FILE NO: 92I

PROPERTY SUBMITTAL/EXAMINATION INFORMATION SHEET

KERR ADDISON MINES LIMITED

EXPLORATION KERR ADDISON INC.

820318

KERADAMEX INC.

SUBMISSION BY: _____

DATE SUBMITTED/EXAMINED: October 1983

PROPERTY NAME: Cominco's Valley Copper

COMMODITY: Cu

PROVINCE/STATE: BC.

MINING DIVISION: _____

TOWNSHIP/AREA: Highland Valley BC.

N.T.S./LAT.-LONG.: _____

REFERENCE MAP: _____

REVIEWED BY: _____

DATE REVIEWED: _____

SUMMARY & CONCLUSIONS: _____

RECOMMENDATIONS: _____

-183-921-

Valley Copper Tube

COMINCO - VALLEY COPPER - R. TAYLOR - DEC 7/83

- NEGOTIATING WITH SMP SHELTERS FOR PARTICIPATION. TO DATE SMPS ONLY INTERESTED IN LOAN
- WILL MAKE DECISION BY APRIL 30/84
- VALLEY COPPER IN PRODUCTION BEFORE RED DOG.
- RECENT FEASIBILITY STUDY PUT COSTS @ 200,000,000 IN 1983 $ — NO CONTINGENCY OR INTEREST.
- 1 - 34' MILL (40-45,000 MT/DAY) SAME AS FORMEX
- CORE RUNS 5.0 oz Ag/TON - ONLY MINOR Au - NOT PAYABLE
- RECOVERY ON NEW MILL 92% - OKC SOFTER (COARSER GRIND)
- CURRENTLY BREAK EVEN ON CASH COSTS @ US55¢/lb Cu.
- ANOTHER ORE ZONE (MINOR) ONLY DRILLED TO 300 FEET — MOLY
- MUST MAKE TAILS DEAL WITH FORMER WHO HAVE ONLY ACRES — LIKE ARB. TO SETTLE COST.

- EASY ONE TO TREAT
- ~~BUT~~ BETHLEHEM MILL 4 MILE HAUL + 1000'
- TAILS BY GRAVITY TO LOCKEY TAILS AREA (3 BILLION TON CAPACITY)
- BETHLEHEM TAILS GOOD FOR 17 YEARS
- EXPECT MUCH LOWER COST & BETTER RECOVERY WITH NEW MILL
- NEW MILL ONLY 1 CIRCUIT - SOME FLEXIBILITY WITH BETHLEHEM MILL OPERATING.
- PRESENT SMELTER CONTRACTS WITH SADS - HIGH GRADE ORE. IN DEMAND!

KERR ADDISON MINES LIMITED

(FOR INTER-OFFICE USE ONLY)

P.B.
J.K.C.
A.H.C.
~~D.M.H.~~
~~D.A.L.~~
J.B.S.
FILE

To File **From** J. K. Carrington JKC.
cc: P. Bojtos

Subject Valley Copper Economics **Date** November 2, 1983

Using the costs and revenues noted in my memo of October 24, Peter Bojtos has created a computer model for Valley Copper economics. Given that many of the parameters are mere guesstimates at this stage the results nevertheless are encouraging, even if somewhat relative.

Basic Parameters

Reserves:	800,000,000 tons @ 0.475% Cu and 0.003 opt Au.
Recoveries:	90% Cu; 80% Au.
Conc. Grade:	45% Cu: R.O.C. 100.
Production:	variable from 50,000 - 110,000 tons/day w/o ratio 1:1
Operating Cost:	variable ($3.05 @ 80,000 tpd)
Capital Cost:	$250,000,000 for 50,000 tpd plant (varying depending on production rate).
Ongoing Capital:	0.5% of initial capital/year.
Prices:	90¢/lb. Cdn. for Cu; $500/oz. Cdn. for Au (varies with scenario) NSR - estimated from typical Noranda contract.
Discount Rate:	12%

(Capital and operating costs estimation methods from O'Hara's paper in February, 1980 CIM Bulletin.)

Results ($Cdn.) - 20 yrs. only

	TPD	NPV_{12}
Cu $0.85/Au $475	60,000	($ 36.7 million)
	80,000	$ 14.7 " ?
	100,000	$ 70.1 "
Cu $0.90/Au $500	60,000	($ 1.8 million)
	80,000	58.0 "
	100,000	123.9 "

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To..... *From*.....

Subject..... *Date* November 2, 1983

Cu $0.95/Au $500	50,000	($ 2.7 million)
	60,000	$ 28.6 "
	80,000	$ 96.9 "
Cu $0.90/Au $475	80,000	$ 54.2 million
Cu $0.85/Au $500	80,000	$ 18.2 "

The results are given graphically on the accompanying sheet.

The results indicate:

(1) A daily production rate in the 70 - 90,000 tpd range is more attractive than the 50 - 60,000 tpd range.

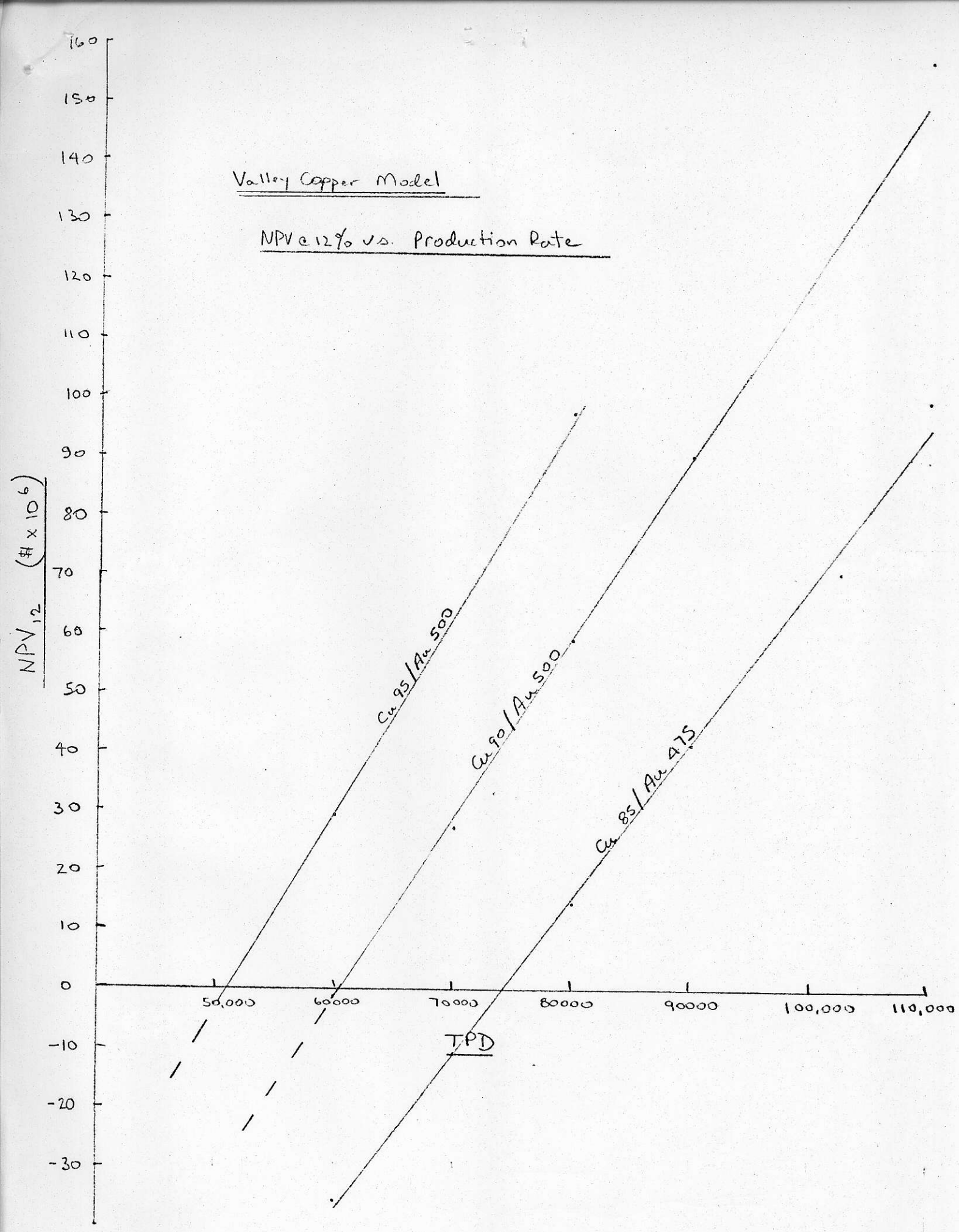
(2) At 80,000 tpd, the sensitivity to Cu and Au price is approximately:

±$7.9 million NPV_{12} for ±1¢/lb. Cu price change.

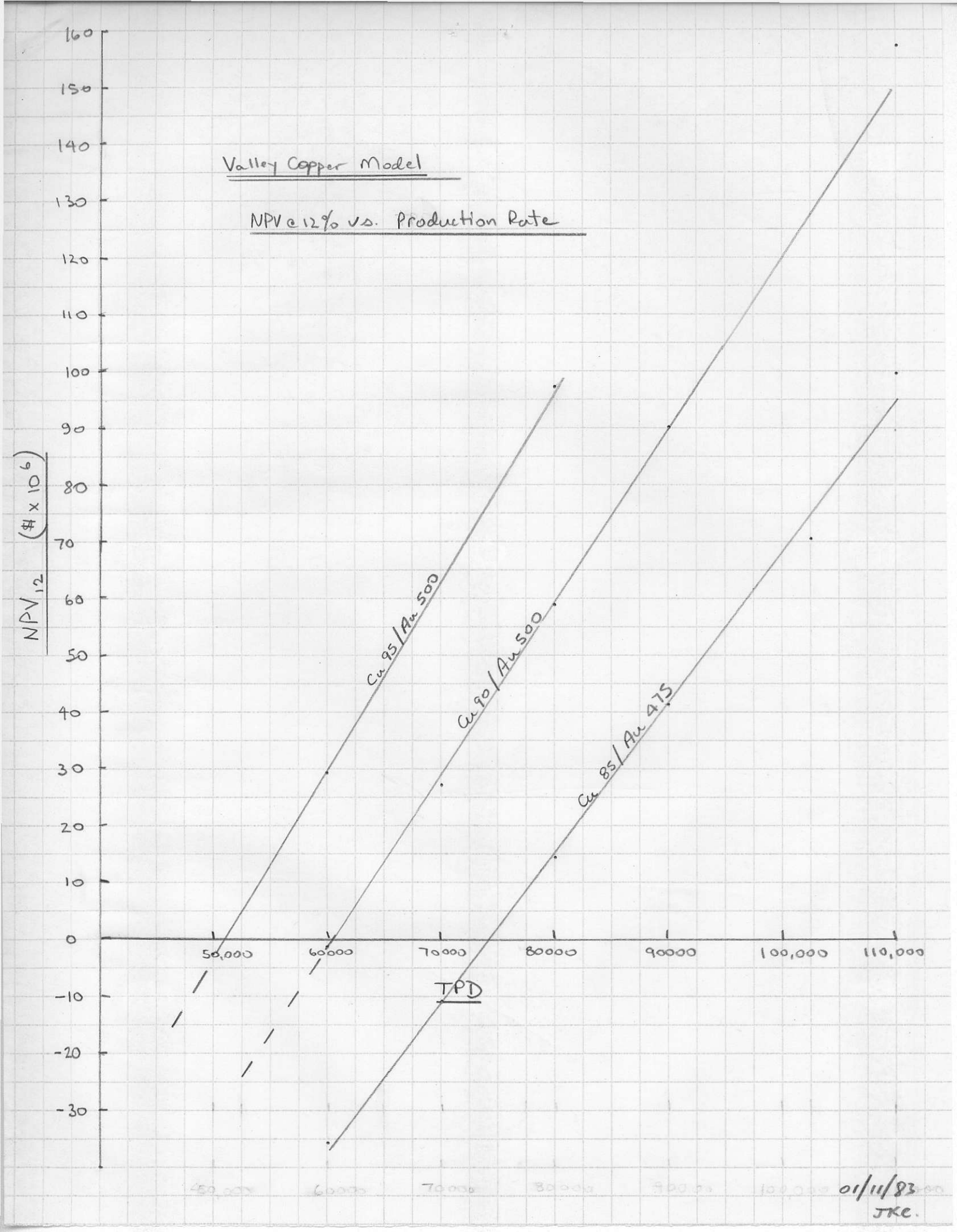
or ±$3.5 " " " $±50/oz. Au " " .

JKC/sm

Attachment


Valley Copper Model
NPV @ 12% vs. Production Rate
NPV12 (# x 10^6)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
Cu 95 / Au 500
Cu 90 / Au 500
Cu 85 / Au 475
50,000
60000
70000
80000
90000
100,000
110,000
TPD

01/11/83


Valley Copper Model
NPV @ 12% vs. Production Rate
NPV,12 (# x 10^6)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
50,000
60000
70000
80000
90000
100,000
110,000
TPD
Cu 95 / Au 500
Cu 90 / Au 500
Cu 85 / Au 475
01/11/83
JKE.

FBM PC Results

Valley Copper Nov. 1/83

Cu: 0.475% Cu 800 000 000 tons // 20 YRS

Cu 85 Au 475	TPD	O.C.	C.C.	NPV,12
	60000	3.40	279,688,000	(36, 743, 000)
	70000	3.21	306, 791,000	(11, 910,000)
	80000	3.05	332, 382,000	14, 185, 000
	90,000	2.92	356, 721,000	41, 514, 000
	100, 000	2.80	380, 000,000	70, 149, 000
	110,000	2.71	402, 364,000	99, 523, 000
Cu 90 Au 475	80,000	3.05	332, 382, 000	54, 166, 000
Cu 85 Au 500	80,000	3.05	332, 382, 000	18, 217, 000
Cu 90 Au500	60,000	3.40	279,688, 000	(1, 807,000)
	70,000	3.21	306, 791, 000	(27,352, 000)
	80,000	~	~	58, 069, 000
	90,000	~	~	90, 033, 000
	110,000	~	~	157, 824, 000
Cu 95 Au500	50,000	~	~	(2, 718, 000)
	60, 000	~	~	+ ~~28, 639, 000~~
	80000	~	~	+ ~~96, 909, 000~~
Cu 80/Au 475	90,000	~	~	-(4, 068, 000)
	100,000	~	~	+ ~~20, 331, 000~~
	110,000	~	~	+ 45, 477, 000

KERR ADDISON MINES LIMITED

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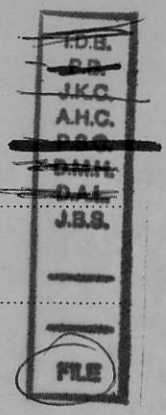

To File **From** P. Bojtos/J. K. Carrington

Subject Valley Copper Costs & Revenues **Date** October 24, 1983

Based on the statement in the L.O.M. Equity Review, October 14, 1983 that "the Valley Copper mine has a break-even cash cost of around $0.50 (Cdn.) per lb. of copper after precious metals credits of around $0.10 per lb." the following is an estimate of costs & revenues.

Cash Costs

Production: 20,000 tonnes/day @ 0.51% Cu & 90% recovery
Daily Cu production = 20,000 x 1.1 x 0.51 x 20 x .90
= 201,960 lbs.
Break-even daily cost = 201,960 x $0.60
= $121,000/day
B.E. cost/tonne ore = $6.06
/tonne ore = $5.51

Revenues

Production: 200 tonnes/day Cu conc. @ 45% Cu
Cu Price: $0.85/lb. Cdn.

Value of Production (SDT basis)
1 Ton conc. @ 45% Cu = 900 lbs. Cu @ $0.85 = $765.00

Deductions:

Freight, say $30/t	$ 30.00	/ton conc.	
Cu deduction, 1.1% (22#@$0.85)	18.70	"	
Smelter charge	100.00	"	
Anode freight, 1¢/lb. payable	8.78	"	
Refining charge, 10¢/lb. payable	87.80	"	
Marketing @ 3¢/lb. payable	26.34	"	
Insurance @ 20¢/$100 net value	0.99	"	
Total Deductions			272.61
Net Smelter Value			$492.39

NSR/lb. produced = $492.39/900 = 54.7¢
PM credit/lb. " 10.0¢ (L.O.M. report)

Total NSR revenue/lb. produced 64.7¢

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To..... *From*.....

Subject..... *Date* October 24, 1983

Concentration ratio = $\frac{20,000}{200}$ = 100/1 i.e. 100 tonnes ore provide 1 tonne concentrate.

Therefore Cu NSR/ton ore = $\frac{492.39}{100}$ = $4.92/ton.

Cu + PM NSR/ton ore = $\frac{(900)\ (\$0.647)}{100}$ = $5.82/ton

Summary

Cu NSR/ton ore at 85¢ Cu = $4.92
(Cu + PM) NSR/ton ore at 85¢ Cu = $5.82

Break-even cash costs/ton ore = $5.51

Current net operating profit = $0.30/ton ore
or $6,600/day

Check:

Pit currently using a 0.40% Cu cut-off.
B.E. Cut-off grade = $121,000/22,000 x 20 x .90 x .647
= 0.472% Cu equivalent.

Very approximately, the PM value = 20% of Cu NSR ($\frac{10}{54.7}$)

Therefore BE c/o grade = $\frac{.472}{1.2}$ = 0.393% Cu - i.e. close to current number.

PB/JKC/sm

KERR ADDISON MINES LIMITED

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~~P.D.B.~~
P.B.
J.K.C.
A.H.C.
~~P.S.C.~~
D.M.H.
~~D.A.L.~~
J.B.S.

FILE

To P. S. Cross/I. D. Bayer From J. K. Carrington
cc: D. A. Lowrie, P. Bojtos

Subject Valley Copper - Background Information Date October 21, 1983

A very preliminary look at this property has provided the following information.

The property is located in the Highland Valley of B.C. near the old Bethlehem Copper Corporation and Lornex mining operations. Discovery occurred in the 1960's with surface drilling and underground sampling being carried out from 1968 - 1970. Originally 20% of the orebody, known as the Lake zone, plus certain royalty and smelter rights were held by Bethlehem with the balance being owned by Cominco. Despite Bethlehem's stated wish to see the property in production, agreement on division of the revenues between Cominco and Bethlehem could not be reached. Between 1977 & 1981 Cominco gradually acquired a controlling interest and finally total control of Bethlehem.

Reserves are estimated at 726 million tonnes at 0.475% Cu, 0.005% Mo plus precious metals. How much? - Not stated, unfortunately

Initially c. 1981, plans called for an 80,000 tonne/day concentrator and mine at a cost over $900 million. Considered too dear, Cominco scaled down the scope and in July, 1982 started on a six month pre-production program to develop a 20,000 tonne/day mine using the existing Bethlehem concentrator and equipment fleet.

Production started offically in January, 1983. Production starts are:

MINE: Pre-production: 6 months; 7 million tonnes moved; $15 million.

Production: 20,000 tonnes/day ore; 19,000 tonnes/day waste
SR 0.95/1
-Ore is trucked 6.5 km. (one way) uphill (300 m. vertical elevation) to Bethlehem mill; waste haul 1 km.
-Pit slopes 38°; benches 10 m; haul road grades 8%; 6.7 m x 7.9 m drill pattern.
-Equipment: 4 x 195B Marion shovels; 3 x 45R BE drills; 21 x 100 t unit rig trucks; 5 dozers, 2 front-end loaders.
-To meet production requirements:
2 shovels, 1 drill, 13 trucks (10 ore & 3 waste) per shift.

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To..... *From*.....

Subject..... *Date* October 21, 1983

Bornite at Bethlehem? and Valley Copper? (Yes) ? ?

MILL: 20,000 tonnes/day; head grade 0.51% Cu; rec. +90%; concentrate grade 45% Cu (ore mineral is bornite); moisture content of conc. 8%; conc. prod'n approximately 200 tonnes/day.

3 stage crushing; 3 stage grinding; conventional froth flotation using large volume Outoukompu cells; mill has moly recovery circuit but uncertain if in use at moment.

PRODUCTION ECONOMICS:

Currently using a cut-off of 0.40% Cu to give 0.51% Cu head grade; 0.25 - 0.40% Cu material being stockpiled as low grade.

Valley Copper has contract with Japanese to deliver a total of 70,000 tonnes Cu conc. over two years.

L.O.M. Equity Review reports (October 14, 1983) that Valley Copper has a "break-even cash cost of around $0.50 (Cdn.) per lb. of copper after precious metal credits of around $0.10 per lb." ? of copper → per lb of Cu produced

FUTURE PLANS:

Cominco are planning to build a 45,000 tonne/day concentrator to handle the Valley Copper production at an estimated cost of $250 million. (Yes) According to L.O.M. the existing Bethlehem mill would continue to operate. (The N.M. has reported (May 19/83) that the Bethlehem mill would be a fine grinding plant and hence part of the new concentrator, I presume, although details are unclear).

JKC/sm

METALS & MINES : *comments on B.C. companies.*

Cominco ($58 3/8): *expect increased loss in 1983 but profit recovery in 1984.*

H. Reimer

The outlook for zinc is currently the most promising of all the metals and there is a good possibility that prices will average around $0.50 (U.S.) per lb. in 1984. Lead prices are showing some signs of recovery but there is a concern that, in the $0.25 to $0.30 per lb. range, scrap could start coming out. Fertilizer prices have improved since mid-summer and there are good prospects for improved deliveries for the fourth quarter and a much improved outlook for 1984.

The Valley Copper mine has a break-even cash cost of around $0.50 (Cdn.) per lb. of copper after precious metals credits of around $0.10 per lb. Cominco is now studying the possibility of expanding the operation by building a 45,000 tonnes per day mill in the valley at an estimated capital cost of $250 million. The existing Bethlehem mill would continue operating. This appears to be Cominco's first priority project at this time.

Cominco's second priority project is the Red Dog high grade zinc/lead/silver property in Alaska on which a feasibility study is being completed. Current planning is towards a start-up in 1988.

The outlook for the electronic metals division is excellent with estimated 20% per annum growth in profits. The company is currently producing gallium arsenide for computer chips and the company believes that it has a one to two year lead on its competitors.

