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GEOLOGY OF THE CRAIGMONT MINE

by

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INTRODUCTION:

The following introduction will illustrate the ideal location of the Craigmont Mine with regard to services and relative ease of development.

The Craigmont Mine is in the Merritt area, 240 miles by road or railroad northeast of Vancouver, B.C. (Fig. 1). The Mine is on the eastern slope of Promontory Hill, ten miles northwest of Merritt. Four miles of existing gravel road in the valley and four miles of switchback road up the hillside, built in conjunction with the B. C. Department of Mines, connect the Mine's 3500-Level to the highway and railroad, six miles west of Merritt, B. C. (Fig. 2).

Moderate local relief ranges from 1850 elevation at Nicola River; 2400 elevation at the proposed mill site; 4200 elevation at the west end of the open pit area; to 5600 elevation at the top of Promontory Hill. The Nicola River and Guichon Creek are the main drainages and occupy broad valleys. Climate is semi-arid with 14" annual precipitation, mostly during January to June, and temperatures ranging from 20° below zero in winter to 100° above in summer.

Merritt, a village of 3,300 population, including most of the mine employees, is served by Inland Natural Gas and B. C. Hydro. Three highways connect Merritt with the Trans-Canada Highway on the west and north, and the Trans-Provincial Highway on the south. The C. P. R. Kettle Valley Line provides daily train service through Merritt from Vancouver and eastern points and there is daily truck service from Vancouver and Kamloops.

B. C. Telephone now serves the Mine with telephone and teletype.

HISTORY AND DEVELOPMENT:

The history of the present Craigmont ore body is short, but early prospect pits in the area may be fifty years old and some diamond drilling was done in 1935 on the Eric prospect just within the eastern boundary of the Craigmont property.

The present group of key claims was staked in 1954, but until 1957 work by the original locators and by Craigmont Mines Ltd. was concentrated north of the present ore body. During the spring of 1957 a reconnaissance geochemical survey indicated the presence of copper and a reconnaissance magnetometer survey showed a high magnetic anomaly over what later proved to be the ore body. An account of this original discovery work, prepared by R. E. Renshaw and F. Price was published in the July 1958 issue of Mining World. Two diamond drill holes on an anomaly 1,000 feet north of the main anomaly were negative, but in May 1957 Hole #3 cut magnetite-chalcopyrite mineralization beneath the main magnetic anomaly (Fig. #3). Under the guidance of Chapman, Wood and Griswold, Consulting Mining Engineers and Geologists, a detailed magnetometer survey and drilling through the summer of 1957 culminated in the completion of Hole #7 in September through 520 feet of 2.22% copper ore.

For this achievement the Directors of Craigmont Mines Ltd. deserve considerable credit. Their persistent exploration, despite negative results, within the financial confines of a small public company has resulted in the discovery of an important copper ore body.

On November 7, 1957 Canadian Exploration Ltd. entered the financing and directing of exploration on the Craigmont property. This phase saw exploratory diamond drilling expanded from one surface machine to four through the winter of 1957 and spring of 1958. This provided sufficient information for underground exploration planning.

Effective June 1, 1958, an agreement between Craigmont Mines Ltd., as owners of the property, and Canadian Exploration Ltd., Noranda Mines Ltd. and Peerless Oil and Gas Company provided for underground exploration of the property, leading to production if warranted.

Since July 1958, to October 1960, an adit at 3500-level has been driven 3,448' with 1,705' of cross-cutting in six cross-cuts; a second adit at 3000-level has been driven 6,062'; and a total of 84,242' of underground drilling has been completed. Total surface drilling since April 1957 is 24,742'. A contract has been let to Peter Kiewit Sons Company of Canada Ltd. for removal of overburden and waste rock in preparation for open pit mining of ore above 3500-level and an industrial site has been levelled at 2400 elevation.

GENERAL GEOLOGY:

The Merritt area is in a broad belt of copper mineralization extending from Lake Chelan in Washington through Copper Mountain, Princeton, the old Aspen Grove Camp, to the Merritt, Highland Valley and Kamloops areas.

In the Merritt area, Jurassic intrusive bodies of grano-diorite, quartz diorite and diorite are present, the largest being the Guichon batholith, which extends from just north of Craigmont to the Highland Valley and from Guichon Creek to the Thompson River.

These rocks intrude the Upper Triassic Nicola series, which is a thick, predominantly volcanic sequence of tuff, agglomerate, breccia and flows, with minor sedimentary horizons of limestone, argillite and greywacke. The resolution of the sequence and structure in the Nicola series is hindered by lack of outcrop and absence of continuous and distinctive marker horizons. In general, the Nicola rocks are steeply dipping with marked variations in strike from one area to another. This may be interpreted as parallelism of attitude with the strike of underlying intrusive contacts as a result of forceful intrusion of igneous masses into the Nicola series.

