Plate 17. Intimately interlayered pyroxene-amphibole, albite and potassic feldspar albite fenites, within darker pyroxene-amphibole fenites, Unit 3C, station P1-5. Perry River area; weakly fenitized core gneisses are exposed on right side of photograph.

Plate 18. Dark pyroxene-amphibole fenite with remnant boudinaged layers of quartz feldspar paragneiss, Unit 3C, station P1-5.
Plate 19. Intrusive carbonatites (light coloured) and pyroxene-amphibole fenites of Unit 3C, just south of station H8SP4, Perry River area: (19A) overview showing location of Unit 3C in foreground and overlying Mount Grace extrusive carbonatite in distance; (19B) detail of interlayered intrusive carbonatite and dark fenite.
Plate 20. Intrusive carbonatites at station H85P1: (20A) swirled discontinuous carbonatite lenses in pyroxene-amphibole fenite (sample H85P1-5); (20B) intermixed buff-weathering carbonatite and fenite, overlain by grey-weathering carbonatite (sample H85P1-8).
Plate 21. Exposure of the Ren carbonatite at station Ren 5.

Plate 22. Boudinaged layers of amphibole-rich fenite within the intrusive Ren carbonatite, station Ren 5.
Plate 23. The Mount Grace carbonatite: (23A) well-layered extrusive carbonatite containing small clasts of dominantly albite (station P3; Perry River area); (23B) subrounded paragneiss and potassic feldspar-albite "syenite" clasts in a crudely layered blocky tephra (station P25; Blais Creek area).
Plate 24. Lithic clasts in the Mount Grace blocky tephra layer: (24A) large gneissic clast and smaller albite clasts (Mount Grace area); (24B) gneiss-amphibolite(?) contact preserved in clast (Kirbyville Lake area, north of Blais Creek).
Plate 25. The Mount Grace carbonatite in the Perry River area: (25A) approximately 1-metre-thick carbonatite layer (beneath hammer), coarser with dominantly albitic clasts 1 to 2 centimetres across at top underlain by finer grained carbonatite tuff, in a marble, calc-silicate gneiss, pelitic gneiss and quartzite succession; (25B) large clast with syenite (r?)-fentite-gneiss contact.
Plate 26. Exposure of the Mount Grace carbonatite in the Blais Creek area: (26A) note large clasts and crude layering; (26B) detail of overturned section with coarse blocky tephra at the stratigraphic base and layered fine-grained tuff and cale-silicate gneiss above (at bottom of photograph).
Plate 27. Exposures of the Mount Grace carbonatite at section H86CB22, Blais Creek area; note section is structurally inverted: (27A) coarse carbonatite tephra layer (CB22-11) near stratigraphic top of section (see Figure 25); (27B) interlayered marble (white) and fine-grained carbonatic tuff; Units CB22-13 at structural base to CB22-16 at top of photograph.
Plate 28. Photomicrographs of Mount Grace carbonatic (field of view = 1.8 millimetres, plane light): (28A) large subhedral porphyroblasts of phlogopite and apatite in a granoblastic calcite matrix; (28B) subhedral amphibole and smaller biotite porphyroblasts in calcite matrix.
Plate 29. Small, zoned pyrochlore grain with calcite and other unknown inclusions in calcite matrix. Mount Grace carbonatite; note apatite grain at top right (field of view = 1.8 millimetres, plane light).
INTRODUCTION

The Cottonbelt deposit, one of a number of somewhat similar stratabound lead-zinc deposits on the eastern side of the Shuswap Complex, is the most important mineral deposit in the Mount Grace area. It is an unusual lead-zinc-magnetite layer in calc-silicate gneiss near the base of Unit 6. Similar mineral occurrences in the area (Table 7; Figure 33) include small widely scattered occurrences of galena, chalcopyrite, pyrite and magnetite in calc-silicate gneiss and marble northeast of Cottonbelt. These are also near the base of Unit 6 and indicate the widespread occurrence of this style of mineralization at a common stratigraphic level. They include the Seymour and Blais occurrences (Table 7) and a number of unnamed occurrences further to the northeast. Disseminated copper sulphides in quartzite, the Copper King deposit, and molybdenite in an orthogneiss are the other metallic mineral occurrences in the area. High concentrations of rare earth elements are present in the Mount Grace carbonatite, an extrusive volcanic tuff unit described in Chapter 4. This chapter describes the metallic deposits and occurrences and compares them to other important lead-zinc deposits in the Shuswap Complex, collectively and informally termed the “Shuswap deposits”. The larger of these include Jordan River, Big Ledge, Colby, CK and Ruddock Creek.

The earliest record of exploration in the Mount Grace area dates back to 1905 when six claims were located on lead-zinc showings by Cotton Belt Mines, Ltd. Considerable work was done on these claims and on claims subsequently located on the McLeod and the Copper King showings from 1905 to 1911 (see Minister of Mines Annual Reports, 1905 to 1928). This work included extensive surface stripping and trenching, bulk sampling, driving of a number of shafts and tunnels along the lengths of the Cottonbelt and McLeod showings, and cutting a trail northward from Seymour Arm (with financial assistance from the British Columbia Ministry of Mines).

Work in the area appears to have been suspended in 1912 and did not begin again until 1922. By then, a 12-metre shaft had been sunk on the Bass showing and a 75-metre shaft on Cottonbelt. A 45-metre tunnel on the Copper King showing exposed “quartz ore” that contained chalcopyrite, pyrite, chalcopyrite, some native copper, and assayed 3.2 per cent copper, 20 grams silver per tonne and trace gold. Underground and surface work continued until 1928. By 1927, 15 buildings had been constructed in the Cottonbelt area (Plate 30) and approximately 500 metres of underground development (drifts, crosscuts and raises) and extensive surface stripping and open-cut work completed. Sixteen short diamond-drill holes put down in the summer of 1926 intersected almost continuous mineralization along a strike length of approximately 2 kilometres, at depths of 82 to 112 metres. Underground work continued through the winter of 1927-1928 and the summer of 1928, concentrating on tunnels that followed the sulphide-magnetite layer at elevations of approximately 1706 metres (No. 1), 1894 metres (No. 2), 1572 metres (No. 3) and 1493 metres (No. 4, Bass showing). The mineralized widths were variable, averaging less than a metre, grades were low and access to the Cottonbelt property was difficult resulting in suspension of work in 1929. Work was also suspended on the two other mineralized layers in the Cottonbelt camp, the “Complex-McLeod” layer a kilometre to the north and now recognized to be a structural repetition of the Cottonbelt layer, and the Copper King showing, a silver-copper deposit in quartzite stratigraphically above the Cottonbelt layer (Figure 33).

