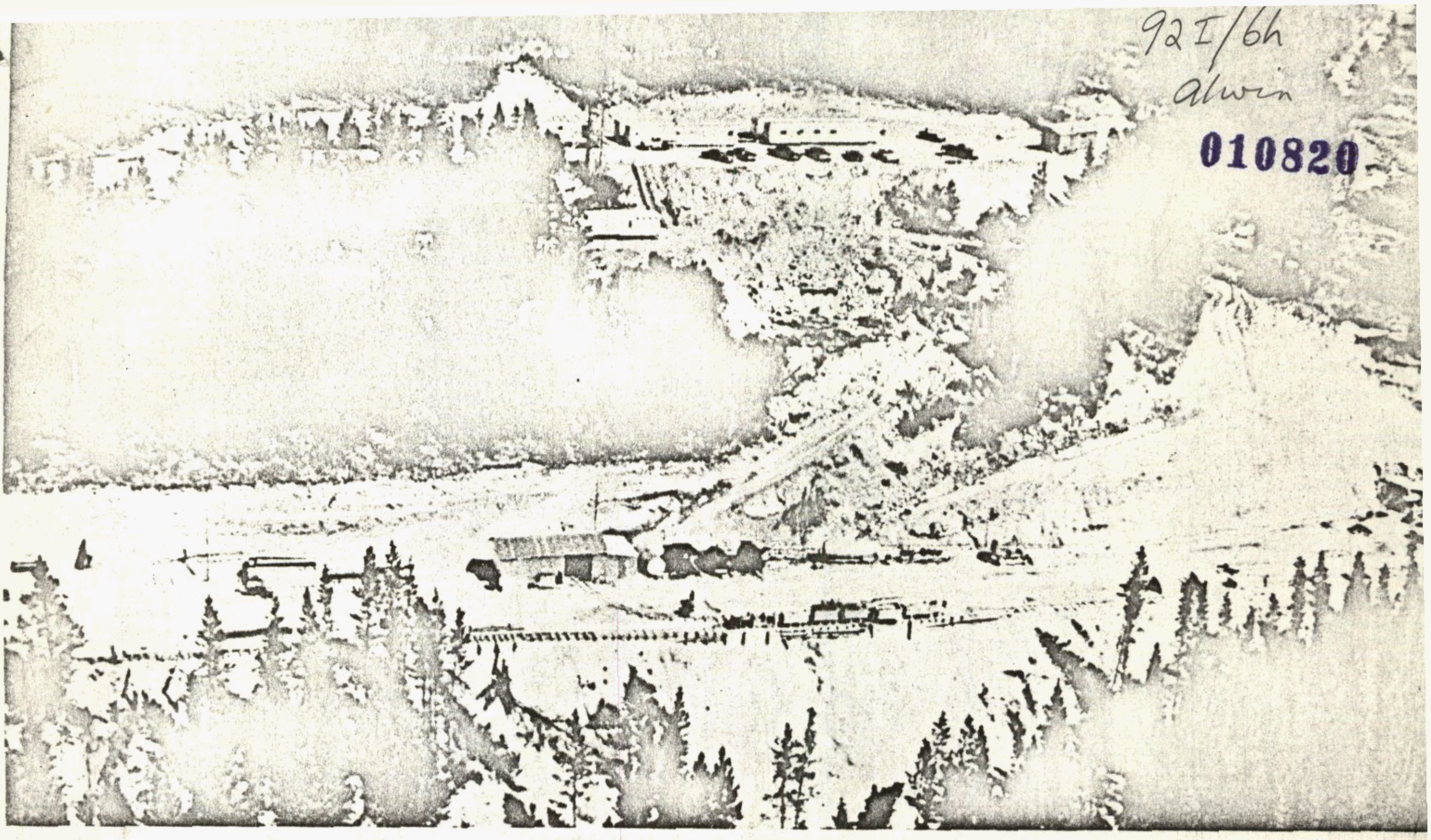


ALWIN—Highland Valley's high grade copper project

By L. C. WAY

IN THE past ten years, during which world copper prices rose to record highs in the 80c range, major Canadian and foreign interests were investing heavily in exploration and development of known low-grade copper-bearing regions of British Columbia. Canada's Pacific Coast province had suddenly awakened to a new era in its century-long mining history: the widespread search for and successive discoveries of large tonnage, low-grade copper ore deposits which could be profitably mined as open pit operations.

Massive deposits averaging as low as 0·40 to 0·50 per cent Cu/ton—in some cases also containing values of molybdenum – became viable. Along with the steadily rising copper prices, the Canadian Government tax incentives also made the reopening of former major producers an attractive proposition.

First of the copper properties was Bethlehem, with its mammoth discovery high in the hills of the Highland Valley overlooking the Thompson river in the Cariboo country. Bethlehem, currently treating 16,000 ton/day, is still the Valley's only producer. Then came Granisle and Endako in the more northern reaches of the province; and Brenda at Peachland in the Okanagan countryside where fruit growing has been the primary industry since early settlement days.

There followed still more discoveries of reserves calculated at hundreds of millions of tons: Cominco-controlled Valley Copper (now estimated at over one thousand million tons) adjoining and at one section overlapping into Bethlehem property; Highmont and Lornex to the south-west of Bethlehem; U.S.-owned Utah Mining's huge project at Port Hardy on the northern tip of Vancouver Island, and more recently Placer's Gibraltar, a $74 million, 30,000 ton/day operation, scheduled to commence production in mid-1972, in the Cariboo's McLeese Lake rangelands.

Alwin, an almost unknown property, meanwhile was exploring a small portion of a 24-claims group about 5 miles west of the Bethlehem concentrator.