Small areas of Lower Cretaceous Kingsvale and Spences Bridge volcanics and Tertiary Coldwater coal measures also occur in the Merritt area, as relatively shallow cappings of the Nicola series.

In the Promontory Hill area the contact between the Guichon batholith on the north with the Nicola rocks on the south can be traced roughly from the vicinity of the Mine westward for approximately four miles (Fig. #2). The strike of this contact trends slightly north of west for two miles then swings south of west, while the general trend of the Nicola rocks is approximately S 70° W, with a predominant steep southerly dip.

Impure limestone of the Nicola series outcrops prominently across the top of Promontory Hill and is tentatively correlated with the limestone that forms the host rock for the ore bodies in the Mine.

Lack of continuous outcrop and absence of marker horizons have not permitted resolution of the structure on Promontory Hill. One working hypothesis suggests an anticlinal axis south of the top of Promontory Hill with large drag folds on the limbs. However, other hypotheses may apply and more work is required to resolve the structure, if resolution is possible.

Agglomerates and flows assigned to the lower Cretaceous Kingsvale volcanics sequence overlay the Nicola rocks unconformably on the east slope of Promontory Hill and appear to dip gently southward. South of this relatively thin sheet of Kingsvale rocks the Nicola rocks reappear, but are intruded by a granitic stock.

On the southwest flank of Promontory Hill, volcanics of Lower Cretaceous Spences Bridge Group appear to overlay the Nicola rocks. Minor intrusive quartz porphyry bodies have also been recognized on the western slope.

PETROLOGY:

In the Mine, the Nicola tuffs, greywacke, limestone and argillite are the dominant rocks exposed by development. These sediments are intruded by andesite, quartz-diorite, diorite and a few dykes of feldspar porphyry. The quarts-diorite and diorite appear younger than the andesite and may be genetically related to the formation of the ore body.

Batholith and Intrusive Rocks:

The south boundary of the Guichon batholith has not been definitely established with relation to the Mine workings, but quartz-diorite and diorite encountered in the workings are believed to be batholithic in origin if not directly attached to the batholith.

(a) Quartz-Diorite-

The quartz-diorite is light gray to gray colour, medium to coarse grained and composed of light coloured plagioclase, hornblende, biotite, quartz and iron oxide. Large anhedral to subhedral crystals of horneblende give the rock a porphyritic texture. This rock may grade into diorite.

Microscopically, the rock has a typical allotriomorphic granular texture and is composed of 50% plagioclase (An 40-46), 32% hornblende, 10% quartz, 5% magnetite and 3% chlorite. Most of the feldspar crystals are highly altered, clouded with sericite and some contain inclusions of iron oxide and apatite. Accessory minerals include calcite, sphene and zircon.

(b) Diorite:

The diorite has much the same appearance as the quartz-diorite, being a light gray colour, medium to coarse grained massive rock, composed mainly of feldspar and hornblende.

Microscopically the rock comprises 55% subhedral to anhedral plagioclase (An 43), 30% hornblende, 10% megnetite, 3% biotite and 2% quartz. Highly altered and saussuritized feldspar crystals are common. Some large anhedral hornblende crystals enclose smaller subhedral plagioclase crystals. Accessory minerals include apatite, calcite and sphene.

(c) Andesite:

Field relationships show that the andesite is irregularly intrusive into the sediments but has a similar general attitude. Megascopically the andesite is dark gray, very fine grained to aphanitic and generally massive, with phenocrysts of light coloured feldspar throughout. Veins of coarser grained quartz-dioritic rock and small patches and veins of yellowish-green epidote, with some garnet, are also present in the andesite.

Microscopically the andesite is 50% hornblende, 35% andesine, 12% iron oxide, and 2-3% apatite. Hornblende, often altered to chlorite, occurs as anhedral or short prismatic crystals in a groundmass that sometimes shows flow structure. Andesine phenocrysts and microlites in the groundmass occur as subhedral grains or short prismatic crystals. Iron oxides are disseminated in the andesite and grains and veinlets of chalcopyrite, usually associated with veinlets of epidote, indicate a pre-mineral age for the andesite.

(d) Feldspar Porphyry:

Feldspar porphyry, a minor intrusive, occurs as narrow dykes and veins cutting the meta-sediments. This rock is pinkish coloured with dark veinlets of tourmaline and chlorite.

Microscopically the feldspar is the major constituent, composing up to 82% of the rock. The feldspar crystals are anhedral and tend to be tabular in form. Calcite in veinlets comprises 10% of the rock. Chlorite, quartz, magnetite and epidote occur as minor constituents.

NICOLA ROCKS:

The Nicola rocks, especially in altered forms, present some problem in terminology as various names have been applied to the rocks by different geologists. For the present, preference will be given to established terminology with mention of alternative names.

In the Mine a definite distinction is possible between rocks characteristically found on the south side of the ore body and those found on the north side. This distinction must be maintained by rock terminology.

