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Maurice J. Young is District Geologist for the Vancouver, B.C., office of Utah Construction & Mining Co. He was born in Brandon, Manitoba, and graduated in 1961 from the University of British Columbia with a B.Sc. in geology.

Prior to attending U.B.C. he was on the staff of Howe Sound Company from 1952 to 1957 and worked in the geology department of the mine at Snow Lake, Manitoba, and later on exploration projects in New Brunswick and northern Manitoba.

After graduation he joined Utah Construction & Mining Co. and has been involved in exploration projects in B.C., Alaska, and Washington State. He is a member of the Association of Professional Engineers of British Columbia and the Canadian Institute of Mining and Metallurgy; and is a fellow of the Geological Association of Canada.

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He received a M.Sci. Degree (Mining Geology) from the Colorado School of Mines in 1956.

Joining the Utah Construction and Mining Co. in 1963 as District Geologist in the Vancouver Office, he was recently appointed as Exploration Manager for Canada and Alaska.

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E. S. Rugg, P.Eng.

Geology and Mineralization of the

ISLAND COPPER DEPOSIT

By

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INTRODUCTION

The Island Copper property, controlled by Utah Construction & Mining Co., consists of 175 mineral claims and fractions located on the north shore of Rupert Inlet about six to eight miles south of Port Hardy on the northern end of Vancouver Island. Port Hardy, a small logging and fishing community of about 2000 people, is about 220 air miles northwest of Vancouver, B.C. Regular flights are scheduled between the two points by Pacific Western Airlines. The area is also accessible via provincial highways and logging roads from Campbell River through Gold River and Beaver Cove. B.C. government ferry service also provides a daily link in the north island-highway between Kelsey Bay, north of Campbell River, and Beaver Cove. Fixed-wing aircraft and helicopter charter services are available at the Port Hardy airport.

The Island Copper property is accessible by public and private roads from Port Hardy. It is also accessible by sea. Barges and moderate size freighters can navigate Quatsino Narrows into Rupert Inlet. A barge docking facility has been constructed in the concentrator area to facilitate moving of equipment and supplies to the construction site.

Elevations on the property range from sea level to 500 feet. Timber cover is dense. Precipitation at Port Hardy is normally about 75 inches a year, including two feet of snow. Yearly temperatures range from 20° F minimum to 80° F maximum.

HISTORY OF EXPLORATION ACTIVITY

The earliest known mining operation in the Port Hardy area was the extraction of coal from beds at Fort Rupert, a short distance south of Port Hardy, and at Coal Harbor, located on the north shore at the east end of Holberg Inlet. The former operation started in 1835. These operations were short lived because of general economic conditions and the poor quality of the coal.

Mining on what is now the Coast Copper property of Cominco, 20 miles to the south, started in 1911 but general economic conditions were such that the operation lasted only a short time. In 1960 activity was renewed there and the mine is currently producing both copper and iron concentrates.

Other nearby producers, both of which ceased operations in the past five years, were the Yreka (copper) and Empire Development (iron) mines.

The Geological Survey of Canada published the first professional report on the geology of Northern Vancouver Island as a result of G. M. Dawson's field work in 1886. Since that time both the Geological Survey and the British Columbia Department of Mines have sponsored field parties in the region at various times. During the latter part of 1962 the Department of Mines financed an airborne magnetometer survey of Northern Vancouver Island. On publication of the results early in 1963,

A paper presented at the Annual Meeting, B. C. Section, Canadian Institute of Mining and Metallurgy, Kamloops, October 1970.

ABSTRACT

Utah Construction & Mining Co. optioned the Island Copper property from Gordon Milbourne, a prospector, in January of 1966. Initial field examinations, including preliminary soil geochemistry surveys, had been made in the fall of 1965 and an option agreement was recommended. After the signing of a formal agreement in January of 1966, a control grid was established with line spacing of 500 feet and 200-foot station spacings using a Brunton compass and tape. A soil sampling survey, geophysical surveys and geologic mapping of the 175 claims were initiated utilizing the grid for control.

Diamond drilling and trenching were carried out simultaneously, in the vicinity of Milbourne's original trenches south of Bay Lake. Float containing massive chalcopyrite had been found there, on the surface and in prospect pits, by the prospector. To test this area, the company drilled over 13,000 feet in relatively shallow holes in 1966 and early 1967. This drilling outlined a narrow sinuous zone of good-grade copper mineralization.

By this time the basic geochemical and geophysical surveys had been completed over the entire claim group. The geochemical work, in particular, outlined a large copper anomaly in soils, located more than a mile from the original prospect pits. The area of the anomaly was covered with thick forest growth. Glacial till ranged from a few feet to 250 feet deep and there were very few bedrock exposures.

The geochemical anomaly over what is now the Island Copper orebody was tested initially with four shallow X-Ray diamond drill holes and low-grade copper mineralization was indicated. In February 1967 a BQ drill hole was collared within the anomaly and it intersected what proved to be ore-grade mineralization over a significant length. Drilling continued in this area on 400-foot centers until May 1969. As many as six drill rigs were active at one time and 128 BQ and NQ holes were drilled for a total of 116,783 feet.

The trend of the ore zone, N60°-70°W, parallels that of the regional folding. The orebody is more than a mile in length, and in places exceeds 1200 feet in width.

Because the orebody does not outcrop, the geological interpretation of the deposit has been made from the drill-hole information. The principal ore control appears to be a dike-like quartz-monzonite-porphyry intrusion, Jurassic in age, which has invaded the Triassic Bonanza tuffs. Only one small outcrop of the dike was visible but the drilling indicates its presence for nearly the full length of the orebody. Brecciation has occurred in the tuffs within the "hood" area over the dike and along the lateral margins as well as within the dike.

Generally the mineralization consists of pyrite, magnetite, chalcopyrite, some bornite and molybdenite in order of decreasing percentages.

Copper mineralization within the porphyry is distributed irregularly. The best copper mineralization is found in the tuffs flanking the porphyry dike and in the "hood" over the porphyry, where the dike does not reach the bedrock surface.

Several types of alteration have been recognized which appear to conform to the usual porphyry-copper-type zoning. They include silicification, argillic and prophylitic alteration, and some development of secondary biotite. Silicification occurs both as pervasive quartz flooding and as veinlets and is associated with the mineralized zone. Several generations of quartz veins are apparent, some of which are completely devoid of sulphide mineralization.

In 1968 a bulk-sampling program was begun. This work involved sinking a 225-foot shaft, driving about 1000 feet of drifts and cross-cuts, and driving two raises. The shaft and raises were driven on drill holes to obtain a direct comparison between the drill-hole assays and the bulk assays. The bulk assays were slightly higher than drill-hole assays.

Metallurgical tests and mill-pilot-plant studies were conducted on drill-core composites and on portions of the bulk sample.

The company announced in July of 1969, just a little over two years after the initial drill hole was collared in the orebody, that 280,000,000 tons averaging 0.52% copper and 0.029% molybdenite had been outlined and that a $73 million dollar investment would be made. Contracts for the sale of the copper and molybdenum concentrates have been signed and construction of the plant facilities on the site is well underway. The production date is tentatively early in 1972.

