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DAY 2: ISLAND COPPER

J.A. Fleming

Utah Mines Ltd.

INTRODUCTION

Location

The Island Copper Mine, controlled and operated by Utah Mines Ltd., is on the north shore of Rupert Inlet (50° 36'N, 127° 27'W), about 16 km south of Port Hardy, on northern Vancouver Island. The property consists of 245 contiguous claims and seven mineral leases extending 18 km east from Quatse Lake (Fig. 1).

History

In January 1966, Utah Mines Ltd. (then Utah Construction and Mining Co.) optioned a group of claims from Gordon Milbourne, a prospector, who had discovered high grade chalcopyrite in volcanic rocks immediately southwest of Bay (also called Frances) Lake. The ensuing exploration program consisted of geological mapping, ground magnetic and IP surveying, soil geochemistry and diamond drilling. In February 1967, hole number 82, drilled within a soil copper anomaly over the present pit, intersected mineralization grading 0.45 per cent copper over 88 m. By May 1969 more than 35,500 m of drilling had been completed in 128 holes, defining a 257 million tonne orebody that graded 0.52 per cent copper and 0.017 per cent molybdenum (Young and Rugg, 1971). The ore would be mined from an oval-shaped pit that would be ultimately about 2300 m long, 1050 m wide and 500 m deep, and extend almost 380 m below sea level, with an overall stripping ratio of 2.23 to 1.

The first shipment of copper concentrate was made in December 1971, less than five years after the option agreement was signed. Production to the end of 1982 has been approximately 135 million tonnes of ore and 395 million tonnes of waste rock and overburden. The present daily mine production is about 105,000 tonnes of waste rock and 40,000 tonnes of ore from which is produced 650 tonnes of copper concentrate grading 23 per cent copper, 6 ppm gold and 50 ppm silver. In addition, about 10 tonnes of molybdenum concentrate are produced daily grading 45 per cent molybdenum and containing 1100 to 1200 ppm rhenium.

KERR ADDISON MINES LIMITED

(FOR INTER-OFFICE USE ONLY)

To: File ✓
c.c. IDB, PSC, DAL, PB

From: J. K. Carrington JKC.

Subject: Island Copper Mines

Date: July 12, 1983

The following is a summary of data compiled to date on Island Copper Mines at Port Hardy, Vancouver Island.

1.0 History and Ownership

The property was originally staked in 1965 by prospector, Gordon Milbourne, based on widespread occurrences of copper mineralization in the area and his discovery of some high grade copper float. Early in 1966 a formal agreement was signed between Milbourne and Utah Construction & Mining Co. In July 1969 Utah announced that they had an orebody of some 280,000,000 tons grading 0.52% Cu and 0.029% molybdenite and a production date of early 1982. Ultimately, Utah Construction & Mining Co. became Utah Mines Ltd., a subsidiary of Utah International of San Francisco. In 1978 (?) Utah International merged with General Electric to become a wholly-owned subsidiary of that firm.

2.0 Production

Production commenced in December 1971 and reached the initial design capacity of 33,000 st/day in 1973. Since then production has gradually increased to the current rate of 46,000 tpd (1982). Published, detailed production stats are scanty and no financial details re recent operations have been obtained yet. What has been obtained is summarized below:

	1982	1981	1980	1979
Tons milled (x 1000)	16,857	15,605	15,192	14,705
Daily milling rate (365 day yr.)	46,184	42,753	41,622	40,288
Average recovery	85.5	85.4	85.2	87.5
Lbs. Cu sold (x 1000)*	118,807	117,012	110,305	110,309
Calc. head grade, % Cu**	0.412	0.439	0.426	0.429
Average price/lb. Cu				
Cu	$0.66	$0.78	$0.98	$0.93
Byproducts	0.29	0.39	0.65	0.43

* about the same as production

** % Cu = (lbs. Cu sold)/(annual tonnage) x 20 x avg. recovery

KERR ADDISON MINES LIMITED

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To.. From..

Subject.. Date..

2.2 Ore Reserves

July 1969	280,000 tons at 0.52% Cu and 0.029% molybdenite (Note: % Mo = 0.6 x % molybdenite)
December 1982	156,000 tons at 0.48% Cu plus Au, Ag, Mo and Re byproducts
	(1980/81 molybdenite reserve grade 0.025% molybdenite)
	approximately 22% of Cu reserves are committed to long term contracts

Note: The calculated head grades in 2.1 do not correlate well with the reported reserve grade for the end of 1982. This could be if, for instance, the reported "average recovery" represented the average of the Cu and Mo recoveries as opposed to the average Cu recovery only.

2.3 Concentrate Production (1981)

Approximately 235,000 sdt of 23% copper concentrate; moisture content ~8-8½%; P.M. content ~0.25 oz/st Au and 1.2 oz/st Ag.

Approximately 3,370 sdt of 40% Mo concentrate with 1,000-1,200 ppn rhenium.

3.0 Technical Comments

3.1 Mine

(1) Large tonnage open pit operation. 1981 production rate was 160,000 st/d of which 41,000 (?) tons are milled. 1981 stripping ratio 2.9/1.

(2) Ultimate pit dimensions approximately 8000' x 4000' x 1200' deep. Net climb to crusher (1981) 600'.

(3) Based on 1982 year end reserves, mine life at 1982 annual production rate is 9.25 years.

To............................From............................

Subject............................Date............................

(4) Area receives ~70 in./yr. rain making road and dump maintenance costly. Pit pump capacity (1981) was 15,000 gpm. Bound to increase with increasing depth.

(5) Increasing pit depth is presenting serious truck haulage problems (personal communication with Island Copper staff in 1982). The currently installed electric wheel drive motors tend to be overloaded as the loaded haul cycle becomes longer with the deepening pit. This results in premature wheel motor failure leading to very high maintenance costs and lost production.

Several solutions are available but all are capital intensive.

- Convert older trucks to a "deep pit" electric wheel motor configuration; estimated cost $300-$500,000 per truck.

- Replace older trucks with new, correctly outfitted trucks; estimated cost $1,000,000 each.

- Install in-pit crushing and conveying; no estimated cost but is expensive.*

- Install truck trolley-assist system; no estimated cost but is expensive.*

* The relatively short remaining life would tend to rule against these options.

It would appear that the mine is re-equipping with 170 ton trucks as the 120 ton versions are replaced. Further they have changed from Unit Rig trucks to Euclids. The Euclid trucks likely are adequate for deep mining but the Unit Rigs may not be.

(6) Mining costs will increase with increasing pit depth (haulage costs, pumping costs and explosive costs as more water is encountered).

(7) Remaining stripping ratio is unknown. The increase in 1982 milling production is due to an incremental plant expansion.

(8) Potential for additional reserves unknown although it is highly likely that the known reserves and hence known mine life are well defined.

3.2 Mill

(1) 1982 Production rate averaged 46,184 tpd.

(2) Ore is crushed; primary ground in SAG mills; and reground in ball mills. A bulk Cu-moly concentrate is produced from which two separate Cu and moly concentrates are made.

(3) Variability in grinding between ore types is a problem and mill feed, to some degree, is dependent on the types' grindability indexes.

(4) The grinding circuit is monitored automatically and a significant proportion of the increases in tonnage are due to on-going optimization of this circuit.

(5) On stream X-ray analyzing is installed in the Cu-Mo flotation circuit. It is not known to what degree the flotation circuit is automatically controlled.

(6) Tailings are deposited underwater in Rupert Inlet. Government, company and an "arm's length" scientific group monitor the Inlet and system for environmental concerns etc. Some concerns were expressed in 1977/78 through an EPS study but it is believed they have been resolved now.

4.0 References

Island Copper Deposit (geology and mineralization), Young, M.J. and Rugg, E.S., Western Miner, February 1981.

Island Copper Mine (description of operation), Western Miner, December 1974.

Report on Pollution Findings (comments re EPS report), Northern Miner, January 26, 1978.

Utah Mines Ltd. (brief update on operation), EMJ, November 1987.

General Electric Company 1982 Annual Report, page 45 for production stats. 1981 report shows same figures and format, i.e. back to 1979 only.

KERR ADDISON MINES LIMITED

(FOR INTER-OFFICE USE ONLY)

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JC

JUL 14 1983

To D. A. Lowrie *From* R. A. Dujardin

Subject Island Copper *Date* July 11, 1983

The only data we have been able to obtain so far are the operating statistics for 1981 which are attached. The financial results are buried in Utah's corporate reports and even people I know who worked for Utah have no specific knowledge of such information. The government agencies collecting taxes must of course have the required information but it is not for public consumption.

Even the 1982 operating statistics are unavailable at present. Please let me know if you want me to make more direct inquiries.

R. A. Dujardin

Enclosure

KERR ADDISON MINES LIMITED

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To R. A. Dujadin From lk

Subject Re: Statistics - Island Copper/Utah Mines Date July 8, 1983

Contact: W. P. Wilson, Statistician, Economics and Planning Division
Phone 387-3787 (Victoria)

1981 Statistics re production are as follows:

Tonnage milled - 14,156,617 metric tonnes

Concentrate actually shipped - 232,652 metric tonnes copper concentrate

Contents:

Molybdenite - 3,091 metric tonnes   Molybedenum - 1,266,788 Kg.

Rhenium - statistics confidential

Gross Metal Content -

Gold - 1,658,562 gr.

Silver - 13,113,910 gr.

Copper - 53,075,826 kg.

GE Co 1982 Annual Report

Supplementary data

(Unaudited)

Effect of changing prices

In accordance with Financial Accounting Standards Board requirements, the table at the right shows two different ways of attempting to remove inflationary impacts from financial results as traditionally reported.

In both "adjusted for" columns, restatements are made to (1) cost of goods sold for the current cost of replacing inventories, and (2) depreciation for the current cost of plant and equipment. The column headed "general inflation" uses only the Consumer Price Index to calculate the restatement, while the column headed "current costs" uses data more specifically representative of costs incurred by General Electric.

Restatements to cost of goods sold recognize the effect of some reduction in LIFO-valued inventories during 1982, which charged cost of goods sold in traditional statements for cost levels applicable to prior years. Restatements of depreciation expense to current levels are relatively large, reflecting the cumulative effect of price increases since the assets were acquired.

The five-year summary on page 46 includes additional selected financial data adjusted for the effect of changing prices.

GE Annual Reports for 1979 and 1980 included technical information about methodology used by GE in preparing these data. Copies of those Reports may be obtained from Investor Relations at the address shown on page 55.

(In millions)	For the year ended December 31, 1982 As reported	Adjusted for (a) general inflation	current costs
Sales of products and services to customers	$26,500	$26,500	$26,500
Cost of goods sold	18,605	18,891	18,852
Selling, general and administrative expense	4,506	4,506	4,506
Depreciation, depletion and amortization	984	1,456	1,382
Operating costs	24,095	24,853	24,740
Operating margin	2,405	1,647	1,760
Other income	692	692	692
Interest and other financial charges	(344)	(344)	(344)
Earnings before income taxes	2,753	1,995	2,108
Provision for income taxes	(900)	(900)	(900)
Minority interest	(36)	(29)	(29)
Net earnings	$ 1,817	$ 1,066	$ 1,179
Earnings per share (in dollars)	$ 8.00	$ 4.70	$ 5.19
Share owners' equity at December 31	$10,198	$15,071	$14,888

(a) In dollars of average 1982 purchasing power.

Mineral resource statistics

Statistical data about the principal mineral assets of Utah International follow.

Coal

(Quantities in millions)	1982	1981	1980	1979
Coking coal (a)				
Metric tons shipped (b)	13.5	16.0	13.1	13.8
Average price/metric ton (c)	$57.88	$55.22	$51.09	$48.39
Steam coal				
Tons shipped (b)	15.2	13.7	10.5	8.8
Average price/ton	$16.47	$13.83	$ 7.82	$ 7.09

(a) Represents Utah's share from five principal mines it operates in Queensland through an affiliate. Utah's share is 89% of one mine and 68% of the others.
(b) About the same as production.
(c) Represents average prices published by an agency of the Australian government for Queensland production, including Utah-operated mines.

Coking coal is mined by a Utah affiliate, Utah Development Company, under long-term, renewable Special Coal Mining Leases granted by the state of Queensland, Australia. At December 31, 1982, Utah's share of export entitlements under Special Coal Mining Leases granted by Queensland amounted to 385 million metric tons. Proven reserve quantities in the leased areas were in excess of the entitlements. About 12% of presently available reserves are committed under long-term sales contracts.

Total proven steam coal reserves where operations or active development plans are under way aggregated about 1.6 billion tons at the end of 1982. About 25% of these reserves are currently committed under long-term sales contracts. In addition, at the end of 1982, Utah had other proven steam coal reserves of about 2.1 billion tons.

The only significant changes in steam coal reserves in recent years were the acquisitions in 1980 of reserves aggregating about 470 million tons in the U.S.

Island Copper Mine

(Quantities in thousands)	1982	1981	1980	1979
Ore milled (tons)	16,857	15,605	15,192	14,705
Average percent recovery	85.5%	85.4%	85.2%	87.5%
Pounds of copper —sold (a)	118,807	117,012	110,305	110,309
Average price per pound of copper				
—copper	$0.66	$0.78	$0.98	$0.93
—byproducts	0.29	0.39	0.65	0.43

(a) About the same as production.

At 1982 year end, proved or probable reserves at Island Copper Mine in British Columbia were approximately 156 million tons of ore with a grade of approximately 0.48% copper. These reserves also include gold, silver, molybdenum and rhenium as byproducts. About 22% of copper reserves are currently committed under long-term contracts. There have been no significant changes in Island Copper reserve estimates in recent years other than for the effect of production.

Note 1981 report virtually the same as the 1982 figures!

Notes to financial statements

1. Planned sale of certain mineral resource assets

On January 27, 1983, General Electric Company and The Broken Hill Proprietary Company Limited (BHP) signed a memorandum of intention whereby BHP, an Australian-owned and -based industrial and natural resources company, would acquire Utah International Inc. and Utah-Marcona Corporation from GE for approximately $2.4 billion in cash. BHP expects to form a consortium to participate in ownership of the Australian coal properties included in the acquisition.

Under the terms of the proposed sale, GE would retain Ladd Petroleum Corp., a wholly owned subsidiary of Utah, as well as Utah's financial interests in the Pathfinder uranium mines in Wyoming, the Trapper steam coal mine in Colorado, and certain land-development properties in the U.S.

Completion of the transaction is subject to a number of conditions, including negotiation of a definitive agreement, approvals by the GE and BHP Boards of Directors, completion of consortium and financing arrangements by BHP, and requisite government approvals. GE and BHP expect to complete the transaction in the latter half of 1983.

Sales, net earnings and total assets for the businesses to be sold are shown below.

(In millions)	1982	1981	1980
For the year:			
Sales	$1,311	$1,466	$1,190
Net earnings	247	207	208
At December 31:			
Total assets	1,838	1,823	1,656

2. Operating costs

The classification of operating costs between cost of goods sold and selling, general and administrative expense was refined in 1982 in view of the increasing volume of services businesses and after extensive review of functional expenses incurred in providing these services. Accordingly, prior year amounts have been reclassified to a consistent basis by increasing cost of goods sold and reducing selling, general and administrative expenses for 1981 and 1980 by $531 million and $420 million, respectively.

Operating cost details

(In millions)	1982	1981	1980
Employee compensation, including benefits	$10,296	$10,208	$ 9,196
Materials, supplies, services and other costs	12,079	13,475	12,696
Depreciation, depletion and amortization	984	882	707
Taxes, except Social Security and those on income	304	346	299
Decrease (increase) in inventories during the year	432	(118)	(182)
Total operating costs	$24,095	$24,793	$22,716
Supplemental details:			
Maintenance and repairs	$822	$897	$784
Company-funded research and development	781	814	760
Social Security taxes	565	567	484
Advertising	353	331	315
Mineral royalties and export duties	92	105	80

3. Pensions

Total pension costs of General Electric and consolidated affiliates were $570 million in 1982, $549 million in 1981 and $478 million in 1980.