(a) Greywacke:

The name greywacke, or alternatively arkosic greywacke, is applied to the rock forming the immediate north wall of the ore body. This rock is greyish white, medium to fine grained and composed of abundant angular to sub-angular grains of quartz and minor dark green mafic minerals in a feldspathic groundmass.

Microscopically, the composition of the greywacke is 60% feldspar, 15% quartz (variable), 5% chorite, 5% pyroxene, 3% calcite, and 2% sphene. The feldspars are highly altered and clouded with sericite and chlorite. Chalcopyrite, magnetite and hematite may be sparsely disseminated in the rock.

(b) Quartzo-Feldspatic Tuff:

The south wall rock has been called quartzo-feldspathic tuff to denote a volcanic origin. Alternatively, it has been called greywacke, but this term provides no distinction from the nαth wall greywacke. This tuff is dark greenish gray to gray, medium to coarse grained and composed of subhedral to anhedral feldspar with larger bluish to colourless subrounded or subangular quartz grains and dark greenish mafics occurring as anhedral grains or as fine grains interstitial with feldspar. Rock fragments are common.

Microscopically, the tuff is composed of subangular to subrounded grains of quartz and aggregates of quarts in a highly altered feldspar, quartz and hornblende groundmass. The rock composition is estimated at 40% quartz, 30% feldspar, 25% calcite and 5% tourmaline.

(c) Grit:

This recently identified rock has not been previously distinguished, but occurs in the south wall rocks. It is characterized by pinkish feldspar and subrounded to subangular grains of quartz set in a light gray to pale greenish groundmass that is generally massive in appearance. Banding, due to gneissic structure in the groundmass, is sometimes present.

Microscopically, the grit is composed of 70% quartz, 15% - 20% feldspar, 15% chlorite and biotite and minor calcite. The quartz occurs as large subangular to subrounded grains or grain aggregates and as fine grains in the groundmass. Feldspars are subhedral to anhedral, highly altered and occur mostly as large grains, but also as fine grains in the groundmass.

(d) Limestone:

The limestone, which is in direct contact with north wall greywacke, occurs in beds estimated to be over 100' thick, as well as in thin beds intercalated with tuff. The limestone is grayish white and fine to medium grained but darker bands are quite common. This limestone is often altered to skarn composed of brown to brownish garnet and yellowish green epidote. This limestone is considered the main host rock for mineralization.

(e) Argillite:

Argillite occurs in relatively thin beds and is commonly intercalated with tuff and grit. The rock, varying from black to pale greenish, is well banded and the pale green varieties appear siliceous. One discontinuous band has been found between the limestone and the north wall greywacke. Euhedral pyrite crystals are occasionally present in the black argillite.

(f) Limy Tuff:

This local term was originally applied to unaltered fragmental rock with a calcite cement, but has become a catch-all term for any limy mineralized sediments, which includes much of the highly altered limestone within the ore zone. A more correct term for these rocks is calcareous sediments.

ROCK ALTERATIONS:

Rock alterations in the order of relative intensities are - propylitization, sericitization, chloritization, development of garnet, development of K-feldspar, and silicification.

Propylitization affects all of the rocks in the Mine to varying degrees. Some of the limestone is completely altered and to an aggregate of chlorite and epidote. Small patches and veins of chlorite and epidote are frequently found in the altered intrusive rocks as well as in the sediments.

Weak sericitization, characterized by alteration of feldspar is widespread in the rocks. Thin sections show minute flakes of microlites of sericite clouding the feldspars.

Chloritization and silicification are less common. Chloritization has changed mafic minerals, mainly hornblende and biotite, partially or completely to chlorite. Pale greenish siliceous argillite appears to be the result of silification.

Light brown garnets occur frequently in the altered limestone and the resultant rock has been called garnet skarn where alteration has been extensive. Brown to dark brown garnets also occur in chloritic rock. Dark brown garnets, commonly associated with epidote and chlorite occur to a lesser extent in the andesite and quartz diorite.

Development of K-feldspar by introduction of potash is common in the north wall rocks and in the ore, but this alteration does not appear to have any significant pattern.

MINERALOGY:

The metallic mineralogy of Craigmont is quite simple so far as is known to date. Magnetite and hematite comprise approximately 15% by weight of the ore body. Chalcopyrite is the principal copper mineral, accounting for almost all of the copper content and most of the sulphide content. Pyrite occurs in subhedral grains as a fringe mineral in the wall rocks and in the garnet skarn, but seldom within the ore body. Pyrrhotite has been recognized in minor quantities in garnet skarn and altered limestone. Recently some massive pyrrhotite was found in the 3000-level extension, but the significance of this occurrence is not yet understood. Very minor amounts of bornite occur in association with massive magnetite at the eastern end of the ore body. Neo-dygenite, the blue chalcolite, has been recognized in one polished section. The average sulphide content is approximately 5.5%.

