93 O/12, 13   GIBRALTAR   93B/9W

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GIBRALTAR MINE (Fig. D, No. 99) By A. Sutherland Brown

LOCATION: Lat. 52° 31' Long. 122° 17' (93B/9W)

CARIBOO M.D. Twelve miles north of McLeese Lake, on western slopes of Granite Mountain, between 3,000 and 4,000 feet elevation.

CLAIMS: Approximately 400.

OWNER: GIBRALTAR MINES LTD., which is a subsidiary held 71 per cent by Canex Placer Limited, 700, 1030 West Georgia Street, Vancouver.

METALS: Copper, molybdenum.

DESCRIPTION:

INTRODUCTION: The Gibraltar mine is a porphyry copper-molybdenum deposit with unusual characteristics. During the early intensive exploration period at the property, only a few geologists, of whom the writer was not one, thought of it as a porphyry deposit. Visiting European geologists are still quick to suggest it represents a stratiform deposit that has been metamorphosed so that it now have a gneissic fabric. Nevertheless, it is now widely thought of as a porphyry deposit with a difference, and the more one learns about it, the more compelling is such a definition.

The writer would classify Gibraltar as a plutonic porphyry deposit. It thus can be compared with similar deposits, such as the deeper deposits, of the Highland Valley (that is) ~~i.e.~~ Lornex and Valley Copper, or with Brenda and Endako. All these have the following characteristics: they occur within medium-sized, zoned plutons composed mainly of granitic-textured rocks with sparse truly porphyritic phases; they have regular veins sets including some large veins; and they lack breccia bodies. A major difference between Gibraltar and these other examples is that, in the former, deformation and metamorphism form part of the continuum between intrusion and mineralization.

HISTORY: The Gibraltar mine completed its first full year of production in 1973, culminating a long period of intermittent investigation and six years of intensive exploration and development. The earliest record of prospecting on Granite Mountain is in 1917 when Joseph Briand and partners worked on quartz veins carrying secondary copper mineralization on what was then called the Rainbow group and later known as the Pollyanna showings (Minister of Mines, B.C., Ann. Rept., 1917, pp. 133, 134). Prospecting on Granite Mountain and vicinity continued through the 1920's and by 1925, mineral showings were prospected on the Gibraltar West zone, then called Arctic and Laughing Water (Minister of Mines, B.C., Ann. Rept., 1925, pp. 155, 156). The persistence of prospecting in view of the sparse outcrop, extensive oxidation and leaching, low primary copper grade, and dearth of precious metals was remarkable, but it tapered off toward the end of the decade and was not seriously renewed until 1949. At that time, C. E. Johnson and R. R. Moffat located claims covering both the Pollyanna and Gibraltar West zones, but they worked primarily on the former which they called the Copper King and made a half-ton ore shipment to the Tacoma Smelter (Minister of Mines, B.C., Ann. Rept., 1950, pp. 106, 107). Activity on the Pollyanna then lapsed. Later an adit was driven on the West Gibraltar zone (Sunset adit) in 1957 by E. Kinder, T. Matier, and R. L. Clothier (Minister of Mines, B.C., Ann. Rept., 1957, p. 17). Claims covering the adit were allowed to lapse, but were relocated in 1962 by J. Hilton who optioned them to what was then a minor company, Gibraltar Mines Ltd. In the same year, Keevil Mining Group Limited started the sequence of modern exploration with extensive geochemical and geophysical surveys over Granite Mountain. Recognition of a leached capping at the Pollyanna by Bill Kerns of Duval Corporation of Canada in 1965 led to that company optioning the property and conducting induced potential geophysical surveys and drilling thirteen NQ core holes prior to their starting a joint venture with Canex Placer Limited in 1967. In the same interval, Gibraltar initiated geochemical, IP surveys, and drilling in the West Gibraltar zone. Cominco Ltd. optioned the property in 1966, and that year and in 1967 with Mitsubishi Metal Mining Co. Ltd. explored this area quite thoroughly. At this stage a mineralized zone of modest size was established in the West Gibraltar zone and a larger low grade body evident at the Pollyanna, but the results were insufficient for Cominco to continue its option and for Duval to continue its share in the joint venture. Later, in 1969, Gibraltar Mines Ltd. drilled a hole into the covered East Gibraltar zone and established the existence of a chalcocite-enriched zone as well as a new mineralized zone. Canex then optioned the Gibraltar property and discovered the hidden Granite Lake zone the same year. Exploration and evaluation followed rapidly and Gibraltar was put into production early in 1972.

