MANSON CREEK MAPPING PROJECT (93N/09)

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KEYWORDS: Regional geology, Manson Creek, Intermontane Belt, Omineca Belt, Slide Mountain Group, Ingenika Group, Wolverine Complex, precious metal veins.

INTRODUCTION

The Manson Creek mapping project was initiated by the British Columbia Ministry of Energy, Mines and Petroleum Resources to provide a detailed geological base map at a scale of 1:50 000 for the Manson Lakes (93N/09) map sheet. In addition an inventory of the mineral occurrences will be compiled, with emphasis placed on the lode gold occurrences. The project is in the first year of a proposed 6-year program.

PHYSIOGRAPHY AND ACCESS

The Manson Lakes map sheet is located in east-central British Columbia approximately 200 kilometres northwest of Prince George (Figure 1-15-1). Primary access is via an all-season gravel road north from Fort St. James which follows the Manson River – Manson Lakes drainage system and diagonally divides the map sheet. The northeastern part of the map area is occupied by the Wolverine Range of the Omineca Mountains with eastern slopes falling off into the Rocky Mountain Trench. Approximately three quarters of the area is accessible by logging roads, the remaining parts are reached by helicopter.

REGIONAL GEOLOGY

The project area straddles the boundary between the Intermontane and Omineca belts of the Canadian Cordillera. This boundary places allochthonous and para-allochthonous oceanic rocks of the Slide Mountain Group to the west, against miogeoclinal Proterozoic rocks of the North American craton to the east (Monger and Price, 1979).

Within the map area the contact between the two terranes is a west-side-down normal fault which increases in displacement to the southeast (Figure 1-15-2) and probably also has a dextral strike-slip component of motion. This normal fault has obscured the overthrust relationships seen elsewhere along this contact (Nelson and Bradford, 1987; Struik, 1986; Rees and Ferri, 1983).

The Slide Mountain Group is Late Paleozoic in age and is composed of a suite of oceanic rocks. These have been intruded by the Early Cretaceous Germansen batholith (Garnett, 1978) and in places covered by Tertiary (?) felsic volcanics (Armstrong, 1949).

The Omineca crystalline belt is represented by a thick sequence of predominantly siliciclastic sediments with minor carbonates and mafic rocks. These have been assigned to the Ingenika Group and are Late Proterozoic in age (Mansy and Gabrielse, 1978). These sediments have been highly metamorphosed within the Wolverine Range and subsequently intruded by granodioritic bodies and associated pegmatites

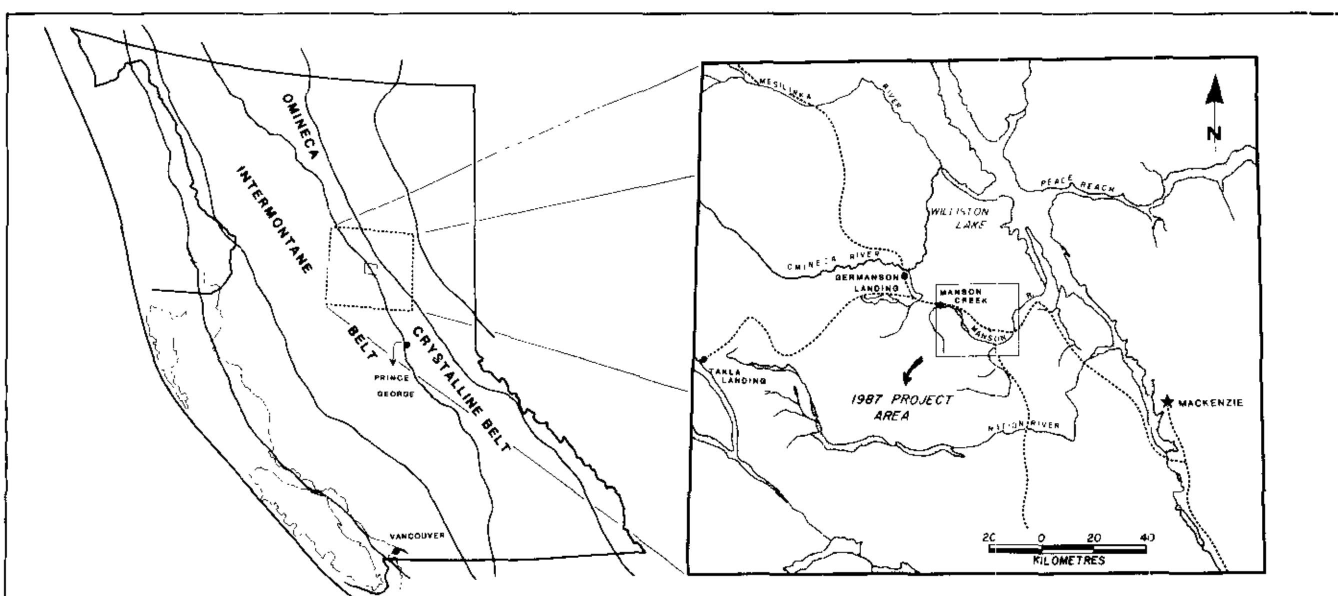

Figure 1-15-1. Location of the project area within the framework of the Canadian Cordillera.

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1987, Paper 1988-1.

