# GEOLOGY of the BETHLEHEM and CRAIGMONT COPPER DEPOSITS[1]

by

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Bethlehem and Craigmont are two large copper mines in the southern interior of British Columbia and are only 20 miles apart. Bethlehem is at the centre of the Lower Jurassic Guichon batholith and is a series of unenriched porphyry copper type deposits, and Craigmont is a copper-iron skarn in Upper Triassic strata at the south edge of the same batholith. Figure 21-1 shows their relative position and those of copper prospects in and around the batholith, which lies at the north end of the so-called Nicola copper belt. Except for a small tonnage of copper ore mined many years ago at a few of these prospects, none has yet achieved production.

1. *Bethlehem.* The Bethlehem property in Highland Valley has four known commercial deposits totalling more than 70 million tons of material containing about 0.70 per cent copper. The orebodies are distributed along a semi-circular arc which is about 1 mile in length and is concave toward the south (Fig. 21-3). In clockwise order the orebodies are the Huestis, Jersey, East Jersey, and Iona. Open-pit mining started in 1962 at the small and relatively high-grade East Jersey orebody and progressed to the Jersey early in 1965. The initial mining rate of 3,400 tons per day is now increased to 6,000 tons per day.

All the orebodies except apparently the Huestis are situated along an embayed, highly irregular intrusive contact between older quartz diorite to the north and younger quartz diorite to the south. Emplacement of the younger quartz diorite, which is a porphyritic rock approaching granodiorite in composition, was followed by intrusion of a porphyritic granodiorite stock on the south side of Highland Valley and by a porphyry dyke swarm that extends northward from the stock across the Bethlehem property (Fig. 21-2). The dykes are of several ages and are mostly dacite porphyrites but include quartz latite and rhyolite porphyries. At Bethlehem the earliest dykes are few in number and are quartz porphyries of dacitic composition. So far as known they occur only in the vicinity of the ore deposits. One of these north-trending dykes (D-D on Fig. 21-3) intersects the weakened contact zone between the quartz diorites and there expands to form a multiple-branched intrusion. Breccia which occurs alongside the branching sheets of this porphyry body is composed of quartz diorite and porphyry fragments set in an abundant matrix mainly of quartz and feldspar. The breccia forms frayed, tabular bodies as much as 50 feet wide and 800 feet deep. It is believed to have formed as the result of intrusion of porphyry into cold, well-fractured rocks. Under these conditions the surfaces of the porphyry sheets would be quickly chilled to form an impervious seal, thus trapping the volatiles being released by crystallization of the remaining porphyry liquid. Explosion of the porphyry sheets resulted when the mounting internal pressure exceeded the confining pressure exerted by the host rocks.

Subsequent intrusion of numerous other porphyry dykes mainly on north and northeast trends was followed by faulting, which initiated mineralization. Most of the rock alteration occurred at about this time and introduced a variety of minerals many of which are present also at Craigmont. They include quartz, sericite, chlorite, kaolin, calcite, orthoclase, biotite, tourmaline, actinolite, and epidote. Zeolites were deposited after the sulphides, as at Craigmont. The principal ore minerals are bornite and chalcopyrite with molybdenite accompanying them in small amounts. Pyrite is present in parts of the

