CANEX PLACER LIMITED

Endako Mines Division

93K006 (3E)

DESCRIPTION OF OPERATIONS

CANEX PLACER LIMITED, ENDAKO MINES DIVISION

(Latitude 54°N., Longitude 125°E., Elevation 3,200 feet)

LOCATIONS, ACCESS AND CLIMATE

The Endako molybdenum deposit is located about 100 miles west of Prince George in Central British Columbia. The mine property is six miles southwest of Endako Village, which is on Highway 16 and the B.C. North Division of the Canadian National Railway.

The Endako area is within the Interior system of the Canadian Cordillera and, more specifically, within the physiographic subdivision referred to as the Nechako Plateau. Local terrain is flat to gently rolling. Pleistocene glaciers moved eastward across the area, and have imprinted and accentuated easterly-trending lineaments. Topographic relief ranges from an elevation of 2,200 feet at Endako Village to 3,500 feet on the crest of Endako open pit.

Climate for Endako area is characterized by relatively cold winters and mild summers. Winter season commences in early November and continues to late March. Temperatures can drop to -40°F. range for short periods during winter. Average temperature for summer months is about 50°F. with periodic hot spells when temperatures rise to 95°F. Snowfall accounts for approximately one-half of annual 20-inch precipitation. Maximum depth of snow on the ground at any time is about three feet.

HISTORY AND OWNERSHIP

The molybdenite deposit was discovered in 1927 by two local hunters who staked four mineral claims to cover an area of mineralized float. They subsequently uncovered a two-foot wide quartz-molybdenite vein. During 1934, a short inclined shaft was sunk on the vein structure and a short adit was driven into the hillside to intersect another vein. The property, during the period 1934 to 1959, was examined by various companies and individuals, but little exploratory work was done and the mineral claims were allowed to lapse.

The key claims were later re-staked and, following a program of trenching and mapping, R and P Metals Corporation Ltd. initiated diamond drilling in 1962. Drilling results were encouraging and Endako Mines Ltd. (N.P.L.) was incorporated, initially as a private company and shortly afterwards as a public company.

Canadian Exploration Limited, a wholly-owned subsidiary of Placer Development Limited, entered into exploration of the property in October 1962. Following the completion and evaluation of 190 diamond drill holes totalling 80,000 feet and 2,700 feet of underground work for bulk sample testing, the decision to develop the property for production was announced in March, 1964. Endako Mines Ltd. was amalgamated with Canex Placer Limited in February, 1971.

Construction of the 10,000 tons per day mine plant and development of the open pit began in June, 1964. The mine was officially opened on June 8, 1965. Modifications to the plant during the first two years allowed mine production to be gradually increased to a throughput of 17,500 tons per day. A major mill expansion to increase milling capacity to 25,000 tons per day was completed in November, 1967.

Mill throughput is currently being maintained at 26,500 tons per day at an average ore grade of 0.15% MoS_2. Two products, molybdenum disulphide and molybdenum trioxide are produced. Estimated mineable ore reserves at December 31, 1975, using a cut-off grade of 0.08% molybdenum disulphide, were 196,000,000 tons at an average grade of 0.156% molybdenum disulphide.