General Electric and its affiliates have a number of pension plans. The most significant of these plans is the General Electric Pension Plan (the "Plan"), in which substantially all employees in the U.S. are participating. Pension benefits under the Plan are funded through the General Electric Pension Trust (the "Trust"). The other principal pension plan is the General Electric Supplementary Pension Plan. These two plans account for more than 90% of GE pension benefits. Approximately 91,500 persons were receiving benefits at year-end 1982.

For funding and annual cost determination purposes, changes were made in 1981 in mortality assumptions and, recognizing the impact of inflation, in projections of pension benefits and by increasing from 6% to 7½% the estimated rate of future Trust income.

The actuarial present value of accumulated plan benefits for the General Electric Pension Plan and the Supplementary Pension Plan, calculated as prescribed by the Financial Accounting

UTAH MINES LTD.: A DEEPENING PIT AND AUTOMATIC MILL CONTROLS

Next month marks the tenth anniversary of the first shipment of concentrate from Island Copper Mines—a copper-molybdenum open pit equipped with a 41,000-st/d concentrator at the northern tip of Vancouver Island. Located on the northern shore of Rupert Inlet, a tidewater inlet linked through narrows with Quatsino Sound and the Pacific Ocean, Island Copper is a product of the exploration and mine development boom of the late 1960s and early 1970s. Last year, this Utah Mines Ltd.* operation produced about 235,000 st of 23% copper concentrate and 3,370 st of 40% molybdenum concentrate containing up to 1,000-1,200 ppm rhenium. The copper concentrate typically averages about 0.25 oz/st gold and 1.2 oz/st silver.

With a pit now 440 ft below sea level and scheduled to be deepened another 600-700 ft, Island Copper is numbered among a growing coterie of world mines searching for solutions to deep-pit transportation problems. The mine will be approaching the efficient capacity of the current diesel-electric truck fleet in two or three years. Daily mining schedules now involve the movement of about 160,000 st/d during three 8-hr shifts—of which 41,000 st/d is trucked to the primary crusher at the mill and the remainder to marginal-grade ore and waste dumps. A typical mill feed grade is about 0.48% copper and 0.017% molybdenum.

Among other distinctive characteristics that influence the operational aspects of Island Copper are such features as:

1) A location within the northern Pacific rainbelt (70-75 in. of precipitation per year);

2) A porphyry orebody composed of several rock types having differing physical responses to grinding; thus, mine engineers regularly plot grinding work indexes for planning purposes;

3) A deposit containing zones having a variable distribution of gilsonite (a hydrocarbon with flotation characteristics disturbingly similar to molybdenite) and which need identification and mapping, for optimal milling campaigns;

4) A pit operations control tower, under the supervision of shift foremen and having two radio channels for communication with all vehicles, as well as the service and maintenance departments. The radio network also contains a third channel for mill and crusher communications;

5) A concentrator equipped with six 32 x 14-ft Koppers (Hardinge Cascade), primary, semiautogenous (SAG) mills, each driven by two 3,500-hp motors, and three downstream secondary ball mills (16.5-ft Allis Chalmers overflow type), each powered from 3,000-hp motors;

6) A concentrator instrumentation program that has permitted the development of appropriate strategies for fully automatic computer control of the SAG mills and ongoing extension of automatic control to the flotation circuits as adequate sensors and long-term strategies are developed;

7) A 14-cell, on-line OK Courier analyzer for monitoring the copper, molybdenum, iron, and (inferred) sulphur contents of 14 pulp streams;

8) A rigorously engineered and closely monitored off-shore tailing disposal system;

9) A modern marine receiving terminal that off-loads standard-gauge rail cars towed on rail barges by sea-going tugs from Vancouver, B.C., an approximate 750-mi trip from the mobilization base; and

10) A concentrate ship-loading terminal that can load 30,000-DWT carriers at rates of 1,000-1,500 st/hr, thus providing a 24-hr turnaround so that freighters can take advantage of favorable tides both entering and departing.

The copper concentrate produced at Island Copper is destined for Japan. The molybdenum product is sold in roughly equal amounts to US and West German outlets.

*Utah Mines Ltd. is owned by Utah International, a subsidiary of General Electric Co., which acquired the assets through a merger in 1976. At that time, the merger was the largest in US corporate history.

MINING ORE AND WASTE

The pit design will ultimately occupy an excavation of 8,000 ft (on a NNW axis) x 4,000 ft (ENE) and is scheduled to a depth of 1,200 ft. Currently the bottom is 440 ft below sea level, a position requiring a net climb of 600 ft to the primary crusher some 160 ft above mean sea level. The haul to the truck dump spans 1.0-1.5 mi. The orebody was topped by glacial till only 15 ft thick near the center. This mantle thickened up to 250 ft to the east and west of the central zone, necessitating the stripping of till sections up to 250 ft thick. In rock, the mine is actively worked in 40-ft benches, which are finished to a double-benched vertical dimension. The haul roads are planned for maximum 10% grades and minimum widths of 100 ft.

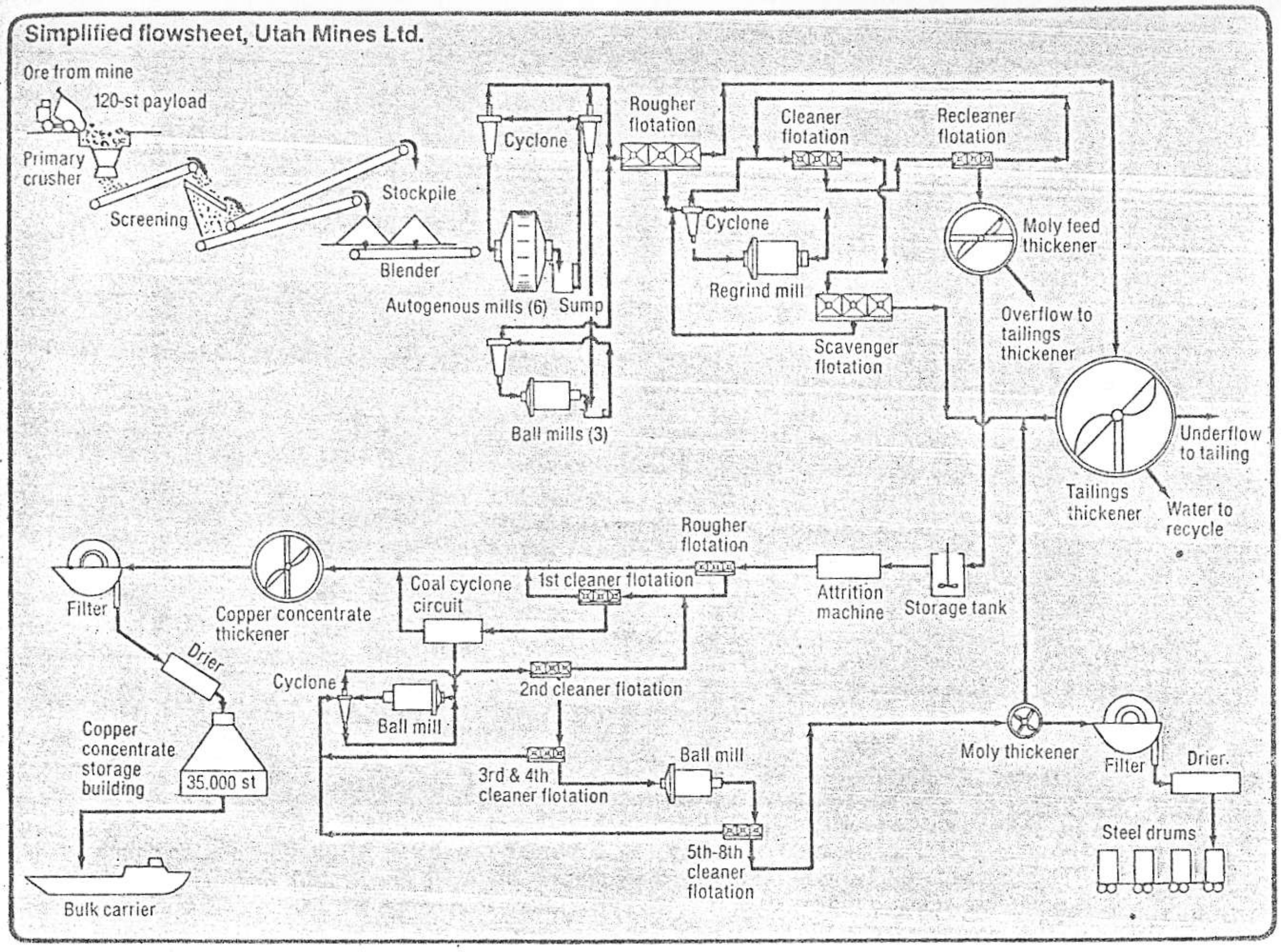
As the pit progresses to depth, pumping capacity is increased and less water gel slurry blasting agents will be required. Blastholes are driven with five drill rigs—four Bucyrus Erie 60R electric and one electric 45R converted from diesel-electric. The holes are 9⅞ in. dia and drilled 8 ft below grade. The holes are placed on a square pattern of 27 x 27 ft. Bulk and packaged Anfo have been used in the past in pumped-out and lined boreholes. Water-based slurries however are being used increasingly. The powder factor has recently averaged about 0.43 lb/st broken. A typical production blast breaks about 200,000 st.

The property is equipped with six 15-yd^3 electric shovels—inclusive of three P&H 2100BL machines, two relatively new 191M Marions, and one older P&H 2100B shovel. The truck fleet includes 14 Unit Rig M120s, 17 Unit Rig Mark 36s, and nine Euclid R170s. Precipitation exceeds the evaporation rate; thus, a large complement of auxiliary equipment is included in the inventory for road patrol, maintenance, and other pioneering efforts. Included are one Cat D-8 and nine D-9 track dozers, three Cat rubber tire dozers, five motor graders, and one front-end loader.

Support efforts that figure prominently in mine and mill planning include location and mapping of the hydrocarbon contours and empirical grindability indexes. Decisions regarding the destination of marginal ore—whether to mill it or stock it in a dump—are sometimes based on the anticipated grinding rate. Advance knowledge of mine-run feed being delivered to the mill assists in defensive circuit manipulations. The mine has 15,000 gal/min of pump capacity installed in three stages. As to the future, mine studies are being launched to investigate the alternatives for moving material from the pit. It is expected that deep-pit motor drives for trucks, conveyors, and other options will be reviewed.

INCREASING THE MILL CAPACITY

Originally designed for fully autogenous grinding at a design throughput of 33,000 st/d, modifications, largely to the



Simplified flowsheet, Utah Mines Ltd.

grinding circuit, and automatic controls have increased the processing capability to the current 41,000 st/d. The crushing plant is essentially the same as the original design—a single 54 x 74-in. Allis Chalmers gyratory (set at 9 in.) followed by subsequent splitting of the product on Jeffrey vibrating grizzlies into plus- and minus-4-in. streams. The two products sizes are stacked side by side on the surface in windrowed stockpiles by tripper conveyors. The stockpiles provide capacities of 50,000 st live and 500,000 st total.

Each of the six primary SAG mills is fed from its own belt line, which crosses under both stockpiles. Three drawpoints with variable-rate feeders are positioned above each of six feed belts so that one is under the coarse pile, one is under the fine pile, and one is beneath the junction of the two piles, reclaiming a mix of coarse and fine feed.

The original grinding plant, designed to be operated in a semiautogenous mode with up to 11% balls, proved inefficient without balls, largely because of a shortage of coarse grinding media.

Remedial measures included conversion of the plant to semiautogenous grinding starting late in 1971 and installing three secondary ball mills in 1973. Each pair of primary SAG mills now operate in partial open circuit with a single secondary ball, thus dividing the grinding circuit into three parallel lines. The SAG mills carry a 7½-8% ball load. Daily charges of 4- and 3-in. balls are added. The large primary mills have a grate discharge and are equipped with trommels, making it possible to recycle coarse discharge.

Bulk Cu-Mo flotation takes place in Wemco-Fagergren circuits, which produce a finished plant tailing. The rougher concentrate is reground along with scavenger concentrate in 9 x 18-ft Allis Chalmers ball mills in closed circuit with cyclone clusters. The cyclone overflow from regrinding is cleaned and recleaned in Agitair machines to produce a final bulk concentrate for Cu-Mo separation. The cleaner tailing is scavenged to recover a froth for the regrind circuits and a finished plant tailing. Recleaner tailing is recycled to the cleaners. All final plant tailing streams are collected at two 375-ft Dorr-Oliver-Long thickeners, which overflow reclaim water prior to off-shore disposal.

The bulk concentrate averages about 23% copper and 1% molybdenum. This product is collected in a 100-ft-dia Eimco thickener and then travels through aging tanks and attritioning cells to destroy reagents and condition particle surfaces. The separation takes place in a roughing circuit followed by 16 stages of cleaner flotation. The tailing of individual cleaner stages generally is reversed countercurrently to the flow of molybdenum concentrate. Reagents consumed in the molybdenum flotation circuit includes up to 20 lb/st of sodium hydrosulphide, 0.7 lb/st of sodium cyanide, and 0.1 lb/st of fuel oil, which is added intermittently.

The bulk Cu-Mo circuits are dosed with a typical reagent suite consisting of 0.01 lb/st potassium amyl xanthate, 0.1 lb/st Shellfroth D50, and 0.25 lb/st slurried lime to achieve a pH of 10.0 in the rougher circuit and 11.5 in the cleaner circuit. Copper concentrate from the moly plant is filtered on Eimco discs to 13-13.5% moisture and then dried to 8-8.5% in rotary kilns. This product is stored under cover in a loadout building having a 35,000-st capacity.

The molybdenum concentrate is filtered, dried, and packed in drums for shipment.

Glen Andrews is general manager of Utah Mines Ltd.'s Island Copper operations.

—*S.H.D.*

climb. This is well above its 1976 average price of $123.05, which accents the new profitability for the gold mining industry today.

Will there be any rush to develop new mines as a result of the current rise? Don't hold your breath, a survey of industry leaders indicates.

Strong comeback in B.C. gold search

By RICHARD J. ROBERTS
Assistant Editor

VANCOUVER — Exploration for gold is coming back strongly in British Columbia, which, in the 1930s, had 30 producing gold mines as opposed to only one (Northair Mines) today.

The search for gold in the province revived in 1973 on the strength of rising prices for the metal in international markets. But subsequent adverse legislation of an NDP government and the weakening of world markets dampened exploration enthusiasm.

The price is again on the upward path with forecasts of it reaching $US200 an oz. this year. Also, mining legislation has improved with the return of the Social Credit government.

In addition to the Northair operation, **Hecate Gold** and **Carolin Mines** are conducting underground programs. **Mosquito Creek Gold Mining** and **Nu-Energy Development** also are engaged in underground work and both are planning production. **Tournigan Mining Explorations, Consolidated Cinola Mines** and **Aquarius Resources** plan exploration.

Silver Standard Mines, A. C. Ritchie, president, told The Northern Miner, is taking a hard look at some of its gold prospects under wraps, and J. A. Mackey, president, **Colt Resources,** says that company is looking at its former gold producer near Greenwood with a view to resuming production.

The management of **Hecate Gold** is a little excited by the results of drifting on the Banks Island property, 70 miles south of Prince Rupert, J. E. Millette, president, said. The underground exploration is on the Bob zone on ground on which the company has an option from **Falconbridge Nickel Mines** to acquire a 60% interest.

Drifting along a length of 105 ft. averages 1.10 oz. gold and 3.00 oz. silver per ton across a width of 5.2 ft. The zone continues strong for another 30 ft., samples from which have yet to be assayed.

The high grade material being opened in the decline is about 850 ft. from the portal and at a depth of approximately 135 ft. below surface.

The development is part of a $1.2 million program that started in August, 1977. Originally, the plan was to drive the adit at a 15% gradient for about 1,000 ft. and to carry out approximately 500 ft. of drifting. In view of the strong mineralization unexpectedly encountered, the company plans to extend the adit to at least 2,000 ft. and to conduct whatever amount of drifting and raising is necessary. This work, a six to eight-month task, would take the adit to about 400 ft. below surface to the point of the deepest drill hole intersection which ran 3.00 oz. gold per ton across 2.0 ft.

