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Geology of the Churchill Copper Deposit

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ABSTRACT

The history, geological setting and local geology of the Magnum vein system, 100 miles west of Fort Nelson in northeastern British Columbia, are described. The system comprises a number of quartz-ankerite veins, mineralized with chalcopyrite and lesser pyrite, occurring in a steep northeastly zone of deformation and subsequent dike intrusion within otherwise little-deformed Precambrian sedimentary rocks. In April of 1970, Churchill Copper Corporation began producing copper concentrates in a 750-tpd mill fed from the Magnum mine.

INTRODUCTION

THE CHURCHILL MINE is 130 miles by road from Fort Nelson and is west of the Racing River in the Rocky Mountains of northeastern British Columbia (*Figure 1*). The mine is at elevations of between 5,200 and 6,300 feet, the mill is at about the 1,300-foot elevation and nearby peaks are as high as 10,000 feet.

Outcrops of chalcopyrite-bearing veins were discovered in 1943 by Mr. Albin Larsen on a steep hillside facing northwest to Magnum Creek, and were first staked by Messrs. Larsen and Lembke in 1950 (*Figure 2*). In 1958 and 1959, the deposit was sampled and drilled by Canex Aerial Exploration Ltd. on behalf of Magnum Consolidated Mining Co. Ltd. From 1967 to 1969, Churchill Copper Corporation conducted a program which included ring drilling at 100-foot intervals on line drives together with a certain amount of cross-cutting and raising. This resulted in the delineation of ore reserves sufficient for production, namely: 1,178,000 tons proven and probable grading 3.92 per cent copper and including a 20 per cent dilution factor. The 750-tpd concentrator was started up in April, 1970; for January 1971, which is the latest month for which figures are available, the monthly production was:

Tons Mined	21,318
Tons Milled	20,066
Mill-Head Grade (% Cu)	4.35
Pounds Copper Produced	1,683,026
Concentrate grade (%)	30.39
Recovery (%)	96.45

The deposit is a system of veins in a northeast-trending zone, the over-all shape of which is tabular and steep. Development to date is on four main levels, namely 5200, 5750, 5900 and 6100, and mining is variously by shrinkage and longholing (*Figure 3*). Initially from the 5900 portal and subsequently from the 5200 main haulage, ore is trucked 12 miles to the mill, from where concentrates are trucked to the present railhead at Fort St. John for shipment to wharves in North Vancouver and thence to Japan. A crew of 180 is employed at the mine and mill.

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GEOLOGIC SETTING

The copper-bearing veins of the region occur within Precambrian rocks which occupy a large area south of the Alaska Highway (*Figure 1*). These rocks form an unmetamorphosed succession, not exposed at the base, of shales, limestones, dolomites and quartzites. They are traversed by diabase dikes which post-date the ore veins at the Churchill and certain other deposits, and which provide a prospecting guide because some of these dikes occur close to veins. Paleozoic sedimentary formations, chiefly limestones, sandstones and shales, rest unconformably on the Precambrian rocks and contain neither veins nor dikes. Although mainly flanking the Precambrian area to the north and east, the Paleozoic strata occur partly inside the area in northwestward-trending belts that are overthrust along their southwestern margins by Precambrian rocks. The Precambrian and Paleozoic strata possess a regional northwesterly strike and dip mainly southwestward at moderate angles, although panels with northeasterly dips also occur. Folding becomes intense near faults and locally elsewhere, and is largely asymmetric with steep eastern limbs. In the Precambrian rocks, much of this folding preceded the dikes and veins and is therefore of Precambrian age.

Most veins and dikes dip more steeply than 60 degrees, and the two tend to occur in parallel. According to the information available, and as shown diagrammatically on *Figure 1*, most veins and dikes in a broad central belt strike northeastward, whereas in contrast the dikes and several veins in the eastern and western flanking belts strike principally north-northwest. These contrasting strikes may be related to stress patterns such as would be caused by differential movements of underlying basement blocks at the depths from which the dikes emanate.