The Vestgron mine has had a good shipping season but ore reserves are a concern with only four years proven; a heading is currently being driven which will take about one year to reach an area where surface drilling has indicated some interesting mineralization. The Polaris mine also had a good season with eight shiploads of concentrates, accounting for about 160,000 tonnes of zinc concentrate and 41,000 tonnes of lead concentrates. The operation is profitable on a cash basis at current prices.

Among other developments, studies are underway on the La Troya lead/zinc deposit in Spain while pilot plant studies are being carried out on a soda ash project in California.

Although most of Cominco's operations are profitable, earnings continue to be adversely affected by its high level of debt and interest charges. The third quarter losses will likely be worse than the losses in the second quarter because of lower fertilizer sales. We expect a profit in the fourth quarter but, for 1983 as a whole, losses could reach $1.00 per share. However, we still forecast earnings of around $3.25 for 1984. The stock remains expensive based on our 1984 earnings forecast.

COMINCO

(2) **Con mine**, gold prod, near Yellowknife, NWT. Shaft to 5,400 ft completed late 1976, & in prod early 1977. Lower grades & labor strike for 8 weeks reduced prod in 1981.1982, underground d d with encouraging results 60 m below workings; $13 million arsenic recovery plant start oper late 1982.

(3) **Polaris mine**, lead-zinc prod, Cornwallis & Little Cornwallis Isls, 75 mi from magnetic N Pole, world's most northerly base metals mine.

Nov 1979, Cominco announced plans to bring to prod in 1982 at cost of approx $162,300,000. Mill, power & service facilities constructed on 100 ft by 400 ft barge & towed to Little Cornwallis Isl & floated into permanent position; conc handling & storage facilities built on site; housing, recreation & dining facilities pre-cut & assembled on site.

Ore was first fed into the mill Nov 4, 1981; commercial prod began Feb 1982 with aver mill rate in 1982 of 1,475 tpd.

(4) **Potash prod**, 61,280 ac, at Vade, SW of Saskatoon, Sask. Extensive drilling indic large dep of high grade potash. In 1965, started $65 million project to bring prop into prod, 2 prod shafts sunk, plant installed with prod started late Mar 1969; capacity 900,000 tons potash products annually. Mine flooded Aug 1970, forcing shutdown; 1971-73, rehabilitated mine at cost $10,156,000, prod resumed Mar 1973.

Expansion program begun 1980 & completed Oct 1982, will incr capacity to 1,200,000 tons per yr; incl equipping 2nd shaft with new headframe & 2nd hoist. Summer 1982, 11-wk shut-down of plant for tie-in of expansion projects & 4 wks while new prod hoist commissioned. 1982, Acq adjacent land.

(5) **Magmont Mine**: lead-zinc-copper prod, 50% int, Bixby, Missouri; shut-down for 2 wks in 1982; dev of Magmont W orebody cont with completion of ventilation shaft expected 1983; also ore expected to contribute to prod in 1983.

(6) **Valley Mine**: copper prod, near Logan Lake, BC started prod Jan 1983 at 1/5 of ultimate potential by using Jersey concentrator; processing 23,000 tpd.

(7) Bethlehem Copper Corp, former wholly owned subsid, amalg with co Dec 1982—(a) **Jersey mine**, copper-molybdenum prod, 513 cl units, 32 km SE of Ashcroft, Highland Valley, BC; principal ore bodies have been in Huestis, Iona, Jersey & E Jersey pits.

E Jersey pit exhausted in 1965, Huestis pit exhausted in 1976, & Iona exhausted in 1979. All ore coming from Jersey pit expansion which closed June 1983, when became uneconomic.

(b) J-A orebody discovered 1971, 2.5 km S of Bethlehem mill on same cl group; res minable by open pit 286,300,000 tons aver 0.43% copper & 0.017% molybdenum (0.25% cutoff); res suitable for underground mining (block-caving) est 130,000,000 tons aver 0.51% copper & 0.27% molybdenum; studies carried out since 1972, but dev considered not economical at present.

(c) Maggie dep discovered 1969, 16 km N of Cache Creek, & 55 km NW of mine; 43,500 ft d d indic res of approx 200,000,000 tons aver 0.27% copper & 0.028% molybdenum; considered not economic to mine at present.

(d) Copper-gold-silver pros, 225 cl units, 11,000 ac, Fish Lake, 175 mi N of Vancouver, BC; optioned 1979, from Taseko Mines L, & can earn 80% int by bringing prop to prod. In 1979, perc d 14 holes; 1980, geol evaluation, surveying, metallurgical research, prelim capital & oper costs studies; dep considered economic mining oper at 25,000 tpd. Explor in 1981 incl core d d & deepening existing holes to confirm res; also explor & drill peripheral areas containing anomalous gold. 1982, geophys & geochem surveys, 5,085 ft perc d, & d d; W extension to main dep delineated but insufficent d d to determine res. Additional 60 units acq in area.

(e) Through jt vent in Nevada, acq int in Buckhorn mine, former gold-silver prod; large rotary d program in 1980; also engineering studies & metallurgical testing; mill facilities on care & maintenance basis pending reactivation of mine.

Production, Yr to Dec 31

	1982	1981	1980
Sullivan mine:			
Ore milled, tons	2,446,000	2,436,000	2,351,000
Lead conc, tons	170,600	148,000	121,000
Aver grade, %	5.0	4.4	3.9
Zinc conc, tons	131,000	131,200	105,200
Aver grade, %	3.2	3.2	2.7
Polaris mine:			
Ore milled, tons	518,000	—	—
Zinc conc, tons	142,400	—	—
Aver grade, %	17.0	—	—
Lead conc, tons	45,900	—	—
Aver grade, %	7.0	—	—
Con/Rycon:			
Ore milled, tons	234,200	194,000	212,000
Aver grade, oz	0.36	0.41	0.48
Gold prod, oz	79,500	74,800	96,900
Vade mine:			
Potash prod, tons	794,000	1,087,000	1,009,000
Jersey mine:			
Ore milled, tons	3,341,000	7,161,000	6,924,000
Aver grade, %	0.38	0.39	0.38
Copper conc, tons	11,000	22,900	20,900
Magmont mine:			
Ore milled, tons	1,107,000	1,127,000	1,084,000
Lead conc, tons	44,500	49,200	54,500
Aver grade, %	6.5	7.0	8.0
Zinc conc, tons	7,000	7,900	6,600
Aver grade, %	1.0	1.1	1
Copper conc, tons	2,900	1,000	2,400
Aver grade, %	0.3	0.3	0.4

Magmont mine is jt vent with Cominco American & Dresser Industries; tons of conc shown is Cominco's 50% sh of prod.

Ore Reserves, Dec 31:

Oper Mines:	1982	1981	1980
Sullivan, tons	49,000,000	51,000,000	53,000,00
Grade lead, %	4.4	4.5	4.5
Grade zinc, %	6.1	6	6
Grade silver, oz	1.0	1.1	1.1
Polaris, tons	11,000,000	—	—
Grade lead, %	4.4	—	—
Grade zinc, %	15.2	—	—
Magmont, tons	5,200,000	5,500,000	5,700,000
Grade lead, %	9.4	7.8	8.1
Grade zinc, %	1.2	1.1	1.1
Grade silver, oz	0.3	0.3	0.3
Rubiales, tons	14,300,000	14,300,000	14,200,000
Grade lead, %	1.2	1.2	—
Grade zinc, %	6.9	7.0	—
Grade silver, oz	0.4	0.4	—
Con/Rycon, tons	2,100,000	2,100,000	2,200,000
Grade gold, oz	0.47	0.49	0.49
Valley, tons	500,000,000	—	—
Grade copper, %	0.475	—	—
Warm Springs, tons	7,300,000	7,300,000	—
Grade P_2O_5, %	30.0	30.0	—
Vade, tons	155,000,000	99,000,000	102,000,000
Grade K_2O, %	25.3	26.3	26.3

Refined Metal Production

Yr to Dec 31:	1982	1981	1980
Zinc, tons	225,800	260,900	233,000
Lead, tons	126,600	131,500	130,000
Silver, oz	9,681,000	7,721,000	8,917,000
Gold, oz	24,800	20,600	24,400

Other Properties: BC: (1) At Pinchi Lake, approx 15 mi from Fort St. James, BC, holds mercury former prod. New trackless underground prod oper & 800 tpd capacity surface plant started in 1968. Oper suspended 1975 due to depressed mercury price.

(2) At Duncan lead-zinc prop, Lardeau dist, considerable underground explor via adit, 1956-60.

Base metals

Smelters weathering supply shortages

From our Japanese correspondent

JAPANESE copper smelters are currently experiencing a tightening of supply in copper concentrates, and will continue to do so through 1984-85, but despite the alarm that has been raised about this in some industry circles most smelters said the shortage will not become critical if prices remained stable, or gradually climbed. It had been supposed that the shutdown of Anaconda's Butte mine and the start up of the Pasar smelter in the Philippines would lead Japanese concentrates buyers on an urgent quest for new feed sources, but the major smelters do not seem too worried at present, largely because refined copper production in Japan is down by roughly 10% this year (MB Jan 25).

Of Japan's six major copper smelters — Sumitomo Metal Mining, Mitsui Mining and Smelting, Mitsubishi Mining, Furukawa Mining, Dowa Mining and Nippon Mining, — only the latter has been seriously affected by Anaconda's closure. If last year's concentrates imports of 3.6m tonnes were to be lowered by 10%, this would match almost exactly the 390,000 tpy traditionally bought from Anaconda.

As well, Duval in the US has agreed to supply 100,000 tpy of copper concentrates to Nippon Mining, which will thus help to offset the loss of the Anaconda material, and Nippon also said the Pasar smelter, which admittedly has diverted concentrates from the Philippines which traditionally accounted for over 23% of Japan's concentrates imports, was a factor that the Japanese industry had been expecting and the industry is not seriously disrupted by the loss of the Philippine feed.

Thus the smelters are not as badly off as earlier feared, and should be able to survive the predicted concentrates tightness until 1986-87 when it is believed that projects in the US and Canada, which had closed in the wake of last year's price slump, would reopen. The only danger for the Japanese would seem to be if there were a sudden jump in demand for copper on the world market which would entail Japanese producers resuming full production, or even expanding their current capacity. If that were to happen, and most analysts think it highly unlikely, then the inevitable short term scramble for supplies could send the price of concentrates soaring.

Barring that, the Japanese producers are confident that reliable supplies from Chile, Peru, Indonesia and Canada will see them through the next two years. One smelter official said that the Valley Copper project, which had been operating since January of this year (MB Jan 18) would supply 70-80,000 tpy to Japan, and that Westmin Resources HW project should be producing 60,000 tpy from early 1986.

However, from the producers MB canvassed, it appears the keenest Japanese interest lies in the copper production second stage of Papua New Guinea's Ok Tedi mine. With proven reserves of 377m tonnes of ore grading. 0.7% copper, the project could produce 81,900 tonnes of concentrates in 1986 and rising to 120,000 tpy by 1988. Led by Nippon Mining, the large Japanese smelters are anxious to participate in the project's second stage, supplying $100-200m of its $60 overall cost. Talks between the two sides are continuing.

While it seems clear that the larger smelters are reasonably well protected in terms of supply, since they have global purchasing power, large financial assets to tide them over during difficult periods, and even access to their own mines around the world, the smaller smelters which buy from Peru, Indonesia, Australia and elsewhere under joint purchasing arrangements with companies such as Bougainville in PNG and Ertzberg in Indonesia, could be squeezed.

While a Nittetsu Mining official acknowledged that all small smelters were having a difficult time at present, the idea that they might contemplate a merger is considered at best a long term possibility. A Miti spokesman said his ministry had neither plans nor policy for the amalgamation of the smaller smelters.

Cominco opens Lake Zone mine JA18/83

COPPER production commenced this week at Cominco's Lake Zone mine in the Highland Valley of British Columbia. Beginning January 17 the company expects to process 20,000 tpd of ore grading 0.48% copper to produce close to 80,000 tpy of concentrate containing in excess of 40% copper, a company official told MB.

The new mine cost $17m to develop, the official said, but using existing equipment and infrastructure from the former Bethlehem mine should allow Cominco to operate the mine profitably even at existing copper prices. Although the official would not say whether sales agreements had been signed, he confirmed most concentrates would be exported to the Far East.

company's molybdenum operations and a setback in iron ore sales snuffed out the nascent recovery this quarter and earnings from operations as a whole totalled only $1m compared with $25m last quarter. Large writedowns in moly and copper inventories and higher losses in magnesium and tungsten than in 1982 were also severe weights on the company this quarter.

On the positive side, the continued drops in interest rates and corporate expenses along with the pared back operations in the areas of highest losses should mean Amax has staunched the losses and can look forward to improved financial results next quarter. As well the company managed to wring earnings from its nickel operations this quarter due to improved margins and silver and copper earnings were up for the quarter, although still below satisfactory levels.

More significantly Amax's aluminium sector, through its 50% that company chairman Pierre Gousseland stressed in presenting the corporation's results to a meeting of analysts in Paris last Thursday.

"Alumax is the most energy efficient producer in the US" he stated, and with capacity of 656,000 stpy from three primary plants, the company is well placed to benefit from growth in aluminium demand. Predicting earnings of approximately $50m for Alumax in 1983, Gousseland extrapolated the current bullish trends to forecast Alumax earnings of $110m for 1984.

The growth in the importance of aluminium to Amax, concurrent with reduced but still important assets in the company's traditional base metals, moly and tungsten gives Amax "three legs to stand on" — energy, aluminium and the other activities. This tripartite structure will return Amax to base line profitability next year, Gousseland said, but whether it will be in the first or second

Output down slightly but Chile presses on

CHILEAN copper production in the first seven months of the year dropped slightly, to 705,600 tonnes compared with 733,000 tonnes in the same period last year but sources in that country said the decrease is a minor aberration which will not affect the country's long term expansion plans. Much of the drop is attributed to lower output at Codelco mines, which has offset a slight increase this year in copper from the small and medium sized mines in Chile. One official said Codelco enjoyed unexpectedly high ore grades last year and a drop to "more normal" ore grades in 1983 has resulted in a production fall off. This means that Codelco is expected to produce about 1m tonnes in 1983, down from 1,033,000 in 1982, while the smaller mines will contribute about 230,000 tonnes, up slightly from last year.

Looking further ahead, the official said Codelco is committed to an expansion plan which will see it produce 1.4m tonnes in 1987-88 and 1.7m in 1993-95. At the same time output from the smaller mines will grow to 300,000 tonnes and 500,000 tonnes respectively.

When asked about civil disturbances either in the mining areas or in the port cities which could affect copper production and exports, officials at both the Chile said no disruptions are anticipated. "Chilean copper output is dictated by economics, not by politics," one said, and stressed that no major disturbances had occurred to date, despite the violence which has made headlines around the world. He pointed to the march on Oct 16 of 1,000 workers at the Chuquicamata mine in northern Chile, which went ahead but did not disrupt production, and said both production and exports were proceeding as planned despite the political tension.

Exports of copper in the first seven months totalled 675,800 tonnes, down slightly from the 688,000 in the same period last year, but company officials said they expect to export only slightly less than last year's total for the year as a whole.

Anamax's Twin Buttes operation continues to produce electrowon copper cathodes although the strike is soon to enter its fourth month. Relying on stockpiled oxide ore, and operating at about 50% of the output it had before the strike using supervisory staff, the plant can continue in this manner for several months yet, officials at the site told MB. Talks between workers and management are currently suspended and officials said there was no quick settlement in

Valley Copper file — ex Levesque Beaubien Analysis July '83

The keys to Con's improved performance over the next few years will be higher gold prices and higher output (mining of higher grade ore) which will keep 1985 costs per ounce almost flat relative to 1982 levels. Some additional gold output (perhaps 3,000 ounces per year) will come from a new arsenic trioxide recovery plant completed in 1982 at a cost of $13 million. The plant is primarily an environmental project however, designed to clean up accumulated arsenic wastes (over a 6 or 7 year period) and is not expected to make a significant contribution to profits until 1985.

Magmont (50%)

The Magmont mine, located at Bixby, Missouri, is primarily a lead producer but also produces minor amounts of zinc, copper and silver. The mine has experienced declining grades for several years, a phenomenon which is expected to continue with the development this year of a new low grade deposit. With lead prices not expected to approach their former levels and ore grades declining, we believe that Magmont's profits in this cycle will be 60% lower than the last peak in 1979. The following table summarizes Magmont's operating and financial record for the period 1978-82 and our forecasts for 1983-85:

TABLE XI — COMINCO LTD.

MAGMONT SALES & FINANCIAL RESULTS

	1978	1979	1980	1981	1982	1983E	1984E	1985E
Operations								
Payable Lead (million lbs)	76	81	84	65	69	72	70	60
Payable Zinc (million lbs)	11	10	7	8	7	8	8	8
Payable Copper (million lbs)	2	3	3	2	2	3	3	3
Payable Silver (000 oz)	130	124	133	114	131	130	130	130
				— ($ millions) —				
Financial								
Revenues	35	50	46	31	24	24	35	34
Operating Costs	18	15	18	18	21	21	23	22
Operating Profit	17	35	28	13	3	3	12	12

Note: Amounts represent Cominco's 50% share
Sources:Reported Corporate Data, Lévesque, Beaubien Inc. estimates.

Valley Copper (100%)

After a decade of anticipation, the Valley Copper mine was finally brought onstream in January 1983 at an operating rate of 23,000 tons per day, one-fifth the originally projected rate. Cominco has not abandoned plans to operate Valley Copper at a higher rate, but it is likely that this will involve a staged expansion occurring over a long period of time (2 or more cycles). The first expansion, which could technically occur in this cycle, would involve modifying the Bethlehem mill and building a new 40,000 ton per day mill closer to the pit, while the next stage would be a twinning of the new mill. As the total capital cost of such an undertaking would likely exceed $600 million ($5,000 per ton of copper), it is not surprising that it will be spread out over a long period of time. The interest on $600 million is equivalent to nearly US$0.30 per pound, raising the break even point (1985 dollars) to the US$1.25 per pound area for the expanded operation, a price level which we cannot see as being sustainable in this cycle.

As far as recent results are concerned, the Valley Copper mine is proving to be profitable even at today's low copper prices. The mine will produce 35,000 tons of copper in concentrate in 1983 and if prices hold up, a $7 million operating profit is expected on revenues of $53 million. With copper prices expected to rise to the US$1.40 per pound area by 1985, Valley Copper will earn a $35 million operating profit on revenues of $89 million. This may sound very good, but it must be remembered that in order to get control of the Valley Copper orebody, Cominco had to borrow $200 million, all of which is still outstanding (interest on this debt is treated as a general corporate obligation and is no longer charged to the mine).

Red Dog (100%-50%)

Red Dog is Cominco's mine for the next cycle. It is such an impressive and important deposit that it deserves a detailed review at this time. The following report originally appeared in the Mining Journal of March 25, 1983, and is a summary of a talk given in March by Mr. G.D. Tikkanen of Cominco.

> "With indicated reserves to date of some 85 Mt of ore grading 17% zinc, 5% lead and 2.4 oz/ton silver, the Red Dog deposit in Alaska is believed to be the world's largest and probably highest grade zinc-lead deposit amenable to open pit mining methods. The project is a joint undertaking between Cominco American Inc., and the NANA Regional

		1982	1981
Ore milled[1]	tons	1,107,000	1,127,000
	(tonnes)	*(1,004,000)*	*(1,022,000)*
Lead			
Average grade		6.5%	7.0%
Concentrate	tons	44,500	49,200
	(tonnes)	*(40,400)*	*(44,700)*
Concentrate grade		78.9%	78.4%
Zinc			
Average grade		1.0%	1.1%
Concentrate	tons	7,000	7,900
	(tonnes)	*(6,400)*	*(7,200)*
Concentrate grade		60.0%	60.8%
Copper			
Average grade		0.3%	0.3%
Concentrate	tons	2,900	3,500
	(tonnes)	*(2,600)*	*(3,200)*
Contained in concentrate	tons	900	1,000
	(tonnes)	*(800)*	*(900)*

[1] *This mine is a joint venture of Cominco American Incorporated and Dresser Industries Incorporated. Ore milled reported is at 100 per cent; the tons of concentrate reported is Cominco's 50 per cent share of production.*

Con Mine

Ore produced at the Con gold mine in Yellowknife, N.W.T., is milled and refined there and the gold is sold in Canada.

Revenues were $37 million in 1982, compared with $40 million in 1981, a result of lower prices for gold. Operating profit was $7 million in 1982, compared with $13 million in 1981.

Despite lower grades encountered and difficult mining conditions in mechanized stopes, gold production increased principally because of a significant increase in mill throughput. Mining was carried out in an area where ore was of lower grade than the average grade of the ore reserves. Underground diamond drilling produced encouraging exploration results at levels 60 metres below the present mine workings. As well, reserves were added in areas adjacent to workings.

The $13-million arsenic recovery plant started operations late in the year and production of refined arsenic trioxide started in December. (See "Environmental Protection", page 19.)

There were 353 persons employed at the beginning of the year and 309 at year-end.

		1982	1981
Ore milled	tons	234,200	194,000
	(tonnes)	*(212,400)*	*(176,000)*
Gold			
Average grade	ozs/ton	0.36	0.41
Production	ounces	79,500	74,800
	(kg)	*(2,471)*	*(2,326)*

Copper Division

On December 31, the wholly owned subsidiaries Bethlehem Copper Corporation and Valley Copper Mines Limited were amalgamated with Cominco. The business and operations of these subsidiaries are now conducted as Cominco's Copper Division which operates the former Jersey concentrator and the new Valley Mine.

Jersey Mine

The Jersey copper mine is located near Logan Lake, B.C. It operated for the first six months in 1982.

Revenues in 1982 were $25 million, compared with $32 million in 1981. The operating losses in both 1982 and 1981 were $5 million.

During its 1982 operation the average grade of ore mined was 0.38 per cent copper. The combined effects of the low-grade ore and the depressed price of copper necessitated an early reduction in the waste stripping program as an interim measure to cut costs and sustain the operation. By mid-year the copper market had weakened to the extent that mining of the Jersey pit was uneconomic. Consequently, operations ceased on June 30.

The concentrate production during the six-month operating period was 25,900 tons *(23,500)*, compared with 66,900 tons *(60,700)* for the year 1981.

There were 373 persons employed at the beginning of the year and 316 when the mine closed in June.