Along with the underground campaign further surface work, including geological mapping and geophysical surveys, is planned. There are a number of other zones to be tested, Mr. Millette said.

Two and three-men crews are working three shifts a day seven days a week in the underground exploration. Equipment for the undertaking was shipped by barge from Vancouver to Survey Bay and then transported over a 7,000 ft. road built from the bay to the property.

See Page 2

Saskatchewan rejects role against 'U' bill

At one stage of last week's Toronto meeting of federal-provincial mines' ministers, called to analyze mining industry problems, it looked as if one notable development emerging from the conference was an agreement by the provinces to form a common front of opposition to the federal government's proposed new Nuclear Control and Administration Act.

Before the ministerial conference, provincial deputy mines' ministers held their own meeting from which it was reported there was a consensus to designate Saskatchewan as the province that should lead the opposition to the planned federal legislation. Saskatchewan officials appeared to confirm the province's

See Page 11

Industry problems "identified"

Mining tax improveme

By N. P. COTTER
Staff Writer

The need for improving the fiscal system governing the mining industry was agreed upon at a federal-provincial mines' ministers conference in Toronto last week, according to federal Energy, Mines and Resources Minister Alastair Gillespie.

"There was general agreement that some improvements could be made in the fiscal system (as it affects the mining sector)," he said following a one-day meeting of ministers.

The meeting, which was preceded by a one-day conference of deputy mines' ministers, was described as part of a "sectoral" group of federal-provincial meetings on key areas of the economy. The deliberations of these meetings will be submitted to a scheduled meeting on the economy next month between Prime Minister Pierre Trudeau and provincial premiers.

Last week's federal-provincial conference of mines' ministers held out no promise of relief over the near term for a mining industry that is badly battered economically in some sectors.

Indeed, the indicated agreement

Canadian gold producers get over $C190 per oz.

By S. J. VITUNSKI
Staff Writer

Canadian gold producers are now receiving record prices for their product as the prevailing U.S. price is translated into devalued Canadian dollars.

For the fourth week in a row this year the price of gold has climbed successively higher. Tuesday's morning fixing of $US177.10 was $2.20 above the week-earlier high and $8.95 above the 1977 high of $168.15 established on Nov. 11.

Most analysts attribute the strength in gold to continuing weakness in the U.S. dollar brought about by negative interpretations of President Carter's State of the Union and budget messages.

It is generally felt that his policies are too expansionary ... and thus too inflationary. The dollar itself is undermined by the forecast $60.6 billion budgetary deficit and the continuing balance of payments deficit which ranges from $30 billion upward. That's a lot of red ink on both sets of books.

On the positive side of the equation the International Monetary Fund's Group of ten industrialized countries ... plus

See Page 8

EPS report called "subjective"

Pollution report challenges Utah's findings

VANCOUVER — The report by the federal government's Environmental Protection Service, Pacific Region, (EPS) on Island Copper Mines (Utah Mines), Port Hardy, B.C., appears to be extremely subjective, declares Clem Pelletier, the company's manager of environmental affairs.

The EPS report states that the mine tailings dumped into Rupert Inlet have spread 15 kilometres into Rupert Inlet, obliterating bottom-living organisms, crippling fisheries resources and reducing visibility in the water to less than half a metre. It said that tailings have moved 10 kilometres up nearby Holberg Inlet and are upwelling to affect the shallow, productive regions in both inlets and into Quatsino Sound.

Darcy Goyette, the author of the report, is quoted as saying "at Island Copper Mines, we feel the situation is basically out of control".

Mr. Pelletier, who, as chairman, standing committee, pollution control, Mining Association of British Columbia, has been attending the recent public hearings in Victoria on pollution control objectives, said he has not had the opportunity to study the report in detail.

On the basis of a quick reading of the EPS report, however, he said, two things are apparent.

"The report appears to be extremely subjective, both in terms of the methods used to collect data and in terms of the conclusions reached from that data. I think it is going to be very difficult to make any useful comparison between EPS's data and the detailed, quantitative data which our own environmental lab at the mine, and the independent agency, have collected over the years.

"The ... report would appear to be challenging, primarily, the independent monitoring agency which is comprised of a group of scientists from the University of B.C. and the University of Victoria. Our relationship with those scientists is of an 'arm's length' nature. We have a

See Page 11

JAN. 26/78

still higher price.

"There is no pioneering spirit in the North today like there used to be," Mr. Byrne laments. "Where would we get the men?"

Will there likely be any significant influx of 'risk capital' for exploration? No, says Arthur W. White who heads the Dickenson Group of companies, unless the regulatory authorities relax their grip. There is just too much regimentation, he feels.

There are, however, several large new gold developments looming that offer new hope for the industry. These are being developed without public financing or fanfare.

Amoco deposit major

What is unquestionably the most impressive new gold discovery to be made in this country in years is that of **Amoco Canada Petroleum** at Detour Lake in remote Northeastern Ontario. Extensive underground work carried out over the past year at a cost approaching $5 million has confirmed an extraordinary tonnage potential – tens of millions of tons. Too, the company feels that grade could be somewhat better than indicated in original surface drilling which showed an average cut value of 0.204 oz. per ton. Now moving into the feasibility stage, this could well develop into Canada's largest gold mining operation.

Another major development is shaping for Northwestern Quebec's Bousquet area, where **Long Lac Mineral Exploration** has been quietly carrying out an extensive and highly successful exploration program. It has tied up a lot of ground. Results on the **Thompson Bousquet Gold Mines'** property have been especially pleasing as the result of which Lac will sink a 1,200-ft. shaft. Too, it has been highly successful at the nearby **Silverstack** capping on the shaft has already been removed, with negotiations now under way for plant and equipment to unwater the old workings on which over $1 million has been spent in the past.

Also in Northwestern Quebec, Vancouver-based **Belmoral Mines** has embarked on a $2.5 million program to bring the B zone at its Val d'Or area property into production (shipping to a custom mill) at the rate of 500 tons daily (N.M., Jan. 12, 1978). Revenues from this would then be used to build a 1,000-ton concentrator to handle ores from other known zones on this property.

In the Kirkland-Larder Lake area of Ontario, **Queenston Gold Mines** has put together a very large interesting deposit (N.M., Dec. 22, 1975). Further drilling is to be carried out this year, as well as metallurgical testing of the ore.

Still another gold situation that is again attracting attention is the Cullaton Lake project of **O'Brien Energy & Resources** and **Cons. Durham Mines & Resources** in the N.W.T. Drilling and underground work have indicated a deposit containing some 285,000 tons with a cut grade of 0.74 oz. (1.13 oz. uncut). Studies are currently under way to determine the feasibility of recovering this gold by a simple heap-leaching method. Such an operation would be carried out only during the short summer season. One of this country's largest mining companies is showing interest.

Holling A & B	51.5¢	Feb. 28	Jan. 31
H.B. M. & S.	...	....	....
Indusmin Ltd.	...	....	....
Inter Mogul pf	...	....	....
Inco Ltd.	...	....	....
Iron Bay Tr.	13¢	Feb. 27	Feb. 10
Joutel	...	....	....
Kaiser Res.	...	....	....
Kam-Kotia	...	....	....
Kerr Add.	...	....	....
Labrador	62.9¢	Feb. 21	Jan. 24
Liberian Iron	...	....	....
Mattag'i "A"‡	...	....	....
McIntyre	...	....	....
Newconex H.	...	....	....
Noranda "A"‡	...	....	....
Northgate	...	....	....
Pato Cons.	...	....	....
Pine Point	...	....	....
Placer Dev.	...	....	....
Preston Mines	...	....	....
Rio Algom, C.	...	....	....
Rio Algom, pf.	...	....	....
Robin R.L.	...	....	....
Sher.G.'A'&'B'			....
Sigma Mines	95¢	Feb. 27	Jan. 30
Teck	...	....	....
Texasgulf	...	....	....
Texasgulf Pref.	...	....	....
United Keno	...	....	....
Voyager Ex.	...	....	....
Western Mines	...	....	....
Yk. Bear	...	....	....
Yukon Cons.	...	....	....

N.B.: Ex-dividend date is normally tw
traded on or after that date do not carry r
1978 payments. † U.S. funds. ‡ "B" shares r

Pollution report

Continued from Page 1

financial understanding with the universities, not with the individual scientists, and I am not in a position to speak for them in response to the EPS report."

A report by the independent monitoring agency is contained in the voluminous brief of the Mining Association of B.C. presented to the public inquiry into pollution control objectives for mining, mine-milling and smelting industries of B.C.

The independent agency report states that Rupert Inlet is deep enough that ample room for tailings solids was available well below the euphotic zone. Island Copper has introduced approximately 80 million tons of tailings into Rupert Inlet 165 ft. below surface.

Prior to submarine disposal of tailings by the mine, the principal question was whether the tailings would remain at the bottom of the axial-trough in Rupert Inlet. Present data indicate that for the vast bulk of the tailings this is so.

Conclusions to date by the independent agency are that no evidence exists of any impact of the tailings discharge on the various components of the marine ecosystem.

J. B. Evans, coordinator of the independent monitoring agency, pointed out at a press conference called by the University of British Columbia (UBC), that originally the Pollution Control Branch, B.C., issued a permit to Utah to operate on condition that an independent agency be employed to monitor the mine effluent conditions.

The Pollution Control Board recommended to Utah that a panel be selected from UBC scientists. The company issued a contract to 12 scientists, who established a monitoring program and submitted their findings regularly to the Pollution Control Board, not to Utah. The company pays UBC directly, and makes no payment to any individual.

The records of the B.C. Pollution Control Branch, according to the branch's director, William Venables, show that Utah Mines has remained in complete compliance with the terms of its B.C. permit.

Official bulletins

ONTARIO S.C.

Cease Trading Orders

Hiview Gold Mines – order issued Jan. 20/78.

Claymac Mines, Crowbridge Copper Mines – order rescinded Jan. 19/78.

VANCOUVER S.E. AND CURB

Cardero Resources – offering 200,000 sh. on best efforts basis at 40¢ per sh. minimum to Feb. 20/78. Agent: West Coast Securities.

Gold Cup Resources – 400,000 sh. sold for net $107,364. Agent: West Coast Securities.

Alina Int'l Industries – option to purchase 200,000 sh. at 40¢ per sh. not exercised by Canarim Investment Corp.

Mabee Minerals – sold 400,000 sh. for net $69,756. Agent: Canarim Investment Corp.

Pan Arctic Explorations – sold 150,000 sh. for net $311,506. Agent: West Coast Securities.

Global Energy Corp. – option to purchase 200,000 sh. at 30¢ per sh. not exercised by Canarim Investment Corp.

Knobby Lake Mines – sold 150,000 sh. for net $43,053. Agent: Continental, Carlisle, Douglas.

Carolin Mines – secondary offering of 165,333 sh. exercised by Norvan Management and Fore Management.

Pan Acheron Mines – option on 100,000 sh. at 21¢ per sh. exercised by Canarim Investment.

Goldbelt Mines – option on 150,000 sh. exercised by Canarim Investment.

Norco Resources – offering 175,000 sh. on best efforts basis at $1.10 per sh. minimum to Mar. 3/78. Agent: Midland, Doherty.

Canzona Minerals – 100,000 sh. for sale for 60 days beginning Jan. 25/78.

MCP Resources – 6,250 sh. for sale for 60 days beginning Jan. 25/78.

Ni-Cal Developments – 7,000 sh. for sale for 60 days beginning Jan. 25/78.

Tormex Resources – 50,000 sh. for sale for 60 days beginning Jan. 24/78.

Rimrock Mining – 35,000 sh. for sale

The Iron Bay Trust

ROYALTY DISTRIBUTION

NO. 34

NOTICE is hereby given that a royalty distribution of thirteen cents

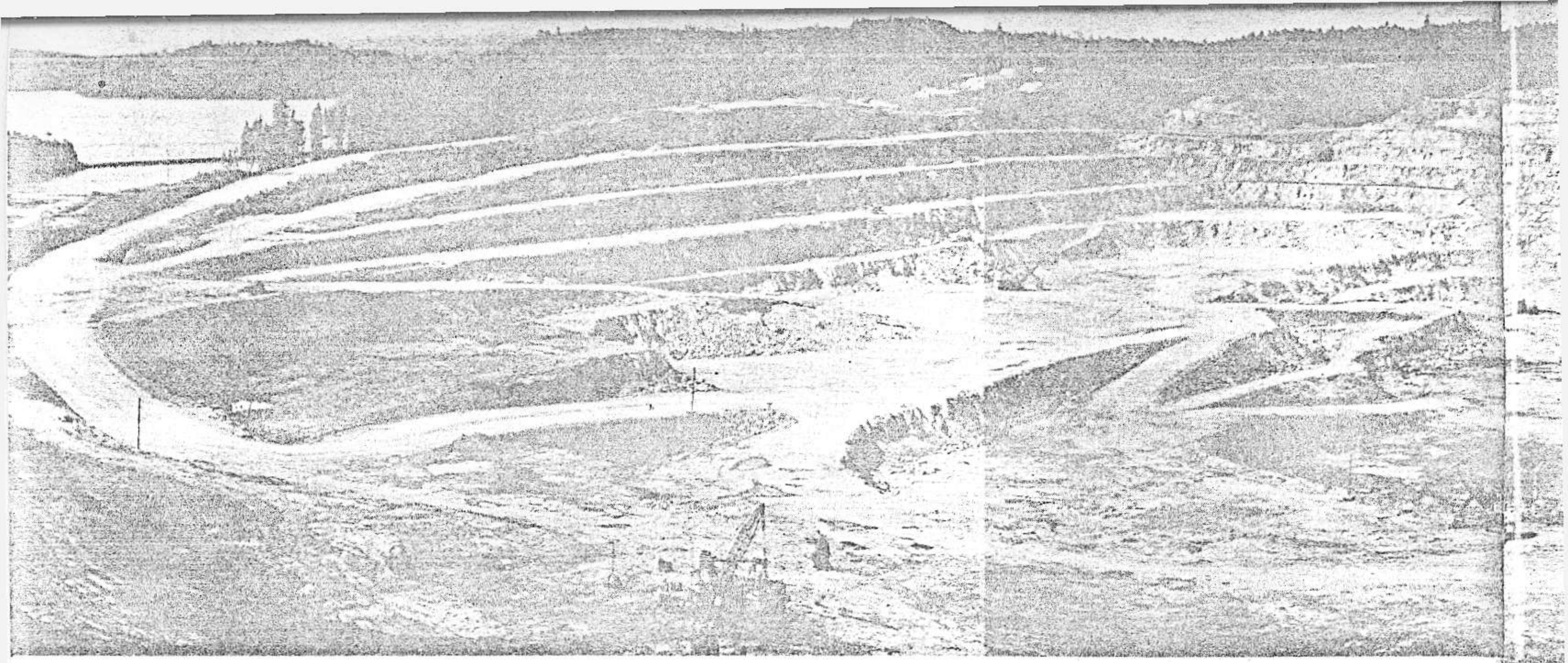
Saskatchewan

Continued from Page 1

opposition role to the federal bill.

However, Saskatchewan Minister of Natural Resources J. R. Messer subsequently rejected the suggestion that his province would lead other provinces in a common front against the bill. Mr. Messer acknowledged that Saskatchewan was opposed to "certain sections" of the bill, but did not reject the overall planned federal legislation.

The new bill, which would replace the 30-year-old Atomic Energy Control Act, would split responsibility for all aspects of domestic nuclear energy among



Island Copper Mine

from discovery to open pit production

One of the largest producers of copper concentrates in Canada, the Island Copper Mine is located near Port Hardy, British Columbia, at the northern end of Vancouver Island. It is operated by Utah Mines Ltd, which was incorporated for the purpose in 1972 and is a subsidiary of Utah International Inc, of San Francisco.

Estimated reserves are near 280-million tons of copper-molybdenum ore with an average grade of 0.52% copper, 0.027% molybdenum sulphide. Developed for a capital cost to start-up of some $88-million, the first shipment was made at the end of December 1971. Full design capacity of 33,000 tons/day was reached in 1973, and this has since been raised to the current figure of 38,000 tons/day.