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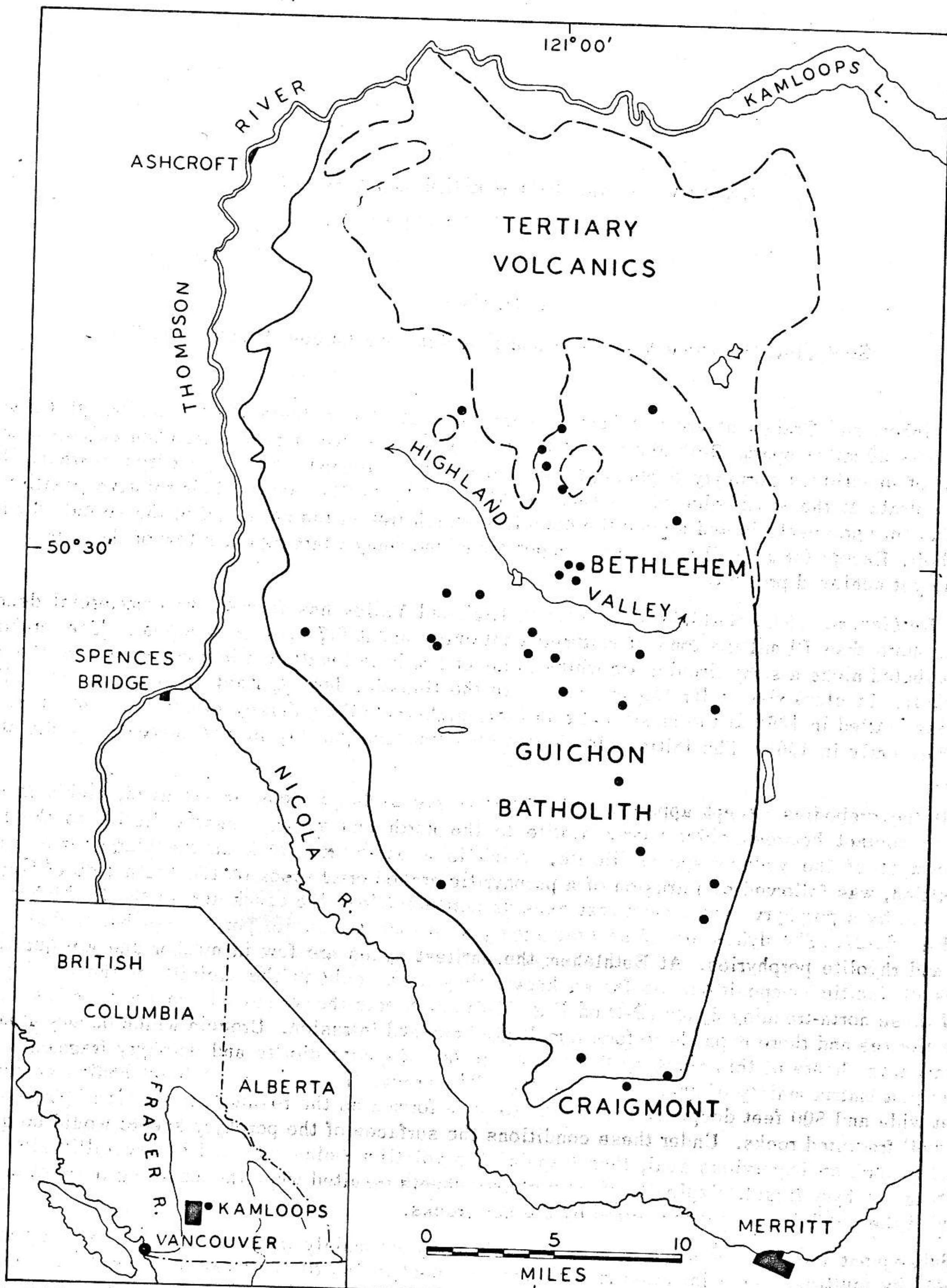


Figure 21-1

Copper deposits in the Bethlehem and Craigmont area.

Iona orebody and as a halo around the Jersey orebody. Malachite occurs at shallow depths but there is no appreciable change in copper content by supergene processes.

The orebodies are a combination of sulphide veins and disseminations that are partly due to replacement and partly to fracture filling. The Bethlehem staff has shown that the assay plans of the three best-known orebodies reflect closely a horsetail fault pattern, which is mapped in each orebody and consists mainly of west dipping northerly faults and attendant well-mineralized northeasterly faults (Coveney, 1962). Factors which served to localize ore at Bethlehem were mainly those contributing to the fracturing and alteration of the rocks, namely: (1) the younger quartz diorite contact; (2) porphyry intrusion and accompanying brecciation; (3) faults. The importance of these factors is demonstrated by a geological cross-section of the Jersey and East Jersey orebodies (Fig. 21-4).

