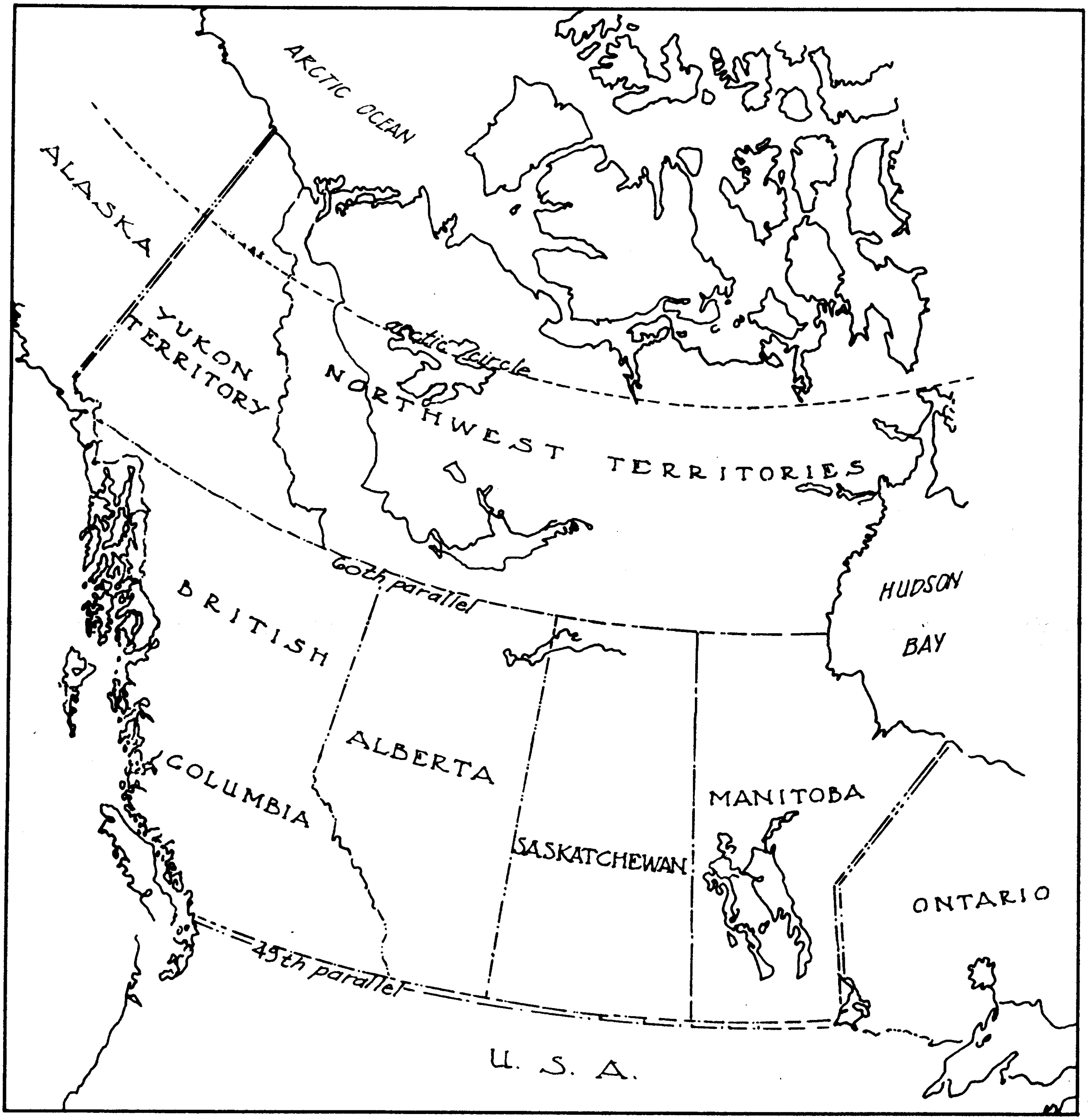
MINERAL INDUSTRIES IN WESTERN CANADA

THE TENTH COMMONWEALTH MINING AND METALLURGICAL CONGRESS – SEPTEMBER 2-28, 1974



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GRANISLE

GRANBY MINING COMPANY LTD.

Babine Lake in north-central British Columbia is the location of the 13,000 ton/day open-pit mine of Granisle Copper Limited.

Granisle is located thirty miles north of Topley. 175 miles west of Prince George on Highway 16. From the village nestled on the western shore of Babine Lake, it is an eight-minute barge crossing to the minesite on McDonald Island. During the months from December to May, the ferry channel is kept ice-free with an underwater bubbler system pioneered and perfected by Granisle Copper. Several bubbler systems, based on this design, are now operating in Western Canada.