The mine has a very strict environmental control system to monitor the effects of tailings disposal into Rupert Inlet, on which the facilities are situated, and which also provides access to the sea.

In the general area of Port Hardy, which is a small logging and fishing community, there was some coal mining as early as 1835 for a short while. The Geological Survey of Canada reported on the geology of northern Vancouver Island following field work by G M Dawson in 1886, and field work has been carried out since then. Mining of copper started in 1911 some 20 miles to the south on what became the Coast Copper property of Cominco Ltd and was revived during the 1960s. Other coal and iron mines operated for some years but are now closed.

The original discovery on the present Island Copper property was made late in 1965 by a local prospector, Gordon Milbourne, who exposed indications of pyrite and chalcopyrite mineralization in a depression under two overturned trees. Early in 1966 an agreement was reached with Utah, and that company's exploration arm started a systematic programme of geologic mapping, geochemical and geophysical surveys, and some drilling.

The Island Copper deposit is a typical copper porphyry. Mineralization occurs in volcanic andesites which have been intruded by a quartz feldspar porphyry. The porphyry is itself occasionally mineralized.

The geology and mineralization of the Island Copper deposit were covered in some detail in an article by Maurice J Young and E S Rugg, both of Utah, which was published in *Western Miner* in February 1971 (p31-40).

DEVELOPMENT

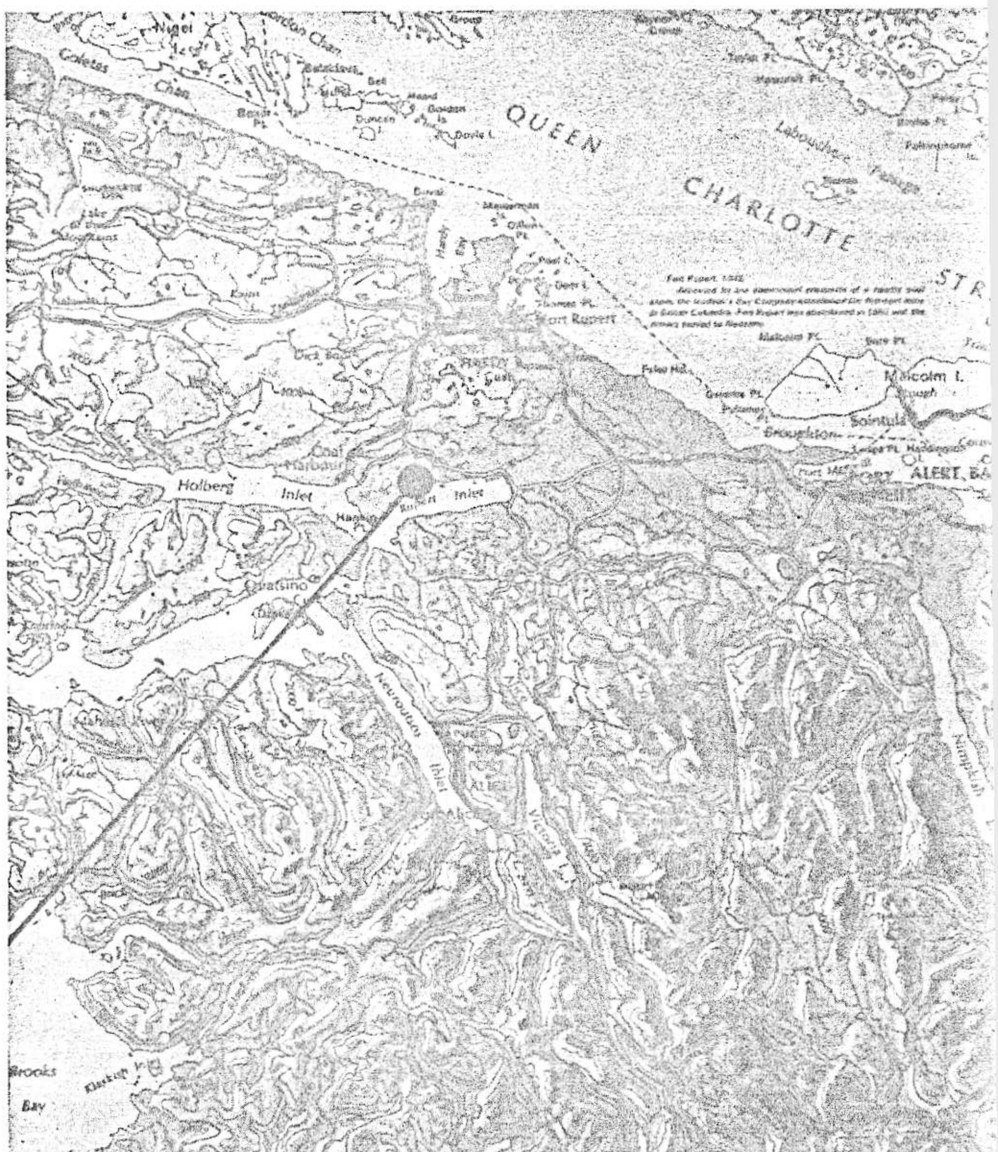
Following the initial exploration work, drilling showed a small orebody of about one-million tons grading just over one per cent copper. While this was being drilled, other targets were defined by geochemcial sampling, and early in 1967 there was recorded the first diamond drill hole into what has become the Island Copper orebody, over a mile southeast of the original discovery.

When it became evident, late in 1967, that there was potential for a large porphyry copper deposit, drilling was accelerated and plans were made for a feasibility study and development programme.

An exploration shaft was sunk in the summer of 1968, and drifts were mined on strike to cross-cut the upper part of the orebody. The material produced was shipped to a Utah International pilot plant at Cedar City, Utah, and samples were provided to equipment manufacturers for grinding and crushing tests. During this period the initial contacts were made with government regulatory

Island Copper open pit

Location of Island Copper Mine (black dot)



bodies. The steps taken to meet environmental regulations are of particular interest and are dealt with in some detail elsewhere in this review of operations.

A formal feasibility recommendation was made to, and approved by, the Utah board of directors early in 1969. By this time studies had been made of marketing, housing, environment, metallurgy, and plant design. It had also been established that the orebody would exceed 200-million tons.

The actual development of the project was announced in June 1969, and from then construction continued to completion by the winter of 1971. The first shipment of concentrate was made on 28 December 1971.

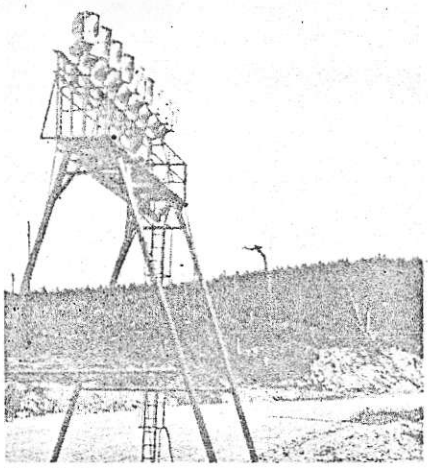
PIT OPERATIONS

The Island Copper orebody is mined by an open-pit operation. The pit will eventually be 8000 ft long, 4000 ft wide, and 1200 ft deep. When visited by *Western Miner* in August 1974 the lowest bench was at the 880 level, or some 120 ft below sea level.

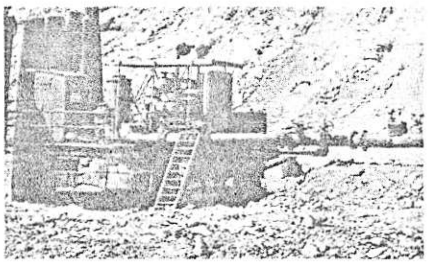
Mine operations, including supporting maintenance work, are continuous and on the same schedule of three shifts a day, for seven days a week, as the mill.

The orebody and waste rock are overlain by glacial till which ranges in thickness from 15 ft in the centre of the pit to 250 ft on the east and west sides. Benches are mined to a height of 50 ft in the till and 40 ft in rock.

Drilling is done with four Bucyrus-Erie units: three 60OR electric and one 45R diesel-electric rig. Drill holes are



Floodlights over open pit



Electrical and diesel pumps in pit

9⅞-inch diameter, drilled to grade in glacial till, and to 8 ft below grade in rock. Drill pattern varies according to local conditions.

Explosives used are largely AN/FO in bulk, with some packaged types, and packaged AN/FO for wet holes that cannot be pumped dry. Powder factors are about 0.4 in till and 0.9 in rock (pounds of AN/FO per cubic yard of material).

Broken material from the pit is loaded into trucks by shovels with 15-cu. yd. buckets. On normal operations, four of five shovels are working. The units used in the mine are all P&H electric shovels: three 2100B models and two 2100BL with lower propel system.

For special loading operations, and as a back-up for the shovels, there are two L700 Letourneau 15-yd front end loaders which are fitted with a 12-cu.yd bucket and extended arms for additional reach when loading into high bodies on large trucks.

The haul trucks used at the mine include 25 Unit Rig M120 units, each of 120-ton capacity, which average something over 100 tons a load with their 78-cu.yd boxes. More recently there have been added five Unit Rig Mark 36 trucks with a rated capacity of 170 tons, and a further five of these units are due to be delivered by early 1975.

The Unit Rig vehicles are diesel-powered with final drive by electric motor in each wheel.

Ore is carried from the pit to the crusher over a distance of 1-1.5 miles, involving a climb of up to 280 ft from the level at 120 ft below sea to the crusher at 160 ft above sea level. Haul roads are 100 ft wide; ramp grades in the pit are 8-10%. Waste is dumped on land to the north of the pit and into a low-level marine fill to the south of the pit.

The mine is in an area of heavy rainfall (about 70 inches a year). This factor, combined with the extensive dumping operations, makes it necessary to have a large fleet of auxiliary vehicles, including three graders, three rubber-tired dozers, five Caterpillar D-8 and five D-9 tractors, and three Fiat-Allis HD-41 dozers.

Also used for auxiliary and back-up work are a Caterpillar 988 loader and four 35-ton Mack trucks. For ditch work there are a Gradall and backhoe.

The operations in the pit are readily supervised from a field office located on high ground. A traffic supervisor in the office can see all vehicles and equipment in the pit, and maintains radio contact with the operators. Large banks of floodlights provide adequate visibility even during hours of darkness.

Operations are controlled by a supervisor and two principal foremen, one on production and one on services, which include pit dewatering and road and dump maintenance.

Electrical power supply is an important feature of the operations. Mobile transformer stations in the pit convert 13.2kV main supply to 4160V for major equipment and to 575V for auxiliary services. The transformers can be quickly moved to serve, for example, new working areas for the shovels and drills. Electrical cables to the shovels are protected in some working areas by ground-level rubber channels instead of overhead gantries.

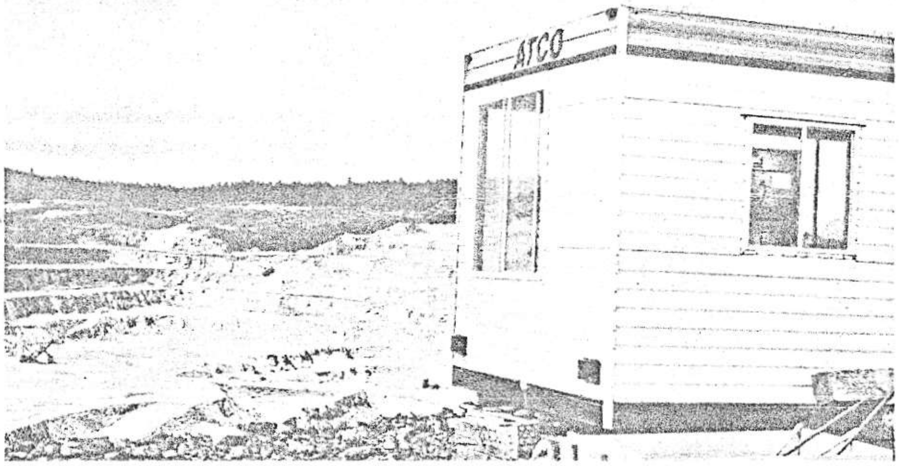
Production from the pit was originally designed at 112,000 tons/day of ore and waste, but was running at 140,000 tons/day during 1974 and is to be further increased.

The stripping ratio, waste to ore, over the five-year period of operation to 1975, is about 3.1:1.

There are two main pumps in the pit, one electrically driven, one by diesel, which are used alternately. There are also many smaller electrical units in different parts of the pit.

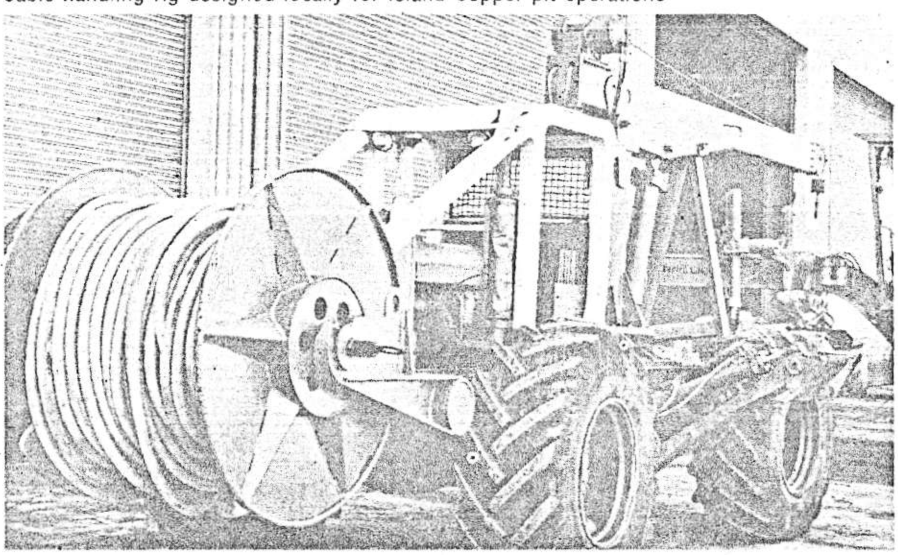
PEOPLE

The Island Copper mine is in an area where there is no ready supply of skilled workers or support services, and it has been necessary for Utah to provide



Control office overlooks all operations in the Island Copper pit

Cable-handling rig designed locally for Island Copper pit operations



housing and other incentives to attract and hold the necessary people.

The company has built about 200 single houses, duplexes, and townhouses which are sold to employees at subsidized prices. There are 15 different models of housing, all built to high standards. A major subdivision in Port Hardy was designed by leading Vancouver architects.

There are also subsidized rental apartments, built and operated by other agencies, and there is to be developed a mobile-home park to accommodate the growing trend to this type of housing.

About half the employees of Island Copper live in the Port Hardy housing, with another group in a camp at the mine site where modular units provide single-occupancy accommodation.