PRODUCTION AND ORE RESERVES: The company stated in its 1972 Annual Report that on 31 December, ore reserves with a stripping ratio of 2.15 to 1 and an average cutoff grade of 0.25 per cent copper were:

Zone	Tons	Copper (per cent)
Gibraltar East	137,000,000	0.372
Granite Lake	120,000,000	0.373
Pollyanna	81,000,000	0.360
Gibraltar West	9,000,000	0.400
Total	347,000,000	0.371 (plus ~~or including~~ 0.016 per cent MoS_2)

Not included in this total is 14,000,000 tons of ore that forms part of the Granite Lake body, but is held jointly by Cuisson Lake Mines Ltd. and Gunn Mines Ltd.

During 1972 and 1973, mine production was entirely from the Gibraltar East pit and was as follows: 1972 - 10,861,500 tons containing ~~74,412,300~~ pounds copper; 1973 -

GEOLOGY:

Regional Setting: Perception of the precise nature of the setting of Gibraltar mine is obscured by abundant glacial drift, alluvium, and Miocene plateau basalts. Figure 1 shows that the Granite Mountain pluton, within which the Gibraltar mine occurs, is situated near the boundary between two major longitudinal elements of the Intermontane Tectonic Belt, that is; the Pinchi geanticline and the Quesnel trough. Although most of the contact of the pluton with its host rocks is covered, it is evident that the body is surrounded by rocks mapped as Cache Creek Group which form the northern extension of a belt stretching southward to the type locality. In the McLeese Lake area, the group consists of

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Gibraltar Mines Ltd

	Milled	Produced	
	Tons	Copper Concentrates Tons	Molybdenite Concentrates Tons
1972	10,861,500	132,100	--
1973	15,082,233	212,383	412

basic volcanic flows and clastic rocks, cherts, argillites, and minor limestones. Adjacent to the pluton these may be transformed to greenschists or to skarny limestone. In this area then, the Cache Creek Group forms a characteristic component of the Pinchi geanticline. In contrast, to the east the Quesnel trough is characterized by Triassic volcanic rocks and flaggy limestone but also contains younger Mesozoic volcanic and clastic rocks. A major fault bordering the Triassic components of the trough strikes northwestward about 10 miles east of the Granite Mountain pluton. Jurassic volcanic and sedimentary rocks occur to the west of the main fault-bounded trough in a belt that may also be bordered on the west by a fault, but these rocks also overlap Cache Creek Group and probably the pluton on the Pinchi geanticline further west. The basal conglomerates of the Lower Jurassic sequence on Dragon Mountain contain granitic cobbles, petrographically similar to rocks comprising the Granite Mountain pluton. A Triassic date recently obtained from Granite Mountain rocks is consistent with such an interpretation. Hence the Granite Mountain pluton is thought to be related to the coeval volcanic rocks of the adjacent Quesnel trough.

The Late Mesozoic and earliest Tertiary appear to have been times of erosion of the area of Figure 1, but in the Eocene epoch acidic and basic volcanic rocks and some sedimentary rocks accumulated. These units now outcrop west of McLeese Lake and are tilted and faulted. Their eastern boundary appears to coincide with a major northerly striking fault zone followed by the Fraser River. The youngest rocks of the area are Miocene olivine basalt flows that cap the plateaus both sides of the Fraser River. These flood basalts are flat lying and appear to be unfaulted. They form buttes west of Cuisson and McLeese Lakes and diamond-drill core shows that they also fill the valley of Cuisson Lake to a depth of about 300 feet overlying Granite Mountain plutonic rocks.