		1982 6 months	1981 12 months
Ore milled	tons	3,431,000	7,161,000
	(tonnes)	*(3,113,000)*	*(6,496,000)*
Copper			
Average grade		0.38%	0.39%
Contained in concentrate	tons	11,000	22,900
	(tonnes)	*(10,000)*	*(20,800)*

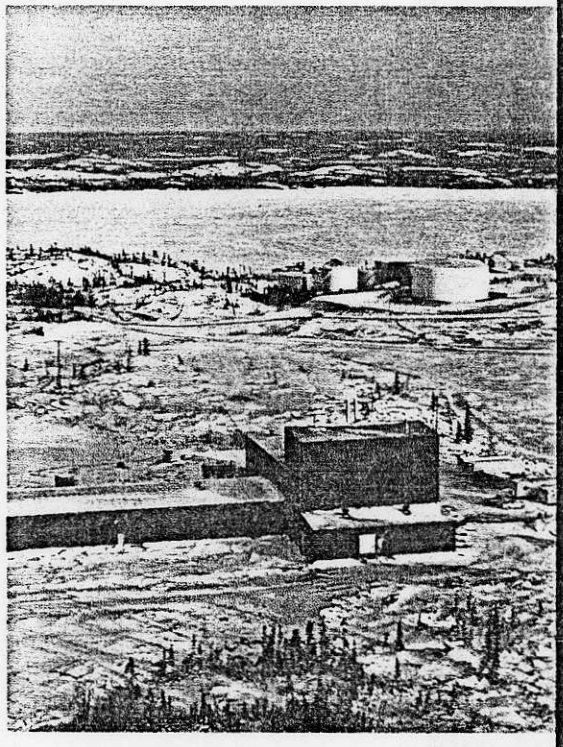
Valley Mine

The Valley Mine, near Logan Lake, B.C., started production in January, 1983. The ore reserve is estimated to be 800 million tons *(725 million)* with an average grade of 0.475 per cent copper, and as such represents the largest known porphyry copper deposit in Canada.

The depressed price of copper during 1982 led to a reassessment of the initial size of development of this deposit. The proposed large-scale development that was under consideration in 1981 was deferred early in 1982. Instead, with the shutdown of the nearby Jersey Mine, a plan was implemented successfully at a capital cost of $15 million to commence operations at this mine at a scale of approximately one-fifth of its ultimate potential by utilizing the Jersey concentrator. Preproduction stripping and stockpiling of ore began in July 1982, using personnel and equipment from the Jersey Mine, and the mill was producing copper concentrate by mid-January, 1983. The Valley Mine will process 23,000 tons of ore a day *(21,000)*.

The combined effect of improved ore grade, easier grinding and higher recovery is expected to result in an increase of copper contained in concentrates from 22,900 tons *(20,800)* obtained from the Jersey Mine in 1981 to approximately 35,300 tons *(32,000)* for the year 1983. The higher level of production together with a lower stripping ratio will result in significantly lower unit cost of production. There were 360 persons employed at the Valley operations at the beginning of 1983.

~70,000 tonnes Cu conc/yr @ 45% Cu grade



The unique technology for the arsenic recovery plant at the Con Mine was developed by the Technical Research Centre at Trail and Cominco Engineering Services Limited.

Cominco's Valley mine now producing

British Columbia's copper-rich Highland Valley and Logan Lake, the town it supports, has waited a long time to see Cominco's Valley Copper deposit come on-stream.

After years of discussions and delays, costs of putting the mine into production at a rate of 80,000 tonne/day skyrocketed to over $900-million. Scaling down the operation to 20,000 tonnes/day, Cominco started mining the 726-million tonne deposit in January 1983, using the concentrator acquired when Cominco purchased Bethlehem Copper Corporation. Preproduction work was completed in six months, at a cost of $15-million.

The mine now employs about 400 people, joining other copper-producing giants in the area — Teck Corporation's Highmont mine and Lornex Mining Corporation — as a major job provider in the region.

In April'83, *Western Miner* mentioned some brief details about start-up of the Valley Copper mine (p41). Following a recent visit to the mine, on the occasion of the official mine opening, here are more details of the operation.

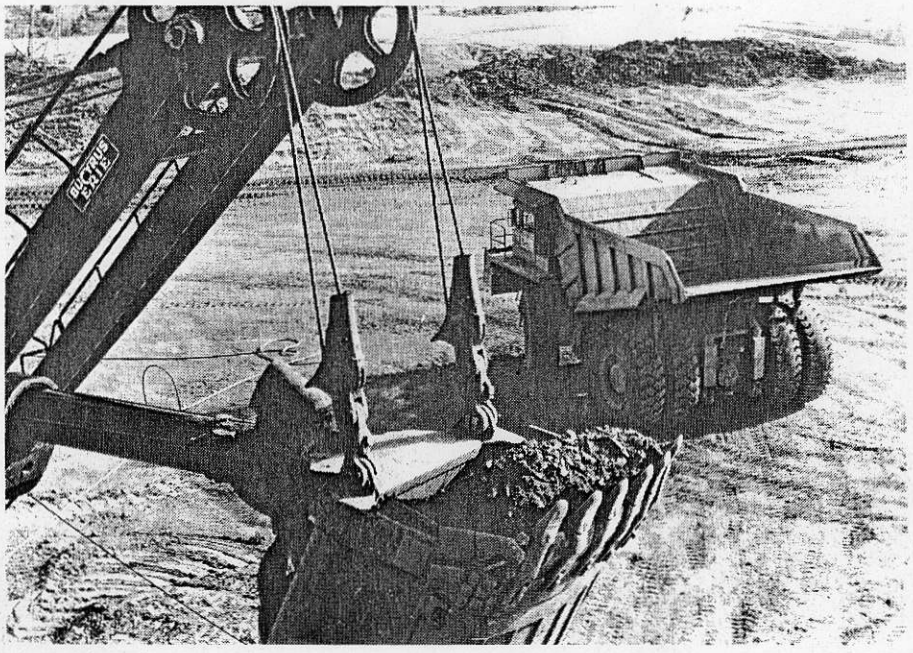
HISTORY

The Valley ore deposit was discovered using geophysical techniques in the first half of the 1960's. Discovery of the neighbouring Lornex orebody and the development of a structural-geologic model based on that information led to the correct target selection for IP survey work. The anomalies discovered were explored by a percussion drilling program in 1968, which resulted in an estimated 600-million tons orebody grading 0.48% copper.

Subsequently in 1969 and 1970 further drilling was carried out and an underground exploration program provided bulk samples for metallurgical testing and a platform for underground inclined drilling. Ore reserves of 726-million tonnes grading 0.475% copper and 0.005% molybdenum were announced.

Preproduction stripping of the orebody started in July 1982. At the same time a haul road between the Bethlehem concentrator and the Valley orebody was started. Because the haul road crosses the main Highland Valley highway it was necessary to construct a bridge capable of supporting a loaded 154-tonne truck. (Bridge Construction, Using Reinforced Earth, was described in *Western Miner*, March'83 p18.)

Bucyrus Erie electric shovel at Cominco's Valley mine
A 100-ton truck backs up prior to loading in the open pit



MINING

Eight 10m benches are developed on the west flank of the valley. The ore, which is mined at a rate of 20,000 tonnes/day, is trucked a distance of 6.5km to the mill situated on the east side of the valley. A strip ratio of 0.95:1 calls for the removal of 19,000 tonnes/day of waste and low grade material. The waste is trucked one km to the north and is placed to form a foundation for low grade stockpiles.

Primary production equipment consists of four Bucyrus-Erie 195B shovels, three 45R drills, twenty-one 100 ton Unit Rig trucks, five dozers and ancillary equipment. Two front-end loaders provide a loading facility at the crusher stockpile and other odd jobs. The mine works on a continuous shift basis and operates two shovels, one drill and 13 trucks on each of the operating shifts. Ten of the trucks are used on the ore haul; a complete cycle requiring 40 minutes.

Pit slopes are in the order of 38° and result from ongoing groundwater and geotechnical studies. Ramps have a design grade of 8%. Drill patterns are laid out on a 6.7m by 7.9m pattern and provide for 2m of subgrade. Presheared line holes, a buffer zone, and sequential blasting are employed to reduce backbreak and wall shock.

A cutoff grade of 0.4% Cu. is presently providing a head grade of greater than 0.5% Cu. Material between 0.25% and 0.39% is being stockpiled for future processing. Grade control and mine design is being assisted by computer application. A reclamation proposal to cover the life of the property has been submitted to the Government for approval. Work on the $100,000 1983 phase, the restoration of old mine dumps, is currently in progress.

PLANT

The plant operation comprises crushing, grinding and flotation through which a daily 20,000 tonnes of run-of-mine trucked ore is processed to yield a final product of 200 tonnes mineral sulfide concentrate grading 45% Cu.

Crushing is a conventional three-stage operation starting with a 1070mm x 1650mm Allis Chalmers gyratory crusher ahead of a 2130mm Symons standard cone unit which in turn feeds a final stage of a pair of 2130mm shorthead cones. The initial two stages are open-circuit, with a 2440mm x 4880mm, 2¼ deck vibratory screen ahead of the standard cone for pebble selection and scalping of undersized particles. The final cones are closed by a pair of 2440mm x 4880mm screens decked to yield a crushed product sizing minus 15mm.

Grinding is also a three-stage operation. The crushed ore is passed through a total of nine Dominion Engineering tumbling mills and emerges as a ground pulp of particles sizing minus 0.25mm (41% minus 200 mesh).

Primary grinding is by three open-circuit, 3810mm x 4570mm, 900 kW rod mills. The secondary stage comprises three 3350mm x 4270mm and one 3200mm x 4270mm ball mills drawing an average 700 kW. These are closed by 1020mm and 1270mm Krebs cyclones. The final grinding stage comprises a pair of 5030mm x 9750mm pebble mills, each drawing 2.2 MW and closed by a cluster of 508mm Krebs cyclones. These final mills employ selected coarse ore chunks, sizing 75-125mm, as the grinding medium and as much as 3000 tonnes of daily throughput is accounted by pebble construction.

Flotation treatment consists of roughing, scavenging and cleaning stages along with two regrind mills interposed to handle middling materials. Roughing is carried out by a combination of Outokumpu OK38, Agitair No 120, and Denver No 30 machines. Rougher tailing is classified by a cluster of 208mm Krebs cyclones to feed a sand scavenging section of Agitair No 96 machines and a counterpart slime scavenging section of Britannia deep air cells. These produce the final plant tailings.

Two stages of cleaning are applied to the rougher product. The initial cleaning is by a line of Denver No 30 units and the finishing treatment utilizes a line of Denver No 24 units.

Regrinding is accomplished by a pair of 2130mm x 2440mm Allis-Chalmers ball mills each drawing 150 kW. One mill treats rougher concentrates while the other grinds sand scavenger concentrates. Both circuits are closed by a cluster of 254mm Krebs cyclones.

Dewatering of the copper concentrate is carried out through a 10600mm thickener feeding to a six-disc 1830mm vacuum filter. The finishing treatment through a 1220mm x 8530mm oil-fired kiln dryer takes the moisture level to a terminal 8% H_2O.

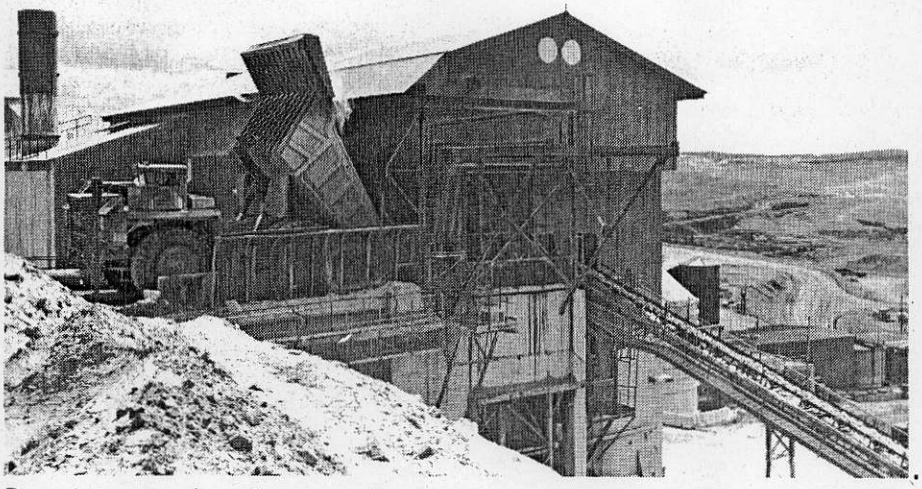
At current production rates, the Valley Mine will produce more than 32,000 tonnes/year of copper concentrate.

In late February, only six weeks after production started, the initial 5000 tonnes of copper concentrate was shipped from Vancouver to Japan. Cominco's Copper Division has contracts to sell 70,000 tonnes over two years to Japanese buyers. By the end of April 16,000 tonnes had been shipped to Japan.

The Valley Mine was one of the first developments in BC to come under new provincial guidelines to license new projects. One of the requirements was investigation of possible heritage sites affected by mine development.

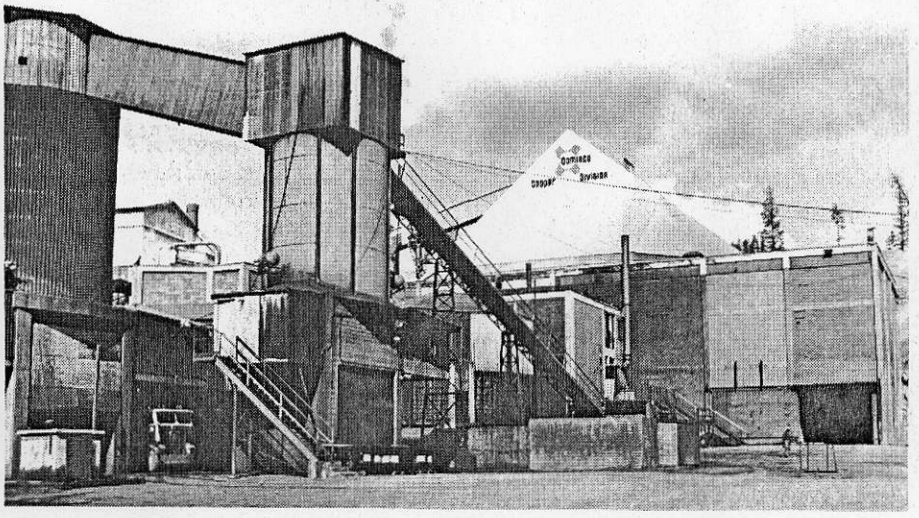
A $70,000 archeological survey funded by Cominco turned up evidence of one of the earliest human dwellings in the interior of BC. Artifacts have been removed for further study.

As well, Cominco made the first contribution of $250,000 to a Provincial Government 'Habitat Conservation Fund' to compensate for the loss of three lakes to be drained as the Valley Mine expands. The fund is for habitat enhancement at or near development sites. *WM*



Dumping ore at the primary crusher

Valley Mine concentrator, formerly operated by Bethlehem Copper for treating ore from its Jersey mine



Canada-wide

activity in the mining world

Gillian Cobban

Cominco looks ahead

At the annual general meeting of Cominco Ltd (21 Apr 83) mention was made of 'one of the worst years in our economic history'. As Cominco chairman, M Norman Anderson, put it: 1982 was an awful year.

From then on, the talks became more positive and hopeful, though Norm Anderson, in mentioning forecasts for recovery, warned that it would be wrong to think in terms of a robust recovery.

Cominco had recorded its first annual loss since 1932. However, the company was in a good position to benefit as the economy slowly improves. Governments must never forget that to consume we must first produce. Government policies must produce fertile, not sterile, assets. All, including industry, must live within our means.

Cominco has reduced capital spending and operated more lean and efficiently. Capital and investments were: $480-million in 1981; $230-million in 1982; and will be not more than $120-million in 1983. Cominco is now operating with about 2200 less people than 15 months earlier, yet at about the same production levels.

It has been difficult to lay off good people, and to face shutdown at Pine Point.

On the positive side, the zinc plant modernization at Trail is nearly complete; the Saskatchewan potash plant has been expanded 25%; Valley Copper stage 1 is operating; the Con arsenic plant was completed; a new gallium arsenide plant, now operating, is due to expand. The Polaris mine was on stream for part of 1982.

Future investments. W G Wilson, president of Cominco, reported on company activities, including some of the plans for the future.

Original plans to bring **Valley Copper** on stream (perhaps with another international mining company) at 88,000 tonnes a day were re-assessed in 1982. The unprofitable mining operations at Bethlehem Copper were discontinued in June 1982. The Valley orebody was then developed on a more modest scale, and the ore trucked some 6.5km to the Bethlehem concentrator.

In January 1983 the Valley Mine started operations. With great support from the workforce, the mine came on stream at a cost of $15-million; some 20% under budget and six weeks ahead of schedule. In Feb-March 83 milling rate was nearly at capacity, at 22,000t/d. Grades mined were about 0.51% copper, and recovery over 90%.

Even at current copper prices, Cominco is operating this mine profitably. Reserves are 800-million tons of ore, and there is opportunity for expansion to 80,000-100,000t/d.

Gallium arsenide. A very promising new material for semi-conductors for the electronic industry, a high demand is projected for gallium arsenide. Cominco's Electronic Materials activity is in a good position for developing gallium arsenide wafers for new chip technology.

Red Dog Project. The Sullivan mine has been the backbone of Cominco for 77 years. It is expected that Valley Copper will also become a great mine for many years. The mine of the future, into the 21st century, may well be the Red Dog.

The Red Dog zinc-lead-silver deposit in Northwest Alaska was announced by Cominco in February 1982, following an agreement with Nana Corporation, an Alaskan native organization. Development will be expensive, but the deposit is of 'magnificent proportions'. Indicated reserves, so far, of 85-million tons of ore grade 17.1% zinc, 5% lead, 2.4 oz/ton silver. It may be the world's largest and highest grade Zn-Pb-Ag deposit, and it is amenable to open pit mining. This one deposit more than doubles Cominco's world-wide zinc and lead reserves, and almost quadruples its silver reserves.

Other projects. As projects to be considered for the future, when conditions improve, Norm Anderson also mentioned: Troya Mine, in Spain, could be a promising, though small, operation (lead-zinc, with some copper and silver). A feasibility study for a 900t/d operation will be undertaken.

A nitrogen fertilizer expansion in Alberta is a possibility; and a soda ash plant could be a project in California.

The many other operations and interests of Cominco are outlined in the 1982 annual report. Cominco Ltd, #2300, 200 Granville St, Vancouver BC, V6C 2R2.

EAGLET MINES LIMITED

Andrew H. von Kursell

ANDREW ROBERTSON, President and CEO of EAGLET MINES LIMITED, is pleased to announce that ANDREW H. von KURSELL has been appointed as EAGLET General Manager and Chief Engineer.

Mr. von Kursell holds a degree in Mining Engineering from McGill University and is a Registered Professional Engineer in both Ontario and Yukon. He has an extensive background in large tonnage production.

Mr. von Kursell previously headed up the Cyprus Anvil Mining Corp., Faro, Yukon operation after six years as Superintendent at Cominco Pine Point Mines. Before coming west he was at Algoma Ore Properties, Wawa, Ontario for six years, where he obtained a broad mining background.

Eaglet's Fluorspar deposit at Quesnel Lake, B.C. is preparing for a feasibility production report under Mr. von Kursell's direction. The immediate program entails extensive underground development of the mineralized zone to provide material for a pilot mill metallurgical test as well as verification of the diamond drill results and information for the planning of the mining system. All phases of the ultimate production complex are now under development.

COGLA Exploration Agreements

During 1982, 47 exploration agreements for rights in the Arctic and East Coast offshore were negotiated under the Canada Oil and Gas Act. In its first annual report, the Canada Oil and Gas Lands Administration (COGLA) notes that the agreements, covering about 26-million hectares, involve 65 wells to be drilled in the next six years at an estimated cost of $3-billion.

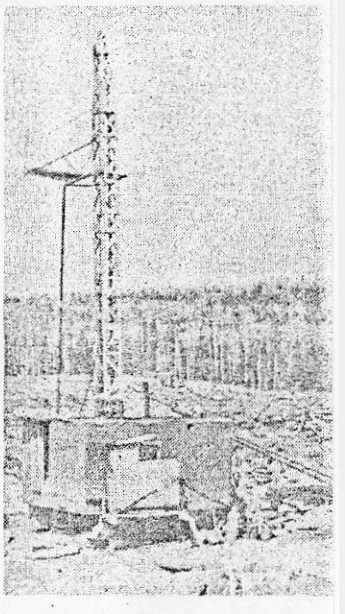
Expenditures by the oil and gas industry in 1982 amounted to

Feature on DRILLING – Sections

The Northern Miner

MAY 19, 1983 VOL. 69 NO. 11

FOUNDED 1915 CANADA'S MINERAL RESOURCES NEWSPAPER — MINES, OILS, GAS — $1.00



Some of the 10 drills under c Golden Giant deposit.

Aim at 60,000 tonnes

Valley Copper expansion seen likely

By David Duval

LOGAN LAKE, B.C. — Cominco's Valley Copper mine near here is now "officially" in production although it's a scaled-down version of the original 80,000-tonne-per-day operation proposed several years ago. But according to Roger P. Taylor, president of the company's copper division, the chances of Valley going ahead with the most recent expansion proposal to 60,000 tonnes "are high indeed."

Arguing that "bigger isn't necessarily better" Mr. Taylor explained that Bethlehem Copper started up at a lower production rate (3,000 tons per day) before it was expanded and this is the route Cominco would wish to follow. The Bethlehem mill is now handling 20,000 tonnes of Valley ore per day and millheads are currently averaging 0.5% copper with a cutoff grade of 0.4% in the pit.

Although the company still considers the expansion plan "a proposal" Cominco wants to construct an entirely new mill (40,000 tonnes) and convert the old Bethlehem mill into what essentially will be a fine grinding plant. There will be no crushing or screening plant and mill feed will be pumped up in slurry form from the main mill through a pipeline. The additional tailings generated from the expanded rate will likely go into the Lornex tailings pond.

Japanese consumer representatives attending the opening ceremony unanimously agreed the proposed expansion will be carried out and one senior official said he hoped "it comes soon." Shipments to Japanese consumers commenced six weeks after production started and Cominco's copper division has contracts to sell 70,000 tonnes of copper concentrate to buyers in Japan over the next two years.