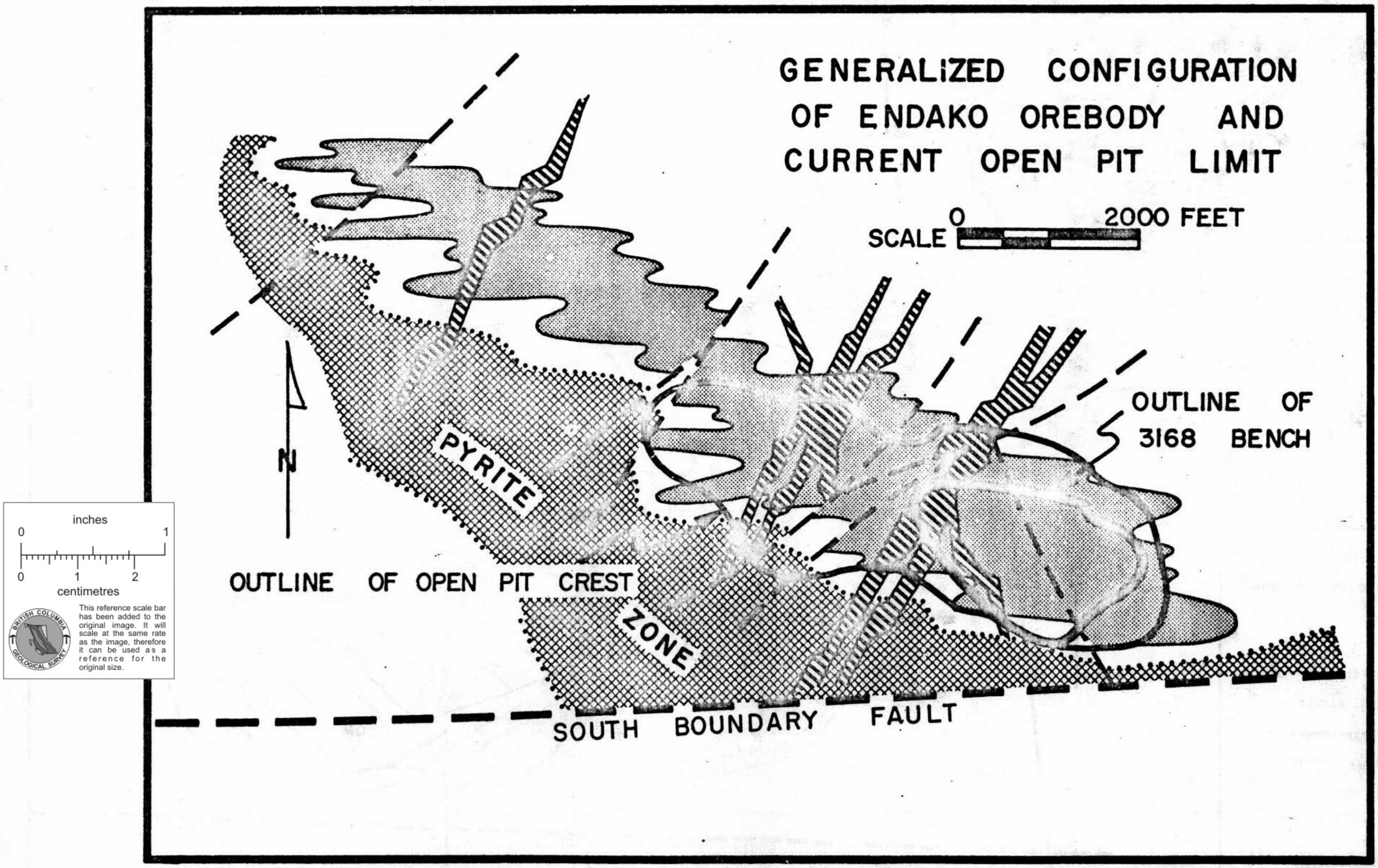
GEOLOGY

The Endako molybdenite orebody occurs in the Topley Intrusions, which are considered to be of late Jurassic age. Topley rocks are intruded into late Palaeozioc and early Mesozioc sedimentary and volcanic rocks. Regional distribution of the Topley Intrusions extends from the center of Babine Lake to Quesnel, a distance of about 180 miles along a regional northwesterly trend. It is a composite batholith in which granite, quartz monzonite, granodiorite, quartz diorite and diorite have been identified.

The Endako deposit is centrally situated within the batholith, and occurs in older Endako quartz monzonite that is bounded on the south by Francois granite and on the north by Casey alaskite and Glenannan granite.

The orebody in plan is roughly an elongated cigar-shaped zone of stockwork. The 11,000-foot-long westerly-plunging body strikes N 70 W. The westerly two-thirds of orebody length dips 30^{o} to 60^{o} south, whereas conjugating 50^{o} south and 20^{o} northwest dips prevail for easterly portion. The host Endako quartz monzonite is intruded by pre-mineral aplite, porphyritic granite and quartz-feldspar porphyry dykes that are proximal and crosscut the orebody. These dykes occur predominantly in two and possibly three concentrated swarms which are aligned to regional northwest and northeast trends. Post-mineral basalt dykes intrude several major faults. Movement along post-mineral faults, which predominantly trend northeasterly, northwesterly and easterly, is generally less than 25 feet. Larger inferred offsets up to 500 feet are apparent along several major northeasterly-striking faults. The major north-dipping South Boundary Fault is located 200 feet south of present East Pit and delimits ore deposit at depth.

Mineralization is simple and consists of molybdenite, pyrite, magnetite, and minor chalcopyrite. Calcite and chalcedony are late vein minerals.


GENERALIZED CONFIGURATION OF ENDAKO OREBODY AND CURRENT OPEN PIT LIMIT
SCALE 0 2000 FEET
OUTLINE OF 3168 BENCH
N
PYRITE
ZONE
OUTLINE OF OPEN PIT CREST
SOUTH BOUNDARY FAULT
inches
0 1
0 1 2
centimetres
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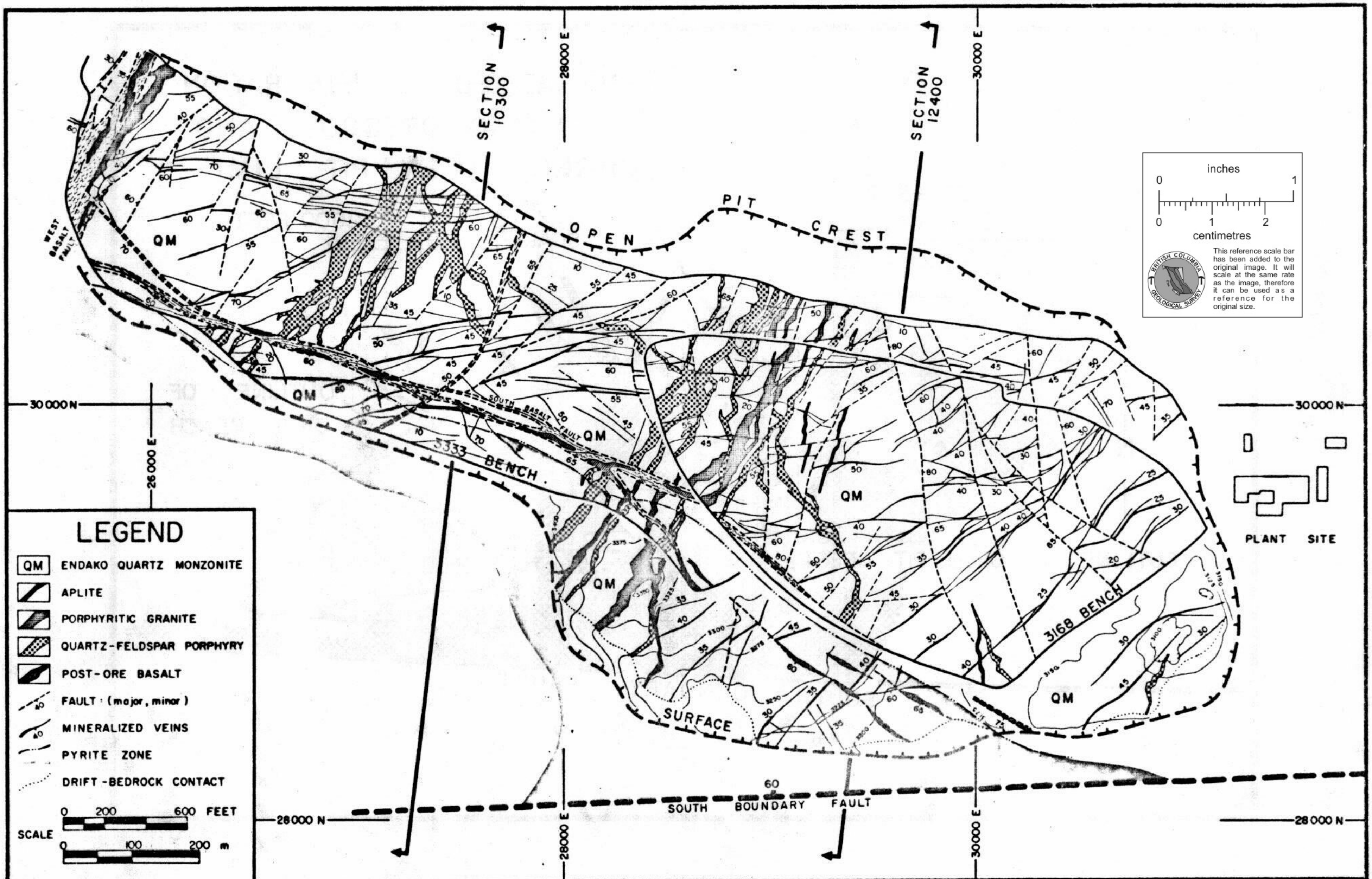
BRITISH COLUMBIA GEOLOGICAL SURVEY