2 Granite Mountain Pluton: The Granite Mountain pluton is a tadpole-shaped pluton about 13 by 7 miles in plan and is characterized by a variably intense foliation striking transverse to its long north-south orientation. The pluton consists of a number of poorly defined phases (see Fig. 2). Transitions between the phases are generally gradational over significant

distances and this together with a superimposed deformation and metamorphism makes distinguishing and mapping the units difficult. A mafic phase is found along the southern boundary of the main mass of the pluton adjacent to metavolcanic wall rocks. Similar mafic-rich rocks occur within the pluton in minor amounts where they appear to be large inclusions. A quartzose, leucocratic phase is found toward the centre of the main mass and this has poorly defined limits. It is associated with quartz feldspar porphyry and related aplite dykes, both of which are rarer elsewhere. The narrow southern extension of the pluton across Sheridan Creek is formed of relatively undeformed rocks that appear to be similar to the least deformed and altered rocks of the main phase.

PETROLOGY:

Main Phase: The petrology, chemistry, and radiometric age of the Granite Mountain pluton described here has been based primarily on two specimens collected near the projected western rim of the Granite Lake pit (see Fig. 2). These specimens, collected about 100 feet apart, are from a small area of the freshest and least deformed rock seen within the pluton, which is a zone of transition between the main phase and a relatively leucocratic variety. Beyond this small area, the character of the rocks grades rapidly to that similar to most of the pluton. Specimen 73-AB-24 is representative of the main phase and 73-AB-25 is relatively leucocratic. Table 1 shows chemical analyses for these two specimens as well as Nockold's (1954) average tonalite (quartz diorite) and granodiorite. A comparison indicates that the specimens are between Nockold's averages and probably closest to granodiorite. Table 2 shows estimates of the modes of these two specimens made, guided by charts. According to the classification recommended by the I.U.G.S. Commission on Systematics in Petrology (Streckeison, 1973), these rocks would also be on the division between tonalite (quartz diorite) and granodiorite.

The main phase rocks are formed of laths of andesite (An_{35}) and hornblende crystals, both up to 5 millimeters long and aligned in a primary foliation (S_1). Books of biotite and large grains of quartz complete the framework between which small grains of alkali feldspar and quartz occur. The plagioclase is clouded by sericite and clinozoisite alteration and is unzoned except for clear thin rims of albite. The alkali feldspar exhibits patchy twinning characteristic of some perthite and appears to consist of albite and orthoclase. X-ray diffraction results prove the presence of the latter. Biotite has been slightly to entirely altered to chlorite. Accessory minerals include sphene, apatite, and zircon, and the former two form some crystals one millimeter or more in length.

Mafic Phases: The mafic phase is more variable in composition and texture than the main phase, and if it is assumed to be analogous to the Hybrid phase of the Guichon Creek batholith, may represent variable contamination by volcanic wall rocks of the main magma. Among the mafic phases, two rock types are prominent: diorite very similar to the main granodiorite but containing 25 to 35 per cent mafic mineral and 5 to 10 per cent quartz and; generally fine-grained rock of similar overall composition but with patchy variation in grain size.