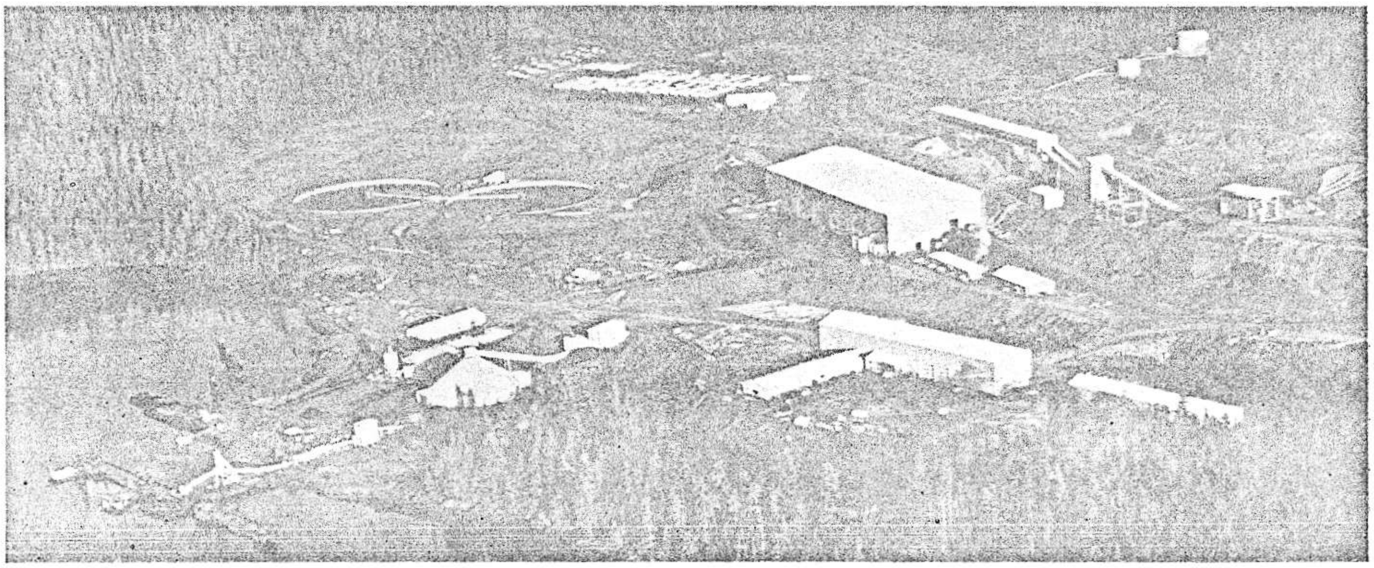
Mine manager at Island Copper is Robert N (Bob) Hickman, who has been with the operation from the start and succeeded to his present position in November 1974, when the former manager, Morton E (Mort) Pratt was made vice-president and general manager of Island Copper, based in Vancouver.

Glen F Andrews is the plant manager with responsibility for mill production, mill maintenance, metallurgy, analytical laboratories, and environmental programme.

Open pit manager is Robert A Leitzman, who heads mine production, engineering, geology, and maintenance.

Project engineer is John C Hannah, with construction and townsite development responsibility.

Personnel manager is G Harold Horwood. H R Tschiedel is office manager, and T L Bon is purchasing agent.



Island Copper Mine

milling for copper and molybdenum

Chris Brown Metallurgist, Island Copper Mine

The Island Copper plant was designed and built by Fluor Utah Ltd, in conjunction with Utah design staff. Originally designed to treat 33,000 tons/day (t/d) of ore, the current average milling capability is 38,000 t/d (Nov'74). The first of six semi-autogenous grinding lines was brought on line in October 1971, start-up of the remainder being governed by equipment delivery schedules.

The summer of 1973 saw the start-up of an additional three ball mills, and attainment of the present production level. The current process flowsheet is shown in simplified form.

CRUSHING

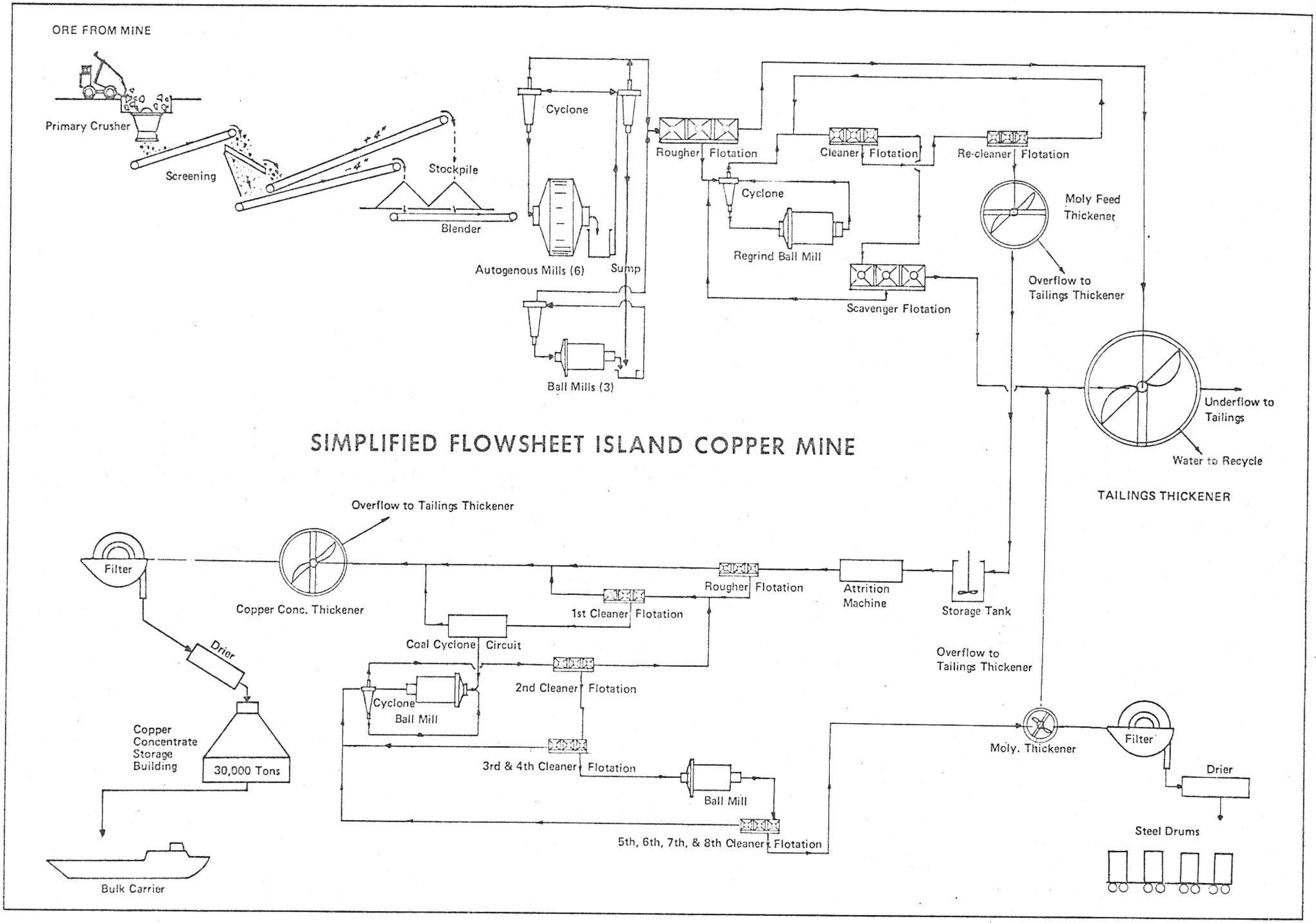
The crushing circuit is relatively simple, comprising single stage crushing of the ore followed by screening to fine and coarse fractions.

The crusher is a 54x74in Allis Chalmers Superior Gyratory with a setting of 9-10in, driven by a 500-hp motor. Trucks dump on three sides of a rectangular dump pocket. An 84inx20ft link belt apron feeder draws crushed ore from a 250-ton surge bin below the crusher, discharging onto a 72-in wide inclined steel cord conveyor belt. A fixed splitter box at the conveyor discharge separates feed to two parallel Jeffreys 6x20ft vibrating grizzlies for screening into +4in and −4in fractions. The fractions are collected on short reversible conveyors which feed the coarse and fine ore stacker conveyors. Trippers distribute ore to outside stockpiles adjacent to, and above, the concentrator grinding floor.

The circuit design capacity is 3000 tons/hour (t/h), crushing operations being on a 3-shift/day 7-day/week basis with 1-shift/week scheduled for preventive maintenance. Operation is supervised from a control room at the crusher dump pocket, a duplicate panel being situated in the main mill control room. Truck dumping is governed by level in the crushed ore surge bin (measurement by nuclear gamma gauge).

The apron feeder is equipped with a vari-speed drive for control of feed rate to screening. Mercoid tilt switches alarm build up at all transfer points, and TV cameras are used for remote monitoring of the crusher dump pocket and apron feeder discharge. Weightometers are installed on the primary and fine ore tripper conveyors.

The circuit has remained unchanged since start-up, minor modifications being: (i) installation of a pneumatic rock breaker and extended crane coverage above the crusher dump pocket to speed clearing of oversize rock. (ii) Replacement of sonic gauge by nuclear gauge for measurement of surge bin level. (iii) Replacement of mechanical brakes on tripper car wheels by brakes on the shafts


SIMPLIFIED FLOWSHEET ISLAND COPPER MINE
ORE FROM MINE
Primary Crusher
Screening
+4"
-4"
Stockpile
Blender
Cyclone
Autogenous Mills (6)
Sump
Ball Mills (3)
Rougher Flotation
Cyclone
Regrind Ball Mill
Cleaner Flotation
Re-cleaner Flotation
Scavenger Flotation
Moly Feed Thickener
Overflow to Tailings Thickener
Underflow to Tailings
Water to Recycle
TAILINGS THICKENER
Overflow to Tailings Thickener
Filter
Copper Conc. Thickener
Rougher Flotation
Attrition Machine
Storage Tank
1st Cleaner Flotation
Coal Cyclone Circuit
2nd Cleaner Flotation
Cyclone
Ball Mill
3rd & 4th Cleaner Flotation
Ball Mill
5th, 6th, 7th, & 8th Cleaner Flotation
Overflow to Tailings Thickener
Moly. Thickener
Filter
Drier
Steel Drums
Drier
Copper Concentrate Storage Building
30,000 Tons
Bulk Carrier

between the motors and gear reducers. (iv) Installation of dust collection equipment in the screening building. Equipment was installed in the main crusher building for start-up.

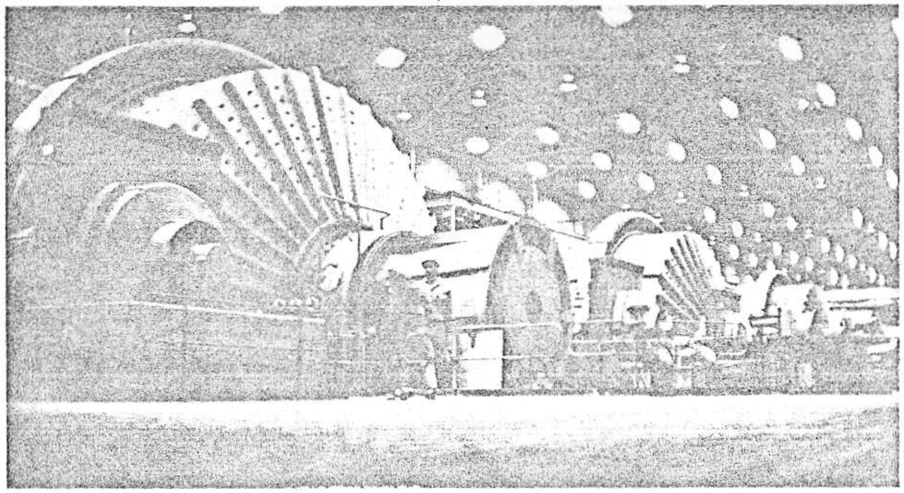
Two major factors limit current output: (i) an annual rainfall of 80-100in/year necessitates frequent clearing of build-up in chutes and screens during the winter months. (ii) Live capacity of the surge bin beneath the crusher limits truck dumping frequency, particularly when crushing wet ore. (120- and 170-ton capacity trucks are in use).

GRINDING

The original grinding circuit comprised single stage grinding in six autogenous mills, each in closed circuit with a cluster of eight hydrocyclones. Cyclone overflows were combined and pumped directly to copper rougher flotation. Two major modifications to this circuit have been made since start-up. The mills have been converted to semi-autogenous grinding units by the addition of steel balls, and three secondary ball mills have been installed. The current circuit comprises three identical grinding lines, two primary semi-autogenous mills producing feed for one ball mill.

Feed to each primary mill is removed from the stockpiles through draw holes under which 42inx10ft Jeffrey apron feeders are located. There are three feeders per mill, one under the fine pile, one under the coarse, and one at the junction of the two piles which is designated mixed ore. The feeders discharge into a 36in wide horizontal conveyor feeding the mill. Ramsey weightometers are installed on the mill feed conveyors. Each Hardinge Koppers mill is 32ft diameter, 14ft long, has a grate discharge, and is driven by two 3000-hp 13,200V wound rotor motors. The mill drive arrangement is motor, gear reducer, pinion, main drive gear. The main drive gear is located centrally on the circumference of the mill shell. To increase useful life of the mill lining, the drive rotation may be reversed. The lining arrangement comprises rows of liner plates separated by rows of lifter and wedge bars, 72 rows of each around the mill circumference. The discharge grates are slotted, the inner slot width being 5/16in, and the outer ¾in. A trommel screen on the mill discharge is used for return of +⅜in material to the mill, screen oversize returning through two ports.

The mills discharge into cylindrical sumps; 12x12in 150-hp Georgia Iron Works centrifugal pumps are used to feed the clusters of eight 20in Wemco hydrocyclones, one for each mill. Overflow product from these cyclones goes to flotation. Cyclone underflow is split, a portion returning to the primary mill, and the remainder feeding secondary grinding. Individual sumps and pumps are used for transport of these underflow portions from the primary cyclone clusters; 8x8in 50-hp GIW pumps feed the secondary mill cyclone feed sumps, 10x12in 200-hp GIW pumps feeding clusters of six 20in Krebs cyclones. Underflow from these clusters is secondary ball mill feed. Overflow is combined with that from the primary cyclones. The three secondary ball mills are Allis Chalmers 16.5x22ft overflow type. Each is driven by one 3000-hp wound rotor motor through almost identical drive trains to those of the primary mills, equipment being duplicated where ever possible to minimize the spare parts inventory needed. Single wave lifter-liners are used in the ball mills.



Inside the Island Copper mill; semi-autogenous mills

GRINDING CONTROL STRATEGY

During the feasibility stage of mine development, the possibility of application of autogenous grinding to milling of Island Copper ore was realized. Factors favouring adoption of this grinding technique over conventional rod and ball milling were: potential capital cost savings, operating cost savings through circuit simplicity, elimination of grinding media usage, and crushing circuit simplicity (an important consideration in a wet climate). This potential was sufficient incentive to proceed with pilot plant testworking using a 6ft diameter by 2ft long Cascade test mill.

Samples for pilot plant work were obtained from a shaft sunk where exploration of the ore body had been most intensive. The outcome of this pilot plant testwork was the decision to install six autogenous mills in closed circuit for primary grinding.

Soon after mill start-up, it became evident that the ore used for pilot plant work was not representative of the main ore body in one critical respect, namely rock structure. The test shaft had been located in a zone of the ore body where fracturing was much less severe than normal for the bulk of the ore mined to date.

Samples tested in the pilot plant typically contained 40-60% +4in competent rock, whereas run of mine ore has averaged 10-15% after crushing. Since autogenous grinding relies on rock-on-rock impact for rapid size reduction, a proportion of large competent rock pieces in the mill charge is essential. With insufficient coarse ore, the prime mechanism of size reduction becomes attrition rather than impact. This was observed to be the case at Island Copper during commissioning. Symptoms of this condition were observed to be low through-put (1/2 - 2/3 that of the design 240 t/h/mill-line), high power consumption (25-50 kW/ton as opposed to the anticipated 18-22 kW/ton), and a much finer than target product at design cyclone feed density (80-90% −200 mesh; target is 70% −200 mesh).

The most expedient solution to this problem, and one that required no flowscheme modifications, was to make up for the coarse rock deficiency by adding steel grinding media to the mill charges. (Mill structural specifications had been written to provide for this possibility, based on other operators' experience.) Steel additions to the mills started November 1971. By February, all but one of the mills were operating with ball charges, the one mill remaining autogenous until May 1972 for comparison purposes. Currently the mills operate with 7-8% by volume charges, make-up comprising 70% 3in and 30% 4in diameter forged steel balls. This combination has been derived as optimum after extensive testing of different ball sizes (1.5-4.5in diameter), combinations of sizes, and varying % charges (1%-9%).

In addition to the ball charging experiments, modification of the circuit was considered. A survey of industry experience suggested production would be improved by operating the mills in partial or fully open circuit. Plant testing confirmed this observation and resulted in the decision to install the three secondary ball mills. Commissioning started June 1973 and, with the refinement of primary mill ball charging strategy, has resulted in achievement of the current through-put capability of 38,000 t/d.

