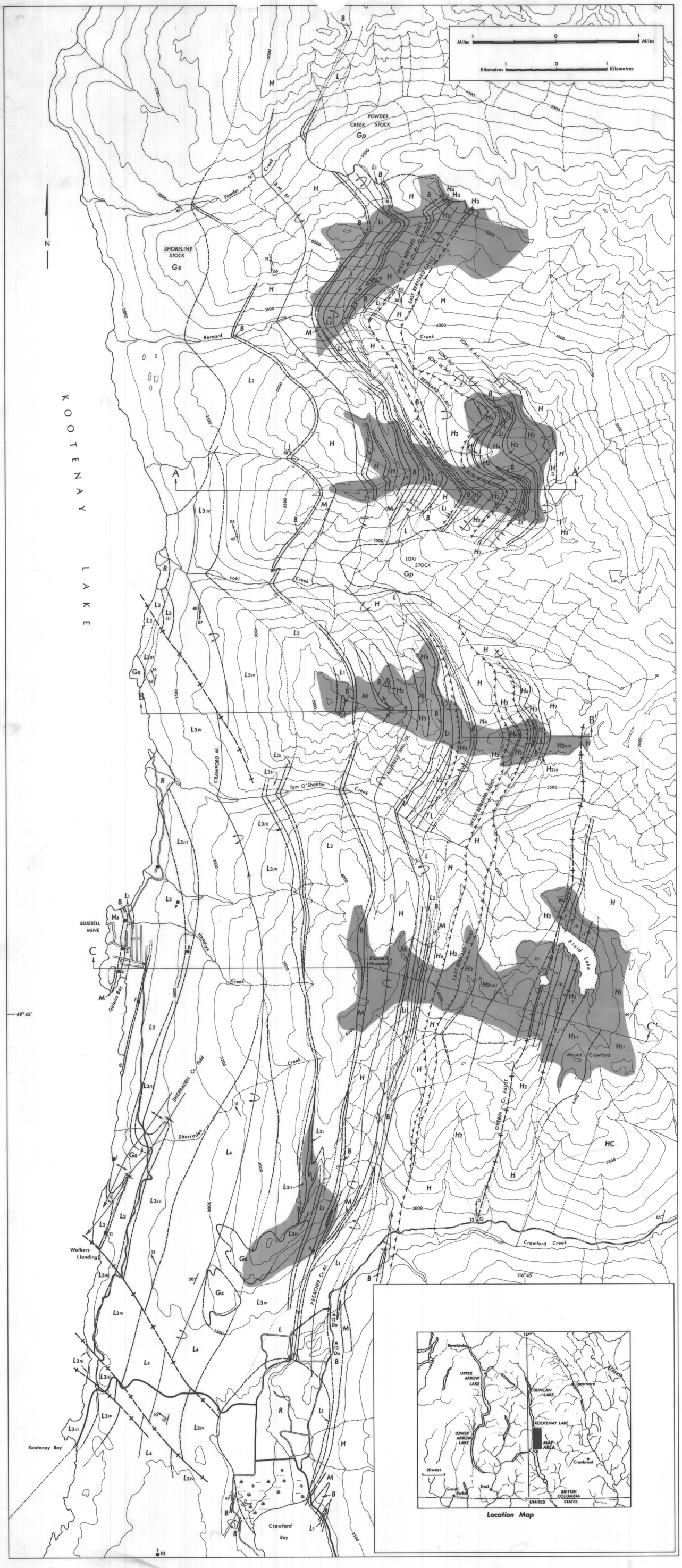

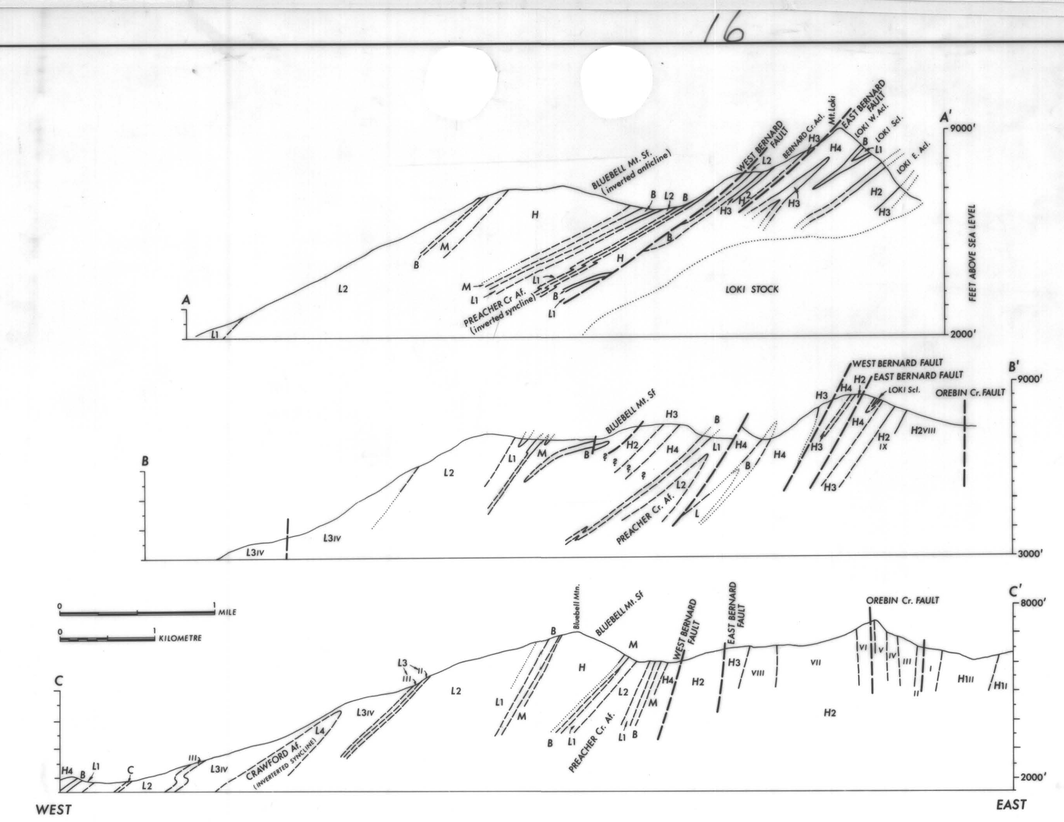

Vertical Structure Sections A, B, C Illustrating Phase 2 Folds

GEOLOGY OF THE RIONDEL AREA

By Trygve Höy

INTRODUCTION

The Riondel area (82F/10, 15) includes approximately 230 square kilometres of mountainous terrain along the east shore of Kootenay Lake in southeastern British Columbia. The area is accessible from a road extending north from Highway 3, along the Kootenay Lake shoreline, to the northern limit of the map-area. The area was mapped in six months, during the summers of 1972 and 1973, and formed the basis of a Ph.D. thesis (Hoy, 1974) submitted to Queen's University, Kingston, Ontario in June 1974.

GEOLOGY

INTRODUCTION

The Riondel area is in the central part of the Kootenay Arc, a north-trending arcuate structural zone in the southeastern Canadian Cordillera characterized by superposed folding and a complex deformational history. The map-area is located within a local metamorphic culmination in the arc and near a structural culmination. North of the Riondel map-area, fold axes generally plunge to the north at low angles (Fyles and Eastwood, 1962; Fyles, 1964; and Read, 1973) whereas to the south, axes most commonly plunge south (Fyles and Hewlett, 1959). Both syntectonic and post-tectonic quartz monzonite stocks are exposed within the northern part of the area.

STRATIGRAPHY

Rocks within the map-area have been correlated with the Eocambrian sequence established in the Duncan Lake area to the north (Fyles, 1964) and the Salmo area to the south (Fyles and Hewlett, 1959). Initial stratigraphic thicknesses of the units are difficult to estimate because they have been modified by deformation; the estimated thicknesses were generally measured in the attenuated limbs of folds and hence are minimum values.

