Haiduk fault. The succession comprises, from the base of exposure: quartz arenite (10 m) of the Gog Group in beds 2 to 20 centimetres thick with 4 per cent partings and interbeds of argillite; black meta-argillite (8 m); thin-bedded dolomite (several metres); and grey talc. The quartz arenites in the 5 metres below the Haiduk fault appear partly talc-pyrite altered. Irregular polygonal outlines of replaced grains in a thin section of talc suggest a dolomite protolith. However, the talc (sample 111) contains 0.1 per cent sphene, minor zircon and perhaps fluorapatite (Table 3-1-1), suggesting a protolith of dolomitic(?) quartz sandstone.

Gog Group: The rocks of the uppermost 50 metres of the Gog section are quartz arenite with interbedded, somewhat slaty argillite and locally dolomitic quartz sandstone. The quartz arenite is generally a dirty white to less commonly subtranslucent light to medium grey on fresh surfaces. It

TABLE 3-1-1
RESULTS OF X-RAY FLUORESCENCE AND X-RAY DIFFRACTION ANALYSES OF TALC AND DOLOMITE HOSTROCKS AT TALC LAKE AND MOUNT WHYMPER

		X-RAY FLUORESCENCE ANALYSES									X-RAY DIFFRACTION MINERALS		
LITHOLOGY Deposit	Sample Number	SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	TiO_2	MnO	P_2O_5	L.O.I.	Total	Major	Minor	Trace
TALC														
Red Mountain	1H3A	58.22	2.52	31.87	0.32	0.25	0.09	0.01	0.14	6.52	100.01	tc	chl	f-ap
	1J1	56.35	2.42	30.81	0.52	2.01	0.56	0.01	0.35	6.91	100.00	tc	chl,py,sid	zr,spn?,f-ap?
Gold Dollar	3A	50.99	7.26	32.25	0.16	0.97	0.32	0.01	0.03	8.12	100.16	chl-tc		spn
	3B	60.74	1.03	31.66	0.37	0.23	0.02	0.01	0.31	5.47	99.92	tc	chl	f-ap
	4-45	61.50	0.08	30.84	0.06	1.32	0.01	0.01	0.01	5.95	99.87	tc		py
Saddle	5C	62.25	0.18	31.74	0.11	0.24	0.01	0.01	0.01	5.25	99.87	tc,qtz	chl,py	
Silver Moon	10A	62.58	0.01	31.38	0.09	0.66	0.01	0.01	0.01	5.16	100.00	tc		
Theoretical		63.36		31.89						4.75[2]				
DOLOMITE														
Red Mountain	1A	0.21	0.02	21.19	30.14	0.63	0.03	0.07	0.04	47.25	99.65	dol	chl, py	
	1H2B	32.55	1.81	28.17	12.27	0.39	0.07	0.01	0.04	24.25	99.68	tc,dol	chl,qtz	cal
	1H4	2.80	1.11	21.79	28.36	0.55	0.03	0.07	0.03	44.70	99.52	dol	tc,chl	qtz,cal
Silver Moon	10B	0.11	0.01	20.01	30.12	2.24	0.02	0.30	0.02	46.59	99.48	dol	chl,tc	cal, py,qtz[3]
	12A	3.02	0.05	21.22	28.95	1.29	0.02	0.07	0.03	44.99	99.75	dol	tc,qtz	py,chl
(Haley, Ont.)				21.1	31.3					47.20				
CLINOCHLORE[1]		18.2	18.2	31.1		6.8				12.7[2]				

NOTES:
1. From Willow Creek talc mine in southwestern Montana (Berg, 1979).
2. % H_2O.
3. Also minor goethite and lepitocrocite identified.
All percentages are wet weight.
Na_2O analyses are all 0.01 or 0.02%.
K_2O are from 0.01 to 0.06%.
XRF analyses by Cominco Ltd. Exploration Research Laboratories in Vancouver, B.C., September, 1992.
XRD analyses by B.C. Ministry of Energy, Mines and Petroleum Resources laboratory, October, 1992.

ABBREVIATIONS OF MINERALS:

cal: calcite	f-ap: fluorapatite	sid: siderite	zr: zircon
chl: chlorite	py: pyrite	spn: sphene	
dol: dolomite	qtz: quartz	tc: talc	

ROCK SAMPLE NOTES

1H3A: near black; mottled, spotted with dirty white talc.
1J1: light grey; 1 to 2% pyrite; occurs in Gog Group, just east of Haiduk fault; 0.1% zircon, locally zoned.
3A: north occurrence; resembles partly talc-altered black argillite; 2% sphene(?).
3B: north occurrence; black, light grey and white spotted; relic dolomite(?) grain outlines.
4-45: south occurrence; 2% pyrite; medium grey with white spots. Talc coarser grained; relic dolomite(?) outlines.
5C: east occurrence; sub-opaque, pale orangish white; 2%, oxidized pyrite.
10A: southwest adit; frosty white with pale greenish grey tinge.
1A: hanging wall of talc, west end; 5% dolomite veinlets; 0.25% pyrite.
1H2B: footwall; partly talc altered, laminated, intergraded dolomite, argillaceous dolomite and carbonaceous argillite.
1H4: footwall, at east adit; weakly talc-altered, laminated dark grey dolomite; penninite(?) in dolomite veinlet.
10B: footwall, 3.5 m below talc at southwest adit; fenestral dolomite; 0.25%, oxidized pyrite; 2% dolomite veinlets.
12A: northeast occurrence, dolomite inclusion in quartz; subtranslucent medium grey; 0.25% pyrite; quartz-dolomite-replaced, prismatic mineral; trace interstitial quartz.

NOTE:
The theoretical composition of pure talc is included for comparison. That of the high magnesium end-member of the chlorite goup, clinochlore, is also included because it may contain most of the aluminum in the first three samples of talc.

weathers dirty white to medium grey. The uppermost 10 metres show a conspicuous increase (to 90%) of rusty orange limonitic patches on shears and fractures. This characterizes the regolith at the top of the Gog Group (J.D. Aitken, personal communication, 1992).

The quartz arenite is very thin through medium bedded (1 to 50 cm). It is weakly laminated and banded with light grey, and generally very fine to fine grained. It commonly contains minor to 0.25 to locally 2 per cent, very fine to fine, disseminated, iron oxide coated pyrite or iron oxide specks with limonitic halos. Dolomite locally forms the matrix of the arenite and is dark buff on fresh surfaces.

Slaty argillite forms 1 to 5-millimetre partings and interbeds to 35 centimetres thick. They comprise about 2 to 4 per cent of the uppermost 20 metres of the Gog Group. In intervals below that they form 5 to 30 to locally 85 per cent of the succession. The argillite is light greenish grey to medium brownish grey (with black laminations) on fresh surfaces. The slaty cleavage is parallel or slightly oblique to bedding which dips gently (5°) to the west.

Quartz veinlets in Gog Group: Quartz veinlets are common in the quartz arenites of the Talc Lake area. It is unclear whether they represent channels for the introduction of silica to the dolomite during talc alteration. Locally, at least, they appear related to shearing. However, more study is required to establish their age and significance.

Intervals of the quartz arenite commonly contain 1 to 5 per cent veinlets, even 200 metres or more below the talc. The milky white veinlets are commonly 1 to 10 millimetres wide, but locally 3 to 15 centimetres thick. Although quartz veinlets are common regionally in the Gog Group, they are usually only 1 to 2 millimetres thick (J.D. Aitken, personal communication, 1992). The veinlets are irregular, discontinuous and commonly sheared and fractured. Locally, they resemble shear and tension gash veins related to simple shear couples. Near the talc, the veinlets commonly strike 155°, 070° and 035° (with decreasing frequency) and dip vertically.

