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THE GRANBY MINING COMPANY LIMITED

VANCOUVER, B. C.

USE OF COMPUTER AT GRANISLE COPPER

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S. D. HANDELSMAN * and K. C. FAHRNI **

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A PAPER PREPARED FOR PRESENTATION AT A SYMPOSIUM ON DECISION MAKING TO BE HELD AT THE BAYSHORE INN, VANCOUVER, B. C.

FEBRUARY 10 TO 12, 1971.

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In 1969 a scheduling study was made to determine the optimum working sequence in the pit. At the end of that year new drill information was added to the file and a new pit design and ore reserve figure were produced. All of the preceding work was carried on by mail and telephone communication with a computer service company in Tucson, Arizona. Up to this point a total of about $27,000 had been spent on various projects.

EXPANSIONS OF COMPUTER WORK

With further verification of the computer method by production and with the expanded operations indicated by drilling in 1969 and 1970 it was decided to change the set up to reduce communication time and give more flexibility. With the addition of an analyst to the company, arrangements were made to set up the necessary programmes using a local computer service bureau for processing. After a period of adjustment this system is now working satisfactorily.

CURRENT STAGES IN RE-EVALUATION OF PROPERTY

Assay and survey results from the recent drilling were keypunched and added to the original data cards. The data cards were loaded onto magnetic tape and new bench average values were calculated.

Interpolated block values were calculated from the bench average values to form a grade matrix representation of the deposit. A comparison was made between these block values and past production history.

From known operating costs and revenues, breakeven stripping ratios were calculated for various grades and metal prices.

Grade contours at each bench were analysed and a smooth pit floor outline was selected. (Fig. 1)

Because of the vertical grade consistency it was possible by lowering the pit floor to obtain tons and grade of various categories of material in a series of expanding pits and by pit differences determine when the increment of the last pit was at the economic limit. (Fig. 2) Several cut-offs were analysed. The final pit provided ore reserve figures for the current year. (not yet declared)

A sequence of working pits was designed within the ultimate pit to give a preliminary waste stripping sequence. (Fig. 3) The incremental S.R. for the working pits was computed in the same way and average haul distances of ore and waste for each increment were determined.

Preliminary mining production schedules were drawn up for several milling rates and financial analyses were made to evaluate them.

Further detailed mining schedules are being drawn up which will allow deferred stripping. (Fig. 4)

COMPARISON OF PRODUCTION WITH COMPUTER CALCULATED TONS AND GRADE

It has been found in actual practice over the life of the mine that the mining operation can make a better ore/waste separation than the computer block summations. This results in a grade improvement with a corresponding reduction of ore tonnage produced from an area. Whether this situation will change with different mining equipment or when a greater proportion of ore is coming from benches where ore completely surrounded by waste is being removed seems uncertain. During the time that present conditions continue, it can be assumed that the mining grade will be higher than grade indicated from the computer blocks. Depletion of the ore reserve will be proportionately speeded up.

USE OF COMPUTER AT GRANISLE COPPER

HISTORY OF PROPERTY

The Granisle Copper deposit is located on an island in Babine Lake in northern B. C. It was known early in the century and only a little development work had been done when The Granby Mining Company Limited became interested in 1956.

Initial drilling in 1957, 1959 and 1962 proved the ore deposit to 300 foot depth. The property was put into production at a rate of 5000 tons per day in 1966 and is now operating at 6500 tons per day.

Additional drilling in 1969 and 1970 has reached to 1000 foot depth and brought the drill total to 115,400 feet. The drill core is sampled in 5 foot sections and samples are averaged for bench intervals. About 3300 bench average assays were used as a base to calculate block values. No shaft or tunnel test work was done.

USE OF COMPUTERS AT GRANISLE IN PAST

In connection with the Feasibility Report ore reserves and mining schedules were verified by computer study by Hewlett.

In 1968 bench heights in the pit were changed and new bench averages were calculated from the existing drill information. New plans and sections were drawn up and interpolated block value plans for each bench were prepared and a new pit design and reserve calculation at the year end was produced.

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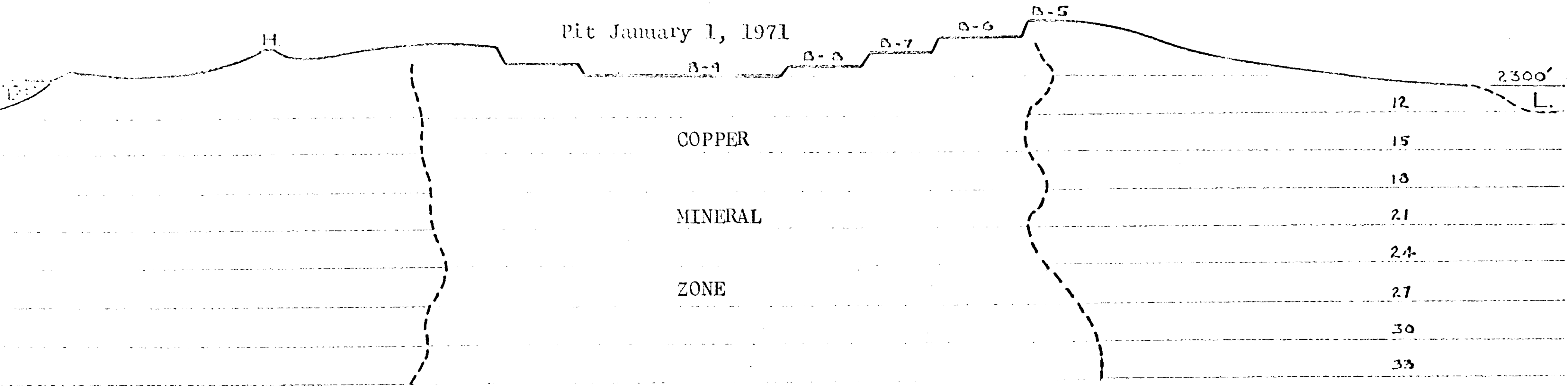
GRANISLE, B.C.