HORSETHIEF CREEK GROUP (HC)

The oldest rocks in the area outcrop only in the southeastern part of the map-area along the Crawford Creek road. These rocks have been assigned to the Horsethief Creek Group. Only the upper part of the group is exposed and consists of 300 to 400 metres of fine-grained light green to grey chlorite and chlorite-muscovite phyllite and schist with rare beds of quartz pebble conglomerate. The top 100 metres of the exposed section includes rare white quartzite layers and one thin marble layer.

HAMILL GROUP (H)

The Hamill Group includes about 3,500 metres of quartzite, schist, siltstone, and rare amphibolite and calcareous layers. The basal quartzite (unit H1) includes approximately 1,000 metres of medium to coarse-grained, grey to grey-green feldspathic quartzite (Hii) overlain by 600 metres of massive white quartzite (Hiii). Very conspicuous crossbedding in the lower unit (Hii) indicates that tops face west.

Unit H2 comprises more than 1,500 metres of white to dark grey quartzite interlayered with dark crossbedded siltstone, phyllite, and schist. The lower half (units H2 i-vii), exposed only in the southeastern corner of the map-area, is predominantly dark quartzite and siltstone; the upper half (unit H2 viii) is predominantly schistose. In the Plaid Lake area, a distinctive dark green (metavolcanic ?) amphibolite (unit H2 viii), approximately 200 metres thick, lies at the top of unit H2.

Unit H3, a layer of nearly pure white quartzite, is a distinctive marker unit within the Hamill Group. Its thickness varies from approximately 60 metres to 200 metres.

The uppermost unit of the Hamill Group (unit H4) comprises at least 200 metres of fine-grained, dark grey biotite-quartz schist and quartzite. Pelitic layers within this unit become more common southward; on Riondel peninsula they comprise at least half the exposed section. A white quartzite layer, 60 to 90 metres thick, commonly occurs at or within 10 to 20 metres of the top of unit H4. This layer, or the base of the first prominent marble layer encountered up-section, has been used to separate the Mohican Formation from the Hamill Group on the map.

MOHICAN FORMATION (M)

The Mohican Formation, a gradational unit between the Hamill quartzite and the Badshot marble, consists predominantly of medium-grained, brown-weathering muscovite schist. Layers up to 6 metres thick of grey dolomite marble commonly are interbedded with the schist and micaceous white quartzite layers, less commonly. A white calcite or calcite-dolomite marble commonly occurs at the base of the Mohican Formation.

BADSHOT FORMATION (B)

The Badshot marble, the host rock for the Bluebell mine lead-zinc mineralization, is the most distinctive marker unit within the map-area. It consists of either white calcite or dolomite marble. It commonly forms prominent cliffs that are recognizable from a distance. The only other units which resemble the Badshot, but which are distinguished by associated rocks, are marble units within the Mohican Formation, particularly the basal Mohican marble, and a marble layer (c) within the hornblende gneiss unit (L2) in the Lardeau Group.

LARDEAU GROUP (L)

INDEX FORMATION

Unit L1, overlying the Badshot marble, is a fine to medium-grained muscovite schist or biotite gneiss. In the Mount Loki area, it is a medium to coarse-grained pelitic schist containing garnet and staurolite porphyroblasts. Further south, at Tam O'Shanter Creek, it is more calcareous with a 2-metre layer of rusty weathering siliceous marble near the centre. East of Bluebell Mountain (in the Preacher Creek antiform) micaceous schist, mapped as L1, contains thin quartzite layers.

Dark grey to black hornblende gneiss and amphibolite which outcrop along the Kootenay Lake shoreline north and south of Riondel and which overlie unit L1 have been mapped as unit L2. Diopside-rich calc-silicate layers, thin rusty calcite marble layers, and less commonly, hornblende-biotite gneiss and micaceous quartzite layers occur within L2. A fairly pure, white calcite marble layer near the centre of unit L2 is similar in appearance to the Badshot marble. East of Riondel this marble layer is attenuated and appears to be the host of a number of mineralized (sphalerite - galena - pyrite) veins.