Chalcopyrite occurs as disseminated grains in magnetite and hematitie, as thin fracture fillings, as platings between specularite lamellae, as disseminations replacing breccia fragments, as coarse grains in calcite breccia cement, as massive patches several feet across and rarely as finely banded replacements.

Magnetite may be disseminated in chloritic limy rock, or may be a massive aggregate of grains, some of which may be euhedral. Hematite, almost all in the specularite form, generally occurs as breccia fillings, but may replace some of the host rock.

Periodic assays for gold and silver show no gold and very low silver content, usually less than o.3 ozs./ton. No silver mineral has been identified.

Magnetic analyses have been made to determine the distribution of magnetic iron minerals. Results show that magnetite predominates at the eastern end of the ore body, is mixed with hematite in the central portion and westward becomes increasingly subordinate to hematite. These analyses indicate that 52% of the average total iron content of the main ore body is magnetic.

The general indicated paragenesis at Craigmont is formation of skarn and chloritic rock in folded Nicola rocks as a result of pyrometasomatism; replacement of garnet by pyrite; replacement of skarn minerals, especially chlorite, by magnetite and hematite and contemporaneous breccia-space filling by hematite. Finally, chalcopyrite replaced chlorite, calcite, magnetite and hematite.

STRUCTURE:

During the course of exploration of the ore body several structural hypotheses have been applied, then modified or discarded as new information became available. Since mineralization appears to be confined to a highly altered and distorted horizon of the Nicola series, structural hypotheses have guided the search for ore. Briefly the hypotheses have ranged from one of a simple limy bed varying in thickness along strike and offset by faulting down dip, to one of reversal of dip at depth of a simple limy bed, then to an anticlinal hypothesis to which a parallel syncline was later added, through to the present hypothesis of large scale drag folding of one limy horizon (Fig. #4).

The present hypothesis is most acceptable because, firstly, the wall rocks in the north wall and south wall are not similar as would be necessary in an anticline unless faulting or lensing had occurred. Secondly, drill holes have indicated the bottom of the upper drag fold and the top of the lower one, but have not indicated a termination of the limestone upward or downward. This drag fold structure suggests an anticlinal axis to the south of the Mine with repeated drag folds on the north limb.

In the mine these large drag structures, apparently controlling the ore bodies, have an indicated eastward plunge of 20° - 25°, calculated from diamond drill hole geology only. No identifiable small drag folds are evident within the underground workings so this plunge cannot be verified.

At the eastern end of the known ore body the structure is truncated by a thick dyke of diorite which presumably originates from, and may joint, the main batholith to the northeast. This dyke tapers out westward along strike on the south side of the ore body. To the west and possibly downward, the favourable structures in the Nicola rocks are open.

Brecciation accompanies the drag folding so that part of the ore occurs as partial replacement of, and space-filling between, breccia fragments that range in size from a fraction of an inch to several feet. Toward the west, where hematite predominates, mineralization appears to be more open-space filling than replacement.

Pre-mineral fractures and small faults also affect mineralization, but are regarded as part of the overall brecciation. Small faults crossing the drifts with a predominant north-south strike may offset strata a short distance but no large faults controlling or displacing mineralization have been recognized.

ORE BODIES:

Continuity of the ore-controlling structures along strike is illustrated by the fact that mineralization is more or less continuous for 2,200' on strike of the "main" ore body and for 1,000' at least on strike of the "syncline" ore body. The known vertical extent of mineralization is 1,500' over the two ore bodies. Horizontal widths of ore range up to 230' in the "main" ore body and up to 310' in the "syncline" ore body.

ORE CONTROLS:

The probable controls of the Craigmont ore bodies are:

(1) Proximity to the batholith contact. The batholith is considered

responsible for the structure, the alteration of the host rock, the temperature control and may be the source of mineralization.

(2) Favourable Host Rock. A favourable host rock bounded by unfavourable wall rocks is necessary and is provided by the impure limestone that alters readily to skarn with some reduction in volume and probable increase in permeability.

(3) Structure in the Host Rock. Structure is important in the host rock since the folding has thickened the favourable rocks to accommodate large ore bodies as compared to the thin limbs of the folds, and has provided open space and permeability by brecciation.

There may be a fortuitous coincidence of these controls at Craigmont, resulting in a unique ore body, but it would seem more likely that these conditions could repeat elsewhere where Nicola rocks contact intrusives.

GENESIS AND CLASSIFICATION OF THE DEPOSIT:

The suggestion has already been made that the batholithic intrusion produced the general structure. In turn the structures developed in the Nicola rocks may have partially controlled the emplacement of diorite and andesite dykes along strike with the ore zone. These dykes would be contemporaneous with, or a late stage of, the batholith. Mineralization is definitely later than the intrusives as it fills fractures in both the diorite and the andesite.

The ore is therefore considered a late stage of the batholith intrusion. At present there is not evidence for assuming more than one age of mineralization.

The deposit is classified as a structurally controlled, pyrometasomatic replacement and breccia-filling of impure limestone.