LEGEND

H - Haul Road
T - Tailings
L - Lake

LONGITUDINAL SECTION THROUGH OREBODY

Fig. 1.

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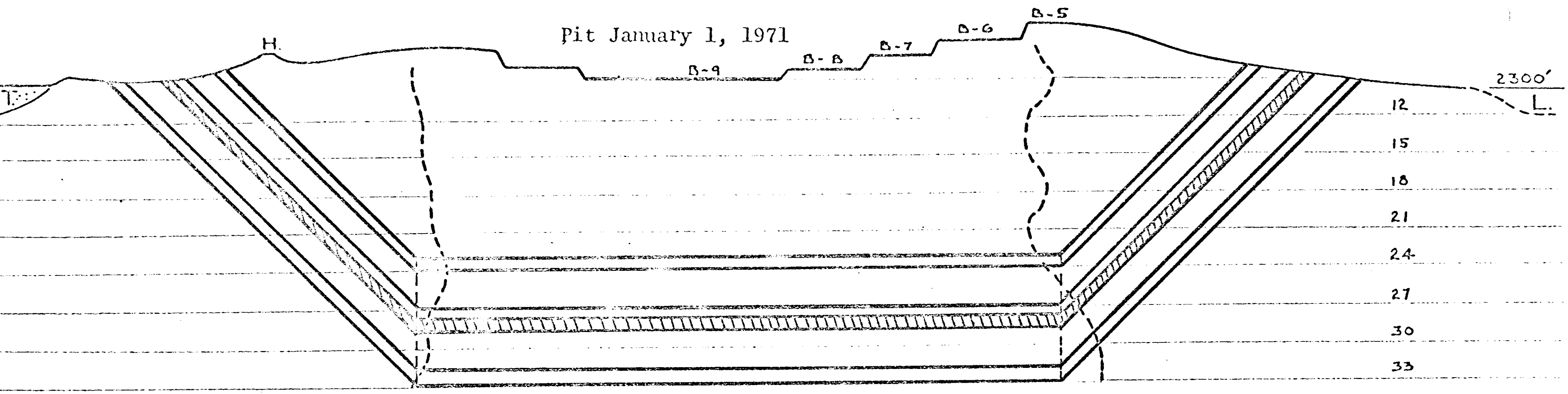

LEGEND

H - Haul Road
T - Tailings
L - Lake

LONGITUDINAL SECTION SHOWING SEVEN ULTIMATE PIT OUTLINES

The difference between ultimate pit with floor at Bench 29 and ultimate pit with floor at Bench 28 is shaded.

Fig. 2.

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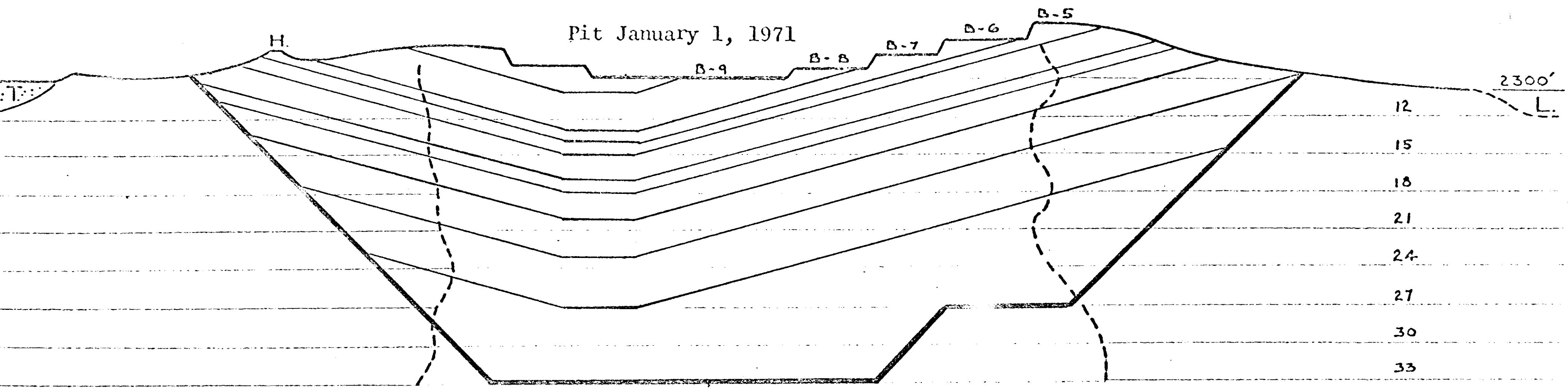

LEGEND

H - Haul Road
T - Tailings
L - Lake

LONGITUDINAL SECTION SHOWING ULTIMATE PIT OUTLINE WITH PRELIMINARY WORKING SEQUENCES

Fig. 3.