To date, the western half of the Precambrian area has given the best prospecting results. The Eagle vein of Davis-Keays Mining Company is reported to contain reserves of various categories, including proven ore estimated at 1 million tons grading 3.56 per cent copper. The Bronson vein system of Windermere Explorations Ltd. is reported, as a result of surface sampling, to contain at least 2,000 tons per vertical foot grading at least 3 per cent copper. The Toad River Joint Property of Fort Reliance Minerals Ltd. and Churchill Copper Corporation possesses a vein for which the reserves indicated by drilling in 1958 and 1959 are 78,000 tons grading 5.15 per cent copper, and recent

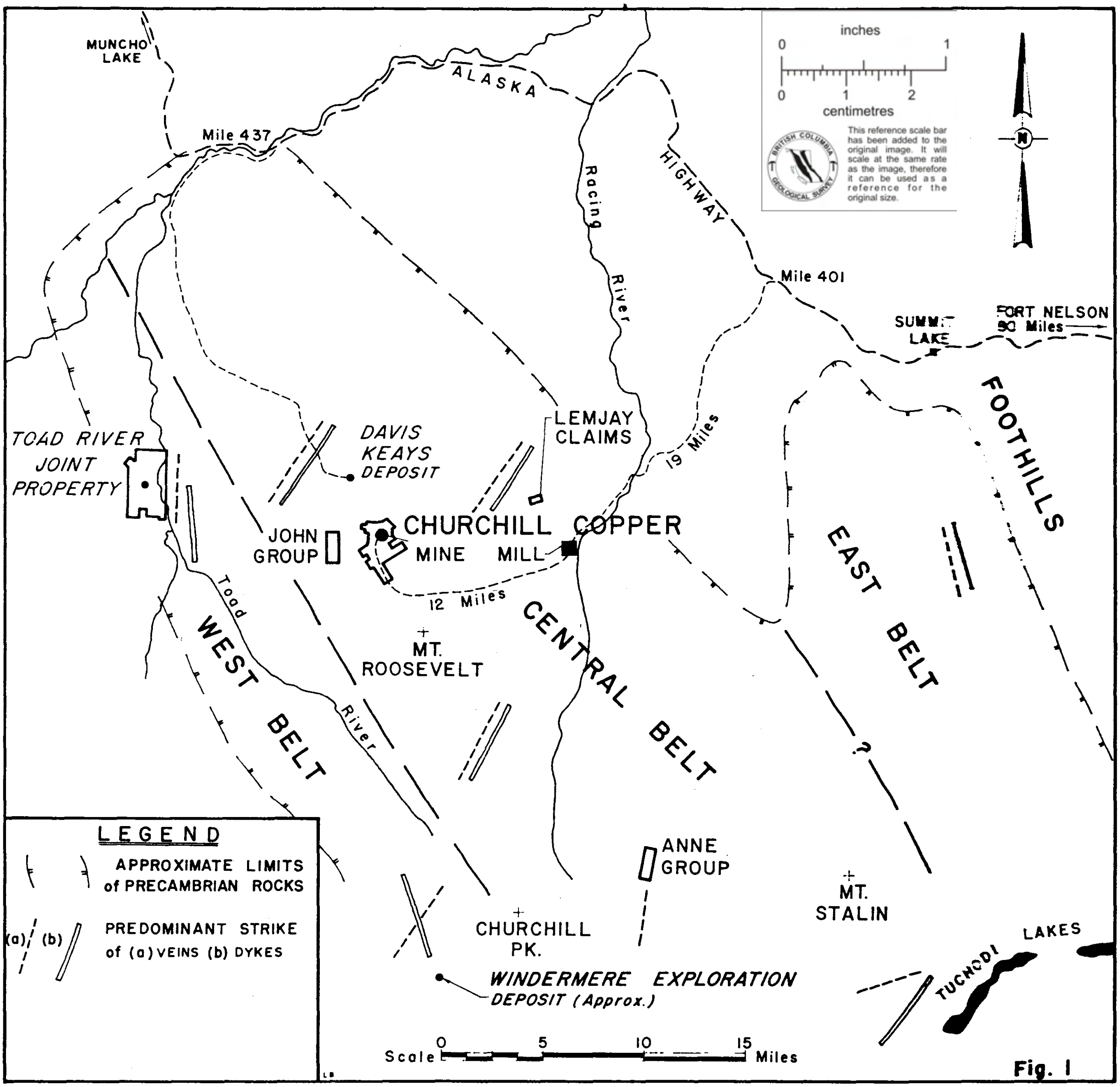

FIGURE 1 — Property index map and simplified geology of the Racing River area.

studies indicate that these reserves are capable of being increased. A number of other veins have been discovered and partly explored within the area. Southwest of the present area, toward the Rocky Mountain Trench, additional areas of Precambrian rocks present problems of access but may prove to be suitable for prospecting.