Citing the profitability of the existing operation with metal prices at historic lows, Mr. Taylor said this fact alone was a good indicator of the project's future viability but, he added, "the expansion is dependent on satisfactory economic conditions over the next few years."

William Price, manager, mine operations, told The Northern Miner that Valley Copper will probably be about the lowest-cost producer in

See Page A2

More ventures to follow

$200-million BP-Petro-Canada oil sands project confirmed

By Nicholas Cotter

CALGARY — The post mega-project oil sands era, brightened considerably by federal and provincial tax and royalty concessions, was given an accelerated push forward early this week by BP Exploration Canada and Petro-Canada as they confirmed a commitment to proceed immediately on the development to commercial production of BP's Wolf Lake oil sands venture in Alberta.

It's a $200-million project that will involve estimated additional capital spending of more than $750 million over a 25-year operating life. BP and Petro-Canada, which are joint partners in the venture, expect the project will be in production at about 7,000 bbl. oil per day in 1985. Production will qualify for the new oil reference (or world) price.

"I believe there's great opportunities for projects like this (in Alberta)", said federal Energy Minister Jean Chretien at a government-industry media event in Calgary.

Commented Mr. Chretien's provincial counterpart, John Zaozirny: "It's very significant for Alberta . . . it's a milestone for Aostra (the Alberta Oil Sands Technology and Research Authority). This is the first project that was initiated by Aostra and the private sector." Aostra invested about $14 million in the cyclic steam project.

Both levels of government are taking heavy credit for fiscal "concessions" that cleared the way for the BP-Petro-Canada commitment.

And both levels of government are confident that the project ushers in a new era of staggered oil sands developments, with capital

Possible gold producer a step closer in Quebec

The possibility of another gold producer in Quebec has loomed a little closer, with news that the Sulli-

Queenston and Inco give mine green light

As expected, Queenston Gold Mines and Inco Limited are going ahead with development of an open pit gold mine near Kirkland Lake, Ont.

The two companies say work will start this month on the new mine, which has geological reserves estimated at 550,000 tons, at a grade of 0.15 oz. gold per ton. Anticipated mine life is from 3-5 years, although Queenston President Michael Gray tells The Northern Miner exploration underground could expand this life span.

As part of the joint agreement, Inco will rehabilitate the former Upper Canada mill, about one

Noranda scram Golden Giant fe

By Kerry Knoll

MARATHON, Ont. — Nora Exploration Co. is holding bac long as it can with the feasib study on the development of Golden Giant deposit. In a sc ble to gain as much informatio possible about the shape and siz the orebody before the study is the company continues work probe the deposit with 10 deep d

Under the terms of its agreem with **Goliath Gold Mines** **Golden Sceptre Resources,** Nora has until the end of next week present a report outlining its p

50% dividend hike

Lac Minerals u

By Peter Envers

Lac Minerals had several item good cheer to impart to its sh holders at the annual meeting. start with, President Peter A announced a 50% increase in company's dividend rate to 30¢ share per annum, starting wit semi-annual disbursement of 15 June 3 to shareholders of record M 24. The previous dividend was per share on Dec. 1 last.

Then, too, Lac is looking at hig production of gold in 1983 tha had predicted earlier, thanks t new agreement with **Noranda M** for the treatment of ore from Mine Doyon for a period of e months. The Cadillac, Que., a

n

pproaching 0.10 oz. gold

s of 2.5 million tons aver-
) oz. gold per ton would
1,000-ton-per-day milling
for seven years, adds
ian.

edominantly oil and gas
is also moving on another
mining project — the 95%-
cture Butte coal property
ridge in southern Alberta.
nbrian is in talks with
rading firms on what the
calls "an exclusive coal
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ity interest in the Picture
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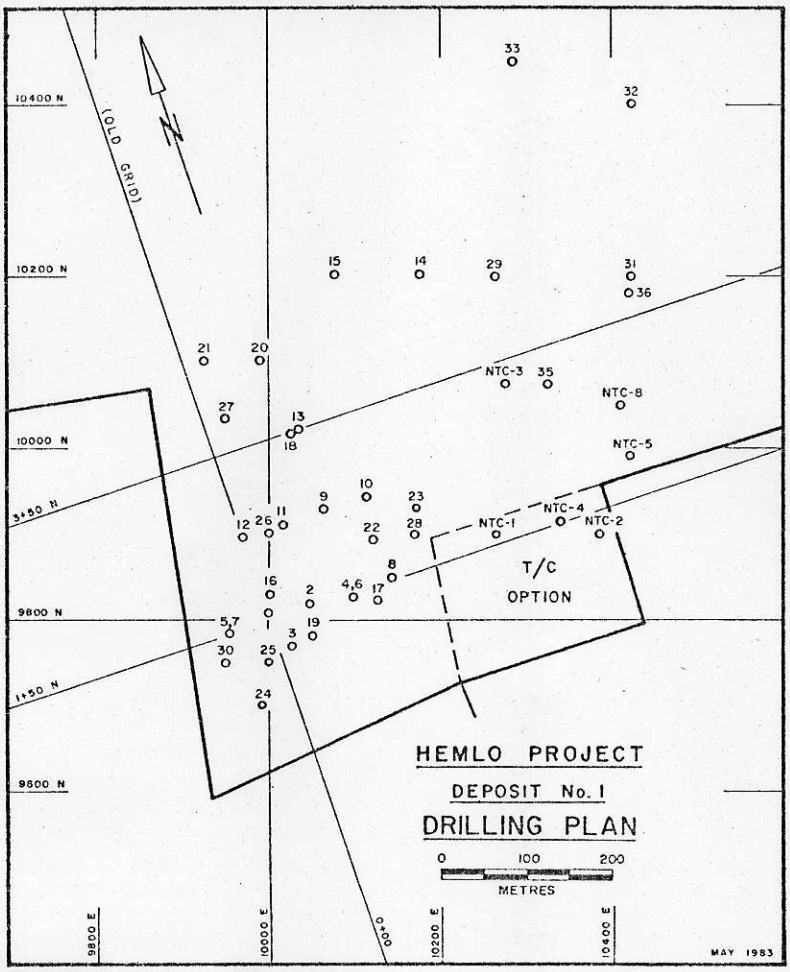
ner said any sale of equity
in the Picture Butte
o Japanese interests would
minority interest.

e-Or placement

tions Banque-Or says it is
a private placement of
ately $250,000 for further
its Klotz Lake gold pros-
e Thunder Bay district of

viously reported (**N.M.**,
3), the company has been
g a gold-bearing zone on
rty and so far has com-
out 6,000 ft. of drilling.
Paul Martin reports that
4 intersected 16.8 ft. of
gold per ton at a depth of
1 ft.

Noranda Golden Giant



The Golden Giant drilling plan.

From Page A1

esting to note that these intercepts trace the zone 600 ft. along strike from the three claims involved in the dispute with **Lac Minerals.** Referring to those results, President John Harvey of Noranda Exploration says that while he "wouldn't want to think they have changed the feasibility study, they might have changed the location where we will begin mining."

The two holes, NGG-35 and NGG-36, graded respectively 0.755 oz. and 0.703 oz. gold per ton over true widths of 44.3 and 44.7 ft. The holes were collared 300 ft. apart.

To keep up the fast drilling pace Noranda has set up a camp that houses 120 staff including contractors on the property. And The Northern Miner understands the company is planning to expand this to 650 workers during the course of the construction phase.

While Noranda's major target is obviously the Golden Giant deposit, the company continues to evaluate its other holdings in the Hemlo area with a massive exploration program.

Senior district geologist Garth Pierce tells The Northern Miner that indicate there would be further drilling: "The best tool you can use for exploration in this area is a drill," he said when asked what exploration techniques Noranda will be employing. "One of the main lessons from Hemlo is that we previously thought we knew the Shield and this proves there is a lot more thinking to do. If your exploration program is too rigid you can miss something."

He estimates that it could take ten years to completely assess the area. "They are still exploring at Timmins," he notes, "and we are just getting our feet wet here. There are no authorities on Hemlo and I think it is important to realize that."

Mr. Pierce says Noranda's approach will be to test the properties with all available methods. "We will throw everything at it until we find a formula that works. One of the biggest mistakes you could make is picking a follow-up program before you have tried everything."

He doesn't think any future discoveries would necessarily be restricted to the type of deposit outlined on the Goliath property. "There is probably going to be more

Valley Copper

From Page A1

North America. Even though its production rate doesn't compare to some of the other low-cost operations in B.C., the company's unit costs are cheaper because the grade of 0.47% copper is considerably higher than its porphyry copper competitors.

Also, the stripping ratio is slightly less than one-to-one (waste to ore), the ore is softer, and there's more bornite (a high grade copper ore) which means over-all recoveries are higher.

Following removal of seven million tonnes of overburden in 1982, the Valley mine achieved production in mid-January with Cominco opting for a "staged development" because of depressed copper prices. Brought into production at a cost of $15 million which was $3 million under budget, the mine also came on stream six weeks ahead of schedule.

Complete control to the Valley Copper deposit, which has ore reserves of some 800 million tons grading 0.475% copper, resulted from the merger of Valley Copper mines and Bethlehem Copper (two wholly-owned subsidiaries) on Dec. 31, 1982.

Besides the extensive stripping required to expose the orebody for mining, Cominco constructed a haul road from the minesite about 3.7 miles to the crushing plant at the concentrator. A round trip cycle to that area takes about 40 minutes, explains Cominco. In order to avoid the hazards associated with heavy trucks crossing the Ashcroft-Logan Lake highway, the company also constructed an overpass to resolve this problem. The bridge now forms a prominent landmark at the mine and the first official truck load of Valley Copper ore crossed the impressive structure after a ribbon-cutting ceremony May 13.

BP-Petrocan

From Page A1

The BP-Petro-Canada development will proceed from two pilots that BP has operated in the Wolf Lake area, located 250 km northeast of Edmonton.

Under the project's fiscal regime, the federal government is providing earned depletion allowance and relief from the oil and gas revenue tax until capital costs have been recovered.

Alberta's royalty regime provides for nominal royalty payments until the project sponsors have recovered their development costs.

The new project will generate 450

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DERGROUND MINING — Sections A, B

rn Miner

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turgeon Lake area

a, for instance, located vest of the 113-claim roperty, is now totally x Lookout recording nt geologist Donald ented that what the iza seems to indicate is lon't want to be caught Hemlo discovery."

Hansen nor Mr. Janes willing to elaborate as ecific companies in- e staking, but The er is informed on sev- that are, including urces, Ego Resources Resources. It's also at Gossan Resources and Keezic Resources are staking in the area.

A spokesman for Canadex Resources, for instance, says the company picked up 31 claims in the area over the past year, and is currently staking more, to the south of the Steep Rock property. He said "it's quite a rush up there." Canadex is associated with Santa Maria Resources, Swansea Resources and Playfair Mines, in the staking.

See Page A2

n decision y year-end

and the subsequent ck market activity. nd now, Inca has drill ves of 1.9 million tons Zone, grading 0.128 ton within 400 ft. of l of this is pretty well e notes. Although the o rises dramatically zon (to approximately

e Page A2

Pezamerica negotiating with Denison Mines

Pezamerica Resources has revealed it is negotiating with Denison Mines for the exploration of the 1,300 claims Pezamerica recently staked 40 miles east of the Hemlo gold discoveries.

Murray Pezim, chairman and president of Pezamerica, tells The Northern Miner that the negotiations are focusing on a joint venture deal that would see Denison reimburse his company for costs to date on the project and that participation would then be on a 50-50 basis. Further details are expected next week.

Cominco resumes work at Bethlehem after $18 million in expenditures

By David Duval

VANCOUVER — Finally — a breath of fresh air in the base metal sector. Cominco says full scale production should be under way by mid-February from the Lake Zone deposit at its Cominco Copper Division in the Highland Valley near Ashcroft, B.C.

Mining has already resumed but it will take several weeks before a 20,000 metric ton throughput is reached at the Bethlehem mill, which has undergone some modifications to improve its efficiency.

Cominco says over $18 million has been spent on the project since last July and much of it went towards renovating the crushing plant, mostly for a vacuum system and insulation work. Power was also brought down to the new mining operation which is approximately 6.8 km by road and 300 m vertical below the Bethlehem minesite. Approximately 5.2 million tonnes of stripping was completed to expose the higher grade deposit for mining.

Compared to the previous grade of 0.38% copper from the Jersey pit, the Lake Zone averages 0.475% copper and while precious metals content is relatively minor in the copper concentrate, these metals enhance the overall grade significantly, adds Cominco.

Besides the grade improvement, the metallurgy of the Lake Zone is much better, which should boost recoveries even though some of this will be offset by increased haulage distances. In the future, consideration is being given to installing conveyors although the mining rate would probably have to be much higher to warrant this, The Northern Miner gathers.

At the moment no consideration is being given to reactivating the

See Page A26

First full year

Co-Enerco to spend $30 million on exploration in Western Canada

By Nicholas Cotter

CALGARY — In its first full year of operations, **Co-operative Energy Development Corp.** (Co-Enerco) will spend about $30 million on conventional oil exploration in Western Canada during 1983.

"We're trying to build from a base in conventional production," Co-Enerco president David Martin advises The Northern Miner.

To date, Co-Enerco has received about $116 million of the joint $200 million in initial funding committed in equal amounts by co-operatives from across Canada and by the federal government.

Co-Enerco recently completed its $103 million purchase of the Canadian oil and gas assets of **Sabine Corp.**, including reserves of six million bbl. oil and gas liquids and 82 billion cu. ft. of gas.

Recent production has averaged 1,500 bbl. oil per day and 10 million cu. ft. of gas per day.

"For the next year, we're anticipating production of 1,600 bbl. oil per day and 12 million cu. ft. of gas per day . . . about 68% of oil production is NORP (new oil reference price) oil," says Mr. Martin.

Co-Enerco is projecting a 1983 cash flow of between $13 million and $15 million after interest costs.

Mr. Martin says that most of Co-Enerco's 1983 exploration will be concentrated on prospects within Alberta "although we hope to expand activities into Saskatchewan and Manitoba."

Land holdings acquired through the Sabine purchase amount to 526,000 gross (182,000 net) acres, with most of the acreage located in Alberta. Prospects are also held in Manitoba, Saskatchewan and British Columbia.

Asked about the likelihood of Co-Enerco's participation in frontier exploration, Mr. Martin said the current emphasis is on building a strong asset and cash flow base in the conventional petroleum sector.

"We're a little small yet to get into

See Page A2

ıo acquiring gold bets Northgate, Red Summit

eter Envers

uing restructuring of lorthgate Exploration make Consolidated urces its outlet for a d exploration push in

the approval of its early next month, agreed to acquire 0% interest in their

ing Northgate's present 15% interest in Orofino to approximately 70%, making it a controlled subsidiary. Regulatory approvals, of course, are also a requirement.

"For the immediate future, Orofino will be the major exploration vehicle within the Northgate group," John F. Kearney, executive vice-president of Northgate and president of Orofino, tells The

Strong profit rebound

Saskatchewan attracts Scurry for oil search participations

Cominco

From Page A1

molybdenum circuit in the mill since markets for the metal are flat and will probably continue to be for the forseeable future.

In what appears to be an emerging trend in this province, the CAIMAW Local 8 union agreed to extend its old contract which terminated Oct. 31 for another year and has agreed to work towards maintaining and improving productivity at the mine.

Cominco says performance will be reviewed monthly and should the operation not be viable after three months management and the union have agreed to discuss ways of avoiding a shutdown.

Cominco estimates its breakeven point at 72¢ per pound copper and hopes that when the Lake Zone production reaches the market the price will be higher.

Meanwhile negotiations are reported under way between Cominco and the union at **Pine Point Mines** which could see that operation reopened if an acceptable agreement can be worked out.

Gold bullish

From Page A1

shrank on the down moves. Most of the activity was centered in the futures markets of New York and Chicago, in contrast to the cash bullion markets in London, Zurich, Hong Kong and Singapore where volume dwindled as the Christmas holidays approached.

Despite the prolonged interruption in dealings around the end of December, the upward momentum did not falter. **Confirmed short sellers had, by the end of 1982, given up all hope that the bear market in yellow metal would resume and take quotations to below the $295-per-oz. level which, in all likelihood, marked the end of bullion's long decline from over $850 in early 1980.**

At the London fixings, the yellow metal was set at the beginning of the month at $440 per oz. By Dec. 7, the buying momentum had pushed the gold price up to $460 in London trading. Selling pressures by producers and central banks forced quotations down to around $434 from where the price jumped to $453 on Dec. 17, followed by another relapse.

A third attempt to jump the $460 hurdle succeeded on Dec. 29, when the fixing price climbed to $460.50. The last fixing price for 1982 was $448, as dealers squared their accounts for year-end balance sheet purposes.

Futures markets

Gold futures markets during De-

The Highland Valley – Canada's newest copper centre

Cominco's Bethlehem purchase paves way for Valley development

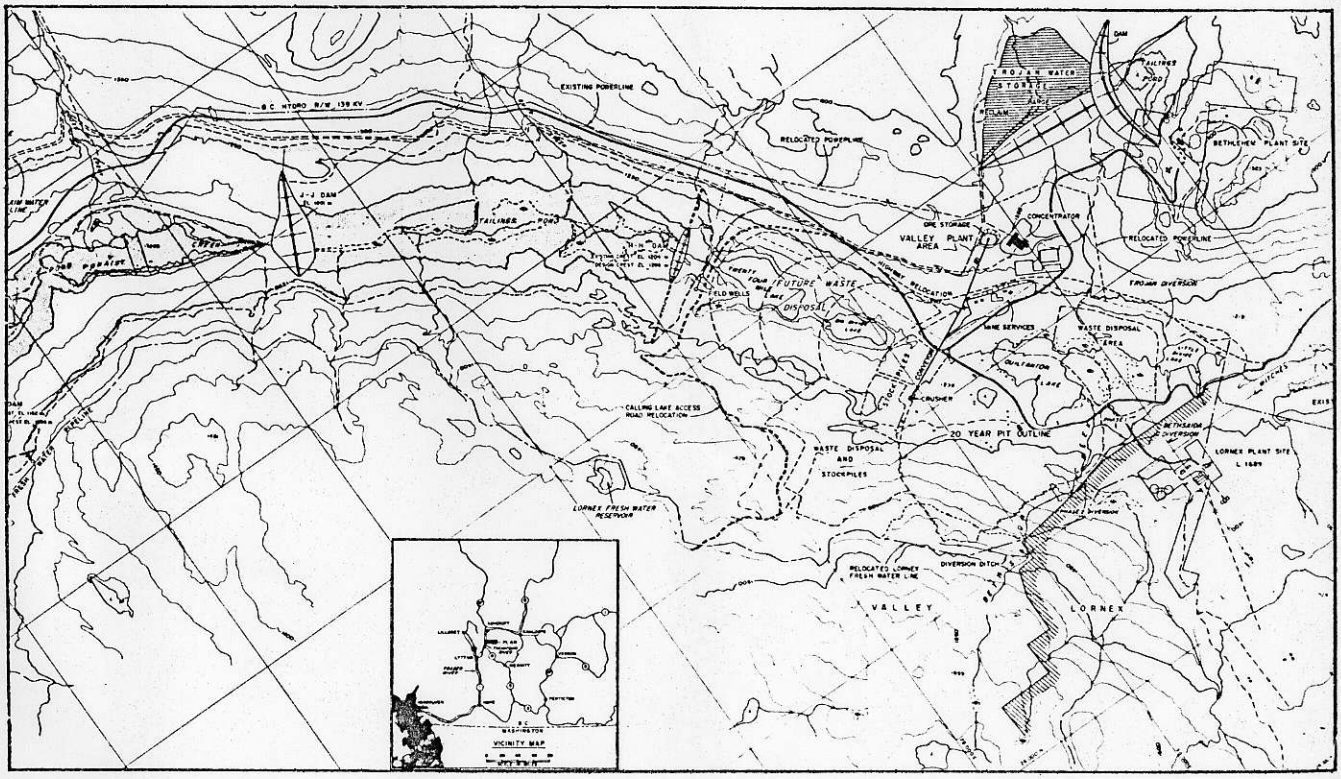
By WILLIAM SCHABAS

It now seems reasonable to speak of Cominco's Highland Valley operations. For almost a year, the giant diversified mineral producer which just celebrated its 75th anniversary, has had control of the Bethlehem mine. But Bethlehem is an old mine, the first of the Highland Valley producers, and according to a recent prospectus, "at current metal prices the mine is not profitable."

Cominco bought Bethlehem to resolve ownership problems standing in the way of developing the enormous Lake zone, which has reserves of 726 million tonnes grading 0.475 per cent Cu and 0.005 per cent Mo, with minor amounts of silver and gold. The orebody will reasonably support an 80,000 t/d mine, according to a Cominco plan. Bethlehem owned 20 per cent of the Lake zone, but with rights to smelter royalties and other privileges its share in the orebody was more like 25 per cent. The rest of the orebody was owned by Valley Copper, a subsidiary of Cominco that was formed in 1964.

Prolonged negotiations between Bethlehem and Cominco were inconclusive. Though Bethlehem management urged Cominco to put the orebody into production, a satisfactory division of revenues could not be made. In 1977 Cominco attempted to

Valley Copper map, 1981 feasibility study



eliminate the difficulties by buying up Bethlehem shares. But it stopped at 39 per cent, and there was still no progress. Then, in late 1980, it acquired a 26 per cent bloc of Bethlehem belonging to Gulf Resources, and this gave Cominco effective control of the aging Highland Valley producer and its most important asset, the 25 per cent interest in the Lake zone.

Early in 1981 Newmont Mining tendered its 22 per cent interest in Bethlehem. By May, callers to the old Bethlehem telephone number were greeted by a receptionist saying "Valley Copper Mines." Over the summer Cominco proceeded with corporate transformations that will have the effect of folding Bethlehem and Valley into Cominco.

Under new guidelines

Ownership problems are only one of the obstacles confronting the developers of a mine on such a scale. Valley Copper has spent the past year obtaining the required permits and authorizations. It is the first mine in BC to come under new and stringent guidelines set up by the ministry.

"We have to present a Stage I report, followed by a Stage II report," explains Valley's secretary and assistant to the president, Milo McGarry. "Then the ministries raise questions, and we try and answer them. The Stage II report comprises four volumes, touching on water problems, reclamation and socio-economic matters.

