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THE RELIANCE GOLD PROSPECT, BRIDGE RIVER MINING CAMP (92J/15)

By M. J. Hanna, D. A. R. James and B. N. Church

KEYWORDS: Economic geology, Bridge River, Reliance, stibnite, gold, quartz veins.

INTRODUCTION

The Reliance property (092J/NE-033, 136) is located at latitude 50°52′ north, longitude 122°47′ west, on the south side of Carpenter Lake, roughly opposite the mouth of Gun Creek. Access is by all-weather gravel road 5 kilometres northeast of the town of Gold Bridge (Figure 2-5-1).

The property consists of 17 Crown-granted mineral claims and fractions including the Nemo, Omen and Eros claim groups. Current exploration is focused on the western part of the property.

The writers visited the property on several occasions in July and August 1987, for survey and sampling and to check on the progress of exploration. In this regard, many thanks are owing officers of Menika Mining Co. Ltd., especially Messrs. Charles Boitard and Lawrence Sookochoff, for their courtesy and cooperation.

HISTORY

The early history of this property was noted by Cairnes (1943): "The Reliance is one of the older properties and has been known from the beginning as an antimony prospect. The original group of four claims was staked in 1910 by Mr. F.A. Brewer, who relocated the property in 1915. By September 1915, it is reported, 4 tons of ore had been bagged for shipment, and the richest carried up to ½ ounce in gold a ton."

In 1917 there was a shipment of hand-cobbed gold-bearing stibnite; no further records are available for this period.

The property was re-organized by Reliance Gold Mines Ltd. in 1933 and development work continued until 1937. This included underground work on several adits and installation of a compressor plant. The mine workings comprised the Old Reliance adit at an elevation of 1100 metres on the Nemo 7 Crown-granted claim, the Fergusson adit (elevation 1023 metres) also on Nemo 7, the Turner adit (elevation 830 metres) on Omen 1 Crown grant, the River adit (elevation 663 metres) on Omen 2 Crown grant, and the Senator adit (elevation approximately 790 metres) on Nemo 1 Crown grant. Short intervals of heavy stibnite mineralization in narrow quartz veins were encountered in the adits.

In 1971, Tri Con Exploration Surveys Ltd. carried out several geotechnical surveys and outlined electromagnetic conductors coincident with a prominent southeast-trending arsenic-antimony geochemical anomaly traversing the western part of the property, including the Senator workings. There appears to have been no immediate follow-up investigation.

In 1984 the property was acquired by Charles Boitard of Menika Mining Co. Ltd., by option agreement from Karl Otting of Lillooet. Subsequent work has been directed toward confirmation of the Tri Con discoveries and further testing for gold. By November 1987, a total of 38 diamond-drill holes had been completed by Menika Mining Co. Ltd.

GEOLOGY AND MINERALIZATION

The geology of the Reliance claims is relatively simple, consisting mostly of greenstones and small infaulted blocks of chert. The greenstones comprise thick and massive pillow lavas and breccias, feeder dykes and sills. The rocks are similar to the Pioneer Formation exposed on the Congress property on the north side of Carpenter Lake. The chert beds are intercalated with phyllite locally and are deformed, as is typical of the Fergusson Group. Generally, bedding laminations dip steeply to the southwest.

On the east side of the property, a northerly striking belt of ribbon chert, about 100 metres wide, traverses the area of the mine workings. The various tunnels follow well-defined shear zones in the intervening greenstones. According to Cairnes (1943): "These zones each carry one or more veins of nearly solid, fine to coarsely crystalline stibnite associated with more or less quartz and calcite gangues."

The Old Reliance adit, the uppermost working, follows a southeasterly striking shear in purplish volcanic rocks, the apparent target being several stringers of stibnite, 2 to 5 centimetres wide, which are exposed in a trench above the tunnel.

Cairnes (1943) also reports on the Fergusson adit which is located below and about 200 metres northwest of the Old Reliance adit: "It runs east-northeast for 80 feet (24 metres) in greenstone along a mineralized shear zone 4 feet (1.2 metres) wide to a mineralized fault fissure which offsets the first shear 13 feet (4 metres) to the southeast. Beyond this offset the drift follows the main shear about 25 feet (7.6 metres) to the face. Between the portal and the fault the shear carries a vein of stibnite up to 6 inches (15 centimetres) wide with some quartz. Beyond the fault the stibnite vein is 3 to 4 inches (7 to 10 centimetres) wide and runs off into the footwall a few feet from the face of the adit, where, however, other small stringers of stibnite were seen. Above the adit the shear zone has been investigated by a long trench from which a shipment of hand-sorted stibnite is reported to have been extracted in 1917."

The Turner adit is about 375 metres northwest of the Fergusson adit. Cairnes elaborates: "This runs southeast in green and purple volcanic rocks for 85 feet [26 metres] to a mineralized shear zone several feet wide striking east-northeast and dipping steeply northwest. This was driven on northeasterly for 55 feet [17 metres] and contains veinlets of stibnite in altered and pyritized greenstone. In the opposite direction the shear was followed for only a few feet to a fault striking southeasterly and dipping 50 degrees northeast. Where cut off, the shear zone contained a vein of stibnite several inches wide. Its probable continuation across the fault appears 6 feet [1.8 metres] to the northwest. Such a displacement is similar to that of the fault in the Fergusson adit."

The River adit is a crosscut to explore the downward projection of the mineralized zones described above.

On the western part of the Reliance property the Senator workings, located about 1100 metres west of the Fergusson adit, are the only remains of the former development. This is the general area of current exploration.