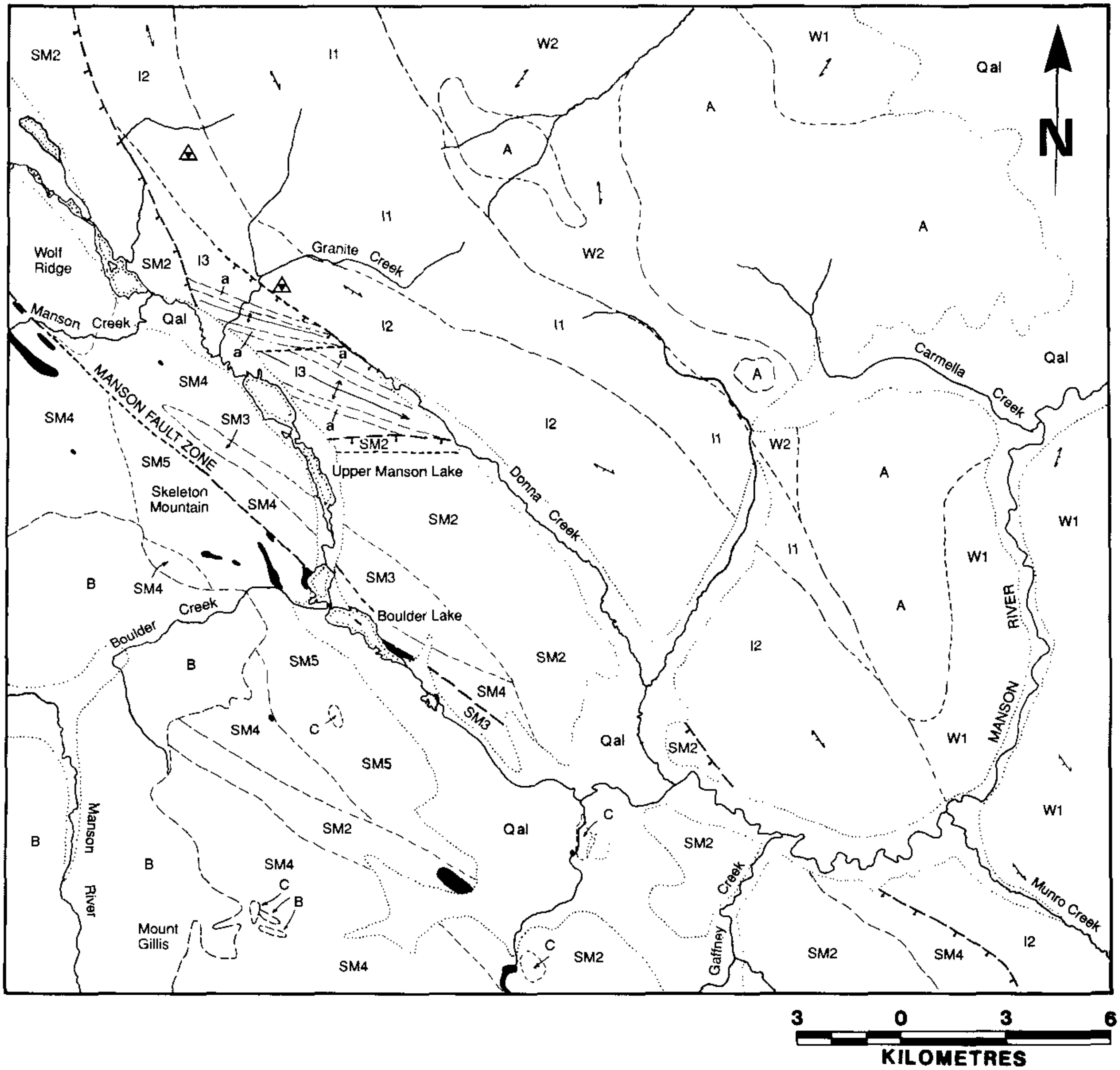

Figure 1-15-2. Geological map of the project area.

which are possibly early Cretaceous (Parrish, 1976). Where deformation, metamorphism and related intrusions have deformed the sedimentary sequence to levels where original lithological determinations are impossible or tenuous, the Wolverine complex has been applied.

INTERMONTANE BELT LITHOLOGIES

SLIDE MOUNTAIN GROUP

Within the project area the Slide Mountain Group was initially mapped as Cache Creek Group by Armstrong (1949). Similar rocks were also mapped as Cache Creek Group in the Aiken Lake map area by Roots (1954) and within the McLeod Lake map area by Armstrong *et al.* (1969). During initial work within the Paleozoic sequences of the Omineca Mountains to the north, Monger (1973) realized that these rocks were correlative with the Slide Mountain Group and Sylvester Group found elsewhere along this segment of the Canadian Cordillera.

The Slide Mountain Group, as seen in the project area, is composed of black phyllite and argillite, mafic and intermediate flows and tuffs, greywackes to gritty phyllites, diorite and gabbro sills and dykes, ultramafic rocks and cherts together with minor carbonates and ribbon cherts. Unit thicknesses in the following paragraphs are rough estimates produced from cross-sections as no continuous section of any one unit was seen in the project area.

LEGEND

QUATERNARY	**PROTEROZOIC**
Qal — *Glacial till and alluvium*	INGENIKA GROUP
TERTIARY (?)	I3 — *Upper: Phyllite and lesser quartzite and argillaceous quartzite. a – Middle carbonate member*
C — *Intermediate to felsic flows and dykes*	I2 — *Middle: Quartzite, argillaceous quartzite, and schist*
UPPER CRETACEOUS	I1 — *Lower: Meta-arkose, meta-grey wacke, schist, quartz-feldspar gneiss and minor calc-silicate and amphibolite gneiss*
B — *Germansen batholith: granite and minor granodiorite*	**WOLVERINE COMPLEX**
UPPER PALEOZOIC AND YOUNGER SLIDE MOUNTAIN GROUP	W2 — *Schist and quartz-feldspar gneiss intruded by granodiorite and related pegmatite**
SM5 — *Argillaceous sandstone, phyllite, gritty phyllite*	W1 — *Amphibolite and calc silicate gneiss, schist and quartz-feldspar gneiss intruded by granodiorite and pegmatite**
SM4 — *Phyllite, argillite, argillaceous limestone*	A — *Foliated granodiorite and pegmatite**
SM3 — *Gabbro*	
SM2 — *Mafic to intermediate volcanics, tuff, siltstone, minor argillite, chert, and gabbro*	
SM1 — *Ultramafics: serpentine, talc-serpentine, and talc-ankerite schists*	
UPPER DEVONIAN/LOWER MISSISSIPPIAN	*Intrusive probably Cretaceous
▲ — *Syenite and carbonatite*	

Figure 1-15-2a. Legend for Figure 1-15-2.

The internal contact and stratigraphic relationships within the Slide Mountain Group are tenuous due to the sparse outcrop. The stratigraphic succession implied in the legend in Figure 1-15-2a is based more on typical oceanic stratigraphy than on field observations.

Unit SM1 (Ultramafics)

Two linear belts containing bodies of ultramafic rock, the largest of which probably has an areal extent of 1.5 square kilometres, trend through the map area. One belt extends from the town of Manson Creek southeast to the mouth of Boulder Creek and along Boulder Lake to the point where Gaffney Creek leaves the map sheet. The second group of ultramafics is found within the belt of predominantly mafic volcanic rocks (Unit SM2, Figure 1-15-2) found immediately northeast of Mount Gillis. Good exposures of this unit can be found on the banks of the Manson River immediately west of Manson Creek and on the main road near Boulder Lake.

Three ultramafic rock types are present: serpentinite bodies, talc-serpentine bodies and talc-ankerite-serpentine schists. Where contact relationships are visible, these bodies are typically found in fault contact with the surrounding rocks.