The succession within unit L3 includes a basal quartzite interlayered with biotite schist (L3i) overlain by thinly laminated dark amphibolite (L3ii) and thin rusty siliceous marble (L3iii) which grades upward into grey-green calc-silicate gneiss (L3iv). The calc-silicate gneiss unit (L3iv) commonly includes sections of muscovite-rich schist and biotite gneiss and layers of rusty siliceous marble. A pronounced layering varying in scale from thin laminations to at least 8 metres thick is common throughout L3iv. The layering is generally parallel to the dominant mineral foliation. It consists of variations in mineral assemblages and proportions which are thought to reflect variations in bulk compositions of the original sedimentary rocks.

Unit L4 comprises the youngest stratified rock exposed in the area, a granitic paragneiss which forms the core of the Crawford antiform. It is generally medium grained and consists mainly of microcline, plagioclase, biotite, muscovite, hornblende, and quartz. This rock forms rusty but fairly resistant outcrops.

STRUCTURE

The most conspicuous structures in the area are a set of very tight to isoclinal 'Phase 2' folds with west-dipping axial surfaces (see cross-sections above). These folds plunge at shallow angles to the north (and locally to the south), and their axial planes dip westward, becoming more upright to the east. A pronounced foliation and lineation are parallel to their axial planes and fold axes respectively. West of the 'West Bernard fault,' they have developed in an inverted panel of rocks; older rocks form the cores of synforms and younger rocks, the cores of antiforms. These folds have been named, from west to east, the 'Crawford antiform' (an inverted syncline), the 'Bluebell Mountain synform' (an inverted anticline), and the 'Preacher Creek antiform' (an inverted syncline). East of the West Bernard fault, the folds have developed in an upright panel of rocks. These include the 'Bernard Creek anticline,' the 'Loki West anticline,' the 'Loki syncline,' and the 'Loki East syncline.'

The oldest recognizable structure (Phase 1) is represented by the overturned stratigraphic succession that represents the underlimb of a large recumbent anticline, the 'Riondel nappe' (see cross-section below). Its axial zone and upper limb have been removed by erosion. The overturned limb extends under Kootenay Lake in the west and is bounded on the east by the West Bernard fault. Its western closure is deduced from regional considerations; in the Duncan Lake area parts of both the lower and upper limbs of comparable style folds are exposed and indicate western closures (Fyles, 1964).

The limbs of Phase 2 folds have been deformed by small-scale folds that plunge to the southwest. The 'Sherraden Creek' antiform-synform pair (south of Riondel) is the largest of these and the only Phase 3 fold shown on the map.

Two west-dipping reverse faults, the 'West Bernard' and 'East Bernard' faults, transect the entire area from north to south. The West Bernard fault, as mentioned above, separates an inverted panel of rocks in the west from a right-side-up panel in the east. The East Bernard fault separates two Phase 2 anticlines, replacing the intervening syncline. Both are parallel to the axial planes of Phase 2 folds. Two strike faults cut the lower Hamill rocks east of the reverse faults. These are steep, and although locally parallel with the layering, cut up-section to the north. They shear the axial plane foliation associated with the Phase 2 structures and appear to be normal faults as stratigraphy is not repeated across them. Steeply dipping, southeast-trending faults with small right lateral displacements are conspicuous just north of Crawford peninsula. These faults cut all other structures.

INTRUSIVE ROCKS

Quartz monzonite intrusions underlie a large part of the area north of Loki Creek. These include the informally named 'Shoreline,' 'Loki,' and 'Powder Creek' stocks. The Shoreline stock is a semi-concordant, westward dipping quartz monzonite intrusion with its long axis approximately parallel to the trend of the Phase 2 fold structures. Its contact zone is more than 300 metres wide and is marked by mixed pegmatite and aplite sills, foliated and layered quartz monzonite, and country rock. The core of the intrusion is a massive, medium-grained, equigranular biotite quartz monzonite.

The discordant Loki and Powder Creek stocks are generally massive, medium-grained biotite quartz monzonites. They truncate the regional structures at high angles, yet do not appear to deform them.

Numerous small plutons ranging in outcrop size from several hundred square metres to approximately 2 square kilometres, and many pegmatite and aplite sills and dykes are distributed throughout the southwestern part of the map-area. Only the largest of these have been included on the map.