"There are so many agencies involved," he adds. "But in the whole process they learn a lot and we learn a lot. It might be slow and involved, but by the time it's finished, everybody is satisfied that the project's going to be successful.

"Right now we have approval in principle to proceed," says McGarry. With the requisite corporate changes, the long-awaited decision to proceed with development of the Lake zone rests in the hands of Cominco's board of directors. Approval of the project by the end of 1981 would put the property into production by late-1984.

The Lake zone orebody is part of the Guichon Greek batholith. The medium to coarse grained rocks vary in composition from porphyritic grandiorite to porphyritic quartz monzonite. Two prophyry dikes intersect the orebody, but they are narrow and do not present ore dilution problems.

The ore itself is nornite and chalcopyrite, in a ratio of about 2:1. There is some molybdenite, principally with quartz veins and along slips in a distinct halo near the perimeter of the deposit. Since the early 1960s, the property has been extensively drilled: at least 200 holes totalling more than 38,000 metres.

In-pit crushing proposed

Perhaps the most unique element of the mining plan is an in-pit crushing system. Two 60 by 89 in. gyratory crushers, located at the side of the pit, will feed minus 20 centimetre ore to the mill via an overland conveyor system. A 183 cm belt will convey ore to a transfer point, and then two 152 cm belts will continue to the crushed ore stockpile, with a live capacity of 70,000 t. The transfer point is included to permit integration of in-pit materials as initial surface crushers are phased out. In addition, the plan calls for a mechanized conveyor-stacker system for waste disposal on the spoil piles.

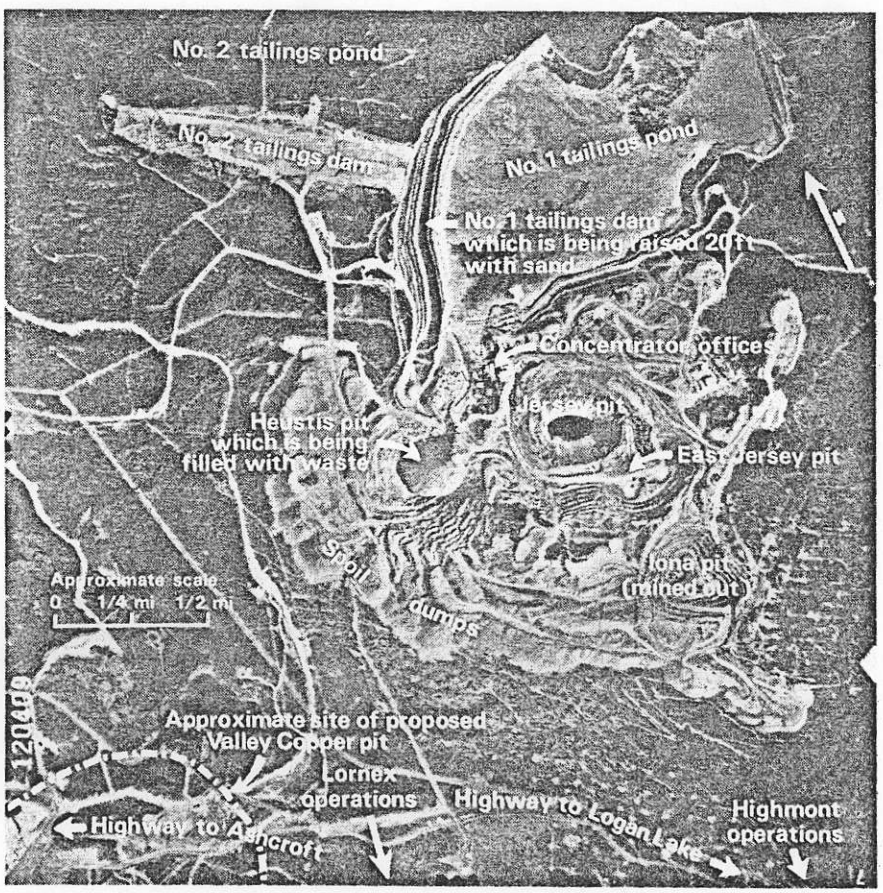
The pit itself is designed to feed 80,000 t/d to the mill. Stripping ratios will vary between 0.7:1 and 1.6:1 over the life of the mine, for an average of about 1:1. Mine design calls for 15 benches, 154 t trucks and 17 m^3 electric shovels. Good fragmentation is anticipated with 250 mm drill holes, low power factors, and 9.0 m burden and spacing. Blasting agents, including Anfo and SBA water-based slurries, will be produced on-site.

Maintenance facilities consist of a shop complex and a mobile service fleet. The field repair units will include heavy duty mobile cranes, tire changers, fuel and lube trucks, belt repair trucks and heavy forklifts. In addition, there will be the usual assortment of graders, sand and water trucks, and rubber-tired dozers for road and pit floor maintenance.

The concentrator will feature four 10 m diameter semi-autogenous mills. Valley Copper is planning to equip these with gearless drives. The mills will discharge through a grate, with 1.25 cm openings, and from there to two 2.4 by 6.0 m primary screens. Oversize will be returned to the mill. Undersize will proceed to a 5.8 m secondary ball mill. Ball mill discharge will be pumped to secondary cyclones, with overflow going to flotation.

Giant flotation cells

Existing plans call for 38 m flotation cells, arranged in eight rows of 10, for rougher and scavenger stages. The three cleaner stages will require thirty-eight 8.5 m^3 flotation cells. Two 3.8 m diameter 4.6 m regrind mills will be installed, one for rougher concentrate and the other for middlings, which



Aerial photo showing the Bethlehem operations and their relation with other properties in the Highland Valley

consist of scavenger concentrate and first cleaner tails.

Bulk concentrate will be thickened in a 30.5 m diameter unit, installed outdoors and covered, and then fed to the molybdenum flotation circuit. Copper will be depressed by preconditioning with depressants. The copper concentrate will be dewatered by a 30.5 diameter thickener, two disc filters, and a 2.75 m diameter by 13.7 m long direct gas fired rotary drier. Moly concentrate dewatering consists of a two-compartment filter, repulping tank, Holoflite drier and loadout facilities.

Moly concentrate will be packaged in drums. Copper concentrate will be stockpiled, loaded by front end loader into highway haulage trucks, and transported to the railhead at nearby Ashcroft, which is served by both CN and CP.

Water protection imperative

There are many environmental issues associated with the Valley mine development, but the local water system is probably the most important. The deposit sits beneath three lakes which will have to be drained. But these lakes are the headwaters of Witches Brook, which runs down the valley floor and passes through ranches and Indian reservations. Thus, protection of the water quality in Witches Brook is imperative.

Environmental research conducted by the company has discovered there is a separation between surface water and groundwater. Several glaciers passed through the Highland Valley, leaving alternating layers of impervious clay and sand and gravel. The sand and gravel zones are virtual underground rivers. To complicate matters, the Valley deposit is on the divide in the Highland Valley. But the surface water and the ground water have different divides. In the proposed pit, surface water is flowing one way and ground water the other. The conclusion reached by Valley scientists, with which downstream users are apparently satisfied, is that dewatering of the pit will not affect the surface water.

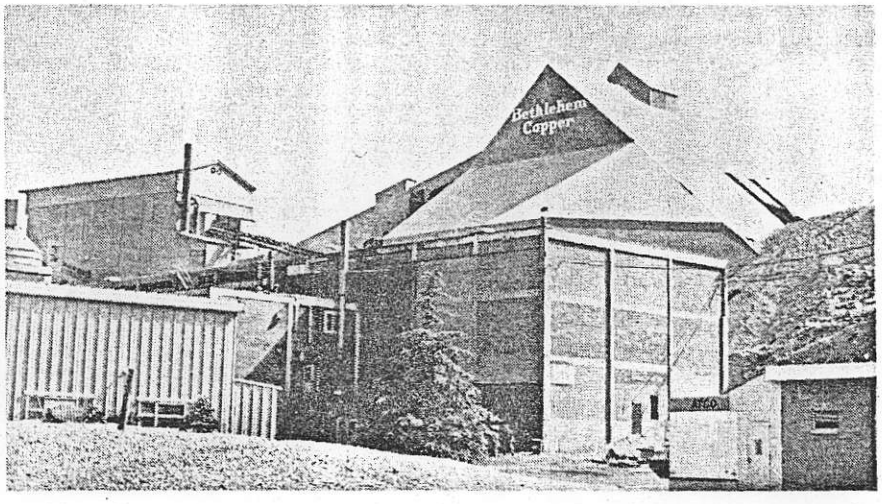
Originally, the Valley project called for incorporation and even possible expansion of the Bethlehem concentrator. Conveyors would haul ore up the side of the valley to Bethlehem's 27,000 tpd mill. A standard rod mill/ball mill configuration, it is somewhat antiquated compared with the Highland Valley's other big copper producers. After all, the mill was originally constructed in the early 1960s for a 3,000 tpd feed. The projected Valley Copper concentrator is roughly 25 times that size. In any case, the Bethlehem concentrator no longer figures in the Valley Copper mining plan.

Bethlehem staked in 1954

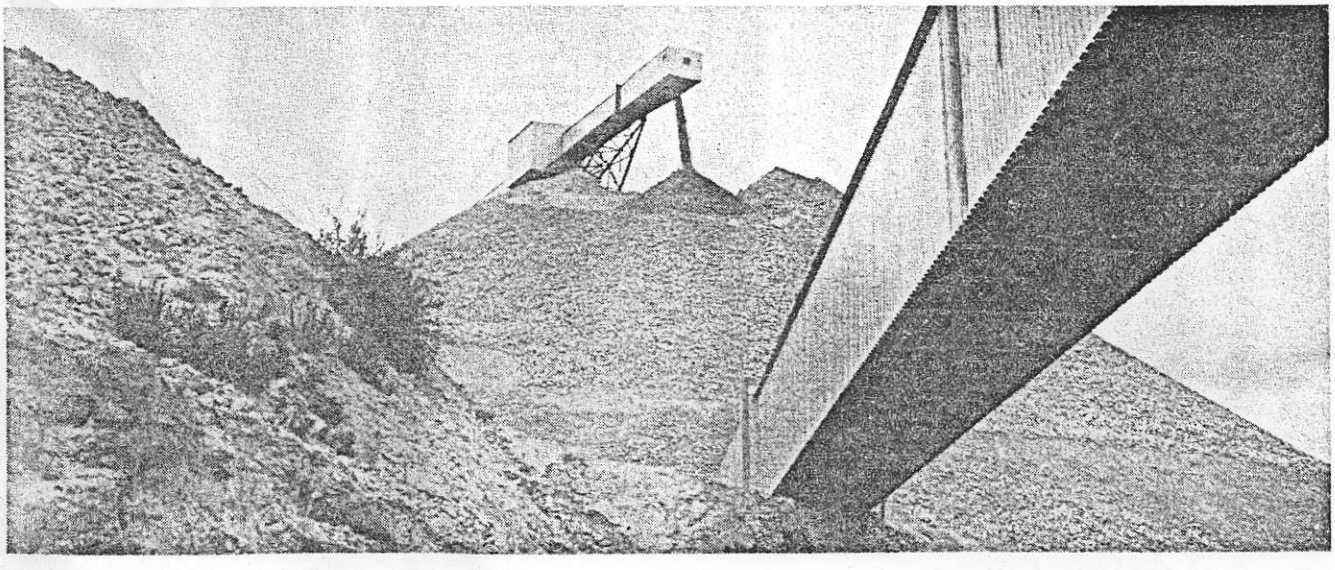
Bethlehem's orebody is still good for several more years of mining, though poor metal prices and the low grades that inevitably come with the later stages of mining have made it marginally economic. A molybdenum plant installed in 1978 gave good payoffs in its first two years of operation, and is still profitable to operate. Mining was being carried out at the time in Bethlehem's Iona pit, which had high moly values. But that pit is now exhausted, and the expanded Jersey pit now being mined has a low and very erratic moly content.

Originally discovered at the end of the 19th century, Bethlehem's orebodies are the furthest northwest of the Highland Valley. Small, high grade operations were carried out on the property. Then in 1954, a syndicate composed of Spud Heustis, Pat Reynolds and the McLallan Brothers

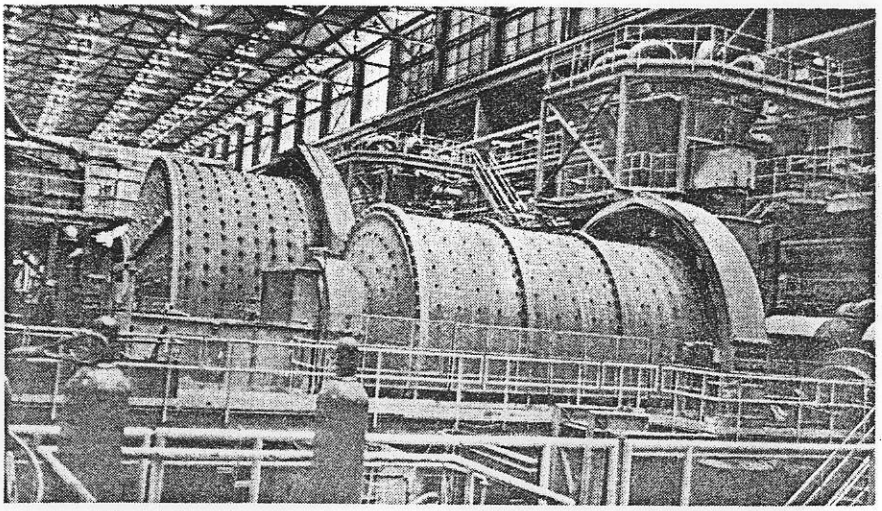
The first Highland Valley copper producer, Bethlehem, has been in operation since 1962



Coarse ore pile and conveyor that feeds the 19,500 tpd concentrator



Mill superintendent Evan Lowe explains operation of Bethlehem's new molybdenum plant



Interior of Bethlehem's copper concentrator, now a relatively old fashioned rod mill/ball mill operation

staked 100 claims, and a year later set up the Bethlehem Copper Corp.

The property has four distinct ore zones, three of which have now been substantially mined out. Initial mining, carried out by a contractor in 1962, had an average grade of one per cent copper, but this has steadily declined. All present production comes from the Jersey pit, placed into production in 1965. As of Dec 31, 1980, its reserves totalled 53 million tons at an average grade of 0.42 per cent Cu, based on a stripping ratio of 1.47:1 and a cutoff grade of 0.25 per cent Cu. Current estimates are that this mill feed will last until 1988.

Possible underground operation

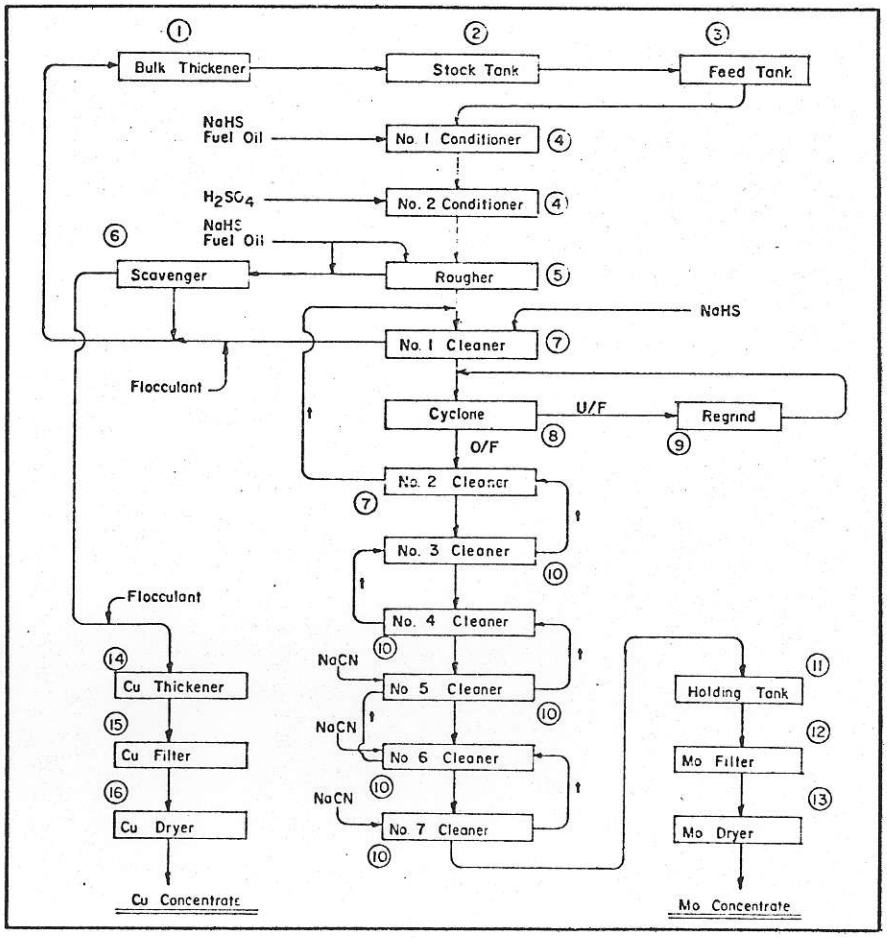
Bethlehem's J-A deposit, discovered in 1971, is approximately two miles southeast of the concentrator. Its mineral inventory is estimated at 286 million tons, grading 0.43 per cent Cu and 0.017 per cent Mo at a cutoff grade of 0.25 per cent and a stripping ratio of 3.4:1. The high stripping ratio, due to deep overburden, makes any mining operation uneconomic at the present time. Bethlehem has been studying the possibility of an underground operation, using block caving methods. However there are a number of technical difficulties, including mine water problems, that make an estimate of costs and feasibility rather difficult.

Mining equipment is relatively small, as Highland Valley operations go. Bethlehem operates a fleet of nineteen 100 ton Lectra Haul trucks and three Bucyrus-Erie 195B 13 cu yd shovels. A new shovel was added recently. Now, the older units are undergoing major overhauls. There are also two Dart 15 cu yd loaders, but, according to general manager Cliff Overton, "We try to use them as little as possible for mining."

Two large Outokumpu OK 1,350 cu ft flotation cells have been added to the mill, in order to extend the length of the rougher circuit. The mill is, according to Overton, "a standard rod mill/ball mill operation". There are three 12½ by 5 ft rod mills, followed in the flowsheet by four ball mills and a pair of pebble mills.

Lornex helped with moly plant

In 1978, encouraged by excellent molybdenum prices, Bethlehem added a molybdenum recovery circuit. It was patterned on the circuit at Lornex, across the valley, and Bethlehem



Flowsheet of Bethlehem's molybdenum plant. Patterned on the Lornex operation, it is still profitable, though moly grades have declined

received a lot of assistance and advice from Lornex personnel. The Lornex technique was facilitated by the successful introduction of a reagent combination of sodium hydrosulphite and sulphuric acid.

Bulk concentrate from the original concentrator is pumped at 55 per cent solids to the moly plant's two 24 ft diameter agitated stock tanks. "This storage system has really helped," explains Overton. "We can store concentrate for 24 hours, and then batch it. We can run at a consistent head grade and tonnage rate for 24 hours, and that's made the plant very easy to operate."

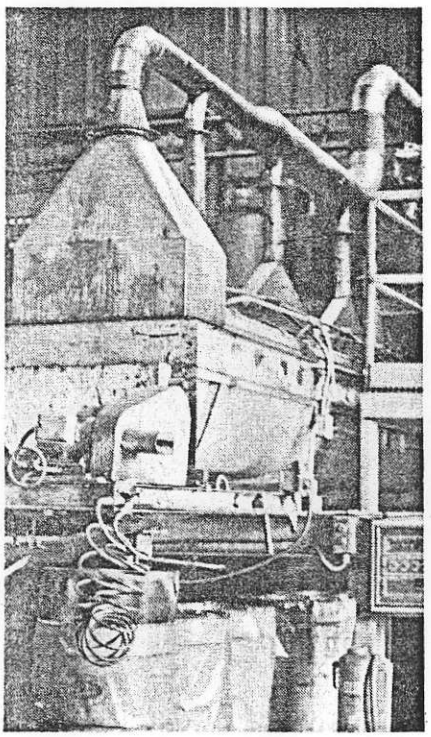
Molybdenite is floated in four Agitair No. 36 cells, and the rougher tailing is scavenged in a similar line. There are supplementary additions of fuel oil and hydrosulphide in the second rougher unit and the scavengers.

Rougher concentrate is cleaned in seven stages by 18 double-laundered Denver No. 15 cells. The first cleaner concentrate is ground in a Sala three foot diameter by five foot ball mill in closed circuit with a Krebs D3B cyclone. The first cleaner tailing combines with concentrate from the scavenger section to form the middlings stream, and is pumped back to the bulk thickener for recirculation.

Rougher tailing, which runs at pH 11.0 to 11.5, is flocculated and pumped to a Dorr-Oliver 48 ft diameter thickener. Underflow is filtered and dried, and forms the final copper concentrate.

The molybdenum concentrate is pumped, at 28 per cent solids, to three six foot diameter by 10 ft holding tanks, dewatered by a Denver four foot single disc filter. After drying in a 22 ft Lockheed Haggerty infrared radiant dryer, the final concentrate grades 53.7 per cent Mo and 0.74 Cu.

Molybdenum is loaded in drums for shipment. The moly plant is now producing about 300,000 lb per year of contained metal



New tailings dam

"The molybdenum plant's done very well for us," says Evan Lowe, chief metallurgist. "It started up about June 14, 1978, and we were pretty well going by the end of June.

"We had some decent moly ore at the outset, by now the moly is a little uncertain or sporadic. The moly circuit runs according to feed from the mill. The production is up and down." Average production, according to Lowe, is about 300,000 lb per year of contained metal.

Bethlehem is adding a new tailings dam. It started pumping into the new basin in August. The original pond has only about 1½ years of life left.

"The new tailings dam abuts the old dam, and encloses an adjacent valley," says Overton. "It's being built out of waste mine rock, and faced with tailing sands. It will be a free draining structure with any seepage trapped below the dam and returned."