GEOLOGY OF THE DEPOSIT

The zone containing the Magnum vein system is partly explored for a length of 4,500 feet and to a depth of 1,200 feet. It is a zone of deformation, alteration, mineralization and dike intrusion that trends N 35°E, dips steeply and is up to 300 feet wide. It occurs in a sequence of Precambrian limy strata which dip more or less uniformly at low to moderate angles southeastward and apparently form the southeastern limb of a broad anticline the axis of which approximately follows Magnum Creek. The strata on either side of the zone are thin- to medium-bedded rocks which include grey and black limestone, limy argillite and limy shale. Westward across Magnum Creek, the opposite flank of the anticline consists of similar rocks which are locally folded sharply and traversed by dikes. One or more mineralized veins occur west of the creek on the Magnum property, and are to date unexplored.

Strata in the zone are buckled by numerous small irregular folds, most of which plunge across the zone in southeasterly directions. An intense cleavage is developed, mainly in the least competent beds, but locally pervasively in all strata. The cleavage is partly curved and wavy and it strikes chiefly south-southwest, with a dip of approximately 60 degrees to the east. All strata in the zone are altered to non-limy rocks by decalcification. Alteration has in addition produced graphite liberally in the strongly cleaved rocks and ankerite as coarse metacrysts and wholesale replacements in the buckled parts of beds. Probably as a result of alteration, pyrite forms seams and disseminations more or less concordant to bedding in strata of the west part of the zone.

The mineralized veins of tne Magnum system lie more or less central in the zone and were formed later than the folds and cleavage, both of which they transgress. They consist of varying proportions of ankerite, quartz, chalcopyrite and locally pyrite, together with partly replaced remnants of the sedimentary host rock. The principal veins strike with the zone and most are nearly vertical. As many as ten such veins have been noted, although some may prove to be extensions of the others. They vary in width from less than 3 feet to as much as 25 feet and possess a continuity, both on strike and in depth, which is measured in hundreds of feet. As many as three parallel principal veins occur within a width of 150 feet or less across the zone. Numerous subsidiary veins are encountered, of which some are parallel to the principal veins and others, with a mainly northerly trend, are oblique and, in part, are branches of the principal veins (*Figure 4*).