SECTION 10300
SECTION 12400
28000 E
30000 E
26000 E
30000 N
28000 N
OPEN PIT CREST
WEST BASALT FAULT
SOUTH BASALT FAULT
3333 BENCH
3168 BENCH
SURFACE
SOUTH BOUNDARY FAULT
QM
PLANT SITE
LEGEND
QM ENDAKO QUARTZ MONZONITE
APLITE
PORPHYRITIC GRANITE
QUARTZ-FELDSPAR PORPHYRY
POST-ORE BASALT
FAULT : (major, minor)
MINERALIZED VEINS
PYRITE ZONE
DRIFT-BEDROCK CONTACT
SCALE
0 200 600 FEET
0 100 200 m
inches
0 1
0 1 2
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BRITISH COLUMBIA GEOLOGICAL SURVEY

The ore minerals are intimately associated with quartz veining and occur in two types of veins: 1. as large four-inch to four-foot-wide veins in which molybdenite typically occurs as thin, closely spaced laminae, and 2. as fine fracture-fillings and veinlets in the form of stockwork. Orientation and limits of economic stockwork are controlled by major sub-parellel sets of south dipping and complementary flat-lying, south-easterly and northwesterly-dipping vein systems.

A pyrite zone bounds the orebody to the south. The zone consists of fine quartz and pyrite, minor magnetite and rare molybdenite mineralization as fracture-fillings in a poorly-developed stockwork. The zone has not been recognized in other peripheral areas of the orebody.

Three distinct hydrothermal alteration products are recognized in the Endako ore zone. Orange-pink K-feldspar has been developed as 1/8-inch envelope to two-foot wide zones on veins and fractures. A quartz-sericite pyrite phase is also developed as 1/8- to 2-inch wide envelope on veins. Pervasive kaolinization of the Endako quartz monzonite is widespread, and varies from a slight development of kaolinite in plagioclase and K-feldspar to a soft creamy white or green clay.

A concept of elongated doming near or at an intersection of regional northwest and easterly structures is proposed for possible development of restructed Endako stockwork. Longitudinal major faulting, with attendant antithetic faulting and repetitive periods of concomitant fracturing across domal structure, is visualized for localization of a favourable fracture system for hydrothermal alteration and economic mineralization.

PROPERTY OPERATION

The surface layer of the Endako mine is shown in Figure 1, "General Plan of Endako Mine Area." The mine operates with six departments under the Administration of a resident Mine Manager and an Assistant Mine Manager. As at 31 May 1976, the total operating crew strength was distributed as follows:

	Hourly Rated	Staff	Total
Administration	-	4	4
Employee Relations	12	9	21
Accounting	11	23	34
Mine Engineering	9	23	32
Mining	130	16	146
Mineral Processing	99	24	123
Plant Maintenance	213	31	244
TOTALS	474	130	604