The veinlets must be Middle Cambrian or younger. They cut the lowest part of a 3-metre interval of black platy argillite of the Naiset(?) Formation immediately overlying the Gog Group on the spur 850 metres southeast of the Red Mountain deposit.

West of the Haiduk Fault

Sheared footwall rocks are exposed in four main areas along 210 metres of the ridge spur. Just west of the eastern adit, black talc is underlain by about 2 metres of laminated to very thin bedded, graded carbonaceous dolomite and dolomite that are partly altered to talc. X-ray diffraction analysis (sample 1H2B) indicates that the black laminations contain talc and minor chlorite. The carbonaceous mineral was not identified as graphite. The talc-altered dolomite is underlain by several metres of thin and very thin-bedded dolomite.

West of the eastern adit 105 to 160 metres, the footwall rocks resemble those east of the Haiduk fault except for the very top of the Gog Group. Here, it comprises medium grey, somewhat slaty, thin bedded argillite. It contains two intervals with three to five interbeds of quartz arenite with 0.5 per cent disseminated pyrite. The interbeds are 3 to 50 centimetres thick. Ten metres to the east, a lens of dark grey argillite 1 metre thick appears to grade upwards and laterally into talc, however, shearing along fracture cleavage disrupts its contacts.

HANGINGWALL ROCKS

Accessible exposure just below the crest of the spur indicates black talc is overlain by gently (25° to 30°) southwest-dipping, platy, black meta-argillite (3 m thick) and very thin bedded (0.5 to 5 cm) dolomite (7 m thick). The basal 4 metres of the dolomite unit is distinctly pyritic: 3 per cent very fine to coarse-grained (to 7 mm) disseminations of subhedral crystals are commonly coated with iron oxide.

Fracture cleavages are locally well developed at a high angle to bedding up to 33 metres west of the talc body and 40 metres west of the possibly related Haiduk fault (Figure 3-1-7). They dip northeast to southwest and are locally filled with dolomite or slickensided graphite(?), and spaced 2 to 15 millimetres apart.

At its western end, the talc body is structurally overlain by rusty orange weathering, thin-bedded, flat-lying dolomite 15 metres wide. The dolomite contains 5 per cent white dolomite veinlets forming a stockwork. The veinlets are paper thin to 1 centimetre thick. Dolomite grains in several veinlets are elongated perpendicular to the walls. The dolomite also contains 0.25 per cent pyrite disseminated along stringer-like fractures. The pyrite is subhedral and up to 4 millimetres in diameter. The faulted contact between the dolomite and talc is irregular, stepped but sheared and truncates bedding in the dolomite.

Gold Dollar – North Occurrence

Black talc is poorly exposed in several sloughed handcuts on the north side of the (next) spur 300 metres southeast of the Red Mountain occurrence (Figure 3-1-6). The showings are at the top of an extensive talus apron below a cliff (Figure 3-1-8).

Fifty metres east of the talc, the Haiduk fault is inferred to cut through the broad saddle between quartz arenites of the Gog Group to the east, and cliff-forming dolomites of the Takakkaw tongue to the west (Stewart, 1991, Section DS-23).

TALC GEOLOGY

This near-black, very rubbly weathering talc is at least 3 metres thick. The talc is weakly to strongly sheared and cut by a well-developed slaty cleavage. It is very fine grained and moderately to very soft.

A breccia of black talc fragments in 15 to 40 per cent matrix of white talc occurs in float. There are also pieces of light grey talc with 10 per cent black and 3 per cent white spots. A thin section (sample 3B) reveals relic polygonal grains outlined by carbonaceous material, suggesting a protolith of brecciated carbonaceous dolomite. The XRF analysis indicates that the black colour probably results from

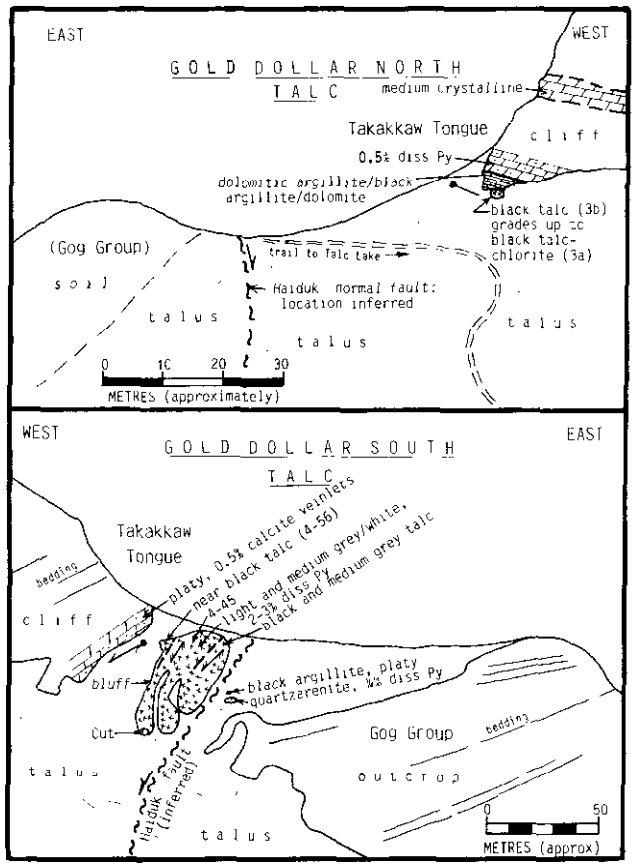

Figure 3-1-8. Geology of the Gold Dollar north (upper frame) and Gold Dollar south talc occurrences on opposite sides of a spur southeast of Talc Lake. The pseudosections are traced from photographs.

extremely fine grained chlorite as well as the carbonaceous mineral (Table 3-1-1). The white spots are coarser grained, partially formed sprays of talc.

Another sample (3A) from the same interval resembles weakly talc-altered black argillite in hand sample. Thin section and XRF analyses indicate it consists of very finely intergrown chlorite and talc. A carbon compound forms 0.5 per cent irregular coplanar wisps to 0.5 millimetre long. Sphene forms 2 per cent, extremely fine, uniformly disseminated, locally clustered grains. The relatively high alumina content (7.3%) may result in part from the large proportion of chlorite.

The slaty cleavage comprises irregular discontinuous hairline fractures that follow relic carbonate grain boundaries. The white-appearing fractures are 2 to 4 millimetres apart and filled with an opaque mineral and talc-altered grain fragments.

HANGINGWALL GEOLOGY

The talc grades upward into several metres of black argillite cut by a few per cent white talc veinlets. The argillite grades upward to a few metres of dolomitic argillite with intervals of black argillite and dolomite, into slaty argillaceous dolomite with 0.5 per cent, fine to medium-grained disseminated pyrite. All are thin to very thin bedded and laminated.

Gold Dollar – South Occurrence

The second largest body of talc in the Talc Lake area is exposed in a bluff that is 30 metres wide and 100 metres south and on the opposite side of the spur from the Gold Dollar – North occurrence (Figures 3-1-6 and 3-1-8). A cut was made several metres into the talc at the base of the bluff.

The contacts of the talc body are covered. The sheared body appears to occupy the hangingwall of the Haiduk fault and occurs between the top of the Gog Group to the east, and the Takakkaw tongue to the west.