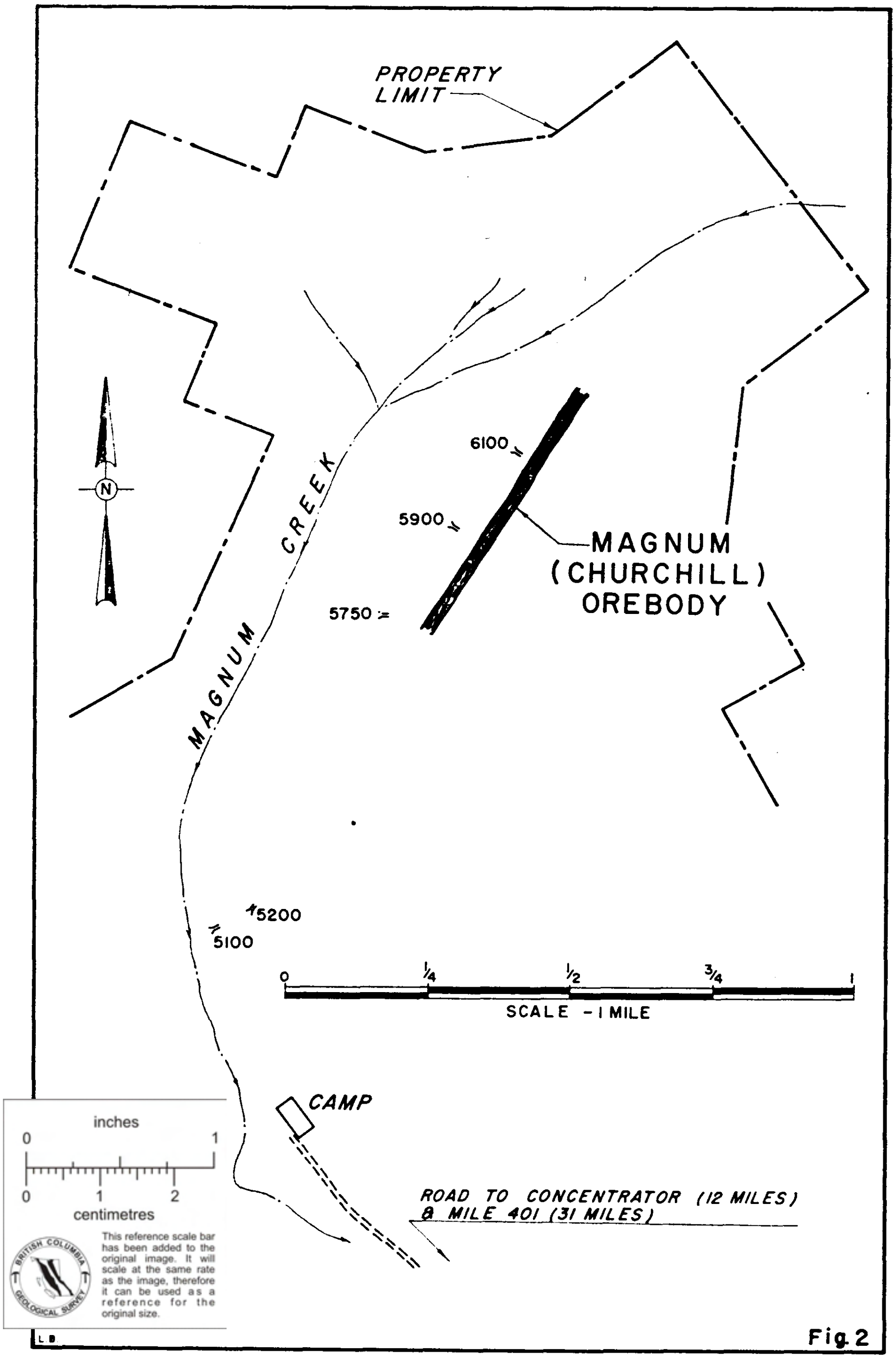

FIGURE 2 — Map of the Magnum property, showing the location of adits and the ore deposit.

From their appearance, the veins were emplaced largely by replacement and in several stages. The first stage was principally ankerite with only minor quartz and sulphide, and the least mineralized portions of the veins apparently progressed little beyond this stage. One or more later stages caused the introduction of quartz and sulphides, principally chalcopyrite, as veins and patches mostly within or adjoining the ankerite veins.

Pyrite is locally prominent, but in general amounts to less than an estimated 10 per cent of the total sulphides in the ore. The precious metal content in the ore is negligible. The association of chalcopyrite with quartz is close, although in places the quartz is so subordinate in amount that veins, or parts of veins, appear to be comprised of massive chalcopyrite. Chalcopyrite is noticeably increased, for example, where a vein jogs or locally changes direction. Such jogs affect the vein only for a few feet and their shape is such as to displace the northern part of the vein westward or, alternatively, the upper part westward by a few feet. The latter sense of displacement is effected also by at least one of several minor intra- and post-mineral faults which occur in the north part of the mine. These mineralized faults dip at about 40 degrees southwestward, and the one in question displaces the upper parts of two principal veins a distance of about 30 feet west on the strike of the fault (*Figure 5*).

Although little in the nature of local controlling structures is seen to explain in detail the emplacement of the veins, the occasional preservation within and along the veins of septa composed variously of schistose wall rock and of brecciated vein quartz probably indicates the former existence of narrow shear zones where veins now exist. Apparently parts of the veins formed initially as fine-scale stockworks of ankerite and quartz in fractured rock, because crowded ghost-like remnants of rock are locally present.