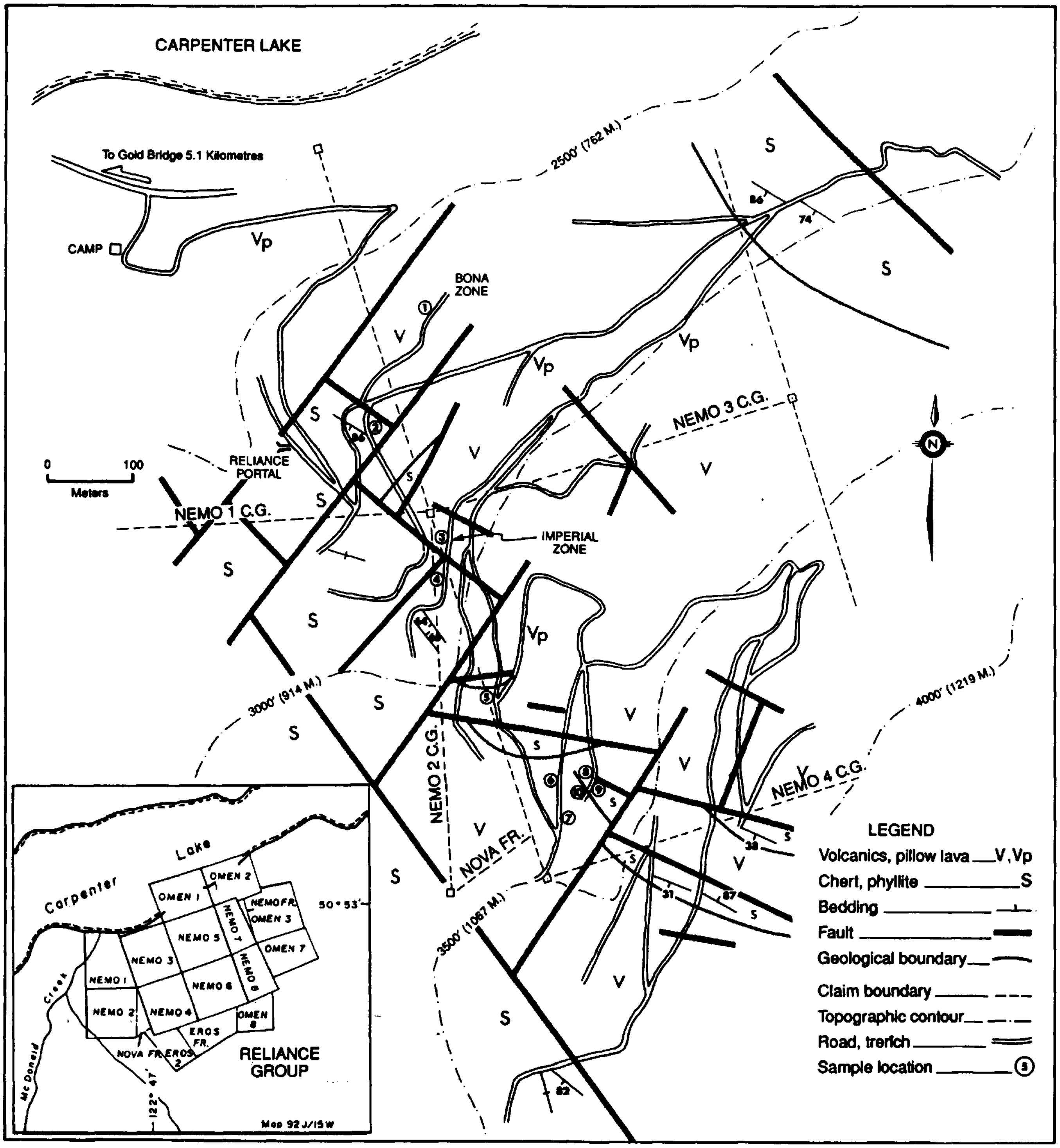

Figure 2-5-1. Geology of the Reliance property, Menika Mining Co. Ltd. (by M.J. Hanna, D.A.R. James and B.N. Church).

The Senator vein is in a northeast-trending shear zone in pyritized and silicified volcanics and ribbon cherts of the Fergusson Group. It contains stibnite in quartz-carbonate yielding assay results in gold to 5.48 grams per tonne and silver to 8.57 grams per tonne.

The Imperial zone, located 200 metres southeast of the Senator portal, is a new discovery. This is an area of northeast-trending stibnite-bearing quartz veins cutting carbonated greenstones and limonitic silicified metasediments. Company assays report 6.34 grams of gold per tonne over 0.3 metre on individual veins and 2.74 grams of gold per tonne across the whole 12 metres of alteration. An east-west fence of recent diamond-drill holes proves similar mineralization to a depth of more than 100 metres. A single grab sample collected by the authors from the north part of the zone (Figure 2-5-1, No. 3) yields gold, 13 grams per tonne; silver, 11 grams per tonne; arsenic, 0.95 per cent and antimony 0.80 per cent.

The Bona zone, located 200 metres northwest of the Senator portal, is another area of limonitic alteration. Sampling by the authors along a 3-metre length of roadcut (Table 2-5-1, No. 1) yielded gold, 12.8 grams per tonne and silver, 2 grams per tonne.

Other interesting zones of alteration and mineralization in this vicinity occur sporadically along the course of the steep northwesterly trending draw located southwest of the Imperial zone, over an elevation interval of several hundred metres.

Control of the mineralization on the Reliance property is governed largely by fractures in the country rocks. Near the old workings on the east part of the property, Cairnes (1943) records: "Two sets of shear zones may be recognized, one striking southeast with steep dips to the southeast and the other trending east-northeast, with steep dips to the northwest. Most of the exploratory work has been done on the latter set."

The same pattern appears to exist in the new exploration area on the west side of the property (Figure 2-5-1). The steep draw passing west of the Senator portal and the Imperial zone is evidently a southeasterly trending fault lineament separating mainly ribbon chert to the west and alternating chert and greenstone panels to the east. A series of subparallel tensional feather-fractures, striking northeast off this fault zone, separates the panels and hosts much of the mineralization.

Dykes intruded into the fracture system are mostly premineralization as evidenced by their usual heavily altered condition — no doubt caused by the same migrating hydrothermal solutions which are responsible for the ore.

TABLE 2-5-1
ANALYTICAL RESULTS*

Station No.	Sample Width (m)	Au ppm	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm
1	3	12.8	2.0	85	10	127	424	108
2	3	1.1	1.0	83	8	267	935	73
3	grab	13.0	11.0	123	8	400	9500	8000
4	3	1.2	2.0	119	17	198	1400	3400
5	3	0.06	0.5	84	17	204	40	144
6	4	6.4	2.0	76	3	110	11300	185
7	grab	0.03	<0.5	29	3	67	232	44
8	grab	11.0	1.0	57	7	102	24000	455
9	3	0.04	1.0	85	13	180	80	15
10	3	0.15	1.0	94	18	148	176	68

* Analyses by Analytical Laboratory, Geological Survey Branch, B.C. Ministry of Energy, Mines and Petroleum Resources.

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GEOLOGICAL RECONNAISSANCE IN THE BRIDGE RIVER MINING CAMP (92J/15, 16, 10; 92O/02)

By B.N. Church, R.G. Gaba, M.J. Hanna and D.A.R. James

KEYWORDS: Economic geology, Bridge River camp, stratigraphy, intrusive rocks, hydrothermal systems.

INTRODUCTION

The Bridge River mining camp comprises five former producing mines and numerous currently active mining prospects. The camp may be roughly defined as those properties lying within the Bridge River drainage basin bounded by the Coast plutonic complex on the southwest and the Shulaps ultrabasic complex on the northeast. Reconnaissance work by ministry field parties in 1986 and 1987 covers approximately 1500 square kilometres of mapping. This includes all of the Bralorne map sheet (92J/15) and parts of the Bridge River (92J/16), Birkenhead (92J/10) and Noaxe (92O/02) sheets (Figure 1-7-1).

GEOLOGICAL HISTORY

The geological history of the Bridge River area began in the Paleozoic era with the deposition of a thick succession of mostly cherty oceanic sediments. These rocks are now known as the Fergusson Group and comprise a highly deformed metamorphic basement complex exposed throughout the region (Plate 1-7-1). During Permian time this basement was intruded along major fractures by Bralorne plutonic rocks.

A diverse assemblage of volcanic and sedimentary formations of the Upper Triassic Cadwallader Group was deposited on this relatively simple terrane. These strata, and some younger Jurassic/Cretaceous buchia-bearing beds of the Relay Mountain Group, were preserved as scattered remnants in the downfaulted basement complex.

In the Jurassic period, the emplacement of dyke-like bodies and large masses of ultrabasic rocks such as the Shulaps and President intrusions accompanied major dislocations.

In the Lower Cretaceous, the uplifted Fergusson Group and younger, poorly lithified Mesozoic formations, provided a ready source of coarse clastic sediments that now comprise the Taylor Creek Group.

Toward the end of the Cretaceous period, uplift of the Coast Ranges coincided with the emplacement of major granitic plutons attended by thermal and dynamic metamorphism. This was also a time of much mineralization such as quartz veining, skarn development and the dispersion of pyrite in country rocks adjacent to the igneous intrusions.

The Rex Peak porphyry of early Tertiary age marks the last major intrusive event. Late downfaulting has preserved a few nearby wedges and patches of felsic volcanic rocks which appear to be the effusive equivalent of this intrusive.

GEOLOGICAL UPDATE

Re-evaluation of the geology of the Bridge River mining camp is based on observations from approximately 3000 geological stations established during the 1986 and 1987 field seasons. As a result of this study some additions and changes are made, building on the previous work of McCann (1922), Cairnes (1937, 1943) and the more recent contributions of Potter (1983, 1986) and Rusmore (1985). The new interpretations apply to the stratigraphy, structure and mineralization.

FERGUSSON GROUP

The name Fergusson Group is an adaptation of "Fergusson Series" which was introduced by Cairnes (1937) in reference to the oldest strata in the area. These are mainly recrystallized and silicified ribbon cherts (in part radiolaria bearing) with intercalated phyllites, micaceous schists and thin marble bands (Plate 1-7-1). The antiquity of these rocks is proven by their intense metamorphic state, the crosscutting relationships of igneous intrusions such as the Bralorne gabbro (Permian), and the superposition and infaulted condition of younger beds.