Recent work in the Cottonbelt area began in the early 1970s with surface geological mapping, trenching, an airborne magnetometer survey, and a VLF-electromagnetic survey by Great Northern Petroleum and Mines Ltd. The Copper King adit was reopened and retimbered. United Minerals
TABLE 7. MINERAL OCCURRENCES, MOUNT GRACE AREA

<table>
<thead>
<tr>
<th>Name</th>
<th>Most Recent Operator</th>
<th>Mineralogy</th>
<th>Deposit Type</th>
<th>Host</th>
</tr>
</thead>
<tbody>
<tr>
<td>COTTONBELT</td>
<td>1978 — Cyprus Anvil Mining Corp.;</td>
<td>sphalerite, galena,</td>
<td>massive, disseminated;</td>
<td>calcareous gneiss near base</td>
</tr>
<tr>
<td>82M-086</td>
<td>Metalgesellschaft Canada Ltd.</td>
<td>magnetite, pyrrhotite</td>
<td>stratabound</td>
<td>of Unit 6</td>
</tr>
<tr>
<td>COMPLEX-McLEOD</td>
<td>1978 — Cyprus Anvil Mining Corp.;</td>
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<td>massive, disseminated;</td>
<td>calcareous gneiss near base</td>
</tr>
<tr>
<td>82M-125</td>
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<td>stratabound</td>
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<tr>
<td>COPPER KING</td>
<td>1976 — G. Adam (owner)</td>
<td>chalcopyrite</td>
<td>disseminated</td>
<td>quartzite in Unit 6</td>
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<tr>
<td>82M-144</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BLAIS — 1</td>
<td>1978 — Cominco Ltd.</td>
<td>galena</td>
<td>disseminated</td>
<td>marble near base of Unit 6</td>
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<tr>
<td>82M-153</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEYMOUR</td>
<td>1978 — Dome Exploration Ltd.</td>
<td>chalcopyrite, galena,</td>
<td>disseminated</td>
<td>thin quartzite layer in marble</td>
</tr>
<tr>
<td>82M-155</td>
<td></td>
<td>sphalerite, magnetite</td>
<td>stratabound</td>
<td>in Unit 6</td>
</tr>
<tr>
<td>D &amp; R</td>
<td>1980 — R.D. Johnson (owner)</td>
<td>molybdenite</td>
<td>disseminated</td>
<td>orthogness in Unit 2</td>
</tr>
<tr>
<td>82M-200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BASS</td>
<td>1978 — Cyprus Anvil Mining Corp.;</td>
<td>sphalerite, galena,</td>
<td>massive, disseminated;</td>
<td>calcareous gneiss near base</td>
</tr>
<tr>
<td>82M-240</td>
<td>Metalgesellschaft Canada Ltd.</td>
<td>magnetite, pyrrhotite</td>
<td>stratabound</td>
<td>of Unit 6</td>
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<td>82M-241</td>
<td>new occurrence</td>
<td>chalcopyrite, magnetite</td>
<td>disseminated, pods</td>
<td>marble-gneiss contact near base of Unit 6</td>
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<tr>
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<td>small pods</td>
<td>impure marble near base of Unit 6</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>impure marble near base of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unit 6</td>
</tr>
</tbody>
</table>

Services Ltd., then acquired the claims adjoining the original Crown grant and these and others in the area (the Complex and Copper King properties) were remapped and sampled, and covered by magnetometer and induced polarization surveys in the period 1976 to 1978 in a joint venture with Metalgesellschaft Canada Ltd. As well, two holes totalling 517 metres in length were drilled in an attempt to intersect the mineralization in the core of the Mount Grace syncline between the Bass and Cottonbelt showings to the south and the McLeod to the north. It was unsuccessful and only a thin (a few metres) mineralized interval was encountered in the upper, western limb. There has been little subsequent work in the Cottonbelt area.

The small showings in the Blais Creek area (Figure 33) have received little attention. Only a few small pits mark the Seymour and Blais showings, and there is no record of work (other than surface mapping or sampling) in the vicinity of the other occurrences.

**COTTONBELT (MI 82M-086)**

**INTRODUCTION**

The Cottonbelt deposit is a thin calcareous layer, containing substantial quantities of galena, sphalerite and magnetite, on the west limb of the Mount Grace syncline. The sulphide-magnetite layer can be traced northward several kilometres where it is referred to as the Bass occurrence, and is repeated on the east limb of the syncline where it is known as the McLeod and Complex showings (Figure 33). These deposits are exposed on the gentle subalpine to tree-covered slopes of Mount Grace, at elevations ranging from approximately 1000 to 1900 metres (3300 to 6300 feet). They are accessible by a well-cut “pack trail” that leads northward from Seymour Arm or by a climb from the Ratchford Creek logging road to the south. The nearest permanent helicopter base is at Revelstoke, 60 kilometres to the south.

Although the general geology of the map area is outlined in Chapters 2 and 3, it is reviewed again as an introduction to the geology of the Cottonbelt deposit.

**STRATIGRAPHY**

The stratigraphic succession in the vicinity of the Cottonbelt deposit is repeated on both limbs of the Mount Grace syncline. It comprises a thick basal quartzite (Unit 3) that overlies the core paragneiss and orthogness, a sequence of calcareous and pelitic schists of Unit 4 (host to the Mount Grace carbonatite), a grey/weathering, white crystalline marble (Unit 5) and dominantly micaceous schist, calc-silicate gneiss and quartzite of Unit 6 (Figure 34). The Cottonbelt layer occurs near the base of Unit 6.

A number of detailed sections through the Cottonbelt deposit is illustrated in Figure 35. Unit 4e, a calcareous section at the top of Unit 4, includes interlayered dark grey, rusty weathering calcareous and micaceous quartzite, quartz-rich micaceous schist, fairly coarse-grained kyanite and sillimanite schist, dark to light green diopside garnet calc-silicate gneiss, and a thin grey/weathering calcite marble layer (see section CB4-3, Figure 35). The Mount Grace carbonatite occurs 8 metres below the base of Unit 5. A coarse-grained pegmatite and a fine-grained quartzfeldspar orthogness occur between the carbonatite and the top of Unit 4. In the drill intersections (Figure 36), hornblende gneiss and a few amphibolite layers occur near the stratigraphic top of Unit 4 and a thin, fine-grained green chlorite amphibolite schist layer occurs immediately below the marble of Unit 5. These amphibolite-rich layers are interpreted as basic volcanic flows and tuffs, correlative with massive amphibolites that occur in the Blais Creek section to the north (Unit 4d, Figure 24).
Unit 5, a grey-weathering, white crystalline calcite marble, with thin dolomite and actinolite-rich layers that weather in relief, is 5 metres thick in section CB4-3. It is overlain by a dominantly calcareous succession (Unit 6a) at the base of Unit 6. Unit 6a includes interlayered sillimanite schist and light grey to green scapolite-bearing calc-silicate gneiss, a prominent, crumbly, grey to light brown-weathering impure dolomitic marble, and the Cottonbelt sulphide-magnetite layer. Very thin chert layers occur stratigraphically above the Cottonbelt layer. Calc-silicate gneiss occurs above the sulphide-magnetite layer at the top of Unit 6a in section CB4-3 and CB4-4, but sillimanite schist stratigraphically overlies it in section CB4-2 (Figure 35). Interlayered sillimanite schist, quartz feldspar gneiss, thin chert and impure quartzite layers of Unit 6b overlie Unit 6a.

STRUCTURE

The structure of the Cottonbelt area is dominated by the Mount Grace syncline, an early Phase 1 isoclinal recumbent fold that is draped around the northwestern margin of Frenchman Cap dome (Figures 2 and 3). The youngest rocks in the Cottonbelt area, schist and gneiss of Unit 6a, are...
TABLE 8. BASE METAL AND PRECIOUS METAL VALUES OF COTTONBELT SAMPLES