Leucocratic Phases: Leucocratic phases include both rocks which are leucocratic in original composition and others than resemble them superficially because the mafic minerals have been destroyed. Truly leucocratic rocks appear to be common northwest of Granite Lake, in the area between the three main ore deposits (Fig. 2). This relationship led Drummond (1972) to propose a quartz-rich core zone. Unfortunately, this zone is sparse in outcrop and drill holes are widely spaced so that the leucocratic core cannot be outlined with assurance at present. The outline shown on Figure 2 is tentative. Within this core most of the rocks are leucocratic and quartzose, and have been cut by quartz stockwork that is commonly barren of primary sulphides. Some main phase is intercalated with the leucocratic phase and is cut by extensive barren quartz stockwork. The contacts between the leucocratic and main phase appear to be parallel to the foliation which is abnormally flat in the central part of the core zone. Some of the drill holes in the central core show not only much quartz feldspar porphyry but also gradations between this type and truly leucocratic granodiorite. Other contacts between these two types are sharp and seemingly intrusive. The quartz feldspar porphyry in turn grades into aplite that constitutes one of the few dyke types present in the area. Hence, there is an apparently complete gradation from leucocratic granodiorite of the central core to quartz feldspar porphyry and outward to thin aplite dykes. This transition in space is evident also petrologically. The leucocratic variety has a semi-porphyritic nature with a framework of chunky plagioclase up to 5 millimeters long and equant grains of quartz and rare masses of chlorite after biotite or hornblende crystals of about the same size. A sparse matrix consists of aplitic fine quartz, plagioclase, and alkali feldspar. Alteration minerals commonly include much sericite, particularly at plagioclase grain boundaries and fractures, poikiloblastic carbonate grains in matrix, and clinozoisite disseminated in plagioclase and chlorite. The quartz feldspar porphyry is similar in texture but matrix forms about half the volume so the phenocrysts are floating. Mafic minerals in the porphyry are virtually absent and quartz forms about 40 per cent of the rock. The aplite is similar to the matrix of the leucocratic phase and quartz feldspar porphyry and commonly contains some phenocrysts or microphenocrysts of quartz and feldspar.

3 Post-Ore Dyke: One post-ore dyke is found in the Gibraltar East pit. It is a microdiorite dyke about 2 feet wide that strikes north 20 degrees east and dips about 75 degrees west. Microscopically, the rock has an insertal holocrystalline texture and is composed of about 60 per cent thin andesine laths, 25 per cent chlorite after hornblende, 5 per cent quartz, and 10 per cent porphyroblastic epidote.

2 AGE: The age of the Granite Mountain pluton indicated by stratigraphic relationships is as follows: the pluton cuts Late Paleozoic Cache Creek rocks, and boulders similar to it occur in basal conglomerates of Lower Jurassic age. Specimens 73-AB-24 and 73-AB-25 collected west of Granite Lake were the freshest found in the pluton and provided clean unaltered hornblende separates in both cases and in 73-AB-24, biotite with very minor interleaved chlorite. These separates were sent to the Department of Geological Sciences at the University of British Columbia and were analysed under the direction of J. Harakal. The results were not entirely consistent in that check analyses did not get acceptable results. Nevertheless, initial analyses on the hornblende-biotite pair gave 200 million years - a Triassic age that would seem most likely.

2 STRUCTURE: The Granite Mountain pluton had an original igneous foliation (S_1) striking westward and dipping steeply southward which is transverse

to the long dimension of the body in plan. This foliation is only obvious macroscopically in selected locales where later deformation is minimal. West of Granite Lake, in the vicinity from which specimens 73-AB-24 and 73-AB-25 were collected, the primary foliation (S_1) is revealed by alignment of primary undeformed plagioclase and hornblende. This foliation strikes 290 degrees ($\pm$ 10 degrees) and dips 60 degrees ($\pm$ 5 degrees) southward. S_1 here grades imperceptably into a subparallel second foliation (S_2) that results from penetrative deformation. Elsewhere in diverse localities, microscopic evidence is fairly commonly suggestive of an origin parallelism of S_2 to S_1. Hence the writer believes that, as S_2 is almost universally developed in the pluton in a similar orientation, it has been guided by an original igneous foliation.

In mapping the East Gibraltar pit (Fig. 3), the writer assigned arbitrary values from 1 to 5 to the intensity of foliation: F_1, the lowest order, has a noticeable orientation of mafic minerals and possibly plagioclase laths and is normally primary igneous flow foliation; F_2 has a modest foliation; F_3, pronounced foliation; F_4, intense foliation; and F_5 is, in fact, a phyllonitic schist. These macroscopic intensity values are consistently related to various microscopic textural criteria.