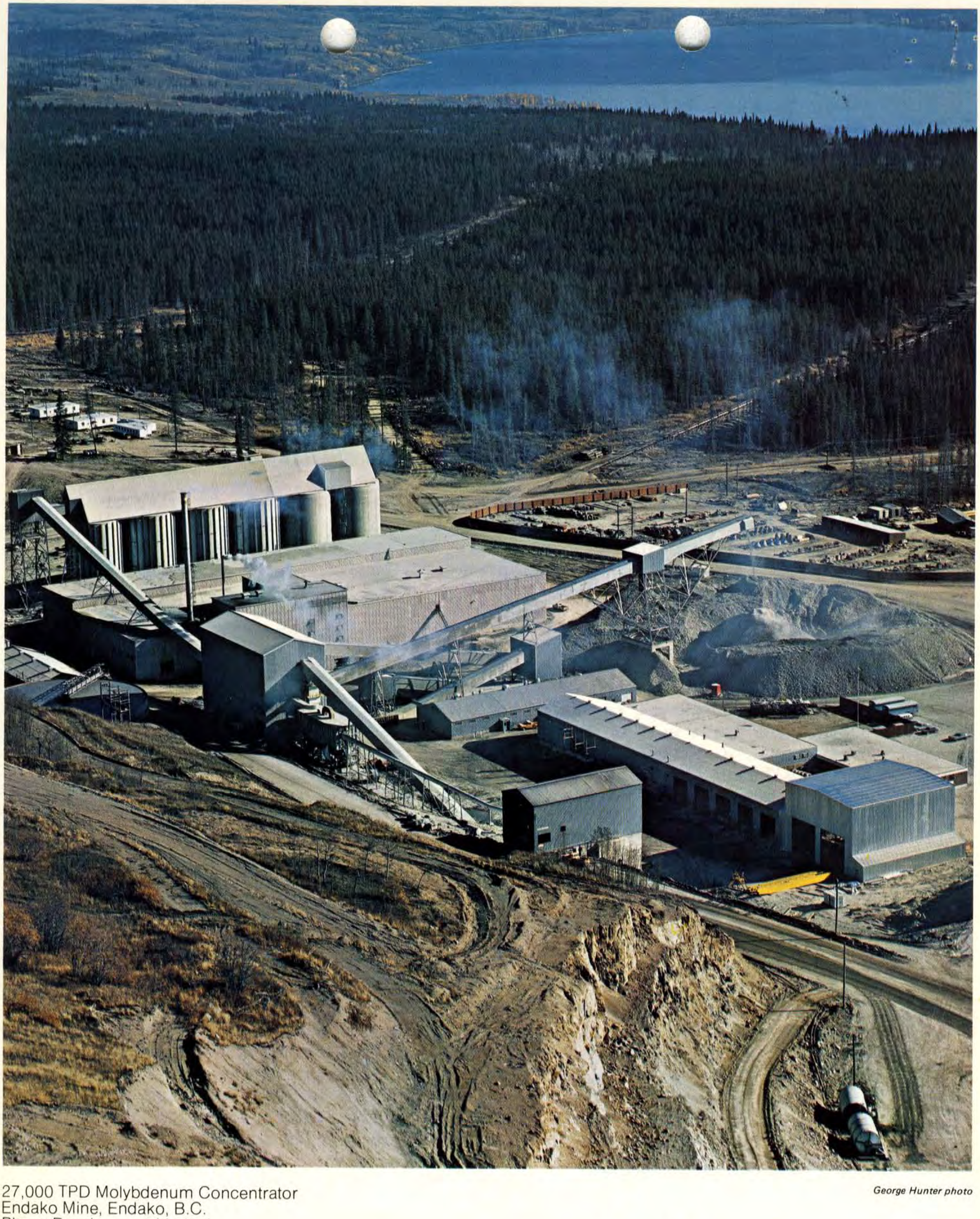
The climate of the Babine Lake area is typical of the interior of British Columbia. Although the lake exerts a moderating influence, winter temperatures can drop to well below zero, but prolonged periods of low temperatures are rare. The annual precipitation averages 20 inches and the normal snow depth is three feet.

MINERAL DEPOSIT

The 1913 annual report to the British Columbia Minister of Mines recorded the first work on the mineralization of McDonald Island. Charles Newman and H. J. McDonald were the discoverers. Scant information followed, but in 1927 Douglas Lay persuaded Cominco Limited to bond the property. Under the guidance of Hank Giegerich, Cominco drilled several long holes, but due to the recession of 1929, work was discontinued and the property returned to McDonald and Newman.

Through the thirties the property lay dormant. Then, in 1943 Dr. Victor Dolmage reported that, in spite of the low tenor of the ore, there was hope for high grade mineralization. A small company was formed and 1700 feet of core were logged. The average grade came to only 0.60% Cu so work was once again stopped.

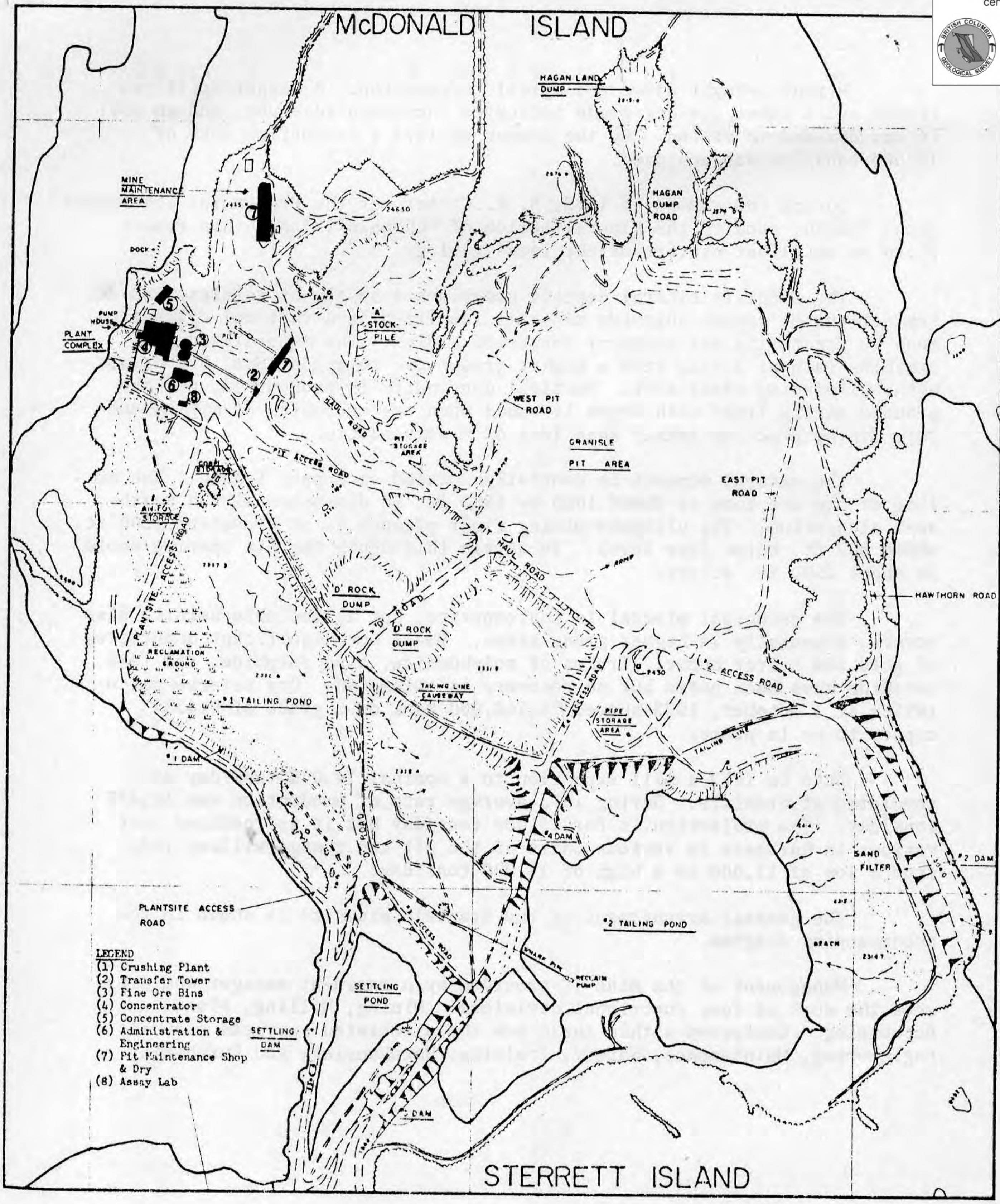
Finally, in August of 1955 the property was examined by Granby. Before freeze-up, additional claims had been staked and eight drill holes sunk. The following summer 49 more holes were drilled and a remarkable continuity of copper values was demonstrated. Subsequent findings, like the favourable results from thirty additional holes in 1959, enhanced the property so that by 1963 work included preliminary flotation testing. After this the pace quickened. A feasibility report was completed in April 1964, and in mid-November 1966 production started at 5000 tons/day.



