PORPHYRY COPPER-GOLD-MOLYBDENUM MINERALIZATION IN THE ISLAND COPPER CLUSTER, VANCOUVER ISLAND

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The Island Copper cluster (ICC), situated at the northern end of Vancouver Island, consists of five porphyry copper-gold-molybdenum systems (Fig. 1) genetically associated with stock and dyke-like rhyodacitic porphyries of Jurassic age (approximately 180 Ma) that intruded the island arc, calc-alkaline basalts, andesites and pyroclastic rocks of the comagmatic Bonanza Group. The systems (Island Copper, Bay Lake, G Zone, Red Island, and Rupert Inlet) are coincident with a series of northwest-trending magnetic highs and regional faults aligned for more than 10 km. All of the systems share many similarities in their alteration-mineralization geometries, but vary largely in size and grade. Copper-bearing skarn and vein-type mineralization also constitutes an integral part of the porphyry systems.

The only economic deposit of the cluster is the Island Copper mine, controlled and operated by BHP ....

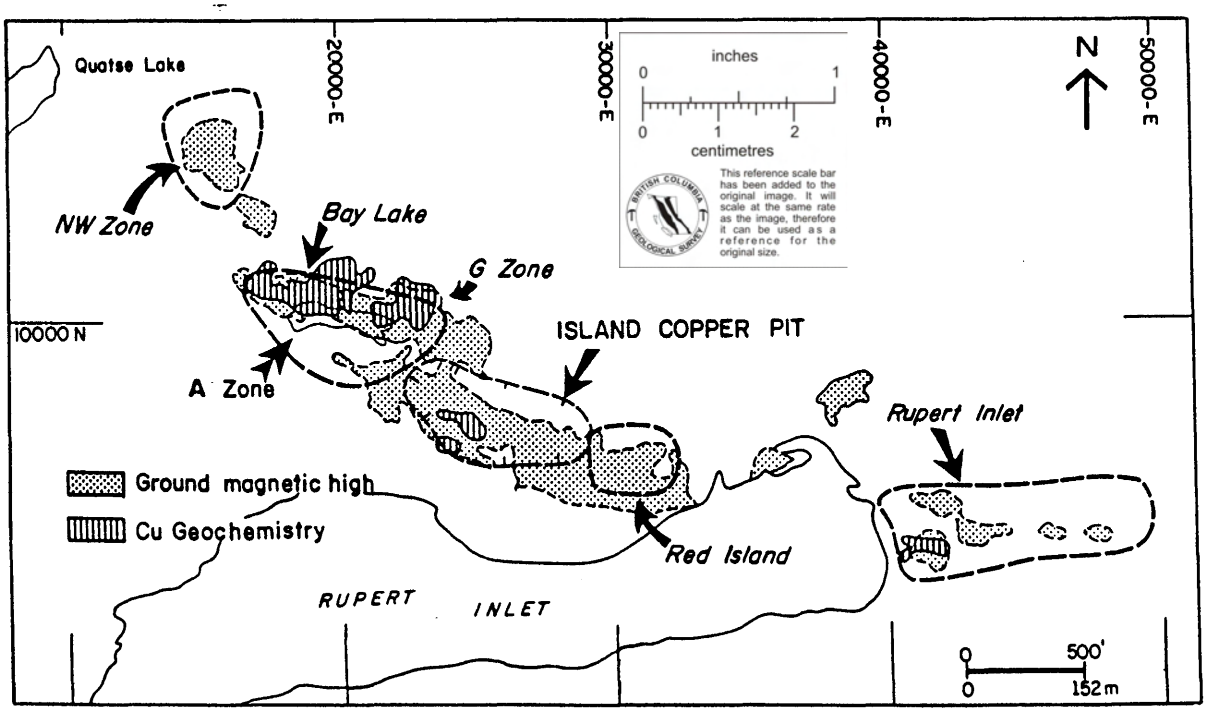


FIG. 1. The Island Copper cluster.