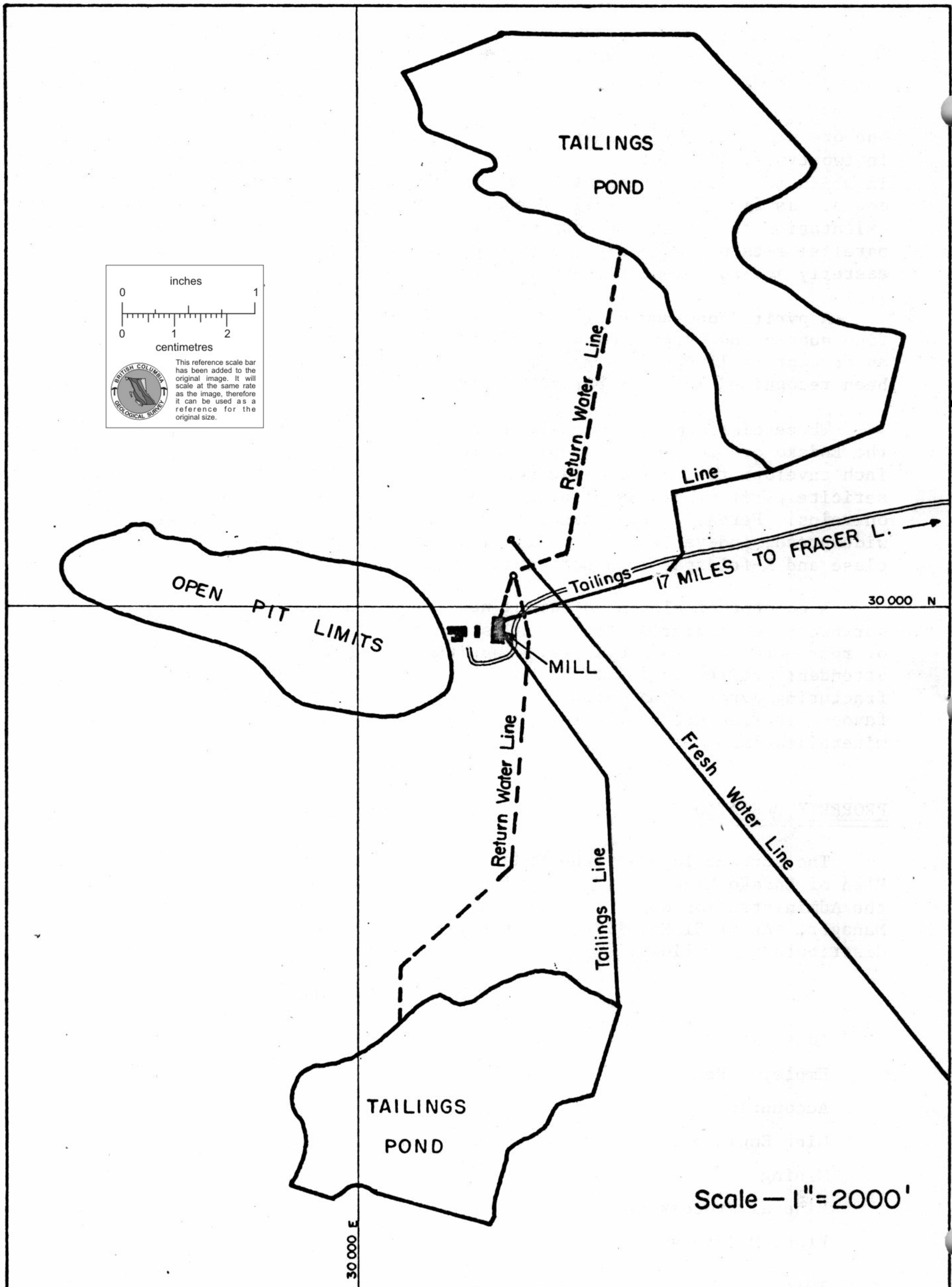


FIGURE 1 GENERAL PLAN OF ENDAKO MINE AREA

MINING ENGINEERING

Pit Planning

Much of the long range planning at Endako is done by means of a Univac 1106 computer located at the Placer Development Head Office in Vancouver, which is accessed through a Comterm Data Communications Terminal at the mine site. 3-Dimensional Pit Design computer programs are used to determine economically feasable pit outlines. Reserves calculations and long range scheduling are also done through the computer.

Design Sequence

The principal consideration in the establishment of a mining sequence is the maximization of the discounted net cash flow over the life of the mine. To this end, the 3-dimensional pit design programs are used to generate a series of optimum pits, within an ultimate pit, from geological interpretations of the diamond drill data. Reserves from each of the optimum pits are calculated at predetermined cut-off grades, by means of a reserves program. The output from the reserves program is stored on tape and used as input for the scheduling program, which determines dates for cut-off grade changes, truck requirements and mine grades by year. The scheduling program is run once for each sequence of pits to be evaluated. The yearly mine grades determined by the scheduling program plus current operating statistics are input to the cash flow program which determines net discounted cash flow for the life of the mine for each sequence.

PIT GEOLOGY

The pit geologist continually records the open pit geology as the benches are mined. This information is used to:

A) Add more information to our diamond drilling data.

B) Assist in projecting reserves to subsequent benches.

C) Assist the ore grader to locate correct areas for the shovels to obtain a good blend of rock types and metal grade.

The pit geologist is also responsbile for monitoring the pit walls for slope movement, and for delineating geologic structures which may produce zones of weakness or instability in the pit walls.

OPEN PIT OPERATIONS

The present open pit excavation encompasses an area of two hundred acres and extends to a depth of six hundred feet.

Currently, the daily mine production rate of 61,000 tons per day of which 26,500 tons per day is mill feed, is mined in accordance with the following design parameters.

Overburden bank slope	34°
Safety berm at base of overburden	40 feet wide
Bench interval height	33 feet
Safety berms in rock	30 feet wide every second bench
Working face slope	68°
Haul road width	80 feet minimum
Haul road grade	10% maximum
Minimum pit wall curvature	Radius not less than 75 feet
Working floor slope	Flat
Blast hole spacing	9 inch and 9-7/8 inch diameter holes with a 15 foot by 22 foot to 17 foot by 35 foot pattern.
Sub-grade drilling	7 feet
Powder factor	0.50 lb./ton

Tabulation of Open Pit Operating Statistics:

Production

1. Production May 1965 through December 1975.

Overburden	6.1 million yards
Waste Rock	29.2 million tons
Stockpiled	
Low Grade	30.6 million tons
Mill Feed	82.3 million tons

2. Production for Year Ending 31 December 1975.

Waste Rock	8.7 million tons
Stockpiled	
Low Grade	3.8 million tons
Mill Feed	9.5 million tons
Total Mined	22.0 million tons

Consumed Supplies for Year Ending 31 December 1975.

1. Blasting

ANFO	9.8 million pounds
Slurry	2.4 million pounds
Primers	39,000
Detonation Cord	1.9 million feet

2. Diesel Fuel	1,097,000 gallons
3. Haulage Truck Tires	$662,000
4. Electric Power	8,728,000 kilowatt hours
5. Drill Bits	174

TABLE NO. 1

OPEN PIT PRODUCTION EQUIPMENT

May 31, 1976

FUNCTION	TYPE OF UNIT	NO. OF UNITS	SCHEDULED PER SHIFT	SHIFTS PER OPERATING DAY	OPERATORS PER UNIT	UNIT PERFORMANCE PER SHIFT
Blast Hole Drilling	- B.E. 40R Electric	3	1	3	1	410 ft. at 9 inch diam.
	- Marion M4 Electric	1	1	3	1	680 ft. at 9-7/8 in. diam.
Rock Loading	- P&H 2100B Electric 13 cubic yard	1	1	3	1	10,900 tons
	- Marion 191B Electric 13 cubic yard	1	1	3	1	10,900 tons
	- P&H 2100 BL 13 cubic yard	1	1	3	1	10,900 tons
	- B.E. 150B Electric 8 cubic yard	1	-	3	1	5,600 tons
	- P&H 1400 Electric	1	-	3	1	3,700 tons
Rock Haulage	- Unit Rig Lectra Haul 85 ton	10				
	- Unit Rig Lectra Haul 100 ton	8	12	3	1	2,000 tons
Dump Maintenance and Shovel Cleanup	- Tracked dozers D-8 Caterpillar	3	2	3	1	
	- Tired dozers 824 Caterpillar 988 Caterpillar	1	1	3	1	
Road Maintenance	- Road Grader					
	- 16 Caterpillar	1	1	3	1	
	- 14 Caterpillar	1	-	3	1	
	- 12 Caterpillar	1	1	3	1	
	- Watering Trucks	1	1	3	1	
	- Sanding Trucks	2	1	3	1	

MINERAL PROCESSING

The Endako concentrator was put into production with a nominal capacity of 12,000 tons per day of mill feed. Shortly after start-up, throughput was increased above normal capacity to reach 17,000 tons per day after 14 months of production. In November 1967, two more grinding and rougher flotation sections were added to raise the throughput to the current level of 26,500 tons per day.

Primary Crushing

Primary crushing consists of one gyratory crusher operating in open circuit.

Pit run ore is dumped from 85 and 100-ton "Lectra Hauls" over a fixed rail grizzly of 6 inch openings. Oversize falls directly into the crusher with a tight setting of 5½ inches. Primary crusher discharge, combined with grizzly undersize, is carried by conveyors to feed the primary screen of the secondary crushing plant. Material flow to the conveyors is regulated by two vibratory feeders, each of nominal capacity of 1,000 tons per hour.

