W.A. NO.

TASU - Queen Charlotte Island

NAME ~~ASITKA~~-WESFROB

SUBJECT EXTERNAL PUBLICATION

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MINERAL INDUSTRIES IN WESTERN CANADA

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

SPONSORED BY: THE CANADIAN INSTITUTE OF MINING AND METALLURGY

THE WESFROB MINE

(Latitude 52° 45.8' N., Longitude 132° 0.26' W., Elevation 150 feet)

LOCATION, ACCESS AND CLIMATE

The Wesfrom Mine is found nestled on a mountainside along Tasu Sound in the Queen Charlotte Islands. This scenic but rugged mountain setting is located about 500 miles northwest of Vancouver, British Columbia.- Figure 1 - "Location Map", depicts the location of Tasu with respect to the west coast of British Columbia. The town of Tasu, located on adjacent Gowing Island, is connected to the mine site by an earthfill causeway.

Passenger access to Tasu is almost exclusively restricted to air travel. There are daily Boeing 737 jet flights direct from Vancouver to Sandspit, and connecting air service to Tasu aboard amphibious aircraft (DeHavilland Beaver and Grumman Goose). During periods of bad weather when air transportation between Tasu and Sandspit is impossible, surface transportation may be employed utilizing boats and land travel over logging roads. Heavy equipment and supplies are barged in from Vancouver on a regular basis every six weeks. The trip takes upwards of 56 hours depending upon the weather.

The climate in Tasu is heavily influenced by the surrounding mountains and nearby Pacific Ocean. The yearly mean temperature is 46.2° F with January being the coldest month at 30.8° F mean minimum, and August the warmest month with a 63.3° F mean high temperature. Very high winds and driving rain are characteristic of winter storms. Total yearly precipitation averages 158 inches per year, characterized by periods of heavy rainfall. In October of 1973 a new record rainfall of 8.38 inches was set for a 24 hours period. The average yearly snowfall amounts to 38 inches at lower elevations.

HISTORY AND OWNERSHIP

The Tasu magnetite-chalcopyrite deposits were first located and explored around 1907 to 1909, and were commercially exploited for copper during the war years 1914 to 1917. During this time, two adits, one stope and an exploratory winze were driven. The stope yielded 5,180 tons of ore grading 1.60 percent copper. In addition, a camp was established and a tram-line erected to tidewater 950 feet below.

The first claims were acquired by Frobisher Ltd. in 1953 at a time when there was no apparent market for the iron ore and the copper content was a relatively unknown factor.

For many years, there had been a political effort in British Columbia to establish an iron and steel industry within the Province. To aid in achieving this objective, legislation was passed in 1951 to prevent the export of iron ore from all but a few properties to which the owners had special title. By the mid-fifties, this legislation had become unpopular and there were moves afoot to have it rescinded. Moreover, a possible buyer for B.C.'s lump magnetite ore appeared, in the form of the Japanese steel companies.

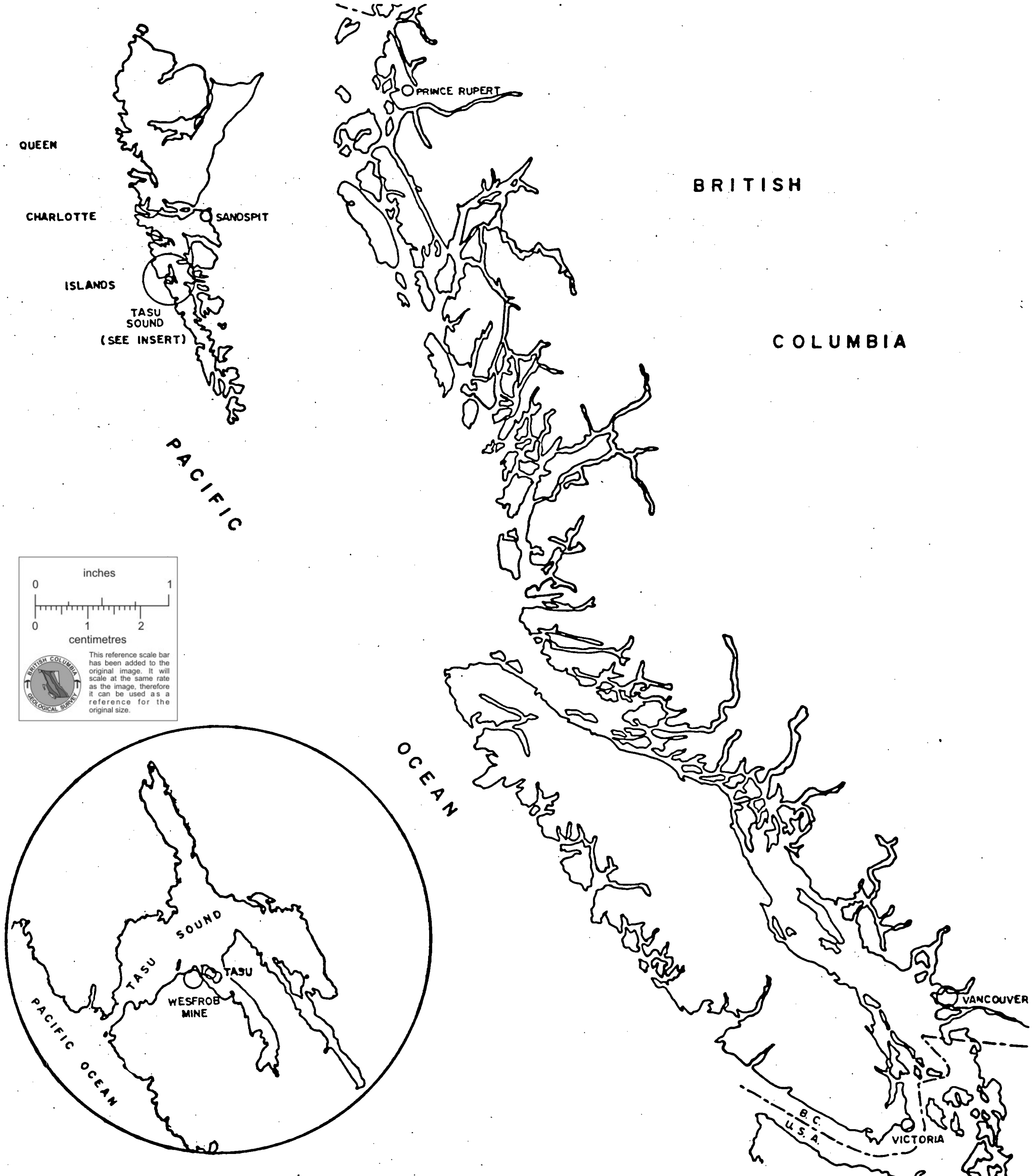


Figure 1 - Location Map

In February 21, 1956, Wesfrob Mines Limited was incorporated in the Province of Ontario as a wholly-owned subsidiary of Falconbridge Nickel Mines Limited. To prepare for the apparently improving political and market climates, Wesfrob embarked upon a small scale of exploration in 1956 in order to discover the order of magnitude of the mineral occurrence at Tasu and its metallurgical characteristics.

In the meantime, the provincial government had been active in the legislative field and new regulations were coming into effect. As anticipated, the restrictions on the export of iron ore were removed, but in their stead the government declared that title to one-half the reserves found by an iron mining company should be retained by the Provincial Crown, presumably for the purpose of supplying some future iron industry with ore. Furthermore, it was proposed that a tax would be levied not upon the ore or concentrates produced by an operating mine but upon its ore reserves still in the ground. These laws immediately and very effectively brought a halt to all iron ore exploration in the Province. However, the two-year program of geological, metallurgical and market investigation brought to Wesfrob a general understanding of the Tasu ore occurrences, the products that could be obtained from these ores and the markets available to these products.