With the speculative and investment-minded public being conditioned by such large tonnages in open-pit low-grade deposits, the news of Alwin's 1¼ million tons understandably caused little excitement. That is until the real significance of Alwin's find was realised: it was a sizeable high-grade deposit in the Highland Valley surrounded by the high-tonnage, low-grade prospects.

Ore reserves

The Alwin copper group consists of three Crown-granted and 21 recorded claims. The Alwin claims are located within the Bethsaida phase of the Guichon Batholith. The ore is in veins or lense-type zones and the mineralisation is contained in sericite schist. The copper-bearing minerals are approximately 90 per cent chalcopyrite and the remainder is in bornite and chalcocite. The zones vary from one to 32ft in width and average about 10·5ft in true width. They are spread along a total strike length of approximately 1,700ft and, although some appear to have weakened or have been delimited by the exploration work, others still open in strike and in depth.

Alwin's presently drilled ore reserves total 1,189,110 tons averaging 2·33 per cent Cu, 0·0346 oz/ton Ag and 0·003 oz/ton Au after allowance for dilution. It is expected that 'substantial' increased tonnages will be found as mining progresses and new exploration gets underway on Alwin's remaining claims. Present reserves are confined to 1½ claims in the 24 claim group.

From the existing underground openings it was possible to probe the structure by long diamond drill holes to about 800ft below surface. No change in the favourable geological environment was observed at this depth. The lower limit of this deep diamond drilling represents an approximate economic limit for further exploration by this means.

Diamond drilling

Bacon & Crowhurst Ltd., in their feasibility report dated May 1970, note that along the strike of the favourable structure, possibilities still exist relative to the discovery of additional zones of the extension of the present ones. Four surface diamond drill holes situated about 400ft easterly from the underground workings cut interesting copper values worthy of further investigation. Similarly, several diamond drill holes directed across the structure about 500ft westerly from the main mineralised zones cut the narrow widths of good grade mineralisation with extensions as yet not fully determined. The report adds that additional ore will undoubtedly be found both easterly and westerly of the presently explored zones with depth extensions possible.

In calculating ore reserves, lengths of intersections and assay values determined from a total of close to 200 diamond drill holes, both surface and underground, were combined with lengths and assay values obtained from chip and channel sampling of mineralisation exposed by underground work. Diamond drilling was directed so as to cut the zones at 100ft intervals.

Areas of influence of any one intersection have been extended halfway to adjacent holes and up to a maximum of 100ft (chiefly in depth) where no other drilling exists. True widths of mineralisation have been obtained by multiplying the drill hole intersection lengths by factors related to the angle of the drill hole and the angle of the mineralisation.

If the true width amounted to less than 4ft, which is considered to be a minimum mining width, the grade of copper has been reduced proportionately. If the grade of copper so calculated amounted to less than 0·90 per cent, the intersection was disregarded, except as noted below. Material containing 0·70 per cent copper has been included if adjacent to an acceptable block. A factor of 11·2ft^3/ton has been used as per specific gravity determinations reported by the Department of Energy, Mines & Resources, Ottawa.

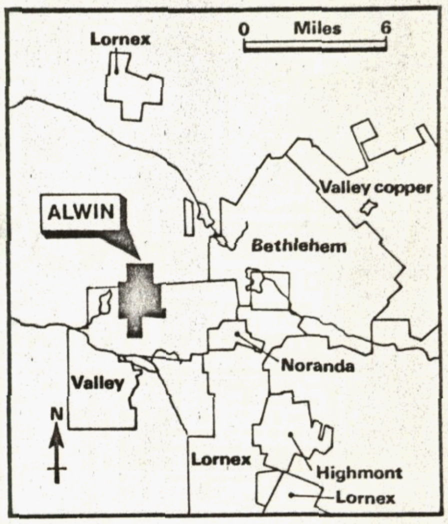
Minimum dilution has been calculated by considering the relative dimensions of the ore zones in relation to the proposed method of mining and the physical characteristics of the mineralisation together with that of the wall rocks. It is considered that both the ore and the wall rocks are competent and will stand well if mined as proposed.

Dilution was therefore calculated as follows:

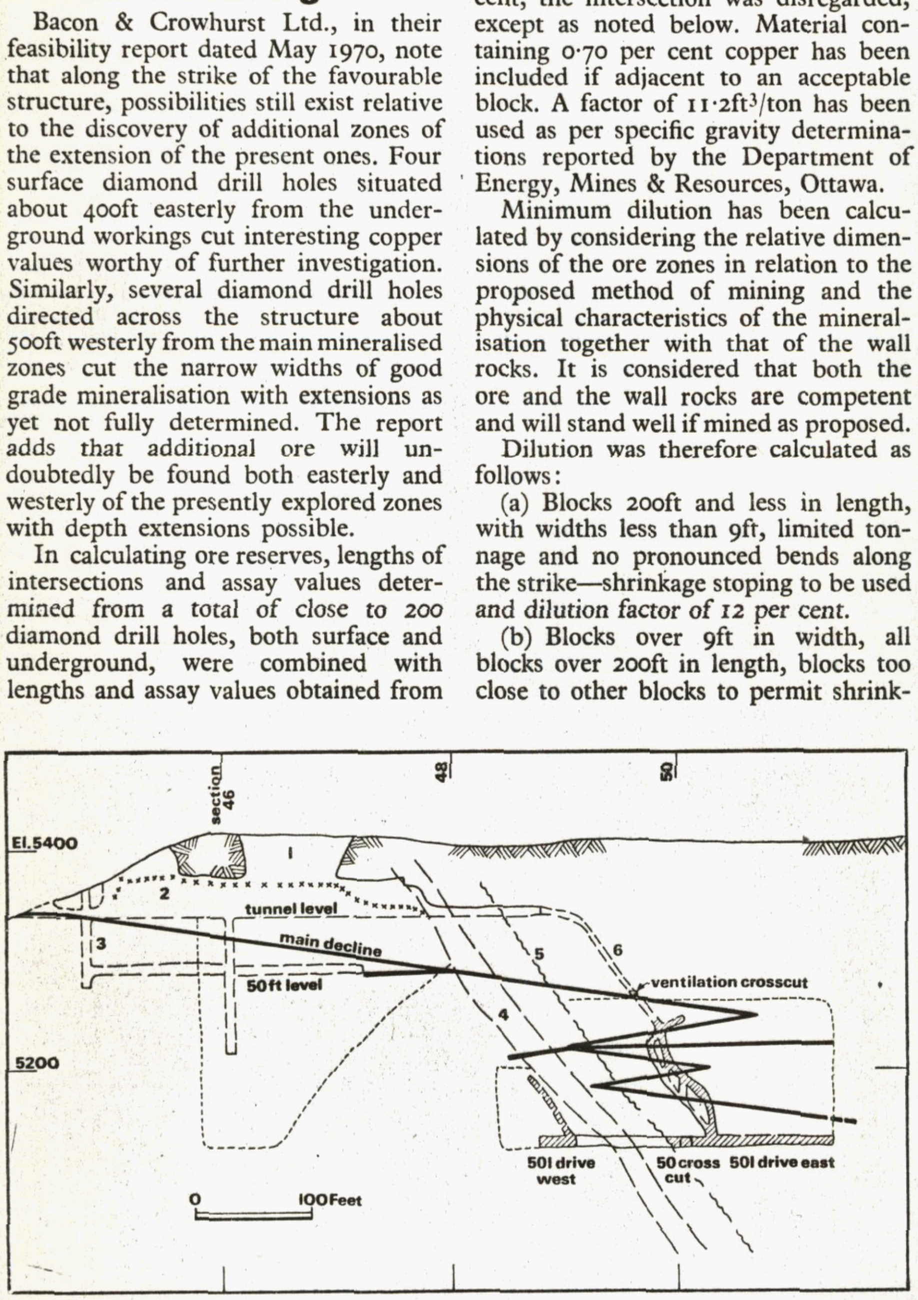
(a) Blocks 200ft and less in length, with widths less than 9ft, limited tonnage and no pronounced bends along the strike—shrinkage stoping to be used and dilution factor of 12 per cent.

(b) Blocks over 9ft in width, all blocks over 200ft in length, blocks too close to other blocks to permit shrinkage; stoping, cut and fill stoping to be used and a dilution factor of 7 per cent.

(c) Blocks up to 9ft in width, but not in category (a), crosscut and fill stoping to be used and dilution factor of 10 per cent.



Alwin Mine site and adjacent properties in the Highland Valley area



Longitudinal section of ore zone 2, showing proposed main decline and cross-cut development. 1, open stope; 2, caved area; 3, shaft; 4, porphyry dyke; 5, main fault; 6, manway and ventilation raise to surface

Potential earnings

In the case of Alwin, a million or more tons of 2 to 3 per cent copper ore promised a potential earnings ratio, with a comparatively minor capital cost, the equivalent of a 0·50 to 1 per cent low-grade operation involving millions of tons of ore and the appropriate capital debt requirements necessary to develop a much larger operation.

Other factors encouraging feasibility of the Alwin project included silver values averaging 0·30 oz/ton, a 96 per cent recovery rate, a concentrate grade of approximately 33 per cent and theoretically low development costs owing to stability of the host rock.

The company's senior financing for plant and related facilities, pre-production development work, and expansion of its existing housing accommodation is now expected to be under $3 million—as against earlier estimates of close to $5 million. This lower figure is the result of newly planned modifications to the plant design and mining system as planned in early 1970.

Since its inception, Alwin has expended over $1·5 million in exploration, road building, camp site, underground development and two major feasibility studies.

As with many Canadian resource development projects, Alwin's production-date plans were retarded by the Canadian and U.S. economic recession of the past two years. Senior financing negotiations with numerous major interests for the construction of a minimum 500 ton/day plant have followed an 'on again, off again' course

—and particularly so during the recent sharp decline in world copper prices.

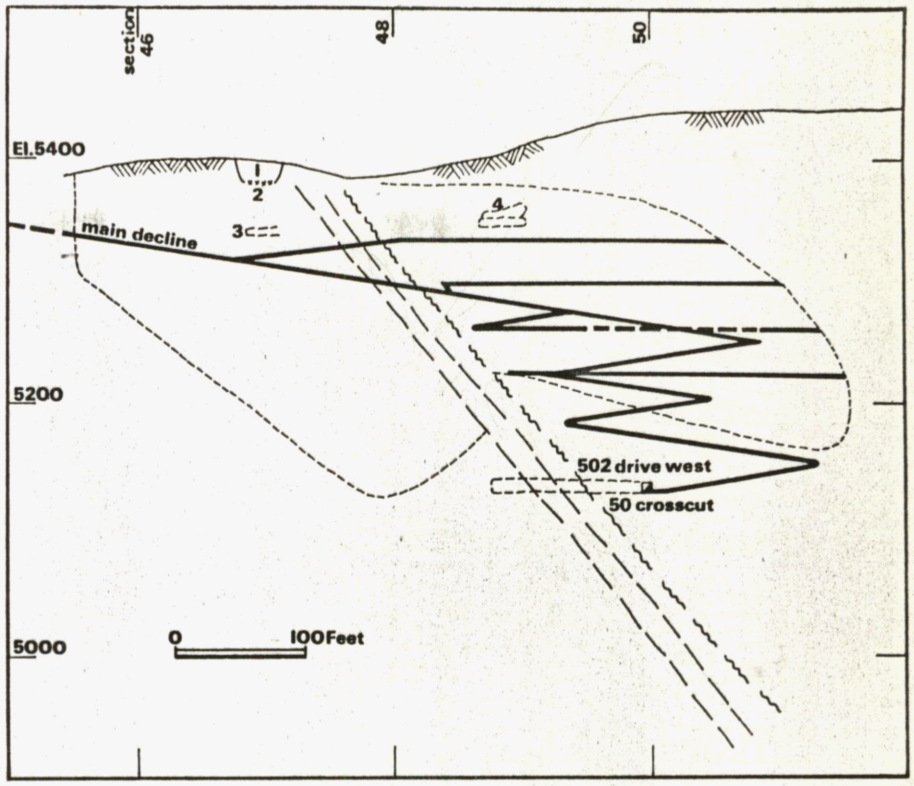
Also restricting Canada's mineral and petroleum developments in the same period has been the federal government's White Paper on tax reform. This is yet to reach the legislative stage. While initial reform proposals would have greatly reduced – or possibly eliminated – tax incentives for mining ventures, industry-wide opposition has resulted in predictions that they will undoubtedly be modified considerably by the time tax reform is enacted.