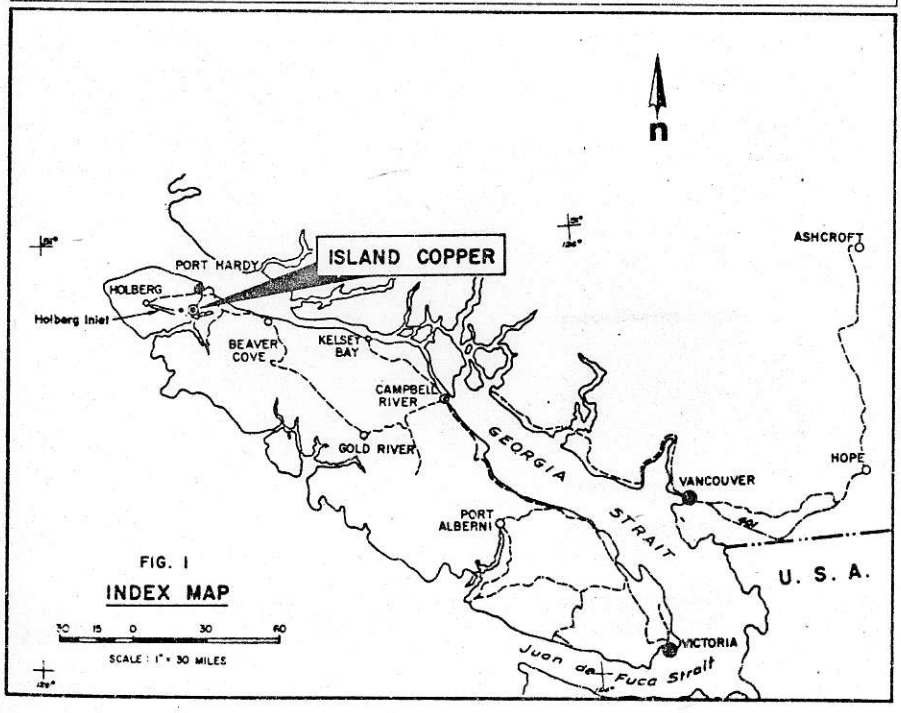


FIG. 1
INDEX MAP

many companies and private individuals examined the many anomalous areas which had been outlined with the hope of finding iron deposits. No significant discoveries were made however, and by 1965 very little interest was being shown in the region.

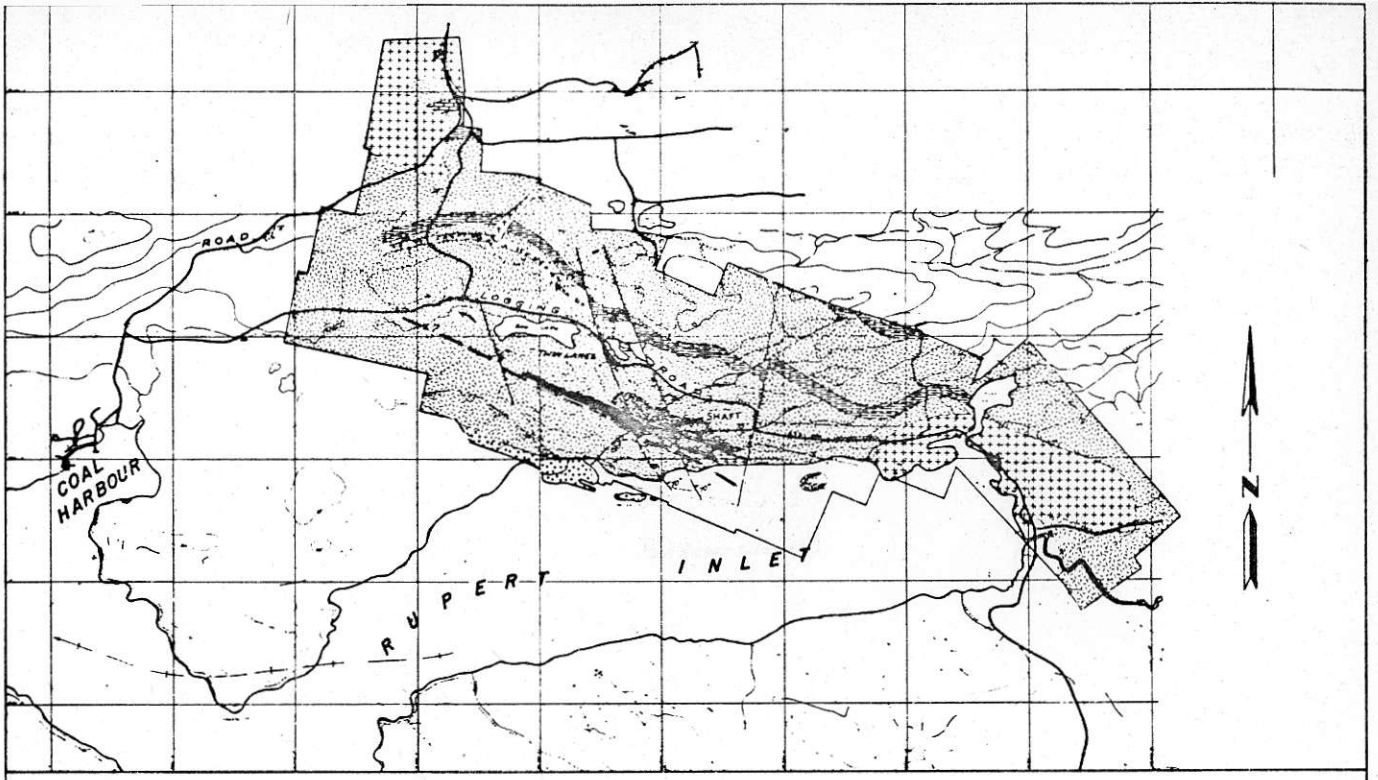
In the vicinity of the Island Copper deposit many isolated outcrops containing small amounts of copper have been noted for many years. On Red Island, in Rupert Inlet, a short adit was driven many years ago in fractured volcanic rocks which contained over 1% copper over short intervals.

During 1965, Gordon Milbourne, a prospector who has concentrated his efforts on the north end of Vancouver Island for many years, staked the Bay claims. His attention was drawn to the area by the widespread occurrence of very small quantities of native copper and chalcopyrite in a few volcanic rock outcrops, in road cuts, and in quarries used as a source of road ballast. The relationship between an aeromagnetic anomaly, delineated by the Department of Mines, and the copper mineralization was speculative. Milbourne had found a small piece of high-grade copper float a short distance south of the west end of Bay Lake early in 1965. The excavation of two shallow pits beneath this float exposed ore-grade material in bedrock. Initial field investigations, including preliminary soil-geochemistry surveys, by company geologists in October, 1965, indicated some exploration work was warranted. A formal agreement was signed in January 1966 between Milbourne and Utah. After signing of the formal agreement a control grid was established with line spacings of 500 feet and 200-foot station spacings using a Brunton compass and tape. A soil-sampling survey, geophysical surveys, and geologic mapping of the 175 claims were initiated utilizing the grid control.

Diamond drilling and trenching were carried out simultaneously in the vicinity of Milbourne's original pits southwest of Bay Lake. To test this area, the company drilled over 13,000 feet in relatively shallow holes in 1966 and 1967. A small orebody having plan dimensions of 200 feet by 300 feet was outlined.

Basic geochemical and geophysical surveys had been completed over the entire claim group prior to completion of the drilling in the vicinity of the original pits.