The serpentinite bodies are almost pure serpentine with minor amounts of disseminated talc, ankerite and epidote alteration accompanying quartz veining. The serpentine is dark green to brown weathering, generally magnetic and may contain thin veins of chrysotile.

Talc is found as either disseminated grains or fine-grained masses 0.5 to 1 centimetre across to radiating crystal masses a few centimetres in diameter, and may comprise more than 50 per cent of the rock. A weak foliation may be developed within the more talc-rich bodies.

Bodies of mariposite-magnetite-quartz-serpentine-talc-ankerite schist are found in some localities. They are composed essentially of talc and ankerite with lesser amounts of the remaining minerals. They are grey-green to brownish weathering and commonly coarsely crystalline with large (up to 1 centimetre) porphyroblasts of ankerite. Mariposite is common and magnetite can be found as finely disseminated crystals which may make up to 2 per cent of the rock.

Unit SM2 (Volcanic and Volcaniclastic Rocks)

This unit is highly variable and is composed of numerous members including: massive to pillowed basalts, intermediate volcanics, tuffs, siltstones, cherts, argillites, conglomerate and minor ribbon chert. These rocks have been intruded by fine to medium-grained gabbro sills and dykes. The best exposures are on the ridge immediately southwest of Donna Creek and in the Gaffney Creek area. The thickness of this unit is at least 1 kilometre.

The basalts are grey-green to green in colour with occasional very finely crystalline feldspar phenocrysts and rare olivine. Some of the more massive flows (especially in the Donna Creek area) appear to be more intermediate in composition and contain medium-grained feldspar and pyroxene phenocrysts. These volcanics are usually highly fractured, chloritized and may be cut by quartz-calcite-epidote veining. The basaltic flows are generally massive but pillow selvages are sometimes seen. The best exposures of basalt flows are on a ridge leading off an unnamed peak north of Mount Gillis.

Associated with the basalts and intermediate flows are predominantly fine-grained tuffs (?) and siltstones of probable volcanic derivation. These rocks are grey-green to olive-green weathering with a dark grey fresh surface. They generally appear massive but faint bedding can be seen occasionally. The siltstone is often quite siliceous. Thick (10-metre) layers of conglomerate and breccia made up of siliceous siltstone, chert and tuffaceous clasts are occasionally present within these tuffs and siltstones.

Grey, green and cream to white chert and siliceous argillite are found as pods within the volcanics or as thin to massively bedded intervals up to 5 metres thick. The cherts are sometimes ribboned.

Dyke or sill-like gabbro bodies ranging from a few metres to tens of metres across, are green to grey-green in colour, very fine to finely crystalline and may contain phenocrysts of feldspar.

Unit SM3 (Gabbro)

Gabbro is found as three lenticular bodies which trend northwesterly across the map area. This rock type is found underlying Wolf Ridge, south of the Upper Manson Lake and north of Boulder Lake; the best exposure is on Wolf Ridge.

The rock is green to dark green in colour and light brown to rusty brown weathering. It ranges in composition from 40 to 60 per cent plagioclase with the remainder of the rock being pyroxene, hornblende and minor biotite. It is typically fine to medium grained, but pegmatitic phases can be seen on Wolf Ridge. Phenocrysts of pyroxene and plagioclase up to 5 millimetres in length may be present.

Most exposures of this unit contain a weak mineral lineation with an accompanying very weak planar fabric. This weak fabric grades into zones of mylonite. These zones are a few metres across and deformation is not uniform throughout any outcrop. Their distribution is sporadic but they are generally found toward the periphery of gabbro bodies.

The contact between the gabbro and the surrounding rocks is not well exposed but a decrease in grain size toward the edge of these bodies may represent chilled margins. This relationship is seen on Wolf Ridge. Nearby, at the Fairview showing, serpentinized ultramafics appear to be in fault contact with this unit and faulted contacts are suspected elsewhere in the map area.

Unit SM4 (Phyllite/Argillite)

This unit underlies the greater part of the map area. Its areal extent, together with structural measurements, suggests it may be at least 2 kilometres thick.

The phyllites are grey to black and are thin to moderately bedded (1 to 5 centimetres). Cleavage is commonly the dominant planar fabric with bedding being impossible or difficult to distinguish. Phyllites are quite lustrous and typically graphitic. They grade into dark grey to black graphitic argillites which are moderately to thickly bedded and may be fairly siliceous. These argillites tend to have a spaced cleavage and, in these horizons, bedding is the dominant planar feature.

The phyllites can become quite calcareous and grade into graphitic, dark grey to black, thin-bedded argillaceous limestones. Small lenses of buff to cream-weathering, thin to moderately bedded recrystallized limestones are observed in the Boulder Creek area and are best exposed along the main road and along the creek flowing southeast into Boulder Lake.

Ribbon chert was seen in a few localities within the argillaceous member. It is characterized by grey to beige chert bands 1 to 3 centimetres thick, alternating with dark grey argillite layers of similar thickness.

Layers of argillaceous sandstone or feldspathic wackes a few metres thick are a minor constituent of this unit. They are grey to light brown weathering and massively bedded.

Unit SM5 (Argillaceous Sandstone – Gritty Phyllite)

This unit is typified by phyllites, silty phyllites and siltstones which are grey-green to green in colour and thin to moderately bedded. Thin to moderately bedded, grey to beige beds of very fine to fine-grained argillaceous sandstone, feldspathic sandstone or quartzite occur in some localities (for example, on Skeleton Mountain). These sandstones are typically interlayered with very thinly bedded grey-green phyllite to siltstone. This predominantly sandstone sequence is approximately 100 metres thick. Small exposures of argillaceous sandstone or quartzite a few metres thick are also found within the phyllite/argillite unit. A minor constituent of Unit SM5 is a buff to dark grey-weathering, thinly bedded, finely crystalline limestone similar to that seen within Unit SM4.

The phyllite and silty phyllites of Unit SM5 can be traced east and north from Skeleton Mountain and grade into the darker and cleaner phyllites of the black phyllite/argillite unit. The southern extent of this unit is obscured by a thick covering of Quaternary material. To the west it has a fairly sharp contact with the underlying argillites.

Unit SM5 is best exposed on Skeleton Mountain and on the ridge immediately south of Boulder Lake. Its thickness is difficult to estimate but is believed to range from 500 to 1000 metres.