GEOPHYSICS & GEOCHEMISTRY:

Since the time that Craigmont began to be recognized as a find of major proportions, thus triggering widespread exploration in the region, the ore body has been used by mining and exploration companies as a testing ground for geophysical and geochemical equipment.

Before outlining the results achieved there are two points which should be kept in mind.

(1) In some cases the tests were limited in extent of area and only two or three lines were run across the ore body. Although this appeared to be sufficient at the time a more detailed test might have provided a better indication as to the equipment's potential.

(2) It must be remembered that the conditions existing at Craigmont and the results obtained will not necessarily be duplicated even a short distance away.

Magnetometer:

The pin-pointing of the Craigmont ore body can be attributed to the Magnetometer. With a variation of 7,000 gammas to 14,000 gammas above background it was readily discernible to any form of magnetic equipment, be it dip needle, airborne, or the most sensitive of modern ground instruments. Since there is a good possibility that economical deposits of copper in the Nicola series will be associated with at least some magnetite, the magnetometer will likely remain the initial method in any program of geophysical prospecting.

Electro-Magnetic:

The electro-magnetic method received the most attention in the test surveys with several makes of both horizontal and vertical loops being used. In only one case, a vertical loop method, did the results appear to be truly significant. In the remainder of all types tested the results were usually classed as poor. Where some weak results were obtained they were generally attributed to magnetite.

The Craigmont ore averages about 5.5% sulphides, which is generally conceded to be the minimum necessary for satisfactory E-M detection.

Self-Potential:

Several SP tests and one complete survey were run over the ore body. The maximum anomaly recorded amounted to about 30 M.V. and it was generally felt that in normal exploration work the ore body would have been missed.

Induced Polarization:

One test was run using this method and it was limited to one line. Although the results did not appear to be particularly significant no firm conclusion should be drawn due to the limited extent of the test.

A recent IP survey on one cross-section at the eastern end of the ore body appeared to definitely indicate the magnetite mineralization.

Geochemical:

An account of a rubeanic acid geochemical survey over Craigmont was published in the July 1958 issue of Mining World by R. E. Renshaw and F.L.C. Price. Subsequently two detailed and several protracted rubeanic acid surveys were conducted over the same area without duplicating the anomaly, although individual samples from gullies where humus had collected were anomolous. However, the original geochemical survey served its purpose by indicating the presence of copper in the area covered by the magnetic anomaly.

A biogeochemical survey on pine trees did not indicate anything anomolous.

WHAT OF THE FUTURE:

To mining men, the significance of the discovery of Craigmont is that once again an ore body has been found close to surface in an easily accessible and well-prospected area. Two questions might be asked: first, why was the ore body not found before, and second, how do we find another.

The first question is easily answered - the ore body did not outcrop and had no surface expression whatever, as it was completely covered by a variable mantle of glacial overburden. Float rock was almost absent and the rare pieces found did not contain much copper stain. Furthermore, the favourable Nicola rocks were not known to be near surface in this area as the only outcrops were Kingsvale volcanics and weakly-mineralized diorite.

An answer to the second question, of how can we find similar deposits, may be that first we require considerable confidence in the idea that not all easily accessible, good-grade ore bodies have been found.

Often this attitude is best developed in the small mine exploration companies who carry out programs on old properties and areas as promotional ventures. These companies provide a very worthwhile service to the mining industry. The small company directors and those who provide risk capital deserve much credit for the exploration they conduct.

The exploration techniques applicable to Craigmont are those in general use, such as selection of a mineralized belt, selection of favourable areas within these belts and detailed mapping and prospecting, geophysical and geochemical surveying and diamond drilling where warranted. The persistent application of these techniques to known favourable areas should be greatly stimulated by the discovery and development of the Craigmont Mine.