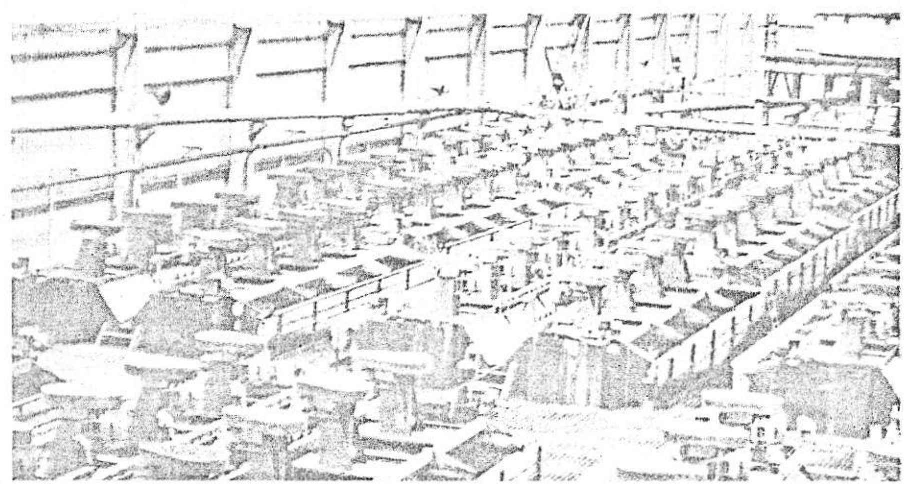
Other major operating statistics for primary-secondary grinding in 1974 are an overall power consumption of 22.5 kW/ton, ball consumption of 2.2 lb/ton, liner consumption of 0.34 lb/ton, and equipment availability of 91%.

Development of an effective primary mill control strategy is also considered to have contributed significantly to achievement of higher than rated average through-put. It was originally envisaged that two basic instrumentation loops would make possible fully automated control of autogenous mill operation. Mill loading was to be 'Cascade' controlled from an analog power draw recorder/controller, varying mill feed rate to maintain kW draw at a set point. (Variation of feed rate is accomplished through vari-speed feeder drives. Ratio controllers govern the relative feed rates from each feeder, so that ratios remain the same even with changes in total feed rate. A mill feed water controller allows cascade control of water addition from the weightometer recorder/controller. The desired ore-water ratio is preset using a separate controller). In practice, cascade control of feed rate based on power draw set point was not possible. The instrumentation could not differentiate between decreasing power draw due to mill overload, and decreasing power draw due to increasing ore amenability to grinding. Power draw alone was hence unsatisfactory as an indicator of mill loading.

Back pressure on the mill trunnion lubrication system was found to be a reliable indicator of actual mass loading. Used in conjunction with the power draw record, it is possible for the operator to determine whether decreasing power draw is due to mill overload or improved ore amenability. Optimum mass loading was observed to vary with changes in ore characteristics. Hence cascade control of feed rate to a pressure set point alone also proved impossible.

Mill sound level offered a third possibility as a cascade control input signal. Monitors have been installed at each mill, but cascade to a set point again proved impractical, optimum sound level also varying with ore type milled. Recording of these three elements does provide the operator with sufficient information for effective manual control however, and could provide the basic elements necessary for a digital computer based control strategy.

The second loop represents an attempt to control cyclone separation. A nuclear density gauge is installed on the cyclone overflow monitoring product specific gravity. A controller regulates water addition to the cyclone feed sump based on an overflow specific gravity set point. This loop is effective for density control, but does not provide control of product particle size. With density held constant, product size distribution varies with ore type milled. An Autometrics Co Ltd particle size analyzer is currently being tested to provide size-, rather than density-based, control of cyclone separation.



Flotation cells in part of the Island Copper mill

Secondary ball mill operation is also manually controlled at the present time. Cyclone feed sump level and mill sound level are used as indicators of mill loading, and cyclone overflow densities are controlled by nuclear gauge. Screen analyses are routinely performed on all cyclone overflows. They produce a guide line for cyclone overflow density required to produce the target flotation feed size distribution.

All control instrumentation for primary and secondary grinding is panel mounted in a central control room. Honeywell instruments are used, the panels being supplied by Swanson Engineering and Manufacturing Co Ltd.

COPPER FLOTATION

Primary and secondary cyclone overflow product is split between two parallel identical Cu rougher flotation sections. Each section comprises five banks of 14 300-cu.ft Wemco cells arranged in a 5-5-4 pattern; 12x12in 200-hp GIW flotation feed pumps transfer pulp at 38-40% solids to stationary distributors feeding the flotation banks. Rougher concentrates from each section are reground separately in two 9ft diameter by 18ft long, 700-hp Allis-Chalmers overflow ball mills. The mills operate in closed circuit with clusters of eight 15in Wemco hydrocyclones. Cyclone overflows are combined and pumped to a fixed distributor feeding five banks of 10 100-cu.ft Galigher 'Agitair' cleaner flotation cells. Cleaner concentrate is recleaned in four banks of eight 53-cu.ft Agitairs. Concentrate from recleaner flotation is molybdenum plant feed, tailings being recycled to cleaner flotation.

Cleaner tailings are pumped to two banks of 14 300-cu.ft Wemco cells for scavenging. Concentrate from this flotation stage combines with rougher concentrate for regrinding. Scavenger tailings are combined with the rougher tailings to become the final plant tailing. Where required, rubber-lined Allen Sherman Hoff centrifugal pumps are used for transport of Cu flotation products. Equipment may be started locally or remotely from the central control room.

Copper flotation metallurgy

The most common rock type containing sulphide mineralization is andesite which is typically dark grey in colour, fine grained and highly fractured. It is estimated that approximately 80% of the ore body is contained in this host rock, the remainder being quartz porphyry and brecciated material. Sulphide mineralization is predominantly along cleavage and fracture planes (70%), the remainder being finely disseminated.

Sulphide minerals in order of abundance are pyrite, chalcopyrite, molybdenite and very minor amounts of bornite, galena, and sphalerite. Gold, silver and rhenium are present. Silicates, magnetite, calcite, clays and gilsonite make up the remainder of the host rocks.

Current mill heads grade 0.50% Cu and 0.017% Mo. Overall circuit recovery has averaged 87% and recleaner concentrate target is 24% Cu.

The present reagent balance is relatively simple, collector and frother being added in rougher flotation only. Additions are made to the flotation feed sumps (60% of total), flotation bank first junction boxes (25%), and second junction boxes (15%). Average consumptions are 0.008 lb/ton potassium amyl xanthate collector, and 0.06 lb/ton of a 93.5% aerofroth 71R with 6.5% Dow SA1012 frother blend. Manually adjusted Clarkson feeders are used for metering reagent additions. Rougher, cleaner, and recleaner feed pHs are automatically controlled using Beckman probes for sensing and on-off squeeze valves for metering. Respective targets are 10.0, 10.8, and 11.5. Overall lime consumption is 1.3 lb/ton. Approximately 65% of this quantity is added to the tailings thickener feed, pH of which is automatically controlled to 11.3-11.5.

Water reclaimed from the thickener overflows is used in the grinding circuit, thus reducing rougher lime requirement. Fresh water is used for launder and sump spray dilution in the flotation circuit. Bubbler tube type pulp level monitors are installed to control sand plugs in all flotation bank junction and tail boxes. Each box has one plug controlled from monitor set point, and one that may be raised or lowered manually.

Copper recovery appears primarily dependent on flotation feed size distribution and the extent of liberation of finely disseminated sulphide mineralization. Target primary grind is 10-12% +100 mesh, 70% −200 mesh. Rougher and scavenger concentrates are reground to 90% −325 mesh, primarily to liberate chalcopyrite-pyrite middlings.

MOLYBDENUM PLANT

The molybdenum plant is situated in the main concentrator building and comprises separation, concentrate filtering, drying, and product packing sections.

The copper circuit recleaner concentrate feeds a 100-ft diameter Eimco thickener. Pulp is thickened to 65-70% solids prior to being pumped to two 26x26ft agitated storage tanks. These tanks provide storage capacity for approximately one day's production from the copper circuit. They smooth fluctuations in molybdenum flotation circuit feed, and provide aging time required for breakdown of residual reagents carried over from the copper circuit.

Feed is pumped from these tanks to a splitter box feeding a bank of four attrition cells which are used for pulp conditioning prior to rougher flotation. Rougher flotation of the molybdenite is performed in a bank of 12 48-cu.ft Agitair cells. Rougher concentrate is pumped to a bank of 16 48-cu.ft first cleaner cells. Concentrate from this stage is reground in a 4x10ft Allis-Chalmers regrind ball mill in closed circuit with a cluster of 4 6-in Wemco cyclones. Cyclone product is pumped to a second cleaner bank of eight 48-cu.ft Agitair cells. Concentrate from this flotation stage is cleaned in six more flotation stages using Denver #16-'Sub-A' cells, fourth cleaner concentrate being reground in a 3x4ft Denver ball mill which is in open circuit.

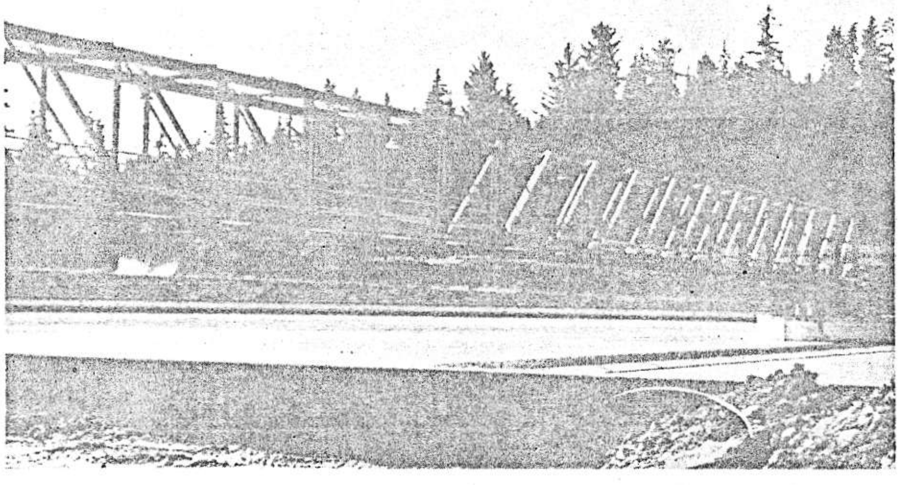
Tails from the eight cleaner stages are generally recycled to the previous stage, although the circuit is designed to be flexible in this respect. Final flotation circuit tails comprise rougher and first cleaner tailings which are pumped to a final copper concentrate thickener, prior to filtering and drying.

The circuit is unusual in one major respect — the ore milled at Island Copper contains a small quantity of gilsonite (a carbonaceous mineral) that has very similar flotation properties to the molybdenite. This mineral is a major contaminant in the molybdenite flotation product. Various schemes have been or are being tried, to remove this material from the molybdenum concentrate. A double cycloning stage between the first regrind and second cleaner flotation stages was installed at start-up, to reject the light mineral, but separation efficiency has proved unsatisfactory. Selective flotation of the eighth cleaner concentrate also failed.

Experiments with a Bartles Mosley table are now in progress, as preliminary experiments using a Wilfley shaking table indicated gravity separation to be practical. Several flow schemes employing the table are under investigation to determine the optimum with respect to metallurgical efficiency. Galigher vertical pumps are used for pulp transport in the flotation circuit.

Final molybdenite concentrate, from either eighth cleaner flotation or tabling, is thickened in a Denver 15ft diameter thickener. Underflow is pumped to two 10x10ft agitated holding tanks using a 1.5in ODS pump. From the holding tanks a second 1.5in ODS pump transfers the pump to a 4ft diameter 4-disc Denver filter. Overflow from the filter boot returns to the holding tanks. Filter cake drops down a chute to a double 7in screw Holoflite dryer, the dryer discharging into a storage silo. Product is packed into 45-gallon drums for sale on lot basis to customers in Europe and the USA. The typical product sold assays 42% Mo. Drums are shipped, four to a pallet, by barge to Vancouver for distribution to purchasers.

One of the thickeners



Molybdenum flotation metallurgy

Molybdenum flotation feed rate is approximately 660 t/d assaying 0.8% Mo. Circuit recovery primarily depends on the gilsonite (carbon) content of the ore which varies over a wide range (0.01-1.0% C in the molybdenum plant feed). Overall plant % Mo recovery varies from 10% to 70%, and averaged 30% in 1974.

Sodium hydrosulphide is the primary copper depressant. It is added to the attrition machine, first cleaner and second cleaner feeds, overall consumption averaging 14 lb/ton Mo plant feed. Sodium cyanide is used as a secondary depressant for chalcopyrite and pyrite. Consumption is 2 lb/ton. A froth modifier, Dearborn Exfoam 636, is used in the cleaning stages, consumption ranging 0.3-1 lb/ton. Fresh water is used for all dilution and spray water additions. Flowmeters are used for sodium hydrosulphide metering, and Clarkson feeders for the other reagents.

Flotation bank sand plugs are manually adjusted, instrumentation being limited to redox potential and mass-flow monitoring of circuit feed.

Cu CONCENTRATE HANDLING

The final concentrate, assaying 23-25% Cu, is thickened to 60-65% solids in a 100ft diameter thickener. Underflow may be pumped direct to filtering, or to three 26x26ft agitated holding tanks. Filter feed is split to two 10x8ft diameter 10-disc Eimco filters. Vacuum supply is by two 200-hp Bingham pumps, two 275-cu.ft/min Tieghman compressors providing the snap blow air supply.

Filtrate returns to the thickener, and 0.3 lb/ton of Cyanamid Aerodri 100 is used as a filter aid. Filter cake, containing approximately 12% moisture, drops to a 30in conveyor feeding the 48x7ft diameter Lockhead-Haggerty rotary kiln dryer. The dryer is fuel oil fired, final product moisture being less than 8%. A cyclone scrubber recovers dust losses for return to the thickener. An inclined 24in conveyor transports dryer discharge to a conical 35,000-ton live-capacity storage building. Product weighing is by Ramsey scale.

For concentrate shipping a deep sea dock was built, capable of receiving bulk carriers of up to 30,000 tons capacity. All production is currently shipped to Japanese smelters of the Mitsubishi and Mitsui Companies. Four Jeffrey apron feeders draw concentrate from the bin, discharging onto a 36in conveyor. A Howe-Richardson weightometer monitors loading rate over this belt (1000-1500 t/h). Concentrate transfers to a 36in shiploader conveyor. The conveyor is track-mounted for movement over the ship.

WATER SUPPLY

Process and mine site water requirement is approximately 10,000 gal/min of fresh water. This is obtained from Alice Lake, about 12 miles west of the concentrator. Four 3000-gal/min Worthington turbine pumps are used to transport water to a head tank one mile from the pump house. Flow is by gravity from this 100,000-gallon head tank to a tank at mine site. The water line is 34in diameter steel pipe. Tank levels are monitored in the concentrator control room and pumps may be started and stopped from this location. Their operation may also be automatically controlled from head tank level.

The mine site head tank capacity is 1.5-million gallons of which 300,000 gallons are reserved for fire protection. Lines from this tank feed the concentrator fresh water distribution system, the 500,000-gallon capacity reclaim water head tank, and an 18,000-gallon capacity potable water tank.