Dust control in the primary crusher building is performed by a baghouse through which is exhausted 42,000 actual cubic feet per minute of dust laden air from above and below the crusher cavity.

Data

Primary Crusher Capacity	1,600 tons per hour
Mantle Life	3,500,000 tons mill feed
Concave Life	4,000,000 tons mill feed

Secondary and tertiary crushing

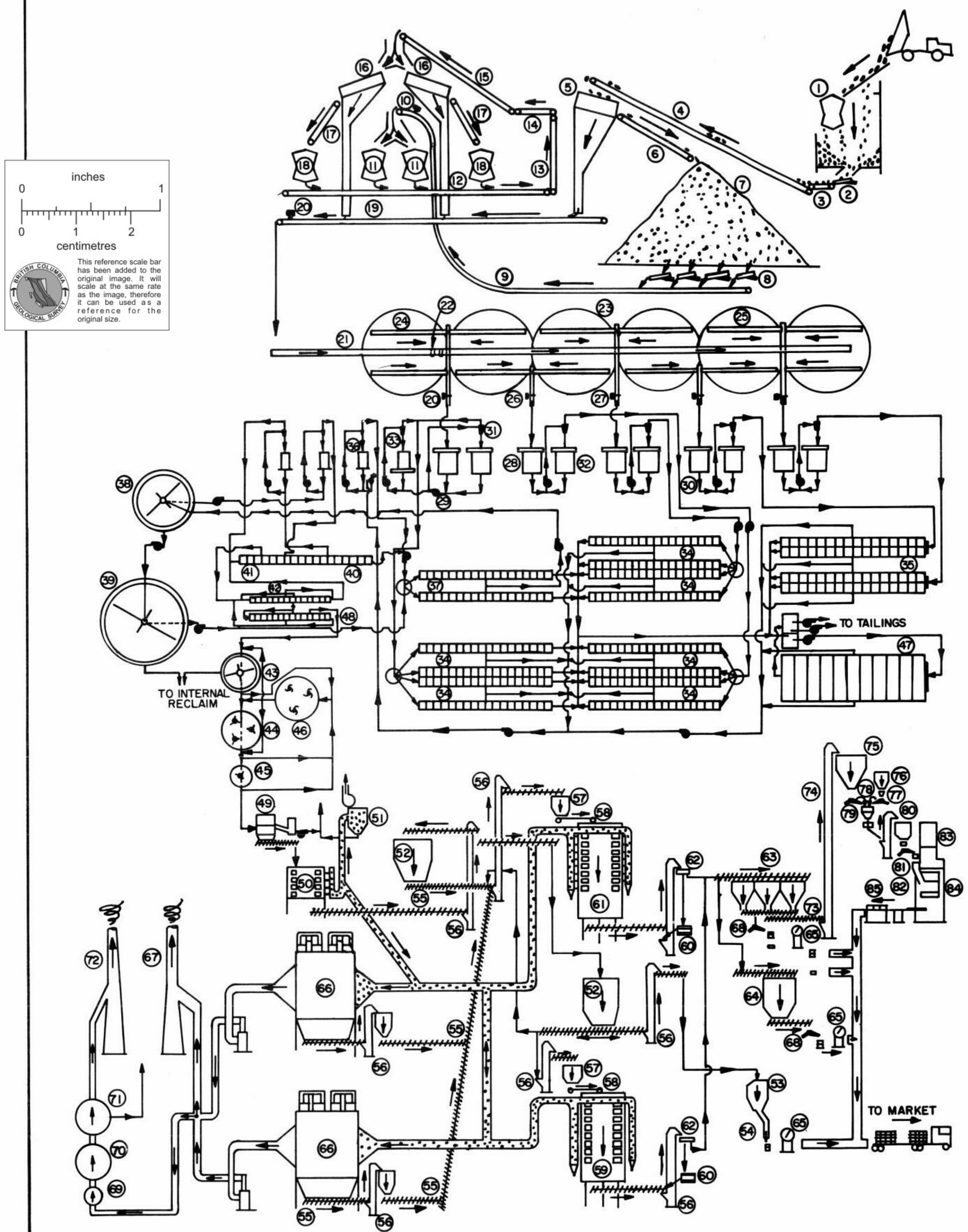
Primary crusher product is first sized on a primary screen, with a top deck of stepped manganese rails set 1½ inches apart and a bottom deck of 1 inch slotted openings.

Primary screen undersize goes directly to the fine ore bins, while the oversize (plus 1 inch) goes to a stockpile which controls surges in the primary crusher production. The normal 100,000 tons dead storage capacity of the stockpile can be raised to 200,000 tons with bulldozers. When the primary production cannot cope with the demand of the secondary crusher, dead storage can be reclaimed.

Four in-line vibratory pan feeders reclaim ore from underneath the stockpile to feed the dual 13 x 84 "Hydrocone" secondary crushers. Secondary crushing is performed in open circuit with the product going straight to the tertiary crushing circuit.

CANEX PLACER LTD.

ENDAKO MINES DIVISION SEPT. 1974



LEGEND

CRUSHING

1 – PRIMARY CRUSHING 42"x 65" CAC GYRATORY
2 – 2-VIBRATING FEEDERS 60"x 102" SYNTRON F88
3 – No. 1 CONVEYOR 54"x 27' BL. 355 F.P.M. 15 HP.
4 – No. 2 CONVEYOR 54"x 372' BL. 520 F.P.M. 300 HP.
5 – PRIMARY SCREEN 8'x 20' CAC MODEL XXH
6 – No. 3 CONVEYOR 48"x 450' BL. 415 FPM. 150 HP.
7 – STOCKPILE 20,000 TONS LIVE CAPACITY 7" MINUS
8 – 4-VIBRATING FEEDERS 42"x 72" SYNTRON FH45
9 – No 4 CONVEYOR 42"x 517' BL 420 FPM. 150 HP.
10 – METAL DETECTORS – RENS
11 – 2 - SECONDARY CRUSHERS 13"x 84" CAC HYDROCONE
12 – No. 5 CONVEYOR 48"x 64' BL 380 FPM. 30 HP.
13 – No. 6 CONVEYOR 48"x 259' BL. 410 FPM. 200 HP.
14 – No. 7 CONVEYOR 54"x 24' BL. 500 FPM. 30 HP.
15 – No. 8 CONVEYOR 48"x 236' BL 490 FPM. 200 HP.
16 – 2 - SECONDARY SCREENS 8'x 20' CAC MODEL SH
17 – No 9a & 9b CONVEYORS 36"x 17' ea. BL. 345 FPM. 10 HP.
18 – 2 - TERTIARY CRUSHERS 5"x 84" CAC HYDROCONE
19 – No. 10 CONVEYOR 48"x 508' BL. 515 FPM 200 HP.
20 – CONVEYOR SCALES TRANSWEIGH
21 – No. 11 CONVEYOR 48"x 355' BL. 300 FPM 50 HP
22 – TRIPPER - STEPHENS ADAMSON 11 FPM. 5 HP.