The geochemical work in particular had outlined a large copper anomaly in soils, located more than a mile southeast of Milbourne's test pits. This anomaly, over what is now the Island Copper orebody, was tested initially in 1966 with four shallow X-Ray diamond drill holes and a low-grade copper mineralization was indicated. In February 1967 a BQ drill hole was



CRETACEOUS
- CONGLOMERATE & SANDSTONE

INTRUSIVE ROCKS
- QUARTZ-MONZONITE PORPHYRY
- GRANODIORITE
- DIORITE

BONANZA GROUP
- VOLCANIC BRECCIA (FORMATIONAL)
- ANDESITE FLOWS & TUFFS
- ARGILLITE AND CHERTS
- QUATSINO FORMATION: LIMESTONE

KARMUTSEN GROUP
- LIMESTONE LENSES
- AMYGDALOIDAL ANDESITE TO BASALT FLOWS

ALTERATION
- PYROPHYLLITIC ALTERATION
- SKARN; AND QUARTZ & CARBONATE VEINS & STRINGERS

MINERALIZATION
- SULFIDES: PYRITE (PY), CHALCOPYRITE (Ccp.)
- FAULT, SHOWING DIP, & RELATIVE MOVEMENT
- 30° BEDDING DIP
- ANTICLINAL AXIS, SHOWING PLUNGE
- ADIT
- OVERTURNED BEDDING DIP
- SHAFT

FIG. 2

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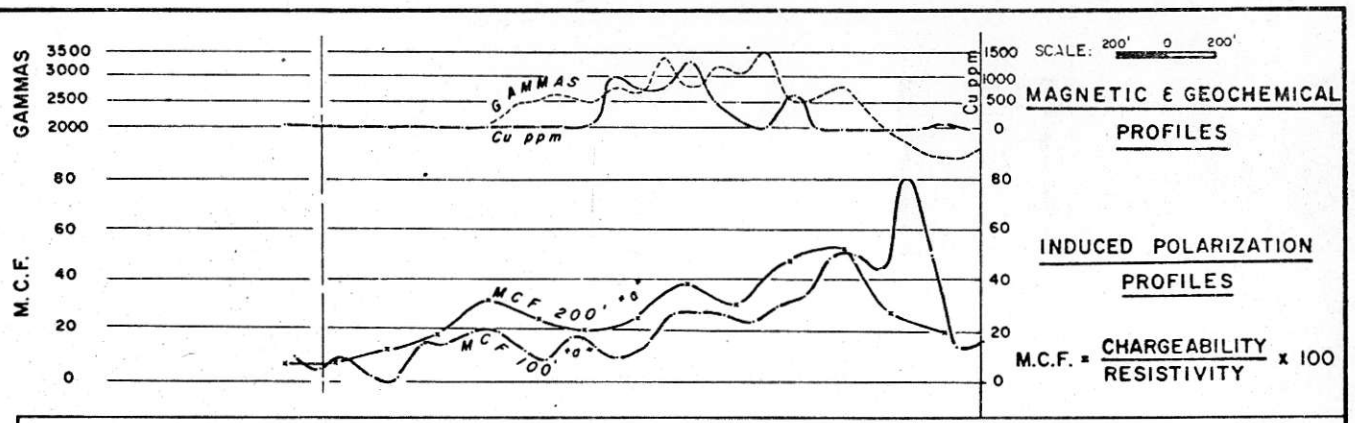
GEOLOGICAL INTERPRETATION

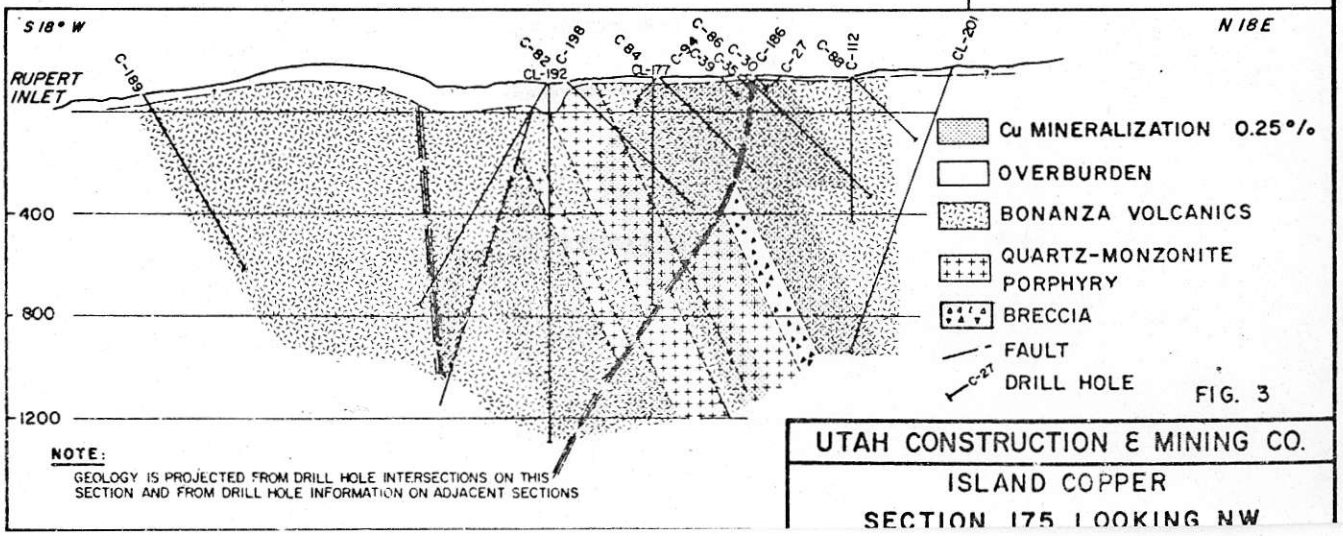
4000 2000 0 2000 4000
SCALE IN FEET



MAGNETIC & GEOCHEMICAL PROFILES

INDUCED POLARIZATION PROFILES

$$M.C.F. = \frac{\text{CHARGEABILITY}}{\text{RESISTIVITY}} \times 100$$



NOTE:
GEOLOGY IS PROJECTED FROM DRILL HOLE INTERSECTIONS ON THIS SECTION AND FROM DRILL HOLE INFORMATION ON ADJACENT SECTIONS

FIG. 3

UTAH CONSTRUCTION & MINING CO.

ISLAND COPPER

SECTION 175 LOOKING NW

collared within the anomaly and it intersected what proved to be ore-grade mineralization over a significant length. Drilling continued in this area until May 1969. As many as six drills were active at one time and a total of 128 BQ and NQ holes were driven.

After the completion of the first few holes in the orebody, a legal survey of the claims was undertaken. A transit control-grid was provided for the 1"= 200' scale surface geologic mapping of the area. A topographic map was prepared for the area by the survey department using a transit and level. The surveyors were also responsible for surveying the diamond-drill holes.

In 1968 a bulk-sampling program was begun. This work involved sinking a shaft approximately 225 feet deep, and driving about 1000 feet of drifts and cross-cuts and two raises. Metallurgical tests and mill pilot-plant studies were conducted on drill-core composites and on portions of the bulk sample in the company laboratory at Palo Alto, California, and the pilot mill at Cedar City, Utah.