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Lab. No.</th>
<th>Description</th>
<th>Pb %</th>
<th>Zn %</th>
<th>Au ppm</th>
<th>Ag ppm</th>
<th>Cu %</th>
<th>Cd ppm</th>
<th>Fe %</th>
<th>Mo ppm</th>
<th>Co ppm</th>
<th>Cl ppm</th>
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<tbody>
<tr>
<td>CB4-1</td>
<td>20025</td>
<td>1</td>
<td>4.45</td>
<td>0.27</td>
<td>&lt;1.0</td>
<td>30</td>
<td>0.0125</td>
<td>25</td>
<td>34.4</td>
<td>13</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>CB4-2</td>
<td>20026</td>
<td>1.5</td>
<td>7.81</td>
<td>0.87</td>
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<td>78</td>
<td>0.0155</td>
<td>55</td>
<td>18.3</td>
<td>14</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>CB4-3</td>
<td>20027</td>
<td>1.5</td>
<td>11.25</td>
<td>1.03</td>
<td>&lt;1.0</td>
<td>65</td>
<td>0.0070</td>
<td>60</td>
<td>19.1</td>
<td>16</td>
<td>7</td>
<td></td>
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<tr>
<td>CB4-4B</td>
<td>20028</td>
<td>1.5</td>
<td>4.18</td>
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<td>23</td>
<td>0.0050</td>
<td>170</td>
<td>23.8</td>
<td>10</td>
<td>10</td>
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<tr>
<td>CB4-4C</td>
<td>20029</td>
<td>1.5</td>
<td>6.75</td>
<td>1.40</td>
<td>&lt;1.0</td>
<td>52</td>
<td>0.0060</td>
<td>87</td>
<td>30.0</td>
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<td>7</td>
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<td>CB7</td>
<td>25528</td>
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<td>0.52</td>
<td>5</td>
<td>0.014</td>
<td>34.8</td>
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<td></td>
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<td>CB5-9</td>
<td>25529</td>
<td>5</td>
<td>8.2</td>
<td>3.90</td>
<td>78</td>
<td>0.0025</td>
<td>26.0</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>&lt;3</td>
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<td>25530</td>
<td>1</td>
<td>3.8</td>
<td>0.20</td>
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<td>0.0025</td>
<td>35.95</td>
<td>5</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Description:
1 — Massive magnetite, sulphides with siliceous gangue.
2 — Marble with disseminated sulphides ± magnetite.
3 — Calcareous gneiss with disseminated sulphides ± magnetite.
4 — Black, graphitic schist, minor magnetite, sulphides.
5 — Dark green, massive, siliceous “skarn” with magnetite, sulphides.

* Basal occurrence.

Exposed in its core, and the calcareous succession that hosts the Cottonbelt deposit and the Mount Grace carbonate layer are repeated in its limbs.

Metallgesellschaft Canada Ltd. attempted to drill the Cottonbelt-McLeod sulphide-magnetite layer in the hinge of the Mount Grace syncline (Wellmer, 1978). However, mineral lineations and minor folds indicate that the fold plunges west to southwest (see Chapter 3) and its closure is therefore located south of Cottonbelt; hence the two holes drilled (Figure 36) penetrated only the inverted upper limb of the fold.

MINERALIZATION

INTRODUCTION

The Cottonbelt sulphide-magnetite layer has been traced or projected on surface for approximately 2.5 kilometres along the upper western limb of the Mount Grace syncline and a thin mineralized interval has been intersected in drill holes a further 2 kilometres to the north. The thickness of the layer varies from 15 centimetres in the drill intersections to a maximum of approximately 3 metres, with average widths of 1 to 2 metres (Plate 31). Geological reserves are estimated at approximately 725 000 tonnes containing 6 per cent lead, 5 per cent zinc and 50 grams silver per tonne. Northwest of Blais Creek, a zone of rusty weathering calcareous schist occurs at approximately the same stratigraphic interval.

The sulphide-magnetite layer in the northeast limb of the Mount Grace syncline, referred to as the McLeod and Complex showings and interpreted to be a fold repetition of the Cottonbelt deposit, is up to 3 metres thick and has been traced approximately 600 metres along strike. It continues for an additional 2000 metres to the southeast as a zone of disseminated pyrrhotite in calcareous gneiss (Kovacic, 1977). It is described in more detail following.

SULPHIDE-MAGNETITE MINERALIZATION

Three types of mineralization are evident in the Cottonbelt deposit. The most abundant is massive to crudely banded, dark green, hard, massive olivine-pyroxene-amphibole calc-silicate gneiss containing variable amounts of sphalerite, galena and magnetite, minor pyrrhotite, and traces of clino-opyrite, pyrite, tetrahedrite and molybdenite (Plate 32). Additional gangue minerals include biotite, carbonate and apatite. Sulphides and magnetite are generally medium to coarse grained and may be closely intergrown or segregated into essentially monominerallic layers or magnetite-sphalerite and sphalerite-galena layers a few millimetres thick. In general, however, the rock is massive and layering is only poorly developed. With an increase in silicate content, the mineralized layer becomes lighter coloured and layering is more pronounced. Thin sulphide-magnetite layers, mineralogically similar to the massive layers, occur interbedded
with thin bands of garnet-diopside calc-silicate and sillimanite schist. The third type of mineralization consists of disseminated galena and sphalerite with only minor magnetite and pyrrhotite in a light grey granular marble (Plate 32). Accessory minerals in the marble include garnet, diopside, actinolite and phlogopite.

Detailed sections through the Cottonbelt zone (Figure 37) illustrate the well-layered nature of the deposit, with massive to bedded sulphides and magnetite interlayered with calc-silicate gneiss, sillimanite gneiss, impure marble and amphibolite. Immediate hangingwall and footwall rocks are most commonly calc-silicate gneiss or impure marble. Sillimanite schist or biotite gneiss that commonly overlies the mineralization are invariably separated from the sulphide layer by a thin selvage of amphibolite or calc-silicate gneiss.

Chemical analyses of both chip and selected grab samples of the Cottonbelt layer are shown in Tables 8 and 9. Samples are located in Figure 34 and some are plotted on the sections in Figure 35. Gangue mineralogy and oxide chemistry are discussed in the section following.

Table 8 shows the highly variable tenor of the sulphide-magnetite layer, largely reflecting the variable nature of the samples, including marble and calc-silicate gneiss with disseminated sulphides, magnetite-rich silicates and massive magnetite and sulphides. Lead analyses vary from 0.05 to 16.4 per cent, zinc from approximately 0.02 to 3.9 per cent, and silver from 10 to 94 ppm. Copper is generally low, with only one analysis approaching 1 per cent. Base metal ratios are also highly variable. Pb/Pb + Zn ratios vary from 0.04 to 0.98 with approximately 40 per cent in the range 0.90 to 0.98.

These metal values and ratios, with relatively high lead and low copper, are more typical of carbonate-hosted than clastic-hosted lead-zinc deposits (Sangster, 1968). However, the unusual gangue mineralogy and chemistry distinguish Cottonbelt from these deposits.
TABLE 9A. MAJOR ELEMENT ANALYSES (A) AND TRACE ELEMENT VALUES (B) OF COTTONBELT SAMPLES

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Lab. No.</th>
<th>Description</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>TiO₂</th>
<th>MnO</th>
<th>P₂O₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB1-5</td>
<td>30318</td>
<td>1</td>
<td>14.31</td>
<td>1.55</td>
<td>55.42</td>
<td>6.92</td>
<td>1.48</td>
<td>0.02</td>
<td>0.009</td>
<td>0.08</td>
<td>2.12</td>
<td>0.02</td>
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<tr>
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<td>15.25</td>
<td>1.20</td>
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<td>5.92</td>
<td>1.68</td>
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<td>0.020</td>
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<td>2</td>
<td>11.75</td>
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<td>11.50</td>
<td>26.59</td>
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<td>0.37</td>
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<td>30322</td>
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<td>18.72</td>
<td>4.91</td>
<td>1.22</td>
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<td>0.026</td>
<td>0.08</td>
<td>7.98</td>
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<tr>
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<td>48.22</td>
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<td>4.62</td>
<td>11.46</td>
<td>0.47</td>
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Description:
1. Massive magnetite, sulphides with siliceous gangue.
2. Marble with disseminated sulphides ± magnetite.
3. Calcareous gneiss with disseminated sulphides ± magnetite.
4. Black, graphitic schist, minor magnetite, sulphides.
5. Dark green, massive, siliceous "skarn" with magnetite, sulphides.

* Bass occurrence.