The Bridge River Series, named by Drysdale (1915) and applied to a major map unit by McCann (1922), is mostly equivalent to the Fergusson Group, however, much of the stratigraphic sense of the term was lost by inclusion of younger beds. For example the area along the Truax Valley, shown by McCann (1922) to be entirely underlain by Bridge River Series, contains sedimentary and volcanic units of the Cadwallader Group (Triassic) and buchia-bearing beds correlated with the Relay Mountain Group (Jurassic/Cretaceous). Elsewhere, such as in the Shulaps Range in the northeast part of the map area, Cadwallader-type strata are also included in the Bridge River assemblage (Leech, 1953; Potter, 1986).

"Bridge River terrane" is a relatively new conceptual term of broad time-stratigraphic and regional tectonic significance (Kleinspehn, 1984; Rusmore, 1985). The terrane includes the Fergusson Group and units correlative with the Cadwallader Group throughout the Bridge River mining camp and the area to the southeast.

CADWALLADER GROUP

The name Cadwallader Group used by Roddick and Hutchison (1973) is an adaptation of the Upper Triassic Cadwallader Series of McCann (1922). The group comprises

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

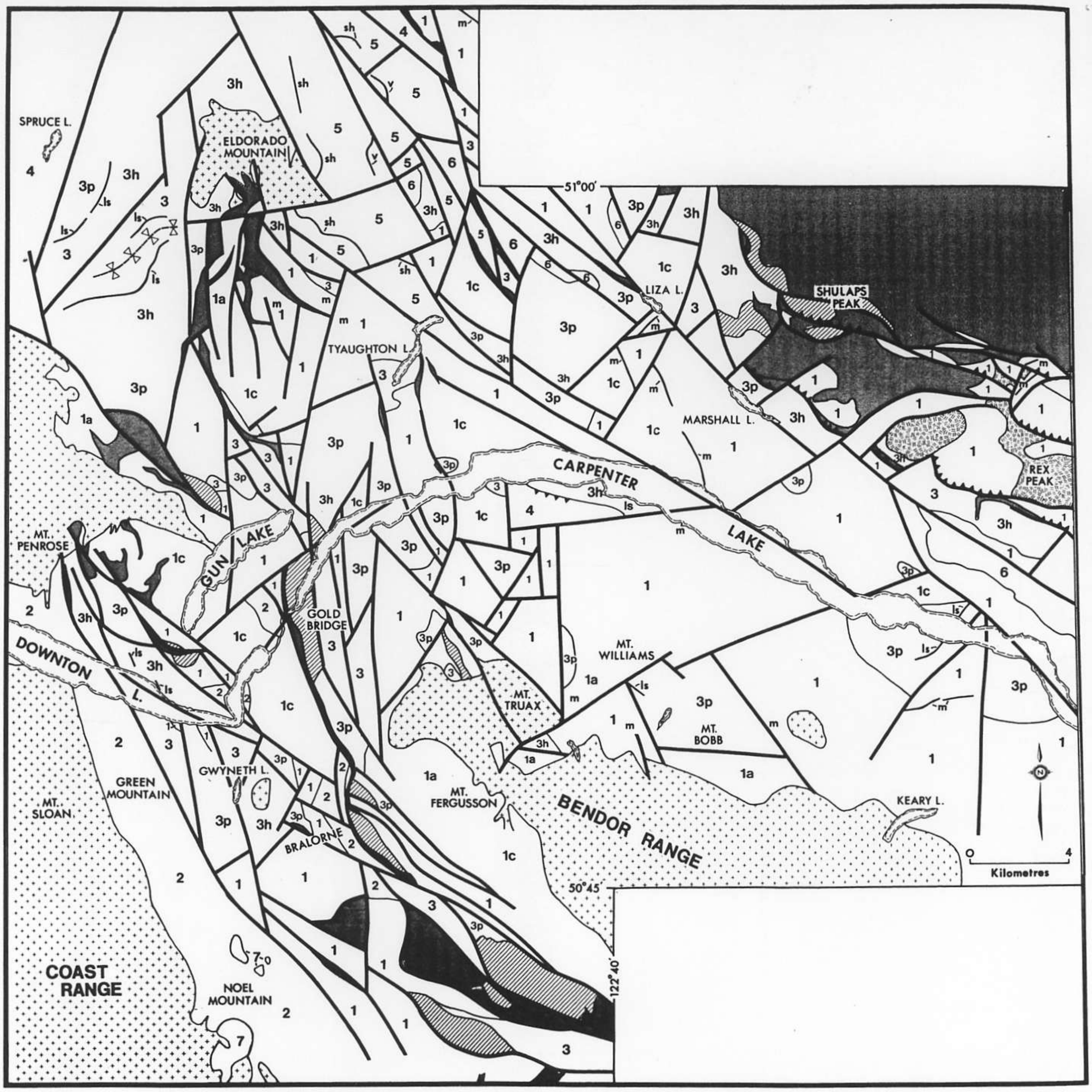

Figure 1-7-1. Geology of the Bridge River mining camp (see page opposite for legend).

the Pioneer, Noel and Hurley formations, and ranges from several hundred metres to a few thousand metres thick. These units are well exposed in cuts on the Slim Creek logging road east of the north end of Gun Lake.

The Pioneer Formation is a widely distributed but somewhat discontinuous basal unit consisting of amygdaloidal basalts, pillow lava and breccia (Table 1-7-1, columns 1 and 2), small limestone lenses, and a few chert bands resting on Fergusson basement rocks.

The Noel Formation consists mostly of thinly bedded black argillites and siltstones which are best developed in the southwest part of the map area where the beds have been locally sheared and grouped with the laminar-bedded cherts and dark phyllites of the Fergusson assemblage.

The Hurley Formation is best developed in the northwest part of the map area where the rocks are folded into a large northeasterly trending syncline. The unit consists of a diversity of volcanic breccias, polymictic conglomerates, sandstones, argillites and limestone beds. The clastic components are mostly a variety of chert, schist and diorite fragments derived from the nearby Fergusson Group and Bralorne intrusions. The age of the Hurley Formation, as

LEGEND
BEDDED ROCKS

TERTIARY

7 — *(Miocene?) "Plateau Volcanics", basaltic lavas and breccias*

6 — *(Eocene?) Lavas, pyroclastics and minor sedimentary rocks*

LOWER CRETACEOUS

5 — TAYLOR CREEK GROUP: *mostly boulder and pebble conglomerate and sandstone with some intercalated shale marker beds (sh) and volcanics (v)*

UPPER JURASSIC

4 — RELAY MOUNTAIN GROUP: *buchia-bearing grey shales, siltstones, tuffaceous and polymictic conglomerate*

UPPER TRIASSIC

3 — CADWALLADER GROUP: *comprising the Pioneer Formation (3p) consisting of basaltic pillow lava,aquagene breccia, tuffs and amygdaloidal lava, and the Hurley Formation (3h) consisting of brown, black and green argillites (siliceous and calcareous) with sandstones, polymictic conglomerates and limestone marker beds (ls); inclusive of all or part of Noel argillites*

PALEOZOIC

2 — *(Permian?) dark argillites, turbidites previously assigned to the Noel Formation*

1 — FERGUSSON GROUP: *mostly ribbon chert (lc), phyllite ranging to biotite quartz gneiss, some marble (m) marker bands, chloritic schist, and fine grained amphibolite (la)*

INTRUSIVE IGNEOUS ROCKS

TERTIARY

REX PEAK PORPHYRY: *a felsic phase of the (Eocene) Mission Ridge pluton*

UPPER CRETACEOUS

COAST PLUTONIC COMPLEX: *biotite and hornblende-bearing diorite, granodiorite and granite stocks and plutons; including the outlying Bendor and Eldorado stocks*

LOWER JURASSIC

Ultrabasic Rocks: comprising the Shulaps and President hartzburgite, peridotite, dunite, serpentine and listwanite bodies

PALEOZOIC

BRALORNE INTRUSIONS: *heterogeneous fine and medium-grained diorite and gabbro stocks characterized by a reticulation of felsic veinlets*

determined by M. Orchard of the Geological Survey of Canada, is Norian (Upper Triassic) based on conodont fossils collected by the writers from limestone pebbles in a conglomerate bed 0.2 kilometre east of the north end of Gwenyth Lake. These fossils, *Epigondolella abneptis* and *Neogondolella* sp., also occur in the collections of Rusmore (1985) from the Eldorado basin.