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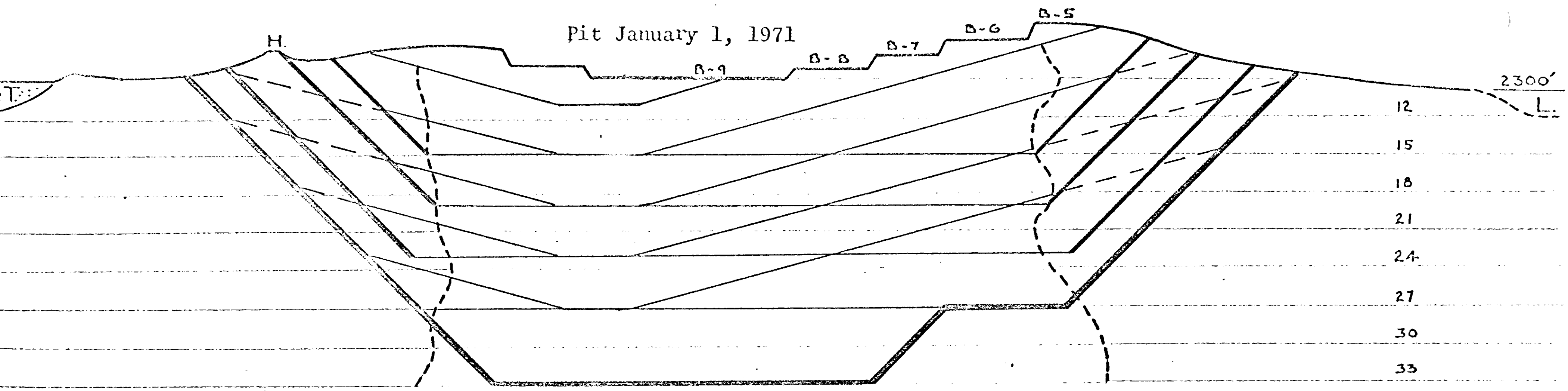

LEGEND

H - Haul Road
T - Tailings
L - Lake

LONGITUDINAL SECTION SHOWING ULTIMATE PIT WITH WORKING SEQUENCE

FOR DEFERRED WASTE STRIPPING.

Fig. 4.

in diameter with a semicircular ring-dyke about the northern circumference (*see* Fig. 10). The pluton consists largely of a single phase, a leucocratic quartz monzonite that has an apparent age of 50 ± 2 million years. This pluton intrudes the Middle Jurassic Hazelton Group consisting locally of dark-coloured pyroclastic rocks, that are only gently folded.

Alteration and mineralization are arranged concentrically to the pluton. Pyroclastic rocks surrounding the pluton are pyritized and weathered in a prominent annular gossan about 3 km in maximum diameter. A smaller exterior annulus is converted to hornfels characterized by very fine new biotite. The core of the pluton has a moderate potassic alteration with about half the original plagioclase phenocrysts converted to potash feldspar. An annulus that overlaps the contact but is principally within the pluton has an intense stockwork of quartz veinlets with accompanying, moderately intense, pervasive silicification.

Molybdenite is widely distributed in trace amounts in the pluton but mineralization approaches ore-grade only in an annulus whose outer margin is roughly coincident with the contact. The maximum grade occurs about 20 metres within the pluton. Beyond the contact molybdenum mineralization falls off sharply but pyrite with minor chalcopyrite continues in the quartz stockwork. Still further out the quartz-filled stockwork grades to dry pyrite-coated fractures.

BERG PROSPECT: By C. S. Ney.

LOCATION: Lat. 53° 48′ — Long. 127° 25.5′ — Twelve km east of the Coast Crystalline Belt and 115 km south of Smithers.

OWNERSHIP: Kennecott Copper Corporation.

The Berg is a somewhat elaborate porphyry with a central cylindrical pluton 800 metres in diameter of quartz monzonite porphyry which is dated at 50 ± 2 million years. The pluton intrudes a homclinally east-dipping sequence of greywacke, tuff, and andesite breccias correlated with the Middle Juraissic Hazelton Group (*see* Fig. 11). Part of the country rock on the east is an irregular quartz diorite stock that preceded the porphyry pluton by a few million years. Dykes and masses of quartz latite porphyry succeeded the central porphyry by a few million years. One such dyke outcrops as a conspicuous spine trending at 040° outside the central stock on the northeast, and less regular masses are

developed within. The porphyry pluton is surrounded by an anular gossan 2 km in diameter.

Alteration and primary mineralization are closely associated in annular zones eccentrically disposed around the central pluton. Potash feldspar, topaz, biotite, and silica are developed in hornfels within 50 to 250 metres of the pluton, and the best primary mineralization is in this zone. Outward the alteration becomes chloritic and barren pyrite predominates as the valuable sulphides decrease. The outer limit of visible gossan, 300 to 600 metres from the stock, marks a decline in pyrite content of about 2 per cent, coincident with little alteration other than epidote. Random fractures spaced at 1 to 3 cm characterize the mineralized zone, and superimposed on this is a reticulate network of low-dipping gypsum veinlets.

Molybdenum and copper are zoned in an irregular annulus centred on the pluton which is weakly mineralized in both metals. Molybdenum attains maximum value immediately adjacent to the stock and falls off slowly outward. Copper increases outward, reaching peak values 100 to 200 metres out, more or less at the chlorite-biotite line.