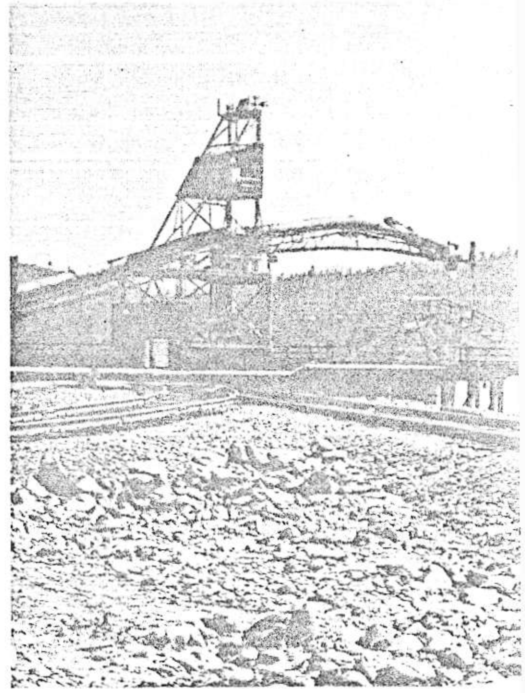
POWER SUPPLY

British Columbia Hydro and Power Authority provide power through a single 138kV transmission line from the Strathcona generating station, about 120 miles south of the mine site on Vancouver Island. Plant demand is approximately 50 megawatts. Two 18 MVAR synchronous condensers are used for voltage control and power factor regulation. Two 25/33 MVA transformers step down the voltage from 138kV to 13.2kV for mill motor power supply, pit, and fresh water pump house distribution centres. Pit, water pump, crusher, and copper regrind mill motors are 4.16kV. Smaller motors in the concentrator operate at 575V.

PERSONNEL

Total concentrator workforce, including technical personnel and staff supervision, is approximately 200 people. Maintenance and operations account for 175 of the total crew strength.

The organization is designed to provide for continuous operation on a seven days per week schedule.



Loading boom at the dock area

Island Copper Mine

tailings disposal and the environment

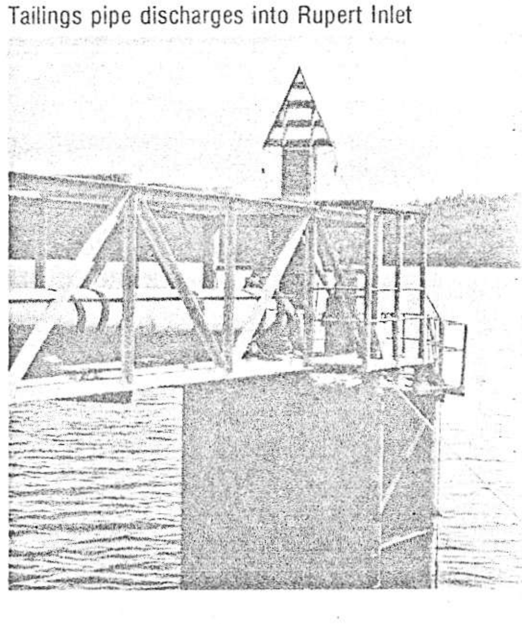
Copper circuit rougher and scavenger tailings discharge into a collection sump in the flotation basement. From here, tailings flow by gravity through a 34in steel pipe line to a splitter box feeding two 375ft Dorr-Oliver-Long thickeners. A stand-by line has been installed since start-up. Thickener feed is 30-34% solids, underflow varying from 40-45% solids; 0.02 lb/ton of flocculant and 0.6-0.8 lb/ton of lime are added to assist settling. Thickener overflow is reclaimed at a rate of 4000-5000 gal/min and pumped to a head tank above the concentrator elevation; four 3000-gal/min Worthington turbine pumps are available for this task. Thickener underflow density is controlled by hydraulic squeeze valves on the underflow lines. Underflows combine and flow by gravity through a pipe line to the marine disposal system. Two pipe lines are available, one of 34in diameter steel, and one of 34in Sclair high density polyethylene.

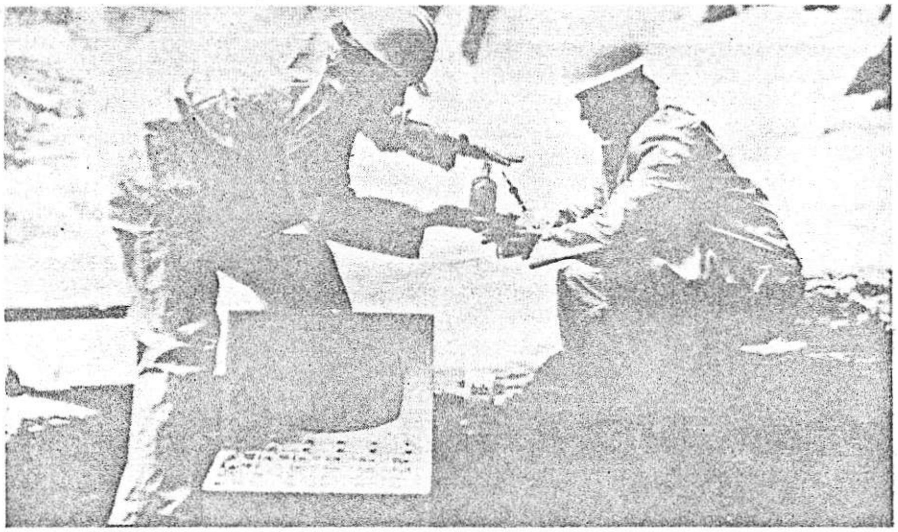
The pipe line discharges tailings into a mixing chamber in which they are diluted 1:1 with sea water, before entering the marine outfall line. The purpose of this mixing stage is to prevent density inversion of the tailings slurry liquid phase. The submerged outfall pipe rests on the inlet bottom which slopes at approximately 5° to the discharge point 1000ft from the shore and 150ft below the surface.

ENVIRONMENTAL MONITORING

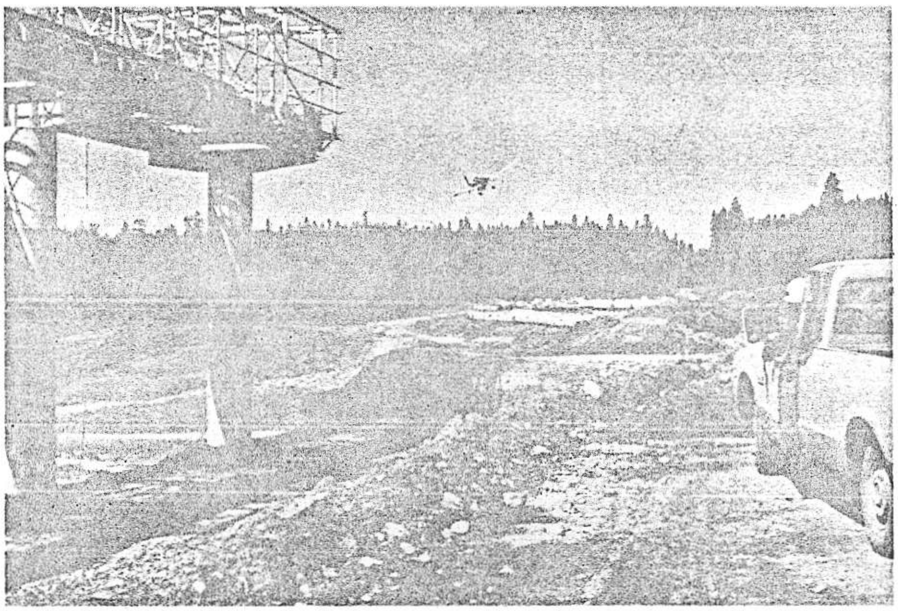
Utah Mines initiated an environmental water sampling program in 1969, before the plant was built. A biological consulting firm was retained to do a chemical and biological assessment of Rupert Inlet and adjacent waters. In January 1971 a permit was issued to Utah by the

Tailings pipe discharges into Rupert Inlet



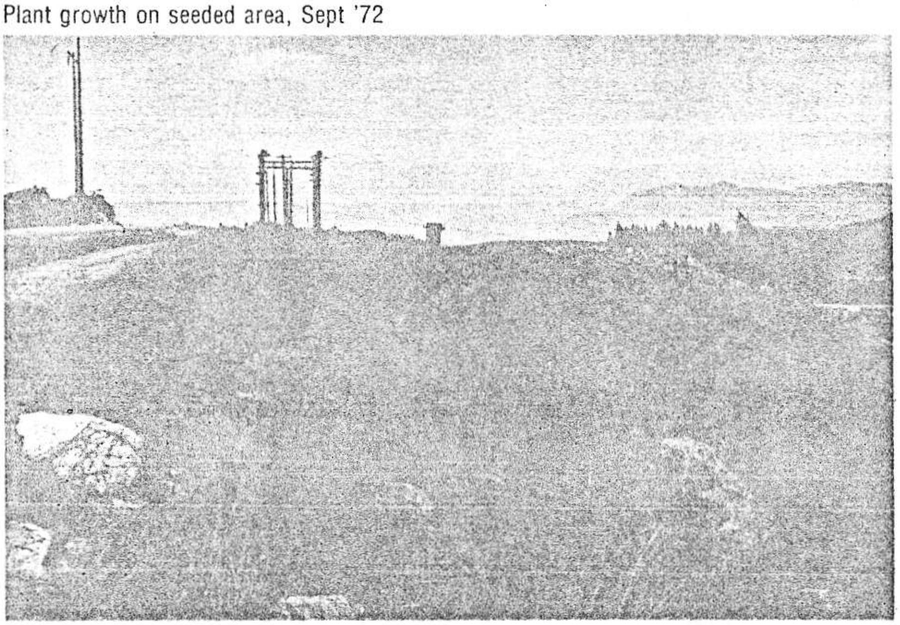


Water sampling by two of the environmental control team



Aerial spraying of fertilizer is part of reclamation work

Plant growth on seeded area, Sept '72



Provincial Pollution Control Branch for the submarine discharge of concentrator tailings following public hearings. The permit, in addition to identifying the physical and chemical limitations of the permitted discharge, directed Utah to retain an independent agency to assist in setting up the programme, establish procedures for sampling and analytical work, and prepare annual reports of programme results for submission to the Pollution Control Board.

Utah selected a team of scientists from the Universities of British Columbia and Victoria to carry out the functions of the independent agency. This team consists of oceanographers, marine biologists, ecologists, chemists, geologists, metallurgists, and mining engineers. The independent agency revised the existing monitoring program to include a wider scope in an attempt to cover all parameters which could be affected by the mill effluent.

The revised program was developed and monitoring started in March 1971. Information gathered since that time in conjunction with surveys which had been carried out by Utah before the Permit was issued, have provided the baseline information against which to compare present and future conditions of the receiving waters.

Monitoring of the inlet waters is carried out periodically, and includes measurement of the following major parameters:

(1) physical characteristics of the inlet bottom including seismic profiles, bottom photography, dredging and coring of the bottom for sediment analysis;

(2) physical characteristics of the receiving waters including temperature, turbidity, and colour;

(3) meteorological characteristics — state of surface water and weather;

(4) chemical characteristics of receiving waters including measurement of dissolved oxygen, salinity, alkalinity, and heavy metal content;

(5) biological characteristics including measurement of the organisms on the bottom in the deep part of the inlet, marine life on the bottom in the shallow intertidal areas, collection and measurement of plankton, and collection of crabs and fish for measurement of numbers, size, and heavy metal content.

Many of these same parameters are also periodically measured in a number of the fresh water streams flowing into Rupert Inlet. The effluent is monitored daily for heavy metals, pH, solids and total volumes. Bi-weekly bio-assays are conducted on the final effluent. Utah has chemists and technicians who carry out a major portion of the data collection and analytical work relating to the physical, chemical, and biological parameters measured. The various measurements are overseen by the scientists from the independent agency.

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.

Maurice J. Young, P.Eng.

E.S. Rugg received an Engineer of Mines (professional) Degree from the Colorado School of Mines in 1943. After three years service in the U.S. Navy, during World War II, he spent two years in Alaska on exploration and placer-mining projects. Succeeding assignments involved a three-year stint in the petroleum industry, work in several underground-mining operations in the Western U.S., and on exploration programs in the search for both metallic and non-metallic minerals in Western North America, Ethiopia, Peru, and Jordan.

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.

He is a licensed Professional Engineer in British Columbia and Montana and is a member of the CIM and SEG.

E. S. Rugg, P.Eng.

Geology and Mineralization of the

ISLAND COPPER DEPOSIT

By

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District Geologist, Vancouver,
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and

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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.

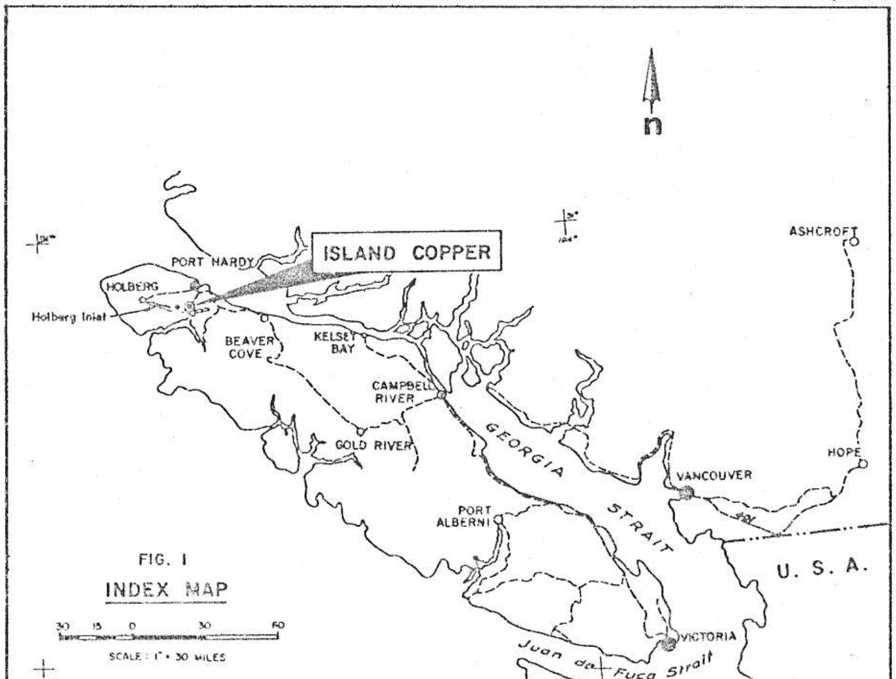


FIG. I
INDEX MAP

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.

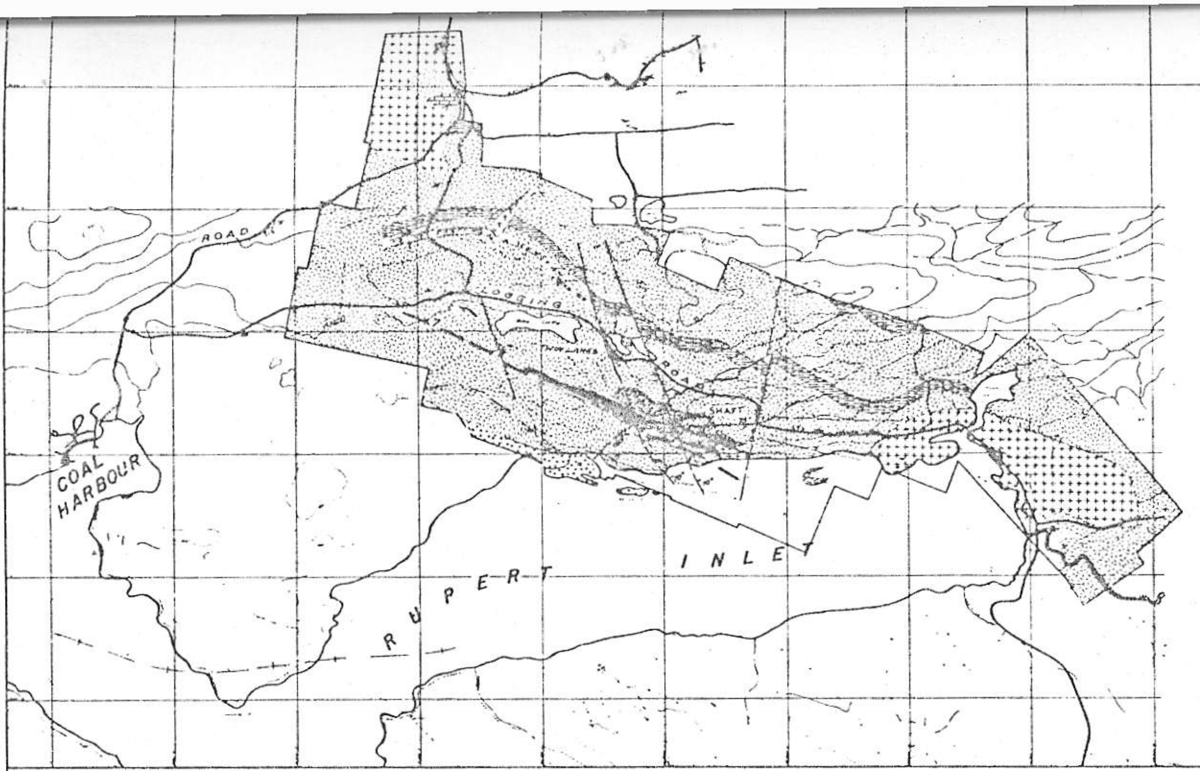
In the vicinity of the Island Copper deposit many isolated outcrops containing small amounts of copper have been noted for many years. On Red Island, in Rupert Inlet, a short adit was driven many years ago in fractured volcanic rocks which contained over 1% copper over short intervals.