These economic setbacks did, however, force management to take a new look at the original plant design and underground mining plan whose cost was projected at just over $4·8 million. As a result there was a major reduction to $3·4 million, in addition to sizeable cuts in earlier operating cost estimates. This latter cost figure could conceivably be cut by at least an additional 10 to 20 per cent. One contributing factor could be a decision to purchase a complete existing plant, rather than erecting a new one. This, of course, would also permit the start up date to be moved ahead of the projected few months period.

Alwin officials are currently negotiating with major financing interests as well as with smelters concerning a concentrate sale agreement.

Alwin's revised plant design and production programme is headed by Donald W. Pringle, who was previously involved in the early planning of the Bethlehem project, Giant Mascot's Western Nickel mine, Granby's Copper Mountain and the reopening and management of the U.S.-owned Howe Sound Co.'s Britannia mine (now owned by Anaconda) near Vancouver. Pringle, executive vice-president of Alwin Mining Co., is in charge of placing the property in production.

Recently, an updated Economic Analysis and Production Outline for the Alwin plant and mining programme was produced. The study resulted in a number of substantial cost savings through modifications to the original feasibility report prepared in May 1970 by Bacon & Crowhurst Ltd. – Sandwell & Co., consultants.



Longitudinal section of ore zone 5 showing proposed development. 1, open stope; 2, caved area; 3, tunnel level; 4, stope

The redesigned plant, camp and mining scheme still maintains the company's objective of a minimum 500 ton/day milling capacity for the first 1½ years, increasing to at least 600 ton/day. Plant flexibility has been provided for future expansion to treat ore from other potential high-grade properties in the immediate area.

The Pringle Report gives a production schedule, based on a minimum 6½-year period (based on processing only presently drilled reserves) as follows:

Year	tons	lb Cu
1971 (5 months)	70,850	3,500,000
1972	175,000	9,240,000
1973	210,000	10,926,700
1974–5–6–7	733,260	29,846,600
	1,189,110	53,513,300

Profits

The study takes into consideration increased materials and labour cost factors in all projections—as well as the recent decline in copper prices. In the latter regard Alwin is fortunate in that its ore reserves are of consistent high grade (2·33 per cent Cu, 0·34 oz/ton Ag and 0·003 oz/ton Au) as compared with a large tonnage but low-grade property. This means a relatively low capital cost factor, plus operating viability even at depressed copper prices.

The study showed that once in operation with capital cost repaid, Alwin could continue with a reasonably profitable production at a copper price even below 40c/lb. Alwin management anticipated concluding a concentrate sale agreement with at least a 40c/lb floor price.

Net operating profit projections based on 45c, 50c and 60c average copper prices are shown in the table.

Year	45c/lb Can. $	50c/lb Can. $	60c/lb Can. $
1971 (5 months)	441,000	616,000	949,000
1972	1,423,000	1,884,000	2,504,000
1973	1,781,000	2,327,000	3,365,000
1974–5–6–7	3,552,000	5,044,000	7,880,000
	$7,197,000	$9,871,000	$14,698,000

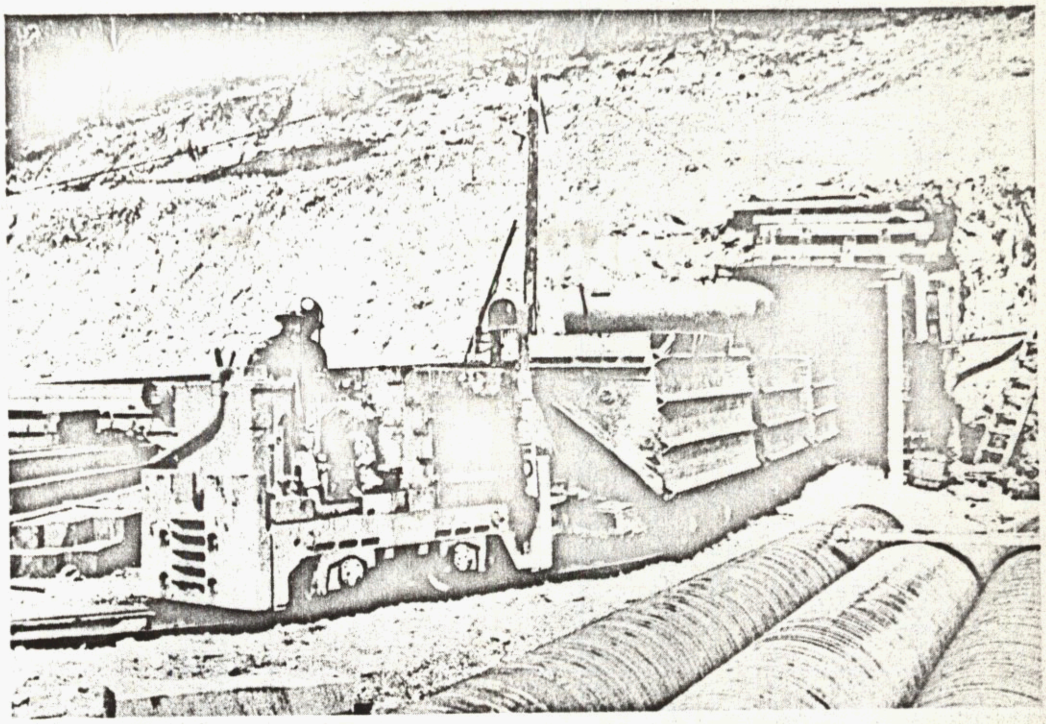
The report also includes an alternative copper price anticipation on a graduated scale of 45c for 1971–72, 50c for 1973 and 55c for 1974 through 1977. This permits repayment of the entire capital cost financing, plus all carrying charges, from the first 27 months' earnings.