2. *Craigmont.* The main features of Craigmont geology may be quickly summarized, although the detailed geology is complex and the exact nature of the ore control is still unknown. The orebodies replace deformed steep strata of the Nicola Group which strike approximately east and are penetrated by offshoots of the Guichon batholith (Fig. 21-5). Southwest from the mine, beyond an expanse of overlying unmineralized Cretaceous volcanics, the Nicola rocks strike northeastward and generally maintain a vertical attitude for distances of several thousand feet from the batholith. The edge of the batholith apparently was emplaced more or less concordantly in the steeply dipping succession and is partly an arm that extends southwest from the main part of the bathelith near Craigmont. This arm separates metamorphosed Nicola rocks north of David Creek from the Nicola rocks southwest of Craigmont. No proper stratigraphy is known for the Nicola rocks which apparently form an upturned, disrupted succession that faces south and is several thousand feet thick. The rocks are partly divisible into belts containing limestone, greywacke, and other beds that were mapped as vitric tuffs but which probably are mylonitized rocks. The mylonites and other rocks, including some limestone, possess a strong foliation and cataclastic textures which are parallel to the bedding and probably were produced when the strata were upturned. The banding and discontinuous shapes of some of the belts could indicate dislocation of the rocks along the zones of mylonite. Some limestone beds show the effects of strike-slip movement in steep eblique foliations and accompanying minor dragfolding of enclosed greywacke layers. Plastic flow of limestone has caused extreme attenuation of the small, steeply plunging dragfolds and has produced breccias consisting of limestone and dispersed greywacke fragments.

The Craigmont ore zone is part of a limestone belt which, according to recent surface drilling, probably continues westward for some distance under the Cretaceous rocks. The ore zone lies between dissimilar assemblages of greywacke and is as much as 600 feet wide at the west end, where it consists of banded limestones and foliated greywackes in vertical beds of rapidly varying thickness. Farther east the zone consists of skarn, other mineralized, strongly altered rocks and some intrusive rocks, which include andesite and quartz diorite or diorite.

As the map and vertical sections show (Fig. 21-6) the ore zone thickens and thins rapidly, partly no doubt because of emplacement of the intrusive rocks. The latter bodies appear to be emplaced semiconcordantly in and around the previously deformed zone. The andesite is a branching body which follows the strike of the zone and is partly strongly banded, probably by shearing. The diorite and quartz diorite bodies are fairly massive and are joined to the batholith lying about 1,000 feet farther north. Quartz diorite enwraps the curved eastern end of the ore zone and persists as an irregular dyke along the strike of the ore zone. The intrusive rocks are altered and weakly mineralized.

The skarn varies in composition according to the relative proportions of its component minerals, which include magnetite, specular hematite, epidote, garnet, actinolite, chlorite, calcite, orthoclase, quartz, and tourmaline. Except for garnet and magnetite these same minerals also occur to some extent outside the skarn as veins and disseminations in the wallrocks. An iron-rich skarn contains much of the ore and becomes increasingly richer in magnetite and correspondingly poorer in hematite toward the east end of the mine. Chalcopyrite is the principal ore mineral and occurs as veins, streaks, patches, and coarse disseminations. Bornite is in small amount and pyrite occurs locally as disseminations in the leaner parts of the ore zone and in the wallrocks. The ore carries almost no gold or silver.

Together the orebodies persist for 2,800 feet horizontally, 1,800 feet vertically, and across mining widths ranging from about 10 feet to 300 feet. Production began in 1961 and in 1964 was at a rate of about 5,100 tons per day, most of the ore coming from the open pit. According to published figures, the mined ore and present reserve together amount to about 29 million tons containing about 1.77 per cent copper.