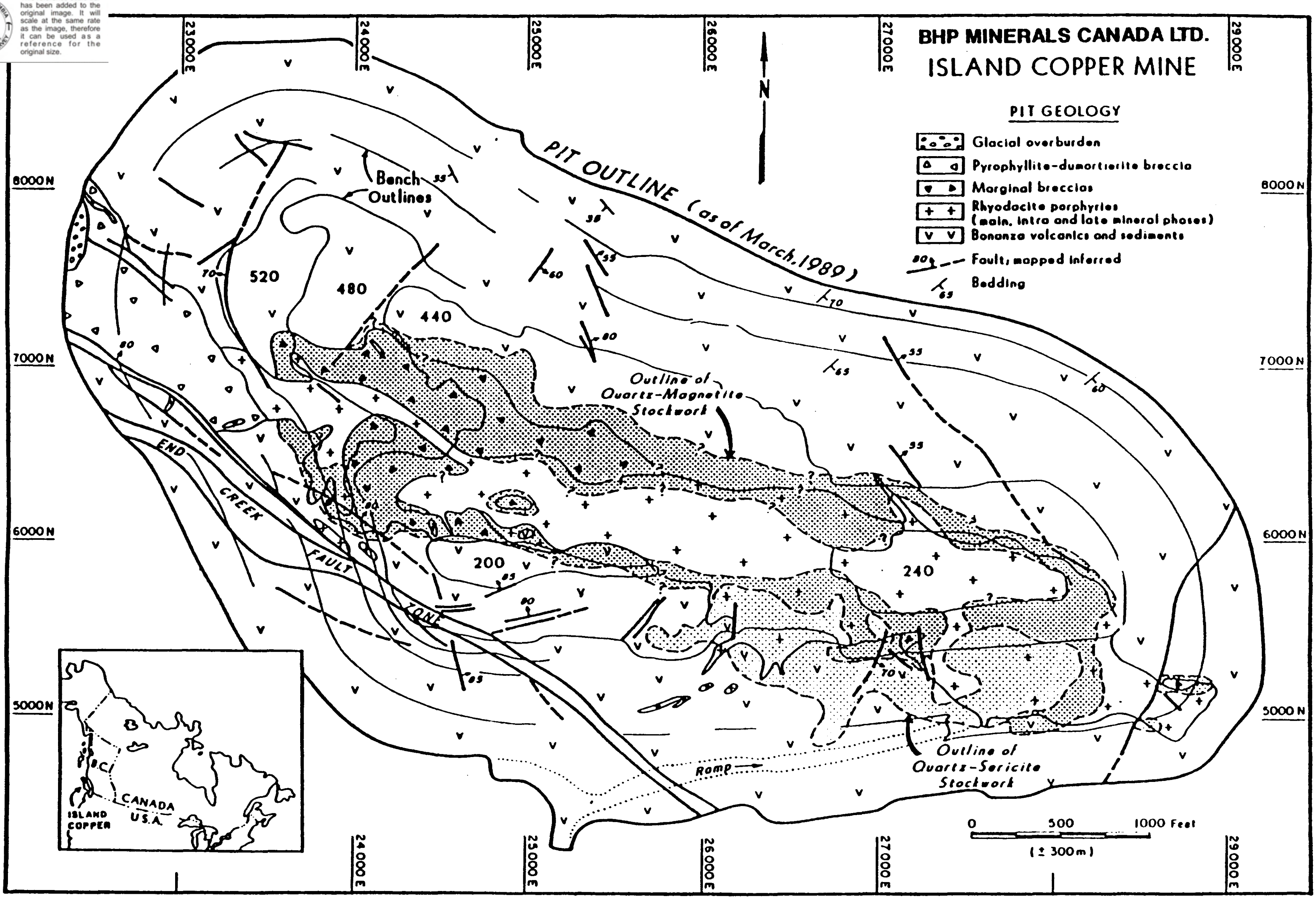

BHP MINERALS CANADA LTD.
ISLAND COPPER MINE
PIT GEOLOGY
Glacial overburden
Pyrophyllite-dumortierite breccia
Marginal breccias
Rhyodacite porphyries (main, intra and late mineral phases)
Bonanza volcanics and sediments
Fault; mapped inferred
Bedding
N
PIT OUTLINE (as of March, 1989)
Bench Outlines
Outline of Quartz-Magnetite Stockwork
Outline of Quartz-Sericite Stockwork
END CREEK FAULT ZONE
Ramp
520
480
440
200
240
23000 E
24000 E
25000 E
26000 E
27000 E
29000 E
30000 E
8000 N
7000 N
6000 N
5000 N
0 500 1000 Feet
(± 300 m)
B.C.
CANADA
U.S.A.
ISLAND COPPER

FIG. 2.

Minerals Canada Ltd., which had initial estimated reserves of 257 million tonnes at 0.52% Cu and 0.017% Mo at a cutoff grade of 0.3% Cu. At Island Copper, mineralization is associated with multiphase rhyodacitic intrusions and hydrothermal breccia bodies. Available data suggest that the porphyry system evolved dynamically from an early, probably juvenile-dominated stage, to one strongly influenced by meteoric waters, as the main heat source cooled and further intrusion and brecciation took place. Three main stages of alteration and mineralization have been differentiated:

1. An *Early Stage*, related to the intrusion of a main rhyodacite porphyry, involved the development of four outwardly progressing zones (Figs. 2, 3, 4): (a) a copper-barren stockwork core of quartz-amphibole-albite-magnetite-(apatite, scapolite); (b) a biotite-magnetite zone containing chalcopyrite, pyrite, and molybdenite; (c) a chlorite zone containing pyrite and minor chalcopyrite and magnetite; and (d) an outermost epidote zone. All are found in Bonanza volcanic rocks except the quartz-amphibole-magnetite stockwork core which, in addition, formed along the margins of the rhyodacite porphyry. The biotite alteration, together with the main copper mineralization, partly overprinted the stockwork core. Preliminary fluid-inclusion data indicate that the fluids associated with the iron-rich core of the system were hot (>500 °C) and saline (>50 equiv. wt% NaCl), consistent with a magmatic derivation. Mass-balance calculations for these assemblages indicate gains of up to 450% Fe and 42% Na.