GENERAL GEOLOGY

Northern Vancouver Island is underlain by Mesozoic and Tertiary volcanic and sedimentary rocks which are, in places, cut by Mesozoic and Tertiary intrusions.

The predominant rocks north of Holberg Inlet are the Karmutsen formation, Quatsino formation, and Bonanza subgroup of Upper Triassic and Jurassic ages.

The Karmutsen formation is of Lower-Upper-Triassic age and consists of at least 3000 feet of volcanic flows with minor pyroclastics and sediments. The flows are primarily basalts and andesites and are commonly a green color due to pervasive chlorite and epidote alteration. Pyroclastics are very limited and irregularly distributed. They occur mainly as explosive flow breccias, with basalt or andesite fragments imbedded in a dark-green groundmass composed of volcanic ash. Karmutsen sediments are limited to the top several hundred feet of the group and consist of argillite, chert, and impure limestone interbedded with volcanics and some breccia.

The Quatsino formation, of Upper Triassic age, ranges from 200 to 3500 feet in thickness and consists almost entirely of limestone with a few thin andesite and basalt flows.

The Bonanza subgroup is from 3000 to over 10,000 feet thick and consists of both sedimentary and volcanic divisions. The sedimentary division is of Upper Triassic age whereas the volcanic division is probably of Jurassic age. Argillite, limestone, agglomeratic and tuffaceous limestone, tuff, quartzite, and minor conglomerate constitute the sedimentary division. The sedimentary division grades upward into and is conformably overlain by a great thickness of flows and pyroclastics of predominantly andesitic composition. Although andesites predominate, basalts, dacites, and rhyolites are also present.

The Karmustsen formation and Bonanza subgroup are conformably overlain by non-marine Cretaceous sediments which occupy local basins on northern Vancouver Island. These sediments consist of conglomerate, sandstone, greywacke, and siltstone, with some carbonaceous and impure coal seams. The Cretaceous section is about 1000 feet thick in the Port Hardy area.

The main North Island intrusions of Middle Jurassic age are part of the Coast intrusive complex, and occur in narrow northwest-trending belts.

LOCAL GEOLOGY

The Bay claims are underlain by a thick section of Bonanza volcanics and pyroclastics which appear to strike about N60°-70°W and dip 30° to 40° to the south. Above its contact with the Quatsino limestone, a 500-foot-thick Bonanza section includes "agglomeratic limestone", argillite, siltstone, and chert of the lower or sedimentary division and a much thicker section of andesite and felsite flows of the volcanic division. Cretaceous sandstone and conglomerate lap over the Bonanza volcanics along the southwest edge of the property. A small altered leucocratic granite plug, ribboned with northwest-trending orthoclase feldspar stringers, outcrops on the Rupert claims in the vicinity of Rupert Lagoon. Quartz-monzonite porphyry outcrops along End Creek about 2500 feet north of Narrow Island. This body has been traced by drilling for over 6000' along a N70°W trend in the Island Copper orebody. The geologic interpretation is illustrated in figure 2.

The granite and quartz-monzonite porphyry are considered consanguineous and are probably of Jurassic age. This age has been confirmed recently through dating done by the B. C. Department of Mines at UBC. Quartz diorite, probably of Jurassic age, has been mapped on the Port Hardy Copper property, about one mile north of the Bay claims and at the northwest end of the Bay claims on the west side of the main logging road.

The entire area is cut by a number of faults which are poorly exposed due to the presence of glacial till and organic cover. These faults generally trend either N70°W or N50°E. One major N70°W fault is exposed about 3000 feet north of Narrow Island, where it is marked by a siliceous, pyrophyllite zone. The pyrophyllitized fault-zone can be traced for about 5000 feet to the northwest. The pyrophyllite is associated with quartz-monzonite porphyry, andesitic flows, and pyroclastics along this