RELAY MOUNTAIN GROUP

The Relay Mountain Group, originally described by Jeletzky and Tipper (1968), is mostly a monotonous sequence of buchia-bearing shales, siltstones and greywackes of Middle Jurassic to Early Cretaceous age. These rocks are up to 650 metres thick and occur along the southeasterly trending axis of the Tyaughton trough (Jeletzky and Tipper, 1968). In the Spruce Lake area, south of the type section, steeply dipping buchia and ammonite-bearing beds are overlain by massive sandstones. Elsewhere in the map area, an unusual occurrence of buchias in conglomerate is exposed on the Grey Rock road west of Truax Creek (Church and MacLean, 1987a). Here the Relay Mountain Group consists of several hundreds of metres of polymictic conglomerate overlain to the east by a few hundred metres of grey siltstone and argillite. The exact origin of chert and graphite clasts in the conglomerate is unknown, however, a westerly source would appear to fit the paleogeographic setting of the deposit, marking the early uplift of the Coast Mountains. This gives a much earlier age for the development of the southwest margin of the Tyaughton basin than the mid-Cretaceous time proposed by Kleinspehn (1984).

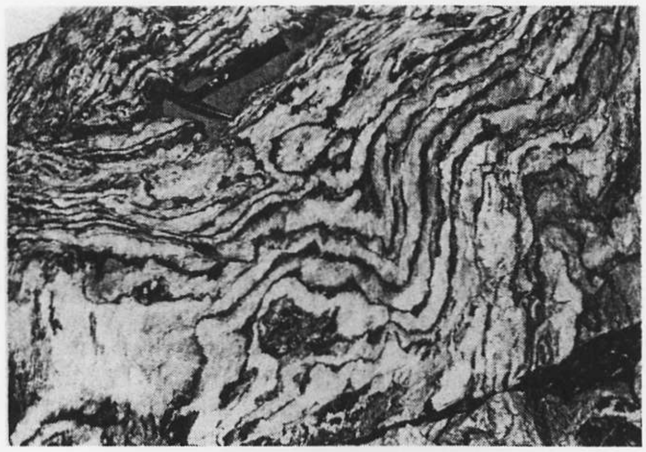

Figure 1-7-1. Biotite quartz gneiss phase of Fergusson Group, on southeast spur of Mount Fergusson, 4 kilometres east of Bralorne.

TAYLOR CREEK GROUP

The name Taylor Group of Cairnes (1943) was expanded to Taylor Creek Group by Jeletzky and Tipper (1968) in reference to what is believed to be the marine equivalent of the Lower Cretaceous (Albian) Jackass Mountain Group located further east. In the Bridge River mining camp these rocks extend easterly and northeasterly from Eldorado Mountain to Tyaughton Creek. The beds are mainly steep westerly dipping pebble and boulder conglomerates with thin intercalations of siltstone and shale and a few volcanic rocks. A dark grey silty argillite, about 50 metres thick, occurring in the upper part of the section on the ridges north and south of Taylor Creek, is one of the few marker horizons in the succession (Plate 1-7-2).

A narrow zone of interbedded basaltic tephra exposed on the east and northeast midslopes at Eldorado Mountain is a local stratigraphic marker horizon.

The clasts in the conglomerate facies are mostly well-rounded chert pebbles and boulders which are accompanied by accessory sandstone and shale clasts and a few igneous rocks reworked from nearby weakly consolidated members of the Cadwallader Group and older metamorphic basement

TABLE 1-7-1
ANALYSES OF EFFUSIVE IGNEOUS ROCKS

	1	2	3	4	5	6	7
Oxides recalculated to 100:							
SiO_2	49.19	49.96	72.43	51.39	59.48	64.68	70.29
TiO_2	2.05	2.99	0.25	1.49	0.88	0.63	0.56
Al_2O_3	15.47	16.13	14.03	19.08	17.31	17.69	15.04
Fe_2O_3	2.70	2.82	1.43	6.93	2.36	2.73	0.84
FeO	6.98	9.57	0.60	2.89	3.73	1.82	4.63
MnO	0.15	0.18	0.02	0.28	0.12	0.07	0.13
MgO	7.87	6.46	1.88	3.56	4.24	1.85	1.30
CaO	11.74	7.72	2.84	9.23	6.18	4.94	0.72
Na_2O	3.35	2.43	4.01	3.96	4.03	4.26	5.96
K_2O	0.50	1.74	2.51	1.19	1.67	1.33	0.53
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Oxides as determined:							
H_2O+	2.94	2.37	2.34	1.09	0.49	1.99	1.02
H_2O-	0.17	0.14	0.60	0.25	0.32	0.20	0.12
CO_2	1.04	0.14	1.40	0.63	0.14	2.57	0.69
P_2O_5	0.23	0.39	0.05	0.41	0.19	0.13	0.08
S	0.04	0.01	0.01	0.01	0.01	0.02	0.14
Molecular norms:							
Qz	—	0.6	28.7	1.9	9.2	20.0	25.1
Or	2.9	10.5	14.9	7.1	9.9	7.9	3.1
Ab	30.0	22.1	36.1	35.9	35.9	38.2	53.4
Ne	—	—	—	—	—	—	—
An	25.6	28.5	12.9	31.1	24.1	24.6	3.6
Wo	13.0	4.2	0.5	6.0	2.6	—	—
En	6.5	18.1	5.2	9.9	11.7	5.1	3.6
Fs	1.8	8.8	—	—	2.9	0.1	5.8
Fo	11.4	—	—	—	—	—	—
Fa	3.2	—	—	—	—	—	—
Il	2.8	4.2	0.4	2.1	1.2	0.9	0.8
Mt	2.8	3.0	0.9	3.6	2.5	2.9	0.9
He	—	—	0.4	2.4	—	—	—
Cm	—	—	—	—	—	0.3	3.7

Key to Analyses:

1 – Pillow basalt, Pioneer Formation; on peak of hill 0.8 kilometre south of Mowson Pond; UTM 5170 56388.

2 – Aquagene basalt breccia, Pioneer Formation; 1 kilometre northwest of Gwyneth Lake; UTM 5084 56277.

3 – Rhyodacite breccia, Cadwallader Group; 2 kilometres southwest of Windy Pass; UTM 5047 56484.

4 – Basalt, Tertiary volcanic rocks; 0.5 kilometre west of Tyaughton Creek; UTM 5173 56499.

5 – Andesite lava, Tertiary volcanic rocks; 0.5 kilometre east of Hurley River; UTM 5061 56217.

6 – Feldspar porphyry dyke, Tertiary effusive; 1 kilometre north of mouth of Gun Creek; UTM 5160 56384.

7 – Aphyric dacite dyke, Tertiary effusive; 1.2 kilometres north of Gun Creek; UTM 5110 56406.

complex. No granitic clasts were observed. Accessory white mica in some interlayered sandstone beds is believed to have been derived from schistose and phyllitc members of the Fergusson metachert. Yellow limonitic clasts, conspicuous in some of the upper pebble conglomerate members, appear to have been derived from some basic volcanic or listwanitic ultrabasic source.