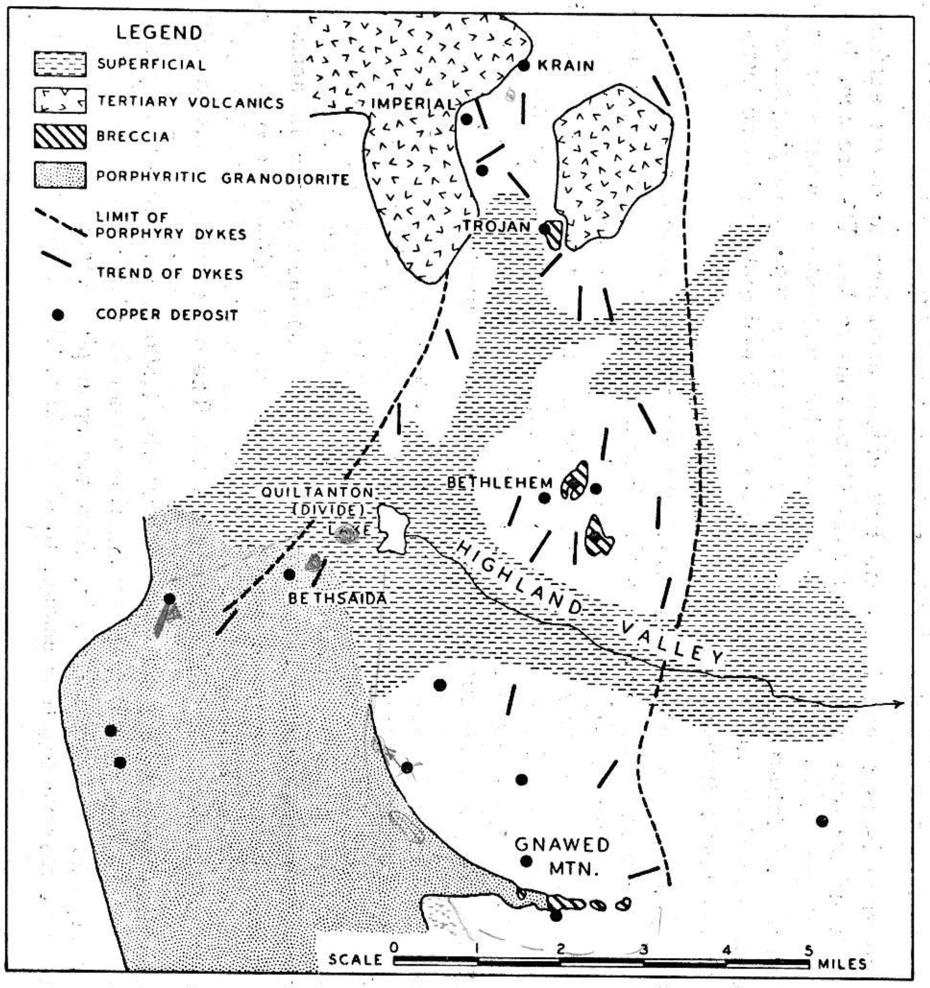


**Figure 21-2**

**Distribution of porphyries and breccia in Highland Valley.**

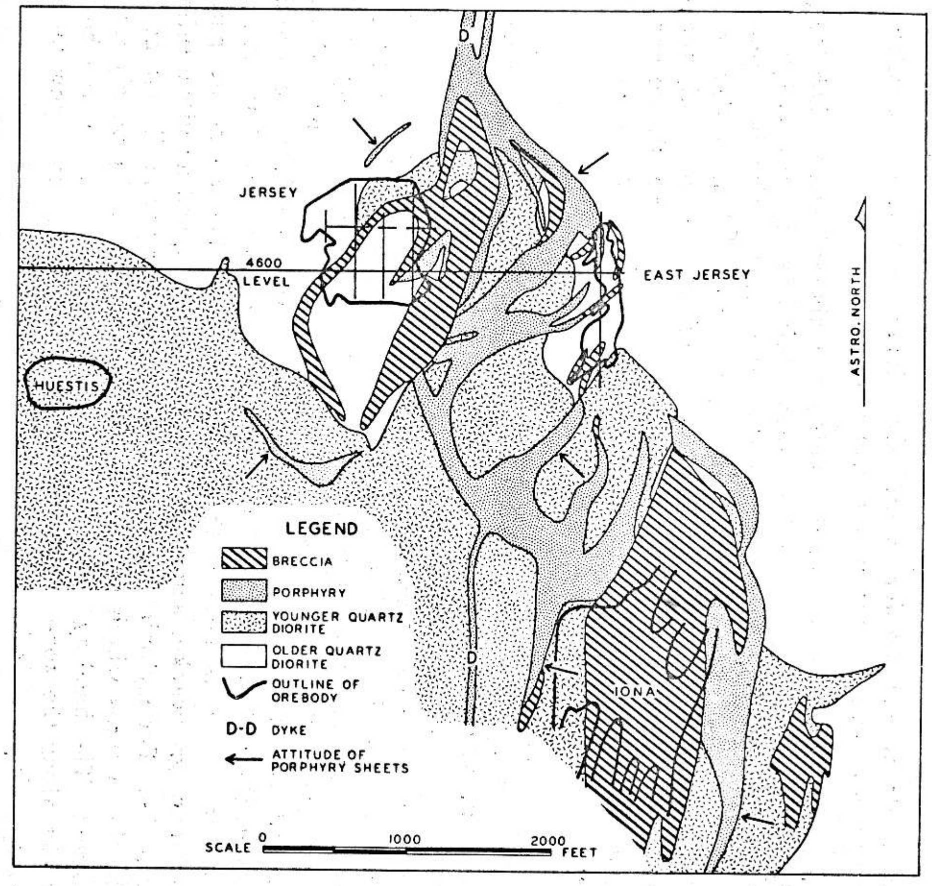