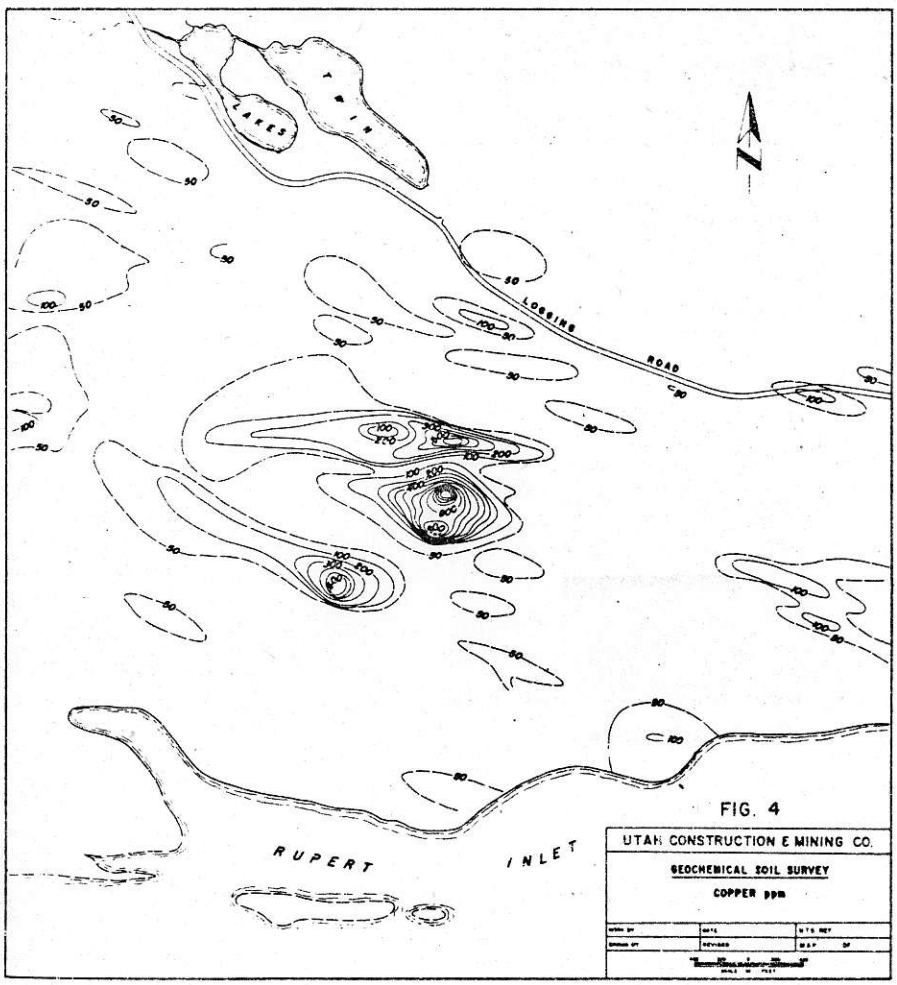


FIG. 4

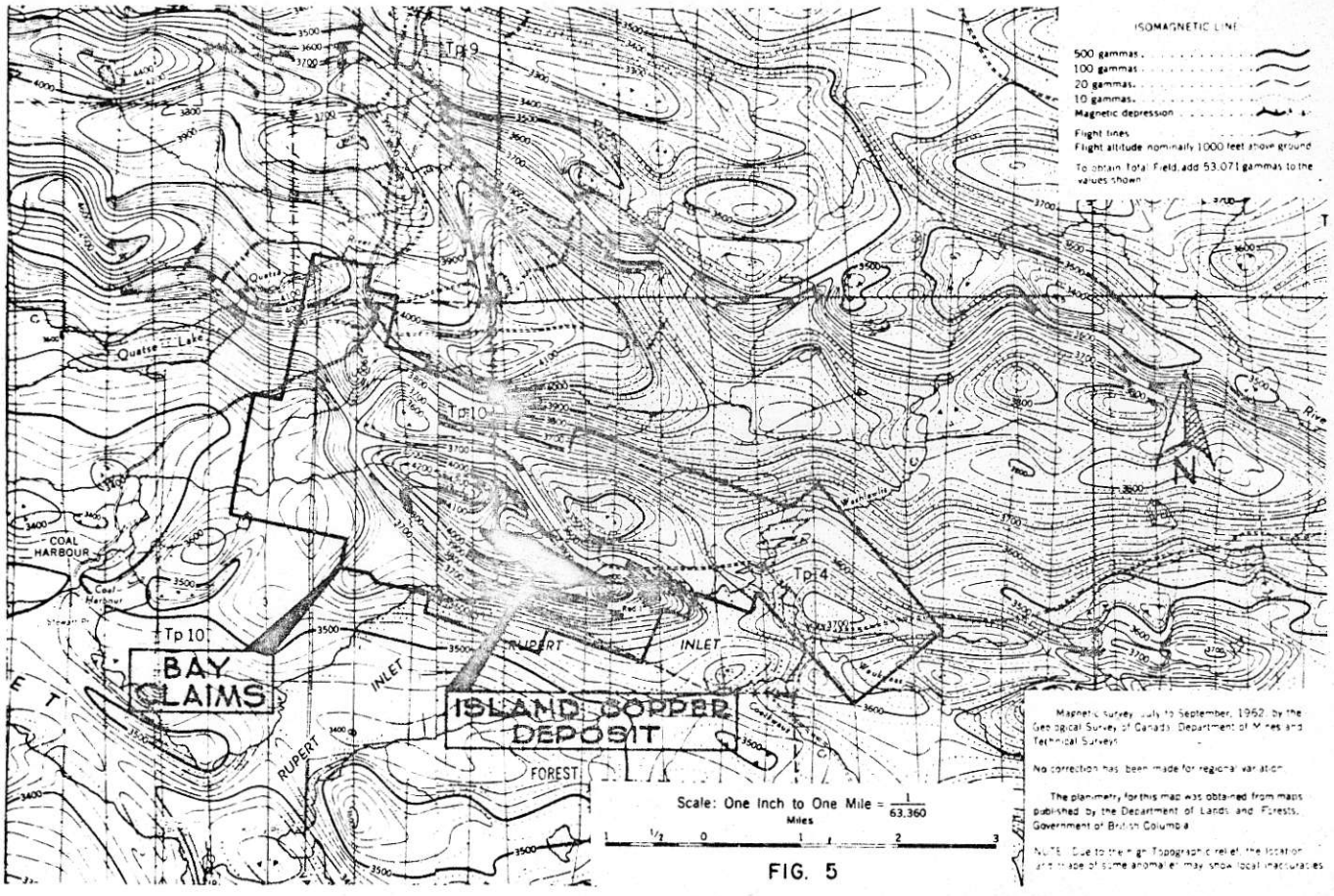


FIG. 5

fault and apparently is the result of hydrothermal alteration.

A study of the lineament pattern on aerial photos of the Bay property indicates a dominant east-west to N70°W pattern roughly paralleling the north shore of Rupert Inlet. Less prominent transverse patterns trending N70°E, N40-60°W, and N20°W are superimposed on this dominant lineation. Main fault and fracture trends encountered in outcrops, in underground workings, and in drilling correspond well with the above lineaments.

Mineralization:

Massive pyrite and chalcopyrite are concentrated along a silicified fault-zone in altered Bonanza volcanics exposed in the prospector's shallow pits in the zone southwest of Bay Lake. The mineralization consists of a number of narrow discontinuous massive-sulphide lenses, individually up to 10 feet wide and 50 feet long, along a complex fractured zone which generally trends N30°W and dips steeply to the northeast. The overall mineralized zone is up to 85 feet wide and 500 feet long.

Low-grade copper and/or molybdenum mineralization has been found in volcanics in other places on the property. Some lead-zinc mineralization associated with manganese occurs in calcareous tuffs and sedimentary units north of Bay Lake.

Chalcopyrite, pyrite, and magnetite are irregularly disseminated through silicified andesite on Red Island and in outcrops along the shore of Rupert Inlet north and northwest of Red Island. In heavily sheared sections (N50°E and N30°W shearing) on the island, the copper grade is above one percent over significant widths.

In the area of the Island Copper deposit, no visible copper mineralization was noted in the sparse outcrops. As indicated by drilling the overburden ranges up to 250 feet in thickness and obscures nearly all geological features in the vicinity of the orebody. Attention was drawn to this area through the delineation of a geochemical anomaly by soil sampling. There were no prospect pits in the area. Shallow drilling indicated the presence of low grade (.2%-.3%) copper in the form of chalcopyrite and deeper drilling resulted in the discovery of the orebody. The principal ore control (see Fig. 3) appears to be a dike-like quartz-monzonite porphyry intrusion, which dips 65° to the north, strikes N70°W and has been traced by drilling for over 6000 feet along the strike. In some places the porphyry occurs as numerous parallel bands separated by fractured andesite and/or brecciated porphyry and andesite. Occasionally this zone ranges up to 900 feet in thickness, although normally it is about 400 to 500 feet thick. Ore is concentrated along both the footwall and hanging wall of the dike structure but occasionally occurs in some sections entirely across the dike. Copper mineralization occurs in all the rock types but is found primarily in fractured and silicified andesite. The porphyry and breccia are nearly barren in some places within the bounds of the orebody.

Pyrite, chalcopyrite, and minor molybdenite are found in all the rock types present in finely disseminated form and also as thin and randomly oriented seams. The pyrite content of the orebody generally varies from two to five percent but there are local concentrations, primarily fracture-controlled, of 15 to 20 percent. Molybdenite occurs as an accessory mineral and its concentration appears to be directly proportional to that of chalcopyrite. The better-grade copper mineralization is normally bounded by a lower-grade auereole. Mineralization extends over horizontal widths of from 500 to 1700 feet. Faulting has complicated the structure and the wider zones of mineralization appear to be due to offsets along relatively-steep faults trending northeast, northwest, and possibly parallel with the dike. Silica is present in variable quantities throughout the orebody.

Dike contacts are often gradational where metasomatism has involved intense pervasive silicification and quartz veining of the volcanics.

Alteration:

Alteration of several types has affected the volcanic host rocks. In order of decreasing intensity they are (1) silicification (2) argillization (3) saussuri-

tization and (4) biotitization. In addition some potash feldspar has been introduced and carbonates, talc, chlorite, and pyrophyllite have been developed in varying amounts. Silicification is generally pervasive through the mineralized zone but is most intense in the brecciated volcanics along the dike margins. The caly alteration is quite closely associated with the silicification and is most evident in fault zones. Saussuritic alteration is quite pervasive and may be largely deuteric. The K-feldspar alteration is closely associated with silicification and produces in places a pseudo-porphyry appearance. It is particularly intense near the porphyry-dike contacts. Zeolites (tenatively identified as stilbite and laumontite) occur commonly as fracture fillings both in the orebody and in surrounding volcanics. Some carbonate is present in fractures. Talc and chlorite are the common alteration products of the mafic elements in the andesite and are probably of both deuteric and hydrothermal origins. Pyrophyllite is developed in the brecciated rock of fault zones lying near the south margins of the orebody. It is closely associated with the silicification.