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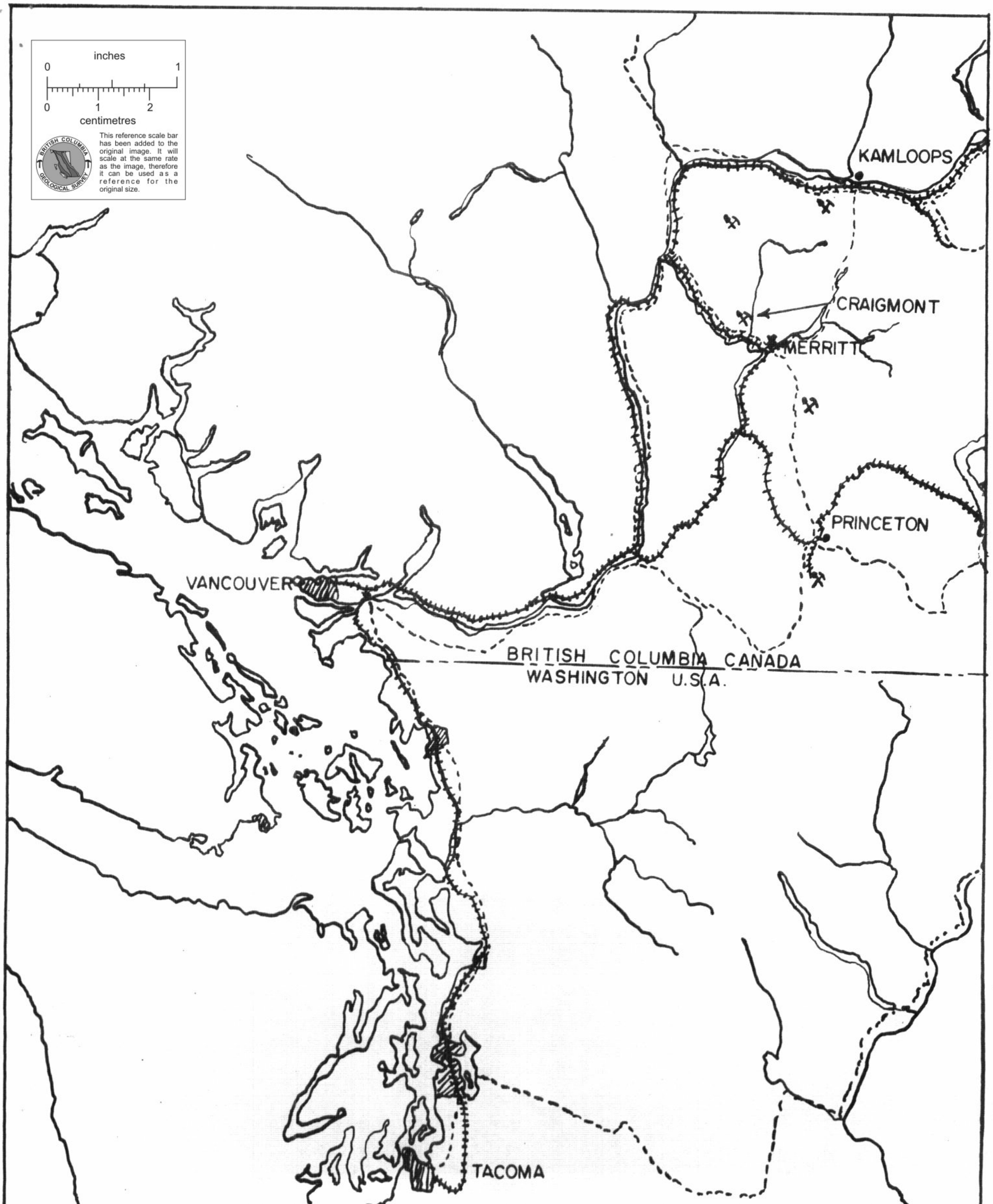
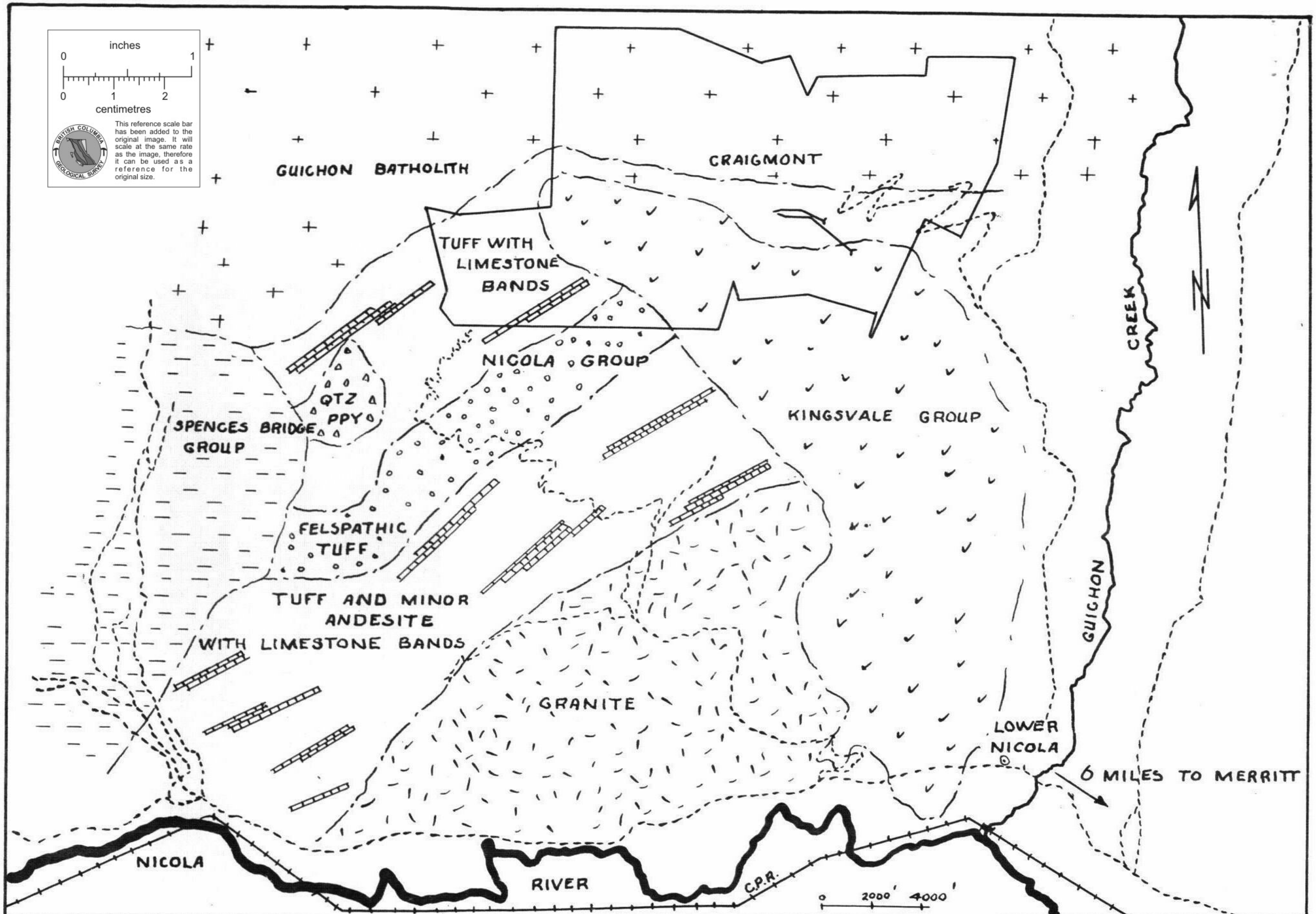