Mining

Mining of the ore zones is based on the trackless mining concept with a modified shrinkage and sublevel caving method. This method allows for unit mechanisation and the use of specialist crews, resulting in production of higher tonnage/manshift and lower operating costs. It also requires less pre-production development work than that previously projected.

The system proposes a trackless decline from 5342 elevation joining an incline up from 5130. This main access will be located close to the various ore blocks, thus reducing the length of cross-cuts required for entry into the ore zones at 36ft elevations.

from this Total Mining costs $16=/Ton



First phase of Alwin's underground development programme consisted of a line drive adit parallel to the known ore zones, to be used as a main haulageway

It is proposed to drift along the ore at each 36ft horizon, this vertical lift of 36ft being removed by one 8ft drift and two 8ft lifts drilled and removed from the back along with removal of the final 12ft crown pillar. In wider stopes, only one lift will be removed resulting in a thicker pillar. The initial drifts will define and delimit the ore and produce approximately 25 per cent of total production.

The first cut from the back in the narrow stopes is started at the furthermost point from the crosscut; the second lift from the back follows, after removal by scraping or load-haul-dump (LHD) unit, of the broken ore in order to establish the correct clearance between the broken muck and the back. The back of the access crosscut is slashed to maintain a reasonable grade in the access crosscut. The broken ore is again removed and the crown pillar is all drilled off by upholes. Pillar blasting follows the normal sublevel sequence, i.e. top pillar first, followed by the second and succeeding pillars.

During the mining of each lift, all walls are scaled and bolted where required. Thus, partial stope ore production can be obtained by mucking and hauling ore from each horizon. Removal of final ore will be made from a drift located along the bottom of the particular ore zone. As the pillar is removed a slice at a time from over this drift, all the muck that runs down from above is removed. The minor remaining portion can then be removed by a slusher or a remote-controlled LHD unit.

The cut-and-fill mining stopes will have the ore removed by LHD unit travelling from the stope via the entrance

PREPRODUCTION CONTRACT

Unit of Work	Footage, etc. from Feasibility study	Price	Total Cost ($)
		CANADIAN MINE SERVICES LTD. Alwin supplies. Board, room, engineering, dry house and administration facilities	
Incline 10ft × 12ft	1,520ft	$77·00	117,040·00
X-cut 10ft × 12ft	970ft	$77·00	74,690·00
Sublevel 4ft × 6ft × 8ft	160ft	$59·75	9,560·00
Sublevel 7ft × 12ft × 8ft	430ft	$66·00	28,380·00
Raise 50°–57°–6ft × 6ft	200ft	$47·75	9,550·00
Raise 50°–57°–6ft × 8ft	0–150–180	$50·75	9,135·00 12,687·50
Slash 5130 10 × 13	7 × 9 1,730ft 115,910ft^3	86c	99,682·60
10 × 13 Entrance	200ft	$120·00	24,000·00
Sublevel 12ft × 20ft × 8ft	330ft	$80·50	26,565·00
Extras			
Shotcrete 10ft × 12ft	304ft	$24·00 (101·00)	7,296·00
Diamond Drill Slashing	16,200ft^3	48·125c	7,796·25
Misc. Slashing	20,000ft^3	48·125c	9,625·00
Bolts	6ft at 4/ft 500ft 2,000 bolts	$7·50	10,500·00
Wire Mesh	10,000ft^2	60c	6,000·00
TOTAL:		(28·6%)	$452,507·35

crosscut to the ore dump. Two-boom automatic one-man jumbos will be used, one air and one diesel-driven. Narrower headings will be drilled by jacklegs. Mucking equipment will be diesel and air LHD types, plus air and electric slushers for the narrow stopes.

Average operating cost/ton milled is calculated at $10·14 over the first 4 years of operations.

Alwin recently accepted firm bids from Canadian Mine Services Ltd. for pre-production mine development work, as well as for stope mining based on the planned production rate of 500 ton/day (minimum) – 175,000 ton/year. The pre-production development contract calls for capital expenditure of $452,507.

The basic contract price for subsequent operational stope ore mining, including scraping, is $2·80/ton for mining 4ft to 10ft true widths and £2/ton for 11ft, to 20ft true widths – averaging, for projection purposes, £2·60/ton.

To this is added indirect costing from Alwin's feasibility report of $4·48/ton covering service and material items: haulage, 63c/ton; air and water lines, 30c; ventilation, 15c; rock bolts, 20c, and miscellaneous, 60c, or a total of £4·48/ton, with Alwin itself supplying all servicing material plus board and room and engineering control (bringing the total cost/ton to an estimated £9.