27,000 TPD Molybdenum Concentrator
Endako Mine, Endako, B.C.
Placer Development Limited

George Hunter photo

DESIGNED BY WRIGHT ENGINEERS LTD.


McDONALD ISLAND
HAGAN LAND DUMP
MINE MAINTENANCE AREA
HAGAN DUMP ROAD
DOCK
PUMP HOUSE
PLANT COMPLEX
'A' STOCK-PILE
WEST PIT ROAD
PIT ACCESS ROAD
PIT HAUL ROAD
GRANISLE PIT AREA
EAST PIT ROAD
AN-FO STORAGE
PLANTSITE ACCESS ROAD
HAWTHORN ROAD
'D' ROCK DUMP
'D' ROAD
RECLAMATION GROUND
#1 TAILING POND
TAILING LINE CAUSEWAY
PIPE STORAGE AREA
#2 ACCESS ROAD
TAILING LINE
#1 DAM
#4 DAM
SAND FILTER
#2 DAM
#2 TAILING POND
BEACH
PLANTSITE ACCESS ROAD
SETTLING POND
SETTLING DAM
RECLAIM PUMP
#3 DAM
STERRETT ISLAND
LEGEND
(1) Crushing Plant
(2) Transfer Tower
(3) Fine Ore Bins
(4) Concentrator
(5) Concentrate Storage
(6) Administration & Engineering
(7) Pit Maintenance Shop & Dry
(8) Assay Lab

Mining brought added geological information. A deeper drill programme and a lower cut-off grade indicated increased reserves, and in 1971 it was decided to expand. By the summer of 1973 a production rate of 13,000 tons/day was achieved.

During the summer of 1965, N. C. Carter, of the Provincial Government Mines Branch, studied the mineralization of McDonald Island. His report gives an excellent picture of the local geology.

The Granisle mineral deposit comprises a system of veinlets and disseminations of copper sulphide minerals localized in a vertical cylindrical mass by fracturing and porphyry intrusive bodies. The mineralized mass exhibits lateral zoning from a higher grade core to gradational boundaries with surrounding waste rock. Vertical continuity is pronounced, and the planned mining limit with depth is based upon the economics of mining and safe mining practice rather than lack of mineralization.

The mineral deposit is centrally located on Copper Island. The outline of the ore zone is about 1000 by 1500 ft. in dimension with a northeast elongation. The ultimate mining floor planned is at elevation 1500 ft. about 800 ft. below lake level. To attain this depth the pit opening would be about 2500 ft. across.

The principal mineral is chalcopyrite, but appreciable bornite also occurs, especially in higher grade areas. Small but significant quantities of gold and silver occur. Traces of molybdenite, zinc sulphide, and lead sulphide have been noted but no recovery is attempted. Ore reserve calculation at 1 October, 1973 showed 78,168,000 tons of a grade of 0.433% copper to be in place.

Late in 1972 a mill expansion to a nominal 14,000 tons/day was completed at Granisle. During 1973 average rate of production was 11,475 tons/day. The projection is for 13,000 tons/day but it is realized that various in hardness in various parts of the pit can change milling rate from a low of 11,000 to a high of 17,000 tons/day.

The general arrangement of the Granisle minesite is shown in the accompanying diagram.

Management at the mine is provided by a resident manager who oversees the work of four functional divisions: Mining, Milling, Plant, and Accounting. Contained within these are the associated services such as: Engineering, Maintenance, Safety, Training, Warehousing, and Purchasing.

The total Granisle Copper employment is 289, with the administration and operating crews distributed as follows:

Administration	9
Mining	94
Milling	71
Mechanical	39
Surface	36
Electrical	9
Engineering	14
Accounting & Warehousing	17
	289

During the 1973 fiscal year, Granisle Copper processed 4,188,483 tons of ore grading 0.46% Cu with the cost per ton of ore milled distributed as shown:

Mining	$1.022
Crushing	0.173
Concentrating	0.539
Tailings	0.049
Indirect	0.606
Administration	0.243
Total unit cost	$2.632

MINE PLANNING

Detailed cutting plans are drawn for five years with a broad mining plan for ten years. These plans are updated once a year as mining progresses. A rolling twelve months forecast is prepared to show tons mined and milled, mill head grades, mill recoveries, tons concentrate produced and unit working costs.

The bench height is 35 ft. Working slop angles are 40° and 45° and ultimate slope angles will be 40°, 45° and 50° on different sides of the pit.

Bench faces stand at approximately 60° with present blasting techniques. A safety berm 30-ft. wide is maintained on every second bench. Ramps are 80-ft. wide with a gradient of 10%.

DRILLING AND BLASTING

Standard staggered patterns are 14 ft. by 28 ft. and 15 ft. by 30 ft. for the Bucyrus-Erie 40R and 45R respectively, with a subgrade of five feet.

Dry holes are loaded with a toe-load of 13% aluminized ANFO and a column load of ANFO to a 15-ft. collar.

Where possible, wet holes are pumped dry and lined with a plastic liner and loaded as above.

Blast holes in sinking cuts and the initial production rounds from bottom benches cannot be dewatered. These holes are loaded with bagged TNT slurry and bagged aluminized ANFO.

Holes are stemmed with drill cuttings. Holes are primed with two Procore 111 primers on a single downline of Reinforced primacord. Holes are connected with Scufflex primacord with 15 and 25 ms delays between rows. Safety fuse with a No. 6 blasting cap is used to initiate the primacord.

PIT PRODUCTION

Production from the pit is approximately 400,000 tons of ore and 540,000 tons of waste per month. The present mining ratio is 1.35:1. The operation runs continuously with a six day on and two days off shift schedule.