F_1 as described above has an alignment of large inequant grains without cataclasis.

F_2 has strained quartz with slight shattering, minor and widely spaced trains of new sericite, and mosaic recrystallized quartz. Biotite (chlorite), with cleavage close to the orientation of S_2, is distorted and drawn out.

F_3 commonly has a variable texture resulting from channeling of deformation and movement along S_2 planes between which cataclasis is substantially less. Movement planes are rarely greater than 5 millimeters apart. Between movement planes quartz is shattered and mosaic quartz common, mafic minerals converted to chlorite and substantially strung out. Feldspar is largely converted to sericite but is coherent. On movement planes feldspars are converted to trains of sericite and fine quartz; mafic minerals to trains rich in chlorite and; quartz to trains of fine mosaic quartz. Dolomite porphyroblasts are commonly present.

F_4 has a more uniform flaser-like texture, with movement planes wrapping around augen of recrystallized quartz that are commonly 3 times as long as thick. Plagioclase is largely destroyed or, if present, occurs as minor small grains of albite. In contrast, dolomite porphyroblasts are significant. Mafic grains have been completely transformed to chlorite-rich schlieren. In addition, kink bands forming S_3 are a common feature.

F_5 has a fairly uniform, fine schistose texture consisting of carbonate, chlorite-sericite, and quartz.

2 METAMORPHISM: Metamorphism of the Granite Mountain pluton is mostly related to deformation and to synchronous mineralization (see later). During the transformation of the plutonic rocks from F_1 to F_5, significant mineralogical changes took place that were not completely isochemical. In the process, all hornblende, biotite, and feldspar were destroyed and the proportion of other minerals changed. Quartz increased from 25 to 35 or 45 per cent, chlorite remained about the same as the original total of mafic minerals, but sericite (muscovite) became considerably less than original feldspar. The loss of feldspar was compensated by new quartz, muscovite, and carbonate (normally dolomite), but there is an apparent net loss in sodium because little can be accommodated in chlorite or muscovite, and paragonite is not present, judged by X-ray diffraction.

Specimens of the Granite Mountain pluton that are little deformed show some of the alteration that clearly relates to deformation in the more foliated specimens. Commonly all biotite and most hornblende is altered to chlorite and plagioclase is variably but fairly intensely altered to a felted mass of sericite and clinozoisite except for clear rims that appear to be albite. This metamorphism is probably synchronous with the similar but more extreme one in the foliated specimens. Adjacent to large veins (V_2 and V_3), there is commonly a pronounced sericitization that is related to the mineralization and probably also to the intense movement adjacent to these planes (see later). Small veinlets (V_1) parallel to the foliation also show narrow selvages of intense movement with resultant sericite and chlorite which superficially appear to be chlorite selvages.

In addition to these changes connected with deformation and mineralization, there are ones clearly later whose age is otherwise unknown. The most obvious evidence of later overprinting is replacement of sericite and muscovite of movement planes and altered plagioclase by coarse epidote not seemingly involved in the deformational process in any way.

2 GIBRALTAR MINE: The Gibraltar mine consists of four orebodies: the Gibraltar

East, Gibraltar West, Pollyanna, and Granite Lake, which are distributed on an elliptical plan with the major axis of about 2 miles long parallel to the plutonic foliation and minor axis about 1 mile across (Fig. 2). Each orebody will be developed by separate open pits in sequence. Gibraltar East provides all the ore from start up until mid-1974, when production of the Granite Lake pit will begin and phase 1 of the Gibraltar East will terminate.