The porphyry-dike fingers out upwards into a zone of intense clay alteration and silicification. Both volcanics and porphyry are affected. Locally the lateral margins of the dike are bordered by a breccia composed of magnetite-rich fragments of andesite in a matrix of vein quartz.

A natural bitumen occurs rather sporadically in small quantities through the mineralized zone. It is invariably found in well-fractured, faulted, and altered sections of the flows and pyroclastics suggesting that the bitumen migrated along faults and fractures into the volcanics from some unknown source. It is a bright, black, soft, material which fractures readily and has a dark brown to black stream. In its usual form of blebs, shards and streaks, it resembles plates of biotite. Its physical and chemical characteristics are similar to coal.

GEOCHEMICAL SURVEY

A geochmeical soil survey was conducted over the property during the period January to June 1966. Traverse lines were run N22°E across the claim area from Rupert Inlet to the north boundary of the property. These lines were surveyed by compass and tape from the main baseline, which was run along the main MacMillan-

along the main MacMillan-Bloedel logging road. They were also tied to adjoining lines at their north and south ends. The traverse lines were spaced 500 feet apart with sample stations marked by flagging at 100-foot intervals. A few intermediate lines at 250-foot line spacing were run to permit better definition of soil anomalies in the vicinity of Bay Lake. The individual

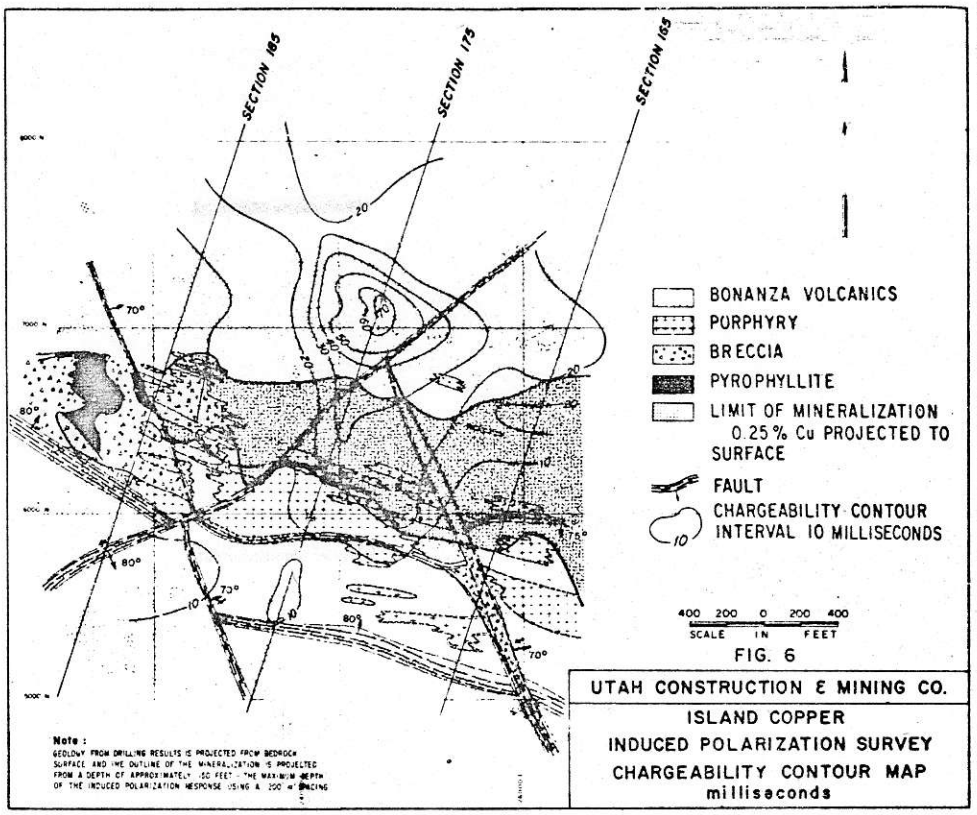


FIG. 6

traverse lines varied in length from 5000 to 15,000 feet, with the average length being about 8700 feet. A total of 61 lines were surveyed and samples for an aggregate of 530,000 feet of traverse, and 4203 samples were taken, representing 78% of the total number of sample stations.

The Bay claims in general have a variable cover of glacial till, peat, and moss, which ranges from a few feet to at least 250 feet in thickness.

The soil samples were taken, where possible, at the 100-foot stations, using a mattock to penetrate the organic cover. In some places, it was physically impossible to reach the soil below the organic material even with a 4-foot auger. The sample was usually taken from the soil horizon below the organic cover and generally consisted of red-brown colored silt with relatively few pebbles and cobbles.

As indicated above, about 22% of the soil samples were omitted due to thick organic cover, swampy ground, or no soil development because of near-surface bed-rock. The samples were dried and analyzed by a commercial laboratory in Vancouver using an atomic absorption spectrometer to report the total copper content in parts per million. The analyses were plotted on one inch to 200 feet base maps of the claim group and the results were contoured using an interval of 50 parts per million.

In order to determine the significant anomalies, usual statistical methods were applied to determine background, possibly anomalous, and anomalous values. Background was determined to be 70 parts per million, possibly anomalous 70 to 105 parts per million, and anomalous values were in excess of 105 parts per million. A profile showing the geochemical plot of Cu in soils in parts per million over a portion of the orebody is illustrated in figure 3.

In the area of the orebody, shown in figure 4, the geochemical anomaly showed a fairly rapid gradient from below 100 to above 200 ppm copper. The anomaly defined by the 200 ppm contour is roughly in the centre of the orebody in plan and conforms well with that part of the orebody generally overlain by less than 30 feet of overburden.

Soil profiles have been taken at several locations in the vicinity of the orebody. One profile taken over the orebody near the shaft gave the following results:

Depth	Soil Description	ppm copper
0' to 2 feet	organic cover	not sampled
2' to 3 feet	red-brown sandy gravel	96
3' to 4 feet	red-brown mixed clay, sand and gravel	189
4' to 5 feet	mixed clay, sand and gravel	194
4' to 6 feet	mixed clay, sand and gravel	51
4' to 7 feet	clay, sand, gravel and leached broken bedrock	880
7' to 8 feet	stained angular bedrock	1680

Assays from drill core near the location of the soil profile indicates the underlying bedrock contains about the average copper content of the orebody. Several other soil profiles taken indicate an anomalous concentration of

copper in the red-brown mixed clay, sand and gravel between depths of 2 to 5 feet. However this information is incomplete because of the inability to continue sampling to the bedrock surface.

Additional geochemical work is planned. Sampling of several soil profiles from the glacial till surface to the bedrock surface and a biogeochemical survey will be completed.

GEOPHYSICAL SURVEYS

Magnetic Survey

The British Columbia Department of Mines sponsored an airborne-magnetic surveys of the north end of Vancouver Island during the period July-September 1962. The results of that portion of the survey over the Island Copper property are shown in figure 5. At that time there was considerable interest in exploration for iron deposits. The Quatsino limestone horizon and the calcareous horizons at the base of the Bonanza series and in the Upper Karmutsen provided favourable target areas. When the results of the survey were published in 1963 many mining companies, including Utah, examined areas covered by magnetic anomalies.