Although glaciers are still present nearby, the Berg basin escaped severe Wisconsin glacial erosion, so that supergene leaching extends down to more than 100 metres from the surface. This leaching was facilitated by the network of soluble gypsum veinlets Chalcocite has developed as a weak irregular blanket particularly in the low valley slopes southeast of the stock where primary copper grade is enhanced by a factor of one-third.

DAY 4

GRANISLE: By N. C. Carter.

LOCATION: Lat. 54° 56.5′ — Long. 126° 00′ — The mine is situated on McDonald Island near the north end of Babine Lake, 65 km northeast of Smithers.

OWNERSHIP: Granisle Copper Ltd. (controlled by The Granby Mining Company Limited).

McDonald Island was first prospected in the early 1900's when several workings were developed on veins in what is now the Granisle mine. In 1929 Cominco drilled five holes that indicated 8 million tons grading 0.8 per cent copper with minor gold and silver. The property was then dormant

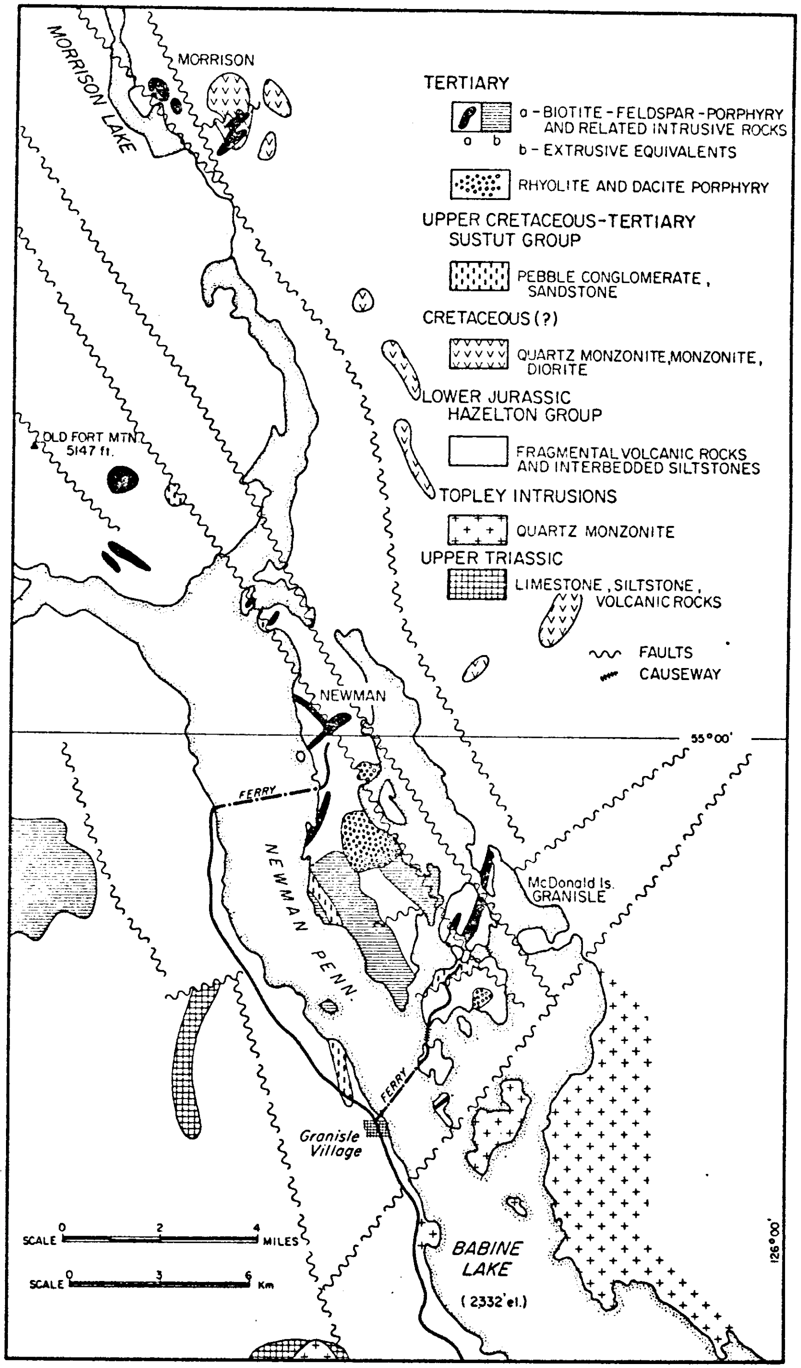

Fig. 12. Northern Babine Lake Area.

until 1955 when Granby acquired the claims, explored them, and formed Granisle Copper Ltd., to develop them. Production began in 1966 at 6,000 tons per day and has amounted to over 9 million tons to the end of 1970. This has yielded approximately 47,750 tons of copper, 54,000 ounces of gold, and 506,000 ounces of silver.

The Granisle porphyry copper deposit is the only representative of the simple and elaborate types of porphyry deposits of the Skeena Arch that is in production. Although the rock types, age, and setting are characteristic of these deposits, Granisle is aberrant in several respects.

Regional Setting

Copper deposits of the northern Babine Lake area are related to small porphyry intrusions of Tertiary age which intrude Mesozoic volcanic and sedimentary rocks (see Fig. 12). These include two main sequences: Upper Triassic siltstones, limestones, and andesites, and Jurassic fragmental andesites and rhyolites, volcanic sandstones, and conglomerates. These sequences are intruded by Mesozoic plutons, some of which are definitely part of an Early Jurassic phase of the Topley Intrusions. Continental sedimentary rocks, believed to be of Late Cretaceous and Early Tertiary age occur as small outliers, commonly adjacent to major steep faults. Tertiary intrusions include quartz latite and dacite porphyries that are not known to be associated with significant mineralization, and biotite-feldspar porphyries which are.