Toward the contact with the Germansen batholith, these phyllites and silty phyllites were subjected to contact metamorphism, and porphyroblasts of chlorite, biotite, garnet and occasionally staurolite were formed. This relationship can be clearly seen across the ridge southwest of Boulder Lake. This zone of contact metamorphism is quite large but can be explained by the fact that the eastern contact of the Germansen batholith dips at a shallow angle below the surrounding sediments in the vicinity of Mount Gillis.

Unit SM5 is problematic within the project area. The sandstones, wackes and gritty phyllites form a distinct package within the Slide Mountain Group. Other layered rocks tend to be grey to black in colour whereas the rocks of this unit have a distinct greenish hue and their gritty nature is not characteristic of an oceanic setting. The sandstones and wackes closely resemble the sandstones and argillaceous sandstones of the upper unit of the Ingenika Group elsewhere in the area and may represent a fault slice of Ingenika Group rocks.

The reasons for including this unit within the Slide Mountain Group are: the presence of thick beds of feldspathic wacke to arkose within the black phyllite unit; the apparent stratigraphic continuity of the phyllites of Unit SM5 into those of the Unit SM4; other workers (Schiarizza and Preto, in press; Nelson and Bradford, 1987) also see similar rocks within Slide Mountain Group equivalents. It should be reiterated here that the lack of outcrop in this area does not allow a definitive answer to this problem and both interpretations must be considered.

Germansen Batholith

The Germansen batholith is a Late Cretaceous two-mica granitic intrusion which occupies the southwestern portion of the project area. It is predominantly granite in composition though granodiorite and diorite phases are seen at its southeastern contact. It is white to grey in colour and weathers beige to pink. It is commonly coarsely crystalline and occasionally phenocrysts of potassic feldspar up to a few centimetres in length are seen. Accessories are primarily biotite and muscovite with lesser amounts of hornblende and, in some areas, chlorite after biotite. Granite pegmatite and aplite dykes, up to a metre in thickness, cut the batholith. The pegmatites are similar in composition to the intrusion but they commonly contain garnet and lesser beryl.

The batholith has been dated by Garnett (1978), using potassium-argon method, at 106 Ma and 86 Ma for hornblende and biotite respectively. These dates come from a sample collected just south of Germansen Lake, which is west of the project area.

Intermediate Volcanics

Small bodies (<1 square kilometre) of andesitic flows and dykes are found in several localities. They are beige to pinkish in colour, locally vesicular and typically contain phenocrysts of plagioclase, biotite and minor hornblende and quartz. The dykes are predominantly north-northwest trending and commonly recessive producing gullys. These rocks appear to be restricted to the Slide Mountain Group but rubble of this material is found within the Wolverine Range. The age of these rocks is not known but they are probably Tertiary (Armstrong, 1949).

OMINECA CRYSTALLINE BELT LITHOLOGIES

INGENIKA GROUP

Within the project area, Armstrong (1949) grouped the sequence of phyllites, siltstones, argillaceous sandstones, sandstones, quartzites, carbonates and their higher grade metamorphic equivalents (with associated granodiorite) into the Wolverine complex. To the north, Roots (1954), having better exposures of the lower grade equivalents of these rocks, was able to subdivide them into two broad groups. the upper Ingenika Group and the lower Tenakihi Group. He confined the Wolverine complex to areas where these rocks are so metamorphically and structurally altered that correlation with surrounding rocks is impossible.

Gabrielse (1975) and Mansy and Gabrielse (1978) found that Roots' divisions were not separately mappable units due to the similarity between the rock types. Mansy and Gabrielse (1978) suggested that the upper part of the Ingenika Group, which is of Early Cambrian age, be reassigned to the Atan Group (correlative of the Gog Group), the Tenakihi Group dropped, and the name Ingenika Group placed on all Proterozoic strata within the Omineca Mountains.

Mansy and Gabrielse (1978) divided the Ingenika Group into four formations, from base to top: the Swannell, Tsaydiz, Espee and Stelkuz formations. Where metamorphism and deformation have been too intense to allow positive lithological determination and stratigraphic positioning, the rocks have been assigned to the Wolverine complex.

Within the project area the relatively unmetamorphosed sediments within the Omineca Belt can be subdivided into three broad sequences: a lower section of feldspar-quartz schist, micaceous quartzite, meta-arkose and wacke; a middle sequence of interlayered micaceous quartzite, quartzite and quartz schist; and an upper sequence which is made up of phyllite, higher grade schist, metasiltstone, impure quartzite, metasandstone and carbonate. The units seen in the Omineca Belt conform to the subdivisions proposed by Mansy and Gabrielse. The lower division corresponds to the lower and middle parts of the Swannell Formation; the middle division to the upper member of the Swannell; and the upper division includes the Tsaydiz, Espee and Stelkuz formations. These rocks appear to be approximately 4 kilometres thick, but undoubtedly this has been significantly increased by faulting and folding.

Toward the centre of the Wolverine Range these rocks are intensely metamorphosed and deformed, and are intruded by granodiorite and related pegmatite. This area has been mapped as Wolverine complex.

To the southwest the sediments and metasediments can be traced into high-grade calc-silicate gneiss, amphibolite gneiss and granitic gneiss, also assigned to the Wolverine complex.

Lower Division

The lower division is composed predominantly of quartz-feldspar-mica schist or gneiss, micaceous quartzite and metamorphosed feldspathic wacke or feldspathic quartzite. Minor constituents are calc-silicate gneiss and amphibolite.

Volumetrically the quartz-feldspar-mica schists and gneisses are the most important, probably making up to 60 per cent or more of this unit. They are composed primarily of medium to coarse-grained muscovite and biotite with lesser amounts of chlorite, a product of retrograde metamorphism. Accessory minerals are commonly garnet and less frequently kyanite.

The metamorphosed feldspathic wackes and feldspathic quartzites are typically grey to grey-brown, medium to very coarsely crystalline and form beds 10 centimetres to 1 metre thick. They occur in intervals up to 10 metres thick and are typically interlayered with the quartz-feldspar-mica schists. They may contain up to 25 per cent potassic and calcic feldspar. The quartzites are similar but typically contain less than 5 per cent feldspar and mica.

Grey-green diopside-bearing calc-silicate gneisses are observed within this unit. These gneisses are massively layered, coarsely crystalline and may contain up to 50 per cent diopside.

Middle Division

The middle division comprises micaceous quartzite, quartzite, quartz-mica schist and minor amphibolite. This unit is not well exposed but is predominantly quartzose.