**Figure 21-3**

**Simplified geological map of the Bethlehem property.**

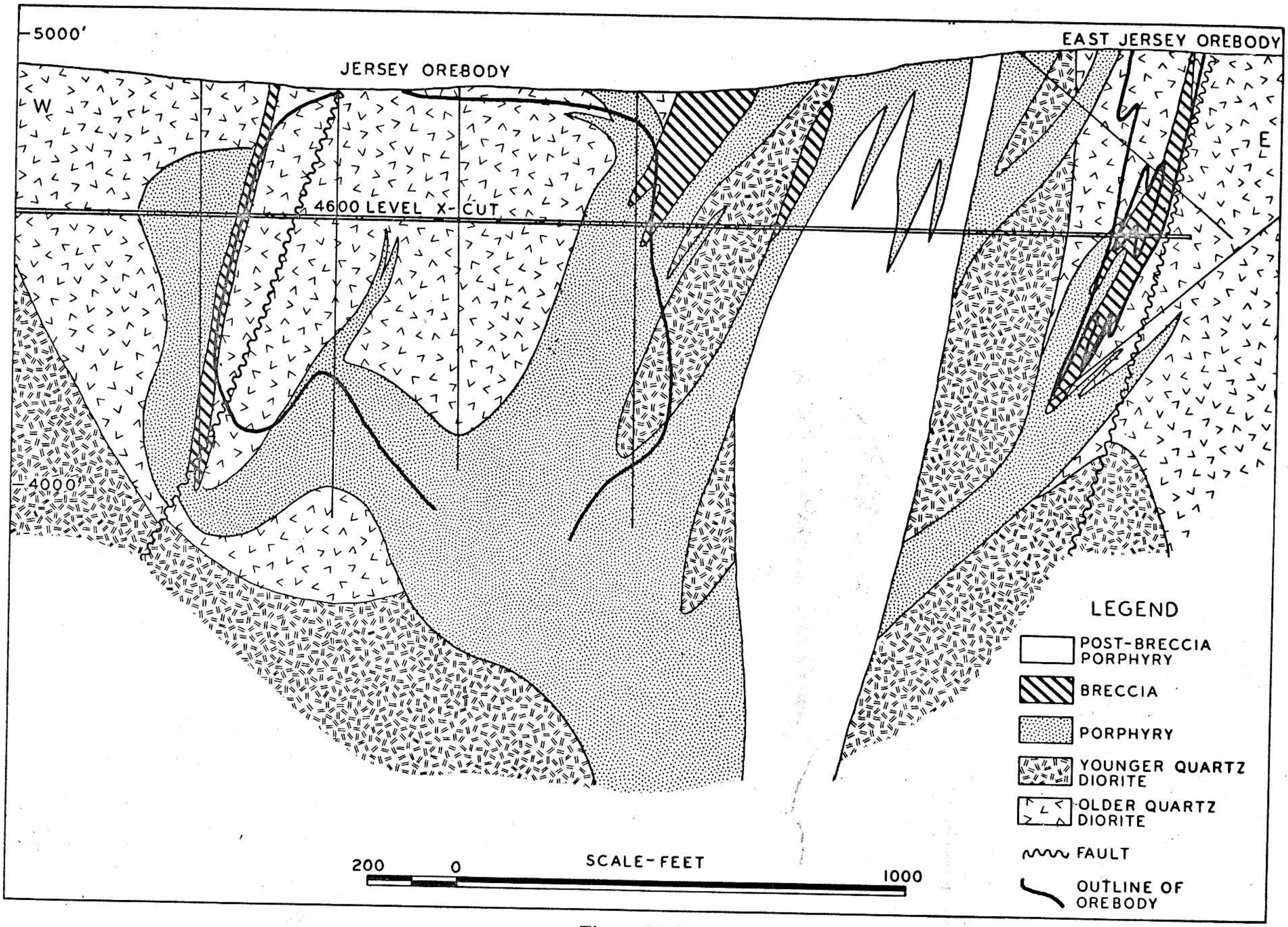


Figure 21-4

Simplified geological section of the Bethlehem property. Not all the drill holes are shown.