TABLE 9B (in ppm except as noted)

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<th>Rb</th>
<th>Sr</th>
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**GANGUE MINERALOGY AND CHEMISTRY**

Major element analyses of the Cottonbelt sulphide-magnetite layer (Table 9A) are highly variable reflecting host rocks that range from impure marble to calc-silicate gneiss. Aikali content is low, generally less than 1 per cent, although one sample of calc-silicate gneiss containing abundant plagioclase, CB4-2B, returned 5 per cent K₂O. CaO varies from approximately 1 per cent in essentially massive sulphide-magnetite samples that have only minor gangue minerals, to greater than 25 per cent in mineralized marbles. A common and distinctive feature of the mineralized layer is the high MnO content, ranging from 1.4 to 13.28 per cent (Table 9A).

Gangue minerals are unusual as they reflect the high manganese content and overprinting of regional metamorphism to upper amphibolite facies. Recognition and identification of these gangue minerals are by standard petrography and X-ray diffraction analyses. Silicate minerals include varying proportions of knabelite (a magnesium olivine), actinolite, diopside and a magnesian pyroxene, spessartite, biotite and minor secondary chlorite. Ankerite is the dominant carbonate, but minor calcite and kuthnaborite, a calcium-manganese carbonate, have also been identified. Accessory minerals include epidote, plagioclase, graphite, garnet and hematite.

A dark green massive olivine is the dominant silicate gangue mineral in many massive sulphide samples. X-ray diffraction analysis indicates it is a manganese fayalite and its optical properties indicate a composition that approximates (Fe₁₀₋₈₃,Mn₁₀₋₂₄,Mg₂₋₂₄)₂SiO₄ (Johnson, 1980a) and, as such, it is called knabelite. Knabelite is a distinctive mineral in metamorphosed iron-manganese deposits. It also occurs as gangue in massive sulphide deposits at the Bluebell silver-lead-zinc deposit in the Kootenay Arc (Höy, 1980b). Pyroxenes include diopside, hedenbergite, a manganese-rich mag-
nesium clinopyroxene called kanoite, and less commonly a manganiferous orthopyroxene, cullite (Johnson, 1980a). Kanoite has been recognized in metamorphosed manganiferous ore in Japan (Kobayashi, 1977) and cullite is reported in some regionally metamorphosed iron-rich sediments (Deer et al., 1978). Actinolite is the dominant amphibole and in some samples is the dominant silicate mineral. Cummingstonite (grunerite?), containing minor manganese, may also be abundant. Porphyroblasts of spessartine-almandine garnet occur in most calc-silicate gneiss host rocks, and biotite occurs as a minor phase in both mineralized impure marble and calc-silicate gneiss. Epidote is uncommon, but was recognized as a minor phase in a mineralized calc-silicate gneiss. Rare plagioclase grains and retrograde chlorite occur in a few samples.

The most common and abundant carbonate mineral associated with the massive sulphides is ankerite. Kuntharorite commonly occurs with ankerite, and calcite is abundant in mineralized marble, but is a minor constituent of the massive sulphide-magnetite mineralization.

**Metamorphism**

The Cottonbelt mineralized layer has undergone the regional amphibolite grade metamorphism that has affected the country rocks. The prevalent mineral assemblages are graphically displayed on an ACF diagram (Figure 38). These assemblages, and the extensive solid solution among minerals, are diagnostic of amphibolite grades in manganiferous iron formations (Haase, 1982). The compositional ranges depicted on the diagram are schematic but reasonable: they are based on ranges typically occurring in these phases at these metamorphic grades. The diagram, however, only depicts two and three-phase mineral assemblages. The common occurrence of four, and less commonly five-phase assemblages (for example, olivine, amphibole, actinolite, diopside and garnet) is likely the result of extensive solid solution among the minerals and the effect of additional components (such as MnO) in the system.

**Depositional Environment**

An understanding of the depositional environment is only possible if the original mineralogy of the Cottonbelt layer can be determined. Premetamorphic assemblages are not known as the layer occurs only within rocks of amphibolite grade. This metamorphism has totally recrystallized and annealed the mineral assemblages, masking any original depositional textures. Determination of the pre-metamorphic mineralogy requires comparison with iron formations and sulphide deposits that occur at lower metamorphic grades.

The most common oxide facies of iron formations are haematite and magnetite. Magnetite may be a primary phase (Klein and Bäkk, 1977), but is more likely formed during diagenesis (Dimroth and Chauvel, 1973), or during regional metamorphism from a reaction involving siderite or haematite. It is unlikely that magnetite in the Cottonbelt deposit formed from an iron sulphide because other massive sulphide bodies in the Shuswap Complex have retained their sulphide (pyrite-pyrrhotite) assemblages at high metamorphic grades (for example, Jordan River, Fyles, 1970a; Big Ledge, Hoy, 1977a). It is assumed, therefore, that magnetite in the Cottonbelt deposit formed early, probably during diagenesis.

The most abundant carbonate in the deposit is ankerite. Ankerite is common in iron formations and is therefore assumed to be formed early and later recrystallized at Cottonbelt. Dolomite is now rare, but was probably more abundant initially, providing a source of magnesium; subsequent metamorphism has converted it and available silica to calcite and calcareous and magnesian silicates. Calcite was undoubtedly present as a primary mineral in the calcite marbles that host disseminated sulphides and magnetite. Kuntharorite, a manganiferous carbonate, may be a metamorphic mineral formed from a reaction involving either a manganese oxide or manganiferous carbonate such as rhodochoresite with calcite or dolomite.

The two more important sulphide minerals, galena and sphalerite, are common in many unmetamorphosed mineral deposits and are assumed to have been present at Cottonbelt before metamorphism. The metamorphic silicate minerals diopside, actinolite, cummingstonite, knebelite and spessartine formed from reactions between aluminous clays or detrital minerals, calcareous and magnesian carbonates, and manganiferous oxides or carbonates.

In summary, pre-metamorphic minerals are inferred to include dominantly magnetite (or perhaps haematite) and minor pyrite, galena, sphalerite and chalcopyrite. Carbonates included ankerite, probably dolomite, and perhaps a manganese carbonate. Calcite may only have been present in calcareous layers that host disseminated sulphides and magnetite. Clay minerals and perhaps detrital feldspars were the source of aluminium, and silica may have been present as iron silicates such as greensite or as chert; thin chert layers in adjacent beds suggest some precipitation of silica, but deposition during formation of the sulphide-magnetite layer was
by graphite. It is therefore concluded that the Cottonbelt sulphide-magnetite layer was deposited directly on the seafloor, in a shallow restricted, perhaps lagoonal basin on a large carbonate-clastic platform.

Volcanism may have been an important factor as the ultimate source of iron and manganese in the deposit and in the generation of a convective hydrothermal system. Basic volcanic rocks occur beneath the projected position of the mineralized horizon north of Blair Creek. The unusually high lead and zinc content, generally characteristic of sedimentary exhalative deposits rather than volcanogenic deposits or iron formations, probably results from scavenging of these metals from the thick underlying accumulation of sedimentary rocks.

CONCLUSIONS

The spatial association of base metals with iron formations is commonly recognized in volcanogenic massive sulphide deposits. Less commonly, iron formations have been described as distal equivalents of lead-zinc deposits. In Ireland, the Tynagh iron formation is believed to have formed as an exhalite in the laterally equivalent Waulsortian mud bank deposits during deposition of the Tynagh lead-zinc-copper-barite deposit (Russell, 1975), and in southwestern Quebec, magnetite-rich iron formations are correlative with stratiform lead-zinc deposits in the Grenville Province (Gauthier and Brown, 1986). Stratabound galena-sphalerite-magnetite deposits similar to Cottonbelt, or iron formations enriched in lead and zinc are uncommon. Gamsberg in South Africa is a stratiform sphalerite-galena-magnetite deposit that has undergone amphibolite facies regional metamorphism (Rozeadaal and Stumpfl, 1984). The La Union lead-zinc orebody in southeastern Spain (Oen et al., 1975) consists in part of disseminated to banded galena, sphalerite and pyrite in a "greentinite-silica/magnetite rock" or banded iron formation (D.J. Alldrick, personal communication, 1986). Alldrick suggests the deposit may be a "primary chemical precipitate" rather than "subvolcanic-hydrothermal" as suggested by Oen et al. (op. cit.).