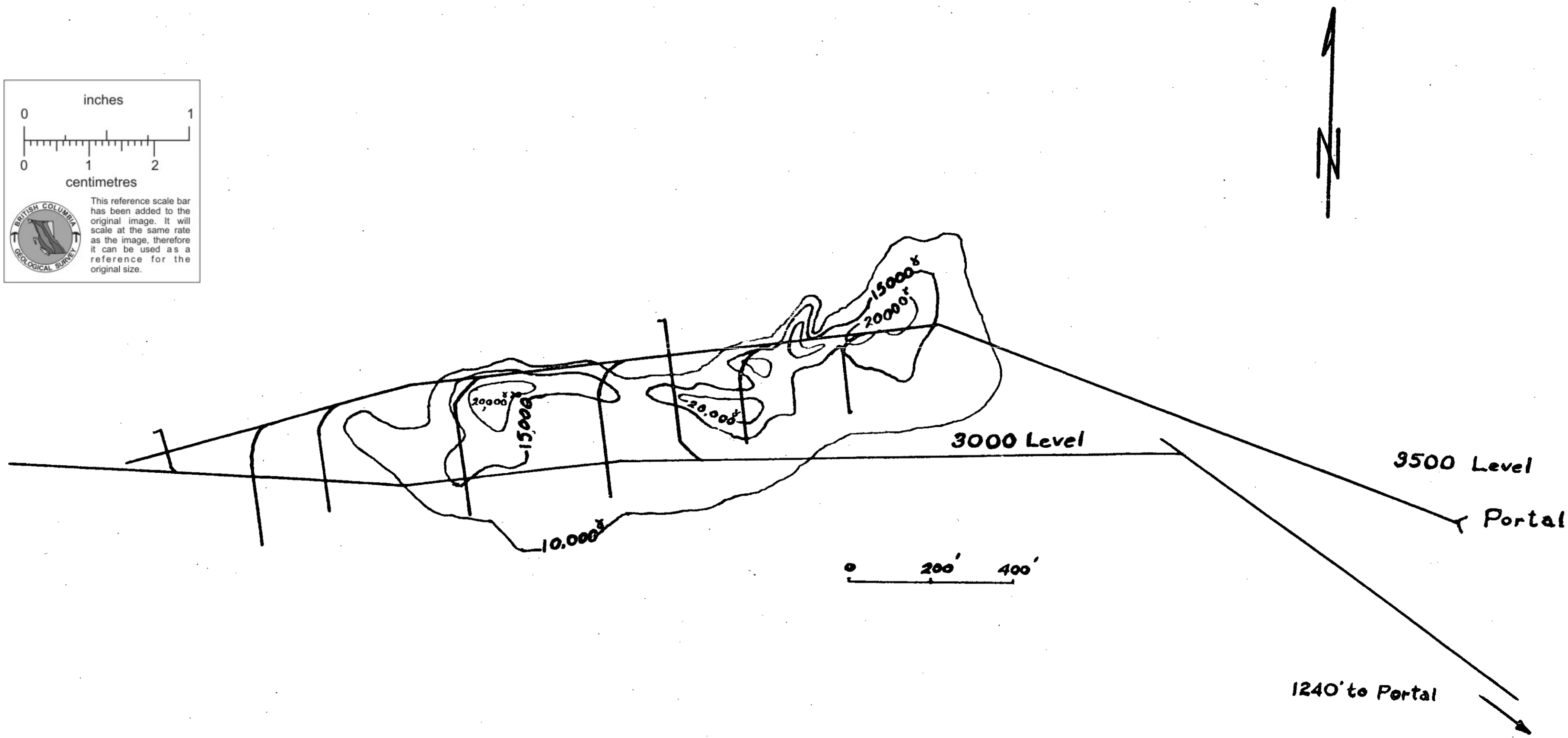
MAP SHOWING THE LOCATION OF CRAIGMONT

FIG #1



GENERAL GEOLOGY & LOCATION MAP — PROMONTORY HILLS AREA

FIG 2



PLAN SHOWING