In October 1960, the provincial government removed its restrictive Crown claim to ore reserves and the taxation of iron ore in the ground and permitted the production and export of ore in return for a fair and equitable royalty. At the same time, the Japanese steelmakers were turning to sinter feed for their blast furnaces and this opened an avenue for the use of Tasu's crushed and concentrated ore.

Exploration was resumed in 1961, and work at the property was continuous until the preparations for production began in mid-1964.

While the feasibility report was being prepared, and later while it was being studied, additional ore tonnages were being found at Tasu, metallurgical tests were providing alternative product specifications for the Japanese steel mills to consider and the Japanese ore buyers were broadening their search for competitive ore purchases. Shipping too was in a state of flux; whereas 20,000 ton ore carriers had been a standard size, carriers of 50,000 tons capacity were now being considered. Although these would reduce freight costs to the steel mills, they would mean considerably increased costs to the ore seller, who would have to install dock and ore-loading facilities of increased size and complexity.

By August of 1963, it was apparent that the increased tonnage potential to Tasu, the greater knowledge of the possible products that could be produced and the likely prices to be offered by Japanese steel companies justified a more detailed and precise study by the consulting design engineers. This time, they were asked to consider a production of one million annual tons of iron concentrate together with the resulting by-product tonnage of copper concentrate. However, from an almost complete reliance upon good-quality lump iron ore in 1957 the Japanese were now, in 1963-64, seeking crushed iron concentrates of the highest quality. Whereas Wesfrob had previously been asked to produce the coarsest possible concentrate, they were now being asked to produce a particle size less than 325 mesh.

Falconbridge metallurgists were equal to the task, however and two grades of concentrate were offered and eventually accepted - one which could be used as a sinter feed and one to be used in making iron pellets.

On July 1, 1964, Wesfrob closed its exploration account at a cost of one-half million dollars and commenced preparation for production. Shortly thereafter, the hectic period of construction began and progressed with numerous problems and frustrations through to production and later shipment of iron concentrate to Japan in August of 1967.

GEOLOGY

Tasu is one in a series of contact metasomatic deposits occuring along the coast of British Columbia.

The country rocks involved are Upper Triassic. A thick series of andesitic and basaltic lava flows known as the Karmutsen is overlain conformably by the Kunga limestone formation. The basal member is a massive white or light grey recrystallized limestone, in places 600 feet thick, in turn overlain by a black flaggy limestone and argillite.

Small stocks of batholiths, typical to the Coast Range intrusions, cut these Upper Triassic rocks. The Tasu deposits are located close to the San Cristoval batholith of foliated hornblende diorite, and are found at or near the contact of the limestone with the volcanic rocks. Structurally, the orebodies are further localized by second-order folds, re-entrants and faults in the basement contact.

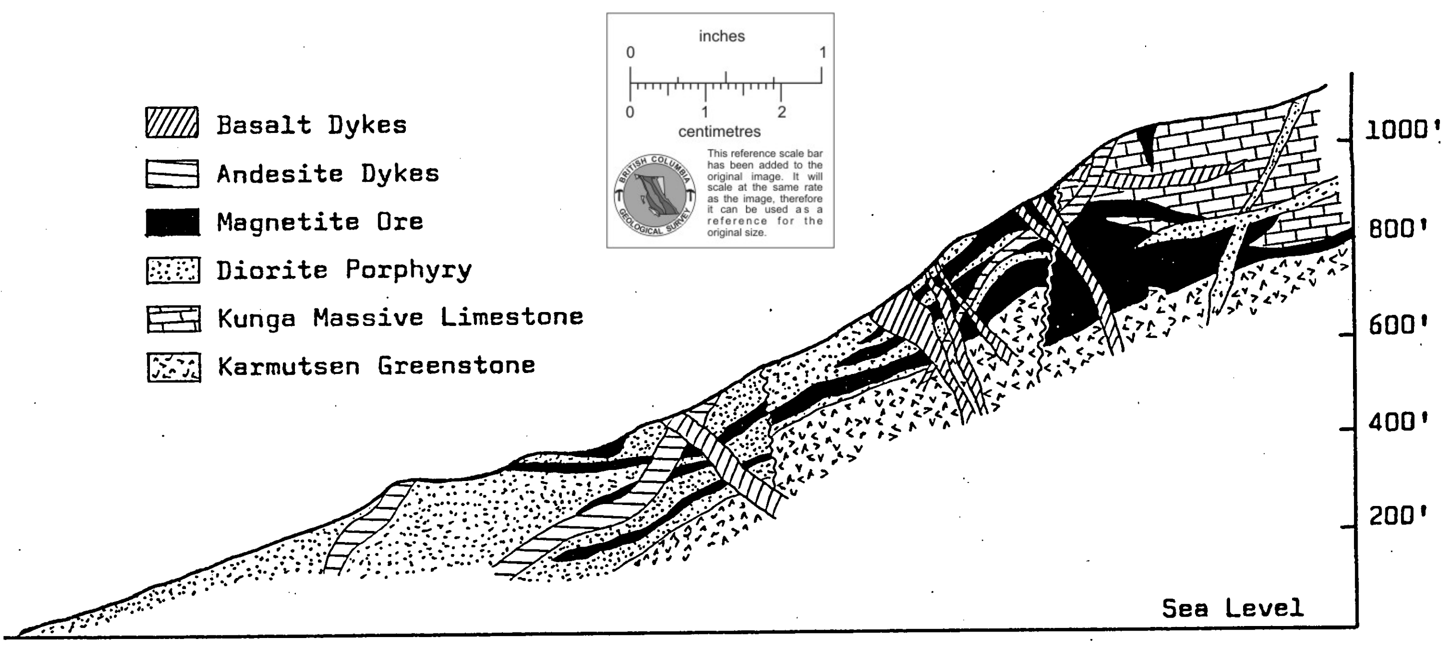


Figure 2 - Typical Geological Section Through The Tasu Orebody

The deposit is associated with skarn, usually made up of garnet-pyroxene-epodite, although amphibole and chlorite may replace pyroxene. Skarn development appears to be primary, with both magnetite and skarn replacing limestone, limey tuffs and early intrusive rocks, the latter being feldspar porphyry and andesites.

The most reasonable source of the deposits is the distillation of iron from the iron-rich Karmutsen series by the heat of the advancing diorite batholith and its associated feldspar porphyry intrusions. The area around the deposits is heavily cut by numerous post-ore basaltic and andesitic dykes.

Zone 1 is a replacement of feldspar porphyries that have been intruded along the limestone contact in the form of a highly complex 'Christmas Tree' laccolith. This orebody is very irregular, with essentially dendritic stringers connecting large lenses of copper-free magnetite.

Zone 3 is more massive, with one large sausage-like orebody lying along the limestone-volcanic contact. This Zone differs from Zone 1 in that it is a replacement of limestone instead of feldspar porphyry. It is also more uniform in its configuration and contains approximately 0.75 percent as finely divided chalcopyrite.

Zone 2 is actually a transition in setting from that of Zone 1 on the north to Zone 3 on the south, with limestone replacement to the south and feldspar porphyry replacement to the north; portions of the orebody contain chalcopyrite mineralization.