2. A structurally-controlled *Intermediate Stage*, superimposed upon the earlier assemblages, was related to the emplacement of quartz stockworks and hydrothermal breccias associated with the intrusion of intermineral rhyodacitic porphyry during the collapse of the hydrothermal system. Alteration was dominated by quartz-sericite and sericite-clay-chlorite assemblages, together with pyrite, chalcopyrite, and molybdenite.

3. A *Late Stage*, related to the emplacement of the Pyrophyllite Breccia assisted by further late-mineral rhyodacitic intrusions, is characterized by a pyrite-bearing, copper-barren advanced argillic alteration assemblage of pyrophyllite, kaolinite, sericite, and dumortierite. Further low-temperature alteration episodes included ankerite-calcite veining, widespread zeolite development, and the precipitation of remobilized carbon-bearing organic compounds.

The bulk of the copper mineralization at Island Copper (Figs. 4, 5, 6) was introduced during the Early Stage in feldspar-stable, K-silicate conditions, and was followed by a main episode of molybdenum in a feldspar-destructive, sericitic environment. All of the recovered copper occurs as chalcopyrite, predominantly hosted by biotite-altered Bonanza volcanic rocks. Similar alteration-mineralization geometries characterize the other members of the ICC, although hydrothermal pyroxene is conspicuous in the quartz-amphibole-magnetite stockwork core at Bay Lake.

Gold production from Island Copper since production started in 1971 through to the end of 1993 is >32,000 kg, and annually amounts to 1,200 to 1,500 kg. This renders Island Copper one of the largest current gold producers, and historically the seventh largest lode-gold producer, in British Columbia. Historical average head-grade of the deposit is about 0.19 ppm gold but includes large volumes having assayed more than 0.40 ppm gold. Only about 50% of the gold is recovered in the copper concentrate, which has averaged about 24% Cu, 7 ppm Au, and 60 ppm Ag.