Zoning of the primary mineralization and of plutonic rocks was demonstrated by a series of articles by Canex geologists (Rotherham, Drummond, and Tennant, 1972; Drummond, 1972; and Drummond, Tennant, and Young, 1973). The induced polarization maps put together by Rotherham, et al., showed maximum per cent frequency effect in a fairly complete zone peripheral to the orebodies that can be related to the distribution of the maximum amount of pyrite. Drummond (1972) and Drummond, et al. (1973) described the existence of a weakly mineralized and a barren core zone which coincides with a zone of leucocratic granodiorite and quartz feldspar porphyry. The central core is not well defined because of the lack of outcrop and drilling in the area and also because of the effect of intercalation of leucocratic and main phase at its periphery and possible effects of faulting (Fig. 2). In general, foliation at its centre, judged by the few drill holes available, is fairly flat which could be consistent with an interpretation of a central dome.

GIBRALTAR EAST DEPOSIT: The only orebody extensively exposed during the writer's visit in the summer of 1973 was the Gibraltar East deposit (see Plate 1). The characteristics of this body and its setting are considered fairly representative but until the others are exposed, a definitive synthesis cannot be made. Figure 3 is a map of the Gibraltar East pit based on the writer's observations augmented by information on the fracture patterns from mapping by mine geologist, Peter Thompson.

The Gibraltar East pit is developed entirely in the main phase of the Granite Mountain pluton and has very minor dyke rocks, a few pre-ore aplites, and one post-ore microdiorite. In spite of this seeming simplicity, major differences exist in geological character from place to place with two features most prominent; a marked oxidized and leached cap related to the present surface and; a major difference in degree of foliation and folding of foliation in the northwestern part in contrast to the southeastern section. The latter variation in combination with the relation to the vein system enables one to form a preliminary synthesis regarding the interrelated development of the structure and vein systems.

4 STRUCTURE: The mutual relationship between the intensity of foliation and the development of folding is evident in Figure 3. Foliations 3, 4, and 5 are found in the northwestern part of the pit, coinciding with numerous folds. Plates 2 and 4 illustrates the nature of the folded foliation in this area. Followed eastward, folding decreases to gently warps with axes oriented in the same orientation (see Plate 5). Further east, folding disappears and the dominant foliation is 2, with rare 1 and 3. Figure 4 is a stereoprojection of these data, from which it can be seen that S_2 averages north 48 degrees west and dips 44 degrees southwestward. The F_3 fold axes maximum is orientated south 31 degrees east, plunging 18 degrees southwestward. Considerable scatter occurs in poles to S_2 and particularly to those measured in the western folded part of the pit. However, a fairly well-developed girdle is evident, virtually normal to the plunge of the fold axes. Scatter of fold axes occurs also as a partial girdle, normal to the one containing poles to S_2. Figure 5 is a stereoprojection of S_3 among other things and shows a partial girdle of this third foliation that commonly appears to be an axial-plane relationship to folds of S_2, and the figure tends to substantiate.

Two other features oriented parallel to the S_2 are the V_1 fracture stockwork (see later) and minor strike faults containing V_2 and V_3 veins. The V_1 fracture set in the pit is a closely spaced one, parallel to the S_2 foliation and folded with it. The strike faults separate packets of folds of S_2 and appear to be décollement surfaces parallel to the original orientation of S_2 on which movement was channeled and which were filled by V_2 and V_3 veins before movement was completed.

The prominent faults trending north to north 30 degrees east on Figure 3 are zones of very minor movement, mostly less than 20 feet or so. They are broad fracture belts of post-ore age whose significance is mostly related to pit-wall stability and movement of ground water. They therefore bear a relationship to the lower surface of secondary enrichment.

4 Vein Systems and Mineralization: The veins are readily classified into sets as previously described by Drummond (1972). The writer has simplified the many assemblages described by Drummond and related the vein sets to definite structural environments. Symbols V_1 to V_4 are used in the following discussion for the various vein sets from oldest (V_1) to youngest (V_4).