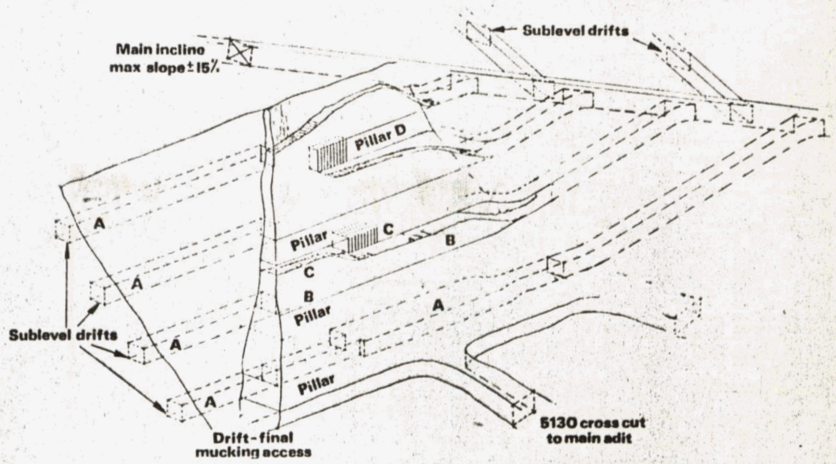
Management, however, is considering contracting out all but the board and room and engineering control factors for both pre-production development and stope mining.

Concentrator and crusher design

In designing the plant, special attention has been paid to providing a simplified, compact layout for maximum efficiency in supervision, maintenance and power distribution. The crushing plant has been placed adjacent to the concentrator with the operating floors in both plants being at the same elevation. An airtight door is provided to afford passage to and from the crushing and concentrating operations.

The design calls for pre-manufacturing and assembling of units in Vancouver area fabricating plants. This gives optimum efficiency in building under shop conditions and reduces field construction time, with capital reduction in plant cost.

Primary crushing will be by a 24in × 24in Eimco horizontal jaw crusher from the coarse ore bin at approximately 40 ton/h, conveyed by a 55ft vertical bucket elevator to the 6ft × 12ft double-deck screen. The coarse product



NARROW STOPES

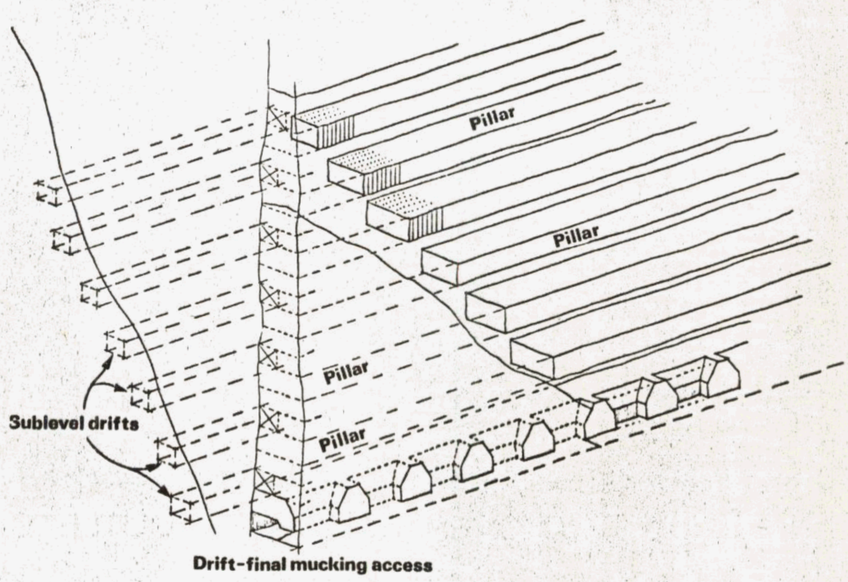
MINING SEQUENCE — TOP DOWN

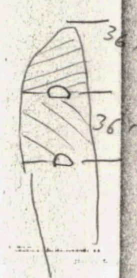
1. **Drift excavation – ore removed on 36 lifts .. .. (A)**
2. **Remove lift from back – swell removal if necessary .. (B)**
3. **Remove second vertical lift – swell removal .. .. (C)**
4. **Drill pillar and retreat by blasting .. .. (D)**

WIDE STOPES

MINING SEQUENCE

1. **Drift excavation – slash to width – remove to orepass**
2. **Remove lift from back – remove to orepass**
3. **Drill pillar and retreat (downholes) drawing on mucking access**
4. **Drill last pillar (upholes) and retreat**





will be delivered to a $4\frac{1}{2}$ft Symons cone crusher, while the fines will be transferred from the screen by bucket elevator to the fine ore bin. The cone product returns to the 55ft bucket elevator and thence to the screen. Fine ore will be delivered to the 8ft × 10ft ball mill, the mill product then being classified by two 10in cyclones—the underflow going to regrind and the overflow to ten 50ft flotation cells. Overflow from the rougher cells goes to the cleaner flotation, consisting of six 40ft^3 cells. From here the overflow is delivered to the thickener tank, the underflow being returned to the rougher cells. Concentrate from the thickener tank is transferred to a 12ft × 14ft high stock tank; from there it is pumped to the 6ft × 4ft disc filter. From the filter the concentrate is then transferred to a 3ft × 26ft long concentrate dryer and thence to the concentrate storage bin (see over).

Concentrate totalling approximately 40 ton/day will be trucked about 30 miles to rail-line for shipment (probably by open gondola cars) to the Port of Vancouver, thence by freighter to foreign markets.