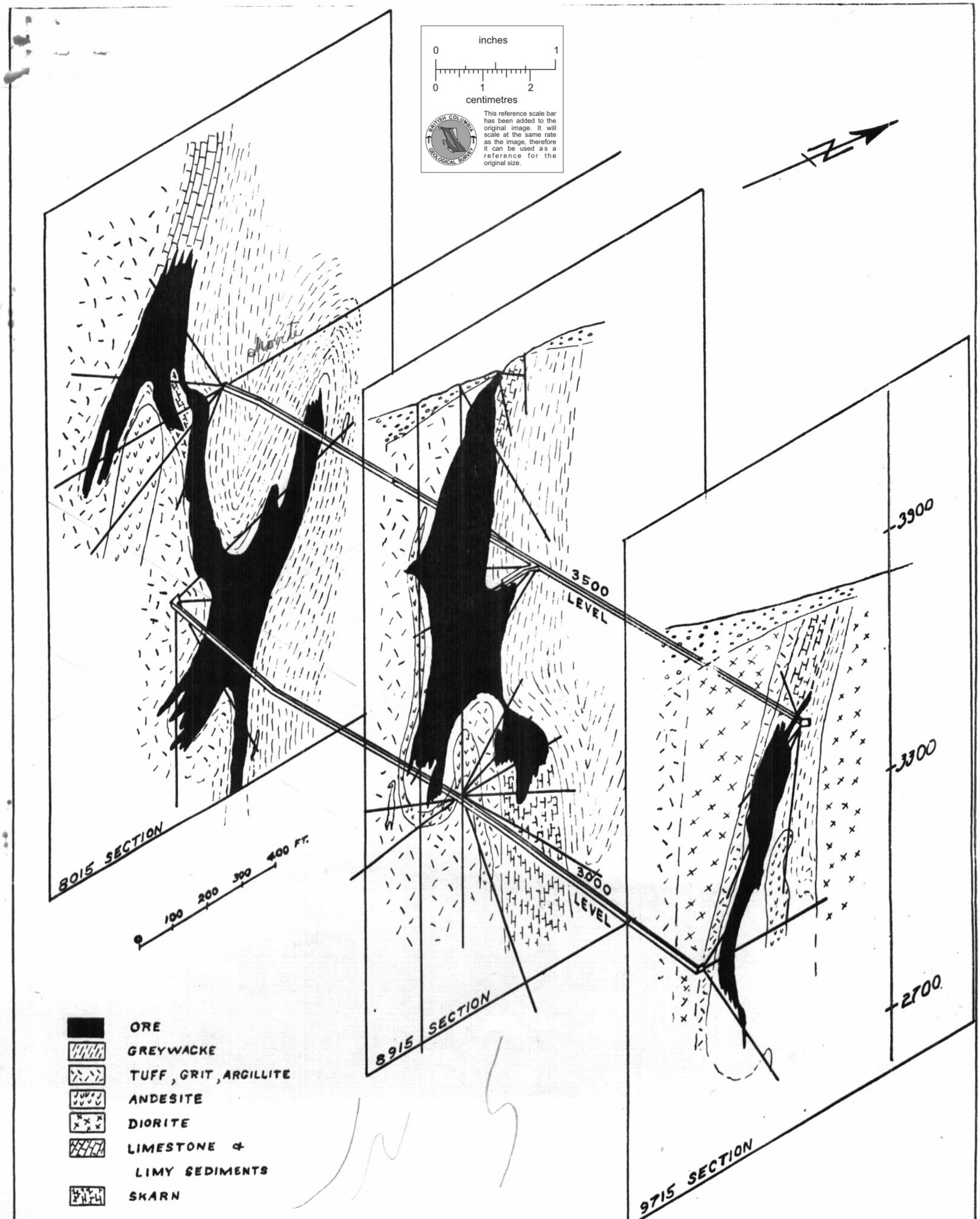
3500 & 3000 LEVELS

WITH

MAGNETIC ANOMALY

ESTABLISHED BY RADAR MAGNETOMETER

Fig #3



3- SECTION ISOMETRIC OF CRAIGMONT ORE BODIES

FIG. #1