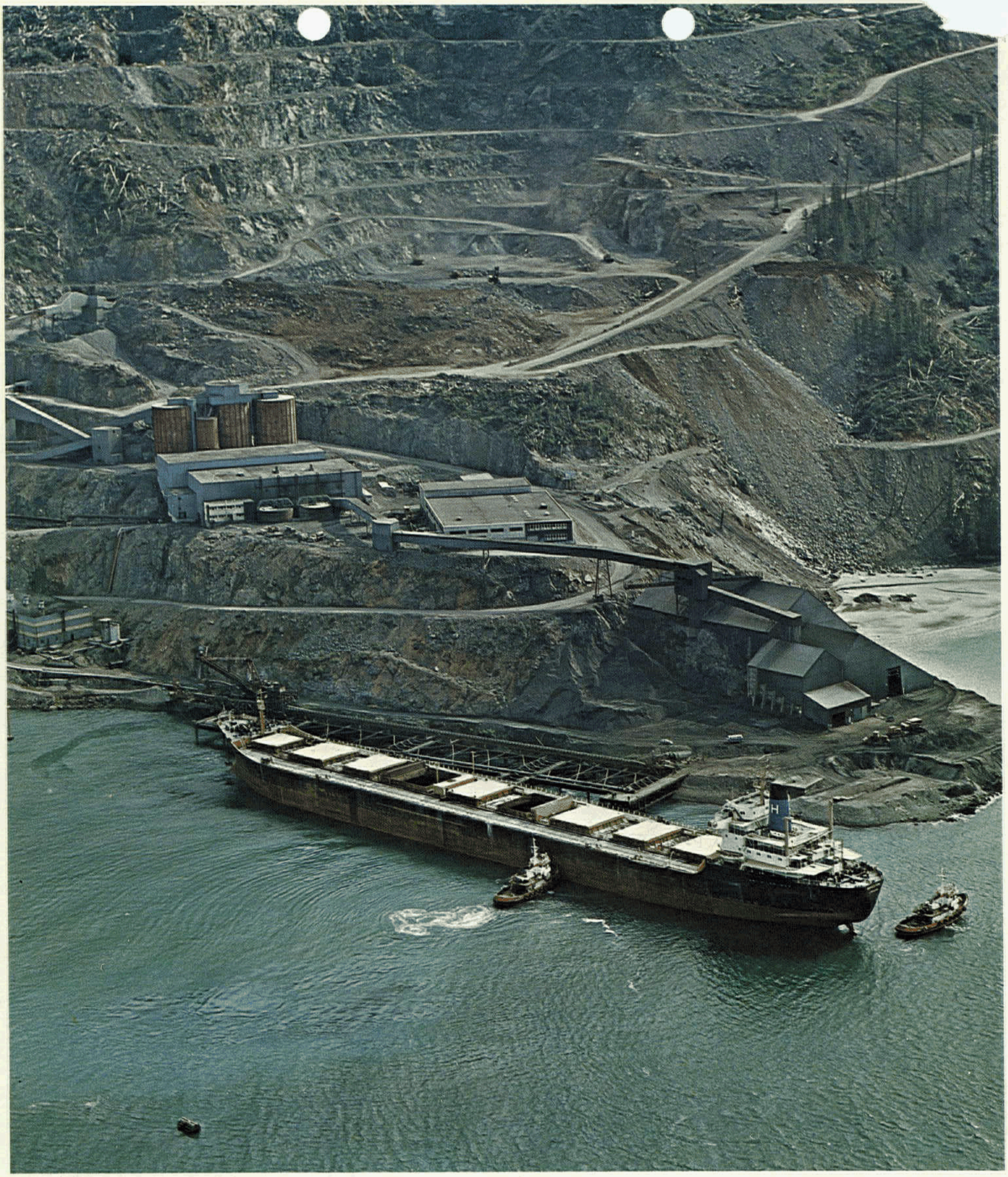
The post-ore basaltic and andesitic dykes present a situation in which the orebodies are criss-crossed with ribbons of waste up to 40 feet in thickness. Figure 2 illustrates a typical geological section of the Tasu orebody.

PROPERTY OPERATION

The Tasu property is under the direction of a resident Mine Manager who is assisted by the Production Superintendent. The Mining, Milling and Maintenance Departments are each headed by their respective Superintendents, and Accounting, Engineering and Warehousing are under the guidance of their own Department Head.

Wesfrob Mines Limited is supplied with such services as purchasing, accounting, barge loading and mining exploration from a Vancouver office. This office acts as Tasu's liason with respect to data transmission and computer facilities. A direct Telex line is maintained between Tasu and the Vancouver office.

Since Tasu is an isolated community, it must maintain a townsite in addition to operating a mine. A dam and fish ladder were constructed on nearby Wright Lake and fresh water is transported 33,000 feet along rugged mountainous coastline through a 16 inch diameter pipeline. This water supplies domestic needs, the concentrator and the fire protection systems. The mine



George Hunter photo

8,000 TPD Copper-Iron Concentrator
Wesfrob Mine, Tasu Q.C.I., B.C.
Falconbridge Nickel Mines Limited

DESIGNED BY WRIGHT ENGINEERS LTD.

site and town of Tasu are under the protection of a company-subsidized volunteer fire brigade. Power for the entire property is generated by five Mirrlees Diesel engines (2200 kilowatt each), driving General Electric generators. The engines burn bunker "B" fuel oil that is transported to Tasu by special barge shipments.

Figure 3 represents an aerial view of the townsite and mine operation. Figure 4 provides a plan and section view of the items seen in the photograph.

As of January 31, 1974, the total operating crew strength was distributed as below:

	Hourly Rated	Staff	Total
Accounting	0	8	8
Engineering	0	8	8
Maintenance			
Plant Shop	16		
Pit Shop	12		
Machine Shop	7		
Electric Shop	6		
Power Plant	9		
Total	50	9	59
Mining	25	6	31
Milling	43	14	57
Warehouse	5	2	7
Townsite	0	5	5
	123	52	175

During 1973 Wesfrob Mines Limited produced the following concentrate tonnages (in Dry Metric Tons):

Iron Concentrate	
Sinter Feed	444,447
Pellet Feed	465,606
	910,053
Copper Concentrate	12,572

All concentrates are sold under contract to Mitsubishi Shoji Kaisha of Tokyo, Japan; of this, 191,110 tons of pellet feed concentrate was delivered to Gilmore Steel of Portland, Oregon during 1973. The balance of the concentrate tonnage was delivered to Japanese ports.

Direct operating costs (in dollars per ton of iron concentrates produced) during 1973 were as follows:

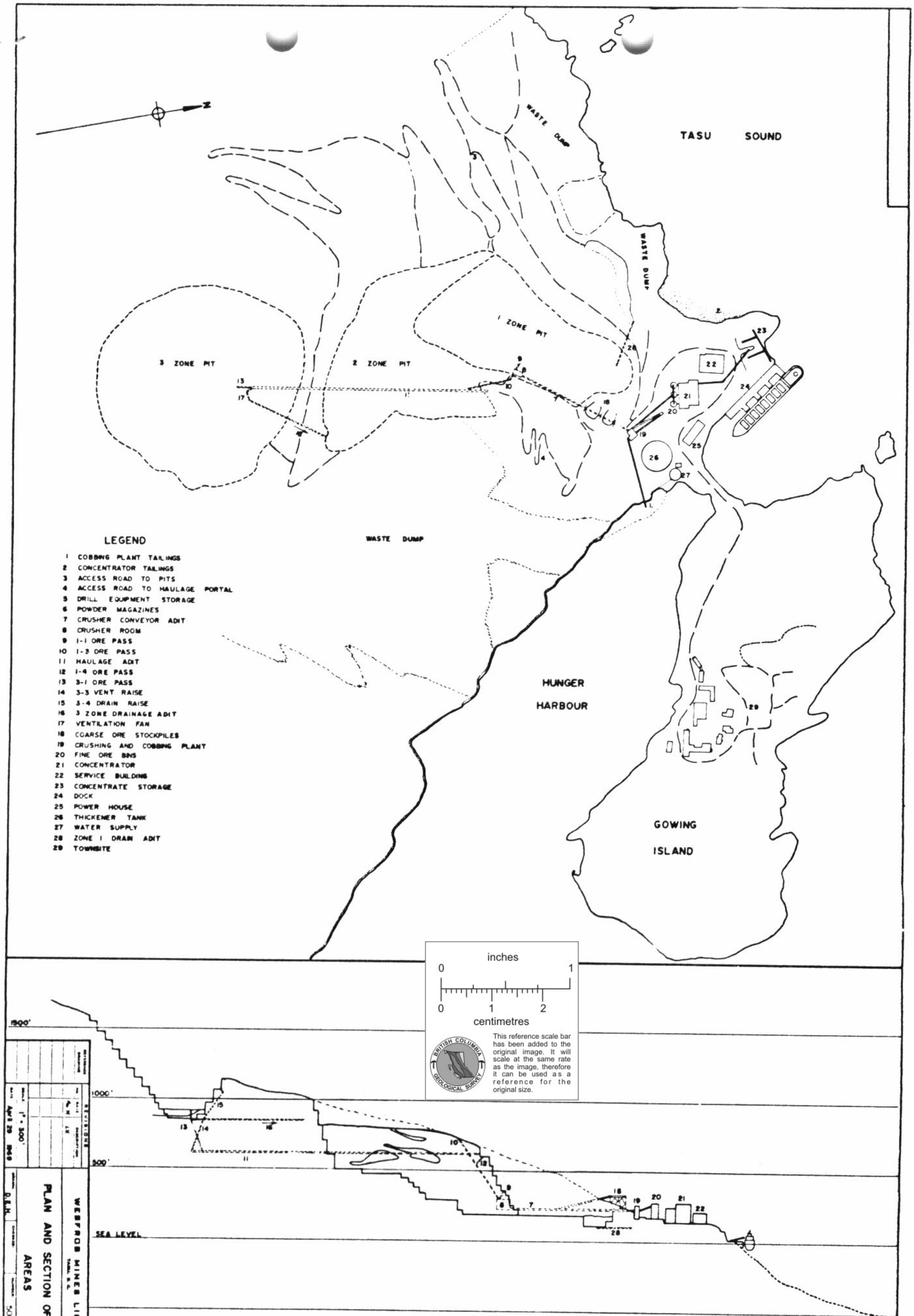

TASU SOUND
WASTE DUMP
WASTE DUMP
1 ZONE PIT
2 ZONE PIT
3 ZONE PIT
WASTE DUMP
HUNGER HARBOUR
GOWING ISLAND
LEGEND
1 COBBING PLANT TAILINGS
2 CONCENTRATOR TAILINGS
3 ACCESS ROAD TO PITS
4 ACCESS ROAD TO HAULAGE PORTAL
5 DRILL EQUIPMENT STORAGE
6 POWDER MAGAZINES
7 CRUSHER CONVEYOR ADIT
8 CRUSHER ROOM
9 1-1 ORE PASS
10 1-3 ORE PASS
11 HAULAGE ADIT
12 1-4 ORE PASS
13 3-1 ORE PASS
14 3-3 VENT RAISE
15 3-4 DRAIN RAISE
16 3 ZONE DRAINAGE ADIT
17 VENTILATION FAN
18 COARSE ORE STOCKPILES
19 CRUSHING AND COBBING PLANT
20 FINE ORE BINS
21 CONCENTRATOR
22 SERVICE BUILDING
23 CONCENTRATE STORAGE
24 DOCK
25 POWER HOUSE
26 THICKENER TANK
27 WATER SUPPLY
28 ZONE 1 DRAIN ADIT
29 TOWNSITE
inches
0
1
0
1
2
centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY
1500'
1000'
500'
SEA LEVEL
WESFROB MINES LIMITED
PLAN AND SECTION OF MINING AREAS
1" = 300'
D.E.H.
500-006

Figure 4

		%
Mining	.65	9.12
Milling	.90	12.62
Maintenance	2.90	40.67
General Expense	2.68	37.59
	7.13	100.00

MINING OPERATIONS

Open Pit Production

Initially, two orebodies were mined, namely Zones 1 and 3; the former to produce sinter feed concentrate and the latter to yield pellet feed and copper concentrates. At the beginning of 1971, Zone 2 pit was begun and now yields all three types of concentrates. Steady production from the Zone 3 pit was suspended in early 1973 so that Zone 2 could be mined at a faster rate to reach the predominantly sinter ore reserve on the lower benches. Zone 1 pit, which supplies only sinter ore, is scheduled for completion at the end of 1974 and by that time Zone 2 pit must be able to supply all sinter ore requirements. In 1976, Zone 3 will be reactivated to supplement the pellet ore reserves being mined from Zone 2.

Zone 1 pit is 1,600 feet by 900 feet and will have an ultimate depth of 750 feet. Approximately 360,000 cubic yards of waste were stripped during pre-production to expose the ore. At the beginning of 1974, ore reserves remaining in Zone 1 were roughly 465,000 tons of sinter ore with the pit scheduled for completion at the end of 1974. The overall stripping ratio from the start of 1974 until completion of the pit will be 1 ton of waste per 1.7 tons of iron.

As can be seen in Figure 4, Zone 2 pit will progress downhill until it actually encompasses the upper portion of Zone 1. The final dimensions of Zone 2 pit will be roughly 1,000 by 1,200 feet, with a depth of 630 feet. The overall stripping ratio will be one ton of waste per ton of ore, but this ratio necessitates a very steep overall pit slope. The stripping ratio will be fairly constant during the life of the pit.

The Zone 3 pit is 1,200 by 1,000 feet and will eventually be mined to a depth of 800 feet. The stripping ratio during the first years was 3 tons of waste per ton of ore, with this ratio declining each year. During pre-production, 3,768,000 cubic yards of limestone waste were removed from this Zone.

The design parameters of the open pits are:

Pit Walls are of the same slope in both Zone 1 and 3. The pit walls are mined in 35 foot lifts with a 54 foot safety berm left every second lift resulting in 70 foot high benches and a final pit slope of 53°. Zone 2 does not have a constant pit slope around its perimeter; however in one location the ultimate pit will will consist of five benches, each with a height of

105 feet. The final pit wall slope of 65° is achieved by mining three consecutive 35 foot lists before a 50 foot safety berm is left.

Ore Handling begins at an ore pass located within each of the three pits. The Zone 1 ore pass dump point is situated on the pit wall 240 feet above the ultimate pit floor and the ore pass leads directly to the primary crusher (located underground). Zone 2 ore pass, at the 757 foot elevation, is accessible by a short ramp from the presently mined 815 elevation and this ore pass dumps to the primary crusher. Ore dumped in the Zone 3 ore pass drops to a chute in the haulage adit where a 12-ton diesel locomotive hauling a 100-ton capacity car is used to tram the ore. The ore is hauled 1,600 feet to the portal and dumps in another ore pass leading to the crusher 300 feet below.