CONCENTRATOR

23 – 6 - FINE ORE BINS 50'x 70' - CAP 27,000 T (LIVE) 1" MINUS
24 – No 12A – 12H CONVEYORS 36"x 43' BL 15–85 FPM 3HP
25 – No 12I – 12L CONVEYORS 48"x 43' BL 15–60 FPM 12.5
26 – No 13 & 13B CONVEYORS 30"x 95' BL 200 FPM 15 HP
27 – No 14A – 14C CONVEYORS 30"x 119' BL 200 FPM 20 HP
28 – 5 ROD MILLS 12.5' DIA. x 15' CAC 1250 HP ea.
29 – 6 PUMPS 12"x 10" SRL - C (3 SPARES) MILL DISCHARGE CAC
30 – 4 PUMPS 12"x 10" SRL-C (2 SPARES) MILL DISCHARGE DENVER
31 – 10 CYCLONES 30" DORR. (3-36" PLUS 4-30" SPARES)
32 – 5 - BALL MILLS 12.5' DIA. x 15' CAC 4 - 1500 HP 1-1250 HP
33 – 1 BALL MILL 9.5' DIA. x 13' CAC 700 HP
34 – 216 ROUGHER CELLS No. 48 AGITAIR 3 SEC. OF 4 – 18 CELL BANKS
35 – 64 ROUGHER CELLS No. 30 DENVER 2 SEC. OF 2 – 16 CELL BANKS
36 – 3 - REGRIND MILLS 6' DIA. x 12' DOMINION 200 HP.
37 – 36 - 1st CLEANER CELLS No. 48 AGITAIR 1 SEC. OF 2 - 18 CELL BANKS
38 – 1 MIDDLINGS THICKNER 50' DIA. x 12' DORR.
39 – 1 MIDDLINGS THICKNER 125' DIA. x 13' DORR.
40 – 12 - SECOND CLEANER CELLS No. 48 AGITAIR
41 – 6 - THIRD CLEANER CELLS No. 48 AGITAIR
42 – 14 - FOURTH CLEANER CELLS No. 15 DENVER 1 SEC. OF 2 - 7 CELL BANKS
43 – 1 FINAL CONCENTRATE THICKNER 20' DIA. x 10' DORR.
44 – 1 STOCK TANK 20' DIA. x 12' 3 LIGHTNIN MIXERS 5 HP ea.
45 – 1 STOCK TANK 10' DIA. x 10' 1 LIGHTNIN MIXER 5 HP ea.
46 – 1 STOCK TANK 17' DIA. x 12' 3 LIGHTNIN MIXERS 5 HP ea.
47 – 11 SCAVENGER CELLS No. 600H DENVER
48 – 14 - FIFTH CLEANER CELLS No. 15 DENVER 1 SEC OF 2 - 7 CELL BANKS

ROASTER

49 – 1 FILTER 6' DIA. – 4 DISC EIMCO AGIDISC
50 – 1 - DRYER 10' DIA. 4 HEARTH NICHOLS HERRESHOFF
51 – 1 - ROTOCLONE TYPE N SIZE 6 A.A.F. 316 SS 4,500 CFM
52 – No. 1 & 4 BINS SULPHIDE STORAGE 90 T CAP. ea.
53 – No. 2 BIN PACKER FEED. 10 T CAP.
54 – 1 - SULPHIDE PACKER GENERAL ELECTRIC 20 HP.
55 – 20 - SCREW CONVEYORS VARIED SIZES
56 – 8 BUCKET ELEVATORS
57 – No. 3 & 5 BINS ROASTER FEEDS 5 T CAP. ea.
58 – 2 - BELT CONVEYORS - ROASTER FEED 24"x 15" BL 190 FPH. 2 HP.
59 – 1 - ROASTER 18' DIA. - 12 HEARTH NICHOLS HERRESHOFF
60 – 2 - BALL MILLS 30" DIA. x 36" 5 HP.
61 – 1 - ROASTER 16' DIA. - 10 HEARTH NICHOLS HERRESHOFF
62 – 2 - VIBRATING SCREENS 12"x 42" SF 380 SYNTRON
63 – No. 1, 2 & 3 BINS OXIDE STORAGE 30 T. ea.
64 – No. 5 BIN OXIDE STORAGE 70 T.
65 – 4 TOLEDO SCALES
66 – 2 - ELECTROSTATIC PRECIPITATORS 4 FIELDS ea. JOY MANUF.
67 – 1 STACK 4'-6" DIA. x 148' HIGH 316 SS
68 – 5 VIBRATING FEEDERS SYNTRON

SO_2 ABSORPTION

69 – 1 PRIMARY COOLING TOWER 17'H x 6'-6" DIA. 6.5" THK. STEEL, LEAD & CERAMIC
70 – 1 SECONDARY COOLING TOWER 32'H x 12' DIA. .5" THK. F.R.P.
71 – 1 SO_2 ABSORPTION TOWER 46'H x 12' DIA. .5" THK. F.R.P.
72 – 1 STACK 4'-0" DIA. x 90' H. .5" THK. F.R.P.

BRIQUETTING

73 – 1 SCREW CONVEYOR 12" DIA.
74 – 2 BUCKET ELEVATORS
75 – 1 OXIDE BIN 25 T. CAP.
76 – 1 PITCH BIN 3 T. CAP.
77 – 2 BIN ACTIVATORS
78 – 4 VIBRATING FEEDERS SYNTRON
79 – 1 BATCH SCALE & BIN
80 – 1 BLENDER
81 – 1 BRIQUETTE FEED HOPPER
82 – 1 BRIQUETTE FEED SCALE
83 – 1 BRIQUETTE PRESS MODEL CU-1 300 T HYDRAULIC
84 – 1 TOLEDO CHECKWEIGHER
85 – 1 QUADNUMATIC DELUXE AUTOMATIC PACKAGING MACHINE - SCHROEDER

Tertiary crushing is performed by dual 5 x 84 "Hydrocone" tertiary crushers in closed circuit with two double deck secondary screens. The top decks have 1½ inch square openings in ½ inch wire; the bottom decks consist of 3/4 inch by 4 inch openings in ½ inch wire.