Waste rock is used for the construction of roads, causeways, and tailings dams. Overburden is stockpiled on a separate dump for possible future reclamation projects.

PIT MAINTENANCE

The pit repair shop, pit offices, change-house and shop warehouse are housed in a single structure with an overall floor area of 21,000 square feet.

All maintenance work is carried out by a thirty-five man maintenance crew and a staff of four, under the direction of the plant superintendent.

The Granisle open pit.

TABLE 1

MINE PRODUCTION EQUIPMENT

Function	Type of Unit	No. of Units	Scheduled per Shift	Unit Performance per Hour
Drilling	B-E 40R	1	1	45.5 ft.
	B-E 45R	1	1	43.2 ft.
Loading	P & H 1400 Electric Shovel 4 cu.yd. bucket	2	1	519 tons
	Marion 151 Electric Shovel 9 cu.yd. bucket	2	2	861 tons
Hauling	Terex R-50 50 ton	8)	9	177 tons
	Terex R-65 65 ton	6)		228 tons
Dump Maintenance and Shovel clean-up	Cat. D9G	1	1	
	Cat. D8H	1	1	
	Cat. 824 rubber-tired	1	1	
Road Maintenance	Cat. 16 Grader	1	1	
	Cat. 12 Grader	1	as required	
	EUC F91 sand/water truck	1	as required	
Blasting	Ford F-900 ANFO mix truck	1	as required	
	Ford F-250 Blasthole Dewatering	1	as required	

TABLE 2

CONSUMPTION OF KEY ITEMS PER 12-MONTH PERIOD

Blasting supplies:	ANFO 4,113,000 lb; aluminized ANFO 1,750,000 lb; packaged slurry 717,000 lb; plastic liners 57,000 ft; primers 396 cases (50/case); Primacord 712 rolls (1000 ft/roll)
Diesel fuel:	805,000 gal.
Tires:	$370,000
Power:	8,400,000 kwh.

TABLE 3

OPERATING CREW FOR CONTINUOUS OPERATION

	Staff	Hourly
Administration	2	-
Equipment instructor	1	-
Shift foreman	4	-
Shovel operators	-	12
Shovel oilers	-	4
Drillers	-	8
Support equipment operators	-	16
Haulage truck drivers	-	40
Blasting crew	-	4
Miner helpers and trainees	-	3
	7	87

TABLE 4

MINING COSTS

Unit Costs, $/ton Mined

	$/ton
Drilling	0.034
Blasting	0.072
Loading	0.045
Hauling	0.135
Pit repair shop	0.020
Support equipment	0.054
General services & supervision	0.015
	0.375

TABLE 5

REPAIR AND MAINTENANCE COSTS

Unit Costs, $/ton Mined

Drilling	0.007
Loading	0.014
Hauling	0.060
Support equipment	0.014
Pit shop operation	0.020
Powerline maintenance	0.002
	0.117

TABLE 6

MAINTENANCE MANPOWER

	Staff	Hourly
Administration	1	-
Shop foreman	3	-
Welders	-	5
Mechanics	-	21
Lubrication servicemen	-	7
Warehouse clerk	-	1
Janitor	-	1
	4	35

CRUSHING & CONCENTRATING

The 800 tons/hour crushing plant is shown in the accompanying diagram. First-stage crushing is through a gyratory, followed by a double deck-screen which separates the 3/4 in. fines to the fine ore bins, while the screen oversize is directed to an open air stockpile. Secondary crushing is done by a single cone crusher, and tertiary crushing by two cone crushers. Secondary screens are in open circuit with the crusher and the tertiary screens in closed circuit. Crushed ore is stored in two fine ore bins of a nominal capacity of 8000 tons each. The crushing plant is not heated.

The grinding and flotation circuits are shown in the concentrator flowsheet. Crushed discharge from the two fine ore bins is fed to two non-identical grinding circuits. The original circuit is described first.

This circuit consists of a single open-circuit rod mill powered by a 1100 HP motor and operating at an average feed rate of 235 dry short tons per hour.

The rod mill discharge is split to two identical, overflow type ball mills powered by 1100 HP motors and operating in closed circuit with 20 in. cyclones. The classified product at a nominal density of 35% solids by weight and at 60%-200 mesh is fed to the rougher-scavenger flotation cell bank where it joins the pulp from the second grinding circuit. Grinding circuit No. 2, fed at an average rate of 320 dry short tons per hour, consists of an open circuit rod mill powered by a 1650 HP motor. Rod mill discharge feeds a single overflow type ball mill powered by a 3400 HP motor and operating in closed circuit with 20 in. cyclones. The nominal specification of classified product is the same as for No. 1 circuit.

Pulp from the grinding circuit is fed to two parallel banks of 300 cu.ft. rougher-scavenger flotation cells arranged back to back in rows of sixteen cells each. Tailing from the scavenger cells, averaging less than 0.045% copper, enters a common sump before being pumped to tailing disposal. Total rougher-scavenger concentrate is reground by an overflow type ball mill powered by a 300 HP motor and operating in closed circuit with 10 in. cyclone before passing to the first stage of cleaning. Further progress may be followed on the flowsheet.

Final concentrate (average 33% copper) is dewatered in a thirty-foot, unbalanced tray thickener to 70-73% solids by weight. Thickener underflow is pumped to an 18,000 gallon stock tank from where it is pumped to a six-disc filter and dewatered to 12-14% moisture. Filter cake is dried to 7-8% moisture in a 4 ft. x 28 ft. rotary drier fired by light fuel oil then stockpiled under cover for shipment by truck to the railhead at Topley, and finally to Vancouver for shipment to Japan.

GRANISLE: CONCENTRATOR STATISTICS

Milling data for the 12-month period ending 30 September 1973.

Total mill feed: 4.19 million tons 0.47% Cu.

Concentrate produced: 52,269 short dry tons 33.406% Cu.

Overall copper recovery: 89.99%

Material Consumption (lb/ton-milled)

Grinding rods (3.5 & 4 in.)	1.01
Grinding balls (2 & 2.5 in.)	0.83
Regrind steel (1.25 in.)	0.034

Reagent Consumption (lb/ton-milled)

Lime (CaO)	0.451
Sodium ethyl xanthate	0.010
Potassium amyl xanthate	0.003
Collector Z200	0.018
Frother (MIBC)	0.050
Frother Frothex 40	0.004
Sodium cyanide	0.005

Power consumption for crushing and concentrating is 18.7 kwh/ton, of which 16.4 kwh consumed in the concentrator.