A post-ore diabase dike of irregular shape and generally steep dip closely follows the southeast side of the vein system and invades it progressively southward in the zone. The dike is partly less than 10 feet wide in the north part of

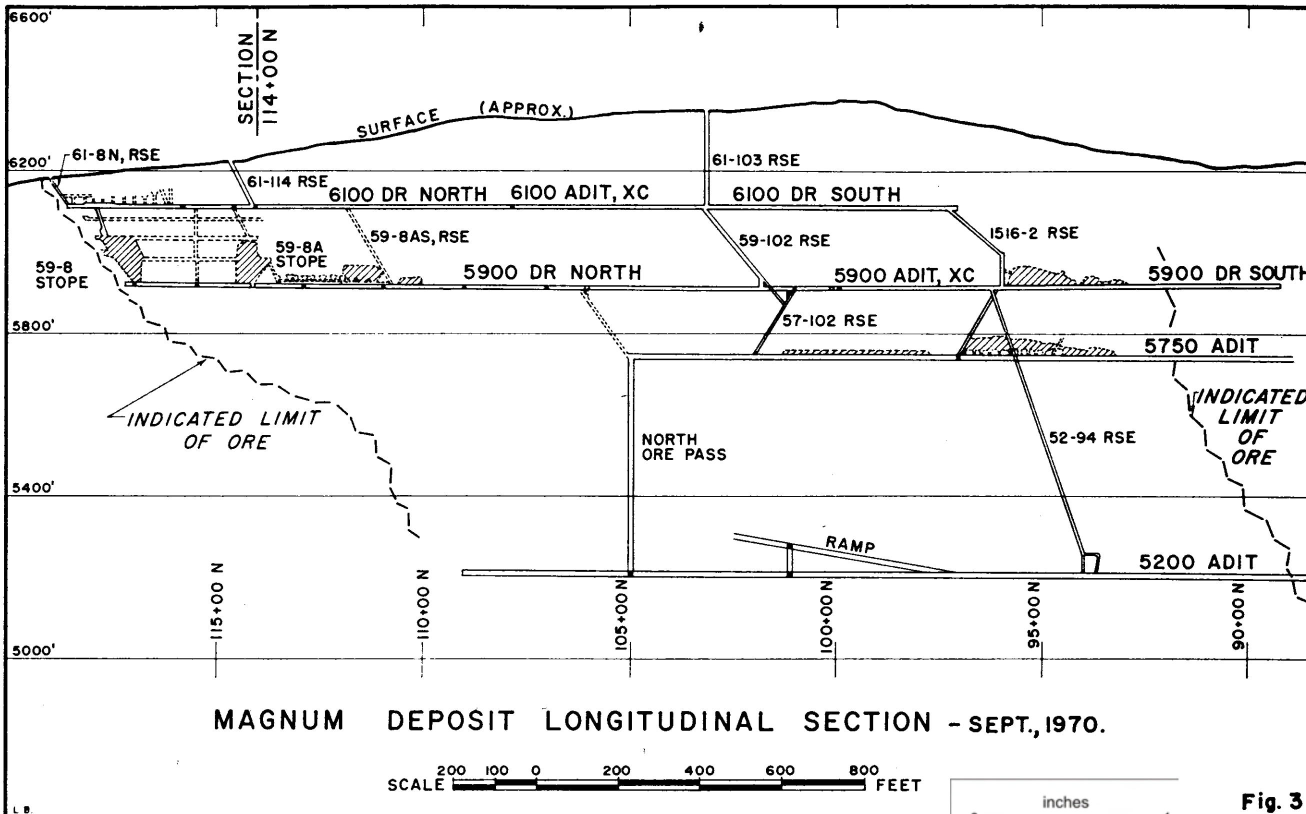

FIGURE 3 — Longitudinal section of the Churchill mine.