The bulk of the gold was associated with Early Stage copper mineralization. Some gold seen to be associated with Intermediate Stage assemblages could have originally been introduced by this event or remobilized from earlier mineralization. Gold has been observed in the native form, as micrometre-size inclusions in chalcopyrite, pyrite, molybdenite, and silicates.

Certain features, such as the positive correlation between gold and copper, the association of gold with the potassic, biotite-rich alteration, and the high content of magnetite in the system (>8% by vol.) are characteristic of gold-rich porphyry copper deposits elsewhere. The spatial arrangement of the ore zones (biotite-chalcopyrite around a copper-barren, quartz-magnetite core) is, however, considered to be unique among porphyry deposits because copper-gold ore normally accompanies the quartz-magnetite stockwork veinlets (*e.g.*, Philippine porphyry deposits).

The copper-gold-molybdenum assemblage at Island Copper confirms that porphyry deposits cannot be exclusively divided into copper-gold and copper-molybdenum categories, but are part of a larger spectrum containing intermediate copper-gold-molybdenum examples that has copper, gold, and molybdenum-only deposits as end members. Comparisons are also valid between the iron-rich, quartz-amphibole-magnetite-albite-(apatite, scapolite) stockwork core of the systems of the ICC, which at Bay Lake contains additional pyroxene, and the iron-ore mineralization of the Kiruna-type.