The quartzite is typically impure, grey-brown in colour and contains 5 to 10 per cent micaceous material (biotite and/or muscovite with chlorite in the lower grade areas or as a product of retrogression) and less than 5 per cent feldspar. It is fine to medium grained and is found in beds 10 to 50 centimetres thick in sequences up to 5 metres thick. These quartzites are typically interlayered with quartz-muscovite-biotite ± chlorite schists which are 10 centimetres to 1 metre thick and may form continuous intervals 2 to 5 metres thick. The schists are silver to greyish silver-brown and may contain considerable quartz. In general the upper part of this unit has thicker sequences of quartzites. These are particularly well exposed in the northern half of the Wolverine Range.

Upper Division

The upper division, characterized by grey-green slate, phyllite, schist, siltstone, impure quartzites and sandstones, has an estimated thickness of approximately 1000 metres. It contains a 200 to 300-metre-thick limestone unit, which serves as an excellent marker along the western flank of the Ingenika package. Thinner carbonate sequences are found in the rocks above and below the thick carbonate. The upper division is best exposed along Granite Creek.

The slates and phyllites of this unit are grey-green to green. They commonly contain abundant very fine-grained quartz. They occur over intervals of greater than 50 metres and are intercalated with minor thin-bedded siltstone layers. Toward the eastern contact, the phyllites begin to exhibit porphyroblasts of chlorite and biotite.

The quartzites and sandstones are grey to grey-brown and very fine grained. They are thin to massively bedded and are commonly interlayered with thin phyllite or slate beds. Intervals of up to 10 metres are exposed in creek beds. These quartzites and sandstones are more common within the upper part of this division.

The thick carbonate marker unit is white, cream or grey to blue-grey and is typically massive though occasionally wispy bedding is evident. It is commonly recrystallized, at times to a coarse-grained marble, and has a strong planar or linear fabric produced by the preferential alignment of calcite crystals. These planes are parallel to the cleavage in the surrounding phyllites. Most often it is these "cleavage" planes that are evident, and bedding is obscure. Where seen in less recrystallized sections, bedding is characterized by thin (1 to 5-centimetre) wavy beds of alternating light and dark grey limestone with the darker beds being somewhat coarser grained or recrystallized. The darker layers are at times stretched out into boudins parallel to bedding.

Pegmatite sills, dykes and minor related granodiorite intrude the Ingenika suite up to 4 kilometres from the contact of the Wolverine complex.

WOLVERINE COMPLEX

The name Wolverine complex is used here to describe a series of high-grade schists and gneisses which have been extensively intruded by pegmatites and large bodies of granodiorite. The grade of metamorphism is so high that accurate correlation of these units or determination of original protolith is impossible. Within the complex, the dominant exposed rock types are pegmatite and granodiorite, typically 70 per cent or more of total outcrop, but recessive metasediments may be under represented.

The margin of the Wolverine complex is marked by a series of steep northeast-facing slopes. Within the complex, the ridges are fairly straight and consistently trend northeasterly, parallel to the dominant foliation in the granodiorites and pegmatites. This supports the inference that much of the complex is underlain by these rock types. These relationships are most evident in the northern part of the complex.

Metasediments in the northern two-thirds of the complex are schists and quartz-feldspar gneisses with minor amphibolite and calc-silicate gneiss. The southern third (beginning at approximately the Manson River) of the complex is characterized by amphibolite gneiss, marble and calc-silicate gneiss in addition to the rocks above.

The schists and gneisses are very similar to those seen in the higher grade areas of the Ingenika Group. Dark brown, rusty weathering sillimanite-garnet-quartz-feldspar-muscovite-biotite schists are found in layers 1 to 100 centimetres thick. They are coarsely crystalline and may be slightly chloritized.

Dark grey to dark grey-brown garnet-muscovite-biotite-feldspar gneisses are interlayered with the schists in bands 1 to 200 centimetres thick. They tend to be quartz and feldspar rich (up to 80 per cent combined) and most likely derived from grits of the lowermost Ingenika Group.

Amphibolite gneiss is composed of garnet, quartz, biotite, amphibole and plagioclase. The amphibole content varies from 20 to almost 100 per cent. These gneisses are often thickly layered and coarsely to very coarsely crystalline. The hornblende shows low-grade retrogression to actinolite.

Marbles and calc-silicate gneisses are associated with the amphibolite gneisses in the southern third of the complex, generally at a higher structural level, as seen in outcrop immediately west of the Manson River. The marbles are grey to cream in colour, coarsely crystalline and contain phlogopite, garnet, diopside and calcite. They are found in bands 0.1 to 2 metres thick interlayered with calc-silicate rocks. The calc-silicate gneisses are predominantly diopside and plagioclase with lesser garnet and calcite. They are dark green to green and coarsely crystalline.

Pegmatite and granodiorite are the most extensive rock types within the complex. Contacts between them are generally gradational and crosscutting relationships, with pegmatite cutting granodiorite, are observed in only a few localities.

The pegmatite typically occurs as dykes and sills up to 5 metres thick and it is common to find large irregular outcrops of pegmatite up to 250 metres in diameter. These bodies are grey to white in colour and are made up of garnet, muscovite, biotite, quartz, potassium feldspar and plagioclase. The quartz is dark and smoky at times. Garnet may be an important accessory and comprises up to 10 per cent of the rock; it is often concentrated toward the contacts of the sill or dyke. Beryl is a rare accessory. Micas may make up to 20 per cent of the rocks with large books of mica, up to 10 centimetres across, present within some of the larger pegmatite bodies. The larger dykes or sills usually do not display any internal fabric except for a discontinuous fracture cleavage or closely spaced jointing. A weak foliation is present within the thinner sills and dykes and they are sometimes boudinaged; some of the thinner dykes and sills show complete dislocation.

The granodiorite is grey to beige in colour, medium to very coarsely crystalline and occurs as small stocks up to 50 square kilometres in area. Their composition is the same as that of the pegmatites and garnet is a very important accessory. The potassic feldspar is oligoclase and it is commonly perthitic. These rocks are very uniform in composition throughout the complex. North and west of Carmella Creek, granodiorite and pegmatite underlie an area of some 60 square kilometres. Bodies of similar size outcrop in the northern part of complex. These rocks display a weak to moderate foliation which is steeply dipping and trends northeasterly.

Parrish (1976) mapped pegmatite and related granodiorite within the Wolverine complex in the Aiken Lake map area and obtained an age of 79 Ma from rubidium-strontium analysis. These rocks are probably related to the same intrusive event, most likely anatexis of the continental crust. Parrish (1976) believes this age has been slightly reset indicating that these rocks are older, probably close to the age of metamorphism.