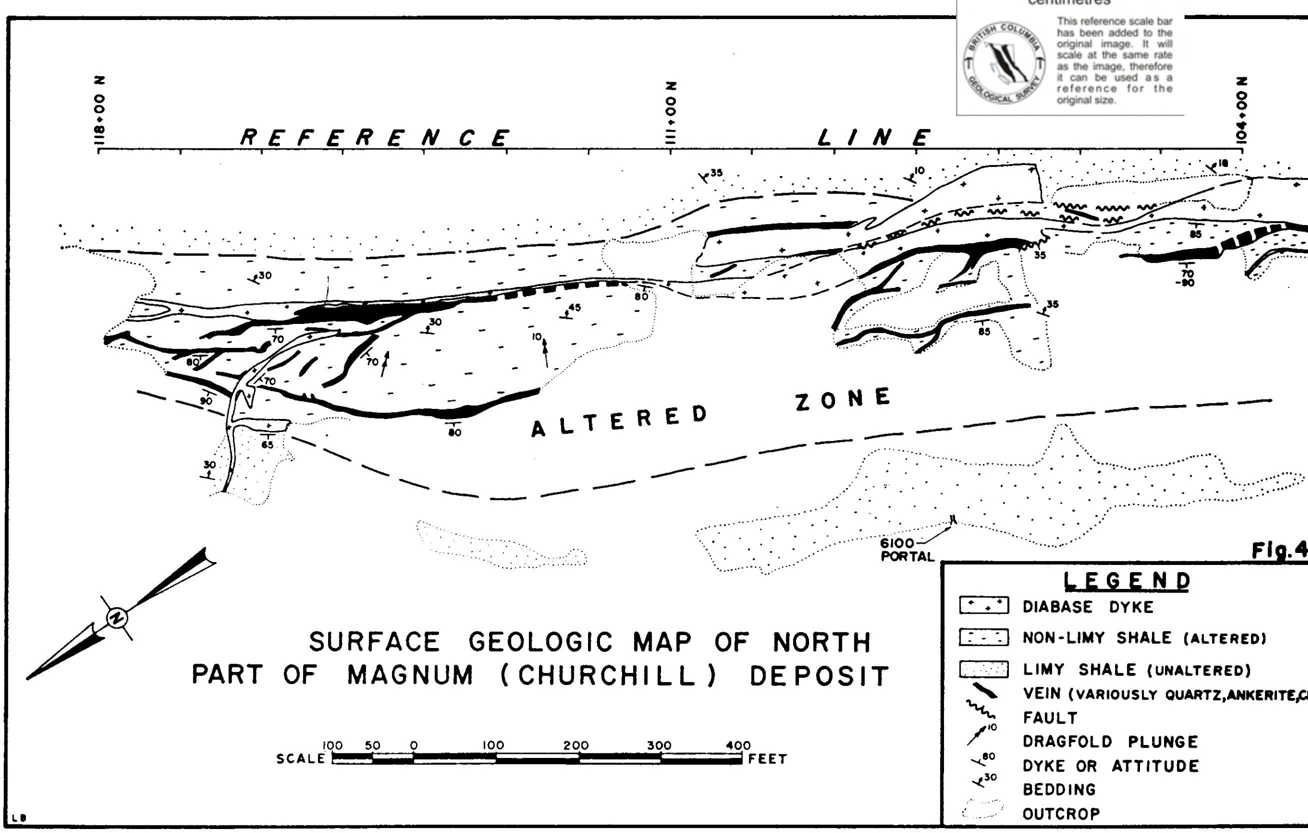

FIGURE 4 — Surface geological map of the north part of the Magnum deposit.

the zone, but it widens southward and splits locally into two or more parallel branches with an aggregate width which may exceed 150 feet. In places, the dike becomes sill-like and, as shown on *Figures 4* and *5*, subsidiary dikes extend west across the vein system. Along part of its length, the main dike is followed by one or more steep faults, with unknown displacement, near to which the diabase is propylitically altered. The dike is a hindrance because, in the north part of the mine, it adjoins one or more ore veins, and locally invades and destroys them. In the south part of the mine, the dike is even more destructive, because it is emplaced partly inside the vein system and either obliterates or displaces the greater part of the veins.

The Magnum vein system remains only partly explored. Ore intersections occur through a length of 2,800 feet and a depth of 1,200 feet, and the zone is considered open for extension at both ends and in depth. The currently indicated ore limits are shown approximately on *Figure 3*.