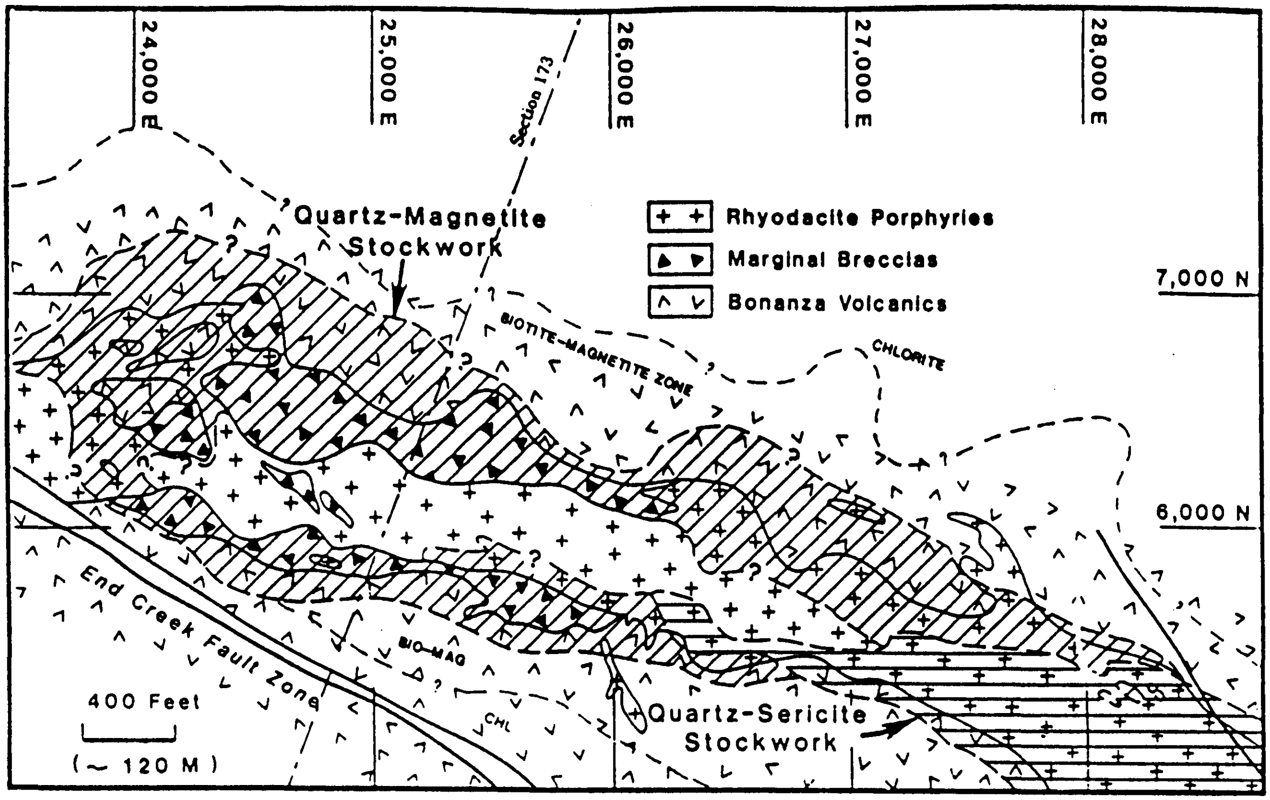


FIG. 3. Geology of 560 bench, Island Copper mine.

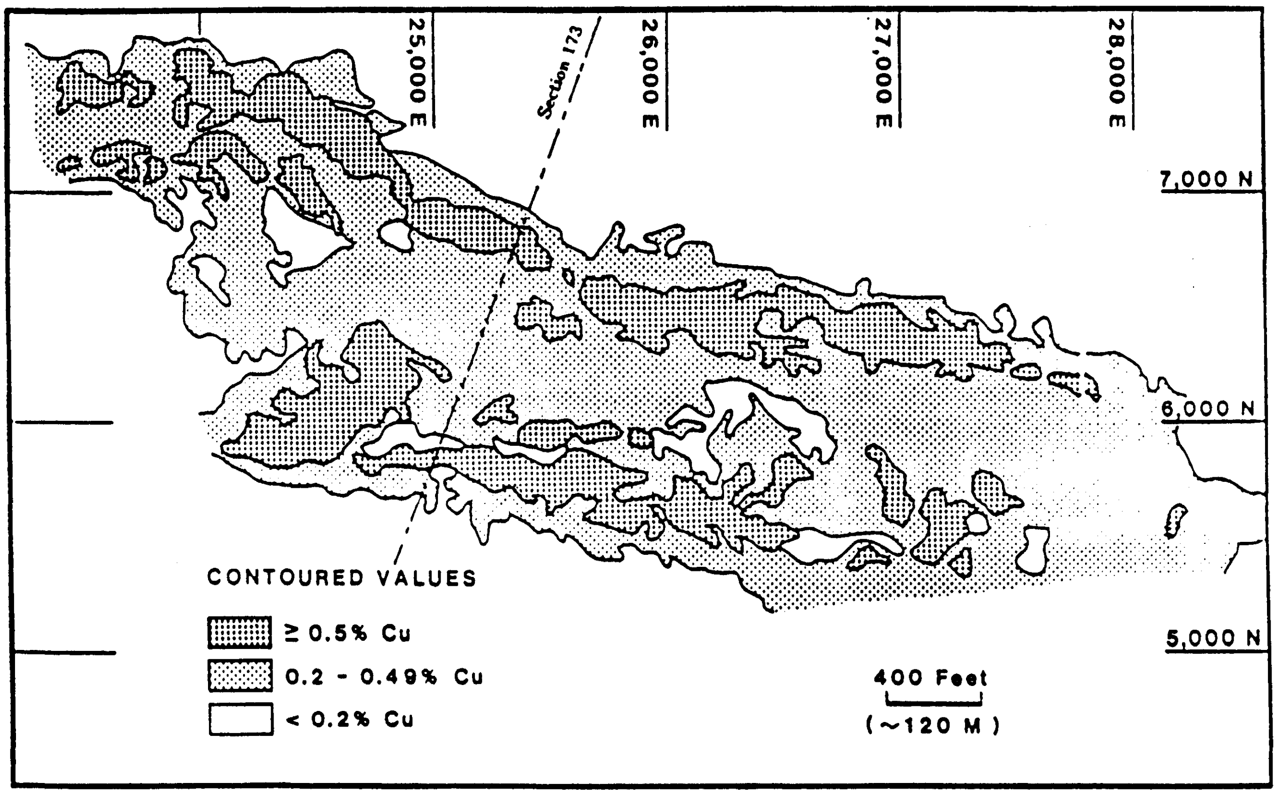


FIG. 4. Contoured copper values for 560 bench.