Drainage is a very important parameter of open pit design and operation in a heavy rainfall climate such as that found at Tasu. Prior to pit production an 8 by 8 foot drainage raise (draining to a drainage adit) was established parallel to the ultimate pit wall in Zone 3. Mining on a lower bench in the pit is usually initiated by positioning the sinking cut near the raise to enable the 40-R drill to drill vertical drainage holes from the lower elevation. Until the new drainage holes are established, water must be pumped to the existing drainage holes on the level above. In Zone 1, drainage is directed out of the front of the pit, but for benches below the 255 foot elevation, drainage holes must be drilled to a drainage adit. Zone 2 drainage is no problem since run-off water can be directed out of the pit just by maintaining a slight grade across the pit floor.

Pit production is scheduled on the basis of a regular six day work week with two shifts operating per day. Currently, daily production is scheduled at approximately 5,800 tons per day of ore and a subsequent waste removal of 3,000 cubic yards. Details of pit equipment and performance are presented in Table No. 1 - "Mine Production Equipment". The parameters governing open pit operation are as follows:

Bench Interval Height	35 feet.
Final Bench Face Slope	Vertical when pre-shearing is effective.
Safety Berms	54 feet, every second bench in Zones 1 and 3; 50 feet, every thrid bench in Zone 2.
Haulage Road Gradients	Maximum of 10%, although usually 10% due to space limitations.
Blasthole Spacing	9 inch diameter holes. Ore - 14 by 14 feet to 14 by 16 feet. Limestone waste - 18 by 18 feet. Porphyry and volcanics - 16 x 16 feet. Special line holes drilled on 10 foot centres 10 feet from the ultimate bench face.
Sub-grade Drilling	5 feet.

TABLE NO. 1

MINE PRODUCTION EQUIPMENT

FUNCTION	TYPE OF UNIT	NO. OF UNITS	SCHEDULED PER SHIFT	UNIT PERFORMANCE PER SHIFT
Blast Hole Drilling	Bucyrus-Erie 40-R rotary drill: diesel	1	2	242 feet in ore, 254 feet in waste 9 inch diameter hole
	electric	1		
Secondary Blasting and Pre-shearing	Gardner-Denver air trace with PR 123 drills	3	2	350 feet of 3 inch diameter hole
	Gardner-Denver portable diesel-powered compressors: SP-600-D	3		
	SP-900-D	2		
Rock Loading	88-B diesel powered shovel, 4.5 cyd bucket	1	1 Shovel	4,300 tons ore, 1,400 cyd waste
	150-B electric shovel, 7 cyd bucket	1		5,900 tons ore, 2,300 cyd waste
	Cat 988 front-end loader 5 cyd bucket	2	1	3,200 tons ore, 1,200 cyd waste
Rock Haulage	Cat 769B truck, 35 Ton	5	4	Zone 1: 1,640 tons ore, 735 cyd waste Zone 2: 2,930 tons ore, 1,060 cyd waste Zone 3: 2,355 tons ore, 460 cyd waste
	Brookville locomotive 100-ton car (underground tramming)	1		4,720 tons ore
Dump Maintenance and Shovel Clean-up	D-8 Caterpillar	2	2	
	Road grader, 14-E Caterpillar	1	1	
	Watering Truck	1	1	
Blasting	Explosive supply truck	1	1	

Blasthole Loading	Done by hand using bagged Hydromex and Metamite slurries, and 50 pound bags of ammonium nitrate mixed with fuel oil during loading.
Pre-shearing	Air-trac line holes drilled on 24 inch centres. Effective only in limestone.
Secondary Breakage	Air-trac drilling in boulders and slash areas, using PowerFrac.

Underground Development

Results of the initial, and several subsequent diamond drill programs, indicated that the mineralized zone of the Tasu orebody extended laterally into the mountainside. A significant amount of this mineralization is located beyond the limits of economic open pit mining.

In 1970, a 2600 foot exploration adit was driven beneath the major underground mineralized area to facilitate a more detailed diamond drilling program. Detailed geological interpretation, planning, and feasibility studies continued until early 1973 when it became apparent that unless a highly mechanized, low unit cost underground mining method was developed, the mining of this underground ore would be uneconomical.

In order to obtain accurate underground development and production costs it was decided to develop a fairly large conventional long hole stope under the southeast wall of the Zone 3 pit at a sill elevation of 600 feet. Access to the stope undercut would be established form the existing haulage adit. A sub-level for this stope will be developed from the bottom of Zone 3 pit when mining from the pit has been completed. A Gardner-Denver twin ring drill jumbo with 6 foot steel sections is to be utilized for production drilling, and the blastholes are to be pneumatically loaded. A 5-cubic yard front-end loader will tram the ore an average distance of 400 feet from the drawpoints to the 100-ton capacity car presently in use in the haulage adit.

While the undercut of the stope is being driven, a mineralized area at the 700 foot elevation will be explored by driving a 1400 foot long exploration drift south, from the end of the present haulage adit at the 600 foot elevation. A detailed diamond drill program will then be carried out in this area.

Underground development commenced in mid-1973 utilizing a Caterpillar 988 front-end loader and a Gardner-Denver three boom development jumbo. Development headings are 18 feet wide by 14 feet high. Auxiliary ventilation is providied for these heading through 48 inch diameter ventilation tubing from a 100 horsepower Joy axivane fan, which will deliver 50,000 cubic feet of air per minute at 8.5 inches water gauge pressure.

Technical and financial information acquired during the development of these small orebodies will, along with the economic climate at the time, determine the feasibility of mining and remaining underground mineral inventory at Tasu.

MINERAL PROCESSING

Primary Crushing

The primary gyratory crusher, 42 by 65 inches, is located underground some 800 feet from surface along a slightly inclined 10 foot 6 inch by 15 foot conveyor adit. Twin variable-speed reciprocating plate feeders, 14 feet 3 inches by 6 feet, operating with a 10 inch stroke, deliver run-of-mine ore directly from the ore passes into the crusher feed box. Discharge from the ore passes is controlled through a double set of air-actuated chain curtains. The operating rate for 1973 was 555 metric tons per operating hour.

From the crusher, coarse ore is conveyed along the crusher access adit and travels up an inclined 8 by 8 foot conveyor raise to the surface stockpiles. A reversible-direction conveyor discharges the crushed material into one of two stockpiles, according to copper content. Copper-bearing ore is dumped on the pellet feed coarse ore stockpile while copper-free ore is fed to the sinter feed coarse ore stockpile.