A significant anomaly with a relief of about 700 gammas was delineated trending northwesterly across the north shore of Rupert Inlet. This anomaly was four miles long, up to one mile wide, and had an hourglass shape. One lobe was centered over Bay Lake and the other near Red Island. Field examinations in this area stimulated only mild interest, although good-grade copper mineralization was found associated with magnetite on Red Island. During 1963 and 1964 sporadic prospecting by individuals and companies was conducted but interest in the area gradually waned until 1965, when Milbourne discovered high-grade copper float, southwest of Bay Lake. This culminated in Utah Construction & Mining Co. signing an option agreement on the property.

Because of the dense vegetation cover and lack of outcrops on the Bay claims it was obvious that an appraisal of the ground would require detailed geophysical and geochemical surveys. These were conducted simultaneously.

The ground magnetic survey grid was designed with lines trending N22°E at 500-foot intervals and station spacing along the lines of 100 feet. Readings were taken with both an Askania torsion balance and a Jalander fluxgate instrument. General confirmation of the airborne results was good. This survey covered all of the claims. A profile of the magnetometer readings on section 175 over the orebody is shown in figure 3.

The magnetic pattern is obviously affected by the geological structure. In the area south of Bay Lake the background intensity is 1500 gammas with an overall range of from 200 to 2400 gammas. This area is underlain by pyroclastics and volcanic flows with a variable magnetite content. There is a gradual increase in magnetic susceptibility north of Bay Lake, where the Karmutsen volcanics become prevalent. A peak of 10,000 gammas was recorded in several irregular lenticular anomalies north of Bay Lake, trending N75°W.

The en echelon pattern in Figure 5 is suggestive of offsets along north to northwest trending faults. Toward the north edge of the Bay claims the magnetic intensity decreases to less than 1000 gammas in a narrow band where argillaceous and calcareous rocks at the base of the Bonanza group are present.

An irregularly-shaped magnetic anomaly of greater than 3000 gammas extends S70°E a distance of 1500 feet from the shaft site on the Island Copper orebody and N55°W a distance of 2500 feet. The magnetic anomaly north of Bay Lake is much larger in aerial extent than the one over the known orebody, but to date no significant sections of ore-grade material have been found there either in surface outcrops or in drill holes.

It is believed the magnetic anomalies in this area are only a rough guide in prospecting because of the ubiquitous character of magnetite in the volcanics. However, nearly all the known significant copper deposits in this area do have a close spatial relationship with areas of

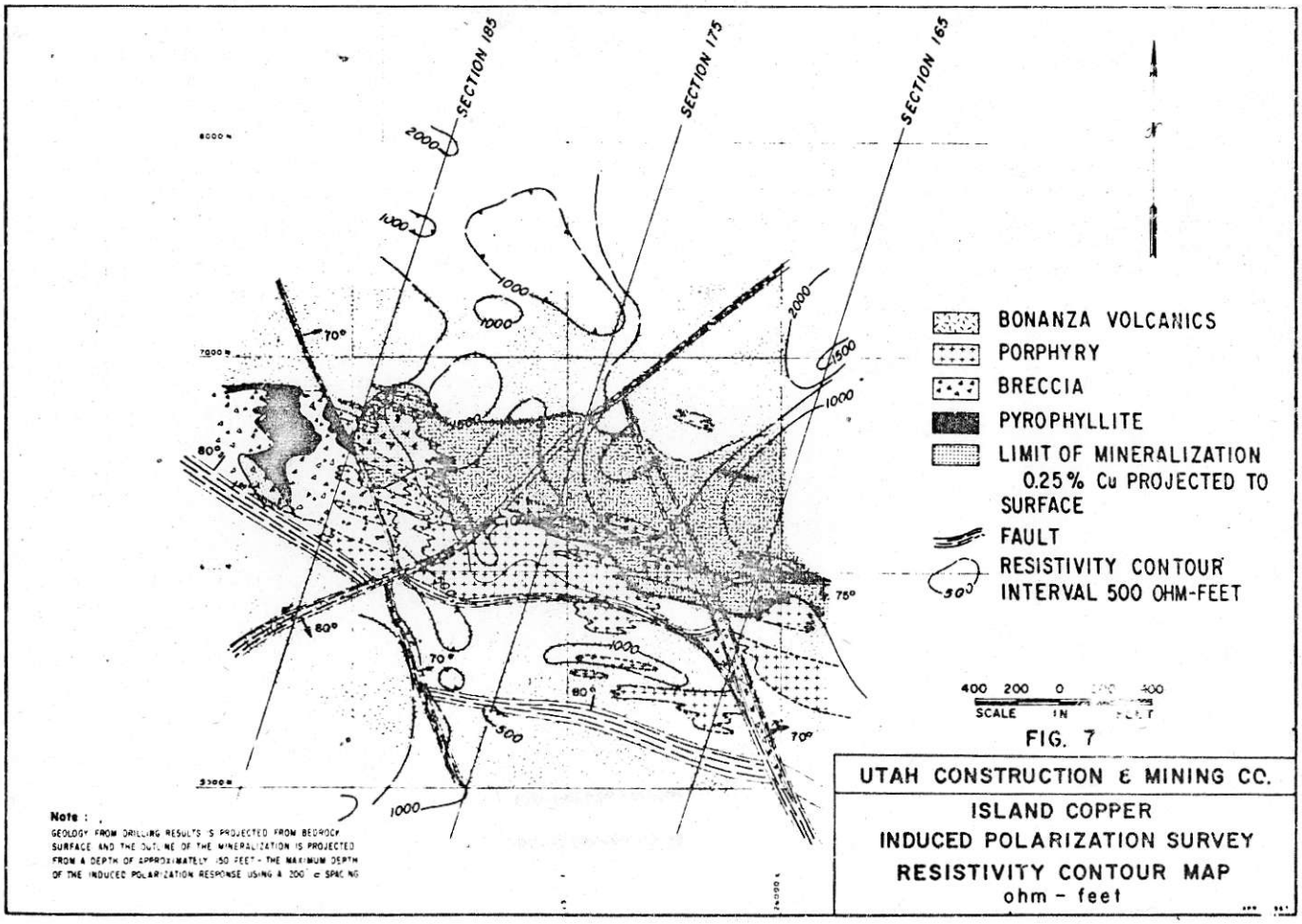


FIG. 7

abnormal magnetic susceptibility and the use of magnetic surveying in prospecting is of value.

Induced Polarization Survey

In view of the significant pyrite content associated with the copper mineralization, it was believed that an induced-polarization survey might be useful in defining drilling targets.

Initially a survey was conducted in the area south of Bay Lake where some good copper mineralization had been penetrated with drill holes. This work was partially experimental and various "a" spacings ranging from 25 to 300 feet were used. Judging from the final drilling results here, the definition by the I.P. surveys of the limits of abnormal sulphide content was good.

Because of the relatively high cost of detailed surveying it was decided to confine the induced polarization work to those areas where geochemical anomalies had been delineated.

The induced polarization response was measured with a pulse type instrument operating on a variable voltage of 300, 600, and 900 volts generated by a completely-portable direct-current battery source.