The unusual association of magnetite rather than pyrite with galena and sphalerite in this deposit type is a function of conditions in the depositional environment. Magnetite deposition is favoured in a basic, reducing environment as would occur in a restricted, highly saline, shallow-marine or lagoonal basin. Furthermore, the availability of sulphur from reduction of seawater sulphate would also be limited in a restricted basin, tending to support magnetite rather than pyrite formation; available sulphur reacts initially with lead and zinc and only excess sulphur is available to react with iron to form pyrite. In basins more typical of base metal deposition, lower Pb, higher Eh, and an increased availability of sulphur allows deposition of iron sulphides producing the typical pyrite-galena-sphalerite association.

BASS

The Bass occurrence is the northwestern extension of the Cottonbelt layer (Figure 33), and as such is chemically and mineralogically similar to Cottonbelt. An adit at 161.5 metres elevation exposes approximately 1.5 metres of massive, siliceous magnetite-sulphide mineralization. It comprises mag-
TABLE 10. ANALYSES OF SAMPLES OF THE McLEOD LAYER AT THE McLEOD ADIT

(See Figure 40 for location.)

<table>
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<tr>
<th>Sample No.</th>
<th>Mineralization</th>
<th>Pb %</th>
<th>Zn %</th>
<th>Ag g/t</th>
<th>Cu %</th>
<th>Fe %</th>
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netite, galena, sphalerite, minor pyrrhotite, pyrite and chalcopyrite. Analyses of a selected grab sample (CB5-14. Table 8) returned 3.8 per cent lead and 0.20 per cent zinc. The high iron (36 per cent) reflects the high magnetite content. The hangingwall and footwall are siliceous marble, 30 centimetres thick, then calc-silicate gneiss. The layer strikes 160 degrees and dips 40 degrees west.

**McLEOD AND COMPLEX (MI 82M-125)**

The McLeod, and its extension to the northwest referred to as the Complex showing, are a repetition of the Cottonbelt layer on the east limb of the Mount Grace syncline. It has been described by various authors, including Boyle (1970), Kovacik (1977) and Shearer (1985); the following description is summarized from these reports.

Mineralization is similar to Cottonbelt, dominantly magnetite with galena, sphalerite, and minor chalcopyrite, pyrrhotite and pyrite in a layer up to several metres thick. In contrast with Cottonbelt, however, the mineralized zone is part of a right-way-up stratigraphic succession that strikes approximately 155 degrees and dips 40 degrees southwest.

The McLeod-Complex layer overlies a white crystalline marble and a fine-grained, rusty weathering biotite schist (Figure 40). Hangingwall rocks include a thin marble band and calc-silicate gneiss followed by more than 30 metres of interlayered biotite schist and calc-silicate gneiss. Elsewhere, biotite schist directly overlies the mineralized layer (Kovacik, 1977).

The mineralization averages 1.5 metres thickness and can be traced 100 metres southeast of the McLeod adit before it is replaced by disseminated iron sulphides in calc-silicate gneiss (Boyle, 1970; Kovacik, 1977). The disseminated sulphide facies can be traced a further 2200 metres to the southeast. It is not traceable to the northwest, although the footwall limestone continues to Blais Creek (Boyle, 1970).

The most recent extensive sampling of the McLeod-Complex layer, 21 surface chip samples along the exposed length of the zone, returned an average of 5.37 per cent lead, 6.51 per cent zinc and 97 grams silver per tonne across an average width of 1.4 metres (Allen, 1966). Analyses of two samples from the McLeod adit (see Figure 40) are summarized in Table 10. More massive magnetite-sulphide mineralization near the base of the layer contains 4.8 per cent lead, 0.1 per cent zinc and 86 grams silver per tonne; a sample of disseminated mineralization in more calcareous gneiss near the top of the layer returned considerably lower values.

**COPPER KING (MI 82M-144)**

The Copper King deposit is hosted by quartzite of Unit 6 in the core of the Mount Grace syncline, south of the McLeod adit (Figure 33). The quartzite is interlayered with thin beds of marble and micaceous schist. It is overlain by interbedded light grey quartz feldspar paragneiss and micaceous schist and underlain by schist. Mineralization, comprising disseminated chalcopyrite and minor bornite, sphalerite and pyrite, ranges up to 3 metres in thickness and has been traced along strike for at least 300 metres. An adit 50 metres in length driven along a more extensively mineralized portion of the zone was reopened and resampled in 1970 (see Boyle, 1970; Table 11); additional analyses of the Copper King mineralization (Allen, 1966) are also presented in Table 11.

**SEYMOUR (MI 82M-155)**

Mineralization on the Seymour claims was discovered in 1978 during a follow-up exploration program of silt and soil geochemical anomalies (Woodcock and Booth, 1978). It includes a number of small occurrences of sulphides and magnetite within or adjacent to a marble layer south of Blais Creek (Figures 3 and 33). Its stratigraphic position, near the base of Unit 6, and its mineralogy suggest that these occurrences and their extension north of Blais Creek may be distal equivalents of the Cottonbelt and McLeod-Complex layer. Descriptions of the occurrences are taken from Woodcock and Booth (1978); only occurrence 155c (Figure 3) has been visited by the author.

**Showing 155a** comprises disseminated chalcopyrite in a quartz-marble breccia bed 10 centimetres thick. Observed mineralization is restricted to a number of boulders at the base of a small cliff. A specimen assayed 1.02 per cent copper.

**Showing 155b** is a 10-centimetre-thick quartzite layer adjacent to a marble bed that contains minor disseminated chalcopyrite. A galena-rich section 2 metres long assayed 16.1 per cent lead and 0.8 per cent zinc.

**Showings 155c and 155d** are along a discontinuous lens of coarse-grained magnetite, garnet and hornblende. Showing 155c has a maximum thickness of 30 centimetres and a possible length of 15 metres; a sample across the lens contained 0.05 per cent zinc, 175 ppm copper and 38 ppm lead. Showing 155d is 25 centimetres thick, possibly 10 metres long and assayed 0.04 per cent zinc, 740 ppm copper and trace lead.

**TABLE 11. ANALYSES OF THE COPPER KING DEPOSIT**

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<th>Sample No.</th>
<th>Sample Width</th>
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<td>~0.15</td>
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Showing 155e is a lens of quartzite 15 centimetres thick and 1 metre long that contains a few coarse grains of chalcopyrite and galena.

BLAIS (MI 82M-153)

The Blais occurrence, and a number of similar occurrences to the northeast (Figure 33), are at approximately the same stratigraphic level as the Seymour showings. Blais consists of a carbonate lens with disseminated galena approximately 15 centimetres thick and up to 20 metres in length (Woodcock and Booth, 1978).

OCCURRENCE CB14-9 (MI 82M-240)

This occurrence consists of magnetite and minor chalcopyrite, marked by conspicuous malachite staining, in a very rusted zone approximately 20 centimetres thick at the contact of a marble and calc-silicate gneiss. A small pit, filled with snow at the time of the author’s visit (July 1978), indicates previous exploration of the zone.

OCCURRENCE CB14-12 (MI 82M-242)

This occurrence, approximately 300 metres east of CB14-9 (MI 82M-240, Figure 33), comprises a 15 to 20-centimetre-thick interval of minor chalcopyrite and magnetite mineralization, associated with hornblende, near the top of the coarse-grained white crystalline marble.