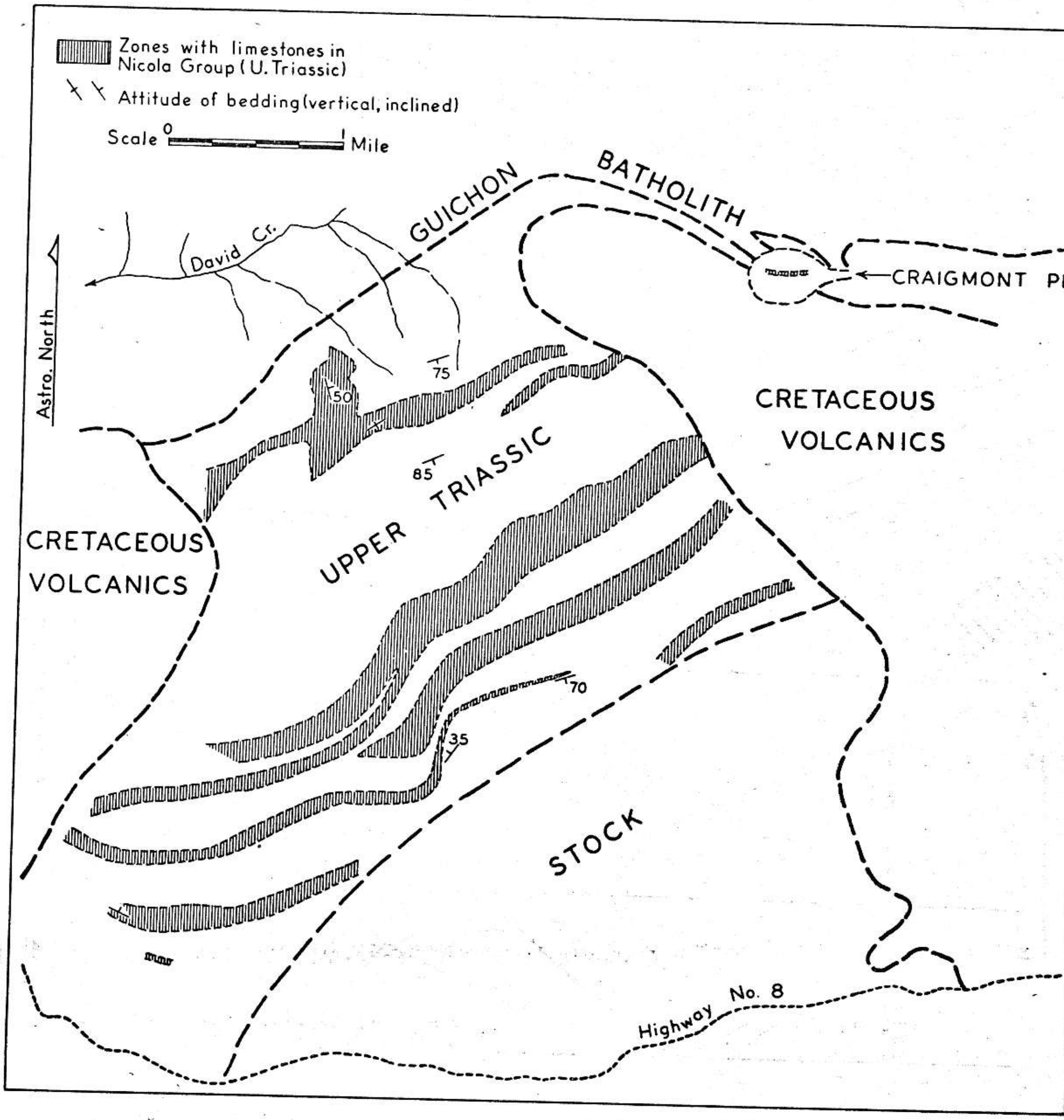


Figure 21-5

Simplified geological map of the Craigmont mine area.

