CHAPTER 6

SUMMARY AND CONCLUSIONS

1. The Buttle Lake Camp is a Paleozoic volcanogenic polymetallic massive sulphide district in central Vancouver Island, B.C. The ore deposits consist of many individual massive sulphide lenses grouped into several major zones within two main felsic volcanic stratigraphic intervals in the Paleozic Sicker Group within the Buttle Lake uplift. They are currently being mined by Westmin Resources Ltd. through the operation of two underground mines, the H-W and Lynx. Total size and grade of the orebodies (current reserves plus past production) are 20,812,000 tonnes at 2.30 g Au/t, 58.3 g Ag/t, 2.12 wt.% Cu, 0.67 wt.% Pb, and 6.46 wt.% Zn. This is a minimum estimate because the large H-W orebody is still open in two directions.

2. A revised stratigraphy is proposed for the Paleozoic Sicker Group rock units in the Buttle Lake uplift. The revised units, in order of decreasing age, are: Price Formation, Myra Formation, Thelwood Formation, Flower Ridge Formation, Buttle Lake Formation, and Henshaw Formation. Only the first four formations are present in the Buttle Lake Camp. Age relationships are not well known with definite ages only determined for the Myra and Buttle Lake Formations. U—Pb dating established a Late Devonian (370 Ma) age for the Myra Formation. Whole rock Rb—Sr isotopic analysis nf the lower Myra Formation units yielded a comparable Late Devonian age of 365 Ma.

3. The lowermost unit exposed in the Buttle Lake Camp, the Price Formation (also referred to as the Footwall H-W Andesite), is a thick sequence (> 300 m) of massive to pillowed, pyroxene + feldspar porphyritic basaltic andesite flows and flow breccias, and minor associated fine to coarse pyroclastic rocks. This unit has been intersected in drillcore throughout the property but is exposed at surface only in a small region southwest of the mouth of Thelwood Creek. The base of this formation is not known.

4. The sulphide deposit-bearing Myra Formation (also referred to as the Mine Sequence) consists of a 310 to 440 m thick sequence of complex volcanic-dominant stratigraphy. Myra Formation lithologic units exhibit remarkable linear continuity (>7 km) along the northwestern trend

of the ore zones, but abrupt lateral northeast to southwest facies changes. The Myra Formation is divided into ten general litho-stratigraphic units (in decreasing relative age): H-W Horizon, Hanging Wall H-W Andesite, Ore Clast Breccia unit, Lower Mixed Volcaniclastics, Upper Dacite / SE Andesite / North Dacite, Lynx-Myra-Price Horizon, G-Flow unit, Upper Mixed Volcaniclastics, Upper Rhyolite unit, and Upper Mafic unit.

The lowermost Myra Formation unit is the predominantly rhyolitic H-W Horizon. This horizon varies in thickness from approximately 15 m to 200 m and occurs throughout the mine-area. It consists of dacitic to rhyolitic flows and domes, pyroclastic deposits, argillite, and sulphide mineralization. H-W Horizon units vary laterally from bedded argillite and felsic tuffs towards the back-arc rifting (ARFT) region to complex felsic domal and flow assemblages towards the volcanic arc (VARC) area. It can be divided into five parts: (1) an argillite member, (2) a felsic flow member (consists of three flow types: a quartz + feldspar porphyritic rhyolite, an aphyric to feldspar porphyritic rhyolite, and a feldspar porphyritic dacite), (3) a pyroclastic and volcaniclastic member, (4) a mafic flow member, and (5) a massive sulphide member. It is this unit that hosts the large H-W massive sulphide deposit.

The Hanging Wall H-W Andesite is an up to 100 m thick unit mainly consisting of feldspar porphyritic basaltic andesite to andesite flows and related breccias. The proportion of flow and flow breccia units to pyroclastic deposits is 80:20 in the central regions of all sections, but approximately 40:60 in the VARC region of the Price section.