Mineral Processing Personnel (Crushing & Concentrating)

	Hourly Rated	Staff
Operations	33	6
Maintenance (millwrights/welders)	15	1
Apprentices	4	-
Maintenance Planning	-	2
Metallurgy & Assaying	3	5
Training		1
Superintendent	-	1
Total	55	16

Granisle: trucking concentrate on to the ferry on the way to railhead

Granisle: about to dump into the primary crusher

TAILINGS DISPOSAL

Babine Lake is one of British Columbia's largest fresh water lakes and an important salmon spawning ground. The location of the mine on an island makes tailings disposal a costly and challenging task. Granisle has solved this problem, while assuring protection for the land and water, by joining McDonald and Sterrett Islands with a system of causeways. The net result is the creation of one island. The causeways are rock-fill constructed with a gradation of facing from +18 inch to slimes. The final upstream faces are built with cycloned sands. At the end of 1973 the tailing area included 240 acres and was forty-five feet above the level of Babine Lake.

Scavenger tailings at 35% solids is pumped by a 16 x 14 SRL-C Denver to nine, fifteen-inch cyclones at the dam face. Underflow products is 86% of +200 mesh at 75% solids. Two parallel pumping and piping systems ensure there are a minimum of production problems associated with the disposal.

A barge-mounted pump station is utilized to return tailings water to the mill. An emergency process water source is provided by a fresh water pumphouse at the lake.

As the tailing area is completed, the land will be reclaimed by planting grass and shrubs indigenous to the area. Rock dumps will be contoured and covered with overburden. Reclamation is discussed in more detail in a separate section.

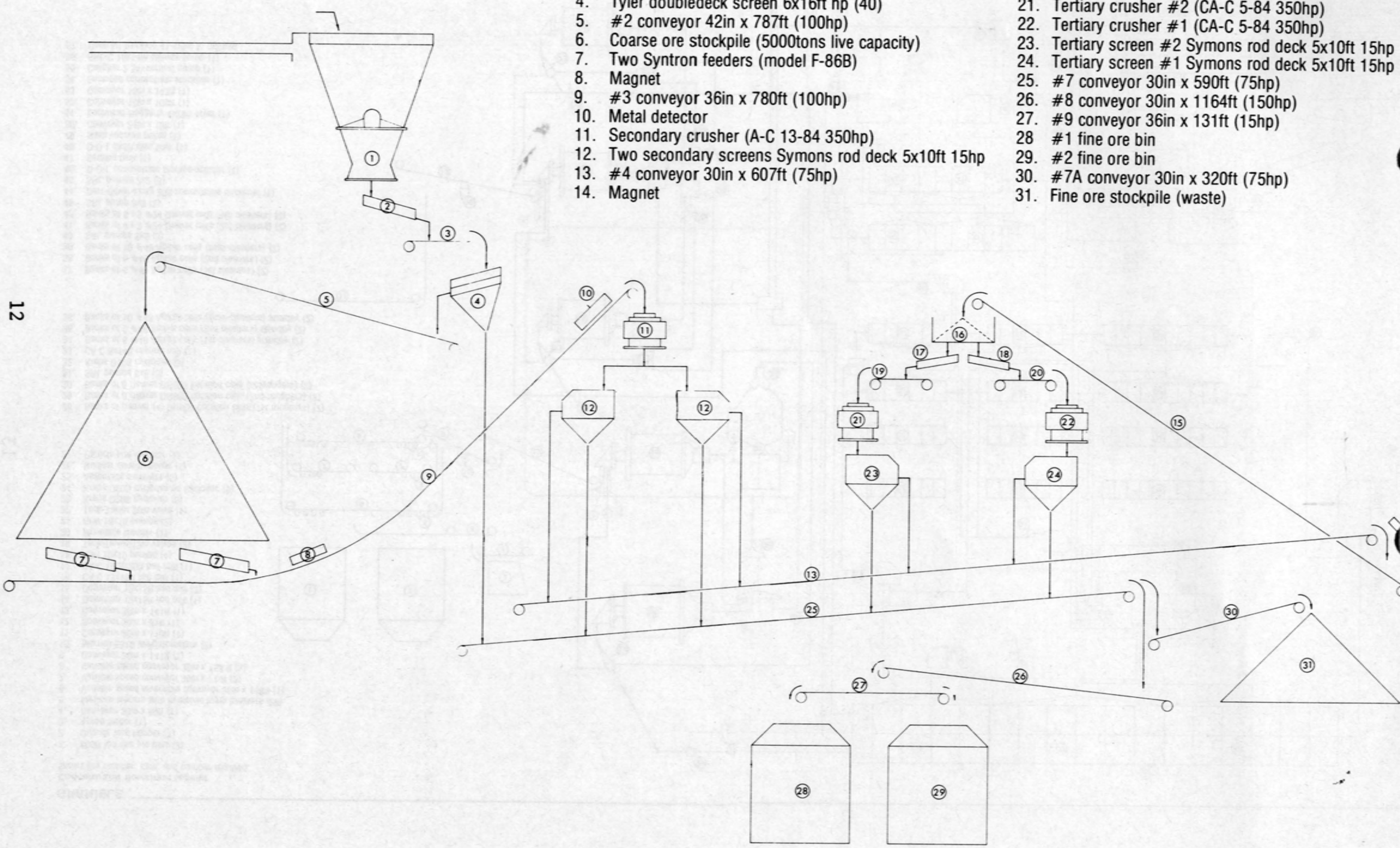
This article was prepared by the staff of The Granby Mining Company Ltd. and the Western Miner and was printed in the Western Miner June 1974 issue.