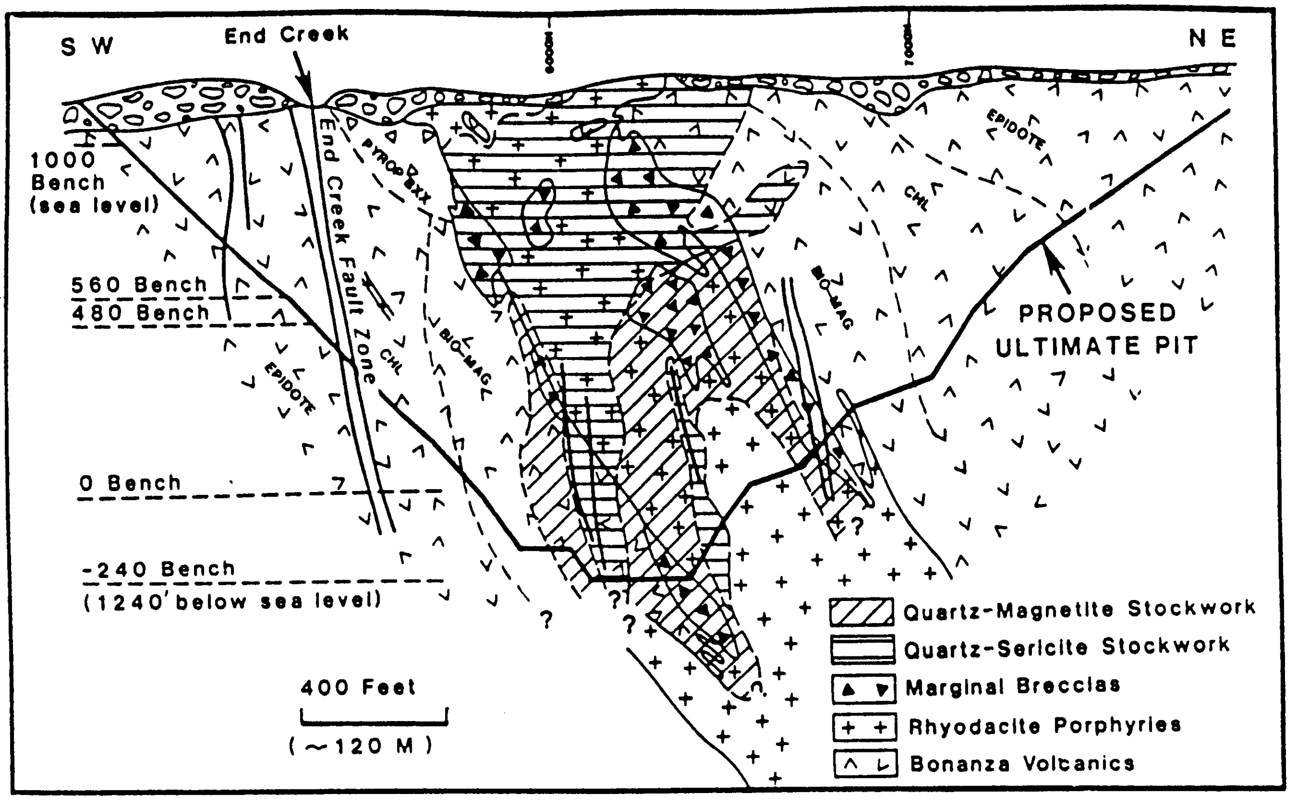


FIG. 5. Geology of section 173W, Island Copper mine.