TERTIARY BEDDED ROCKS

Tertiary bedded rocks comprise a few small scattered volcanic outliers. The oldest of these, estimated to be early Tertiary age, is a narrow panel of felsic lava and tuff which

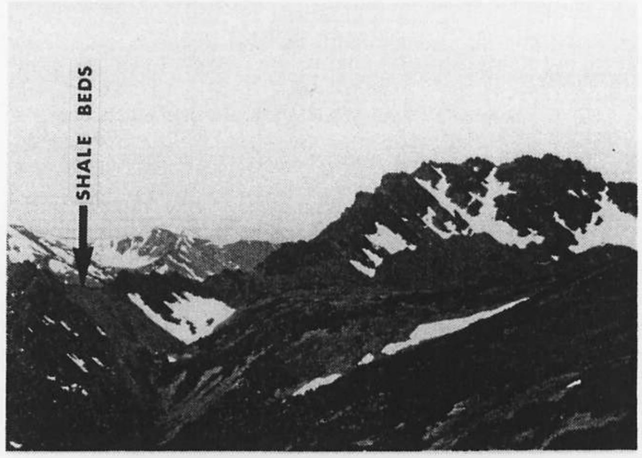

Plate 1-7-2. A westerly dipping mid-section in the Taylor Creek Group, on east spur of Eldorado Mountain, north of Taylor Creek.

follows the west side of the Marshall Creek fault from the east boundary of the map area to a point north of the mouth of Marshall Creek. Other volcanics of about the same age occur near the confluence of Taylor Creek and Tyaughton Creek. These rocks, and numerous related dykes found throughout the map area, range from basalt to dacite composition (Table 1-7-1, columns 4 to 7).

Small remnants of "plateau lava" of mid-Tertiary age occur at high elevations on the north and south spurs of Noel Mountain (Plate 1-7-3). These are horizontally layered basalts 100 to 150 metres thick, similar to the tiered lava flows forming the summit area of Cardtable Mountain and on Castle Peak in the Noaxe area to the north.

BRALORNE INTRUSIONS

The "Bralorne Intrusions" of Cairnes (1937) comprise augite diorite of the Bralorne-Pioneer belt and a number of associated phases including hornblende diorite and gabbro (Table 1-7-2, column 3). These rocks are notable in being the oldest igneous intrusions* and the primary host rocks

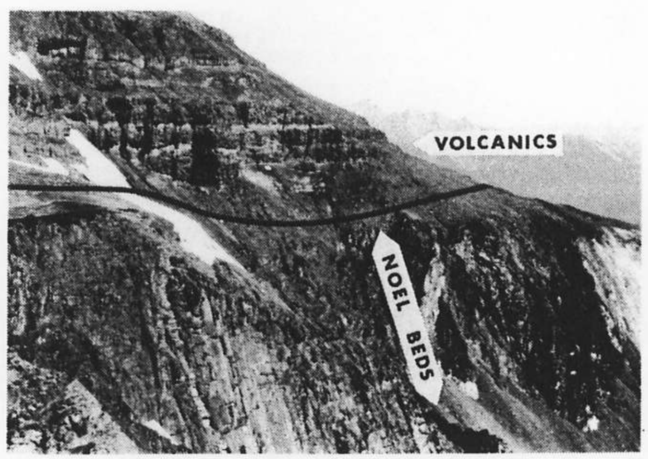

Plate 1-7-3. Tertiary basaltic volcanics (horizontal beds) resting unconformably on steeply dipping Triassic argillites and siltstones (Noel Formation).

*Determination of amphibole from a diorite phase of Bralorne intrusions exposed in the B.C. Hydro quarry north of Gold Bridge, yielded a potassium-argon age of 287 ±20 Ma (Permo-Carboniferous) – R.L. Armstrong, *The University of British Columbia*, from Potter, 1983, page 27).

TABLE 1-7-2
ANALYSES OF PLUTONIC ROCKS

	1	2	3	4	5	6	7	8
Oxides recalculated to 100:								
SiO_2	40.54	53.25	49.27	61.14	64.28	66.98	75.06	77.43
TiO_2	0.01	0.07	0.27	0.75	0.72	0.65	0.26	0.08
Al_2O_3	0.35	2.19	19.53	16.74	16.20	16.11	12.94	12.82
Fe_2O_3	6.83	1.28	0.92	1.07	1.16	1.02	0.78	0.23
FeO	3.92	6.12	3.92	4.79	3.86	2.95	2.20	0.43
MnO	0.19	0.16	0.10	0.10	0.07	0.06	0.06	0.01
MgO	48.10	19.80	9.67	3.82	3.35	2.06	1.03	0.08
CaO	0.05	17.09	14.26	5.78	4.42	3.80	2.92	0.68
Na_2O	0.00	0.04	1.62	3.70	3.89	3.83	4.46	2.55
K_2O	0.01	0.00	0.44	2.11	2.05	2.54	0.29	5.69
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Oxides as determined:								
H_2O+	8.81	1.47	2.10	0.43	0.28	0.26	1.33	0.02
H_2O-	0.11	0.12	0.10	0.09	0.17	0.15	0.10	0.07
CO_2	6.94	0.56	0.35	0.14	0.69	0.69	0.07	0.28
P_2O_5	0.00	0.01	0.00	0.13	0.12	0.13	0.03	—
S	0.14	0.02	0.02	0.01	0.01	0.02	0.04	0.01
Molecular norms:								
Qz	—	—	—	10.9	16.2	20.7	36.5	36.9
Or	0.1	—	2.5	12.5	12.1	15.1	1.7	34.1
Ab	—	0.4	14.3	33.3	34.9	34.4	40.5	23.3
Ne	—	—	—	—	—	—	—	—
An	0.2	5.7	43.8	22.8	20.7	18.9	14.6	3.4
Wo	—	31.0	10.2	2.3	0.5	—	—	—
En	13.9	51.9	14.6	10.5	9.2	5.7	2.9	0.2
Fs	0.1	8.1	2.8	5.6	4.2	3.0	2.6	0.4
Fo	78.3	1.3	8.8	—	—	—	—	—
Fa	0.8	0.2	1.7	—	—	—	—	—
Il	—	0.1	0.4	1.0	1.0	0.9	0.4	0.1
Mt	6.4	1.3	0.9	1.1	1.2	1.1	0.8	0.2
He	—	—	—	—	—	—	—	—
Cm	0.2	—	—	—	—	0.2	—	1.4

Key to Analyses:

1 – Hartzburgite, President intrusions; north bank of Cadwallader Creek by Pioneer mine; UTM 5154 56231.

2 – Websterite, President intrusions; on ridge 0.4 kilometre west of Jewel Creek; UTM 5038 56389.

3 – Gabbro, Bralorne intrusions; in B.C. Hydro quarry 1 kilometre north of Gold Bridge; UTM 5110 56340.

4 – Diorite, Coast intrusions; on ridge 1.5 kilometres southwest of Green Mountain; UTM 5044 56246.

5 – Granodiorite, Eldorado intrusion; 0.9 kilometre southwest of Eldorado Peak; UTM 5098 56498.

6 – Granodiorite, Bendor intrusion; immediately west of Truax Peak; UTM 5200 56297.

7 – Granite, "soda granite"; in highway cut 0.4 kilometre north of Gold Bridge; UTM 5111 56334.

8 – Granite, Coast intrusions; on ridge 1.2 kilometres north of Dickson Peak; UTM 5010 56391.

for mineralization in the area. They resemble outlying diorite-gabbro bodies at Lajoie Lake, near the headwaters of Sumner Creek and Steep Creek, and a series of small gabbro bodies in the Shulaps Range described by Leech (1953).

The typical Bralorne rocks are mottled grey-green, medium to fine grained, and characterized by a reticulation of felsic stringers. In contrast, the feeder gabbroic intrusions of the younger Triassic Pioneer basaltic lavas are generally fresh, relatively homogeneous and commonly distinguished by a light rust weathering.

The elongated outline of many of the individual intrusions, and the linear arrangement of these bodies in the Cadwallader-Hurley valley, suggest emplacement on a major fracture system.

ULTRABASIC ROCKS

An unusual abundance of ultrabasic rocks occurs in the Bridge River mining camp. These are an assortment of small talc-carbonate and serpentine lenses on steeply dipping faults, and large bodies of mixed peridotite, pyroxenite and dunite composition associated with possible thrust zones, such as the main President intrusion and the Shulaps complex.