TALC GEOLOGY

The talc weathers dark rusty orangish brown and has a very irregular, rough weathered surface. The eastern 7 metres of the talc body is medium to light grey with streaks and lenses of black on fresh surfaces. Partly talc-altered, very thin bedded and laminated dolomite interbedded with carbonaceous(?) argillaceous dolomite is locally apparent.

The central 19 metres of talc is light grey and white with variable proportions of medium to dark grey and a few per cent near-black carbonaceous lenses and patches. The interval is variably pyritic, 0.5 to 4 per cent, to very locally 10 per cent, but averaging 2 to 3 per cent. The pyrite is very fine to medium grained (dust size to 6 mm) and tends to cluster in irregular patches. The talc is harder than normal. However, in thin section (sample 4-45) there is only a minor dusting of impurities. Distinct outlines of relic anhedral carbonate grains indicate they are replaced by randomly oriented single grains of talc 0.1 to 0.5 millimetre in diameter.

The western 5 metres of talc is carbonaceous and near black with a few per cent white spots and a few, thin (to 3 mm), sheared lenses of white talc. In thin section, relic dolomite(?) grains are outlined by a carbon compound forming 5 per cent angular patches (Plate 3-1-2). They suggest the dolomite protolith had a high porosity prior to talc alteration and filling of interstices by the carbon compound. Original polysynthetic twins in the grains are replaced by single, slightly bent talc grains. The remainder is replaced by extremely fine, randomly oriented talc. A white veinlet of extremely fine talc has diffuse boundaries suggesting talc replaced a dolomite veinlet with no impurities to show grain boundaries.

The talc body is strongly sheared along a well-developed, moderately west-dipping (45° to 60°) fracture cleavage. Locally, stepped slickensides on cleavage surfaces indicate dip-slip displacement with the west side down. This may be subparallel to displacement on the Haiduk normal fault.

FOOTWALL GEOLOGY

Ten metres east of the talc bluffs, and presumably in the immediate footwall of the Haiduk fault, 3 metres or more of black argillite overlie gently west-dipping (10° to 20°), somewhat rusty weathering quartz arenite and argillite of the Gog Group. The black argillite is platy (1 to 3 mm) and cut, together with the quartz arenite, by abundant limonitic

Plate 3-1-2. Photomicrograph (crossed nichols) of near-black talc from west end of the southern Gold Dollar talc body (sample 4-56). The boundaries of the protolith dolomite(?) grains are preserved after alteration to very fine grained talc and chlorite(?). The original polysynthetic twins (light bands) are replaced by single grains of talc. A black carbonaceous material fills the angular protolith grain interstices. Very fine grained talc replaces(?) a dolomite veinlet on right side of photograph.

shears and fractures. The quartz arenite is weakly translucent white. It contains 0.25 per cent disseminated pyrite and a few per cent irregular veinlets of white quartz.

HANGINGWALL GEOLOGY

A covered interval 14 metres wide separates the talc bluffs from a cliff of argillaceous dolomite of the Takakkaw tongue to the west. The dolomite locally grades into weakly dolomitic black argillite. The beds in the basal 10 metres are gently west-dipping (30°), very thin (1 to 4 cm) and laminated and platy weathering. They are cut by thin (15 to 40 cm) intervals of slaty cleavage parallel to bedding, and 0.5 per cent white calcite veinlets (to 6 mm thick). Rare veinlets of dolomite, with or without quartz, step across and follow bedding.

SADDLE OCCURRENCES

Two small exposures of white talc are located 1.4 kilometres northwest of the Red Mountain occurrence (Figure 3-1-6). They are 230 metres apart and on the east and west sides of a steep ridge. The exposures are just above talus aprons, at a narrow break in slope between a lower cliff of rusty weathering quartz arenites of the Gog Group to the north and a cliff of bedded dolomites of the Cathedral Formation to the south (Figures 3-1-9 and 3-1-10). They are 750 metres north of the Cathedral escarpment and 130 and 300 metres southwest, respectively, of the Hadduk fault that cuts through the prominent saddle between the Talc Lake and Mummy Lake basins.

There is a prominent angular discordance between the subhorizontal Gog Group bedding and the overlying gently southwest-dipping (15°) Cathedral dolomite (Figures 3-1-9 and 3-1-10). This may reflect an angular unconformity between the two units. There is shearing at the top of the talc that locally truncates bedding in the overlying dolomite at low angles. However, the substantial offset that would be required on a low-angle fault to account for the discordance between units is not evident.

The talc differs markedly from that at the Red Mountain and Gold Dollar occurrences. It is a much more uniform near-white and strongly resembles the Silver Moon talc 19 kilometres to the northwest

EAST OCCURRENCE

An interval of white talc 2.5 metres thick, is stratabound in thin-bedded dolomite of the basal Cathedral Formation 2.5 metres above pyritic, possibly weakly talc-altered quartz arenite. These relationships are poorly exposed along 15 metres and disrupted by offsets of up to 2.5 metres of dip slip on steeply dipping, northwest-trending (345°) faults.

TALC GEOLOGY

The talc is subopaque, pale orangish white to limonitic and rusty orange on fresh surfaces. Shear and fracture surfaces cutting the talc weather medium to dark, rusty orange-brown. Very strong fracturing yields a rough and rubbly weathering surface.

A thin section of the talc (sample 5C) indicates it comprises very fine plates and fibres. The quartz identified by XRD analysis probably causes the somewhat increased hardness of this talc. It appears to form a very small fraction because the XRF analysis resembles that of nearly pure talc. The section contains 2 per cent, commonly completely oxidized pyrite as generally uniformly disseminated, but locally clustered, subhedral grains to 0.15 millimetre in diameter. The grains have halos of limonitic stain 0.05 millimetre wide.

The talc is weakly sheared. Strongly developed fracture cleavages cut the talc into fragments 0.5 to 3 centimetres in diameter. The most prominent and regular fracture cleavage is spaced 1 to 2 centimetres apart and dips gently southwest (15°), parallel to the upper contact of the talc. The other prominent cleavage is anastomotic and dips steeply southwest.

FOOTWALL GEOLOGY

The talc is underlain by 2.6 metres of dolomite resting on quartz arenites of the Gog Group (Figure 3-1-9). In one exposure the footwall contact is sharp and appears to follow