Over the years, Bethlehem has acquired interests in a number of other mineral properties. Among its prospects is the Maggie porphyry copper deposit, about 45 miles from the present operations. Discovered in 1970, it has indicated geologic reserves of more than 200 million tons grading 0.28 per cent Cu and 0.029 per cent Mo. The company also has an option to earn an 80 per cent interest in the Fish Lake copper-gold deposit, 150 miles north of Vancouver. Early in 1981 Bethlehem conducted diamond drilling on the property and its latest estimate of reserves is 200 million tons averaging 0.24 per cent Cu and 0.014 oz of gold per ton. Finally, it owns about 25 per cent of the shares of Bar Resources, which holds a leasehold interest in a Nevada gold-silver property known as the Buckhorn mine. Bethlehem is involved in exploration on this property, as well.

Cominco's absorption of Bethlehem means it will now be managing these exploration projects. Bethlehem estimates its total 1981 exploration and development expenditures, not including work on the Lake Zone or J-A Zone, to total $3 million.

Progress and innovation at Bethlehem Copper's Highland Valley concentrator

Location map for Bethlehem Copper Corporation's copper mining operation in British Columbia.

Since its commissioning in late 1962 with a design throughput rate of 3,000 s. ton/day low grade copper ore, Bethlehem Copper Corporation's Highland Valley concentrator has been expanded in four stages to the current throughput capacity of 18,000 s. ton/day. This article examines the various changes made over this 13 year period which has seen the introduction of four-stage grinding and sand-slime flotation. The plant is currently considered one of the more efficient copper concentrators in North America.

IN the Highland Valley, British Columbia, Bethlehem Copper Corporation operates a flotation concentrator which has a rated capacity 18,000 s. ton/day of open pit ore grading 0.48% copper. This contrasts with a feed of 3,000 s. ton/day at 1.0% copper when the plant commenced operating in December, 1962. In the intervening 13 years the plant has operated continually through a succession of four expansions carried out at intervals of two to three years. Economics of future expansions are constantly being surveyed.

Bethlehem's plant is one of the lower cost operations in North America. In all the expansion programmes, careful attention was directed to capital and projected operating costs. Detailed planning, extensive testing and close co-operation of equipment manufacturers have contributed to the favourable cost performance.

The general plant operation, involving crushing, grinding and flotation recovery of a 33% copper concentrate, has been described in an earlier article[1]. A selection of some of the more innovative features of the plant is presented here.

Crushing

The crushing plant started with a 42×65in Allis-Chalmers gyratory coupled to a 7ft short head Symons, which produced 3,500 s. ton/day of rod mill feed in open circuit. In successive expansions a 7ft standard and another 7ft short head were added with attendant screens and belts to allow for closed circuiting the short heads. The last crusher was added in 1965 and the plant rated at 10,000 s. ton/day rate at a sized product of minus ½in screen. The size of the primary screen increased from 5×10ft to 6×16ft and finally, to the present 8×16ft unit when pebble production became a requirement.

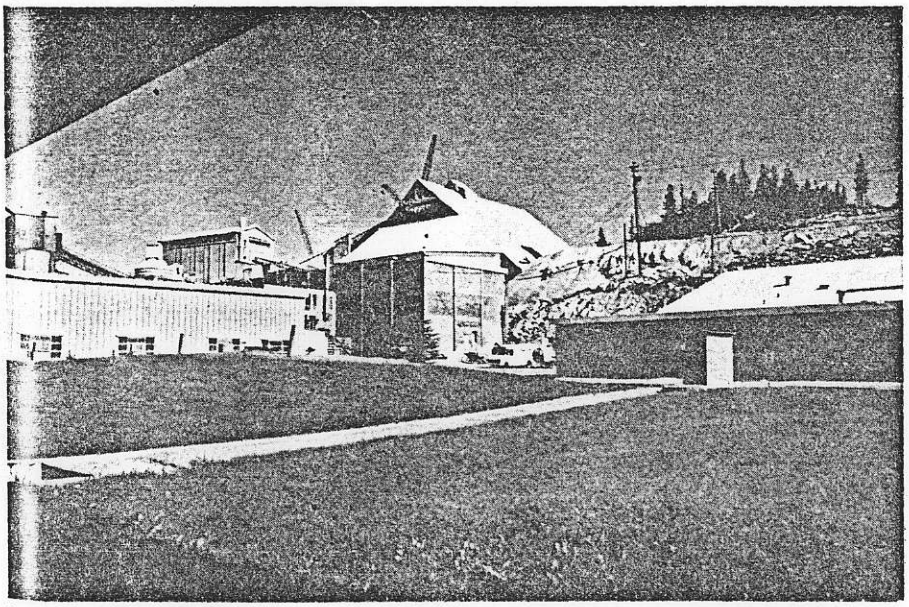
Since 1966 tonnage throughput has increased to the present 18,000 s. ton/day rate without the addition of any major crushing equipment. The increase has been achieved by introducing fine blasting in the pit; tighter than normal setting of the primary crusher (4-5in on the closed side) and speeding the primary crusher by 10%, which is the maximum recommendation.

The three 7ft crushers utilize Sangamo ammeters which show the average power draught for the previous 10 minutes. This information gives the operator a good indication of what the motor thermal protection condition is so that he can utilise motor capability fully, including the 15% service factor, without fear of an unexpected tripping due to overload. The conventional undampened ammeters usually provided give very little feeling of confidence for working the crushers to the full extent.

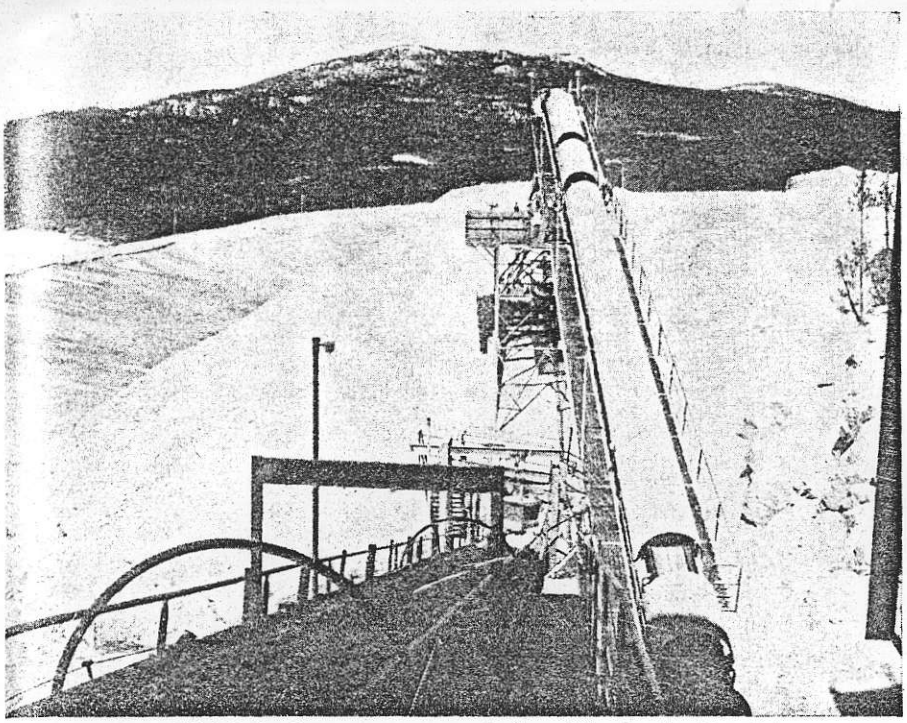
Because of the close primary setting and fine blasting the standard crusher feed is unusually small in size. The setting of this secondary unit to draw full power is also unusually tight (¾ to 1in). This condition provides a fine feed to the short head tertiary section, permitting these latter crushers to be set $\frac{3}{16}$ to ¼in, closed side.

The small sized crusher feeds usually call for small apertures at the top of the conical opening in order to spread the work load evenly down the cavity. In Bethlehem's circumstances, use of such openings resulted in a lowering of throughput and power draught. These restrictions were eliminated by installation of cone liners designed for coarser feeds.

The three 7ft crushers were also upgraded by conversion from manual to hydraulic clamping and setting, result-



Exterior view of Bethlehem Copper Corp.'s concentrator in the Highland Valley area of British Columbia, Canada.



No. 1 conveyor (right) feeds coarse ore stockpile, while the No. 2 reclaim conveyor is on the left.

ing in lower adjustment time and better safety. In screening, the wire sizes for cloths were reduced to $\frac{1}{4}$ and $\frac{5}{16}$ in from the original $\frac{3}{8}$in size. Slots were lengthened to 4in or more. The resulting cloths were more flexible and less susceptible to blinding by mud and near-size pieces of rock.

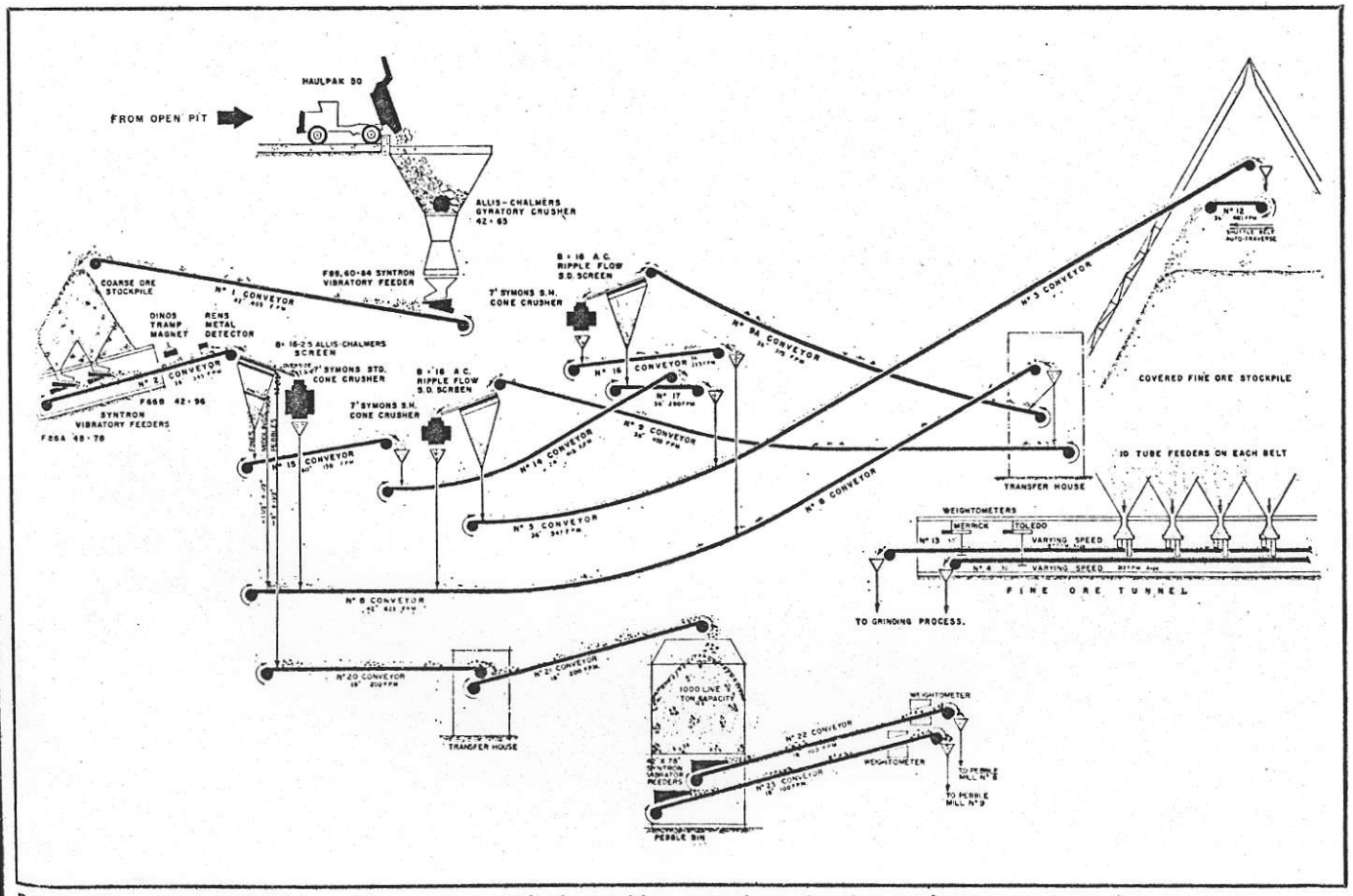
In conveying operations, some drives were modified and speeds were increased where necessary. Replacement of certain 20° idlers by 45° counterparts increased belt carrying capacity with no change in speed. With deeper troughs some belts formed their own skirting, resulting in lower wear and maintenance.

Operation of the crushing plant is on a three-shift seven-day basis with a maintenance schedule of 6 to 8 hours one day per week. Operating time in the secondary-tertiary sections registers 90%.

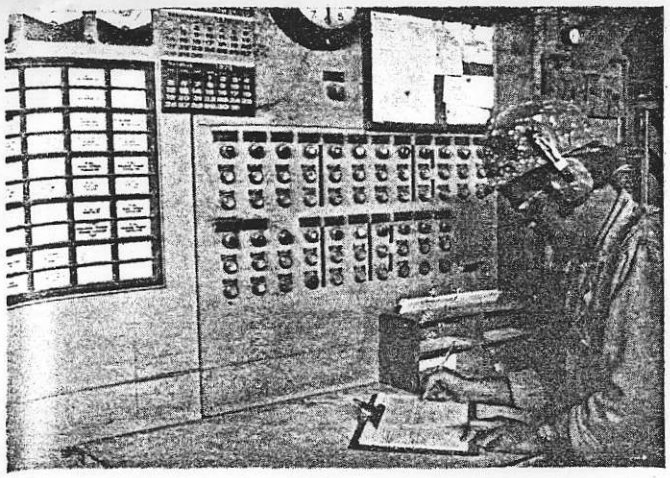
Grinding

Bethlehem's grinding circuit is unusual in its multiplicity of stages as well as in ancillary features. It is a four-stage operation comprising rod milling, two stages of ball milling and a final quaternary stage of two 16.5×32.oft grate discharge pebble mills. This arrangement results in a short range grind with a reduced production of gangue slime. Key aspects of the circuit include high-capacity feeding, high-capacity classification and the pebble mill finishing stage.

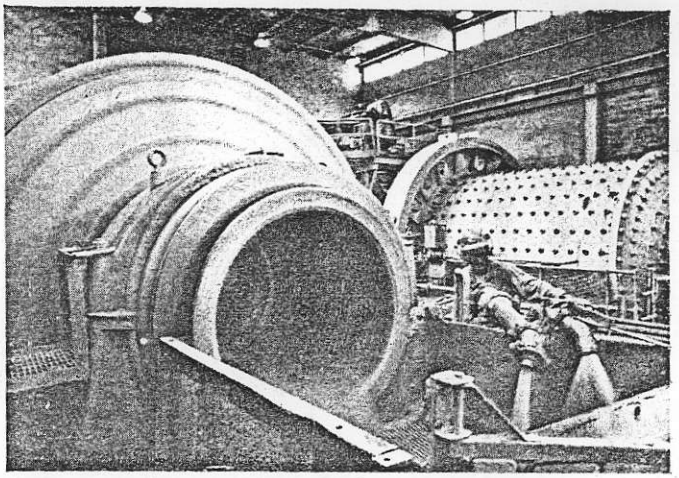
1. *High-Capacity Feeding* of two primary stage rod mills has, until very recently, been accomplished by a pair of 30in conveyor lines drawing directly from the fine ore bin through chicken-feed hopper type feeders. Each line was capable of delivering 450 s. ton/h. The rate was governed by speed regulation on main sections. Testing is currently under way on drawing the full tonnage using only one of the 30in main belts, discharging through a small surge hopper that acts as a splitter to the two lines leading to the rod mills. This new arrangement has been handling 800 s.



Detailed flowsheet of Bethlehem Copper Corporation's crushing operations showing equipment used, ore flow rates etc.



Mill control panel.



Rod mill discharge in the Bethlehem concentrator.

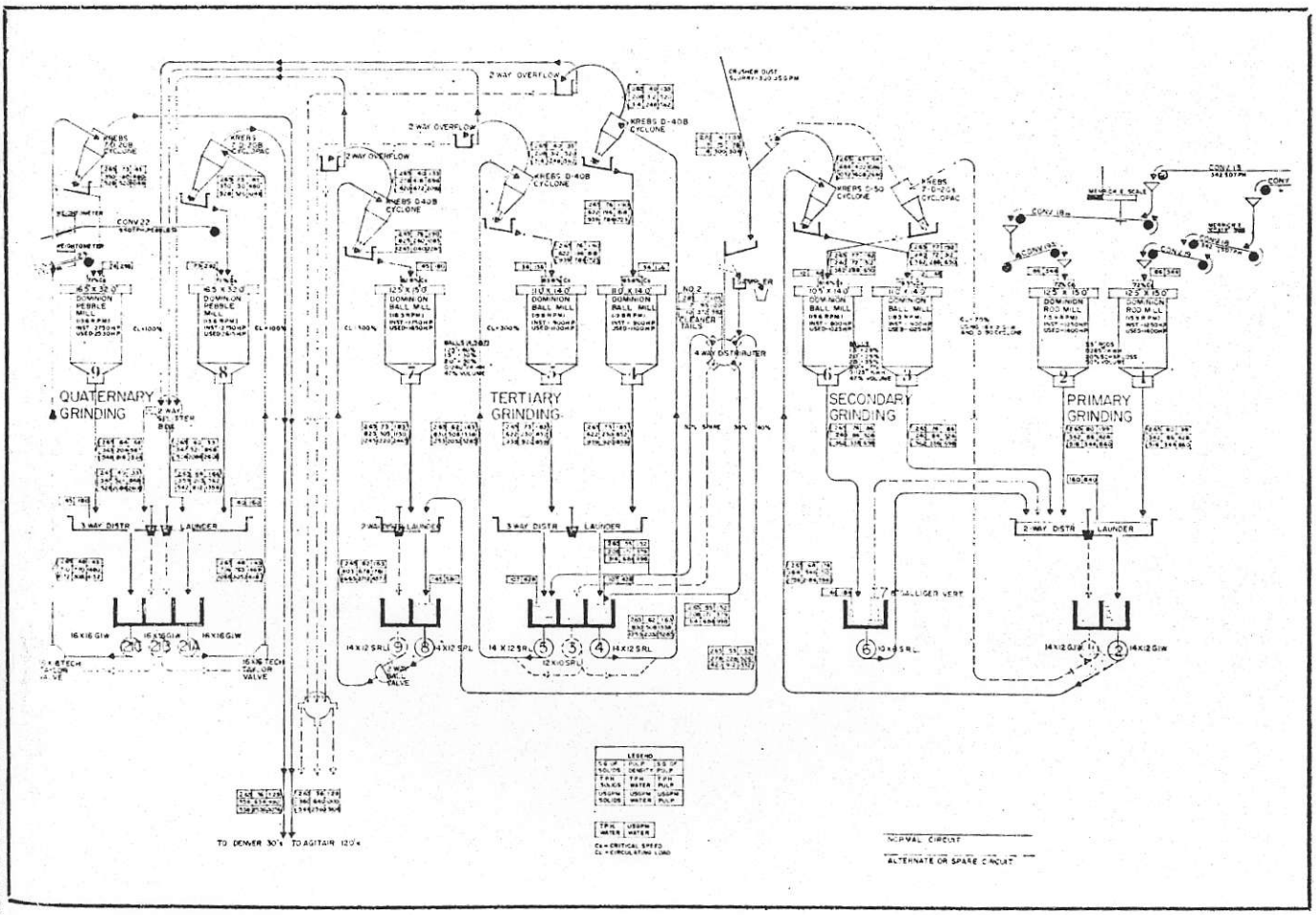
ton h with no problems. In winter months some difficulty is experienced with icing and packing in the feed hoppers but normally this part of the operation is free of trouble.

2. *High-Capacity Classification* for the two ball milling stages is accomplished by two sizes of prototype large-diameter wet cyclones. In the secondary grinding stage, comprising two ball mills, the circuit is closed by a single 50in diameter cyclone which handles the full section load totalling 1,300 s. ton/h, inclusive of circulating load. This duty was previously handled by a cluster of six to eight 20in cyclones. The 50in unit yields lower classification efficiency, but the main concern at this point is high throughput with a minimum of maintenance.

In the tertiary grinding stage three ball mills are each closed by a single 40in diameter cyclone. Classification results have been found to be equivalent to that given by the earlier installation of a cluster of four 20-in cyclones. In both cases, the larger diameter cyclones have demonstrated substantial advantages in installation, maintenance, and ease of operation.

3. *The Quaternary Stage* of pebble mill grinding came on stream in May, 1972. and has since contributed significantly to the milling operation[2]. A payback of the capital outlay of $C2.6 million was made in less than three years. Fineness of grind showed an improvement from 45% minus 200 mesh to 60% minus 200 mesh while a gain of 3,000 s. ton/day has been made in combined ore and pebble throughput—15,000 to 18,000 s. ton/day.

Continued testing has returned a steady improvement in performance of the pebble mills. Liner studies showed

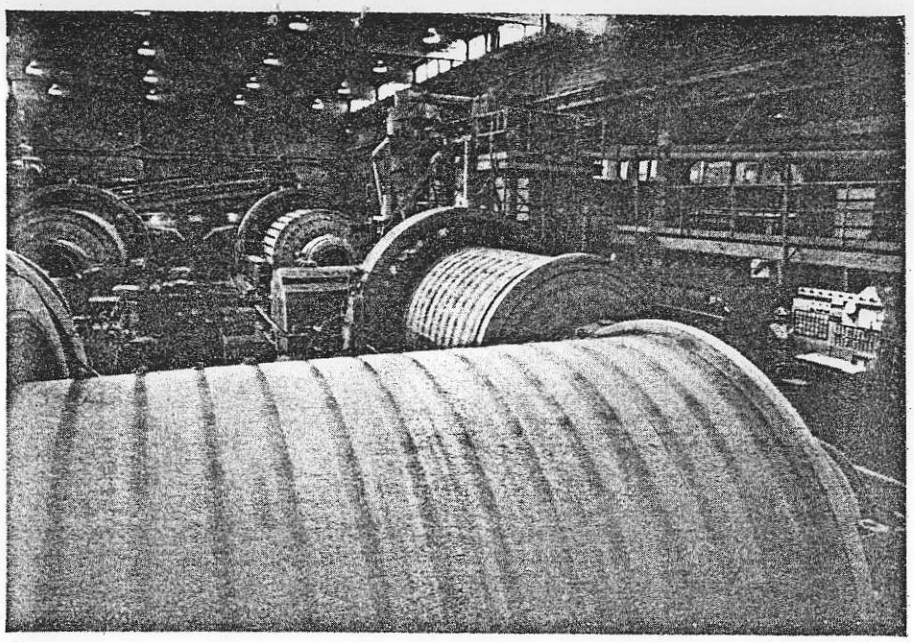


Details of Bethlehem's grinding section showing the four stages. One quaternary stage mill is now operated at 83% critical speed. Changes are also being made to bring mill No. 7 from tertiary stage operation into the primary stage.