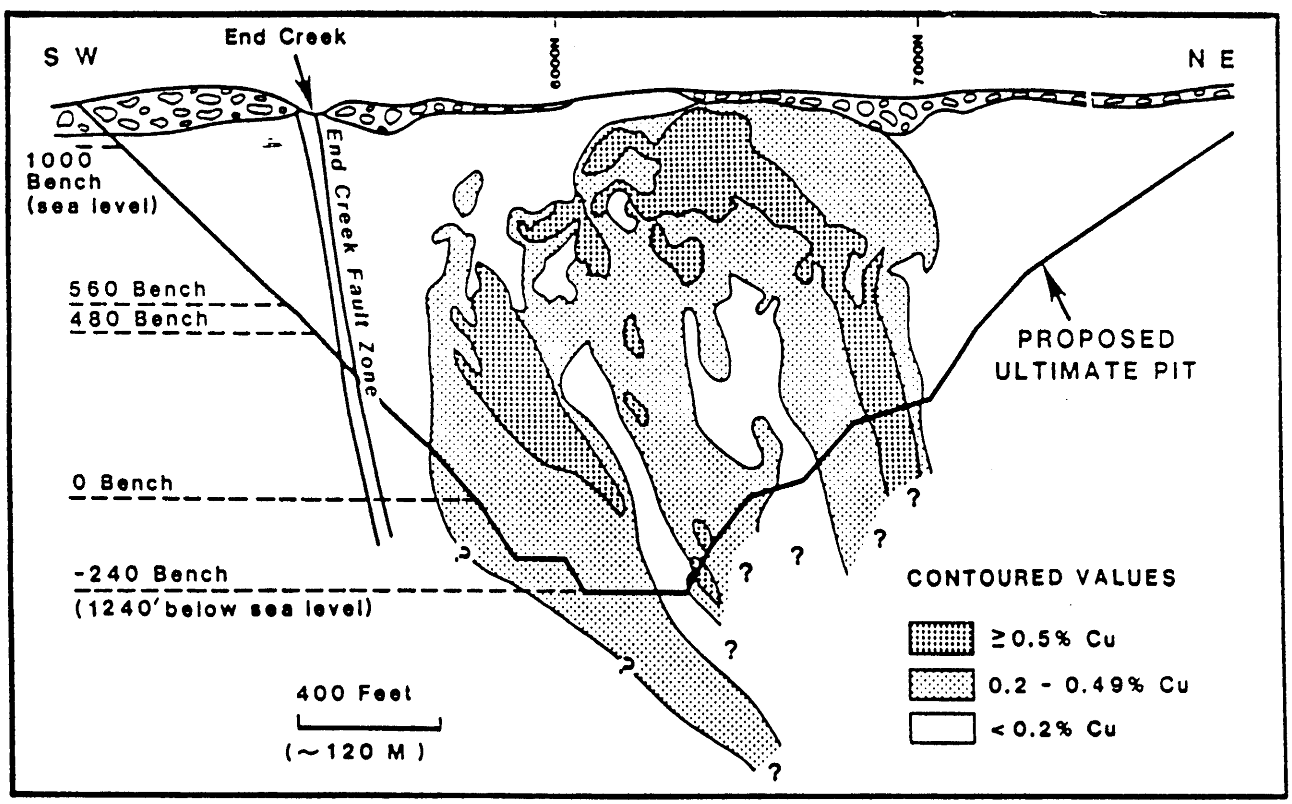
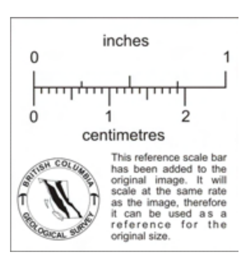


FIG. 6. Contoured copper values for section 173.



About the speaker:

John A. Fleming, P. Geo., was born in Montreal and received his B.Sc. (major in Geology) from McGill University. He worked for Eldorado Nuclear Ltd. at Eldorado, Saskatchewan from 1968 to 1974, initially as an exploration geologist involved in projects in northern Saskatchewan and the Northwest Territories, and later as an underground-mine geologist at the Fay and Hab mines. He joined Utah Mines Ltd. as an open-pit mine geologist at the Island Copper mine in 1974; since 1982 he has been Chief Geologist, Island Copper mine, with responsibilities for mine geology and property-wide mineral exploration.

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