OCCURRENCE CB16-2 (MI 82M-241)

Occurrence CB16-2 includes a number of small rusty zones within the coarse crystalline marble. The zones contain chalcopyrite, magnetite and pyrrhotite in a siliceous matrix that includes pyroxene, garnet, amphibole and fayalite, an iron-rich olivine.

D & R (MI 82M-200)

The D & R occurrence consists of minor disseminated molybdenite in a quartz syenite orthogneiss within rocks correlated with core gneisses (Figure 33). It is similar to a small molybdenite showing in syenite orthogneiss in the Perry River area (see Chapter 4). The host syenite (Figure 3) has a maximum exposed width of about 200 metres and a strike length of at least 1300 metres. Petrographic descriptions of the syenite (Johnson, 1980b) indicate it consists mainly of feldspar (35 to 55 per cent), perthite (up to 50 per cent), and plagioclase (30 to 50 per cent) with minor biotite and less than 5 per cent quartz. It is conformable with host hornblende and pelitic paragneisses.

Molybdenite mineralization appears to be restricted to an area of approximately 4 square metres near the structural base of the orthogneiss. Three assays of the mineralization returned 0.10 per cent, 0.65 per cent and less than 0.01 per cent MoS₂ (Johnson, 1980a).
SHUSWAP MASSIVE SULPHIDE DEPOSITS
INTRODUCTION

A number of large stratound lead-zinc deposits occur within dominantly calcareous successions along the margins of Frenchman Cap dome and Thor-Odin nappe to the south (Figure 41). Although a number of these have been extensively explored, there has been no significant production from them. They are thin but very extensive laterally, are commonly structurally complex, and many are in formidable mountainous terrain. These deposits, and others within the complex (Table 12), consist of a single layer of massive to irregularly banded sulphides or a series of lenses generally within thin calcareous or graphicitic schist units. They are folded and metamorphosed together with their host rocks.

The Cottonbelt and Jordan River deposits are in paragneiss that overlies core gneiss of Frenchman Cap dome. Raddock Creek, located approximately 40 kilometres north of Cottonbelt (Figure 41), is also within a highly deformed, dominantly calcareous succession that structurally overlies the Cottonbelt and Jordan River succession. Big Ledge, located 60 kilometres south of Revelstoke, along the southern margin of Thor-Odin nappe, is within a paragneiss succession that correlates approximately with the Cottonbelt succession. Other stratound lead-zinc deposits within the Shuswap Complex include Colby and CK; the Rift deposit north of Revelstoke is similar to the Shuswap deposits although it occurs just east of the Columbia River fault.

JORDAN RIVER (MI 82M-001)

A sulphide-rich layer less than a metre to 6 metres in thickness forms part of the lithological sequence in the Jordan River area (Fyles, 1970a) on the southern margin of Frenchman Cap dome (Figure 41). On the Jordan River (King Fissure) property, it is exposed in the limbs and hinge of the tight south to southeast-plunging Copeland synform. Reserves in the south limb have been calculated as 2.6 million tonnes containing 5.1 per cent lead, 5.6 per cent zinc and 35 grams silver per tonne (see Fyles, op. cit.).

The mineralized bed consists most commonly of a “fine-grained intimate mixture of sphalerite and pyrrhotite with conspicuous eye-shaped lenses of grey, watery quartz and scattered grains of pyrite and galena” (Fyles, op. cit., page 41). Locally, it is well layered and includes minor pods and lenses of calc-silicate gneiss, schist, marble or barite. It is within a calcareous succession of calc-silicate gneiss, micaceous schist, marble and quartzite, and is structurally overlain by a quartzite-rich succession followed by a silimanite gneiss unit.

Correlation of this succession along the western margin of Frenchman Cap dome (Höy and McMillan, 1979; Höy and Brown, 1981) indicates that the Jordan River sulphide layer lies within Unit 6 at approximately the same stratigraphic level as the Cottonbelt deposit (see also Figure 8).

RÜDDOCK CREEK (MI 82M-083)

Raddock Creek (Figure 41) is a sulphide layer up to 15 metres thick that comprises interlayered calcareous quartzite, marble and minor schist with one or more layers or lenses of locally contorted sulphides and quartz, and lenses of fluorite and barite (Fyles, 1970a). It is exposed or projected several kilometres in strike length. Locally it has been thickened in the hinge of a Phase 1 isoclinal syncline and here it is referred to as the E showing. Estimated reserves in the E showing by Falconbridge Nickel Mines Ltd. are approximately 5 million tonnes containing 2.5 per cent lead, 7.5 per cent zinc and trace silver. Mineralization consists of massive sphalerite, pyrrhotite, galena, pyrite and minor chalcopyrite that commonly contains rounded quartz eyes, and as scattered grains of galena and sphalerite in marble, calcareous quartzite and fluorite (Fyles, op. cit.).

The sulphide layer is in a succession of calcareous schist, quartzite and impure marble above the Monashee décollement and autochthonous cover succession that hosts Cottonbelt. Although its age is unknown, it has been tentatively correlated with the Hadrynian Windermere Group (R.L. Brown, personal communication, 1985). The succession is highly deformed, metamorphosed to amphibolite grade, and extensively invaded by pegmatite.

BIG LEDGE (MI 82LSE-012)

Big Ledge is a stratound zinc deposit contained in mantling gneisses of Thor-Odin dome, 60 kilometres south of Revelstoke (Figure 41) (Reesor and Moore, 1971: Read, 1979). It is hosted by a rusty weathering, calcareous graphitic schist interlayered with calcareous quartzite, calc-silicate gneiss and marble (Höy, 1977a). Within the schist, referred to as the “Ledge”, are lenses of massive, medium to coarse-grained pyrite or pyrrhotite with variable amounts of dark sphalerite. Sulphides are also disseminated throughout the schist, and occur in discontinuous laminations 1 to 2 millimetres thick and in small fractures crosscutting the layering and foliation (Höy, 1977a).

**Table 12. Stratound Lead-Zinc Deposits in the Shuswap Complex**

<table>
<thead>
<tr>
<th>Name</th>
<th>Estimated Reserves*</th>
<th>Deposit Type</th>
<th>Dominant Host Rocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonbelt</td>
<td>0.7; 6% Pb, 5% Zn, 50 g/t Ag</td>
<td>stratound layers</td>
<td>calcareous gneiss</td>
</tr>
<tr>
<td>Jordan River</td>
<td>2.6; 5.1% Pb, 5.6% Zn, 35 g/t Ag</td>
<td>stratound layers, lenses</td>
<td>calcareous gneiss, barite</td>
</tr>
<tr>
<td>Raddock Creek</td>
<td>~5.0; 2.5% Pb, 7.5% Zn, tr Ag</td>
<td>stratound lenses, layers</td>
<td>marble, quartzite, barite</td>
</tr>
<tr>
<td>Big Ledge</td>
<td>6.5; 4% Zn</td>
<td>disseminated, lenses</td>
<td>graphitic schist</td>
</tr>
<tr>
<td>Colby</td>
<td>~1.0; 7% Zn, &lt;1% Pb</td>
<td>disseminated, lenses</td>
<td>marble, quartzite, calcareous gneiss</td>
</tr>
<tr>
<td>CK</td>
<td></td>
<td>stratound layer</td>
<td>calcareous gneiss</td>
</tr>
<tr>
<td>Rift</td>
<td>~2, 29% Zn, 5% Pb</td>
<td>stratound layer, lenses</td>
<td>calcareous gneiss</td>
</tr>
</tbody>
</table>

* In million tonnes.
TABLE 13. ANALYSES OF MINERALIZED SAMPLES FROM THE COLBY DEPOSIT