Secondary Crushing and Cobbing

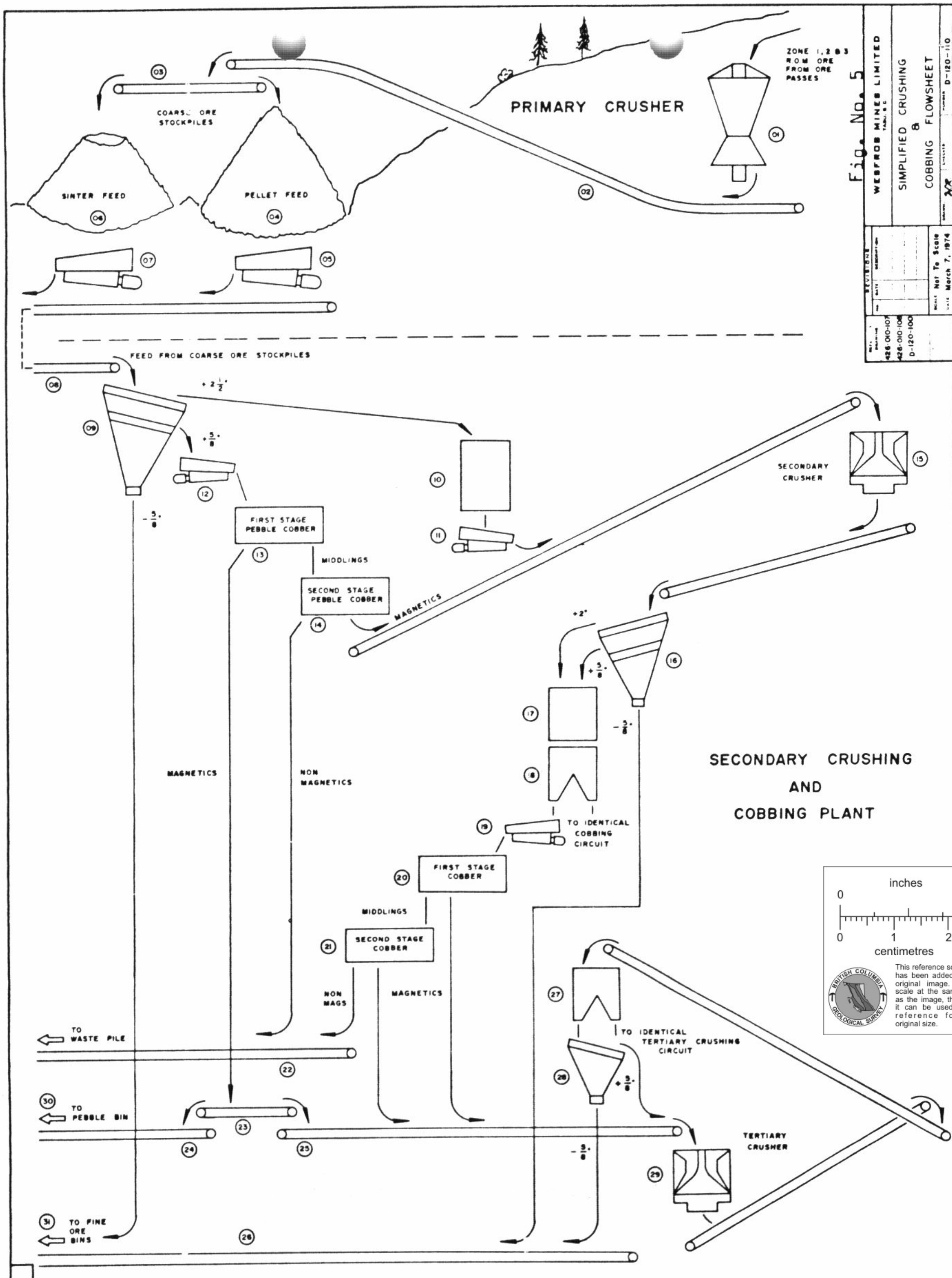
Both types of ore are handled by the same circuit inside the secondary crushing and cobbing plant. Coarse ore is withdrawn from the stockpiles at 600-700 tons per hour by 48 by 72 inch vibrating feeders discharging onto a 36 inch feed belt located in the primary crusher access adit. The ore is conveyed directly to a 6 by 14 foot double-deck vibrating primary screen located in the secondary crushing and cobbing plant. Minus 5/8 inch undersize is conveyed directly to fine ore storage. Intermediate material, -2-1/2 inch + 5/8 inch, passes directly over two consecutive 36 inch diameter by 48 inch cobbers for production of magnetite grinding pebbles in the case of copper-bearing ore, or simply to upgrade the material before secondary crushing in the case of copper-free ore. Non-magnetics are rejected as waste.

The coarse deck oversize (+2-1/2 inches) discharges directly to a 40 metric ton secondary crusher feed bin. A 5-1/2 foot Symons standard secondary cone crusher further reduces the ore before it passes to the secondary screen. The double-deck 6 by 16 foot secondary screen passes -5/8 inch material to fine ore storage and directs the +5/8 inch to two parallel banks of two-stage 36 inch diameter by 48 inch magnetic cobbers. Non-magnetics are rejected and magnetics directed to two Symons 5-1/2 foot shorthead tertiary cone crushers operating in the closed circuit with two 5 by 14 rod deck vibrating screens.

Fine ore is stored in three 4500 ton concentrator feed bins and the pebble bin has a 1200 ton capacity. All -2-1/2 + 5/8 inch non-magnetics are conveyed to a waste pile. Figure 5 presents a simplified flowsheet of the primary crushing, secondary crushing and cobbing processes.

Concentrating

The grinding and concentrating circuits may be considered as two individual entities; a copper-bearing pellet feed circuit and a copper-free sinter feed circuit.



Item	No.	Description	Item	No.	Description	Item	No.	Description
01	1	42" x 65" gyratory crusher	12	1	36" W x 11-3/4" x 96" Vibrating feeder	22	7	Service of waste conveyors
02	1	42" wide conveyor	13	1	Eriez permanent magnetic cobber	23	1	Reversible direction conveyor
03	1	Reversible direction conveyor	14	1	Eriez permanent magnetic cobber	24	1	24" wide conveyor
04	1	Pellet feed stockpile, 6000 metric tons live capacity	15	1	5½' standard Symons cone crusher	25	1	30" wide conveyor
05	2	48" W x 9" x 72" vibrating feeder	16	1	Double deck secondary screen, top 2", bottom 5/8"	26	1	30" wide conveyor
06	1	Sinter feed stockpile, 4000 metric tons live capacity	17	1	30 metric ton storage bin	27	1	S,litter
07	2	48" W x 9" x 72" vibrating feeder	18	1	Splitter		2	Identical circuits of items 25, 28 & 29
08	1	36" wide conveyor		2	Identical circuits of items 19, 20, 21 & 25	28	1	Tertiary screen, 5/8"
09	1	Double deck primary screen-top 2½", bottom 5/8"	19	1	42" W x 9" x 60" vibrating feeder	29	1	5½' shorthead symons cone crusher
10	1	Storage bin, 40 metric ton capacity	20	1	Eriez permanent magnetic cobber	30	1	1200 DMT Pebble bin
11	1	48" W x 9" x 72" vibrating feeder	21	1	Eriez permanent magnetic cobber	31	3	Fine ore bins, 4600 tons live storage each

The sinter feed circuit utilizes a relatively coarse grind (from the open circuit rod mill) which is passed through a magnetic separation and the magnetics are cycloned and filtered to provide the sinter feed concentrate. The cyclone overflow contains fines undesirable in the sinter feed concentrate, so they are directed to the pellet feed circuit for iron recovery. The copper-barren non-magnetics from the magnetic separation are discarded as tailings.

The pellet feed circuit is designed to produce a higher grade of magnetite concentrate together with a subsequent removal of chalcopyrite and a majority of iron sulphides. The pebble mill cyclone overflow is passed through magnetic separators for upgrading, and the magnetics are sent to "iron flotation" for removal of chalcopyrite and iron sulphides from the final pellet feed concentrates. Non-magnetics, from the separators, and sulphides from the "iron flotation" are directed to a copper circuit where a low grade copper concentrate is recovered. Figure 6 - "Simplified Concentrator Flowsheet" provides the details of the concentrating process.