According to Leech (1953) and Wright (1971), hartzburgite, consisting of a mixture of orthopyroxene and olivine (Table 1-7-2, column 1), is the most common rock type in the major ultramafic bodies. This rock is readily identified in the field by rust-orange weathering on a warty surface. Dunite is less common and clinopyroxene-rich rocks such as websterite (Table 1-7-2, column 2) are uncommon.

Although these ultrabasic bodies have been classified as massive "alpine type", Leech (1953) found that parts of the Shulaps complex show rhythmical layering of hartzburgite, dunite and pyroxenite. A similar feature is seen in the President intrusion (Plates 1-7-4 and 1-7-5). Wright (1974) as-

Plate 1-7-4. Finely layered structure in President ultramafic body, Sunshine Mountain area south of Cadwallader Creek.

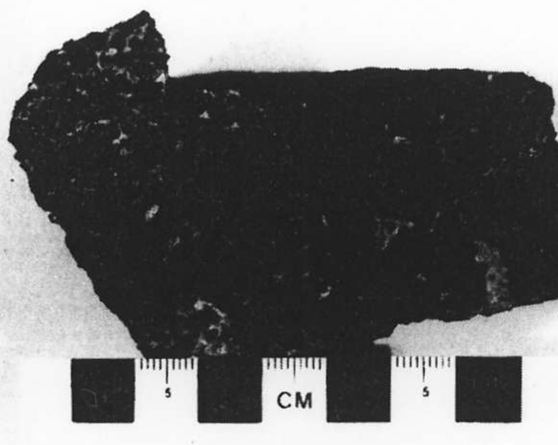

Plate 1-7-5. Cumulate chromite in President ultramafic body, Sunshine Mountain area.

cribes this prominent layering to tectonic forces "resulting from plastic deformation and recrystallization accompanied by metamorphic differentiation producing alternate olivine and orthopyroxene-rich layers". However, there is no completely satisfactory explanation of the chromite bands by this method. Consequently some magmatic or crystal mush origin is suspected. This magmatic attribute is further suggested by the apophyses and dyke-like form of some phases of the ultrabasic rocks, the presence of reaction selvages around gabbroic xenoliths, and evidence of thermal metamorphism along some contacts as indicated by Potter (1986).

The writers find no evidence that the ultrabasic rocks are volcanic in origin as suggested by McCann (1922). There seems to be little doubt that the ultrabasic rocks gained entry to the country rocks along major fissure systems both on thrusts and steeply dipping faults, and that these rocks were affected by renewed episodes of movement.

The age of emplacement of the Shulaps ultrabasic body is known to postdate the Late Triassic Cadwallader Group rocks which it cuts, and predates Lower Jurassic chromite-bearing sedimentary rocks in the Yalakom Valley discovered by Leech (1953).

COAST PLUTONIC COMPLEX

The Coast plutonic complex comprises the contiguous granitic terrane marking the southwest extremity of the Bridge River mining camp and including the outlying Bendor and Eldorado plutons to the east and smaller related plugs and dykes scattered throughout the region. The composition of these rocks varies from diorite to granodiorite, granite and aplite, biotite hornblende granodiorite being most common. The quartz content of these rocks ranges from less than 11 to more than 36 per cent and the total ferromagnesian content ranges from about 1 to 20 per cent (Table 1-7-2, columns 4 to 8).

Small bodies of soda granite are found on the Bralorne-Pioneer lineament, commonly associated with the older Bralorne diorite/gabbro intrusions (Plate 1-7-6). At the Bralorne mine the soda granite appears to expand with depth, forming a cupola from which quartz veins and mineralization appear to emanate.

The age of the Coast intrusions, based on several potassium-argon dates, varies from 59 to about 80 Ma. A recent analysis of the Eldorado Peak stock by K. Dawson of the Geological Survey of Canada yields 63.7 Ma (personal communication, 1987).

The soda granite, assigned to the "Bralorne Intrusives" by Cairnes (1937), is now thought to be much younger. This rock could be the source of the granite pebbles found in the Relay Mountain Group near the Truax Valley or just another phase of the Coast intrusions.

DISCUSSION

Similarities were noted by Campbell (1975) comparing the Bridge River camp and the Mother Lode camp of California: "the two camps not only have striking similarities in ore, vein mineralogy, wallrock alterations and wallrocks, but also are remarkably similar in the association of the ore veins with a major fault along a belt of elongate serpentine bodies that flank the margin of a granite batholith."

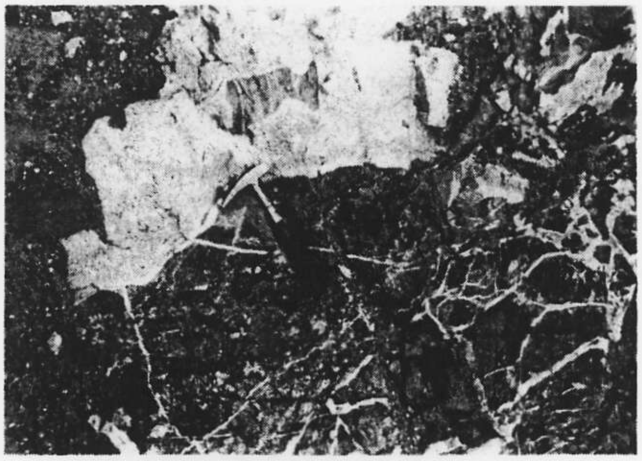

Plate 1-7-6. Apophysis of soda granite in Bralorne intrusive complex, highway cut 0.4 kilometre north of Gold Bridge.

The allochthonous terrane theory of Umhoefer (1987) and others would place the Bridge River terrane juxtaposed with Baja California in pre-Upper Cretaceous time. This gives an improved spatial fit to Campbell's observations. Such a hypothesis might also relocate the Greenwood mining camp of south-central British Columbia which is similar in many ways to the Bridge River camp (Table 1-7-3).

In each camp an intricate system of fractures is thought to control movement of the ore-bearing solutions; the most profound crustal rents are commonly the main solution channelways and also the loci of repeated igneous intrusions. For example, in the Bridge River camp the Cadwallader "break", on which the principal mines are situated, hosts several Bralorne diorite stocks, a belt of ultrabasic rocks and the soda granite bodies.

The source of the mineralizing solutions was considered by Cairnes (1937) to be magmatic – a process of differentiation which also produced the soda granite. The Bralorne diorite was thought to be the ultimate source and also the prime host rock of the ore fluids because of the location of these bodies on the major faults and the brittle, fissure-sustaining character of the rocks.

TABLE 1-7-3
GEOLOGICAL COMPARISON OF THE BRIDGE RIVER AND GREENWOOD CAMPS

Age	Lithology	Bridge River Camp	Greenwood Camp
U. Cret. L. Cret.	granitic plutons granitic plutons	Coast plutonic complex	Greenwood - Wallace Cr. plutons
Jur./Cret.?	ultrabasic rocks	Shulaps and President intrusions	unnamed ultramafic bodies
U. Trias.	clastics, shale, limestone, volcanics	Cadwaller Gp.	Brooklyn Gp.
Permian	black argillites	lower Noel Fm.	Attwood Gp.
M.-L. Perm.	gabbro, diorite stocks	Bralorne intrusions	"Old Diorite"
Paleozoic	deformed ribbon chert-schist basement complex	Fergusson Gp.	Knob Hill Gp.

In the present study, a genetic relationship between the soda granite and the Bralorne diorite is not proven.

In the Greenwood camp linear coherence of lead isotope ratios from the diverse mineral deposits suggests single cycle mixing of the ore solutions. It is thought that the plutons served principally as heat engines in a convecting hydrothermal system. A similar model may hold for the Bridge River camp.

