affecting the stability of an alteration or sulphide phase, but on a megascopic scale temperature gradients have controlled the relative abundance of mineral assemblages in the orebody area.

Conclusions

The Endako stockwork was localized within an early quartz monzonitic phase of the Topley batholith by wrench-faulting and doming generated by cooling of the batholith and intrusion of pre-ore dykes. Hydrothermal fluids effecting alteration and mineralization of the stockwork were generated contemporaneously with the cooling of the Endako pluton. Abundant early potassic alteration and relatively high fluid-inclusion temperatures attest to the paramagmatic affiliation of vein and alteration mineral assemblages. Crosscutting relations indicate a relative age sequence among the alteration stages which is in agreement with a chemical control based primarily on the activity ratio of K^+/H^+. Concurrent north-south zonation of stockwork mineralization, principal alteration types, fluid inclusion temperatures, and minor element content of pyrite indicate thermal gradients diminished southward across the orebody from a "high" centred over the potash feldspar zone.

Day 6

GIBRALTAR: By A. D. Drummond.

LOCATION: Lat. 52° 31′ — Long. 122° 17′ — Nearly 160 km south of Prince George on the western slopes of Granite Mountain, and near McLeese Lake.

OWNERSHIP: Placer Development Limited (71 per cent).

The adjoining Gibraltar and Pollyanna properties have been developed independently as small vein deposits since their discovery around 1920. Since 1969, the two properties received combined exploration programmes which led to the recognition of a major porphyry copper deposit. On November 6, 1970, Placer Development Limited announced its intention to place the co-mingled properties into production at 30,000 tons per day. Target date for production is scheduled for June 1972. Current ore reserves are 358 million tons grading 0.37 per cent copper with a 0.25 per cent cut-off and 0.016 per cent molybdenite. Four individual pits are planned and 55 million tons of ore grading 0.44% Cu will be available in the early years of operations.

Regional Setting

The region around McLeese Lake is overlain in part by Late Tertiary flood basalts which allow limited perception of earlier geology and tectonics. It is a region of major northwest faulting that bounds the eastern side of the Pinchi geanticline which is dominated by Carboniferous and Permian basic volcanic rocks, chert, and limestone (Cache Creek Group). Flanking the geanticline are troughs containing Mesozoic volcanic and clastic rocks covered in part by Cenozoic volcanic rocks. South of the region, the Fraser River follows major faults, and strands of these likely continue through the region to connect with the Pinchi fault system east of the geanticline.

A north-south trending line of isolated batholithic rocks outcrop along the eastern side of the probable Fraser River fault system. In the immediate vicinity of Granite Mountain, a regionally foliated and metamorphosed quartz diorite (the Granite Mountain pluton) has intruded the Cache Creek Group.

Local Geology

The copper-molybdenum deposits of Gibraltar occur entirely within the foliated and regionally metamorphosed Granite Mountain quartz diorite pluton, a body about 16 km in diameter (*see* Fig. 17).

The quartz diorite host is extremely uniform in its mineral assemblage. The rock is composed of quartz (25 to 30 per cent), "plagioclase" which is presently a mixture of albite-epidote-muscovite (50 to 55 per cent), chlorite (20 per cent) which originally was biotite with minor hornblende and disseminated magnetite (1 per cent or less). Grain size is generally 1 to 2 mm. This rock may be classified as a saussuritized quartz diorite. The present silicate assemblage is comparable with those of the greenschist facies of regional metamorphism.

The only rocks encountered in the Granite Mountain pluton which were not regionally metamorphosed are a quartz feldspar porphyry and an aplite. These rocks both occur as dykes intrusive into the saussuritized quartz diorite mainly in a central core, where they are only weakly mineralized.