FEASIBILITY STUDY

—Milling and metallurgical tests on Alwin orebody

A FEASIBILITY report produced by Bacon and Crowhurst Ltd. and Sandwell and Co. Ltd. describes milling and metallurgical test work.

Representative samples were submitted to the Department of Energy, Mines and Resources, Ottawa, to Lakefield Research of Canada Ltd., Lakefield, Ontario, and to Allis Chalmers Metal Processing Research and Test Centre, Oak Creek, Wisconsin, for flotation and grinding tests.

The copper in the ore occurs largely as coarse to medium-grained chalcopyrite disseminated in gangue. A smaller amount of copper (about 10 per cent) is present as bornite and chalcocite. The head sample assayed 2·50 per cent Cu, 0·0025 oz/ton Au and 0·54 oz/ton Ag.

Satisfactory concentrate grades and recoveries were obtained by flotation at a grind of 55 per cent minus 200 mesh. In a seven-stage locked-cycle test, a copper concentrate assaying 33 per cent Cu was produced with Cu, Au and Ag recoveries of 95·1 per cent, 85·4 per cent and 89·7 per cent respectively. Calculated gold and silver assays for this test were 0·0024 and 0·41 oz/ton respectively.

The work index determined for the ore was 17·4 kWh/ton. Calculated average work index for 55 per cent passing 200 mesh was 7·0.

Flotation tests were conducted on the products from the grinding series on Composite No. 1. One additional test was performed on ore ground to only 50·2 per cent —200 mesh. The same procedure was followed in all five tests. This involved a roughing stage and two or three cleaning stages.

Reagent additions to the roughing stage were 0·2 lb/ton sodium isopropyl xanthate (Z-11) and 0·1lb/ton Dowfroth 250. Addition of 0·5 lb/ton lime to the ball mill resulted in an initial pH of 9·5 to 10·0 in the cell. The rougher concentrates were cleaned by re-flotation using 0·02 lb/ton Dowfroth 250 when required.

Optimum results

The best results were obtained with the coarsest grind. After grinding to 54·2 per cent —200 mesh, a copper concentrate was produced assaying 32·8 per cent Cu at a recovery of 96·7 per cent. All five tests yielded Cu concentrates assaying between 32 and 34 per cent Cu at recoveries ranging from 95 to 96·7 per cent. In one test Cyanamid collector S-3501 was compared with isopropyl xanthate (Z-11). On a weight for weight basis the isopropyl xanthate collector was more efficient than reagent S-3501.

Composites No. 1 and 2 had similar flotation characteristics and were combined for subsequent locked cycle, settling and filtering test. Two tests on each composite were used in the comparison, the results of which are given below.

Increasing collector additions from 0·2 lb/ton to 0·3 lb/ton Z-11 did not improve the grade-recovery characteristics of the composition.

The results of the six-stage flotation cycle test showed that the recirculating cleaner tailings approached a steady weight after four cycles. If the recirculating cleaner tailings should be omitted from the calculations of the last two cycles, the metallurgical balance indicated that a copper cleaner concentrate assaying 33·6 per cent Cu at a recovery of 97·7 per cent could be produced. Overall copper cleaner concentrate grade in the six cycles was at 33·5 per cent Cu at a recovery of 96·9 per cent.

Thickening tests were conducted on the copper cleaner concentrate at natural pH; (a) without flocculant; (b) with 0·5 lb/ton lime; (c) with 0·01 lb/ton Separan AP30 (an anionic polyacrylamide) and (d) with 0·01 lb/ton Polyhall 402 (a non-toxic polyacrylamide). No solid-liquid demarcation was observable in the sample settled without flocculant. The organic flocculants Separan AP30 and Polyhall 402, notably the latter, produced good results.

Test	Composite No.	Grind time (min/1,000g)	Collector Type	Collector Addition (lb/ton)	Cu cleaner conc. Assay (%)	Cu cleaner conc. Recovery (%)
4	1	5	Z-11	0·2	32·8	96·7
5	2	5	Z-11	0·2	33·2	95·8
7	1	10	Z-11	0·3	33·1	96·3
8	2	10	Z-11	0·3	32·4	97·0

Water and power

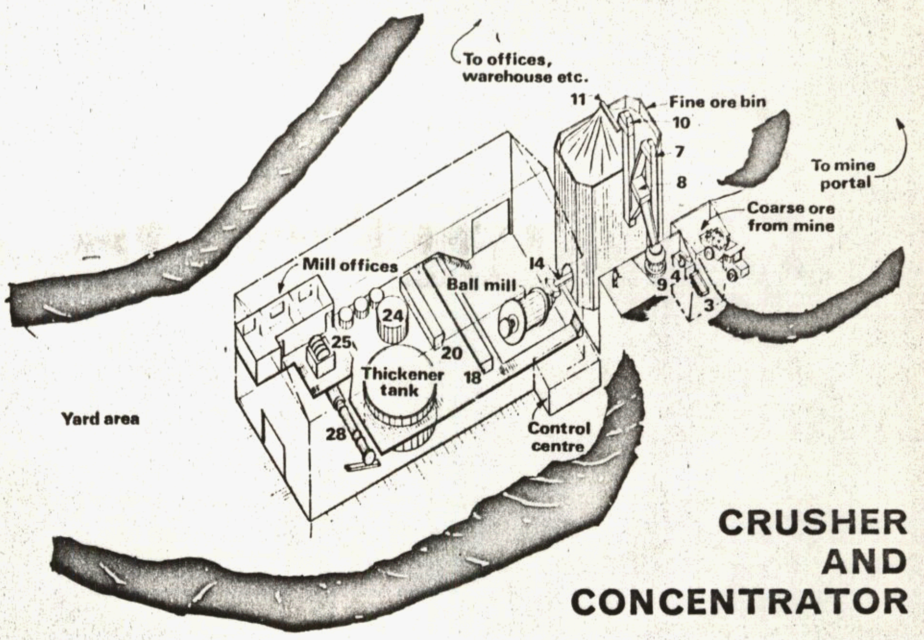
Fresh water supply will come from a lake approximately 3,000ft from the millsite. The lake will be dammed at the outlet and water pumped to the mill and mine, as well as to the camp quarters for domestic purposes. It is estimated that approximately 75 per cent of mill requirements will be reclaimed water from the tailings disposal pond located some 500ft from the mill. Fresh water requirements are calculated at approximately 100 U.S. gal/min.