The Ore Clast Breccia unit represents a series of volcaniclastic submarine debris flow deposits and lesser pyroclastic deposits. The unique feature of this unit is the presence of massive sulphide clasts and lenses or 'rafts' (olistoliths) of pyrite mineralized rhyolite coarse tuff to lapilli-tuff. The horizon is up to 90 m thick and is found thoughout the mine-area, being best developed in the central region in the Price end. The Ore Clast Breccia unit can be divided into three mappable members: (1) a rhyolite-rich volcaniclastic breccia having from 10 to 50 percent non-andesite or mafic volcanic constituents (average is 25 percent); (2) a rhyolite-poor volcaniclastic breccia with less than 10 percent non-andesite or mafic volcanic constituents; and (3) the Interzone Rhyolite, a

rhyolite pyroclastic horizon. Generally, the rhyolite-rich member occurs in the lower to middle parts of the unit whereas the rhyolite-poor member is found in the middle to upper portions. The Interzone Rhyolite generally is found in the middle to upper portions of the Ore Clast Breccia unit but it can occur at any level within the Ore Clast Breccia unit because it marks a paleosurface present at the time of its emplacement.

The Lower Mixed Volcaniclastics represent andesite dominant volcaniclastic deposits. The unit is up to 90 m thick and occurs throughout the property. It contains deposits of volcaniclastic breccias, tuff-breccias, bedded lapilli-tuff and coarse to fine tuff, and minor subaqueous pyroclastic flow deposits. The coarse clastic deposits occur mainly in the central region in the Price end and the West G end of the mine-area, whereas the Lynx and H-W—Myra sections contain ralatively greater sequences of finer grained, bedded deposits. Generally the Lower Mixed Volcaniclastics thicken from the Price area to the H-W—Myra section, before gradually thinning towards the Lynx and West G sections. Towards the ARFT region this horizon 'merges' with the Hanging Wall H-W Andesite and Ore Clast Breccia units resulting in an andesite-rich volcaniclastic unit. The Lower Mixed Volcaniclastics in the VARC area directly overlies the Hanging Wall H-W Andesite.

The Upper Dacite / SE Andesite / North Dacite units represent three approximately contemporaneous yet different eruptive events which occurred in non-overlapping relationships throughout the mine property. The Upper Dacite unit is present in the Price section and comprises two general parts: the Upper Dacite lower member and the Upper Dacite upper member. The lower member consists of dacite to rhyolite hyaloclastite, flow breccia and subaqueous pyroclastic deposits. The upper member is made up of feldspar porphyritic intermediate flows containing variably rounded felsic flow blocks, and subaqueous pyroclastic deposits. The SE Andesite is best developed at the West G end and consists of up to a 250 m thick sequence of massive to pillowed, feldspar porphyritic basaltic andesite to andesite flows and lesser flow breccia deposits. Both the Upper Dacite and the SE Andesite units are thickest in their respective central regions; they thin markedly towards the middle sections (Lynx and H-W— Myra) of the mine-area. The North Dacite, a feldspar porphyritic felsic

flow unit, is only present in the YARC area-where it occupies the same general stratigraphic position as the other two litho-stratigraphic units.

The Lynx-Myra-Price Horizon represents the upper massive sulphide mineralized felsic volcanic units in the mine-area (i.e. the West G, Lynx, Myra and Price ore zones). This unit consists of mainly quartz + feldspar crystal vitric rhyolite tuffs and lapilli-tuffs, and can be divided into two spatially distinct units: (1) the G-Zone member, and (2) the G-Hanging Wall Zone member. The latter contains an additional lithologic unit comprising pale chert, jasper and black argillaceous chert. The two members are separated by units from upper parts of the SE Andesite in the West G and Lynx sections, and by the Upper Dacite upper member in the Price section and possibly the H-W--Myra section. In the West G and Lynx areas the separation is 30 to 150 m whereas in the Price end, it is 10 to 60 m. Both zones vary in thickness from 1 to 45 m, but generally the G-Zone member is thicker than the G-Hanging Wall Zone member (though the latter is more laterally extensive).

The G-Flow unit represents a number of thin (2 to 15 m thick) but widespread, massive to pillowed, pyroxene-phyric ultramafic flows and related breccias, and hyaloclastite deposits overlying the two members of the Lynx-Myra-Price Horizon. In the H-W--Myra, Lynx and West G sections, the G-Flow unit also contains distinctly purple zones. These zones mainly consist of hyaloclastite and flow breccia, and are moderately to intensely altered to carbonate and hematite. The unit, thickest in the West G and Lynx areas, becomes steadily thinner towards the Price section. Laterally, it disappears towards the YARC region but thickens towards the ARFT area.

The Upper Mixed Volcaniclastics represents a mafic to intermediate volcanic dominant volcaniclastic unit consisting of bedded fine to coarse tuff and lapilli- tuff sequences, and massive coarse lapilli-tuff to tuff-breccia deposits. Purplish hematite alteration is present irregularly in both types. The unit is up to 50 m thick and occurs throughout the mine property, being best developed in the central regions of all four sections.