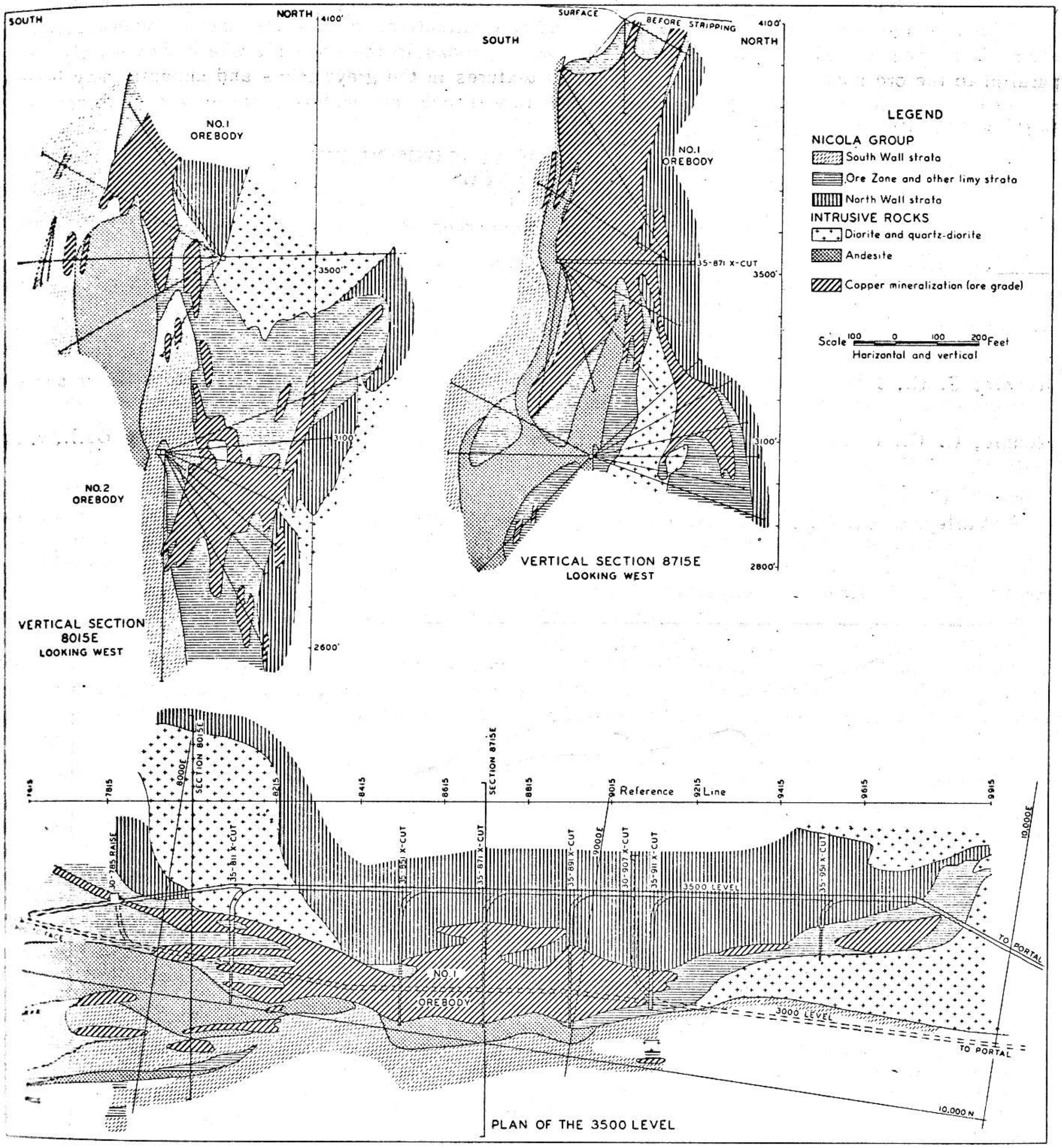


Figure 21-6

Simplified geological plan and cross-sections of the Craigmont mine.

The shape of the ore bodies suggests that they replace dragfolded strata, although other structural factors, such as shear zones, probably are involved. A longitudinal section of the ore bodies illustrates the easterly plunge possessed by the highest ore body (Fig. 21-7). The iron-rich skarn probably is a replacement of limestone beds. In it are preserved the relics of small distorted dragfolds similar to those seen in limestones in outcrop farther west. Apparently at the mine these beds were buckled, dragfolded, and sheared prior to their alteration and mineralization. Faults have mostly been recognized after mining began, and are numerous in the south wallrocks in the open pit where they mainly strike parallel to the ore zone and dip steeply. Foliated textures in the greywackes and andesite may largely reflect the attitude of nearby faults, and in the south wallrocks are mainly parallel to the ore zone and in the north wallrocks are oblique to it.

## REFERENCES


Carr, J. M., 1960; Minister of Mines and Petroleum Resources, B. C., Ann. Rept. p. 26-40.