CARBONATITES

Several bodies of carbonatite and syenite outcrop at Granite Creek and immediately southeast of Treb Creek (Figures 1-15-1, 1-15-3; Table 1-15-1). These bodies are small, with the Granite Creek exposure being 50 metres wide and 500 metres long. They contain significant concentrations of rare earths, particularly niobium. They have been dated by Pell (1987), using uranium/lead ratios, as being Late Devonian to Early Mississippian. For a more detailed account of these bodies *see* Pell (1987).

STRUCTURE

The rocks of the Omineca and the Intermontane belts contain structural and metamorphic elements quite distinct from each other. In the project area the Slide Mountain Group rocks generally contain one phase of deformation (locally two) and metamorphism. The Ingenika Group has undergone polyphase deformation and metamorphism. The structural fabric present within these rocks was developed during the emplacement of oceanic Slide Mountain Group rocks over Ingenika Group rocks of the North American craton. This is thought to have occurred during the middle to late Jurassic, with the main period of metamorphism occurring shortly afterward (Monger and Price, 1979; Parrish, 1979). These rocks were subsequently affected by a lower grade metamorphic event sometime in the early Tertiary.

Within the map area structures trend northwest and, for the most part, are inclined to the northeast. The two belts are separated by a west-side-down normal fault along which displacement increases to the southeast. This is demonstrated by the change in metamorphic grade across the fault as it is traced southward. The change in grade across the upper Manson Lake is negligible, whereas in the southern part of the map area greenschist facies in the Slide Mountain Group are placed against middle amphibolite facies of the Ingenika Group.

INTERMONTANE BELT

Within the Slide Mountain Group, lack of a reliable marker horizon inhibits delineation of large-scale structures, and thrust fault repetition is difficult to document as the internal stratigraphy is poorly defined. However, the rocks are intensely folded and thrust repetitions are probably present, as elsewhere in this belt. On a smaller scale, folds seen within the phyllites, argillites and carbonate units are usually tight to isoclinal and sometimes limbless. A subvertical cleavage is the most dominant planar fabric. A weak to moderate crenulation (and rarely a weak crenulation cleavage) is developed locally in the sandstones, greywackes and gritty phyllites of Unit SM5.

The large bodies of gabbro commonly exhibit a strong south-plunging mineral lineation associated with a weaker planar fabric. This planar fabric may become quite strong and grade into northwest-trending mylonitic zones up to a few metres thick. These zones cannot be traced over any significant distance due to the lack of outcrop, but they are common within the two northern bodies of gabbro.

The Manson fault zone mapped by Armstrong (1949) extends from Gaffney Creek, through Boulder Lake, to the town of Manson Creek. Brecciated and silicified rocks of the Slide Mountain Group occur along it. Kinematic indicators, including subhorizontally stretched fault breccia clasts (Plate 1-15-1) and subhorizontal slickensides, indicate strike-slip motion. This fault zone is made up of a series of parallel faults.

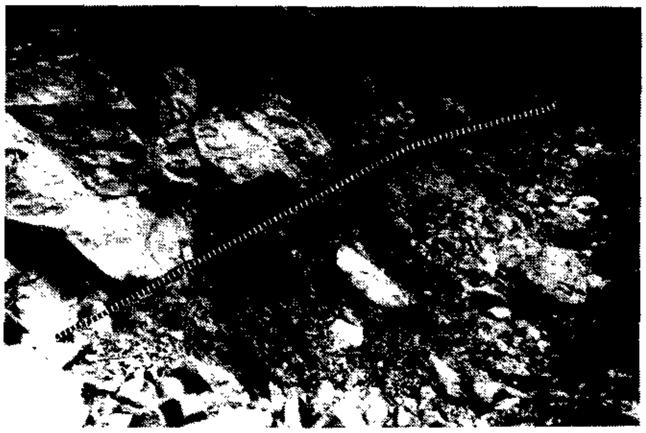

Plate 1-15-1. Talc-ankerite schist of Unit SM1 resting on sandstones and quartzites of unit SM5. Both units have a strong planar fabric which increases in intensity toward the contact (dashed line). Boulder Creek showing, the Bold Claims, near Boulder Lake.

Plate 1-15-2. Fault breccia found on an island in the central part of Boulder Lake. Matrix-supported quartzitic clasts up to 10 centimetres in length are contained within a sericite-quartz-carbonate matrix. Disseminated pyrite is also present. These clasts are stretched out into the viewing direction and produce a prominent lineation which trends 320°/17°. The internal fabric of the clasts indicates that the protolith to the clasts was highly strained prior to brecciation.

A number of small ultramafic bodies outcrop along the Manson fault zone. Typically they have steep contacts with their surrounding rocks and where seen, the contacts are tectonic with subhorizontal slickensides. In one locality, close to the mouth of Boulder Creek, an ultramafic body is found overlying sheared sandstones and quartzites of Unit SM5 (Plate 1-15-2).

OMINECA BELT

The rocks of the Omineca Belt have recorded quite a different structural history than those of the Slide Mountain Group, with at least four periods of deformation recorded within the Ingenika Group rocks.

The first period produced the strong, layer-parallel fabric present in these rocks and the south to southwest-trending limbless isoclinal folds associated with it. A weak to moderate mineral lineation, produced by synkinematic growth of metamorphic minerals, parallels the axes of these folds.

The second period of deformation is represented by south to southeast-trending, tight, parallel folds (within the more competent units) which fold and/or crenulate the layer-parallel schistosity in their cores. The axial planes of these folds are also parallel to layering.

The third phase is represented by a series of poorly developed subvertical northeasterly trending crenulations with a wavelength of 1 to 2 centimetres. These crenulations are roughly parallel to a foliation or strong parting found within the granodiorite and pegmatite, indicating that they may be genetically related.

The fourth phase of deformation warps the larger first phase structures into a broad anticlinorium which plunges gently to the southeast along the core of the Wolverine Range.

On the west flank of the Wolverine Range, the general strike of bedding or compositional layering changes from southerly in the northern part of the range to northwesterly further to the south. Large-scale structures within the lower and middle divisions of the Ingenika Group cannot be delineated due to lack of a suitable marker. Small-scale second phase structures indicate larger folds are present and have most likely thickened the package considerably.

The carbonate marker in the upper division of the Ingenika Group was most helpful in delineating larger structures at this level. Within this package, large-scale folds have a wavelength of approximately 1 kilometre and are upright to slightly west verging. This contrasts with the folds within the lower and middle divisions which are east verging with axial planes dipping moderately to the southwest. This difference most likely reflects the different structural levels at which each package was deformed.