Ni-Hard superior in wear performance to rubber shell lining, whereas rubber discharge grates gave trouble-free operation in contrast to metal designs. Originally at 71% critical speed, one mill has been successfully modified to 83% of critical and consideration is being directed to a similar increase for the second mill. Power draughts for the two speed levels register 1,945 and 2,243 kW and the unit power input averages 5.2 kWh/s. ton. Operating cost for this section is currently $Co.059/s. ton and operating time registers 96%.

Movement of slurry through the four stages of grinding is facilitated by appropriate use of oversize (16in) Georgia Iron Works pumps running at low impeller speeds. The pumps are in service on moving the highly abrasive rod mill and pebble mill discharge slurries, a duty which they handle commendably.

A notable feature of the various pumping arrangements in both the plant grinding and flotation operations is the extensive use of Tech-Taylor automatic ball valves on the slurry lines. Both two-way and three-way types are in service in sizes up to 16in (19in ball). As with the large diameter cyclones, the Bethlehem plant was the forerunner in applying the quick-change commercial Tech-Taylor ball valve.

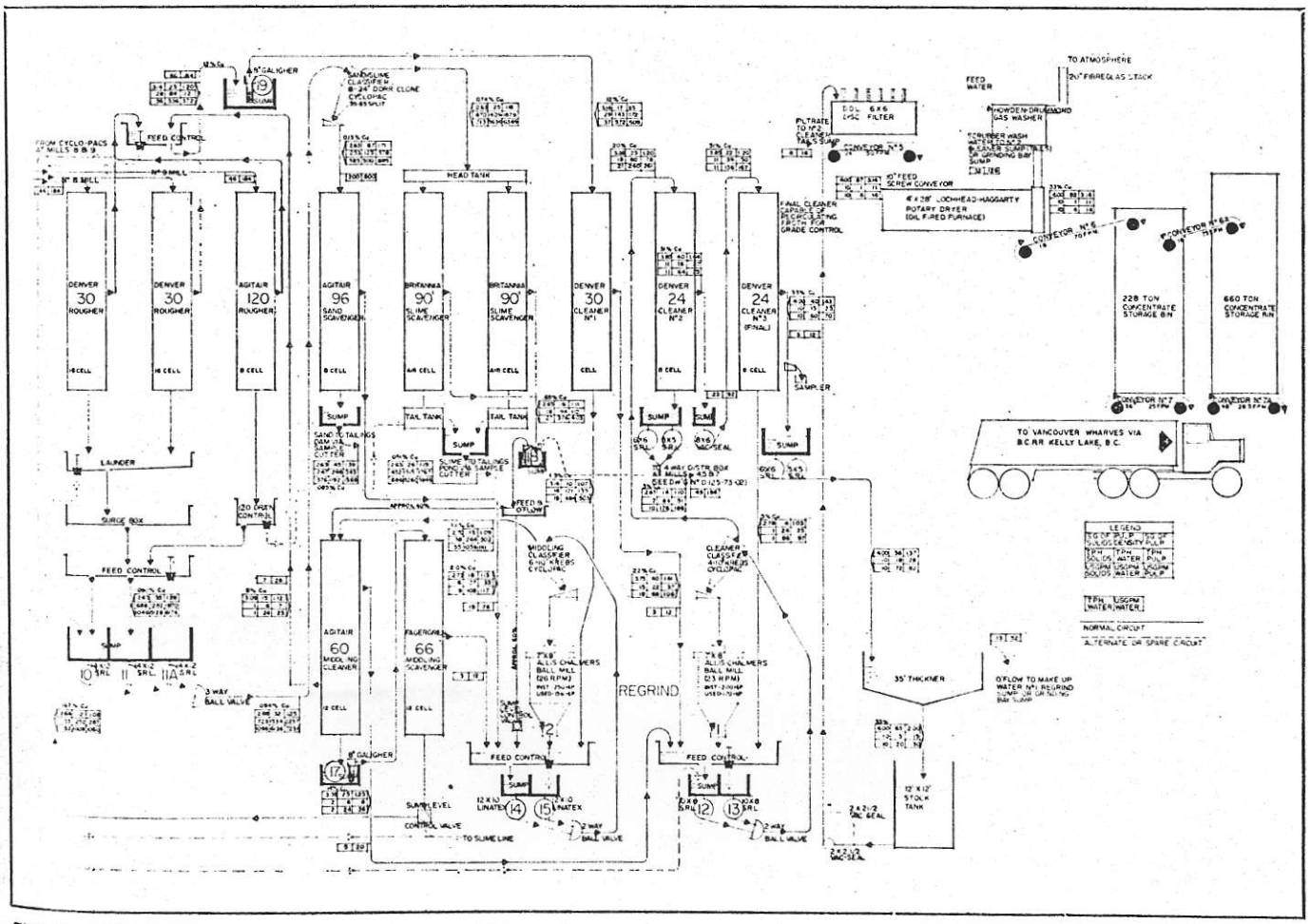


General view of grinding area in the concentrator.

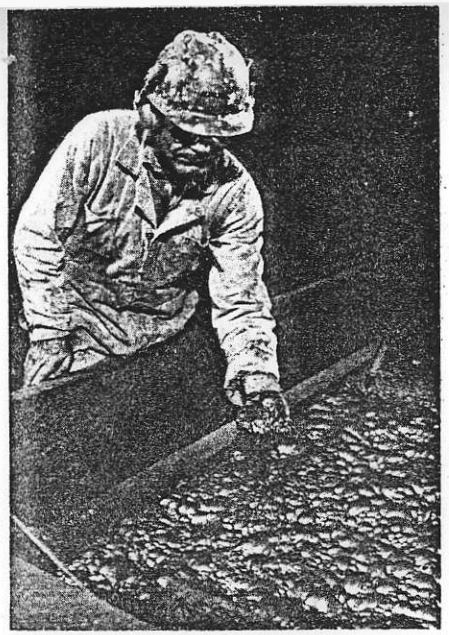
4. *Current Test Work* in the grinding operation involves conversion of a tertiary 12.5×15.0ft ball mill to primary grinding service. The second main 30in conveyor has been adapted to serve this mill. The alternative of conversion to a rod mill may also be investigated since the size of this mill matches the two existing rod mills and this recourse would tend to complement the existing operation. The preliminary results of this test utilising balls in the mill indicate that the total rate will increase from 18,000 s. ton/day to 20,000 with an attendant coarsening of flotation feed.

Flotation

Bethlehem's flotation plant was converted to sand-slime treatment in mid-1967 when installation of new equipment



Flotation, filtering and drying flowsheet for Bethlehem Copper.



Examining flotation concentrate in the Bethlehem mill.

brought the designed rating to 12,000 s. ton/day. Since that time there have been no major changes, but accommodations have been made to handle a steadily increasing feed tonnage such that the same equipment now processes 18,000 s. ton/day. The flotation treatment consists of roughing in Agitair No. 120 and Denver 30 (converted to DR) machines followed by sand scavenging in Agitair No. 96 and slime treatment in Britannia deep air cells (Forrester type). Cleaning is carried out in three stages in Denver 30 and Denver 24 machines (converted to DR), with separate regrinding of first cleaner concentrate and plant middlings.

Principal features of the plant are high-capacity flotation and a capability for maximum recovery of sulphide copper values. Bethlehem was an early innovator in the trend to treating ever larger tonnages through longer lines of flotation cells. Not only is plant treatment time unusually short but there is also no provision for conditioning throughout the circuit. Table 1 details the salient operating features of the rougher and scavenger sections based on the current throughput of 800 s. ton/h/operating day.

The Bethlehem ore has a fine-grained texture, demanding rigorous grinding and flotation measures for reasonable recovery of sulphide copper values. The normal liberation size is minus 400 mesh. Preferential reduction of sulphide and middling material is accentuated by the three stages of cycloning in the main grinding operation. In the flotation plant enhancement of recovery is provided by adequate regrinding measures and application of the sand-slime scavenging technique.

Independent scavenging of the cycloned rougher tailing sands in a pulp environment largely free of interfering slimes makes for optimum recovery of the difficult middling sand copper values. To the total copper recovery of 85% the sand and slime sections account for a contribution of 5-6%, returning a premium of two per cent over conventional straight scavenger flotation.

Regrinding of the first cleaner concentrate, instead of the conventional rougher concentrate, involves the handling of a lower tonnage of material and produces a more select feed for subsequent cleaning stages. Recent installation of an 8in Morris vertical pump has stabilised movement of a frothy pulp through this concentrate cyclone-regrind stage. Plant middling material, consisting of first cleaner tailings and scavenger concentrates, is isolated and treated in a separate regrind-scavenger section reserved for low grade products. Contamination of the final plant concentrate is thus held to a minimum.

Filtration and drying

Thickened concentrate is dewatered by a 6.oft×6 disc vacuum filter and dried through a 4.0×28.oft oil-fired rotary kiln. These units were designed for treating the original output of 100-150 s. ton/day of concentrate. When expansion increased mill feed throughput to 10,000 s. ton/day the production of concentrate reached levels of up to 350 s. ton/day, straining the capability of the filtration-drying system. To accommodate the higher output a number of modifications were implemented. The original 700ft³/min vacuum pump was replaced by a 1,000ft³/min unit which handled the work load and also provided an additional two inches of Hg. Capacity of the dryer was correspondingly increased by doubling the number of air ports on the combustion chamber and installing a manifold with a supercharging fan. Larger ducting was installed and the size of the gas washer was increased to match. More recently, the increases in plant feed tonnage have been accompanied by a drop in copper grade so that no additional demands have been imposed on the dewatering system.

Tailing and water system

The main tailing dam was constructed of overburden and waste rock from the mine. The dam is 300ft high and 6,000ft in extent across the top. Mill tailing sand, consisting largely of the sand scavenger tailing stream was applied for facing and sealing the upstream side. This was facilitated by use of a portable tower, situated on top of the dam and carrying two banks of cyclones and a 12in vertical pump in an arrangement allowing either single-stage or two-stage classification for maximisation of sand recovery. Overflow from the first stage of cycloning can either be fed to the second stage or, if necessary, be pumped directly to the pond. With intermittent supervision and periodic relocation of the tower this arrangement has been more than adequate for maintaining a safe margin of freeboard above pond level.

The original reclamation system utilised a combination of thickening and pond decantation for production of reclaim water. This system was adequate up to a throughput of 10,000 s. ton/day, beyond which it failed to meet water demand notwithstanding the addition of excess amounts of lime and flocculants. To overcome the water limitation the thickeners were removed from the system in favour of a pumping station floating directly on the tailing pond. In this arrangement a barge carrying a number of vertical pumps delivers the reclaim water to a shore booster station which, in turn, feeds the plant storage tank. This system incurs higher pumping costs because of higher head but results in a net saving of several cents per ton due to elimination of settling reagents. Furthermore, as the plant moves to higher tonnage, the reclaim system tends to keep pace because the rising pond level creates a gradual lowering of pump head.

Acknowledgments

Thanks are due to Mr. T. P. Liss, Vice President-Operations at Bethlehem Copper Corp., for his help in the preparation of the above article and to Mrs. M. G. Collins, Manager-Community Relations, for providing the photographs used.

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1. Anon, Bethlehem Copper—Canada's First Major Open Pit Porphyry Copper, *Mining Magazine*, November 1973, Vol. 129, No. 5, pps. 406-410.
2. Overton, C. W., J. W. Smith and E. A. Lowe, Pebble Grinding at Bethlehem Copper Corporation, Canadian Mineral Proceedings Seventh Annual Meeting, Ottawa, January, 1975.

Table 1. Rougher and scavenger flotation operating details

Section	Machine	Volume ft³	Tons solids per ft³/hr.	Pulp density % solids	Treatment time, min
Roughing	8 Agitair No. 120	2,100	0.19	35-40	4-5
Roughing	2 @ 16 Denver 30 DR	2,800	0.14	35-40	6-7
Sand Scavenging	8 Agitair No. 96	1,150	0.28	45-48	4-5
Slime Scavenging	2 @ 90′ Britannia	5,400	0.09	25-28	6-7

Barium-Strontium relationships

at the Highland Valley porphyry copper deposits, BC

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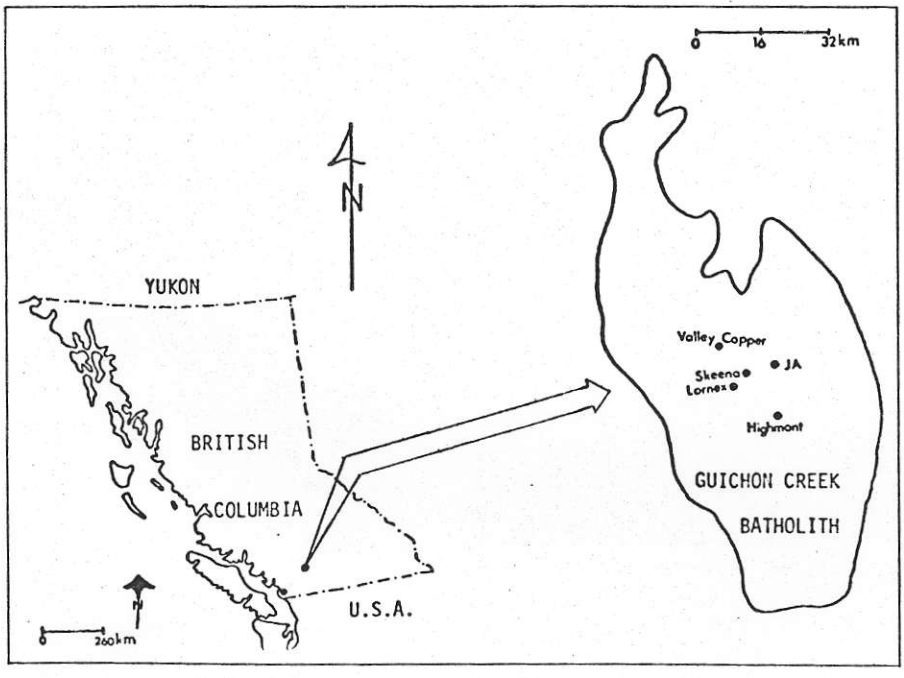
Variations in Ba and Sr concentrations in granitic host rocks of the Highland Valley porphyry copper deposits are reported. At Valley Copper and a large part of Lornex, Ba concentrations decrease progressively from the outer margins to central zones of intense argillic/phyllic alteration and mineralization. In contrast, at Bethlehem/JA and part of Lornex where potassic alteration is dominant, enhanced values are encountered. Sr levels consistently decrease from the periphery to inner zones of alteration and metallization. Ba/Sr ratios exceeding 1 define mineralized zones. On the basis of these results, absolute and relative concentrations of Ba and Sr could be a useful geochemical tool in exploration for porphyry copper deposits in the Highland Valley.

In a recent study, Warren *et al* (1974) demonstrated that the relative and absolute concentrations of Ba and Sr in volcanic wall rocks of a Ag-Au and a Cu deposit in British Columbia were indicative of hydrothermal alteration associated with mineralization. Studies by Olade and Fletcher (in press) demonstrate that primary halos of Rb and Sr around porphyry copper deposits can be utilized in outlining zones of intense hydrothermal activity and metallization. These encouraging results and the fact that Ba and Sr are readily determined by either semi-quantitative emission spectroscopy or X-ray fluorescence spectrometry, prompted further studies on Ba-Sr relationships at porphyry copper deposits in granitic host rocks.

Geochemistry of Ba and Sr in igneous rocks has been documented by numerous workers (Goldschmidt, 1954; Turekian and Kulp, 1956; Fischer and Puchelt, 1972). Because of similarity in ionic properties, Ba generally substitutes for K in alkali feldspars and micas and, of course, occurs as barite in hydrothermal environments. Sr substitutes for Ca in plagioclase as well as K in alkali feldspars. During hydrothermal processes, Sr is commonly enriched in Ca-carbonates and sulphates. Average abundances of Ba and Sr in high-Ca granites are 420 and 440 ppm respectively (Turekian and Wedepohl, 1961).

The objective of this paper is to examine the nature, relationships and applications of Ba and Sr halos around porphyry copper deposits in the Highland Valley district (Fig 1).

Fig. 1 Location of study area



General geology

Geology and mineral deposits of the Highland Valley have been described by numerous workers, notably White *et al* (1957), Northcote (1969), McMillan (1970, 1972) and Hylands (1972). Major porphyry copper deposits in the district are associated with the relatively youngest central facies of the Guichon Creek batholith.

The Valley Copper deposit is localized within a porphyritic granodiorite to quartz monzonite of the Bethsaida Phase (Fig 2). Wall-rock alteration is characterized by moderate to intense pervasive argillic alteration (sericite-kaolinite), on which has been superimposed a later phase of quartz veining in the southeast, and intense quartz-sericite and K-feldspar alteration in the central and northwest portions of the property.

The Lornex orebody occurs mainly within granodiorite of the Bethlehem (Skeena) Phase, east of the Lornex Fault. Fresh rocks of the Bethsaida Phase outcrop west of the fault (Fig 3). Quartz porphyry and aplite dykes occur within the deposit. Hydrothermal altera-

tion is characterized by propylitic alteration (epidote-chlorite-carbonates) at the eastern periphery of the deposit. This zone grades westward into mixed assemblages of propylitic and argillic (kaolinite-montmorillonite) and finally into intense argillic (sericite-kaolinite) at the central and western zones of intense mineralization. Irregular zones of quartz-sericite and argillic selvages are relatively abundant adjacent to the Lornex Fault and within a (?) porphyry dyke. Gypsum and quartz-carbonate veins are common in the ore zone.

The recently discovered Bethlehem-JA deposit (Ewanchuk and Anderson, 1972) is localized along the contact between quartz diorite of the Guichon Phase and granodiorite of the younger Bethlehem Phase, within and north of an intrusive quartz latite porphyry (Fig 4). Hydrothermal alteration effects comprise a core of potassic alteration (sericite-K-feldspar) centred upon the porphyry dyke and adjacent Bethlehem Phase. Argillic and typical propylitic alteration are confined to the periphery of the deposit.

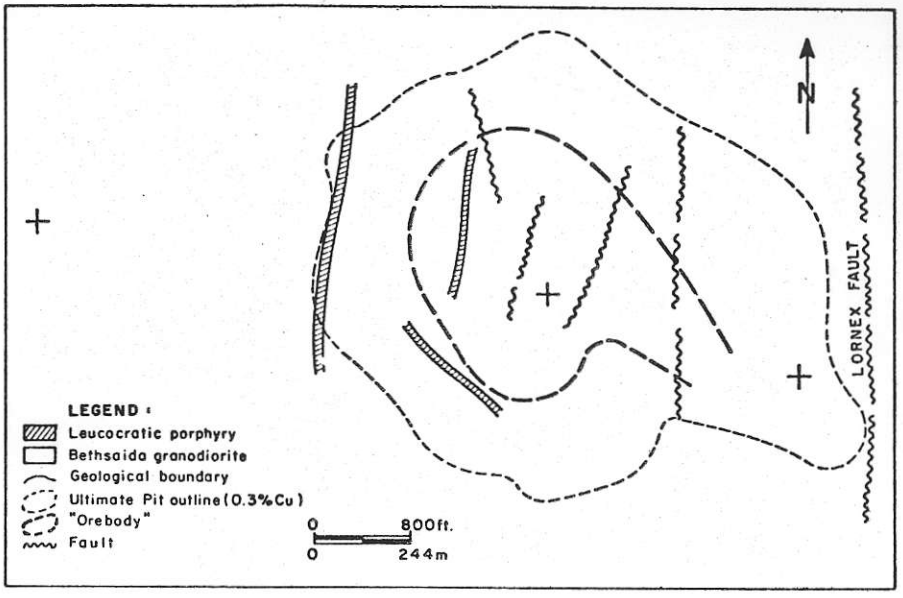


Fig 2. Generalized geology at Valley Copper (Modified in part from McMillan, 1970)

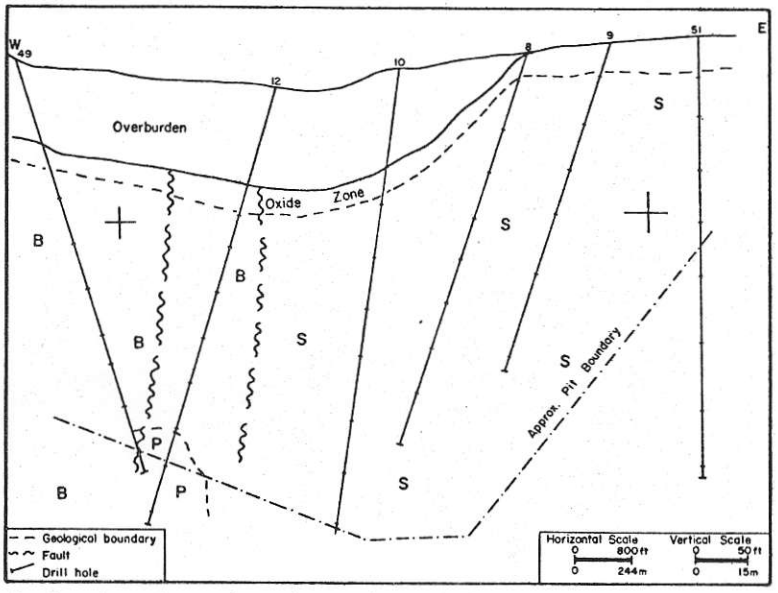
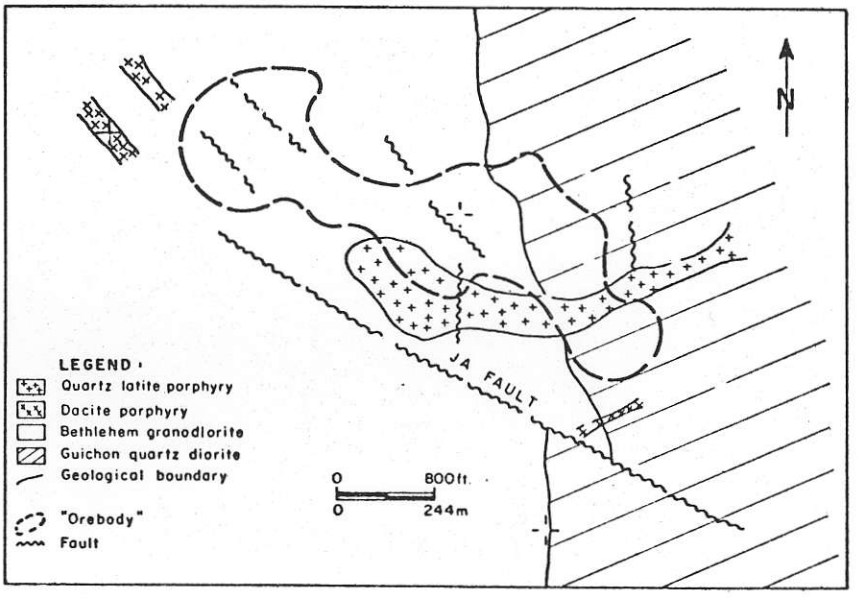


Fig 3. Generalized geology of a section at Lornex (based in part on data provided by Lornex Mining Corporation)

Fig 4. Generalized geology of the 2800 level at Bethlehem JA (based in part on data provided by Bethlehem Copper Corporation)



Sampling and analysis

Sixty-one rock-chip samples were collected from the '3600 level' of Valley Copper, eighty-five samples from a section across Lornex, and fifty-four samples from Bethlehem—JA '2800 level'. Each sample, weighing approximately 4 kg, consisted of several half-fist-sized drill-core chips collected over a distance of 3m around a central sampling point. Samples were collected within and as far from the mineralized zone as available drill holes permit. Fresh, unmineralized samples, used and described by Northcote (1969) were utilized in the estimation of regional background concentrations.