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Rock Type</th>
<th>Zn %</th>
<th>Pb %</th>
<th>Cu %</th>
<th>Cd ppm</th>
<th>Ag ppm</th>
<th>Au ppm</th>
<th>Showing</th>
</tr>
</thead>
<tbody>
<tr>
<td>14311</td>
<td>marble</td>
<td>5.8</td>
<td>0.11</td>
<td>tr</td>
<td>tr</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>14312</td>
<td>quartzite</td>
<td>22.1</td>
<td>6.6</td>
<td>0.015</td>
<td>0.025</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>14313</td>
<td>marble</td>
<td>0.34</td>
<td>0.04</td>
<td>tr</td>
<td>—</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>14314</td>
<td>marble</td>
<td>6.3</td>
<td>0.27</td>
<td>tr</td>
<td>tr</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>14315</td>
<td>marble</td>
<td>7.7</td>
<td>0.70</td>
<td>tr</td>
<td>tr</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>14316</td>
<td>marble</td>
<td>11.3</td>
<td>0.98</td>
<td>tr</td>
<td>tr</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Mile 12</td>
</tr>
<tr>
<td>14317</td>
<td>marble</td>
<td>5.3</td>
<td>0.49</td>
<td>tr</td>
<td>tr</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Mile 12</td>
</tr>
<tr>
<td>14318</td>
<td>quartzite</td>
<td>1.58</td>
<td>0.12</td>
<td>0.015</td>
<td>tr</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>14319</td>
<td>marble</td>
<td>0.88</td>
<td>0.06</td>
<td>0.015</td>
<td>&lt;0.005</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>14320</td>
<td>marble</td>
<td>7.2</td>
<td>0.31</td>
<td>0.015</td>
<td>tr</td>
<td>&lt;3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>16269</td>
<td>calc-silicate gneiss</td>
<td>1.3</td>
<td>0.2</td>
<td>0.007</td>
<td>0.002</td>
<td>3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>16270</td>
<td>marble</td>
<td>3.3</td>
<td>0.3</td>
<td>0.005</td>
<td>0.002</td>
<td>4</td>
<td>&lt;0.3</td>
<td>Mile 12</td>
</tr>
<tr>
<td>16271</td>
<td>marble</td>
<td>8.9</td>
<td>0.96</td>
<td>0.005</td>
<td>0.006</td>
<td>3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>16272</td>
<td>quartzite</td>
<td>8.5</td>
<td>8.5</td>
<td>0.01</td>
<td>0.02</td>
<td>5</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
<tr>
<td>16273</td>
<td>marble</td>
<td>7.1</td>
<td>0.25</td>
<td>0.007</td>
<td>0.001</td>
<td>3</td>
<td>&lt;0.3</td>
<td>Central</td>
</tr>
</tbody>
</table>

The "Ledge" layer can be traced or projected for a distance of over 10 kilometres. It is within a succession of thinbedded quartzite, marble and calcareous and pelitic schist that structurally overlies core gneisses. Although its age is not known, it is correlative with a similar succession hosting both the Jordan River and Cottonbelt deposits on the margins of Frenchman Cap dome and with Eocambrian platformal rocks in the Kootenay Arc to the east (Wheeler, 1965; Reesor and Moore, 1971; Höy, 1977a). Read (1979) has suggested, however, that these mantling rocks may correlate with the Late Proterozoic Purcell Supergroup.

COLBY (MI 82ESW-062) (KINGFISHER, BRIGHT STAR)

Colby is located 48 kilometres by road east of Enderby (Figure 41). It is a stratiform lead-zinc deposit in marble, quartzite and calc-silicate gneiss units of the Monashee Group. These units have been traced 6 kilometres on the Colby property, with mineralization restricted to five zones (Höy, 1977b).

Mineralization consists of dark, medium-grained sphalerite with varying amounts of pyrrhotite, pyrite and minor galena disseminated through a medium to coarse-grained white calcite marble. The marble is structurally overlain by calc-silicate gneiss that contains crude layers or irregular zones of sphalerite, pyrrhotite, pyrite and minor galena. Dark sphalerite and pyrrhotite are also concentrated in thin layers in overlying quartzite or disseminated throughout the quartzite. Galena is more abundant in quartzite than in the marble, but is nearly always subsidiary to sphalerite. Sulfide concentration in the quartzite varies from widely scattered individual sulphiderite and pyrrhotite grains to almost massive sphalerite-pyrrhotite- (± galena pyrite). Assays of selected samples from the mineralized zones are given in Table 13.

RIFT (MI 82M-190)

Rift is a stratiform zinc-lead-copper-silver) massive sulphide showing located approximately 100 kilometres north of Revelstoke (Figure 41) (Gibson and Höy, 1985). Although it is east of the Columbia River fault, within the Selkirk allochthon, it is included in a description of Shuswap occurrences because of its similarity to these deposits.

TABLE 14. ANALYSES OF MINERALIZED SAMPLES FROM THE CK DEPOSIT

<table>
<thead>
<tr>
<th>Showing</th>
<th>Sample Type</th>
<th>Pb %</th>
<th>Zn %</th>
<th>Fe %</th>
<th>Cu ppm</th>
<th>Cd ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Boulder</td>
<td>grab sample</td>
<td>1.45</td>
<td>5.8</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Main Boulder</td>
<td>grab sample</td>
<td>4.50</td>
<td>27.1</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Main Boulder</td>
<td>grab sample</td>
<td>6.31</td>
<td>23.37</td>
<td>7.76</td>
<td>247</td>
<td>252</td>
</tr>
<tr>
<td>Main Boulder</td>
<td>0.6-metre chip</td>
<td>4.88</td>
<td>23.45</td>
<td>14.34</td>
<td>423</td>
<td>260</td>
</tr>
<tr>
<td>New</td>
<td>0.6-metre chip</td>
<td>4.19</td>
<td>25.20</td>
<td>12.24</td>
<td>408</td>
<td>255</td>
</tr>
<tr>
<td>North</td>
<td>0.6-metre chip</td>
<td>4.81</td>
<td>8.95</td>
<td>19.44</td>
<td>515</td>
<td>87</td>
</tr>
<tr>
<td>Mist</td>
<td>0.6-metre chip</td>
<td>2.66</td>
<td>20.70</td>
<td>11.33</td>
<td>512</td>
<td>230</td>
</tr>
</tbody>
</table>
TABLE 15. BASE METAL ANALYSES OF MASSIVE SULPHIDE LENSES AND HOST ROCKS, RIFT SHOWING

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Pb</th>
<th>Zn</th>
<th>Cu</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>84R-10</td>
<td>5.75</td>
<td>29.3</td>
<td>0.017</td>
<td>upper massive sulphide lens</td>
</tr>
<tr>
<td>84R-9C</td>
<td>13.9</td>
<td>25.1</td>
<td>0.009</td>
<td>main massive sulphide lens</td>
</tr>
<tr>
<td>84R-8F</td>
<td>6.83</td>
<td>31.7</td>
<td>0.067</td>
<td>main massive sulphide lens</td>
</tr>
<tr>
<td>84R-8E</td>
<td>7.01</td>
<td>31.3</td>
<td>0.067</td>
<td>main massive sulphide lens</td>
</tr>
<tr>
<td>84R-9B</td>
<td>0.048</td>
<td>0.012</td>
<td>0.018</td>
<td>siliceous, calcareous schist</td>
</tr>
<tr>
<td>84R-9A</td>
<td>9.01</td>
<td>23.9</td>
<td>0.039</td>
<td>lower massive sulphide lens</td>
</tr>
<tr>
<td>84R-8C</td>
<td>5.00</td>
<td>26.8</td>
<td>0.032</td>
<td>lower massive sulphide lens</td>
</tr>
<tr>
<td>84R-8D</td>
<td>0.015</td>
<td>0.074</td>
<td>0.021</td>
<td>chert, quartzite, siliceous schist</td>
</tr>
</tbody>
</table>

The Rift sulphide layer is within a 400-metre-thick, largely schistose zone between two massive calcite and dolomite marble units. The lower marble is underlain by graphitic and calcareous schist and greater than 900 metres of predominantly grit and laminated chlorite schist. This succession has been traced southward (G. Gibson, personal communication, 1987) and correlated with the succession hosting the Goldstream massive sulphide deposit, and is therefore tentatively assigned to the Lower Palaeozoic Hamill or Larder Group.