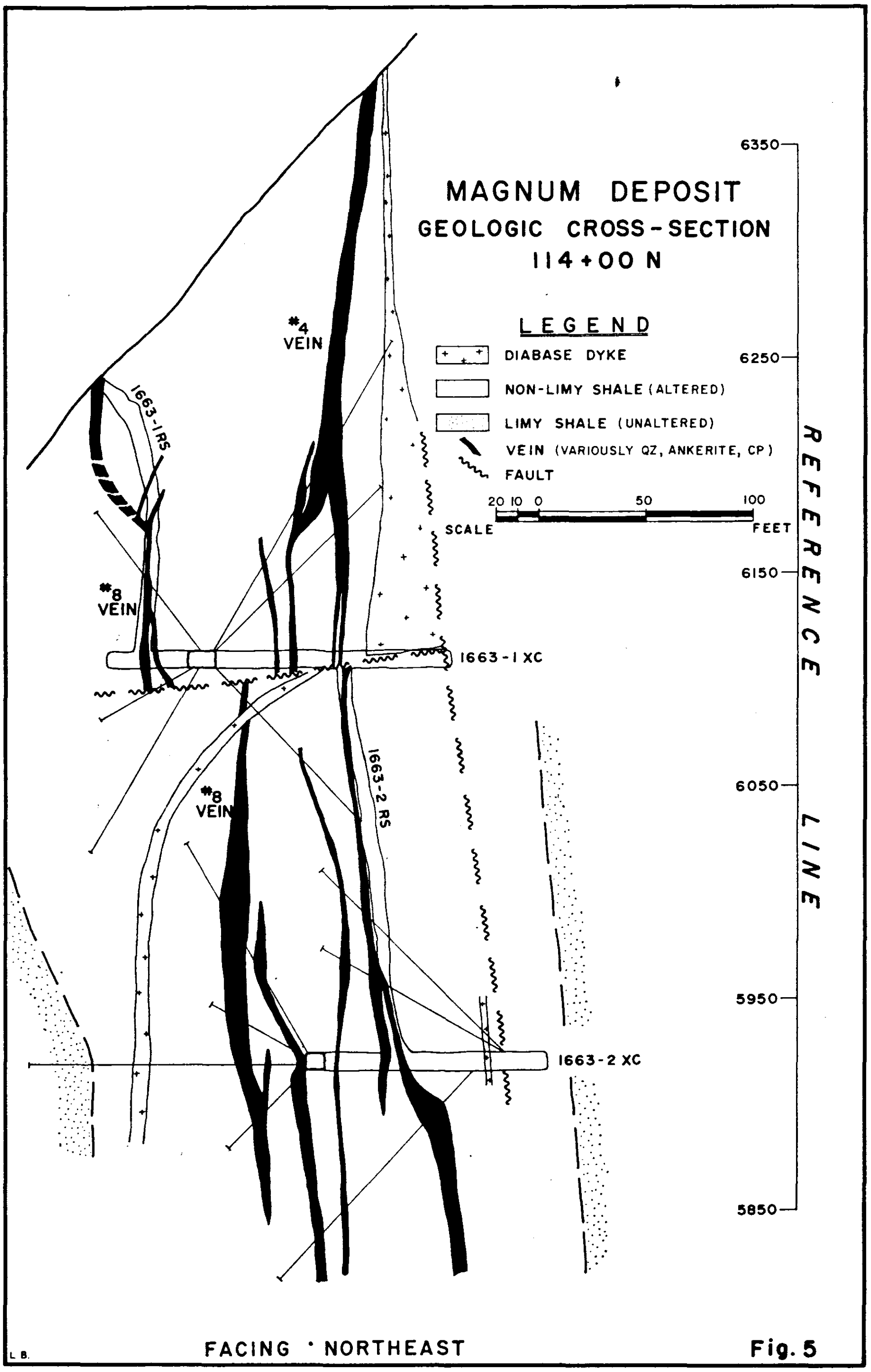

FIGURE 5 — Vertical geological cross section on 114N of the Magnum vein system, from surface to the 5850 elevation.

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