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The courtesies and support of the residents of the communities of Bralorne and Gold Bridge are gratefully acknowledged. Appreciation is owing mining personnel working in the area including W. Howell of Chevron Canada Resources Ltd., J. Kristofferson of Levon Resources Ltd., T. Sandburg of Cook Geological Consultants Ltd., C. Boitard and L. Sookochoff of Menika Mining Ltd., T. Carpenter of Azimuth Geological Consultants Ltd. and J. Dawson of Pilgrim Holdings Ltd. Special thanks go to K. Dawson, T. Poulton and M. Orchard of the Geological Survey of Canada who provided valuable scientific support. Information was also exchanged with C. Leitch of The University of British Columbia and J. Garver and P. Umhoefer of the University of Washington. Field trips were conducted jointly with ministry colleagues including K. Glover, P. Schiarizza and R. Meyers.

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THE DOUBLE DERIVATIVE INTERPRETATION OF REGIONAL MAGNETIC FIELDS IN THE BRIDGE RIVER MINING CAMP (92J/15, 16)

By B. N. Church and D. A. R. James

KEYWORDS: Aeromagnetic data, double derivative, regional geology, structure, alteration.

INTRODUCTION

The double derivative method of screening aeromagnetic data assists regional geological interpretations. According to theory, the "second vertical derivative" maps the rate of curvature of magnetic fields. The zero contour on the calculated surface has special geological significance and coincides with inflection points on the original magnetic profiles. These inflections commonly trend subparallel to lithological or mineralized boundaries and fault zones.

In the Bridge River mining camp the federal-provincial aeromagnetic maps, Tyaughton Lake (92J/15) and Bridge River (92J/16), at 1:63 360 scale, provide a ready base for analysis. Regional geological control is provided by current mapping and by the Geological Survey Branch (Open File Map 1987-11, *Geology of the Gold Bridge Area*) and previous work by Leech (1953), Roddick and Hutchinson (1973) and Potter (1986).

GEOLOGY

The magnetic signatures of the principal geological formations underlying the Bridge River camp depend on several factors such as the iron content, mineralogy, alteration and metamorphic conditions of the rocks. Ultimately the amount of magnetite and grain size are the most important factors. Generally, igneous rocks have the greatest magnetic susceptibility, having more combined magnetite and ilmenite and coarser grain size than the sedimentary units. Table 1-8-1 gives the total iron, magnetite and ilmenite percentages for a selection of igneous rocks from the area.

The Pioneer volcanic rocks comprise the lowest formation in the Upper Triassic Cadwallader Group. The unit consists mostly of basaltic pillow lavas and breccias ranging up to several hundred metres thick. These volcanics are sandwiched between thick sedimentary sequences characterized by relatively low magnetic susceptibility; the older Fergusson cherts and phyllites lying unconformably below; the slightly younger Hurley argillites, limestones and clastic beds lying conformably above.

Generally the Pioneer volcanic assemblage has been affected by greenschist-grade metamorphism which has destroyed much of the primary mineralogy. Calcic feldspar has been transformed to more sodic varieties and the ferromagnesian minerals partly replaced by chlorite. Individual magnetite grains may have survived the effects of regional metamorphism, however, much of the iron is contained in very fine-grained opaque dust associated with the decomposition of the original mineral and vitreous components. In areas of mineralization, the basaltic walls of quartz veins are commonly carbonated and much of the iron is tied to siderite, hematite and pyrite. These altered rocks have low magnetic susceptibility.

The ultramafic rocks of the President and Shulaps intrusions cut units of the Cadwallader and Fergusson groups. These intrusive bodies, consisting mostly of iron-rich harzburgite (with lesser amounts of diorite and websterite), contain much granular magnetite. The common high magnetic susceptibility of these rocks is in sharp contrast to the low magnetic susceptibility of the adjacent formations. The primary magnetite does not appear to be much changed by serpentinization of the ultramafic rocks, although much new fine-grained, opaque iron oxide has resulted from the conversion of pyroxene to serpentine and talc.

The Bralorne intrusions are relatively small Paleozoic diorite and gabbro bodies that appear to have been emplaced on major rifts in the Fergusson terrane. These plutonic rocks have relatively low iron content and have been extensively affected by retrograde metamorphism resulting in lower than expected magnetic susceptibility.

The Coast intrusions are Upper Cretaceous biotite hornblende granodiorite plutons with diorite and granite phases. These rocks are typically fresh with hypidiomorphic granular texture. The magnetic susceptibility of these rocks is generally low because of low ferromagnesian content, however, the occurrence of magnetic anomalies in adjacent country rocks may be due to the development of skarns and hornfels zones during intrusion.

METHOD OF ANALYSIS

The preparation of second vertical derivative maps is in accordance with the mathematical theory and procedures of Henderson and Zeitz (1949, page 512). The general equation for this purpose:

$$\overline{\Delta T}(r) = \Delta T_0 - \frac{r^2}{4}\frac{\partial^2 \Delta T}{\partial z^2} + \frac{r^4}{64}\Sigma\, \mu_k{}^4 A_k + \cdots$$

reduces to a nine-point system in a square grid

$$\frac{\partial^2 \Delta T}{\partial z^2} = 2(3\Delta T_0 - 4\overline{\Delta T}_1 + \Delta T_2)$$

where T_0 is gamma value at each cell centre in the map grid, T_2 the value at each corner of the cell, and T the value at the mid-points on the sides of the grid.

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

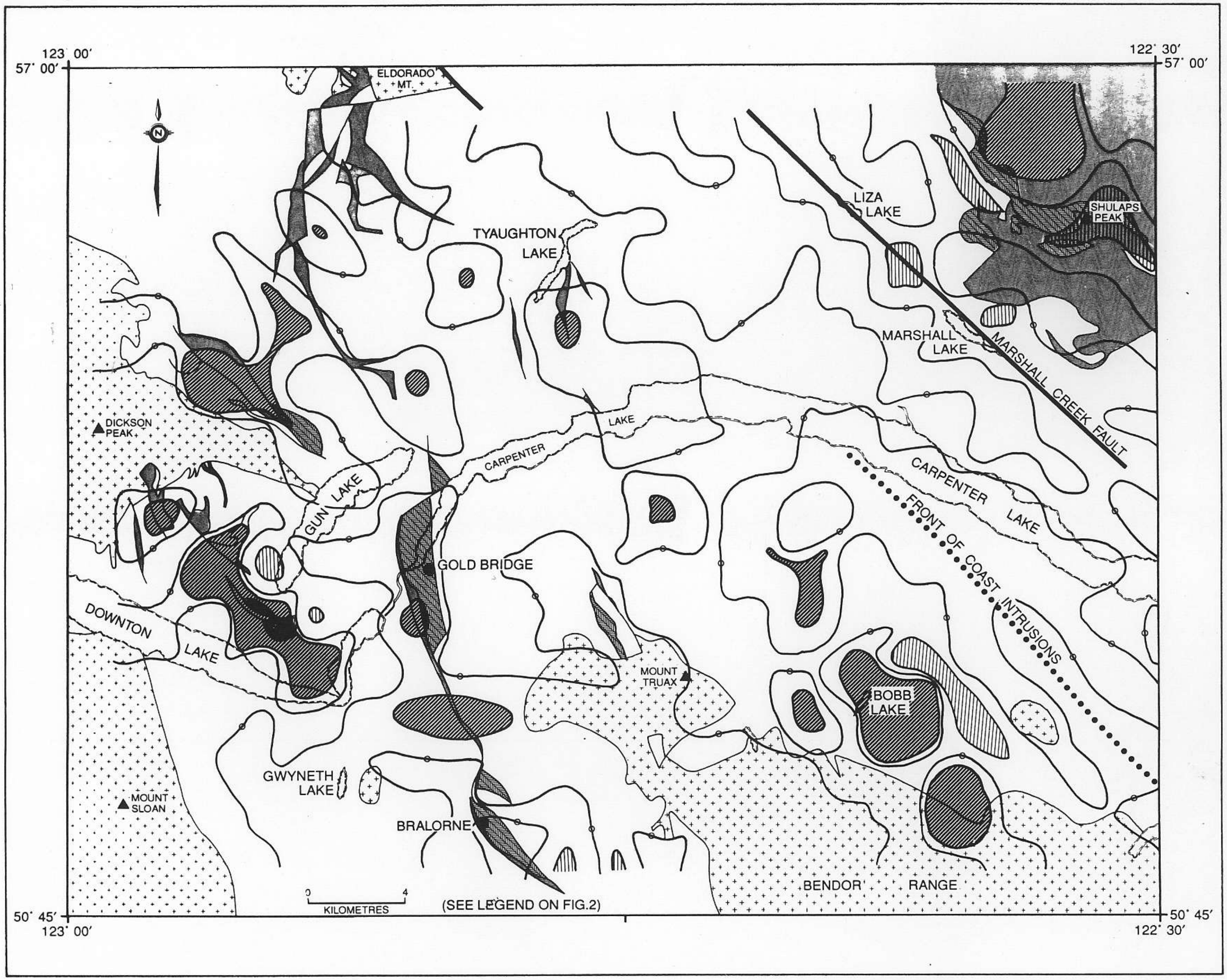

Figure 1-8-1. Tyaughton area (92J/15) showing the principal igneous intrusions and second vertical derivative contours of the total magnetic intensity (computed on a 1-mile grid interval from data on Geological Survey of Canada Map 8552G).