The Granisle and other copper deposits of the area are all associated with dykes and plugs of biotite-feldspar porphyry of quartz diorite composition. Potassium-argon determinations carried out on 10 biotite samples from the porphyries and related types yielded a mean age of 51.2 ± 2 million years (Middle Eocene). These crowded porphyries are of distinctive appearance and show a marked spatial relationship to northwest-striking faults of regional magnitude. Extrusive equivalents of these rocks occur as flat-lying sheets exhibiting columnar jointing near the south end of Newman Peninsula and west of Babine Lake. These rocks, while of similar appearance to the intrusive biotite-feldspar, differ by having a fine-grained, green to purple matrix and hornblende, which imparts a flow texture, as the chief mafic mineral. Locally the rocks are crystal tuffs and some flow breccias were noted west of Babine Lake.

The major structural trend of the area is northwesterly as indicated by the strike of the bedded rocks and the major high-angle block faults. Volcanic and sedimentary rocks underlying Newman Peninsula and surrounding area have been folded into a broad synclinal structure which has been modified by later block faulting. Northeasterly faults are also common and while they do not appear to be of the same regional extent as the northwest faults, they may have been equally important in localizing the Tertiary intrusions.

Local Geology

The Granisle mine is in the central part of McDonald land, which is triangular shaped, each side being about 5 km long.

The island is underlain chiefly by volcanic and sedimentary rocks of the Lower Jurassic Hazelton Group which are divisible into two distinct members. Green to purple water-lain andesite tuffs and breccias with intercalated chert pebble conglomerates underlie the central and eastern part of the island. These rocks, which strike northerly and dip at moderate angles to the west are apparently overlain in the western part of the island by massive and amygdaloidal andesitic flow rocks and thinly bedded shales (*see* Fig. 13).

Porphyry Intrusions

Copper mineralization is associated with a series of porphyry intrusions which occur in the central part of the island. The oldest of these is an elliptical plug of quartz diorite, however the largest and most prominent is a 120 to 200-metre wide dyke of biotite-feldspar porphyry which rikes northeasterly across the island. This wide dyke is ident as a ridge which before mining culminated as a 0-metre hill above lake level. There are small dykes very similar in composition that post-date mineralization. The multiple intrusions are well displayed in the present open pit.

The first intrusive stage is represented by a northeast-oriented ovaloid cylindrical pluton of fine-grained dark grey quartz diorite, the original dimensions of which were approximately 300 by 500 metres in plan. The quartz diorite is commonly a microporphyry with 1-mm phenocrysts of zoned andesine set in a fine-grained quartz-plagioclase-biotite matrix. Original amphibole grains, now completely altered to fine masses of biotite, locally impart a foliation to the rock.