The Rift showing consists of a number of thin layers of massive sphalerite, pyrite, pyrrhotite and galena exposed for approximately 25 metres of strike length in a steep-sided creek gully; the thickest of the layers is about 2 metres thick. These layers are separated by schistose, quartz-rich and somewhat calcareous rocks with disseminated sulphides. A second massive sulphide zone, the "upper showing", is exposed approximately 90 metres stratigraphically above the main showing. Intervening rocks include calcareous schists and thin marble bands, overlain by more pelitic schists.

The massive sulphide layers are irregularly laminated on a <1 to 10-centimetre scale. Sphalerite is commonly the most abundant sulphide; pyrrhotite is abundant in the southern part of the gully exposure, whereas pyrite predominates to the north (Hicks, 1982). Galena averages from 5 to 8 per cent, and chalcopyrite and arsenopyrite occur in trace amounts. Prominent gangue minerals in the massive sulphide layers include quartz, muscovite, calcite, and minor amounts of clinozoisite. Thin calc-silicate and quartz-rich gangue layers, with variable amounts of disseminated sulphides, occur within the sulphide bands.

Chemical analyses of the massive sulphide layers reflect the high sphalerite content with zinc ranging from 24 to 32 per cent (Table 15). The weighted average of 25 chip samples is 29.75 per cent zinc, 5.28 per cent lead and 0.03 per cent copper (Hicks, 1982). Precious metal values range from 0.06 to 0.25 gram gold per tonne and 0.3 to 10 grams silver per tonne in seven grab samples collected by J.M. Leask (personal communication, 1980). Gold and silver values for the six massive sulphide samples analysed in this study (Table 15) were below the utilized detection limits of 0.3 and 10 grams per tonne respectively.

SUMMARY — SHUSWAP MASSIVE SULPHIDE DEPOSITS

A number of features of Shuswap deposits have been summarized by Fyles (1970a):

1. The deposits comprise thin, but regionally extensive, sulphide-rich layers in a well-layered platformal succession of dominantly carbonate, schist and quartzite. The host is generally a calcareous schist.
2. The deposits consist dominantly of pyrrhotite and sphalerite, with minor galena and pyrite. Magnetite is the abundant iron phase at Cottonbell.
3. The deposits are part of the enclosing stratigraphic succession and have been metamorphosed and deformed along with it.

Shuswap deposits represent highly deformed and metamorphosed examples of the "exhalative sedimentary group" of base metal deposits of Hutchinson (1980). Host rocks range from calcareous schist and gneiss (Cottonbell) to dominantly graphitic schist (Big Ledge) within a well-layered and heterogeneous succession that includes relatively pure crossbedded quartzite, grey crystalline marble, hornblende gneiss, and abundant pelitic and calcareous schist and gneiss. Sulphides are presumed to have been deposited with the enclosing calcareous shale in restricted shallow marine basins in a platform environment. They are hosted by clastic rocks but also have features typical of "carbonate-hosted" deposits (in particular, the "Remac" type of Sangster, 1970), such as their association with clean carbonates and their occurrence in a shallow marine platformal environment (Hutchinson, 1980). They are transitional between the "clastic-hosted" and "carbonate-hosted" types, supporting the statement by Hutchinson (1980, page 665) that there are no distinct boundaries between these deposit types.

Shuswap deposits contrast with lead-zinc deposits in the Kootenay Arc to the south (Fyles, 1970b; Hoy, 1982). Kootenay Arc deposits include the Bluebell, Duncan and Wigwam deposits and deposits in the Salmo camp (Figure 41). They are hosted by a relatively pure, but locally dolomitized, silicified and brecciated Lower Cambrian carbonate unit. Although deformation may be intense, the regional metamorphism is generally greenschist facies.
Plate 30. Remains of exploration camp, Cottonbelt property, viewed to the northeast across the southern tributary of Blais Creek.

Plate 31. Exposure of very rusted massive sulphides of the Cottonbelt layer within calc-silicate gneiss, pelitic schist, marble and minor quartzite; viewed to the south.
Plate 32. Photograph contrasting two styles of mineralization within the Cottonbelt layer; dark, crudely layered, massive sphalerite, galena and magnetite occur below granular marble that contains disseminated galena and sphalerite. At top of photograph is finely layered calc-silicate gneiss and quartzite.
REFERENCES


APPENDICES

APPENDIX 1.
METAMORPHIC MINERAL ASSEMBLAGES IN PELITIC ROCKS, MOUNT GRACE AREA

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Host Unit</th>
<th>slab ky and qz</th>
<th>mus</th>
<th>bi</th>
<th>gnt</th>
<th>pi</th>
<th>kf</th>
<th>ct</th>
<th>chl</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB2-A</td>
<td>6a</td>
<td>X X X X X X X X</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>CB-7</td>
<td>6a</td>
<td>X X X X X X X</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CB-8</td>
<td>6a</td>
<td>X X X X X X X X X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>CB1-6</td>
<td>6a</td>
<td>X X X X X</td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td>CB1-8</td>
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<td></td>
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<td></td>
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<td></td>
<td>?</td>
</tr>
<tr>
<td>CB1-12</td>
<td>6b</td>
<td>X X X X X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CB1-14</td>
<td>6b</td>
<td>X X X X X</td>
<td></td>
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<td></td>
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<td>X</td>
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Note:
Accessory minerals such as zircon, apatite, tourmaline, etc., not listed. Andalusite and cordierite are retrograde minerals, some muscovite and biotite are also retrograde.

tr-trace amount; ?-positive identification not established.
APPENDIX 2. ANALYSES OF INTRUSIVE (AND HYDROTHERMAL) CARBONATITIES OF UNIT 3C, PERRY RIVER AREA

APPENDIX 2A

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<th>CaO</th>
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<th>K₂O</th>
<th>TiO₂</th>
<th>MnO</th>
<th>P₂O₅</th>
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By XRF—Analytical Laboratory, British Columbia Geological Survey Branch.

APPENDIX 2B

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<th>Ga⁴</th>
<th>Ba²</th>
<th>Cu²</th>
<th>Pb²</th>
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¹ XRF — X-Ray Laboratories, Don Mills, Ontario.
² Atomic absorption — Analytical Laboratory, British Columbia Geological Survey Branch.
³ Neutron activation — Bondar Clegg.
⁴ XRF — Analytical Laboratory, British Columbia Geological Survey Branch.

APPENDIX 2C

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By neutron activation — Bondar Clegg.
APPENDIX 3. ANALYSES OF THE MOUNT GRACE EXTRUSIVE CARBONATITE, 
PERRY RIVER, MOUNT GRACE AND BLAIS CREEK AREAS

APPENDIX 3A

(All %)

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Notes:
Total iron is expressed as Fe₂O₃.
With the exception of volatiles, all oxides were determined by atomic absorption spectroscopy. Analytical Laboratory, British Columbia Geological Survey Branch.
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(in ppm)

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**Notes:**

1. XRF — X-Ray Laboratories, Don Mills, Ontario.
2. AA — Analytical Laboratory, British Columbia Geological Survey Branch.
## APPENDIX 3C
(in ppm)

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1 Neutron activation — Bondar Clegg.
2 XRF — Analytical Laboratory, British Columbia Geological Survey Branch.