The details of the concentrator circuits are as follows:

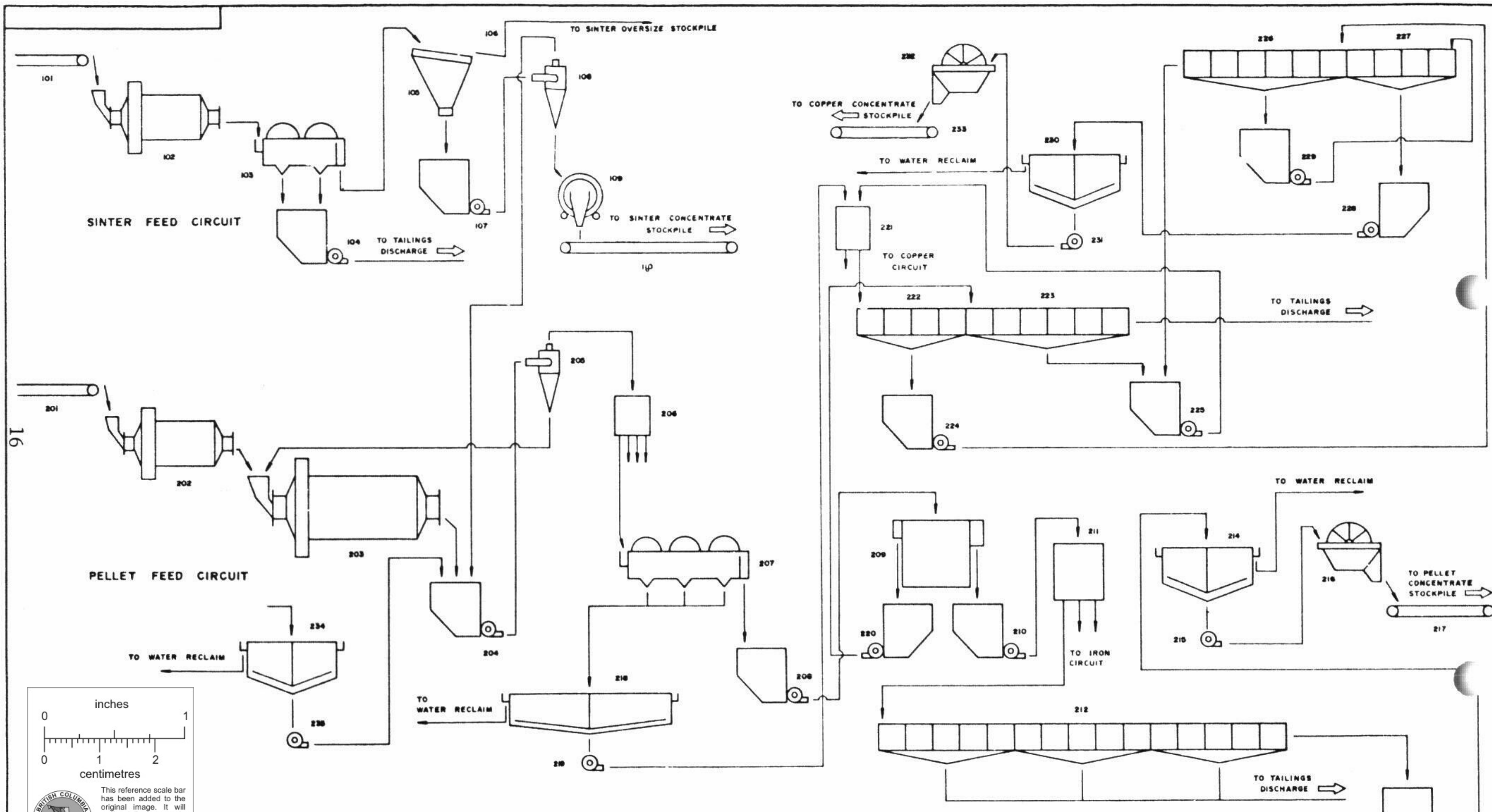
The Sinter Feed Circuit is fed copper-free fine ore at a preset rate of 80 - 110 metric tons per hours. The feed to the 9 by 12 foot open-circuit rod mill is proportioned with dilution water to achieve 78 - 80 percent solids. Density control is extremely important in view of the open-circuit single stage reduction in which a product of 100 percent -5 mesh is required with a minimum of fines production. Further dilution water is added at the rod mill discharge to maintain a density of 30 percent solids into the 36 inch diameter by 72 inch double-drum wet magnetic separators. Two-stage separation roughs and cleans the magnetics to produce a 61 percent iron product at a recovery of 91 percent iron.

Fresh water dilution is used in the sinter circuit to minimize contamination from the pellet circuit process water. Maximum allowable copper content in the sinter concentrate is 0.05 percent.

Magnetics are deslimed in a 15 inch cyclone discharging directly into a 12 foot 8 inch diameter by 8 foot internal drum filter. Cyclone overflow and filtrate water are reclaimed in the pellet feed circuit. The filter cake, at 6.5 to 7 percent moisture, is conveyed to an open stockpile where it drains freely to about 5.0 percent moisture.

The Pellet Feed Circuit has two identical grinding circuits, rated at 70 metric tons per hour each, consisting of a 9 by 12 foot rod mill in series with a 12 foot 6 inch by 22 foot rubber-lined pebble mill operating in closed circuit with four 15 inch cyclones. Pebble grinding media and cyclone oversize are added to the rod mill discharge to form the pebble mill feed.

The cyclone produce from each grinding circuit (80 percent - 325 mesh) is distributed to four banks of 36 inch diameter by 72 inch triple-drum magnetic finishers. Magnetic recovery has averaged 98 percent producing a 69 percent iron concentrate. After magnetic separation, the pruducts from the two pebble grinding circuits are combined. The non-magnetics flow by gravity to a 200 foot diameter center-well thickener.



ITEM	NO.	DESCRIPTION	ITEM	NO.	DESCRIPTION	ITEM	NO.	DESCRIPTION	ITEM	NO.	DESCRIPTION
101	[illegible]	[illegible]	202	2	ROD MILL, 9' DIA x 12', ALLIS CHALMERS	214	1	IRON CONC THICKENER, 40' DIA	226	1	6-CELL BANK CU CLEANERS
102	[illegible]	[illegible] CHALMERS	203	-	PEBBLE MILL, 12'-6" DIA x 22', ALLIS CHALMERS	215	1	IRON FILTRATION FEED PUMP, 6" x 6" x 17" ASH	227	1	4-CELL BANK CU RECLEANERS
103	2	MAGNETIC SEPARATOR, [illegible] DRUM	204	4	CYCLONE FEED PUMP, 14" x 12" x 26" ASH	216	4	EIMCO 8-DISC FILTERS	228	1	RECLEANER CONC PUMP, 3" x 3" x 14" ASH
104	1	SINTER TAILS PUMP, 6" x 6" x 17" ASH	205	8	10" CYCLONE	217	4	CONVEYORS, 24" w	229	1	CLEANER CONC PUMP, 3" x 3" x 14" ASH
105	1	5 MESH VIBRATING SCREEN, TYLER	206	2	DISTRIBUTOR TO MAGNETIC SEPARATORS	218	1	NON-MAGNETICS THICKENER, 200' DIA	230	1	COPPER CONC THICKENER, 40' DIA
106	1	CONVEYOR 18" w	207	8	MAGNETIC SEPARATOR, 3 DRUM	219	2	COPPER FLOTATION FEED PUMP, 6" x 6" x 17" ASH	231	1	CU FILTRATION FEED PUMP, 3" x 3" x 14" ASH
107	1	CYCLONE FEED PUMP, 6" x 6" x 17" ASH	208	2	PUMP, 6" x 6" x 17" ASH	220	1	ROUGHER CONC PUMP, 3" x 3" x 14" ASH	232	1	3-DISC EIMCO FILTER
108	1	10" CYCLONE	209	3	TIMM FLOTATION CELL, 12' DIA x 12'	221	1	2-WAY CU DISTRIBUTOR	233	3	CONVEYORS, 24" w
109	1	INTERNAL DRUM FILTER, 12'-8" DIA x 8'	210	1	IRON UNDERFLOW PUMP, 6" x 6" x 17" ASH	222	2	4-CELL BANKS OF CU ROUGHERS	234	1	RECLAIM WATER THICKENER, 40' DIA.
110	3	CONVEYOR 24" w	211	1	3-WAY DISTRIBUTOR	223	2	6-CELL BANKS OF CU SCAVENGERS	235	1	DILUTION WATER PUMP, 3" x 3" x 14" ASH
			212	3	15-CELL BANK, IRON SCAVENGERS, #66 WEMCO	224	1	ROUGHER CONC PUMP			
201	2	CONVEYOR 24" w, 120 TPH	213	1	IRON CONCENTRATE PUMP, 6" x 6" x 17" ASH	225	1	CLEANER TAILS PUMP, 6" 6" 17" ASH			