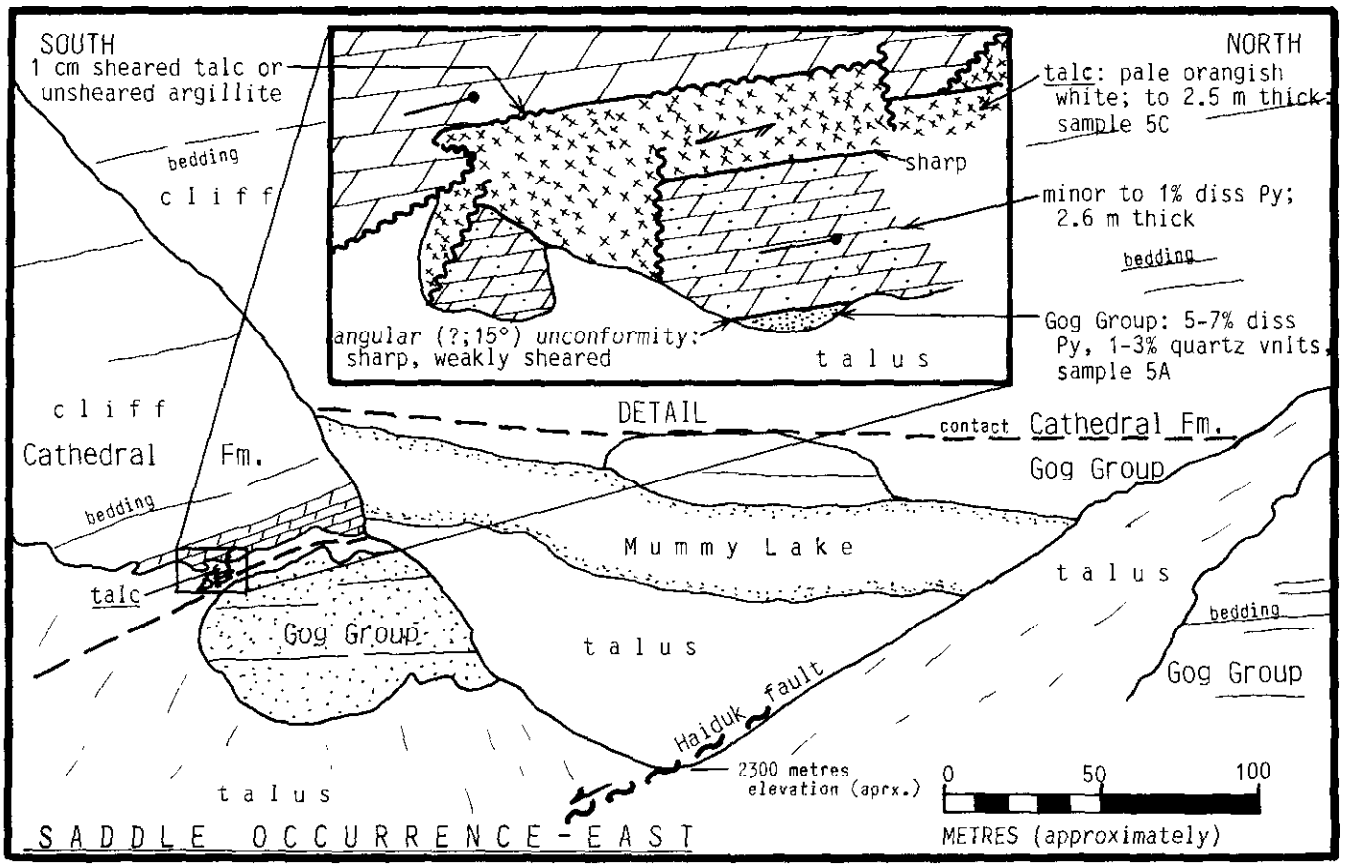

Figure 3-1-9. General and detailed (inset) geology of the easterly saddle talc occurrence northwest of Talc Lake. The pseudosection is traced from an oblique aerial photograph looking westerly at the saddle, Mummy Lake and slope beyond.

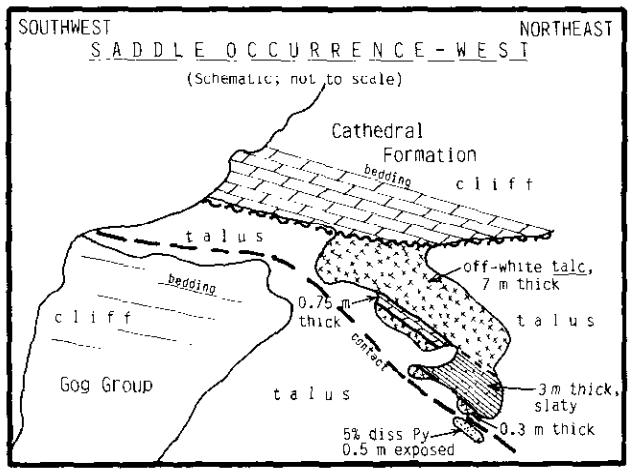

Figure 3-1-10. Schematic pseudosection of the saddle-west talc occurrence northwest of Talc Lake. The exposure is on the opposite side of the ridge from the saddle-east occurrence.

bedding in the underlying dolomite. Talc fills a V-shaped notch 4 centimetres deep in the upper surface of the dolomite. The contact is offset by steeply southwest-dipping faults.

The footwall dolomite is spotted medium and light buff on fresh surfaces and very fine grained. The beds are thin (2 to 5 cm) and dip gently southwest (10°). The dolomite contains minor to 1 per cent, very fine disseminated limonitic specks.

The poorly exposed contact (angular(?) unconformity) between the dolomite and underlying quartz arenite is sharp and locally sheared. It dips about 5° northwest.

The pyritic quartz arenite of the Gog Group weathers very rusty dark brown to medium rusty orange. On fresh surfaces it is subtranslucent light grey. The medium-bedded quartz arenite is moderately fractured and weakly sheared. Pyrite forms about 5 to 7 per cent of the rock and is either clustered or more evenly disseminated. The rock also contains 1 to 3 per cent quartz veinlets.

A thin section (Plate 3-1-3) shows quartz arenite consists of subangular to subrounded quartz grains 0.1 to 0.8 millimetre in diameter, with rims of talc(?). They show deformation features including wavy extinction, microfractures, trains of inclusions, irregular boundaries and embayments. The talc forms 5 to 7 per cent of the rock, as groundmass to the quartz grains. The extremely fine talc grains and fibres have irregular contacts with the quartz grains and appear to partially replace them. Narrow seams of pale brown chlorite(?) in the centre of the talc groundmass may mark the pre-alteration quartz grain boundaries and indicate dense packing. Zircon(?) forms about 0.1 per cent of the section; it

Plate 3-1-3. Photomicrograph (crossed nichols) of partly talc-altered pyritic quartz arenite of the Gog Group from just below the easterly saddle talc occurrence (sample 5A). Very fine grained talc appears to replace the rims of quartz grains with various deformation features. Pyrite (black) overgrowns quartz and talc.

is very fine grained and disseminated irregularly in the talc. Pyrite is concentrated to 25 to 40 per cent in patches 0.5 to 4 millimetres in diameter. It is has irregular subangular to subrounded outlines and appears to have overgrown and replaced quartz grains.

Hangingwall Geology

The upper contact of the talc is parallel overall to the gently southwest-dipping (15°) bedding in the overlying dolomite and to the fracture cleavage in the talc. Locally it is irregular and crosscuts bedding in the dolomite or is offset by steep-dipping faults. The contact is marked by a zone, of sheared talc 1 to 2 centimetres wide, or locally, an unsheared argillaceous rock.

The dolomite beds are 1 to 13 centimetres thick and have irregular surfaces. The dolomite is light orangish buff on fresh surfaces, very fine grained and contains 2 per cent rounded, clear, grey, fine quartz grains.

WEST OCCURRENCE

The poorly accessible west occurrence of white talc appears stratabound in a faulted interval, 7 metres wide and more than 20 metres long, between dolomite and argillite at the base of the Cathedral Formation (Figure 3-1-10). The talc resembles that of the eastern occurrence.

A dolomite unit, 0.75 metre thick, is exposed near the base of the talc interval. However, 2 metres away the dolomite is absent and the talc is underlain by 3 metres of medium greenish grey, platy argillite that weathers similar to the talc. The argillite is underlain by 0.3 metre of whitish talc and, in turn, an exposure of pyritic quartz arenite 0.5 metre high.