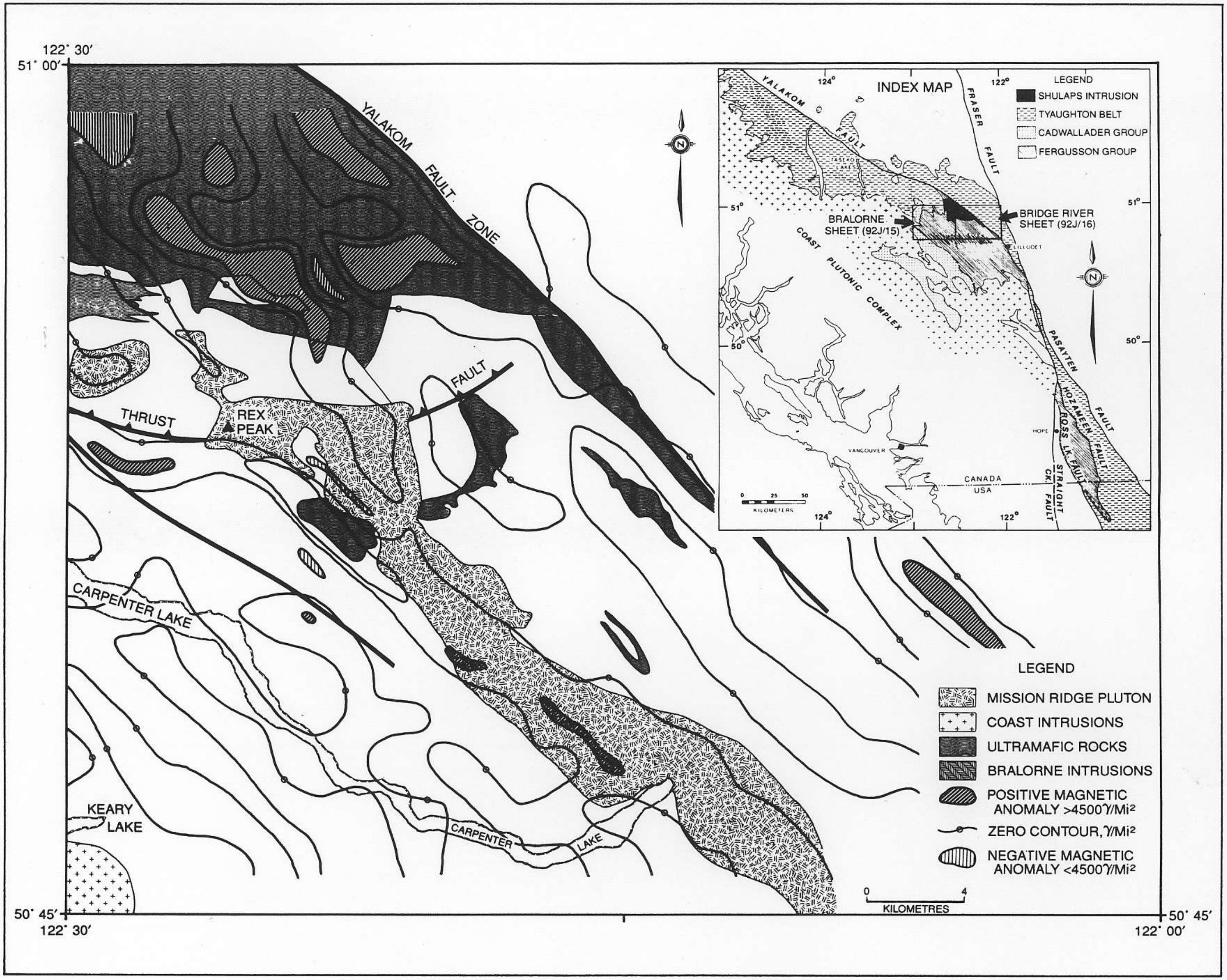

Figure 1-8-2. Bridge River area (92J/16) showing the principal igneous intrusions and second vertical derivative contours of the total magnetic intensity (computed on a 1-mile grid interval from data on Geological Survey of Canada Map 8548G).

For the Bridge River mining camp an orthogonal north-south, east-west grid with a 1-mile spacing is superimposed on the available aeromagnetic maps. A total of 792 grid points is necessary to cover the combined Tyaughton–Bridge River map sheets, each sheet measuring approximately 22 miles east-west and 18 miles north-south. The following general formula (algorithm) is applied to compute the second vertical derivative across the map area. Gamma values are interpolated and recorded at the grid points.

$$X(I,J) = 12X(I,J,) - 4[X(I-1,J) + X(I,J-1) + X(I+1,J) + X(I,J+1)] + X(I+1,J-1) + X(I-1,J-1) + X(I-1,J+1) + X(I-1,J+1)$$

for the interval X(1,1) to X(1,22) through X(18,1) to X(18,22); where I and J represent the rows and columns in the matrix of gamma readings (X). The final product is a contoured map showing gammas per square mile (*see* examples, Figures 1-8-1 and 1-8-2).

DISCUSSION OF RESULTS

The registration of the double derivative contours on the principal geological features of the Bridge River mining camp appears to be very good (*see* Figures 1-8-1 and 1-8-2). For example, the strong northwest-trending fabric delineated by the zero contour across the Bridge River sheet (92J/16) and the easterly part of the Tyaughton sheet (92J/15) conforms with the direction of the Yalakom and Marshall Creek faults and the front of the Coast intrusions. Also conforming well with this pattern is the young (Tertiary age) Mission Ridge pluton. The most anomalous magnetic zones coincide with the Shulaps and President ultramafic intrusions. A series of positive magnetic anomalies follows the hornfelsed margins of the Bendor and Dickson Peak granitic plutons and a series of negative anomalies occurs near a number of small Bralorne "diorite" bodies associated with the Shulaps ultramafic complex.

The broad magnetically flat area northeast of the Yalakom fault is underlain mostly by Cretaceous sedimentary formations characterized by low magnetic susceptibility.

It is concluded that the double derivative method of processing primary magnetic data provides some clear insight into regional structural patterns and lithology continuities in the Bridge River mining camp that may have useful potential for mineral exploration. The various igneous intrusions and adjacent fracture lineaments delineated on the double derivative maps point to possible prospecting targets.

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TABLE 1-8-1
IRON, MAGNETITE AND ILMENITE PERCENTAGES FOR SELECTED IGNEOUS ROCKS

	Fe %	Magnetite + Ilmenite %
Basalt (Pioneer Formation)	0.3–9.4	5.6–7.2
Ultramafic rocks (President intrusions)	5.7–7.8	1.3–6.5
"Diorite" (Bralorne intrusion)	4.5	1.3
Dioritic rocks (Coast intrusions)	3.0–4.5	2.0–2.2
Granitic rocks (Coast intrusions)	0.5–2.3	0.3–1.2