METAMORPHISM

The Riondel area is on the eastern flank of an elongate metamorphic culmination extending north to the Duncan Lake area. This metamorphic culmination is located within a regional structural culmination in the Kootenay Arc. Within the Riondel area, the metamorphic grade ranges from the upper greenschist facies in the east (with quartz - muscovite - biotite - garnet - chlorite assemblages in pelitic rocks) to the upper amphibolite facies in the west (sillimanite or kyanite - garnet - biotite - muscovite - quartz assemblages). Metamorphic isograds, which have been defined in both pelitic and calcareous rocks, trend north-south approximately parallel to the dominant structural trends though locally cutting across them.

MINERAL DEPOSITS

The Riondel area contains a number of lead-zinc-silver deposits and occurrences. These and a dolomite and quartzite quarry are plotted on the map and listed in the accompanying table.

Total lead-zinc-silver production, virtually entirely from the deposits at the Bluebell mine, exceeds 5.3 million tons from which 7.1 million ounces of silver, 515 million pounds of lead, and 548 million pounds of zinc have been obtained. The Bluebell deposits are fracture controlled replacement deposits in Badshot marble. The other lead-zinc-silver occurrences are in the form of veins in Badshot marble (the Les-Ann occurrence), or in Lower Index schist, calc-silicate gneiss, or pegmatite. Mining development includes trenching (Les-Ann and Broster occurrences), some tunnelling (Hotshot, Jackpot), and drilling (Tam O'Shanter).

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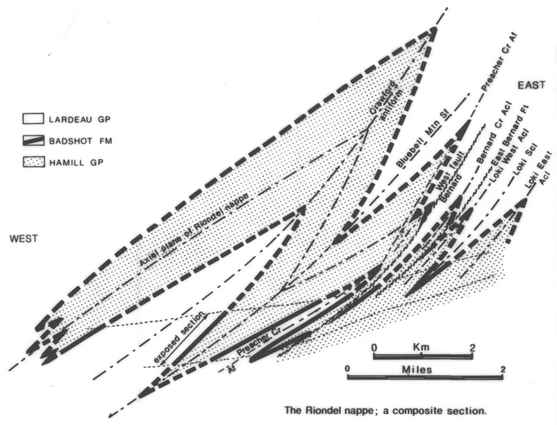
MINERAL SHOWINGS IN THE RIONDEL AREA

NO.	NAME	LOCATION	COMMODITY	HOST	MODE OF OCCURRENCE	STATUS
1.	Berengeria	Sherraden Creek	Pb, Zn, Ag	L2 or B ?	large marble boulder	124 tons produced
2.	Comfort zone	Riondel peninsula	Pb, Zn, Ag, Cu	B	disseminated, cross-veins	past producer
3.	Bluebell zone (Bluebell mine)					
4.	Kootenay Chief					
5.	Tam O'Shanter	Indian Creek	Pb, Zn, Ag	L2	vein	occurrence
6.	Les-Ann	2 miles (3 km.) NNE of Crawford Bay	Pb, Zn, Ag	L2	vein	occurrence
7.	Sutcliffe	¼ mile (.4 km.) SE of Riondel	Pb, Zn	L2	vein	occurrence
8.	Hotshot	½ mile (.8 km.) E of Riondel	Pb, Zn	L3 ?	vein in pegmatite and schist	occurrence
9.	Jackpot	1 mile (1.5 km.) NE of Riondel	Pb, Zn	L2	vein	occurrence
10.	Broster	Crawford peninsula	Pb, Zn	L3	vein	occurrence
11.	Kootenay	Walker's Landing	Pb, Zn	L2	vein	occurrence
12.	Crawford Creek dolomite	Crawford Creek	dolomite	B	marble layer	producer
13.	Crawford Creek quartzite	Crawford Creek	quartzite	H	quartzite layer	producer



The Riondel nappe; a composite section.