A grid was surveyed over part of the area now known to cover the Island Copper deposit. Here the I.P. response indicated an anomaly, the peak of which lay a few hundred feet north of the copper orebody found by drilling. The pyrite content of the volcanic rocks adjacent to the orebody ranges up to 20% in some places. Within the orebody the combined pyrite-chalcopyrite volume is about 4% to 5%. Drilling indicated an abnormal concentration of pyrite at a shallow depth in this area which confirmed the results of I.P. surveys designed for penetration to varied depths.

Chargeability values over most of the orebody fall in the range of 20 to 60 MV/V with a background of about 10 MV/V. Plots of chargeability and resistivity (figures 6 and 7) accompany this report. To the north the polarization effect increases to over 1000 MV/V in isolated peaks about 5000 feet from the orebody. The I.P. response then appears to decrease farther to the north. The anomalous induced-polarization effects form a broad belt about 10,000 feet wide trending N70°W across the Bay property. The south edge of this belt, in the 20-40 MV/V range, passes through the Island Copper deposit.

In all the interpretations made of the induced polarization data, it has been assumed that sulphides were responsible for most of the anomalous conditions. However, it is possible that argillic alteration, magnetite, and in the case of the broad belt mentioned above, carbonaceous argillites and limestone, could also have affected the results.

DRILLING

During the early stages of the exploration program of the Bay claims, which commenced in January of 1966, one X-Ray diamond drill machine owned by Utah was in operation. Adaptations were made in this machine to allow the use of EX (⅞-inch core diameter) equipment instead of the XRT (¾-inch core diameter) for which it was designed. This drill was used initially in the area of the initial discovery south of Bay Lake and later to test the areas underlying other geochemical anomalies, including the Island Copper anomaly. The small drill was limited to use in areas with 50 feet or less overburden, and core recovery was low. However it was a valuable tool for testing new areas.

The first drill contract was let in February 1966 and drilling was concentrated initially in the vicinity of the prospect pit south of Bay Lake. About 13,000 feet was completed in this area.

In February of 1967 drilling was accelerated on the Island Copper deposit. Eventually as many as six machines were drilling 400-foot centers. Drilling continued until May 1969 and a total of 128 BQ and NQ holes were drilled for a total footage of 116,783.

Core recoveries averaged about 84% in the early days of the program and advance per 12 hour shift per machine was only 20 feet.

By increasing the core size to NQ and using larger machines with mud as a circulating medium, core recovery was increased to 94% with an average penetration rate per shift per machine of about 40 feet.

Direct drilling costs varied from month to month depending upon average hole depths, depth of overburden, length of moves between sites, and the physical character of the rock being drilled. The average cost increased from about $11.00 per foot initially to about $13.50 per foot at the time of completion of the program.

BULK SAMPLING PROGRAM

Because of the favorable drilling results obtained during 1966 and 1967, a bulk sampling program was conducted.

This was a multi-purpose project in that it (1) provided some comparison between drill-hole-assay results and the much larger bulk sample, (2) allowed examination of the geology across the mineralized zone, and (3) provided material for a pilot-plant beneficiation test.

In the zone selected for bulk sampling the overburden was thin, no water problems were expected, ground conditions appeared good (as indicated by the appearance of drill core and core recovery), and the grade of material in the shaft was expected to be near the calculated average for the orebody. The program involving shaft sinking and drifting commenced in June 1968 and consisted of a two compartment (6′ x 12′) shaft completed to a depth of 225 feet, approximately 1000 feet of 5′ x 7′ drift and two short 5′ x 6′ raises, centered on drill holes which were driven up from the level.

Broken ore was crushed in a portable plant and reduced to minus ¾-inch mesh. This material passed through a system of sampling devices in a tower designed for the project. Approximately 10% of all the material removed from underground was placed in drums as a representative sample. Sufficient ore for beneficiation tests was shipped to Cedar City, Utah, for processing in the company's pilot plant and the remainder was retained at the property.

Assays of samples from the shaft averaged 0.58% copper whereas the average for the drill hole through the same rock section was 0.52% copper. The higher average obtained in the bulk sample may be a result of (1) the shaft samples representing 100% of the material penetrated as compared with the drill hole recovery of 92% and/or (2) the physical distribution of copper sulphides wherein the chalcopyrite content along fractures and in disseminated form varies considerably within a few inches. Assuming proper mixing of the crushed product, the larger sample should be more representative.

A feasibility study was undertaken by the company in 1969 utilizing the drill-hole and bulk-sample data. Ore-reserve calculations were made with a computer using fixed geometric projections and also by the geology department using geologic projections. There was very little difference in the results using both methods.

The company announced in July of 1969, just a little over two years after the initial drill hole was collared in the orebody, that 280,000,000 tons averaging 0.52% copper and 0.029% molybdenite had been outlined and that a $73 million dollar investment would be made. Contracts for the sale of the copper and molybdenum concentrates have been signed and construction of the plant facilities on the site is well underway. Production is tentatively scheduled for early 1972.

ACKNOWLEDGEMENTS

The successful culmination of the Island Copper exploration program under the direct supervision of the company's Vancouver district office was the result of the contributions of several staff members.

Mr. H. G. Peacock, Vice-President (Exploration) with headquarters in San Francisco, offered many constructive ideas during the planning and implementation of field work and during the compilation and assessment of data. He also offered valuable suggestions during the preparation of this paper.

Mr. L. A. Hansen analysed the drill-

log data and provided a noteworthy assessment of the geological relationships.

Mr. G. A. Noel made the initial examination of the property and later was involved in supervising both field work and office compilation of data at various times.

Mr. A. G. Humphrey was field supervisor during the exploration program and his dedicated efforts were responsible for the maintenance of an efficient field program. He was also instrumental in interpreting the geological data.

Messrs. B. D. Pearson, C. A. Aird, F. D. Gatchalian, B. B. Marceno, and K. B. McHale developed many ideas regarding mineralogical and structural associations while concerned with the drilling program.

Numerous other individuals working in a subordinate capacity made significant contributions to the overall program, often under rather difficult field conditions due to weather and terrain.

This paper is a condensation of all these contributions plus those of the authors.

Permission by the Utah Construction & Mining Co. to allow presentation and publication of the results of this project is graefully acknowledged.

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Letters to the Editor

Government Administration Building,
Regina, Saskatchewan,
January 27, 1971.

The Editor,
Western Miner,
1200 West Pender Street,
Vancouver 1, Canada.

Dear Sir:

The Department of Mineral Resources has noted the letter by Mr. R. W. Johns that appeared in the December 1970 (Volume 43, No. 12) issue of the Western Miner.

In connection with this letter we must take issue with the statement by Mr. Johns that the Saskatchewan Government has contributed practically nothing to the knowledge of the Athabasca Sandstone. We would draw the attention of your readers to the following projects in which the Saskatchewan Government participated on a cost sharing basis:

(1) An aeromagnetic survey of the Athabasca Sandstone area;

(2) Gravity studies in the Stony Rapids area extending over the Athabasca Sandstone;

(3) Seismic studies of the Athabasca carried out by the Geological Survey of Canada;

(4) Scintillometer flying of the Athabasca Area;

(5) Drilling of several holes through the Athabasca Sandstone during the period 1965 - 1969.

The Saskatchewan Government paid a total of about $300,000.00 towards the cost of the above program.

Yours very truly,

J. G. Wotherspoon, P.Eng.,
Deputy Minister of Mineral Resources.
Province of Saskatchewan