Granisle: plastic pipe conveys tailings to pond

GRANISLE

crushing plant flowsheet

1. Primary crusher (A-C 42-65 350hp)
2. Syntron feeder (model F-86)
3. #1 conveyor 42in x 78ft (20hp)
4. Tyler doubledeck screen 6x16ft hp (40)
5. #2 conveyor 42in x 787ft (100hp)
6. Coarse ore stockpile (5000tons live capacity)
7. Two Syntron feeders (model F-86B)
8. Magnet
9. #3 conveyor 36in x 780ft (100hp)
10. Metal detector
11. Secondary crusher (A-C 13-84 350hp)
12. Two secondary screens Symons rod deck 5x10ft 15hp
13. #4 conveyor 30in x 607ft (75hp)
14. Magnet
15. #5 conveyor 30in x 523 ft (75hp)
16. Surge bin (500 ton)
17. Tertiary feeder #2 (Vibranetics)
18. Tertiary feeder #1 (Jeffrey model 5 DL)
19. #6A conveyor 36in x 72ft (5hp)
20. #6 conveyor 36in x 40ft (5 hp)
21. Tertiary crusher #2 (CA-C 5-84 350hp)
22. Tertiary crusher #1 (CA-C 5-84 350hp)
23. Tertiary screen #2 Symons rod deck 5x10ft 15hp
24. Tertiary screen #1 Symons rod deck 5x10ft 15hp
25. #7 conveyor 30in x 590ft (75hp)
26. #8 conveyor 30in x 1164ft (150hp)
27. #9 conveyor 36in x 131ft (15hp)
28. #1 fine ore bin
29. #2 fine ore bin
30. #7A conveyor 30in x 320ft (75hp)
31. Fine ore stockpile (waste)



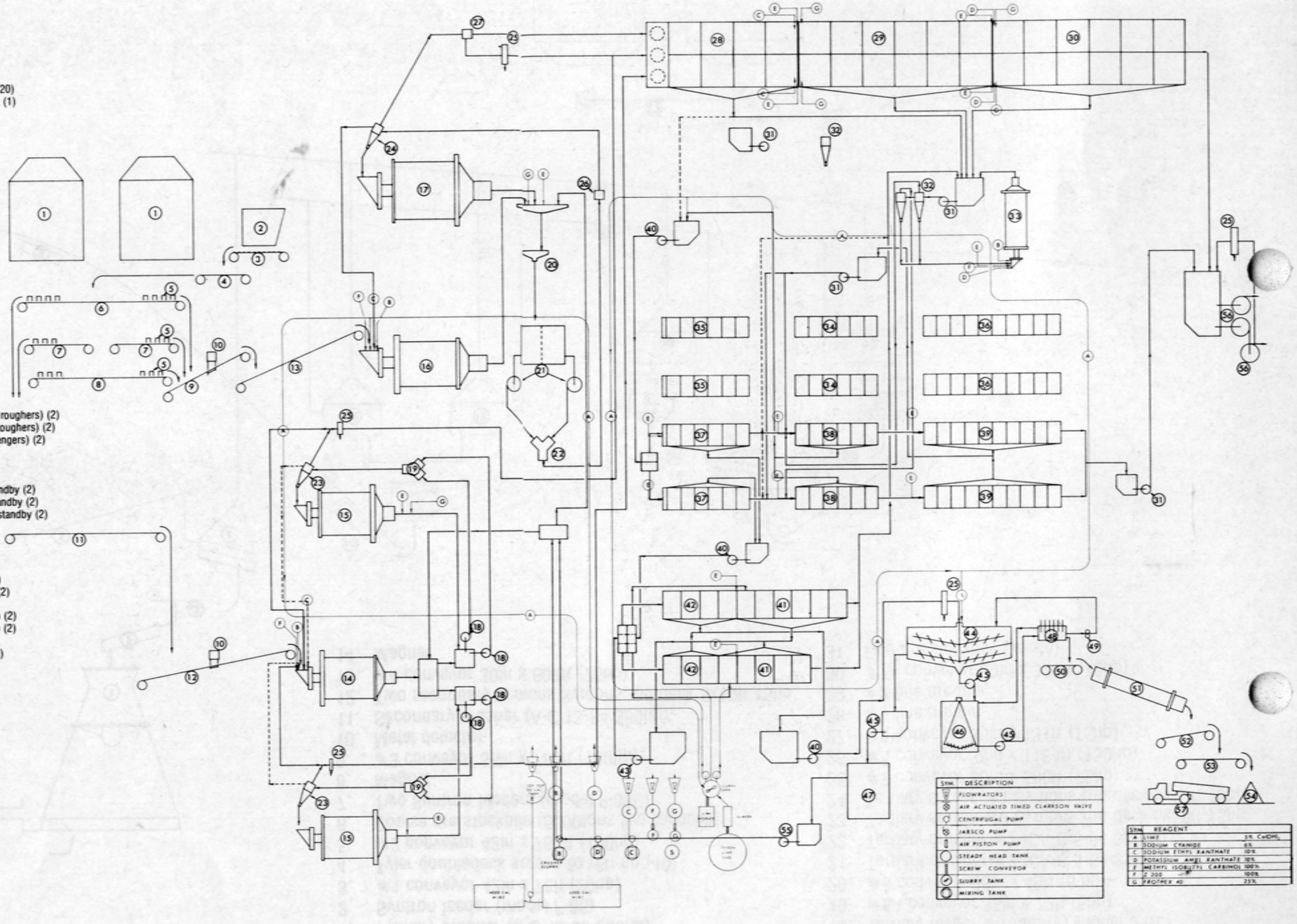
GRANISLE

Concentrator flowsheet legend
Shows key number, item, and number required

1. 8000-ton fine ore bins (2)
2. Outside feed hopper (1)
3. Apron feeder (1)
4. Conveyor 30in x 59ft (1)
5. Mexican feeders with hydraulic lump breakers (20)
6. Variable speed reversible conveyor 36in x 158ft (1)
7. Variable speed conveyor 36in x 71 ft (2)
8. Variable speed conveyor 36in x 158 ft (1)
9. Conveyor 30in x 141ft (1)
10. Merrick E310 Weightometers (2)
11. Conveyor 30in x 110ft (1)
12. Conveyor 30in x 81ft (1)
13. Conveyor 30in x 141ft (1)
14. Dominion 12x15ft rod mill (1)
15. Dominion 12x15ft ball mill (2)
16. CA-C 13x18ft rod mill (1)
17. CA-C 16.5x20ft ball mill (1)
18. ASH 10x10 pumps (4)
19. Teck-Taylor 12in valves (2)
20. Moveable launder (1)
21. GIW 16x16 pumps (2)
22. Teck-Taylor 20in valve (1)
23. Krebs D20B cyclones (8)
24. Krebs D20B cyclones on Cyclopac (9)
25. Automatic samplers (5)
26. Nuclear density gauge (1)
27. Particle size monitor (1)

28. Banks of Denver (4) DR600 flotation cells (1st roughers) (2)
29. Banks of 6 Denver DR600 flotation cells (2nd roughers) (2)
30. Banks of 6 Denver DR600 flotation cells (scavengers) (2)
31. SRL pumps 6x6 (3)
32. Krebs D10B cyclones (3)
33. CA-C 6x14ft regrind mill (1)
34. Banks of 6 #48 Agitair cells (1st cleaners) standby (2)
35. Banks of 6 #48 Agitair cells (2nd cleaners) standby (2)
36. Banks of 10 #48 Agitair cells (scav-cleaners) standby (2)