The Upper Rhyolite unit is the stratigraphically highest rhyolite horizon in the Mine Sequence. Distribution of rock types in the Upper Rhyolite unit consists of two general parts: (1) a pyroclastic deposit-rich member; and (2) a siliceous argillite -- chert dominant member. In

most areas the siliceous argillite – chert member underlies the pyroclastic member. The pyroclastic deposit member is up to 50 m thick and made up of bedded, rhyolite coarse tuff to lapilli-tuff, and lesser fine tuff and tuff-breccia deposits. This member displays a distinct lateral facies variation from the VARC region to the ARFT area: it is thickest and coarsest towards the VARC region. The pyroclastic deposits in the central region are variably but distinctly purple due to pervasive hematite alteration. The siliceous argillite – chert member consists of thin to medium laminated beds of grey to black siliceous argillite, pale chert, rhyolite fine tuff, and minor jasper. This member ranges from 1 to 15 m in thickness and is largely confined to the central regions of all sections.

The Upper Mafic unit is the uppermost litho-stratigraphic unit in the Myra Formation. It is present throughout the property being thickest (> 200 m) in the ARFT region and thinning to approximately 5 to 20 m towards the VARC area. As the Myra Formation – Thelwood Formation contact possibly represents an unconformity, this unit is missing in areas and notably thin in others. The main rock types present are basaltic in composition and occur mainly as hydroclastic and pyroclastic deposits largely composed of pyroxene + feldspar porphyritic mafic flow clasts. Less common deposits include flow and flow breccia units, and mixed sedimentary and pyroclastic units.

5. The Thelwood Formation (also referred to as the Sharp Banded Tuff) is a 270 to 500 m thick bedded sequence of siliceous tuffaceous sediments, subaqueous pyroclastic flow deposits and penecontemporaneous mafic sills. This unit is present throughout the mine property but the best exposures occur on the west side of the mouth of Thelwood Creek and around Myra Falls. The rock units can be grouped into three general, repetitive units: (1) tuffaceous sediment units, (2) pyroclastic deposit units, and (3) mafic sills. Components of all three occur within each generalized unit. Tuffaceous sediment units range from 5 to 30 m in thickness and consist of massive to bedded tuffaceous mudstone and siltstone, mudstone, and vitric ± crystal fine tuff. Minor chert layers are also present. Also present are up to 20 percent coarse grained subaqueous pyroclastic deposits. Pyroclastic deposit units range from 4 to 25 m in thickness and consist of vitric-lithic; fine lapilli-tuff to coarse tuff beds intercalated with up to 50 percent tuffaceous sediment deposits. Mafic sills consists of 1 to 90 m thick, massive basaltic to basaltic andesite sills. They are found throughout

the Thelwood Formation but are generally more common in the lower portions. They also seem to be associated with the tuffaceous sediment units. Some of thickest sills are found at the Myra Formation — Thelwood Formation contact. Contacts of sills can be finer grained than the interiors and reflect chilled margins. Locally, flame-like protrusions of tuffaceous sediment into sills, and hyaloclastitic margins are observed, and are interpreted to be the result of intrusion into wet, unlithified sediment.

6. The Flower Ridge Formation is the uppermost Paleozoic unit exposed in the Buttle Lake Camp. The unit is basaltic in composition and consists mainly of moderately to strongly amygdaloidal feldspar ± pyroxene porphyritic basaltic lapilli-tuff, tuff-breccia and pyroclastic breccia. Some of these units represent agglutinate deposits. Other rock types of this formation are fine to coarse mafic tuffs, basalt flows and flow breccias, and bedded tuffaceous mudstone and argillaceous sediments. The top of the Flower Ridge Formation is not on the mine property — only the lower 650 m can be observed. Traverses on the west side of Flower Ridge south of the south end of Buttle Lake, however, show that this formation extends to the contact with the overlying Buttle Lake Formation. The contact with the underlying Thelwood Formation is conformable and characterized by the first appearance of abundant scoriaceous volcanic clasts in either pyroclastic or sedimentary beds.

7. Subsequent intrusive phases on the mine property, from oldest to youngest, are: (1) Paleozoic or Triassic diabase dikes, (2) Triassic basaltic sills and dikes related to the Karmutsen Formation, (3) Jurassic feldspar porphyry and quartz diorite dikes related to the Island Intrusions, and (4) Jurassic or younger quartz + feldspar porphyritic rhyolite and hornblende gabbro dikes. The Jurassic feldspar porphyry and quartz diorite dikes are the most abundant intrusive phase.