Fig. No. 6

REFERENCE DRAWING	REVISIONS	
D-130-109		WESFROB MINES LIMITED TASU B.C.
D-130-113		SIMPLIFIED CONCENTRATOR FLOWSHEET
	SCALE Not To Scale	
	DATE March 12, 1974	

Magnetics are pumped directly to the "iron flotation" where sulphide middling constituents (pyrrhotite, pyrite and chalcopyrite) are floated from the magnetite. The copper content of the pellet concentrate is here reduced from 0.1 to 0.02 percent. The "iron flotation" circuit consists of three 12 foot diameter by 12 foot Timm cells in series followed by three banks of 15 flotation cells, 60 cubic feed each, in parallel. Froth from the first two Timm cells, containing most of the chalcopyrite, is pumped to the copper circuit. All the remaining froth from "iron flotation" is discarded as tailings.

Non-magnetics from the finishers are accumulated in the 200 foot thickener, a 1.8 million gallon reservoir for process water recycling to the grinding and separation circuits. The large capacity effectively blends and stabilizes the feed to the copper flotation cells.

Roughing and scavenging of the copper flotation feed is performed in two parallel banks of four rougher and six scavenger cells. Froth from "iron flotation" is introduced at the scavenger cells. High-grade rougher product goes directly to the copper thickener while low-grade rougher and high-grade scavenger froth goes first to a bank of six cleaners and thence to a bank of four recleaner cells. Low-grade scavenger froth and cleaner tails recirculate to the feed end.

Total copper recovery during 1973 has averaged 93 percent, from flotation feed of 1.2 percent copper, producing a concentrate of over 20 percent copper.

Flotation reagent consumption is presently 0.15 pounds copper sulphate, 0.16 pounds frother, and 0.18 pounds amyl xanthate per ton of iron flotation. These reagents are all added to the iron flotation circuit where pyrrhotite removal is a problem, and there is sufficient carry-over of reagents with the iron circuit froth to eliminate the necessity of adding reagents at the copper flotation circuit. The pH is controlled by addition of lime at the cleaner tails pumps. Lime addition of 1.5 pounds per ton of copper flotation feed maintains a 12.4 pH at the copper cleaners.

For convenience, a set of mineral processing statistics has been tabulated and presented in Table II.

TABLE II - MINERAL PROCESSING STATISTICS FOR 1973

SECONDARY CRUSHING AND COBBING PLANT

a) Sinter Ore	
Feed Grade	40.87% Fe
Portion of Feed Rejected as Waste	18.4 %
b) Pellet Ore	
Feed Grade	43.96% Fe, 0.361% Cu
Portion of Feed Rejected as Waste	17.0 %
a) Sinter Feed Circuit	
Feed Rate	84.7 tons*/hr.
Feed Grade	48.19% Fe, 0.049% Cu
Sinter Feed Conc. Grade	60.84% Fe, 0.037% Cu
Iron Recovery	90.7 %
Rod Consumption	0.45 lbs./ton feed
b) Pellet Feed Circuit	
Feed Rate	116.6 tons/hr.
Feed Grade	51.54% Fe, 0.108% Cu
Pellet Feed Conc. Grade	69.63% Fe, 0.017% Cu
Copper Concentrate Grade	20.38% Cu
Iron Recovery	90.1 %
Copper Recovery	92.7 %
Rod Consumption	0.52 lbs./ton feed
Reagent Additions	
1) Copper Sulphate	0.15 lbs./ton feed
2) Xanthate	0.18 lbs./ton feed
3) Dowfroth 250	0.16 lbs./ton feed
4) Lime	1.5 lbs./ton Cu flotation feed

*All tonnages refer to dry metric tons

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(Wesfrob Mines Limited - Tasu, B. C.)

Figure 7 - Shiploader loading iron concentrate aboard M. S. Jasaka.

CONCENTRATE HANDLING AND SHIPPING

Concentrates from the mill are stored in three separate stockpiles. Because of the high annual rainfall at Tasu, precautions must be taken to ensure that the stockpiled concentrates have a maximum moisture content below that prescribed by the Canadian Bulk Cargoes Code. Pellet feed concentrate and copper concentrate are stored in separate but adjacent buildings of 85,000 and 7,000 dry metric ton capacity respectively. The relatively coarse sinter feed concentrate is stockpiled adjacent to these two buildings on flat area that is capable of stockpiling 100,000 dry metric tons. The high permeability of the stockpile allows rainfall to drain out of the pile and concentrate losses in the run-off water are negligible.

A centrally located transfer tower enables concentrates from the mill to be conveyed to the top of the individual stockpiles.

A tunnel reclaim system utilizing draw points and belt conveyors is used to transfer concentrates from the stockpiles to a conveyor running the entire length of the shiploading dock. The tunnels are 10 foot, five percent elliptical, one gauge corrugated multiplate design around 42 inch belt conveyors travelling at 600 feet per minute. When copper concentrate is being loaded, a Caterpillar 988 front-end loader is used for moving material to the feeders. In the pellet feed concentrate building, two front-end loaders are used for dumping concentrate into the chutes. Loading from the sinter feed stockpile is much more flexible; two front-end loaders are used as much as possible because of their high loading capacity although Caterpillar tractors can be utilized should front-end loaders be unavailable due to breakdowns or mine production requirements. Maximum loading capacity on the conveyor belts is 3,000 metric tons per hour for the iron concentrates.

With the mine being adjacent to a natural harbor, the obvious means of concentrate shipment is by ore carrier. The shiploading dock has been designed for vessels of 55,000 tons dead-weight and it supports a travelling shiploader mounted on rails. A movable tripper system mounted on the shiploader enables concentrates from the tunnel reclaim system to be transferred to the shiploader conveyors anywhere along the 450 foot traverse distance that the shiploader can travel along the dock. Figure 7 shows the shiploader loading iron concentrate aboard the M. S. Jasaka and the movable tripper is visible in the right foreground of the photograph. Material is conveyed from the transfer chute, up an incline, and transferred to the boom conveyor. The boom conveyor discharges into an "elephant's trunk" attached to the underside of the operator's cab and the concentrates drop into the hold of the ship. The shiploader boom is capable of being extended from 28 feet to 68 feet forward from the face of the dock. A cable and drum arrangement allows the seaward end of the shiploader to be raised and lowered whenever the occasion arises.

All concentrates are sold under contract to Mitsubishi of Japan, who in turn arrange the concentrate shipments. Since iron concentrate storage capacity is limited, ore carrier arrivals are scheduled to prevent full stockpile situations. In the case of copper concentrates, shipments are arranged whenever sufficient cargo for a vessel is available. The contract covering copper concentrate does not specify a minimum yearly tonnage; however Mitsubishi agrees to purchase all tonnage produced. During 1973, 19 shipments of iron concentrate totalling 892,491 dry metric tons and 3 shipments of copper concentrate total ing 16,579 dry metric tons, were made from Wesfrob Mines Limited.