METAMORPHISM

Metamorphism is lower greenschist facies within the Slide Mountain Group, as indicated by the presence of actinolite within some of the gabbro units and the persistent lack of biotite in the slates. Grade increases to lower amphibolite facies around the Germansen batholith where contact metamorphic garnet and staurolite are developed in the slates.

Within the Omineca Belt, metamorphism increases quickly from lower greenschist facies around Upper Manson Lake to middle to upper amphibolite facies within the Wolverine complex. The determination of metamorphic grade is often difficult due to the persistent lack of index minerals except garnet; kyanite or sillimanite are present in only a few localities.

The presence of chlorite around biotite and actinolite around hornblende within amphibolite gneisses, indicates overprinting by a low-grade metamorphic event. This has been observed throughout the southern part of Omineca Belt (Monger and Price, 1979) and is of early Tertiary age.

The recrystallized nature of the micas and other minerals in these rocks indicates that the main period of metamorphism was synkinematic with the first two phases of deformation and outlasted them. The presence of kinked micas in a few areas may reflect the affects of the last two phases of deformation. Microscopic examination of several samples of lower grade metasediments from the west flank of the Wolverine complex indicates the presence of mylonitic texture which is postmetamorphic and parallel to layering. The significance of these rocks is uncertain, but they may be related to the uplift of the complex.

MINERALIZATION

Mineral occurrences within the map area can be categorized as: (1) carbonatite, (2) ultramafic-hosted chromite, (3) sediment-hosted barite, (4) vein-hosted molybdenum and tungsten, (5) sulphide-bearing amphibolite gneisses and (6) vein-hosted precious and base metals. The last type is of widespread occurrence along the Manson fault zone, which appears to have localized mineralization in the area, and is presently of interest. Table 1-15-1 lists and describes the occurrences in the area; locations are shown on Figure 1-15-3.

Gold, in association with sulphide mineralization, is found in significant concentrations along the Manson fault zone which extends northwest of the study area. At present most significant gold showings are found immediately northwest of Manson Creek (for example, Farrell and Flagstaff showings). This mineralization occurs within quartz veins and

TABLE 1-15-1.

TABLE OF MINERAL OCCURRENCES (93N/09)

Map Type No.	MINFILE No.	Name	Economic Minerals	Description
1 Carbonatites (Nb, Ti, Ta, U, Th, V, Zr)	93N-174	Wolverine/Virgil	Columbite, pyrochlore ilmenorutile, zircon	Pure carbonate and syenitic carbonatite rocks containing disseminated columbite, pyrochlore, etc. Intruded within metasedimentary rocks of the Ingenika Group.
2 ,,	93N-190	Granite Creek	,,	,,
3 ,,	93N-012	Lonnie	,,	,,
4 Ultramafic-hosted chromite	93N-135	Manson Creek	Chromite	Mineralization is found disseminated in fault-bounded serpentinized bodies.
5 Sediment-hosted barite	93N-087	Omineca Queen	Barite, sphalerite, galena, tetrahedrite	Mineralization occurs stratabound in an argillaceous unit of the Slide Mountain Group. Minor amounts of galena, sphalerite and tetrahedrite are known to exist.
6 Vein-hosted molybdenum and tungsten	93N-118	Blackjack East	Molybdenite	Molybdenite is developed in small quartz veinlets in a fine-grained granodioritic phase of the Germansen batholith.
7 ,,	New	Jordi	Molybdenite	Molybdenite occurs in feldspar-quartz-muscovite veins near the contact of the Germansen batholith.
8 ,,	93N-119	Blackjack South and Central	Molybdenite ± chalcopyrite	Mineralization is hosted by quartz veins in hornfelsed sedimentary pendants within Germansen batholith.
9 ,,	93N-078	Tait Tungsten (Billy, Glo)	Scheelite	Scheelite is found in quartz stringers parallel to axia plane cleavage of folds within the Manson fault zone.
10 Vein-hosted precious and base metals	93N-030	Kathy (Joy, Troy)	Galena, tetrahedrite, sphalerite ± scheelite, bornite, chalcopyrite, gold, molybdenite	Mineralization occurs in quartz veins, fault breccia zones and hydrothermally altered rocks related to the Manson fault zone. Veins are hosted in limestones, argillites, ultramafics and chlorite schists of the Slide Mountain Group.
11 ,,	93N-027	ASP (Bold)	,,	,,
12 ,,	93N-137	Bold (Stroh)	,,	,,
13 ,,	93N-028	Berthold (Bold)	,,	,,
14 (Pb ± Ag, Au)	93N-117	Lost Creek	Galena ± silver, tetrahedrite, gold	Sulphide-bearing quartz veins in limestones, argillites, greenstones and cherts of the Slide Mountain Group within the Manson fault zone.
15 ,,	93N-136	Not named	,,	,,
16 ,,	93N-148	Blackjack Mountain	,,	,,
17 (Ag, Au)	93N-113	Not named	Silver, gold	Low-grade gold and silver mineralization in quartz veins within Ingenika Group rocks northeast of the Manson fault zone.
18 ,,	93N-134	,,	,,	,,
19 (Au, Ag, Cu, W)	93N-023	Fairview	Tetrahedrite, gold, azurite, malachite, chalcopyrite (?)	A 0.5-metre-wide quartz vein is found in a shear zone bounded by quartz-carbonate-altered ultramafics and gabbros. It is traced for approximately 50 metres.
20 Sulphide-rich mafics	New	Not named	Chalcopyrite	Disseminated pyrite and chalcopyrite of varying concentrations occur within amphibolite gneisses and amphibolites of the Wolverine complex.