V_1 is the earliest vein that is almost invariably developed in a fracture stockwork parallel to S_2. The veinlets are small, normally only 1 to 2 millimeters wide, but may be very continuous, parallel, and separated by only 3 to 5 centimeters (see Plates 3 and 6). They are composed principally of quartz and pyrite with chalcopyrite, but within the ore zone chalcopyrite may become dominant. Pyrite is well crystallized as cubes but may be elongate. Chalcopyrite is commonly peripheral to pyrite in ameoboid forms. Sericite and chlorite may be present in the vein and are characteristic of the selvages which commonly have the fabric of planes of intense movement. The chlorite gives the envelopes a dark colour. Rarely veins in the V_1 orientation contain magnetite and epidote. In areas of very intense deformation, the V_1 veinlets may only be apparent as trains of pyrite (and chalcopyrite) in quartz, muscovite, and chlorite schist.

amoeboid

V_2 and V_3 are major veins developed parallel to the average orientation of S_2, hence parallel to V_1 or the original orientation of V_1. They differ from one another mainly in mineralogy but there is also some evidence that V_3 is the younger. Veins of both sets may be 1 foot (30 centimeters) or thicker and are traceable for 500 feet (150 meters) or more along strike. Both commonly have marked sericite envelopes and similar structural position - normally oriented in minor strike faults parallel to S_2 or the original orientation of S_2.

These faults appear to be surfaces on which décollement took place during folding of S_2. V_2 is characterized by massive quartz with significant pyrite and chalcopyrite that may occur in large nests, but with no chlorite blebs (see Plate 6). They may be drusy in a minor way. V_3 is very similar but is characterized in addition by ribbon structure and molybdenite. V_2 and V_3 seem discrete in their characteristics, but the same fault may contain both vein types. Rather inconclusive evidence of crosscutting indicates the molybdenite-bearing veins are younger.

V_4 are veins and veinlets of variable orientation commonly at a high angle to V_1, V_2, and V_3. They are most characteristically oriented in S_3 (parallel to fold axes of S_2) and as gash veins related to V_2 and V_3. Figure 5 demonstrates an interrelationship of S_3 and V_4 which was suspected in the field. A girdle is formed by the poles to S_3 and V_4 that is virtually complete. This suggests that S_3 and V_4 are related and were both formed toward the end of the deformational and mineralizing process. V_4 veins are irregular and their individual continuity small in spite of widths up to 1 foot (30 centimeters) or more. They commonly appear to grade into V_1 or V_2 or V_3's, but can definitely be found cutting each of these vein sets. They are composed of white quartz with large blebs of chlorite, carbonate, chalcopyrite, and minor pyrite. They have no alteration envelopes. They appear to be secretional veins formed by mobilization of earlier veins and wall rocks late in the deformational and mineralizing process with movement into low pressure habitats.

4 Relationships between Structure and Mineralization: The relationship in space and time between the structural development and mineralization can be rationalized on the basis of the foregoing. Primary igneous foliation S_1 was intensified by a continuing couple with the upper "plate" moving upward and northward. After initial formation of S_2, the V_1 fracture stockwork formed parallel and movement was channeled along these planes until filled and "frozen". However, general movement continued on S_2, intensifying it, eventually forming the strike faults with coinciding crumpling of S_2, and later filling with V_2 and V_3. During the process of folding S_2, the S_3 foliation formed, and secretional mobilization of V_4 from available veins and walls moved into these low pressure sites.

Leaching and Secondary Enrichment: The Gibraltar East orebody has a leached cap extending 50 to 70 feet deep as a subdued reflection of the bedrock surface. An enriched zone extends 100 to 200 feet below the leached cap is related in part to zones of intense fracturing or faulting and presumably ground-water flow. Figure 3 shows the approximate location of these surfaces. Most of the enrichment consists of chalcocite which coats and replaces pyrite and chalcopyrite. Malachite and azurite are only found near the upper surface of the enriched zone. Cuprite is also commonest in the upper part of the zone and some masses have a native copper core. The latter occurs also in wiry masses within fault zones. During the Pleistocene, glacial ice moving from the southeast out of the Cariboo Mountains overrode the area and bedrock was actively eroded and shaped. Therefore the close relationship between the shape of the enriched and leached zones to the present surface indicates that the oxidation and leaching continued after the Pleistocene, although much of the process may date from the Tertiary.