SYMBOLS

- GEOLOGICAL CONTACT: DEFINED, APPROXIMATE, ASSUMED*
- THRUST FAULT: DEFINED, APPROXIMATE
- 'LATE' FAULT: DEFINED, APPROXIMATE
- ANTIFORM, SYNFORM – AXIAL SURFACE TRACE
- OVERTURNED ANTIFORM, ANTICLINE – AXIAL SURFACE TRACE
- OVERTURNED SYNFORM, SYNCLINE – AXIAL SURFACE TRACE
- FOLIATION (S_2) PARALLEL TO LAYERING (S_0)
- MINERAL LINEATION (L_2)
- LEAD – ZINC OCCURRENCE 8
- QUARRY: Do = DOLOMITE; Q = QUARTZITE 13
- LIMITS OF DETAILED MAPPING
- AREAS OF EXTENSIVE OUTCROP
- LOCATION OF VERTICAL STRUCTURE SECTION

*DEFINED CONTACT – observed and 'walked out' in the field; APPROXIMATE – constrained between adjacent outcrops; ASSUMED – projected from defined or approximate contacts.

LEGEND

QUATERNARY

- R — PLEISTOCENE AND RECENT ALLUVIAL DEPOSITS

JURASSIC – CRETACEOUS (?)

GRANITIC ROCKS

- GP — 'POST–TECTONIC' QUARTZ MONZONITE
- Gs — 'SYNTECTONIC' QUARTZ MONZONITE, PEGMATITE

MIDDLE CAMBRIAN

LARDEAU GROUP

INDEX FORMATION

- L4 — BIOTITE – QUARTZ – FELDSPAR ± GARNET GNEISS; MINOR AMPHIBOLITE
- L3iv — CALC–SILICATE GNEISS WITH AMPHIBOLITE, SCHIST, AND MARBLE LAYERS; MAY INCLUDE UNITS L3i, L3ii, AND L3iii
- L3iii — CALCITE MARBLE WITH CALC–SILICATE, AMPHIBOLE, AND SCHIST LAYERS
- L3ii — AMPHIBOLITE
- L3i — MICACEOUS QUARTZITE
- L2 — HORNBLENDE GNEISS, AMPHIBOLITE; c = CALCITE MARBLE
- L1 — BIOTITE – MUSCOVITE SCHIST AND GNEISS

LOWER CAMBRIAN

BADSHOT FORMATION

- B — CALCITE MARBLE, DOLOMITE

MOHICAN FORMATION

- M — CALCAREOUS SCHIST, QUARTZITE, MARBLE

HAMILL GROUP

- H4 — DARK QUARTZITE, QUARTZ–RICH SCHIST
- H3 — WHITE QUARTZITE; q = MASSIVE WHITE QUARTZITE WHICH MAY IN PART BE UNIT H3
- H2 — MUSCOVITE – BIOTITE – CHLORITE SCHIST, QUARTZITE, SILTSTONE
  - ix DARK MUSCOVITE SCHIST, DARK QUARTZITE
  - viii EPIDOTE – CHLORITE – AMPHIBOLE GNEISS ('GREENSTONE'?)
  - vii MUSCOVITE – CHLORITE SCHIST
  - vi DARK QUARTZITE; MINOR CHLORITE SCHIST, DOLOMITE
  - v CHLORITE – MUSCOVITE SCHIST; MINOR QUARTZITE
  - iv MASSIVE WHITE QUARTZITE, DARK GREEN CHLORITE SCHIST
  - iii DARK BROWN TO GREY CHLORITE SCHIST, DARK SILTSTONE
  - ii LIGHT TO MEDIUM GREEN CHLORITE SCHIST
  - i BROWN SILTSTONE, DARK GREEN CHLORITE SCHIST; MINOR QUARTZITE AND CALCITE MARBLE
- H1 — QUARTZITE
  - ii MASSIVE WHITE QUARTZITE, MICACEOUS QUARTZITE
  - i GREY–GREEN FELDSPATHIC QUARTZITE

HADRYNIAN

HORSETHIEF CREEK GROUP

- HC — MUSCOVITE – CHLORITE SCHIST AND PHYLLITE; QUARTZ PEBBLE CONGLOMERATE

British Columbia Department of Mines and Petroleum Resources

GEOLOGY OF RIONDEL AREA

Geology by Trygve Höy

Preliminary Map No. 16