The lower contact of the talc interval appears to parallel the underlying, very gently west-dipping beds of quartz arenite. The upper contact of the talc is inferred to be a fault that truncates the overlying dolomite beds at 0°.

GEOLOGY OF THE SILVER MOON OCCURRENCE, MOUNT WHYMPER

Location And Geologic Setting

Three talc occurrences were examined on the southeast slope of Mount Whymper, 20.2 kilometres northwest of the Red Mountain occurrence. They are 2.5 kilometres southwest of the Alberta border, and 840 metres northwest of, and 270 metres above Highway 93 (Figures 3-1-2, 3-1-4 and 3-1-6). The occurrences were originally staked by the Banff Talc Company in about 1915 (Spence, 1940) and later Crown granted (Lot 11708). Several cuts and two short adits were driven into the talc bodies.

The irregular bodies of white talc are 10 to 20 metres high and contain a complex series of large, sheared inclusions of quartz-dolomite and bedded dolomite. They are at nearly the same elevation (1890 m) along 150 metres of the slope, near the base of horizontally bedded dolomites of the Cathedral Formation. The upper and lower contacts of the Silver Moon talc bodies appear parallel to bedding.

The lateral contacts of the bodies are covered but appear irregular, stepped and interfingering, and in part bounded by fracture cleavage. The bodies coincide with, and perhaps are localized along zones of well-developed northwest-striking fracture cleavage. The two northeast bodies have exposures elongated to the northwest.

The geologic setting most resembles that of the saddle occurrences. The base of the talc is about 15 metres above the rarely exposed Gog Group. They are 5.5 kilometres northeast of the inferred location of the facies change between the Cathedral and lower Chancellor Formations on the lower ramp(?) of the Cathedral escarpment (Price *et al.*, 1978; *see* Figure 3-1-3), and 2.5 kilometres northeast of the escarpment (Figures 3-1-2 and 3-1-4).

The informally named Consolation Valley fault is 475 to 550 metres west of the occurrences (Figures 3-1-2, 3-1-3 and 3-1-6). The northwest-trending, southwest-dipping normal fault has about 300 metres of dip separation at Mount Whymper (Price *et al.*, 1978; Figure 3-1-3). It is parallel to and 4 to 6 kilometres southwest of the Haiduk fault. The talc bodies are also near what appears to be a significant change in dip of the Consolation Valley fault from very steep, north of the talc, to about 40°, south of it. A steeper dipping normal fault is inferred to splay southwards from the main fault from an apparent offset of the top of the Gog Group (Figure 3-1-6). A few talc veinlets were found in the immediate footwall of the splay.

The southwest talc body is 10 metres high (vertical) and 30 to 37 metres wide. An adit 7 metres from the southwest end of the body was driven northwesterly 9 metres. The middle body is 8 metres high and 23 to 29 metres northeast of the southwest body. The northeast body is 40 metres northeast of the middle body and up to 16 metres wide and 23 metres high. An adit was driven northwesterly 6 metres into the talc.

Talc Geology

Only 15 to 40 per cent of the complex Silver Moon bodies is exposed. The outcrops have low relief on moderately steep slopes between bluffs of the more competent bedded dolomite (Figure 3-1-11). The footwall contacts are locally exposed; other contacts are not. The talc bodies contain irregularly distributed, sheared lenses, pods and veins of highly variable proportions of quartz and dolomite. In addition, bedded dolomite forms lenses and intervals in the bodies.

The southwest body is 15 per cent exposed, but appears to contain the highest proportion of talc, with about 10 per cent bedded dolomite lenses and locally to 10 per cent quartz pods and lenses.

The talc is generally weakly translucent, frosty white with a pale greenish grey tinge on fresh surfaces. Locally, it is limonite stained and light to medium rusty orange in zones 1 metre or more wide. Very locally, the talc contains dark grey bands to 2 centimetres thick. Fracture and shear surfaces bounding talc weather medium to dark brown and are smooth. Otherwise, fracturing produces a very jagged, off-white weathered surface with patches of limonitic stain. The very strongly fractured talc is cut by a complex mosaic of criss-crossing fractures producing pieces measuring 0.5 by 1 by 1 centimetre. Slickensided shears commonly cut the talc. The more prominent strike northwest; one displays slickensides plunging 40° southeast. The talc between quartz-dolomite pods and lenses generally is cut by strongly developed fracture cleavage and shears that wrap around the pods.

Pyritic lenses are surrounded by talc at both the southwest and northeast occurrences, 1 to 3 metres above the basal contact. The lenses are up to 13 centimetres thick and 1 metre long, and dip subhorizontally to 25° southwest. The southwest lens of talc contains 10 per cent, very fine to fine anhedral pyrite irregularly scattered along stringers and within patches. The northeast lens consists of gossanous talc with patches of clear grey dolomite with 8 per cent disseminated pyrite.