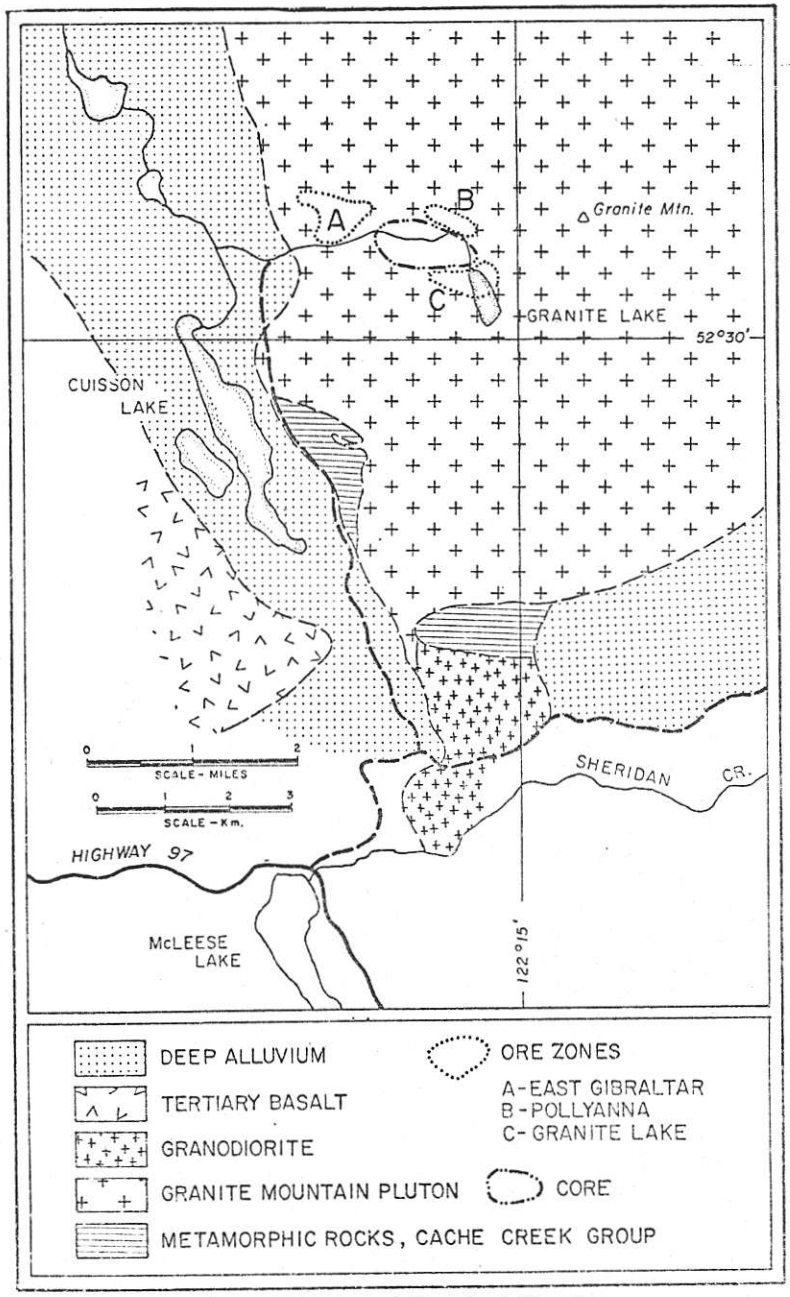

Figure 17 Geological Sketch of Gibraltar

Structure

The major structural feature associated with the metamorphism is the foliation which strikes about 110° and dips 20 to 30° southerly. Foliation is a result of cataclastic deformation within the Granite Mountain pluton. Locally, within shear zones, the foliation becomes extremely contorted and at times completely obliterated.

Mineralization

Four stages of mineralized stockwork are superimposed on the premineral foliation that is developed in the saussuritized quartz diorite. In addition to being superimposed on the regional foliation the stages are superimposed on each other sequentially, hence indicating a complete separation of the two geological events.

A central weakly mineralized or barren core in and around which the unfoliated porphyry is found, is elongated approximately parallel with the regional foliation. Mineralization and fracture intensity increase outward from this core area in such a manner that the overall size of the elliptical-shaped area of stockwork development is about 3.25 by 8 km. Within this area and situated around the core are three main orebodies called Gibraltar East, Pollyanna, and Granite Lake zones (*see* Fig. 17).

Sequence of Stockwork Veins

The following mineralized veins crosscut or locally parallel the foliation and are listed in chronological sequence based on crosscutting relationships.