Alwin will construct 4 miles of 13·8 kV power line to connect with the provincial government hydro mainline.

When the initial exploration programme was launched the original narrow dirt road from the hard-surfaced main highway through the Highland Valley was relocated, gravelled and upgraded with future construction and concentrate haulage in mind.

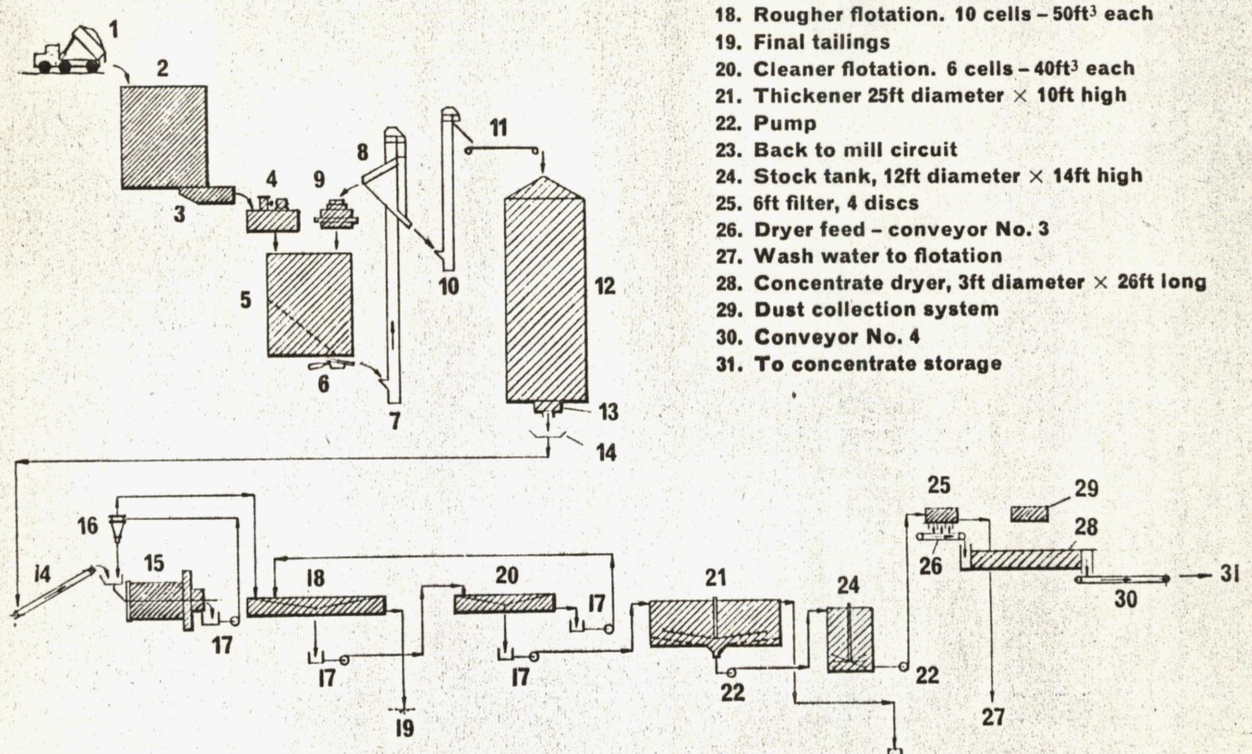
Fully winterised housing consists of modern mobile sleeping, dining, administration, lounging and recreation units which were adequate during the exploration and underground development stages. These will be expanded to accommodate the tripled personnel required when production starts.

At the outset of production, Alwin will employ 98 people – mining, 67; milling, 17; and 14 in plant services and campsite administration.



CRUSHER AND CONCENTRATOR

1. 16in coarse ore from mine
2. 350 ton coarse ore pocket
3. 34in × 96in reciprocating feeder
4. 24in × 24in Eimco horizontal jaw
5. 150 ton coarse ore pocket
6. 24in × 60in Jeffrey vibrating feeder
7. 55ft c/c Jeffrey vertical continuous bucket elevator
8. 6ft × 12ft D.D. screen
9. $4\frac{1}{4}$in Symons cone (SH) or (STD)
10. 35ft c/c Jeffrey vertical continuous bucket elevator
11. Conveyor No. 1
12. Fine ore bin
13. 2 × 10in tube feeders
14. Conveyor No. 2
15. Ball mill, 8ft × 10ft
16. 2/10in cyclone classifier
17. Pump box and pump
18. Rougher flotation. 10 cells – 50ft^3 each
19. Final tailings
20. Cleaner flotation. 6 cells – 40ft^3 each
21. Thickener 25ft diameter × 10ft high
22. Pump
23. Back to mill circuit
24. Stock tank, 12ft diameter × 14ft high
25. 6ft filter, 4 discs
26. Dryer feed – conveyor No. 3
27. Wash water to flotation
28. Concentrate dryer, 3ft diameter × 26ft long
29. Dust collection system
30. Conveyor No. 4
31. To concentrate storage



FLOW SHEET