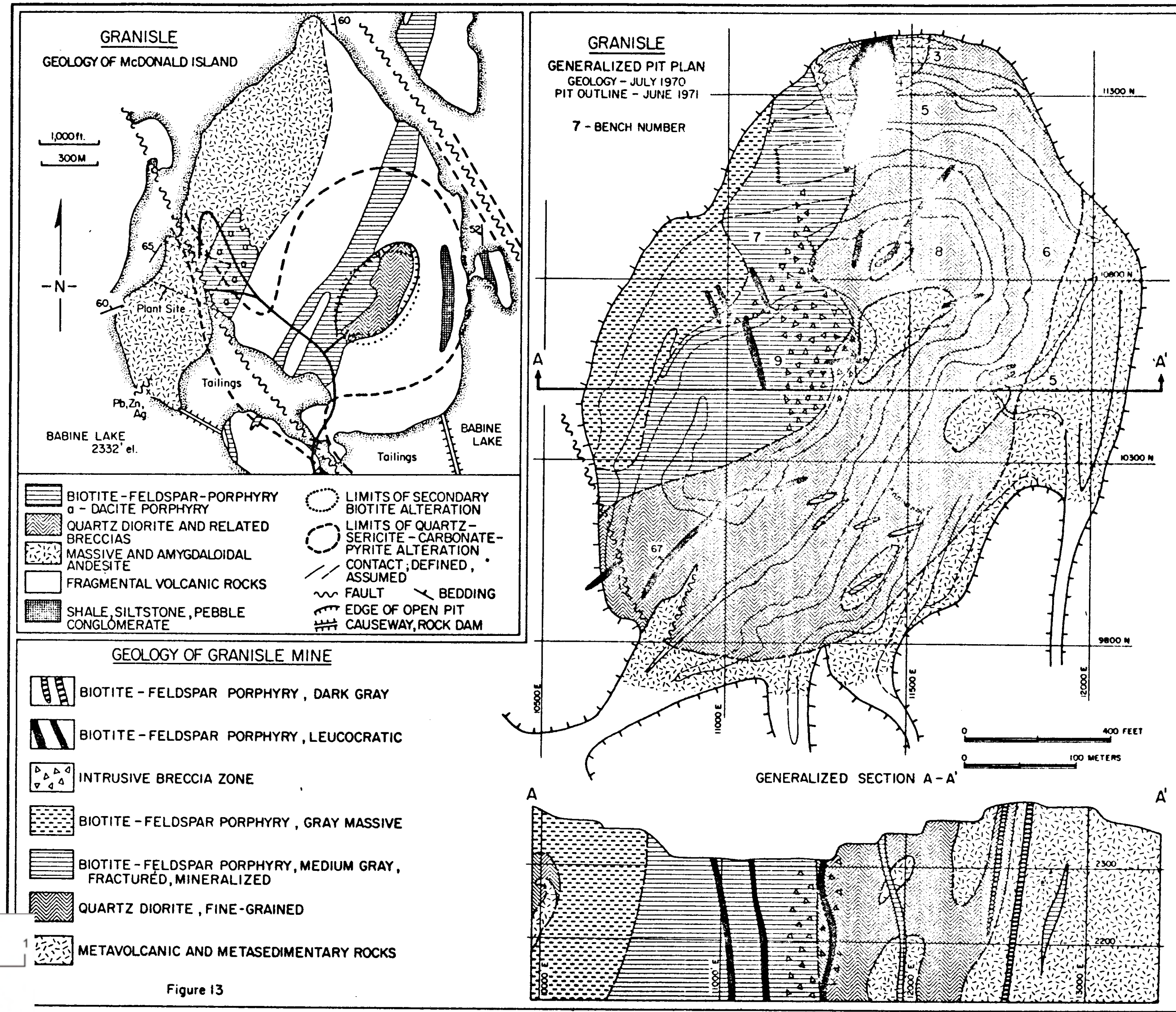

Figure 13

Within the quartz diorite, particularly along its eastern edge, are irregular inclusions of metavolcanic and metasedimentary rocks which had a wider distribution in the original outcrop. Three varieties occur, two of which are breccias believed to be the product of recrystallization and metasomatism of the fragmental volcanic and sedimentary rocks marginal to the intrusive. One variety of breccia includes 1 to 3-cm rounded chert and volcanic fragments in a fine-grained diorite matrix, while another consists of chert fragments in a white felsic matrix which also contains 4-mm clots of very fine-grained quartz and chloritized biotite. The third variety of inclusions consists of fine-grained, light to dark grey, hornfelsed volcanic and sedimentary rocks.

The most important intrusions are biotite-feldspar porphyries of several distinct but very similar phases that overlap the period of mineralization. The largest and oldest is the wide northeasterly trending dyke which is intrusive into the western edge of the quartz diorite pluton. In plan, a salient of this porphyry projects into the quartz diorite in the pit area and the contact between the two is nearly vertical. Small dykes of porphyry radiate outward from the main dyke. The main porphyry is light to dark grey and ranges in composition from quartz diorite to granodiorite depending on the amount of potash feldspar present, most of which is of secondary origin. Characteristically the rock is a crowded porphyry with between 35 and 50 per cent by volume consisting of 2-mm euhedral fresh, zoned plagioclase (oligoclase-andesine) phenocrysts and 1-mm flakes and books of fresh brown biotite. These phenocrysts are set in a fine-grained matrix consisting essentially of quartz, plagioclase, patches of fine-grained biotite, some of which is pseudomorphic after amphibole, potash feldspar, and apatite. Outside of the pit area, the porphyry is a uniform grey colour and contains hornblende phenocrysts as well as biotite and plagioclase.

Several of the phases of porphyry intrusions can be recognized within the pit area. While these are all grossly similar in appearance and composition as described above, they can be distinguished by slight differences in the colour of the matrix, resulting mainly from variations in grain size, by crosscutting relationships, and by the presence of inclusions of earlier phases contained in later ones.

The earliest and most widespread porphyry phase is the medium-grained, well-fractured and mineralized biotite-feldspar porphyry exposed in the central part of the pit.

Small dykes of similar material were noted cutting the quartz diorite. Bordering this type on the west is a massive grey porphyry of uniform appearance, differing mainly by having a slightly coarser matrix and by a relative absence of fracturing and mineralization. These two varieties of biotite-feldspar porphyry are probably products of the initial stage of porphyry intrusion with fracturing being best developed in the contact area between the porphyry and the quartz diorite.

Occurring along the contact between the biotite-feldspar porphyry and the quartz diorite are narrow discontinuous dykes and stringers of intrusive breccia which range in width from several inches to several feet and follow the principal fracture directions. The dykes and stringers are contained in a northerly trending, vertical zone which is up to 60 metres wide. The intrusive breccias commonly contain 1 to 2-cm rounded fragments of both the medium grey mineralized porphyry and the quartz diorite in a fine-grained light to dark grey granulated matrix of strained and fractured quartz, broken plagioclase grains, and locally abundant very fine-grained biotite. The breccias are also mineralized, with some disseminated chalcopyrite occurring in the matrix.

Dykes of light grey, relatively leucocratic biotite-feldspar porphyry up to 3 metres wide, that also parallel the dominant fracture pattern, occur as northwest-trending vertical dykes in the main porphyry mass and northeast-trending vertical to steeply dipping dykes in the marginal quartz diorites. These dykes have a coarse matrix which has a lower biotite content. Rounded inclusions of mineralized porphyry are common in the leucocratic type which are only locally mineralized themselves by minor disseminated pyrite and chalcopyrite.

The latest porphyry phase, post-mineral in age, occurs as dykes of dark grey biotite-feldspar porphyry which intrude diorite rocks in the eastern part of the pit. The plagioclase phenocrysts are sparser than in earlier phases and the dark grey matrix is due to the presence of very fine-grained biotite and uniformly disseminated magnetite. No sulphide minerals were noted in this phase.