8. Various lithologic and structural observations suggest that the Myra Formation — Thelwood Formation contact is a possible unconformity (either a period of erosion or non-deposition) in the Late Devonian to Early Mississippian. After deposition of the Thelwood Formation, the contact may have become a site for low angle faults in Late Paleozoic time, or a décollement during Mesozoic deformation due to different deformational behavior above and below the contact.

9. Price and Myra Formations are composed of a range of mafic to felsic volcanic rocks. Intermediate phases are the dominant rock type. Fieldwork has defined four volcanic source regions

for Myra Formation lithologies. Along with the Price Formation, volcanic products from these areas can be grouped into five volcanic series: the early arc series (EARC: Price Formation), the volcanic arc series (VARC: H-W Horizon, felsic flow member; Ore Clast Breccia unit, Interzone Rhyolite; North Dacite; Lynx–Myra–Price Horizon; and Upper Rhyolite unit), the Price seamount series (PSMT: H-W Horizon, dacite flow unit; and Upper Dacite, lower member), the West G seamount series (WSMT: Hanging Wall H-W Andesite; 5E Andesite; and Upper Dacite, upper member), and the arc rifting series (ARFT: H-W Horizon, mafic flow member; G-Flow unit; and Upper Mafic unit).

10. The volcanic series are the result of at least three distinct and partly contemporaneous magmatic lineages: Early Arc Crust – Price Seamount lineage, Volcanic Arc lineage, and Arc Rifting lineage. Source region for the ultramafic to intermediate magmas was an upper mantle peridotitie depleted in high field strength elements and variably enriched in LIL elements (both relative to N-type MORB) as a result of a subducted, dehydrating oceanic crust slab. The felsic volcanic series, the PSMT and VARC series, originated from two distinct sources. The PSMT series represent products from evolved EARC magma whereas the VARC series represent products from magma formed by partial melting of lower crustal portions of a volcanic arc.

11. Clinopyroxene-phyric lavas in the ARFT series, called komatiitic basalts on chemical and mineralogical grounds, represent primary melts. These liquids probably formed at 1300° C at pressures between 15 and 25 kb by moderate to high degree ($\geq$ 15 percent) of partial melting of a hydrous upper mantle peridotite.

12. Mafic units in the Thelwood and Flower Ridge Formations are from magmas derived from less depleted (relative to N-type MORB) and LIL element poorer mantle sources than those for the Price and Myra Formations. Magma generation may have occurred in a region further removed from a subduction zone.

13. The Price and Myra Formations represent deposition within an intra-arc setting which followed a general sequence of repeated events comprising: mafic to intermediate arc volcanism; rifting, hydrothermal convection and sulphide mineralization; felsic arc volcanism; ultramafic to

mafic rift volcanism; and volcanogenic sedimentation. This sequence was repeated twice and formed two massive sulphide mineralized horizons (H-W and Lynx—Myra—Price). Deposition of the volcanics and volcanogenic sediments probably occurred in an evolving rift basin and was strongly controlled by basin floor morphology.

14. Massive sulphide mineralization was governed by configuration of the hosting extensional depressions (trough structures). Where the trough was barren of sediment, large mound-like sulphide deposits of the H-W deposit formed. Variable filling of troughs by felsic pyroclastic material yielded narrower, thinner, but more linear massive sulphide bodies such as the G-Zone and G-Hanging Wall Zone deposits. Life of the sulphide-producing geothermal system commonly was ended abruptly by the sudden eruption of ultramafic rift volcanic units.

15. Thelwood Formation indicates a major change in depositional style and environment from the underlying Myra Formation. It represents a sediment-sill complex consisting of siliceous tuffaceous sediments, subaqueous pyroclastic deposits and penecontemporaneous mafic sills. The complex probably formed in part because of high sedimentation rate relative to mafic sill magmatism. The sills represent an early phase of the magmatic event responsible for the overlying volcanic units of the Flower Ridge Formation.

16. Flower Ridge Formation is the final main Sicker Group volcanic phase in the Buttle Lake Camp and represents basaltic explosive to effusive activity from a possible back-arc spreading center. Deposition was in a much more shallow marine setting than during the underlying Thelwood event. End of this volcanic episode (documented outside the mine-area) was followed by a minor period of erosion before extensive deposition of the shelf carbonates of the Buttle Lake Formation.