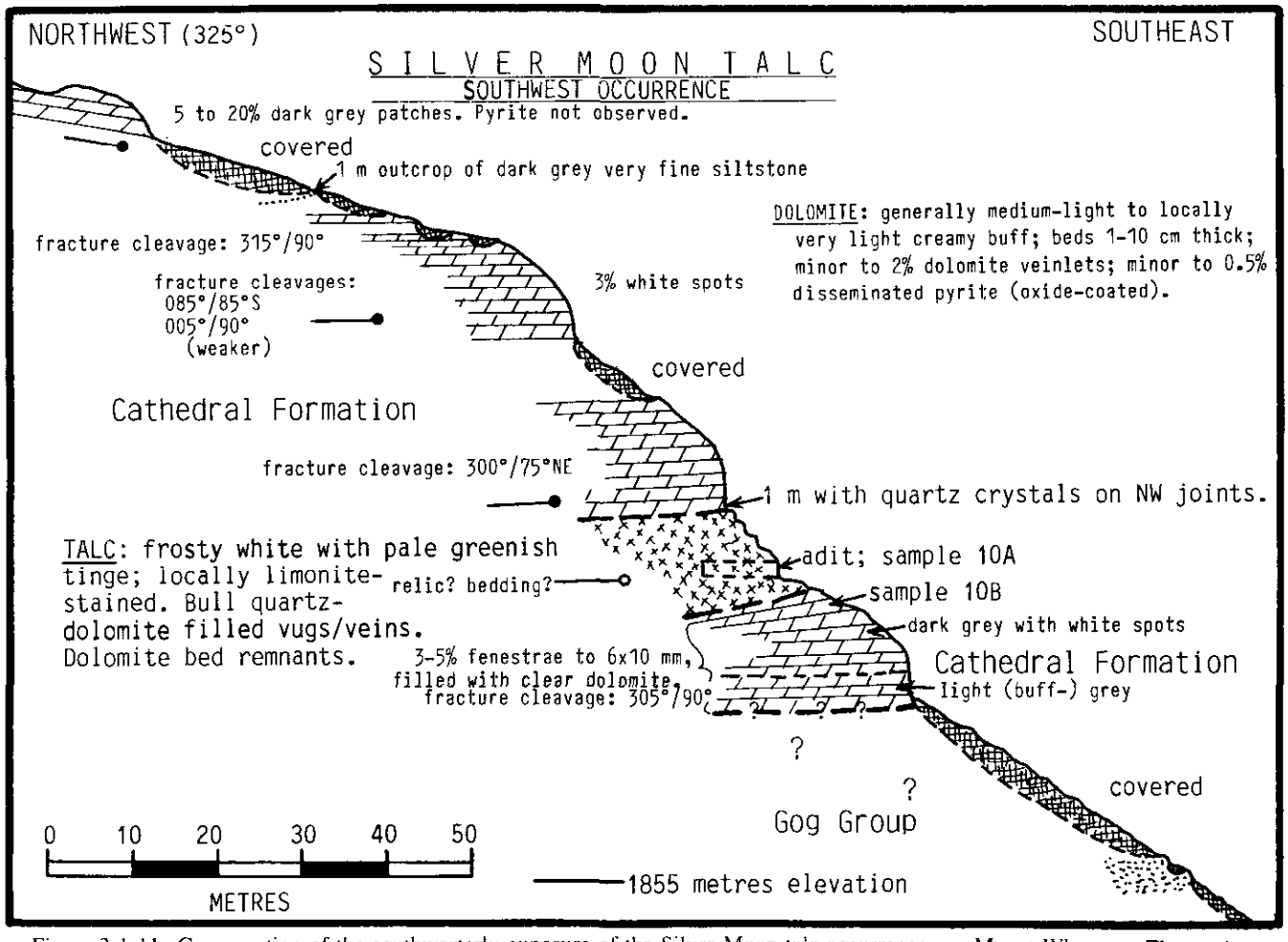

Figure 3-1-11. Cross-section of the southwesterly exposure of the Silver Moon talc occurrences on Mount Whymper. The section is based on a hip chain and compass traverse.

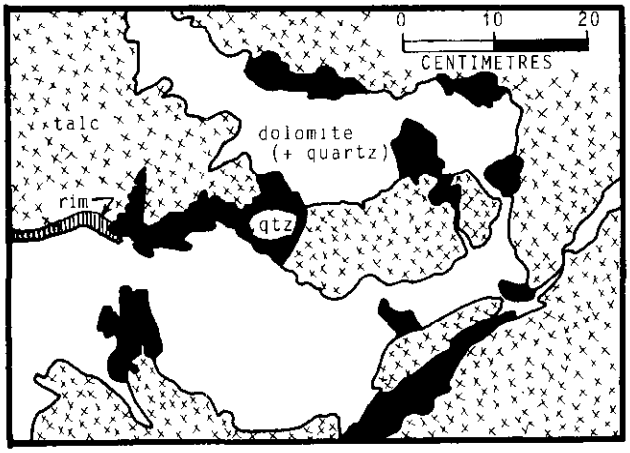

Figure 3-1-12. Coarse-grained dolomite and quartz fills irregular vugs in microcrystalline white talc. The tracing is from a photograph of a cut 20 metres northeast of the adit at the southwest Silver Moon talc body. Note the fine-grained recrystallized talc rim on the margin of a dolomite-filled vug.

Vugs and filled vugs in talc are a local feature (Figure 3-1-12). They are flattened, shallow dipping and range up to 0.7 metre long. Several are lined with dirty white botryoidal talc. They are filled with coarsely crystalline dolomite and white quartz.

In thin section the talc (sample 10A) comprises very fine elongate, irregular and weakly fibrous grains in a complex interlocking mosaic (Plate 3-1-4). A talc-replaced dolomite(?) veinlet is apparent in thin section but not in hand sample because it has the same grain size as the host talc. The thin section also contains hairline talc veinlets along a criss-crossing mosaic of fractures. They comprise very fine fibrous and non-fibrous talc grains elongated perpendicular to the veinlet walls.

Quartz-dolomite veins, pods and lenses have uncertain relationships to the talc because their contacts are generally sheared (Figure 3-1-13). However, at the southwest adit less deformed talc shows clearly that quartz and dolomite not only fill vugs, but form the matrix to coarsely fractured talc. They also form an anastomotic network of sheared and irregular fracture-offset veins to 15 centimetres thick. The quartz is moderately to very strongly shattered, coarse grained and milky white with limonitic fractures. The dolomite is generally coarsely crystalline and either surrounds or is intergrown with large quartz grains.

The quartz-dolomite bodies commonly contain 10 to 15 per cent angular to lens-shaped fragments of bedded dolomite measuring up to 0.4 by 1 metre. A thin section (sample 12A) indicates one fragment consists of a mosaic of variably sized, anhedral dolomite grains and 0.25 per cent, fine-grained, disseminated iron oxide coated pyrite. The XRD analysis indicates the dolomite is weakly altered to talc (Table 3-1-1).

Talc also encloses tabular, gently dipping, shear-bounded bodies of dolomite from 0.2 to 3 metres thick and 8 metres or more long. The weakly to moderately fractured dolomite

Plate 3-1-4. Photomicrograph (crossed nicols) of white, relatively pure talc from the southwestern Silver Moon body (sample 10A). The talc comprises a complex interlocking mosaic of elongated to irregular very fine grains and short fibres.

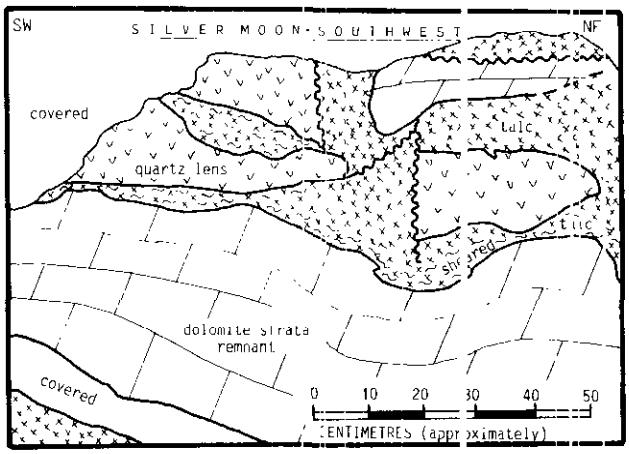

Figure 3-1-13. The complex, sheared, faulted and interlayered relationships between talc, coarse-grained quartz and lenses of bedded dolomite in the southwest Silver Moon talc body. The pseudosection is traced from a photograph of the steep slope 8 metres northwest of the adit.

is subtranslucent, dark grey to irregularly banded light buff and medium buff-grey. One dolomite lens is cut by a few per cent (early?) dolomite veinlets and several talc veinlets 1 millimetre thick, within a few centimetres of its contacts. Another dolomite layer contains 7 per cent quartz and quartz-dolomite veinlets and pods. The veinlets are 1 to 20 millimetres thick and irregular, but commonly parallel bedding or fill a northwest-striking fracture cleavage. The pods measure up to 0.6 by 1 metre or more.

Quartz crystals commonly occur on fracture cleavages and joints cutting the dolomite. The quartz forms up to 10 per cent randomly oriented prismatic crystals to 1 by 20 millimetres in subhorizontal zones 4 centimetres wide on the joints.

The contact between talc and the underlying dolomite is sharp, locally weakly sheared and overall parallel to bedding. However, in detail it is irregular and locally stepped 0.4 metre or more and crosscuts bedding. Limonite fills small (1 by 1.5 cm) pockets in the dolomite surface.

Footwall Geology

The talc is underlain by a bluff to 13 metres high of moderately fractured fenestral dolomite of the Cathedral Formation (Figure 3-1-11). It is thin to medium thin bedded and very fine grained but subtly laminated.

The dolomite contains minor to 0.5 per cent pyrite as very fine to locally fine, subhedral to anhedral grains. The pyrite is commonly rimmed or completely altered to goethite and lepidocrocite (both iron hydroxides identified by x-ray diffraction). Lens to eye-shaped fenestrae form 3 to 5 to locally 10 per cent of the rock. They commonly measure 0.5 by 1 to 6 by 10 millimetres and are filled with clear, fine-grained dolomite. X-ray diffraction analyses of dolomite from 3.5 metres below the talc body (sample 10B) identified minor amounts of chlorite and talc and traces of quartz; they are not apparent in thin section.