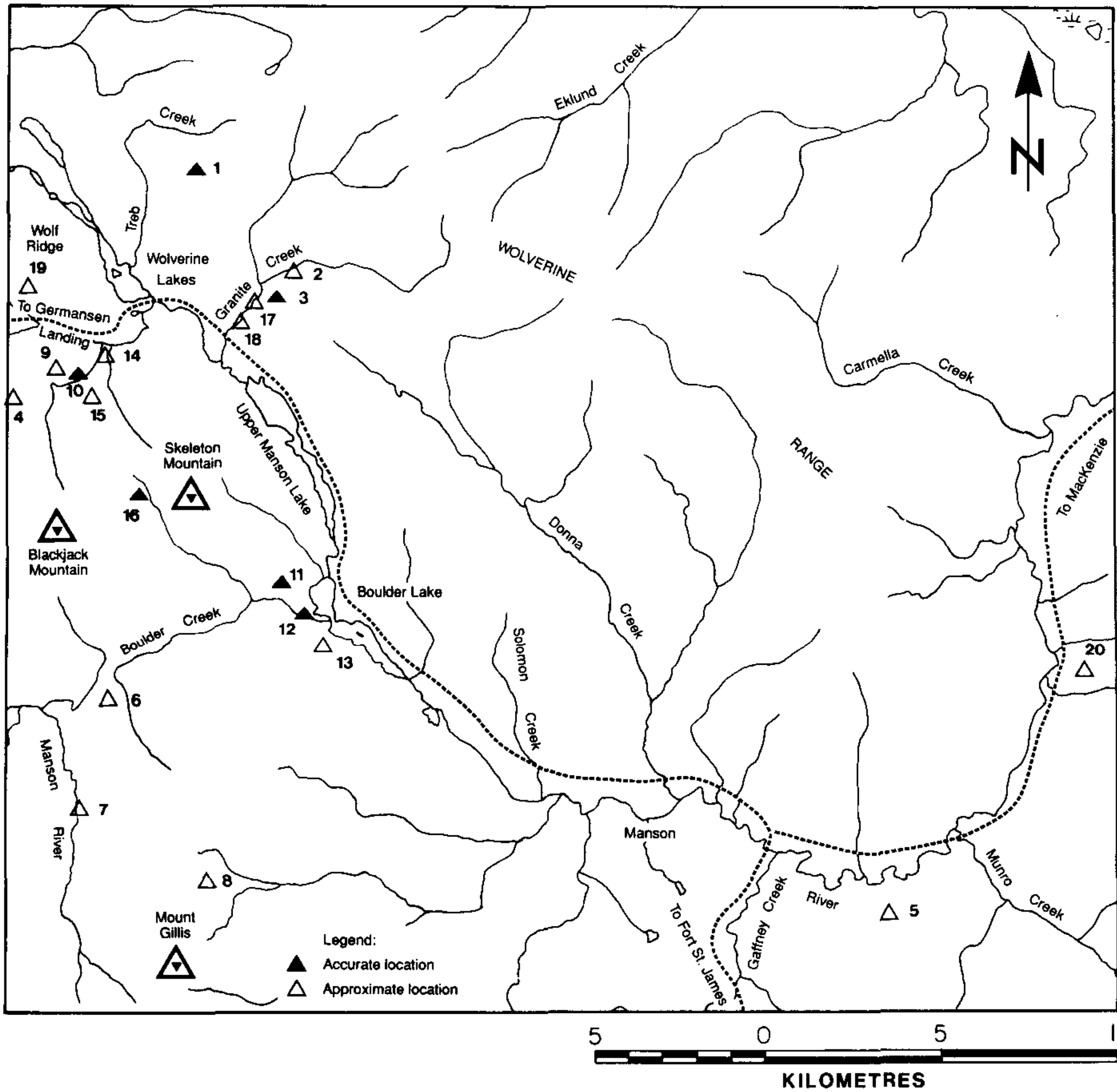

Figure 1-15-3. Location of known mineral occurrences within the project area. Numbers on the map correspond to listed occurrences in Table 1-15-1.

stockworks associated with quartz-ankerite-pyrite ± sericite ± mariposite alteration of the country rocks, and spatially related to silicified and carbonatized ultramafic bodies.

This alteration is characterized by the presence of disseminated and/or porphyroblastic ankerite and pyrite with accompanying sericitization and silicification of the host rocks. The ultramafic rocks exhibit the most intense alteration. These bodies are transformed to talc-ankerite-quartz ± mariposite ± magnetite assemblages that may also contain remnants of the original rock. Altered zones are typically buff weathering, are massive to slightly foliated, and are cream to grey on fresh surfaces.

Within the map sheet, significant gold concentrations are found at the Fairview showing (Figure 1-15-4). Pyrite and tetrahedrite mineralization is hosted by a quartz vein 1 metre wide and traceable for a strike length of approximately 50 metres. The vein occupies a silicified and slightly carbonatized fault zone between gabbro to the northeast and ultramafic rock to the southwest. Armstrong (1949) reported assays of 0.28 ounce per ton gold and 22.3 ounces per ton silver on a sample from the most strongly mineralized zone and 0.02 ounce per ton gold and 0.96 ounce per ton silver from a grab sample.

Sulphide-bearing quartz-carbonate veins (for example, Bold and Kathy showings) are found southeast of Manson

Creek, along the Manson fault zone. Some of these veins contain slightly anomalous gold values (Oddy, 1978; Melnyk, 1982). This mineralization is associated with carbonatized ultramafic rocks and to a lesser extent, sediments.

Two localities with pyritiferous quartz veins with reported anomalous gold values (*see* Table 1-15-1) are found on Granite Creek. These veins are hosted by phyllites and sandstones of the Ingenika Group, are less than 1 metre wide and are not extensive.

Several other zones of altered Slide Mountain Group rocks crop out along the Manson fault zone. Altered ultramafic rocks are exposed along the main road near Boulder Lake. They are cut by numerous quartz-calcite veins with mariposite developed within the ultramafic body. No alteration of the surrounding phyllites was seen.

Highly fractured, silicified and mariposite-bearing serpentinite crops out along the first major creek west of Gaffney Creek and running parallel to it. These exposures are on strike with the southern extension of the Manson fault zone. A large body of talc-ankerite-serpentine schist crops out upstream from this occurrence. Exposure is restricted to the creek valley and no other rock types are exposed. The outcrop exhibits the typical alteration present within ultramafics associated with gold occurrences.

CONCLUSIONS

(1) The Intermontane Belt in the project area is represented by the Slide Mountain Group which has been subdivided into five mappable units.

(2) Within the Omineca Belt, a threefold subdivision has been proposed for rocks outside the Wolverine complex which is correlative with the Ingenika Group to the north.

(3) The Ingenika Group has recorded at least three or possibly four periods of deformation.

(4) The Wolverine complex is composed predominantly of granodiorite and related pegmatite which have extensively intruded high-grade schists and gneisses of the Ingenika Group.

(5) The two tectonostratigraphic provinces are separated by a west-side-down normal fault.

(6) The Manson fault zone may have a strike-slip component of motion along it.

(7) Precious metal and sulphide mineralization is spatially related to the Manson fault zone and is associated with carbonate alteration and ultramafic bodies.

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