Secondary screen undersize is the final product which is distributed among the six fine ore bins by a tripper. Each bin is 60 feet high and 50 feet in diameter, with a live load capacity of 4,500 tons. The tripper is operated continuously to distribute the ore among the bins for a well blended mill feed. Bin levels are measured with a mechanical device.

The greater part of dust control is carried by a baghouse through which 42,000 actual cubic feet per minute of dust laden air is drawn through 16,800 square feet of nylon bags. Water spray and auxiliary dust collection systems operate at various points of the crushing circuits to ensure the dust count remains within acceptable levels. Regular scheduled dust counts are taken by mine personnel using the same type and make of equipment as the British Columbia Department of Mines.

<u>Data</u>

Primary Screen	Top deck life	Replaced as worn out
	Bottom deck life	3 Weeks
Secondary Screen	Top deck life	3 Weeks
	Bottom deck life	3 Weeks
Secondary Crusher	Mantle life	4,000,000 Tons mill feed
	Concave life	7,000,000 Tons mill feed
	Tight side setting	1¼ inches
	Throw	1 3/4 inches
Tertiary Crusher	Mantle life	3,810,000 Tons mill feed
	Concave life	5,000,000 Tons mill feed
	Tight side setting	½ inch
	Throw	2 inches

<u>Primary Grinding</u>

Of the five primary grinding sections, three were originally installed when the mill was built in 1965 and two added on later in the 1967 expansion.

Each section is comprised of one rod mill followed by one ball mill in closed circuit with cyclones. All ten mills are identical, 12½ feet in diameter by 15 feet long.

No. 1 primary grinding section has an extra 9½ foot diameter by 13 foot long ball mill in closed circuit with a cyclone, giving this section an extra 800 tons daily grinding capacity.

Rod mills are directly driven through disc clutches with 1,250 horse power, 240 revolutions per minute, synchronous motors through a single helical gear mounted on the feed end. Ball mill drives are identical, except that all but No. 1 primary ball mill are driven by 1,500 horse power motors.

The gears of the rod and ball mills are lubricated by a pneumatic system operated automatically. Trunnion bearings are lubricated by a dual pressurized system, with a manual start dip system on standby.

The rod mills of the three original sections (No. 1 to 3) are fed by twenty-four tube feeders. Each tube measures 9½ inches across, arranged in threesomes per belt and two or three belts for each section. Belt speed under the tube feeders varies from 33 to 100 feet per minute. The conveyor is driven by a variable speed drive which is pneumatically controlled by the belt scale. The belt scale weighs, records and regulates within a pre-set limit, the weight of feed to each of the three rod mills.

The two new rod mills (No. 4 and 5) are fed by slot feeders driven by belt scale controlled variable speed motors.

The feeding system works satisfactorily except when frozen lumps plug up the tube feeders in severe winter weather.

Classification of discharge from each ball mill is performed by dual 30 inch cyclones, with a single 36 inch cyclone for sections 1, 2 and 3, and dual 30 inch cyclones for sections 4 and 5 as standby units. Inlet pressure is 3 to 5 pounds per square inch, gauge pressure giving a classifying efficiency of 80%.

Piping of cyclone feed is schedule 80 unlined pipe with victaulic fittings. Wear has not been severe despite velocites of 7 feet per second.

Cyclone overflow from the three original grinding sections is pumped to one of three rougher sections, each containing four banks of Agitair cells. A four way splitter, which is a cylindrical tank with four equally spaced slots, is used to distribute the cyclone overflow. The two new grinding sections discharge by gravity directly to their rougher cells arranged in two back-to-back banks per section.

Data

	Rod Mill	Ball Mill	Total
Size feet Ø x L	12½ x 15	12½ x 15	
Throughput tons/day	6,000	6,000	
Mill feed	6,800*	6,800*	
Mill speed r.p.m.	13.9	17.2	
% Critical	63.5	78.5	
Motor rating	1,250	1,500**	
Type	Synchronous	Synchronous	
r.p.m.	240	240	
Power H.P.	1,115	1,485	
K.W.	835	1,110	
KWH/ton milled	3.3	4.7	8.0

Foot Note: * Grinding # 1 section ** # 1 Ball mill 1,250

	Rod Mill	Ball Mill ,	Total
Grinding media size, inch	4	2	
Material	SAE 1090	Forged	
Consumption, lb./ton milled	0.96	.082	1.68
Liner, material - lifter	chrome moly	n/a	
Shell	NiHard	NiHard	
Ends	Cr-Mo	NiHard	
Consumption lb./ton milled	0.052	0.055	0.107
Density mill discharge	78.0	74.0	
% Solid cyclone overflow			40

Flotation

Basically flotation is carried out in one stage straight through roughing followed by four successive stages of cleaning. Each of the first three cleaners is preceded by a regrinding ball mill in closed circuit with a cyclone. Except that first cleaner tailings go to the scavenger cells, all the cleaner tailings are recirculated back to the preceeding cleaning stage.

A bank of eleven 600H Denver cells were recently installed to scavenge the combined rougher tailings and first cleaner tailings. The scavenger concentrate is recirculated to No. 1 regrind ball mill. The scavenger tails are the final tailing to be pumped to tailings ponds for disposal.

Rougher flotation takes place in five sections, one for each of the five primary grinding sections. The three original rougher sections (No. 1 to 3) consist of four banks, each of eighteen No. 48 Agitair cells. The two new sections (No. 4 and 5) are each double banks of No. 30 Denver DR cells. Ratio of rougher concentration is about 120 to 1. Each rougher section is sampled for head, concentrate and tailing.

Collector oil used is "Texaco No. 3491" which has a gravity API of 23 and viscosity SUS 100 seconds at 100°F. "Vapour Oil" was previously used but the practice is discontinued due to short supply. To enhance the stability of the froth, "Syntex L" is used, which is a mixture of sulphated monoglycerides. This reagent also acts as a frother. Guardsman No. 60 pine oil is used as a frother.

In the cleaner circuits, sodium silicate is added to prevent slimes from covering up exposed molybdenite surface and lowering recovery. To suppress the flotation of small amounts of pyrite and chalcopyrite in the ore, sodium cyanide is used as a depressant.