SYNTHESIS: A preliminary synthesis has been made from the data available. Geologic mapping and petrologic study indicate the existence of a modest zoning of the Granite Mountain pluton from a mafic exterior to a felsic core, and a consistent foliation transverse to the orientation of the long dimension of the pluton which is not known in the wall rocks remote from the pluton. Study of the relationship between primary igneous foliation, the secondary deformational foliation, and vein formation indicates a continuum of movement of similar orientation. The relationship between the second foliation (S_2), third foliation (S_3), and the structural relationship of the four vein sets indicates the mineralization was an integral part of this process. The Granite Mountain pluton would thus appear to have been intruded as a tongue-shaped pluton rooted to the south and probably steepening downward. A central tongue of leucocratic nature forms a domal core with peripheral bodies characterized by quartz sulphide stockworks. Emplacement, deformation, and mineralization appear to have been a continuous process, acting under a couple with the upper southern plate moving upward and northward. This couple may have been related to magma pressure continuing to act like a piston from below on the upper arcuate portion of the congealing plutonic mass.

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TABLE ASB-1

CHEMICAL ANALYSES

GRANITE MOUNTAIN PLUTON

	1 73-AB-24	2 73-AB-25	3 Average Quartz Diorite	4 Average Granodiorite
SiO_2	68.0	70.5	66.15	66.88
Al_2O_3	15.16	14.75	15.56	15.66
MgO	1.51	1.39	1.94	1.57
CaO	3.99	3.03	4.65	3.56
Na_2O	3.93	4.02	3.90	3.84
K_2O	1.99	2.38	1.42	3.07
TiO_2	0.45	0.37	0.62	0.57
MnO	0.076	0.075	0.08	0.07
FeO	1.76	1.54	3.42	2.59
Fe_2O_3	1.91	1.61	1.36	1.33
$+H_2O$	1.24	1.00	0.69	0.65
$-H_2O$	0.16	0.04	-	-
CO_2	0.07	0.055	-	-
P_2O_5	$<$ 0.18	$<$ 0.18	0.21	0.21
S	0.01	0.01	-	-

1 - Main phase - Granite Mountain pluton from 2,000 feet west of Granite Lake. Analysis - P. F. Ralph, Analytical Laboratory, B.C. Department of Mines and Petroleum Resources.

2 - Transitional leucocratic phase - Granite Mountain pluton, 100 feet northwest of 73-AB-24. Analysis - P. F. Ralph, Analytical Laboratory, B.C. Department of Mines and Petroleum Resources.

3 - Nockold's average tonalite (quartz diorite).

4 - Nockold's average granodiorite.

Nockolds?

TABLE ASB-2

ESTIMATED MODAL COMPOSITIONS

GRANITE MOUNTAIN PLUTON

	Mafic	Main Phase 73-AB-24	Transition 73-AB-25	Leucocratic Phase	Quartz Feldspar Porphyry	Aplite
Quartz	5-10	25	25	25	40-45	10*
Pc (± sericite)	65	50 (An_{35})	55 (An_{35})	60	50-55	22*
Alkali feldspar	?	10	10			5*
Hornblende		10	7			-
	25-30			7	?	
Biotite (Chl.)		5	3			-
Opaque (pyrite, chalcopyrite, ilmenite)		< 1	< 1			
Matrix (per cent)	-	-	-	20-35	50	> 60
Carbonate	-	-	-	8	5	3

* Microphenocrysts

Common accessory minerals - apatite, sphene, and zircon. Opaque minerals - pyrite, chalcopyrite, and ilmenite, are quite variable but, except in vein stockworks, are commonly much less than 1 per cent.