_____, 1960; Porphyries, Breccias, and Copper Mineralization in Highland Valley, B. C., Can. Min. Jour., v. 70, p. 71-73.

_____, 1961; Minister of Mines and Petroleum Resources, B. C., Ann. Rept. p. 31-37.

Coveney, C. J., 1962; The Bethlehem Copper Property; Western Miner and Oil Review, v. 35, p. 41-43.

Rennie, C. C., 1962; Copper Deposits in the Nicola Rocks, Craigmont Mine, Western Miner and Oil Review, v. 35, no. 2, p. 50-52.

Rennie, C. C., et al., 1961; Geology of the Craigmont Mine; Can. Inst. Min. and Met. Bull., v. 54, p. 297-301.

White, W. H., Thompson, R. M., McTaggart, K. C., 1957; The Geology and Mineral Deposits of Highland Valley, B. C., Can. Inst. Min. and Met. Trans., v. LX, p. 273-289.


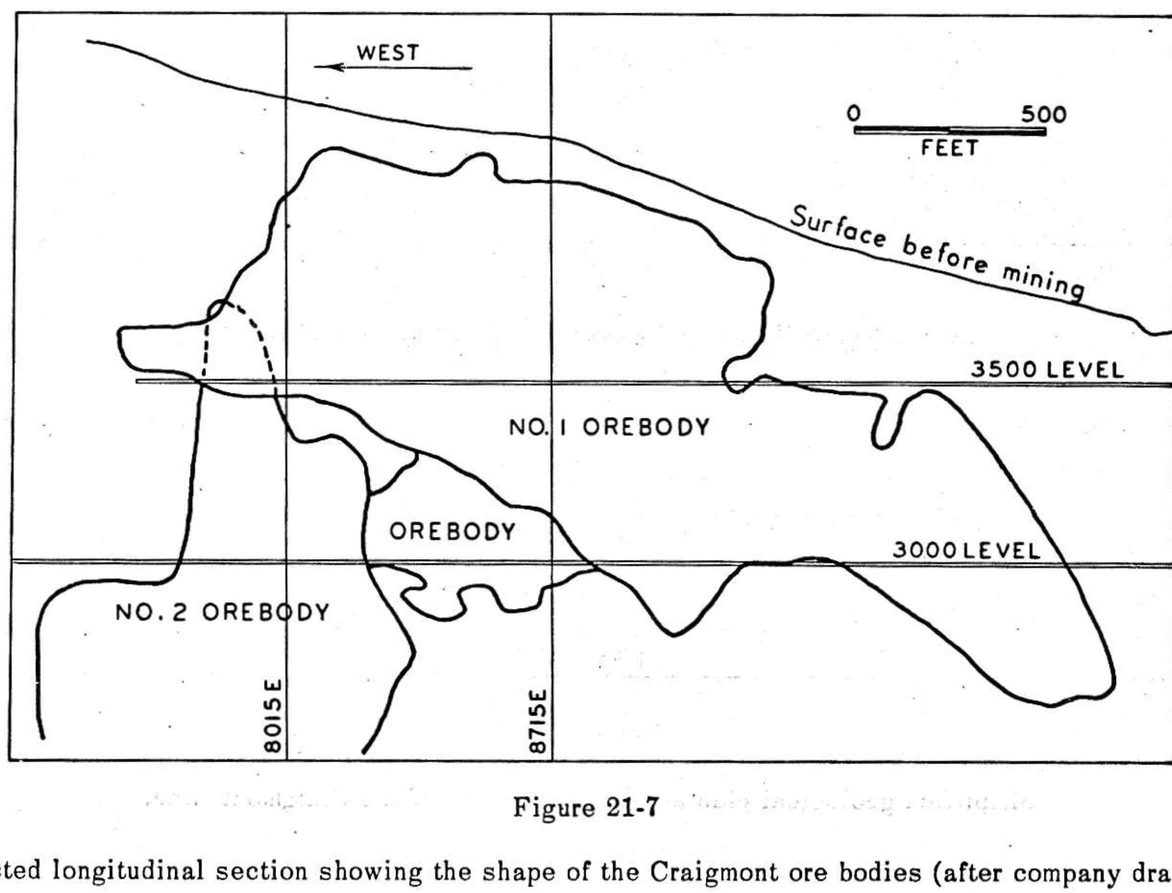


Figure 21-7

Projected longitudinal section showing the shape of the Craigmont ore bodies (after company drawings).