Structure

The porphyry dyke on McDonald Island is bounded by two parallel northwest block faults. The westernmost of these is marked by a topographic lineament which crosses the island to the south of the mine and extends through the western part of McDonald Island in the vicinity of the plant site. The eastern fault extends along the channel separating McDonald Island from the east shore of Babine Lake.

Within the pit area, the main fractures are vertical to steeply dipping and include the following sets: north 20° to 40° east; north 70° to 85° east; and north 30° to 60° west. Horizontal to slightly inclined fractures are also common. In general the resulting fracture spacing may vary from 0.1 to 1 metre.

Movement has occurred along many of the fractures; the most common faulting directions being north 20° east and north 30° to 60° west.

Alteration and Mineralization

An oval zone of potassic alteration is roughly coincident with the ore zone or the pit outline (*see* Fig. 13). Within this zone, the intrusive rocks appear relatively fresh in hand specimen and plagioclase phenocrysts are essentially unaltered. The main alteration product is secondary biotite which occurs as very fine-grained aggregates which retain original amphibole outlines in both the porphyries and the quartz diorites. Fine-grained biotite is also uniformly distributed in the matrix of the intrusive rocks. However secondary potassium feldspar is also present within the ore zone, occurring most commonly as fine grains in the matrix of the biotite-feldspar porphyry, and only detectable by staining. Pink potassium feldspar also forms thin envelopes enclosing veinlets and fractures in the lower benches of the pit. Similar alteration was noted at depth in cores of holes drilled in the centre of the orebody.

The potassic alteration zone is gradational outward to a quartz-sericite-carbonate-pyrite zone. This zone, apparent by iron staining on weathered surfaces, is visible on the higher benches at the north end of the pit and along roads south of the pit. This pyrite halo is elliptical in plan, and is roughly coaxial with the ore zone, extending 150 to 250 metres beyond. It merges with a similar alteration along the regional fault southwest of the pit. The entire quartz-sericite-carbonate-pyrite zone measures 1,000 by 1,200 metres. Within this zone, the intrusive rocks and most of the volcanic rocks are weathered to a uniform buff color. Abundant fine-grained quartz has been introduced, mafic minerals have been altered to a mixture of sericite and carbonate, and plagioclase is clouded by sericite. Pyrite occurs both as disseminations and as fracture fillings.

Outside the pyrite halo, most of the rocks on McDonald Island display varying degrees of propylitic alteration; chlorite, carbonate, and epidote are common constituents in the matrix of volcanic rocks and carbonate-filled fractures are widespread. Pyrite also occurs in fractured zones. Clay mineral alteration is confined to narrow gouge and fault zones.

The principal minerals within the ore zone are chalcopyrite, bornite, and some pyrite. Medium to coarse-grained chalcopyrite is most widespread, occurring principally in quartz-filled fractures which vary from 1 to 5 mm in width. The mineralized fractures have preferred orientations of north 35° to 60° east and north 30° to 60° west, and dip steeply. A horizontal fracture set in the pit is only weakly mineralized. Chalcopyrite is also disseminated in the quartz diorite and associated metasedimentary and metavolcanic rocks.

Bornite is most widespread in the southern half of the ore zone where it occurs with chalcopyrite and quartz in fractures. The greatest concentrations of bornite were confined to the upper 250 feet (76 metres) of the south end of the orebody. During the first few years of mining operations a number of veins up to 0.3 metre wide and composed of coarse-grained bornite, chalcopyrite, quartz, biotite, and apatite were uncovered. They were vertical and had a strike of north 50° east but were discontinuous.

Gold and silver are recovered from the copper concentrates. Molybdenite occurs locally within the ore zone, most commonly in drusy quartz veinlets which appear to be later than the main mineralizing stage. Magnetite and specularite are common in the north half of the ore zone where they occur in fractures with chalcopyrite and pyrite.

The greatest concentration of pyrite is peripheral to the copper orebody where it occurs as blebs, stringers, and disseminations.

Near the southwest end of the island, approximately 1,200 metres southwest of the pit, a narrow quartz-carbonate-pyrite-galena-sphalerite-chalcopyrite vein containing silver values follows a northeast-striking fault for a limited distance.

Age of Mineralization

Potassium-argon age determinations on four biotite samples collected in and near the Granisle orebody yielded a mean age of 51.2 $\pm$ 2 million years. The biotites analysed were from the following samples: (i) medium grey, well-mineralized biotite-feldspar porphyry from the south-central part of the orebody, (ii) a quartz-chalcopyrite-bornite-apatite vein, also from the southern end of the orebody, (iii) an unmineralized dyke of biotite-feldspar porphyry 915 metres southwest of the orebody, and (iv) a dyke of dark grey biotite-feldspar porphyry of definite post-mineral age, collected from the east side of the pit.

The similarity in age for all these samples indicates not only the close time relations between intrusive and hydrothermal activity, but also that mineralization is apparently synchronous or nearly so with intrusion.

Other Deposits of the Northern Babine Lake Area

Copper mineralization is associated with intrusions of biotite-feldspar porphyry at several other prospects in the northern Babine Lake area, but only two of these are known to be of economic importance: the Newman mine of Bell Copper Division of Noranda Mines Limited, situated 8 km northwest of Granisle; and the Morrison deposit also owned by Noranda Mines Limited, situated on the southeast side of Morrison Lake about 23 km north of the Newman mine.