Stage 1

(a) Quartz-pyrite ± chalcopyrite with a sericite envelope. (Sericite envelope assemblage is quartz, sericite, pyrite ± chalcopyrite with all saussuritized feldspar being made over to sericite-clay (?) mixture.)

(b) Quartz - chlorite - pyrite - chalcopyrite - magnetite ± carbonate with a chloritic envelope. (Chlorite envelope assemblage is quartz, chlorite, pyrite ± chalcopyrite with a pronounced absence of epidote in the saussuritized feldspar.)

Stage 2

(a) Quartz - chlorite - pyrite ± magnetite.

(b) Quartz - chlorite - pyrite - chalcopyrite - epidote ± magnetite.

(c) Quartz - chlorite - pyrite - epidote ± magnetite.

(d) Quartz - chlorite - pyrite - chalcopyrite ± magnetite.

(e) Quartz - chalcopyrite - bornite ± pyrite (restricted to porphyry area between Pollyanna and Granite Lake zone) (all with ± carbonate).

Stage 3

Quartz - molybdenite - chalcopyrite - pyrite ± magnetite ± carbonate.

Stage 4

Largely barren quartz with fine-grained chlorite blebs or chalcopyrite blebs.

Sericitic and chloritic envelopes which are associated with Stage 1 veins are definitely of hydrothermal origin.

A second hydrothermal feature is only observed microscopically. Under regional metamorphism of the greenschist facies, plagioclase in the original quartz diorite has been reconstituted to a mixture of albite-epidote-zoisite-sericite (minor). A suite of rock samples across the Pollyanna and Gibraltar East zones indicated that the sericite-epidote ratio in the saussuritized feldspar increased directly with copper values across the mineralized zones.

Relationship of Structure, Mineral Zoning, and Induced Polarization Response

The Gibraltar East zone, Pollyanna zone, and Granite Lake zone are situated along the inner side of a band of higher induced polarization response. Mineral sequence outward from a porphyry-bearing barren core is as follows:

(1) Minor chalcopyrite, minor bornite, ± pyrite (low sulphide area).

(2) Pyrite-chalcopyrite or chalcopyrite-pyrite.

(3) Pyrite-minor chalcopyrite. The latter is generally associated with numerous sericite envelopes such that the outer zone may equally well be termed a pyrite-sericite zone. Molybdenite-bearing veins are scattered throughout the zones, but locally may be more concentrated, with an increase in copper values.

Supergene Zone

Throughout the entire mineralized area, there is a leached zone above the supergene copper zone but it is irregular in

development and thickness. A weak to strong development of limonite is characteristic of this zone.

Supergene copper minerals include chalcocite with minor amounts of native copper, azurite, malachite, cuprite, and traces of covellite. All are found throughout the whole zone.

Summary

(1) The Granite Mountain pluton intruded Cache Creek Group rocks during Jura-Cretaceous time.

(2) Deformation of the general area has produced simultaneous development of (a) regional foliation and (b) regional greenschist facies type of metamorphic assemblages within the quartz diorite of the Granite Mountain pluton.

(3) During continued deformation, quartz-feldspar porphyry intruded the pluton and formed a structurally more competent core.

(4) During further deformation, a fracture pattern developed around the more competent core. This fracture system which is imposed on, and partly controlled by, the regional foliation contains a wide but regionally restricted sulphide zone. This zone is possibly related to a buried intrusive. Within the sulphide zone, a chalcopyrite-secondary chalcocite-molybdenite zone occurs between the low-sulphide core and a pyritic halo.

(5) At some later time, movements on the Fraser River fault system differentially uplifted the Granite Mountain pluton. Relatively downdropped areas were filled by Tertiary volcanic rocks. Weathering under semi-arid conditions caused a leached zone and an underlying zone of secondary enrichment.

(6) Pleistocene glacial activity deposited till and gravel over the entire area of the Gibraltar-Pollyanna copper-molybdenum deposit.

END

Day 7

THE HIGHLAND VALLEY PORPHYRY COPPER DISTRICT: By W. J. McMillan.

LOCATION: Lat. 50° 20′ to 30′ — Long. 120° 58′ to 121° 08′ — The Highland Valley is 40 km southeast of Cache Creek and 54 km southwest of Kamloops.