37. Banks of 6 #48 Agitair cells (1st cleaners) (2)
38. Banks of 6 #48 Agitair cells (2nd cleaners) (2)
39. Banks of 10 #48 Agitair cells (scav-cleaners) (2)
40. SRL pumps 5x5 (3)
41. Banks of 4+3 #24 Denver cells (3rd cleaners) (2)
42. Banks of 6+5 #24 Denver cells (4th cleaners) (2)
43. SRL pump 3x3 (1)
44. Dorr-Oliver-Long 30ft concentrate thickener (1)
45. SRL pumps 2x2 (3)
46. D-O-L concentrate storage agitator (1)
47. Settling tank (1)
48. D-O-L 6x6ft disc filter (1)
49. Nash vacuum pump (1)
50. Conveyor 24in x 10ft (1)
51. Lochhead Haggerty 4x28ft dryer (1)
52. Conveyor 18in x 109ft (1)
53. Conveyor 18in x 143ft (1)
54. Enclosed concentrate stockpile (1)
55. Caligher 2.5in vertical pump (1)
56. SRL-C 16x14in tailings pump (1)
57. Contract trucking 41 miles to railroad



GRANISLE 1972
The Granby Mining Company Limited
14,000 T.P.D. Copper
Topley, B.C.

George Hunter photo

RECLAMATION AND ENVIRONMENTAL CONTROL

AT GRANISLE AND PHOENIX*

The history of The Granby Mining Company from Phoenix days through Anyox and Copper Mountain to Granisle reflects the history of the mining industry since the beginning of the century. The gradual upward trend of metal prices in spite of short term ups and downs has been well documented elsewhere. This increase is attributed to increased demands with population growths and increasing industrialization. Labour shortages during war time and the current desire of workmen to live in cities at the expense of the labour supply in rural and back-woods settings, have forced mining companies to increase mechanization to meet the increasing demand for metals. Greater operating and manpower efficiency is gained with larger equipment, resulting in trends toward large, lower-grade metal deposits.

The wholesale mining of low-grade material is by its nature and the size of equipment limited to surface operations. Underground operation with selective mining of higher grade ores continues, but there is little chance to capitalize on the efficiencies of large mining machines. Underground mining is usually carried out with a minimum of surface disturbance. Surface mining changes the surface profile.

Open-pit mining has today supplied a solution to the problems of increasing metal demand and decreasing labour availability. However, the resultant changes in topography and the destruction or covering of useful land surface are often undesirable side effects. Instead of maintaining surface rock and soils intact, as with underground mining, open-pit mining requires removal of covering rock and also material surrounding the ore to permit access to it and to maintain safe wall slopes. This material must be stored in permanent waste piles which for efficiency should be as close to the rim of the ultimate pit as possible to minimize hauling and prevent double handling. Any low-grade material below allowable treatment levels but of possible future value must be stockpiled at some point where it will be accessible for milling at a later date. The mill tailings must also be impounded. Current practice is to recycle water to protect creeks from pollution. To minimize pumping costs the tailing pond must be as close as possible to the concentrator. Since a short haul to the concentrator from the pit is also desirable, one ends up with all of these various storage piles clustered around the pit. To satisfy aesthetic and conservation demands, these structures must be reclaimed, as far as possible.

The kind of ore deposits, particularly copper ores, which are mined by open-pit methods are usually disseminated ores with gradational boundaries. After mining, there remains in place a surrounding shell of sub-ore grade of which removal cannot be justified by today's metal prices and costs. In a somewhat similar way the depth of mining is often established by the economics of removal rather than by the bottom of the mineralization. With increased metal demands in the future the pit could be widened and deepened to supply additional ore. Therefore, for resource conservation it may not be desirable to backfill open pits.

* See Article G

Waste removal in open pit mining often exceeds the tonnage of ore recovered (at Phoenix about 4 times and Granisle 1.5 times as much). Allowing 50% volume increase with breaking one gets proportionately increased disposal problems. Total areas of waste dumps are commonly many times the surface area of the open pit itself. Rock waste presents reclamation problems because of the coarse texture and relative inability to retain moisture.

The sands residue from the milled ore is stored in a tailing pond which can eventually be drained. The sizing of this material allows it to retain moisture except for a thin layer of a few inches at the surface even through hottest summer months. However, the sand particles contain little plant nutrient and this must be supplied in the form of fertilizers. Reclamation of tailing ponds by grass planting is a well established procedure.

In spite of advances in geophysics and remote sensing most mining operations continue to be extension of surface indications found in outcropping rocks. Since outcropping rocks occur most plentifully in mountainous areas and near ridge tops where soil cover is absent or limited, this is the general setting for many mines. This kind of country has limited use. There is not usually any serious contest for land use with farmers. Forests cover most of the upland country in B.C., so arrangements for joint use of the land must be made with logging interests. Discharges into streams and lakes must be controlled to prevent pollution of stream or lake waters and possible harm to sport and commercial fishing. The value of the recreation resource is often increased by the access provided to hunters, hikers and campers by mine road systems. The principle of the joint use of Provincial Lands has been well established, and mining companies are working on this basis.

With the multiple use of lands, users must be controlled in case side-effects of their activities might affect others adversely. Conservationists have brought an awareness of the limits of our resources not only in the way of metals and timber but also the wild land resource with its native plants and animals. This limit is recognized and, where damage to land is unavoidable by mining, best efforts are put forward to reconstruct the land by grading and replanting to be at least as good as original land for various other uses. Reclamation regulations have been established, and completion is guaranteed by bonds placed with the Provincial Government. As a mining operation is developed and goes into production each stage must be cleared through the Provincial Government with all other potential users of resources available in that area before permission to proceed is granted. Monitoring and inspection branches keep track of progress of work.

Nature with the help of time is a pretty good reclaimer. Most people in B.C. have seen evidence of this in the regrowth of forests over abandoned towns. In earlier times, old mine workings were considered not much more hazardous than natural rock faces, and erosion and regrowth eventually produced a new crop of vegetation. Today with large open pit mines and the relatively great areas of waste dumps to be covered, the normal processes of nature would be very slow, since leaf fall and development of a new top soil layer can only spread a few feet per year from adjoining forests under the best of conditions. With a little help in the way of soil cover and fertilization together with the planting of particularly suited species the processes of nature can be greatly accelerated by the mining company and in a few years a new vegetation can be established.