The Newman deposit, discovered in 1962, is scheduled to be in production by the summer of 1972 at a daily milling rate of 10,000 tons. Ore reserves are in the order of 50 million tons of 0.50 per cent copper. The Morrison deposit, still in the exploration stage, is believed to be of larger tonnage but is of lower grade.

The Newman deposit is grossly similar to Granisle, inasmuch as the copper mineralization is related to a plug-like intrusion of biotite-feldspar porphyry which is oriented in a northeast direction and measures 450 by 900 metres. Radial dykes projecting from the west side of the plug suggest it is probably a volcanic neck which has come up along the contact area between siltstones on the west and fragmental volcanic rocks on the east. The Newman orebody is unique in that it is one of the few deposits in British Columbia with a substantial zone of supergene mineralization. This zone is best developed over the southwest end of the pluton, where it extends to depths of as much as 120 metres. Sooty chalcocite coats pyrite occurring in fractures and quartz veinlets in porphyry and adjacent siltstones that also exhibit intense clay mineral alteration, most of which is supergene. Underlying this supergene zone is the best primary mineralization which forms a vertical pipe-like zone 150 metres in diameter, centred on the southwest contact of the pluton and extending to a depth of at least 760 metres. Within this zone, fine-grained chalcopyrite occurs in a stockwork of quartz veinlets and in irregular silicified areas in biotite-feldspar porphyry and bordering siltstones. Lower grade copper mineralization is peripheral to a higher grade zone on its eastern side.

Relatively unaltered and unmineralized biotite-feldspar porphyry, bordering the supergene zone on the east and capping fair-grade primary mineralization at depth, may represent a later, possibly post-mineral porphyry phase.

The alteration pattern at Newman is similar to Granisle, but is modified near surface by supergene clay-mineral alteration. Within the zone of primary mineralization, a potassic zone, consisting of secondary biotite alteration is coincident with the ore zone and is surrounded by a quartz-sericite-carbonate-pyrite zone extending outward 600 to 900 metres.

Copper mineralization at the Morrison deposit consists of chalcopyrite in fractures and quartz veinlets in north-trending dyke swarms of biotite-feldspar porphyry which occurs west and east of a small pluton of similar composition.

Day 5

ENDAKO: By K. M. Dawson and E. T. Kimura.

LOCATION: Lat. 50° 02′ — Long. 1125° 06.5′ — North of the east end of Francois Lake, 185 km west of Prince George.

Endako mine is the largest molybdenum producer in Canada and second largest in the world after Climax, Colorado. The deposit is an elongate stockwork of quartz-molybdenite veins developed within the Endako quartz monzonite phase of the Topley Intrusions. In comparison with other Cordilleran porphyry-type copper and molybdenum deposits, Endako is notable for the paramagmatic affiliations of hydrothermal alteration and mineralization, the well-defined sequence of potassic, sericitic, and argillic alteration stages, and the lack of ore-controlling breccias and minor intrusions. Sutherland Brown, et al. (1971) would classify it as a plutonic porphyry deposit.

The original discovery on the property, the Stella vein, was found in 1927, but the large tonnage potential of the deposit was not recognized until 1962, when a small but encouraging drilling programme was initiated by R. & P. Metals Corporation Limited. Canadian Exploration Limited examined, optioned, and commenced drilling the property in late 1962. The decision to develop the deposit for production was announced in March 1964, and the mine was officially opened on June 8, 1965. Total production to the end of 1970 was about 39,000 tons of molybdenum. Normal daily production is 27,500 tons of ore at an average grade of 0.16 per cent molybdenite from an open pit with a low stripping ratio. Reserves in 1971 are estimated at 209 million tons of ore averaging 0.15 per cent molybdenite, calculated at a cut-off grade of 0.08 per cent molybdenite.

Regional Setting

Geologic knowledge of Endako area is based primarily upon mapping by Armstrong (1949), Tipper (1963), Carr (1966), and the writer (Dawson, 1971).

The Topley batholith, of Jurassic age, extends west-northwestward from Quesnel to Babine Lake, a distance of some 290 km. The batholith flanks and intrudes the southwestern margin of the Pinchi geanticline, an elongate, fault-bounded belt of Permo-Pennsylvanian (Cache Creek Group) rocks in central British Columbia. This belt of basic volcanics, chert, and limestone was uplifted in Late Triassic time along steeply dipping peripheral faults which subsequently may have controlled emplacement of rising Topley magma. South and west of the Pinchi geanticline, the Topley batholith intrudes volcanic and sedimentary rocks of Late Triassic to Middle Jurassic age.

Nine phases of Topley Intrusions have been distinguished in the Endako area (Carr, 1960) and have subsequently been dated radiometrically (*see* Fig. 14 and Table 1). The oldest and most extensive Topley unit, the Middle Jurassic Simon Bay diorite complex, is a concordant mesozonal pluton whose prominent foliation parallels the northwest batholith trend and probably reflects pre-existing structural controls upon its emplacement. In the Endako area, Simon Bay rocks are intruded by Late Jurassic Topley phases (Endako, Nithi, Glenannan, Casey, and Francois plutons) of discordant, epizonal type and west-northwest elongation. The predominantly quartz monzonitic plutons are closely grouped in radiometric age (137 to 141 m.y.) and represent a relatively short