Dolomite veinlets form up to 2 per cent of the dolomite. They are fine grained, discontinuous, coplanar and en echelon, and criss-crossing.

At the southwest occurrence, a talus interval 20 metres high separates the base of the dolomite bluff from the small uppermost outcrop of quartz arenite of the Gog Group. The top of the Gog may be immediately below the base of the cliff because 530 metres to the southwest it is exposed at the base of a similar dolomite section.

Hangingwall Geology

Prismatic quartz crystals occur on northwest-striking fracture cleavage surfaces in the 1-metre interval of dolomite immediately above the southwest talc body (Figure 3-1-11). These have the same habit as those in the dolomite inclusions previously described.

The dolomite in the three bluffs in the 50 metres above the southwest talc body, resembles that below the talc with some variations. The gently dipping (10° to 5°) to horizontal beds are 1 to 10 centimetres thick. Bedding surfaces are irregular and wavy. Oxide-coated pyrite forms up to 0.5 per cent disseminations. Up to 2 per cent dolomite veinlets commonly occur along fracture cleavages and bedding surfaces. They are hairline to 1 to locally 15 millimetres thick.

The covered intervals between the dolomite bluffs are probably underlain by platy siltstone, at least in part.

Fracture Cleavages

Coplanar and complexly intersecting fracture cleavage sets are generally well developed in the rocks under and over, as well as in the talc bodies. The most prominent generally strike northwesterly (305° to 345°). Two additional sets of vertical fracture cleavage are locally prominent: an east-striking (085° to 105°) set and a northerly (005°) set. The spacing between the fractures commonly varies between 1 and 15 centimetres.

The fracture cleavages are probably of several generations and appear to have strongly influenced the geometry and perhaps localization of the talc bodies. An early fracture cleavage hosts dolomite(?) veinlets that were later altered to talc, together with the host.

Two of the talc bodies have exposures elongated subparallel to the northwest-striking fracture cleavage. The irregular sides of the bodies are probably in part controlled by this cleavage. Their upper and lower contacts jog up to 1 metre or more along fractures. Later fracture cleavages cut and offset the talc and enclosed lenses of dolomite. Talc fills those cutting talc, quartz and dolomite.

CHEMISTRY AND MINERALOGY OF TALC AND DOLOMITIC STRATA

Table 3-1-1 summarizes the results of XRF and XRD analyses on seven samples of talc and five samples of dolomite and argillaceous dolomite wallrocks from the occurrences described above.

A comparison between the theoretical compositions of talc (Table 3-1-1) and the Silver Moon white talc (sample 10A) indicates only minor impurities of calcium and iron. Interestingly, the lighter grey to white talc generally contains pyrite (up to 2%) whereas the black talc rarely does. Perhaps the iron is captured by chlorite.

Chlorite

Three samples of black talc contain higher alumina (2.5%, 7.3% and 1.0% Al_2O_3 in 1H3A, 3A and 3B, respectively) and minor or major amounts of chlorite. It appears that the black colour may result as much as from the chlorite as the locally conspicuous carbon compound. The XRD analyses did not detect graphite, indicating that the carbon compound identified in hand samples and thin section is amorphous.

Chlorite was not positively identified in thin sections. It is, therefore, probably intergrown with the extremely fine grained talc. The maximum amount of chlorite might be 14, 40 and 6 per cent in the three talc samples if all the aluminum is in clinochlore (Table 3-1-1). This is a high magnesian member of the chlorite group common in the talc deposits in Precambrian dolomites of Montana (Berg, 1979). The precursor of the chlorite may clay.

Fluorapatite

X-ray diffraction analyses identified minor amounts of fluorapatite ($Ca_5(PO_4)_3F$) in one grey and two black talc samples from the Talc Lake area. All three (1H3A, 1J1 and 3B) have significantly higher percentages of P_2O_5 (0.14%, 0.35% and 0.31%) and contain chlorite. Grains resembling apatite were not recognized in thin section. Roe and Olson (1983) noted that 22 talc samples from deposits in sedimentary rocks worldwide contained 0.11 to 0.48 per cent fluorine.

Trace Elements

Inductively coupled plasma analyses for 35 trace elements in three black and four white talc samples from Talc Lake and Mount Whymper indicate they contain low background levels of the more common metals and lack an obvious geochemical signature. The talc samples contain 1 to 15 ppm copper, 4 to 9 ppm lead, 1 to 64 ppm zinc, 4 ppm arsenic, 2 to 12 ppm tungsten, 0.2 to 0.5 ppm silver.

The black talc samples contain more zinc (22 to 64 ppm) than the white talc (1 to 12 ppm). This probably reflects the argillaceous and carbonaceous nature of the dolomite protolith.

Silt And Soil Samples

Four samples suggest there are no obvious trace element indicators in the silt or soil downslope from the talc deposits. The two silt samples (TL-1 and -2) are from the creek that drains Talc Lake, 650 metres northeast of the Red Mountain talc occurrence (Figure 3-1-6, left). The two soil samples (SM-1 and -2) are from two low-relief draws 800 metres southeast of the Mount Whymper talc bodies (Figure 3-1-6, right). The samples contain low background levels of copper (18 to 24 ppm), lead (18 to 33 ppm), zinc (113 to 180 ppm), arsenic (4 to 11 ppm) and tungsten (3 ppm) which is similar to the talc.

TALC EXPLORATION GUIDELINES

The following preliminary exploration guidelines are based on the major similarities between the modes of occurrence of talc in the Talc Lake area and at Mount Whymper summarized in Figure 3-1-14. Although they may have similar origins, the significant differences between them cannot be explained without additional study. The considerable amount of vein-quartz and dolomite mixed with the talc at Mount Whymper distinguishes it from the other occurrences.