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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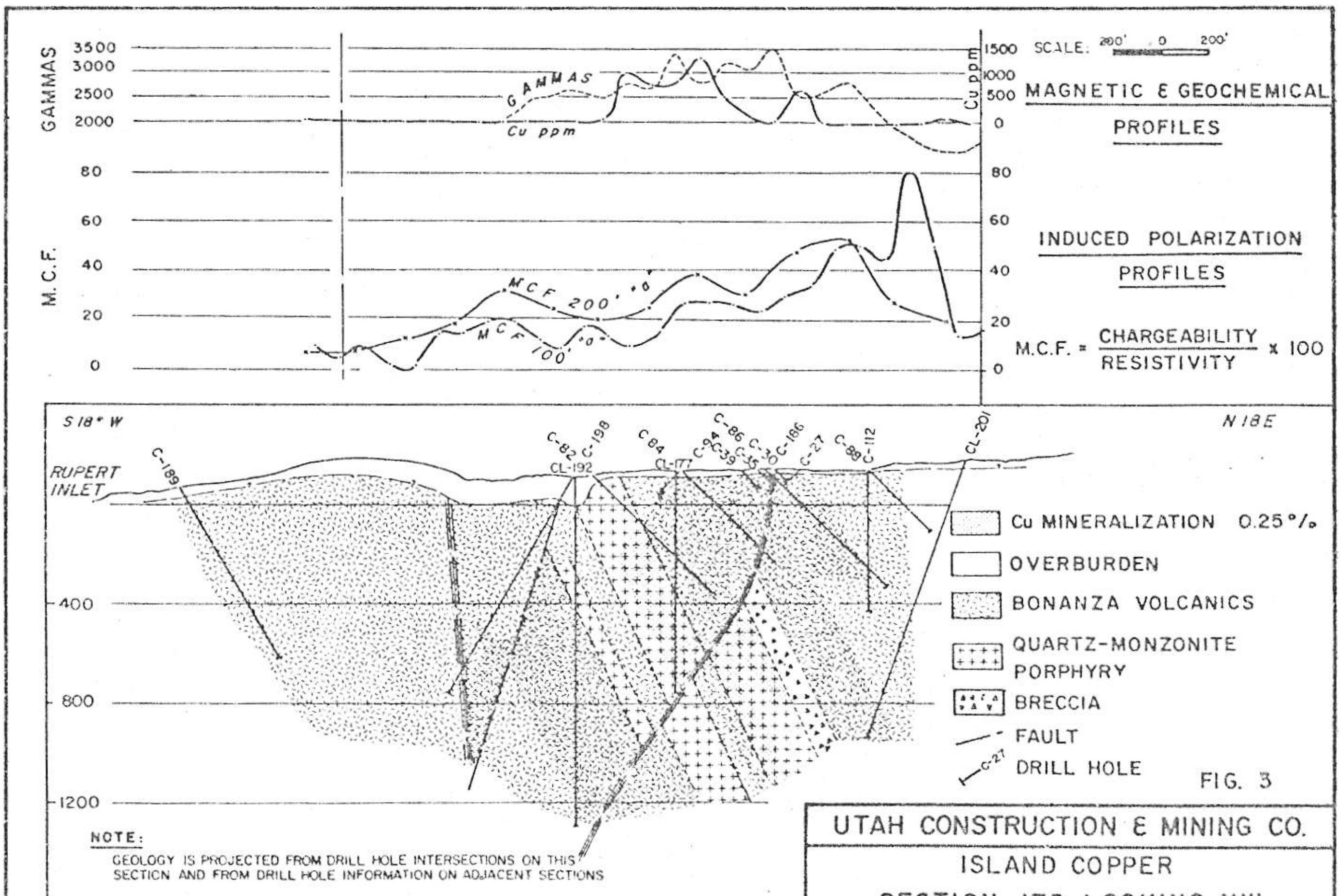
GEOLOGICAL INTERPRETATION

4000 2000 0 2000 4000
SCALE IN FEET



MAGNETIC & GEOCHEMICAL PROFILES

INDUCED POLARIZATION PROFILES

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

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

FIG. 3

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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

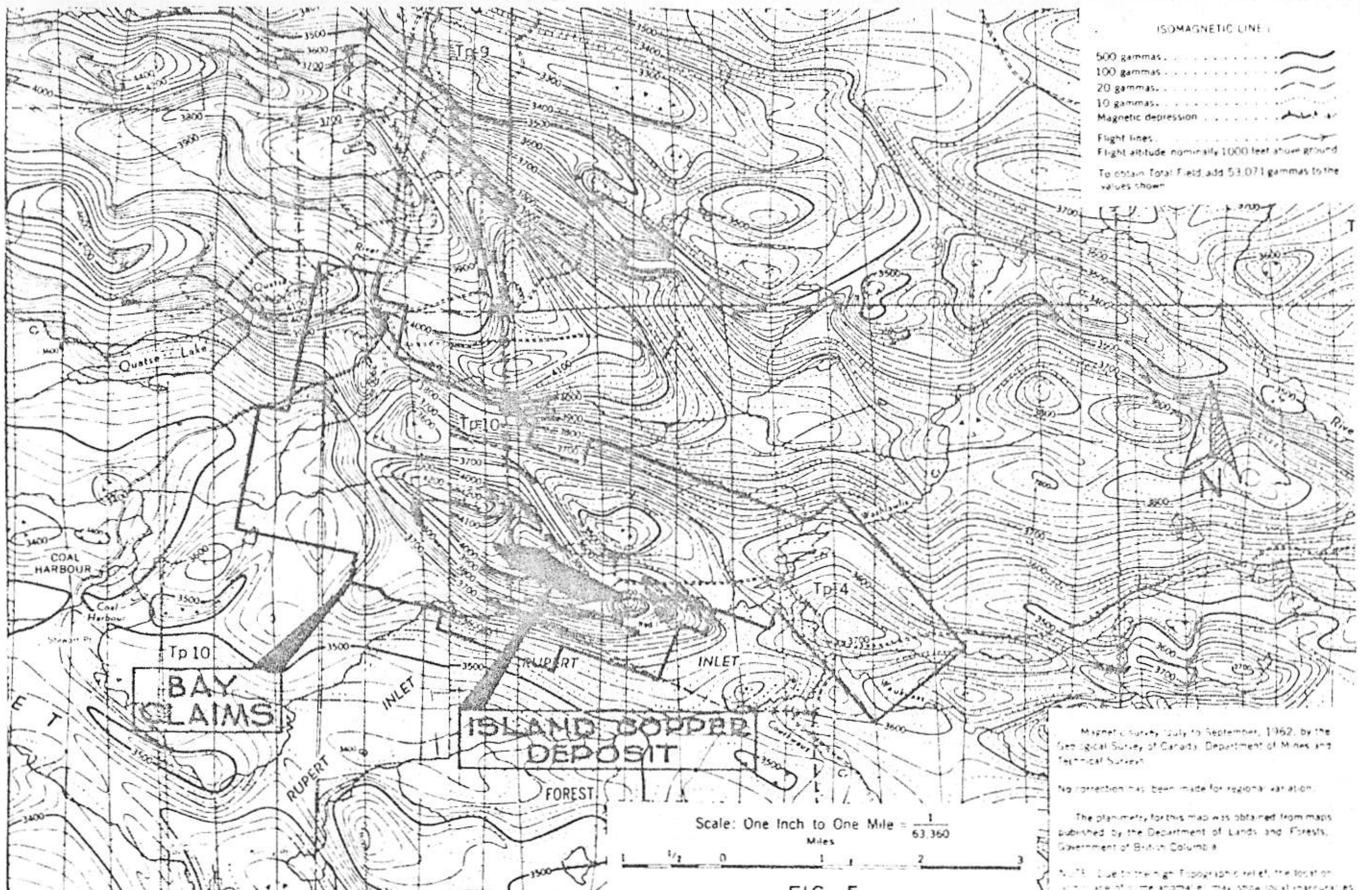

FIG. 5

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 aureole. 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) saussuritization 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

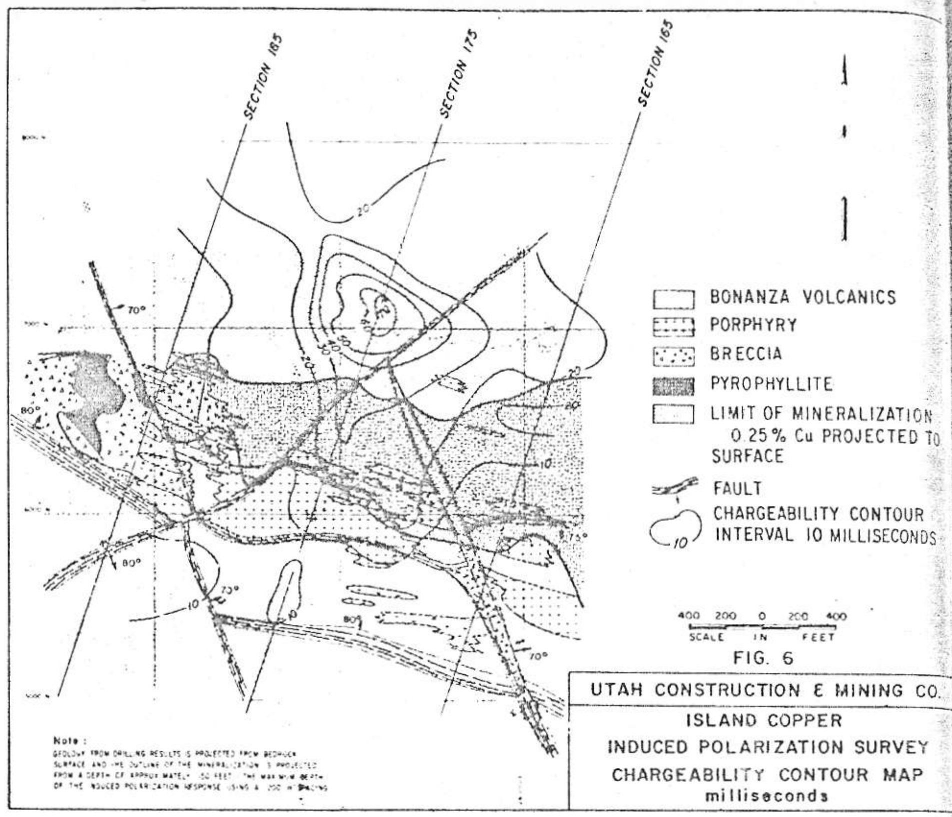

FIG. 6

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INDUCED POLARIZATION SURVEY
CHARGEABILITY CONTOUR MAP
milliseconds

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

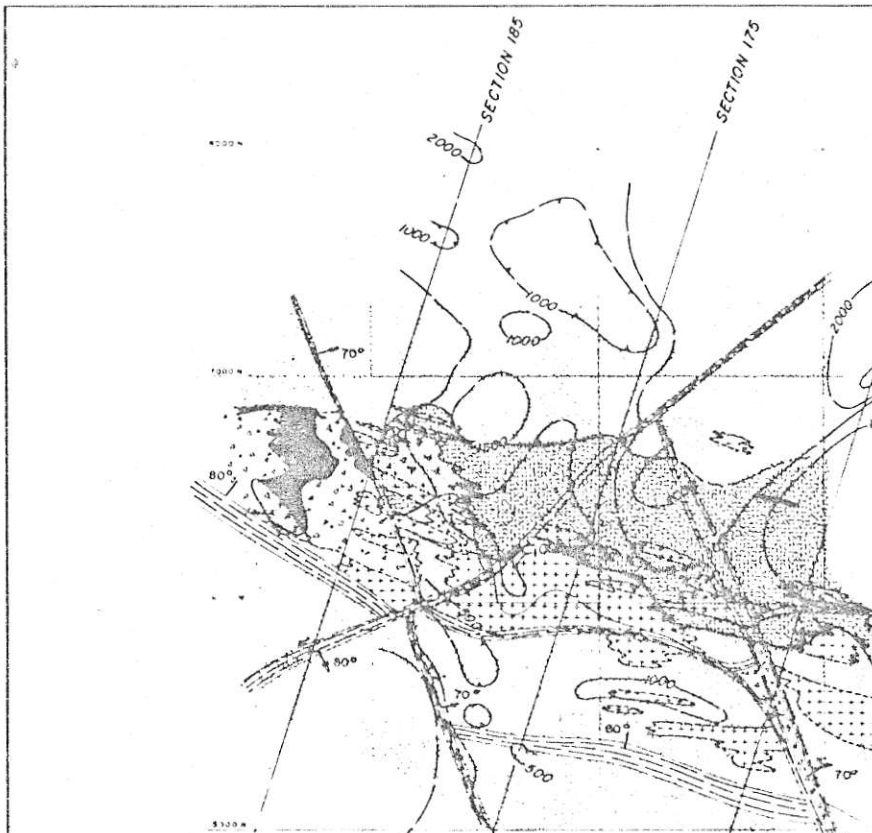

FIG. 7

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INDUCED POLARIZATION SURVEY
RESISTIVITY CONTOUR MAP
ohm - feet

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.

REFERENCES

The following references were of value in compiling information on the regional geology:

Dawson, G. M. (1887): Report on a Geological Examination of the Northern part of Vancouver Island and Adjacent Coasts; Geological Survey of Canada, Annual Report 1886, Volume 2, part B, pp. 1-107.

Gunning, H.C. (1929): Geology and Mineral Deposits of Quatsino-Nimpkish Area, Vancouver Island; Geological Survey of Canada Summary Report, 1929, Part A; pp. 94-143.

Hoadley, J.W. (1953): Geology and Mineral Deposits of the Zeballos-Nimpkish Area, Vancouver Island, B.C.; Geological Survey of Canada, Memoir 272.

Jeffery, W.G. (1962): Preliminary Geological Map, Alice Lake — Benson Lake, B. C. Dept. of Mines and Pet. Resources.

Jeletzky, J.A. (1969): Mesozoic and Tertiary Stratigraphy of Northern Vancouver Island (92E, 12L, 102I): Report of Activities, Part A: April to October 1968; Geol. Survey of Canada, Paper 69-1 Part A, pp. 126-134.

Muller, J.E. (1967): Port McNeill Area and Nanaimo Basin, Vancouver Island; Report of Activities, Part A; May to October, 1966; Geological Survey of Canada, Paper 67-1, Part A, pp 81-83.

Muller, J.E. (1968): Northern Vancouver Island (92E, K, L, 102I); Report of Activities, Part A; April to October, 1968; Geol. Survey of Canada, Paper 69-1 Part A, pp. 27-29.

O'Rourke, J.E. (1962): Geology and Ore Deposits of Northern Vancouver Island; Utah Construction & Mining Co. Private Report November 13, 1962.

Muller, J.E. (1969): Northern Vancouver Island 92E, K, L, 102I. Report of Activities Part A. April to October 1969. Geological Survey of Canada, Paper 70-71. Part A pp. 44-49.

Muller, J.E. and Carson, D.J.T. (1969): Geology and Mineral Possibilities of Vancouver Island, Canadian Mining Journal, May 1969, pp. 66-70.

Northcote, K.E. (1970): Verbal Communication.

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.