LAND RECLAMATION AT PHOENIX

At Phoenix Mine, on the return of Granby in 1956, little trace remained of the old city of Phoenix, abandoned in 1919. The disappearance of the town was to a considerable extent due to the depredations of man. The buildings had provided a free supply of bricks and lumber for the taking to anyone building a house or barn. Before mining could start a title search of the old city records was made and any titles in good standing were purchased. A brick transformer station was still in good shape and it continued in use for several years as an equipment store house until the advancing pit rim overtook it. Other structures, bins, headframes and sheds were demolished and burned to make way for the new operation. The old area had been considered one of B.C.'s more accessible ghost towns and had been well searched for relics of the past by collectors.

The Phoenix open pit operation is approaching an end. It is expected that the total area of the land surface which will be affected by the mine will be about 425 acres. Of this area 50% will be waste dumps. 30% will be tailing disposal areas, and the remaining 20% will be occupied by the actual open pit, roads, and the mining plant. Waste dumps and tailing ponds predominate as reclamation projects.

In 1968 the earlier tailing disposal area, located on an abandoned farm plot about a mile east of the mine at a considerably lower elevation was shut down and drained. The following year experimental work was begun to reclaim this area. Its extent is about 46 acres.

In the upper, southern part of the pit the ore zone was completely worked out. The waste dumps which were formed on the west side were considered to be in their final state. These dump were also prepared for reclamation in 1968 on an experimental basis.

To provide technical agricultural supervision of this work an East Kootenay company, Interial Reforestation Co., was retained. A number of trial plots were established for varying planting methods using several species and plant types.

Reclamation by grass plantings have given good results on the flat top of the tailings pond. Mixed seed to provide ground cover and nitrogenization and liberal amounts of fertilizer are used; fertilization continues for three years. Side slopes present problems due to drying out and wind erosion as coarser sand fractions are deposited around the rim of the dam. Evidently terracing and slope reduction will have to be done there. Various trees and shrubs have been tried. Good survival has been recorded for poplars and wild rose bushes. Plantings of these may provide adequate protection from wind erosion until adequate sod depth has been established.

Rock waste dumps at Phoenix have been reclaimed by two methods: By the first, a layer of top soil saved from initial stripping has been spread over the broken rock surface a few inches thick to receive the mixed grass seed and fertilizer. The second method is by hydroseeding in which a base of peat moss with fertilizer and seed is blown in a slurry onto the surfaces of the dumps. The first method is most successful but it depends upon a supply of top soil and upon dump surfaces being accessible to equipment used for spreading the soil and planting the seed. The hydroseeding mulch can be blown 100 feet or more from the supply tank. Tree plantings on the waste dumps have been made on top of grass planting and as independent plantings with a shovel-full of soil for a starter. Spruces of a local variety appear to survive well, and local seeds have provided young trees for more extensive plantings.

POLLUTION CONTROL AT PHOENIX

At the Phoenix operation 1.2-million gallons of water are used each day as a medium for grinding and concentration of ore. Various reagents are added to prepare the slurry for concentration, but most of these are carried over into the concentrate. The tailing pond, which has been created behind a large rock-fill dam at the head of Twin Creek, contains between 25-million and 40-million gallons as a reservoir for recycling to the mill. Twin Creek flows, at Greenwood, into Boundary Creek, which flows into Kettle River at Midway. Many farms and villages depend upon these waters and it is vital that pollution be avoided.

The mill-tailing pond cycle is not completely balanced since heavy run-off from spring snow melt might raise water in the pond to dangerous levels. Arrangements have been made to store surplus water in a second nearby artificial lake at the head of Providence Creek. Small amounts of seepage make their way through the dams into Twin and Providence Creeks during the run-off period.

An operating permit granted by the Pollution Control Branch of the Water Resources Service sets out quality and quantity limits in sections of the system. Flow measurements and piezometric readings behind the dam are maintained continuously. Chemical analyses to parts per billion are carried out monthly. Once a year a bio-assay of water in the tailing pond is made in which survival of trout is tested over a 48-hour period. Evidence to date is that this water, where the highest concentration of chemicals would be expected to build up, is harmless to fish life.

RECLAMATION AT GRANISLE

At Granisle the initial west tailing pond has been completed, but the area is being used as an emergency dumping area for the tailing pipeline to the current dam. For a period an agricultural engineer, Guy Lautard, was employed at the mine to determine experimentally suitable plant combinations for Granisle climate and soil conditions. A section on the top surface and part of the front face has been seeded and produces a thriving annual grass crop. Other tailing areas and waste dumps at Granisle are being actively expanded at this period in the mine's life so no general reclamation can be carried out. Lessons learned from trials here and at Phoenix will be applied ultimately to restore these areas to provide forage and living space for moose and deer of the region and to provide camp grounds for holidayers. The wonderful recreational potential of Babine Lake which has been known to a few for many years is becoming known to many with advantages of roads and services provided for the mining community of Granisle.

At Granisle tailings are impounded behind rock fill dams across arms of the lake between two islands. During the start-up stage it is necessary to gradually expel the surplus lake water trapped behind the dam as tailings are emplaced until lake level is reached. From this point on the system becomes properly balanced and the pond is raised vertically as tailings sands are deposited. About the end of 1973 Granisle reached this point with its No. 2 dam. During the latter part of the preliminary stage an auxiliary settling area was established to prevent turbid water from the pond from entering the clear water of the lake. Careful monitoring and bio-assays demonstrated that water entering the basin and the lake contained no harmful amounts of metals or chemicals and that fish were unaffected by it. Babine Lake is an important salmon spawning lake so a careful watch on the mining operation is maintained by local Fisheries officers in addition to controls and inspections by the Pollution Control Branch of the Water Resources Service.

Granisle has participated with other resource companies and various government departments in a study project organized by the Department of the Environment named Babine watershed change programme. Scientists of this group have studied every conceivable physical and chemical aspect of Babine Lake with a view to establishing a consistent background against which environmental changes can be detected. Water and air currents and temperatures are related, and patterns have been established with which plankton and zooplankton cycles have been related. Chemical studies have been made of waters and of rocks surrounding the lake. Fish and animal movements have been traced, and community and summer camp locations analysed to determine the human impact on the basin. The committee is on-going and a full report has not yet been completed, but it appears that with the present degree of control there are no significant changes in the lake ecology being produced by the mining operations.