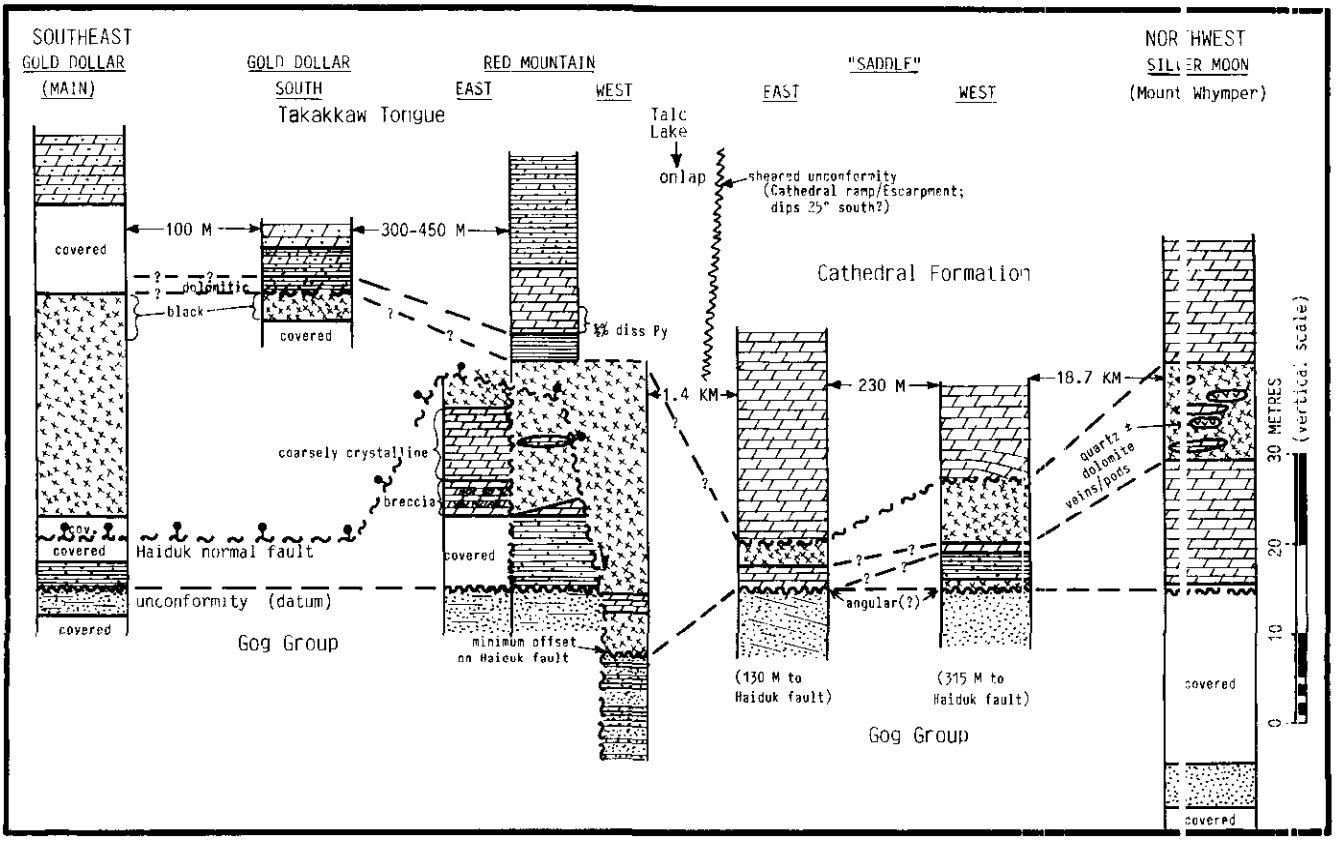

Figure 3-1-14. Correlations between schematic lithostratigraphic columns for the main talc occurrences at Talc Lake and Mount Whymper. Note the proximity of the talc bodies to the unconformity at the top of the Gog Group and their relationship to the Haiduk fault.

Permeable reef facies along the Cathedral escarpment are thought to have channeled fluids that formed the Kicking Horse, Monarch and Mount Brussilof deposits. The talc deposits, however, are below the stratigraphic level of the steep (reefoid) part of the escarpment. Evidence is lacking for structures channeling the fluids in rocks beneath the escarpment at the lead-zinc and magnesite deposits. However, the proximity of the talc deposits to the escarpment is probably more than fortuitous and it appears reasonable to conclude:

- The escarpment reflects prominent structures in the underlying Lower Cambrian and older rocks, which mark the hinge between platformal and basinal sedimentation.
- These structures localized the talc alteration.

The proximity of the talc deposits to one of two north-northwest trending normal faults probably is also not fortuitous. They are probably old structures with more than one episode and sense of displacement (Cook, 1975). The faults may have, in fact, channeled alteration fluids, as suggested by Westervelt (1979). If the faults predate the Cretaceous to Eocene shortening, then the Simpson Pass thrust must offset the upper part of the normal faults from their lower extensions.

The talc deposits appear to be localized by the following structural and lithologic controls (Figure 3-1-14):

- The Talc Lake bodies occur within 1 kilometre of the northeast end of an embayment in the Cathedral escarpment which appears to have an anomalous southerly dip. An embayment in the escarpment is not apparent near the Silver Moon occurrence but the location of the escarpment is not well constrained in this locality. The Talc Lake embayment may reflect an underlying pre-Middle Cambrian transverse (east-west) structure that controlled the location of the escarpment and caused permeable regions of dilatancy. Overburden in the Vermilion River valley conceals any large-scale northeasterly cross structure that might control the location of the talc occurrences.
- The Talc Lake bodies are in the hangingwall of the northwest-trending Haiduk normal fault. South of the escarpment the fault marks the contact between the Gog Group and the Takakkaw tongue. The main exposures of the Mount Whymper talc are east of a similar fault where it appears to change its southwest dip by 40°, and splay. These faults may have channeled the alteration fluids.
- Sets of closely spaced fracture cleavages of several ages are well developed in the talc bodies and enclosing rocks. The northwest-trending sets at Mount Whymper appear to have strongly influenced the geometry, elongation and perhaps localization of the talc deposits. At Talc Lake, quartz veinlets in quartz arenite parallel several northeast-trending fracture sets that may have channelled silica-bearing fluids into the overlying dolomite during talc alteration.
- Brecciation of the protolith dolomite at the Red Mountain deposit may have provided porosity at a small scale. Intergranular porosity is locally indicated at the microscopic scale.
- Talc is commonly strongly sheared and cleaved although upper and lower contacts appear to show relatively small offsets. The relatively incompetent talc may occur along fault-controlled linear topographic depressions, as at Talc Lake.
- Talc alteration appears stratabound at larger and smaller scales although it cuts bedding locally. Its upper and lower contacts vary from knife sharp and weakly sheared to gradational over a few metres or less. It is difficult to infer the amount of control the lithologies exercised on its extent because the most favourable hosts are presumably completely altered.
- Talc occurs near the base of the Middle Cambrian Cathedral Formation and its slope-facies equivalent, the Takakkaw tongue.
- The base of the talc is about 2.5 to 8 metres (at Talc Lake), to 15 metres (at Mount Whymper) above, or locally at the unconformity at the top of the Lower Cambrian Gog Group.
- The uppermost Gog quartz arenite at Talc Lake is locally partly to completely altered to talc, and contains disseminated pyrite. Quartz veinlets and veins form up to several per cent of the rock, which may be unusual for the Gog.
- Talc overlies the lowermost occurrence of dolomite. South and west of the Cathedral escarpment at Talc Lake it is in an interval of very thin bedded and laminated, graded black argillite, dolomite and argillaceous dolomite. The black argillite in thin intervals above and below the talc bodies is partly to completely altered to chlorite, talc and a carbon compound.
- A distinct, coarsely recrystallized dolomite immediately underlies the Red Mountain deposit at the Haiduk fault. The unit contains up to 2 per cent pyrite and minor talc veinlets. It is older than the talc but may be related to the same alteration event.
- Prismatic quartz crystals occur on fractures in the 1-metre interval of dolomite immediately above the Silver Moon occurrence.
- Pyrite generally forms 1 per cent disseminations in the lighter coloured talc. This and the pyrite in the footwall rocks might be detected by an induced polarization survey.
- Coarser pyrite is disseminated in the lower 4 metres of the dolomite unit overlying the Red Mountain deposit.

ACKNOWLEDGMENTS

I am pleased to acknowledge Z. Dan Hora of the British Columbia Ministry of Energy, Mines and Petroleum Resources for the background information and his ongoing assistance; he also conceived the study. I am also grateful to Peter Fischl for his assistance in field mapping. Finally, I would like to thank Perry Jacobson, Chief Park Warden of Kootenay National Park and Environment Canada (Parks) for permitting the fieldwork. The project was funded under contract number 93-663 by the British Columbia Ministry of Energy, Mines and Petroleum Resources.

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