After crushing samples to minus 10-mesh, the powders were analysed for Ba and Sr by semi-quantitative emission spectroscopy, and for Sr (Valley Copper and JA) by X-ray fluorescence spectrometry as described by Volborth (1963). Analytical precision at the 95% confidence level is estimated as ±39% for Ba, ±42% for Sr (ES) and ±1% for Sr (XRF).

RESULTS

Regional background contents of Ba and Sr in fresh rocks of Guichon Creek batholith are tabulated with corresponding data from Valley Copper, Lornex and Bethlehem-JA in Table 1.

I. Valley Copper

Geochemical dispersion of Ba, Sr and Ba/Sr ratios are depicted in Fig 5. Ba levels decrease from more than 700 ppm at the outer margins of the deposit, to less than 440 ppm at the core of intense metallization and phyllic alteration (Fig 5a). The apparent extension of relatively

TABLE 1: *Means and Ranges for Ba and Sr

	Ba (ppm)	Sr (ppm)
Valley Copper	568	[1]562
(61 samples)	400-1000	72-2223
Lornex	384	[2]464
(85 samples)	100-950	150-1500
Bethlehem-JA	493	[1]579
(54 samples)	100-1500	100-932
Regional background samples		
(i) Bethsaida phase	554	588
(6 samples)	500-700	55-627
(ii) Bethlehem phase	538	693
(12 samples)	500-800	580-829
(iii) Guichon phase	306	935
(8 samples)	200-500	434-2013

*Geometric means. [1]X-ray fluorescence. [2]Emission spectroscopy.

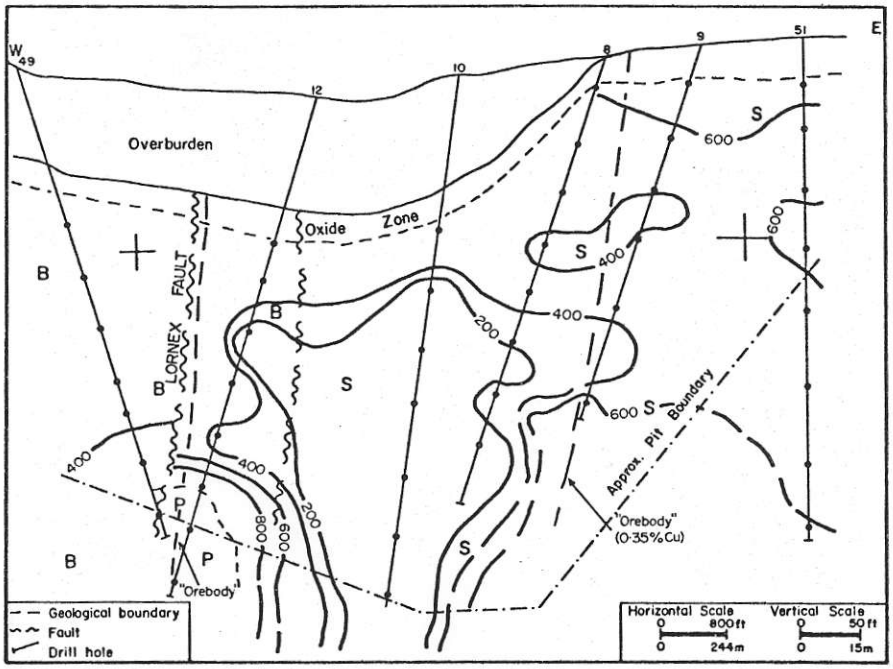
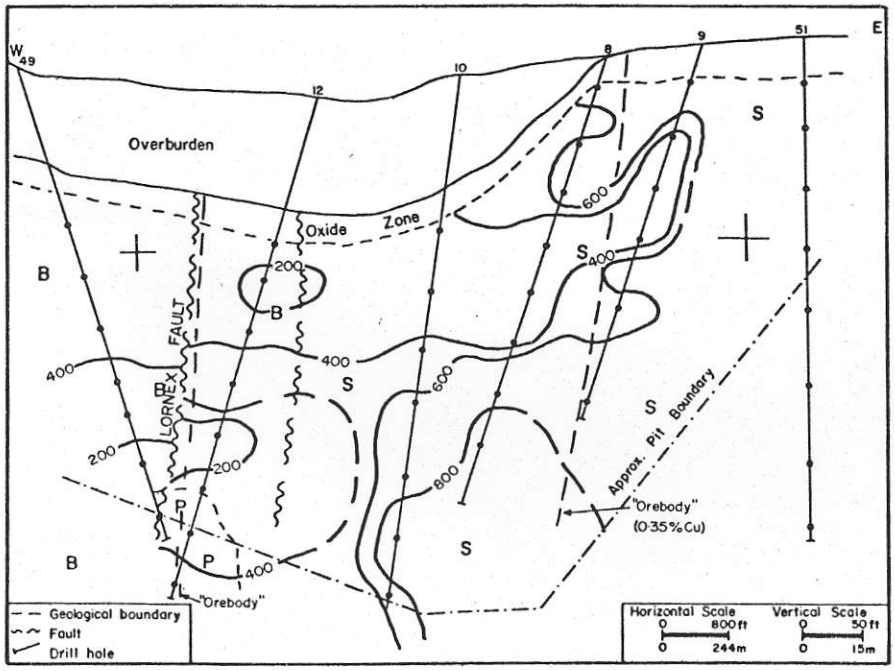


Fig 6a. Distribution of Ba at Lornex (values in ppm)

Fig 6b. Distribution of Sr at Lornex (values in ppm)



low values to the eastern margins of the property reflects the Lake Zone mineralization (Bethlehem Mines) which adjoins Valley Copper in the East. Small salients of enhanced Ba levels (700-1000 ppm) in the southeast and immediately northwest of the orebody are related to greater abundance of K-feldspar in association with quartz and sericite veins respectively.

Sr distribution is similar to that of Ba (Fig 5b). Enhanced values exceeding 700 ppm occur at the periphery, progressively decreasing towards the centre, and attaining lowest values (300 ppm) in the eastern half of the orebody. Ba/Sr ratios are generally less than 1 at the outer margins, but exceed 1 in a broad central zone which opens out to the south, and defines the orebody and its possible extensions (Fig 5c).

II. Lornex

Ba concentrations at Lornex range from 100 to 950 ppm. Values decrease from the eastern periphery of the deposit (Hole 51) to less than 200 ppm in a central zone of intense argillic alteration and metallization (Fig 6a). Ba levels are enriched (>800 ppm) immediately east of the Lornex Fault, where K-feldspar veins are relatively abundant.

Sr shows a slightly different distribution from Ba. Low values (<200 ppm) occur immediately east of the Lornex Fault (Fig 6b). In contrast anomalous levels are confined to the lower parts of Holes 8 and 10 where Ba values are lowest. This anomaly is attributed to the relative abundance of gypsum veins. Ba/Sr ratios do not show consistent patterns as a result of the irregular occurrence of gypsum veins. Nevertheless, Ba/Sr ratios are less than 1 at the periphery, but exceed 1 in a large part of the ore zone.

III. Bethlehem-JA

Distribution of Ba is controlled partly by primary lithology. Rocks of the Guichon Phase in the eastern portion of the property are relatively impoverished in Ba (<450 ppm) (Fig 7a). In contrast, the more felsic rocks of the Bethlehem Phase and the porphyry dyke are characterized by values exceeding 450 ppm. A narrow belt of anomalous Ba levels (650-1500 ppm) coincides with a large portion of the orebody and zone of potassic alteration.

Sr concentrations range from 100 to 932 ppm. Values progressively decrease from the outer margins of the property, to less than 200 ppm within the porphyry dyke and zone of potassic alteration (Fig 7b). Ba/Sr ratios exceeding 1, define a broad anomalous zone which includes most of the orebody (Fig 7c).

DISCUSSION

Results of this study demonstrate that Ba levels may either decrease or increase as

mineralized zones are approched, depending on the type and intensity of wall-rock alteration. Primary lithology has only a subtle effect on Ba distribution as demonstrated at Bethlehem-JA.

At Valley Copper and Lornex, intense argillic and phyllic alteration are associated with obvious depletion of Ba in the mineralized zone. In contrast, at Bethlehem-JA and immediately east of Lornex Fault at Lornex mine, enrichment in Ba is associated with K-feldspar alteration. The close relationship between Ba and K-feldspar distribution is attributed to the geochemical affinity between Ba and K in alkali feldspars. However, depletion of Ba in the phyllic (quartz-sericite) zone at Valley Copper and parts of Lornex suggests that Ba might not enter sericite lattices in appreciable amounts. Moreover, no obvious or significant relationship is evident between overall distribution of Ba and K, as demonstrated by correlation coefficients r = −0.18 at Valley Copper; 0.23 at Lornex; and 0.30 at JA). According to Fischer and Puchelt (1972), juvenile hydrothermal fluids do not contain significant amounts of Ba, but obtain this element by metasomatic leaching of suitable wall rocks. Thus, the enhanced Ba levels in the potassic zone might be of local origin.

Except at the lower part of the Lornex deposit where gypsum veins are abundant, Sr shows a consistent pattern of distribution in all the deposits examined in this study. It generally decreases from the outer margins where host rocks are fresh or weakly altered, to inner zones of mineralization and intense alteration where K-feldspar, sericite and kaolinite

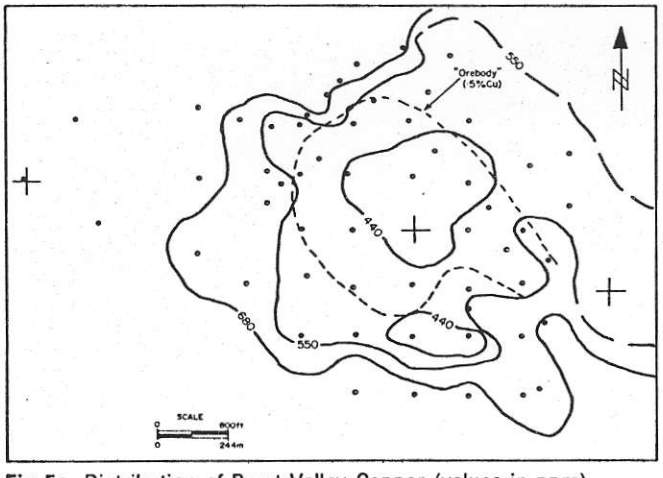


Fig 5a. Distribution of Ba at Valley Copper (values in ppm)

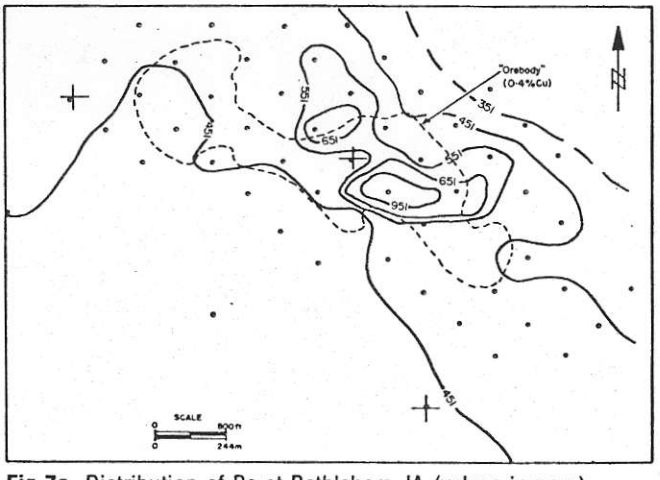


Fig 7a. Distribution of Ba at Bethlehem JA (values in ppm)

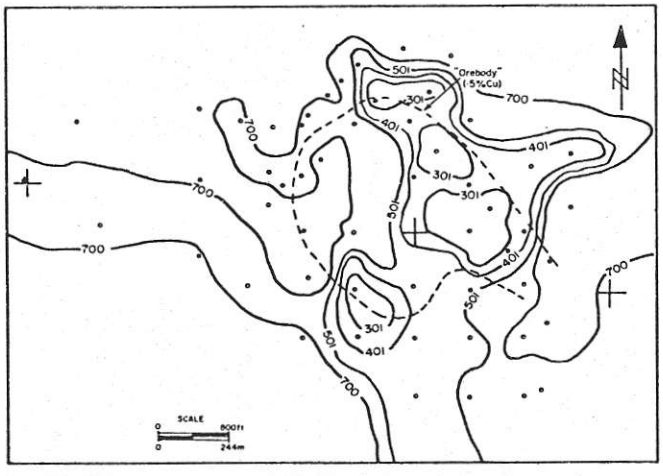


Fig 5b. Distribution of Sr at Valley Copper (values in ppm)

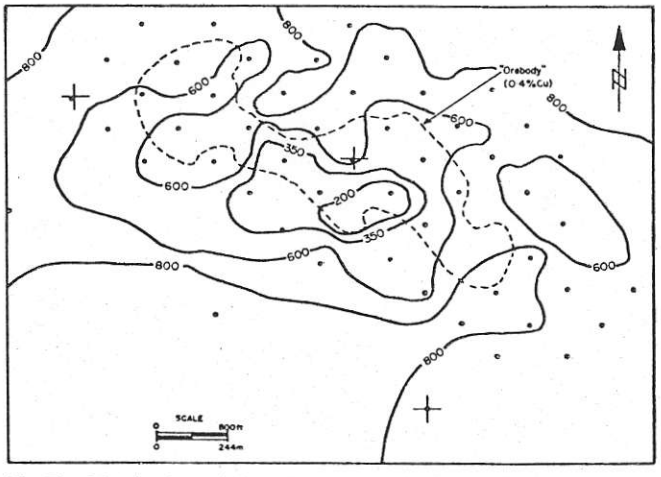


Fig 7b. Distribution of Sr at Bethlehem JA (values in ppm)

Fig 5c. Distribution of Ba/Sr ratios at Valley Copper

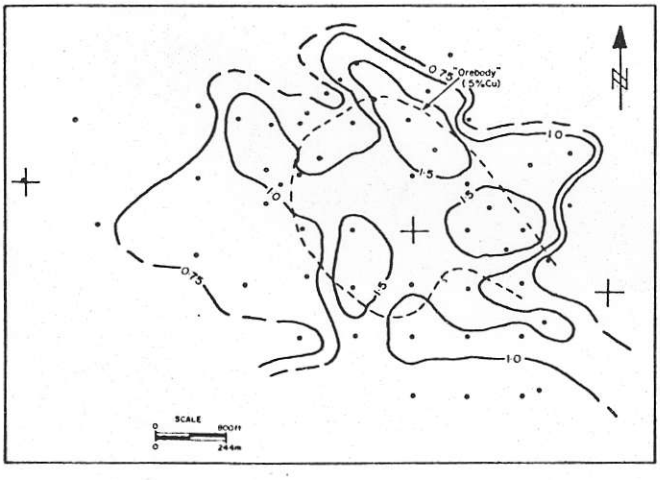
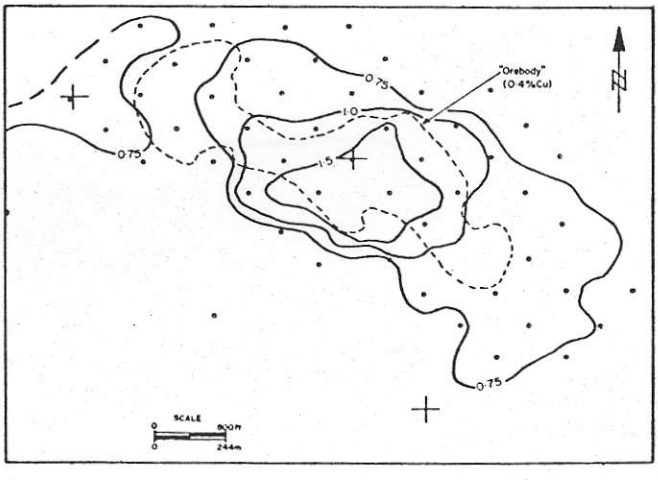


Fig 7c. Distribution of Ba/Sr ratios at Bethlehem JA



are prevalent. Since plagioclase feldspar, which carries most of the Sr, is most susceptible to alteration by acidic hydrothermal solutions, Sr is readily leached from zones of intense hydrothermal activity and metallization. The leached Sr is deposited at the periphery of the deposits in association with carbonates and other propylitic minerals.

Despite the inconsistency in the behaviour of Ba, Ba/Sr ratios consistently increase from values less than 1 in fresh background samples, to more than 1 in mineralized and altered rocks. This relationship applies both where Ba and Sr decrease, and where Ba increases and Sr decreases as the ore zone is approached. Greater depletion of Sr than Ba in altered rocks is attributed to the greater solubility of Sr relative to Ba in thermal solutions (Tooker, 1963).

From the foregoing discussion, it is apparent that Ba and Sr dispersions are related closely to intensity and type of hydrothermal alteration. Dispersion patterns are equally apparent in data obtained by both semi-quantitative emission spectroscopy and more precise X-ray fluorescence spectrometry. Furthermore, Ba/Sr ratios delineate intensely altered and mineralized zones. Since both Ba and Sr are determined readily by routine methods, and their distribution more readily quantified than fine-grained mineralogy characteristic of alteration zones, Ba and Sr analyses can be useful in outlining orebodies in the Highland Valley.

CONCLUSIONS

Anomalous dispersion of Ba and Sr is associated with hydrothermal and mineralization processes in granitic wall rocks of the Highland Valley porphyry copper deposits. Ba/Sr ratios exceeding 1 define mineralized zones in rocks of Guichon Creek batholith. In conjunction with wall-rock alteration studies, determinations of Ba and Sr can be useful in detailed exploration for porphyry copper deposits.

Acknowledgements

We wish to thank members of the mining industry — notably Bethlehem Copper Corporation, Canex Placer, Cominco, Highmont Mining Corporation, Lornex Mining Corporation, and Quintana Minerals Exploration. Specifically we wish to mention Drs J M Allen and W J McMillan, Mr R F Anderson, and our colleagues at the Geological Sciences Centre, for their contributions to the project. The study was, in part, funded by the National Research Council of Canada under PRAI grant P-7303 and operating grant 3563. Dr A J Sinclair offered constructive criticism of an earlier draft of the paper.

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28/10/83

Project: VALLEY COPPER
Location: B.C. CANADA
Owner: COMINCO 100%

Reserves:	800000000	Cu recov:	0.9
Grade %Cu:	0.5	Au recov:	0.8
Grade opt Au:	0.003	Conc.grade %Cu:	45
W:O ratio	1	R.O.C.:	100
$/lb.Cu:	0.9	T.p.d.:	80000
$/oz.Au:	500	T.p.yr.:	28000000
		Op.cost/ton:	$3.05

Cap.cost:	$332382070.48		
Work cap:	$24383531.20	NPV:	0.12
Ongocap/yr:	$1000000.00		$83929991.19

			Cu	Au	Total
NSR calc:	Grossmetallb/oz:		900	0.240	
perton conc.	Deduct:		22	0.080	
	Payable metal:		878	0.160	
	Gross rev:		$810.00	$120.00	$930.00
	Net rev:		$790.20	$80.00	$870.20
Smeltcharge:		$100.00	($100.00)		($100.00)
Anodefrt:		$0.01	($8.78)		($8.78)
RefchargeCu:		$0.10	($87.80)		($87.80)
RefchargeAu:		$5.00		($0.80)	($0.80)
M.T.M.:		$0.03	($26.34)		($26.34)
Ins/$100:		$0.20	($1.17)	($0.24)	($1.41)
Conc.frt:		$30.00	($30.00)		($30.00)
Total ded:			($254.09) ✓	($1.04)	($255.13)
NSR:			$536.11	$78.96	$615.07 ✓

Dep 30%

Tax 50%

27/10/83

Project: VALLEY COPPER
Location: B.C. CANADA
Owner: COMINCO 100%

Reserves:	800000000	Cu recov:	0.9
Grade %Cu:	0.5	Au recov:	0.8
Grade opt Au:	0.003	Conc.grade %Cu:	45
W:O ratio	1	R.O.C.:	100
$/lb.Cu:	0.9	T.p.d.:	50000
$/oz.Au:	500	T.p.yr.:	17500000
		Op.cost/ton:	$3.50
Cap.cost:	$250706503.05		
Work cap:	$17500000.00	NPV:	$0.12
Ongocap/yr:	$1000000.00		($3262034.22)

		Cu	Au	Total
NSR calc:	Grossmetallb/oz:	900	0.240	
perton conc.	Deduct:	22	0.080	
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