Due to the high ratio of concentration in roughing, the concentration of reagents in the cleaner concentrate makes a very stiff and stable froth. Excess reagent is removed in the overflow by thickening the first cleaner concentrate. Water and reagents so removed are recirculated to the primary grinding circuit as part of process water.

Thickening of the first stage cleaner concentrate takes place in two successive thickeners, a 50-footer discharging the overflow to feed a 125-footer. No flocculant is added because adhesion of slime particles to exposed molybdenite surface is detrimental to recovery.

Rougher Data

	Sections No. 1,2,3	Sections No. 4,5
Make of cells	Agitair	Denver DR
Size, cu. ft.	40	200
H.P. per cell	7½	7½
No. of cells per section	72	16
Volume of cells/section, cu. ft.	2,880	3,200
Retention time, minutes	12.9	14.3
Pulp density, % solids	40	40
Impellor type	Cells 1-6 standard Cells 7-18 Chill X	Standard
Shaft Speed r.p.m.	173	180
Peripheral speed ft./min.	1,222	1,272

Reagents	Lbs. Per Ton Milled	Points of Addition
Texaco No. 3491	0.20	Rod and ball mills
Syntex L	0.030	Rod mills
Guardsman #60 pine oil	0.050	Ball mill discharge

Cleaner Flotation	1st	2nd	3rd	4th
Make of Cell	Agitair	Agitair	Agitair	Denver
Volume/cell in cu. ft.	40	40	40	12
H.P. per cell	5	5	5	1½
No. of cells	36	12	6	14
Total Volume of cells, cu. ft.	1,440	480	240	168
Pulp density, % solid	11	12	8	8
Retention time, minutes	15.6	14.5	9.6	9.9
Impeller type	Standard	Standard	Standard	Standard
Shaft speed r.p.m.	190	190	190	420

Reagents	Lbs. Per Ton Milled	Points of Addition
Texaco No. 3491	0.025	No. 1 regrind ball mill
Guardsman No. 60 pine oil	0.006	No. 1, 2 and 3 cleaners
Sodium silicate	0.16	No. 2 & 3 regrind ball mill & No. 2 cleaners.
Sodium cyanide	0.025	No. 1, 2 & 3 regrind ball mills No. 2 cleaners.

Scavenger Cells

Make of cell	Denver
Volume/cell, in cu. ft.	600
H.P. per cell	100
No. of cells	11
Total volume of cells, in cu. ft.	6,600
Pulp density, % solids	38
Retention time, minutes	5.6
Impeller type	Denver DR
Shaft Speed, r.p.m.	162

Reagents	Lbs. Per Ton Milled
Texaco No. 3491	0.02
Guardsman No. 60 Pine Oil	0.003
Syntex-L	0.005

Regrinding

Preceding each of the first three cleaning stages is a regrinding stage. The third regrind stage is run intermittently to maintain a final concentrate sizing of 60 to 70% minus 9 microns.

Each regrind stage consists of a ball mill in closed circuit with a rubber lined cyclone. Regrind mills are overflow ball mills 6 feet in diameter by 12 feet long.

Power consumption in regrinding is about 600 H.P. For No. 2 and No. 3 regrind ball mills, rejects from primary ball mills are used as grinding medium. To No. 1 regrind ball mill 1½ inch balls are charged. The rate of grinding medium consumption is 0.03 pounds per ton of mill feed.

Metallurgy

In Endako ore, the occurrence of molybdenite is concentrated along planes of weakness, so that a relatively coarse grind is sufficient to liberate the mineral. This, together with the easily floatable nature of molybdenite, makes it possible to float it at a coarse grind. No mineral other than molybdenite is recovered.

In general, recovery in the rougher circuits fluctuates around 84% with overall recovery differed by around 0.5%. The extra 2% recovery of the scavenging circuit compensates for the effect of 98% efficient cleaning circuit.

Past experience indicated that for all practical purposes, increasing the concentration of collector in rougher flotation improves recovery. However, this is limited by the collapse of froth by even slight excess in collector. As a result, excess collector addition cannot be practiced to take care of slight increase in head assay. Thorough blending of mill feed to maintain a steady head assay and addition of collector oil emulsified with Syntex L help to ensure maximum recovery.

The grade of rougher concentrate is controlled to give a ratio of 120 to 1, and rougher recovery appears insensitive to changes in this ratio.

A close relationship exists between the fineness of regrinding and the grade of final concentrate after four cleaning stages. Fineness can be adjusted by running or bypassing the third regrind ball mill.

Flocculation of slime is very harmful to the recovery of molybdenite. In the cleaner circuits, sodium silicate is added to ensure that exposed molybdenite surface is not passified by a coating of slime.

Dewatering

Final concentrate produced by the fourth cleaners is thickened to about 50% solids in a 20-foot diameter thickener using Separan as flocculant. The underflow is pumped to a stock tank, 20 feet in diameter and 12 feet high, with a 3 by 3 soft rubber liner (SRL) pump controlled by a pre-set on-off timer.

The stock tank serves to control surges in mill production, to blend final concentrate for a more uniform grade and to serve as a leaching tank for a muriatic acid leach. Leaching reduces the amount of calcite in the concentrate ensuring the sulphur content of roasted concentrate can be reduced to below 0.10%.

The leached concentrate is filtered to about 30% moisture by a three disc, 6 foot diameter filter. Sprays on the filter cake wash out the dissolved calcium from the leaching step.

Moisture is reduced from 30% down to about 3% in a natural gas fired 10 foot, 4 hearth dryer. Revolving arms with rabble teeth attached stir and transfer the feed across each hearth and down to the next hearth through alternative in and out dropholes. Natural gas burners are installed to provide heat for drying, three on No. 1 hearth and two on No. 2 hearth. The dryer is downdraughted.

Residual moisture along with collector oil remaining in the concentrate is maintained around 5 to 7% for a high bulk density and good dust control for the canning process.

Dried concentrate is conveyed to either one or two 100-ton storage bins to provide feed for the canning line and roasters.

10-foot Dryer

Diameter	10 feet
Hearths	4
Total Area Utilized	360 square feet
Feed rate, dry tons/hour	1.5 to 2.5
Hearth loading, lbs./sq.ft.	3.0
Temperature - No. 1 Hearth	1400 - 1600°F.
- No. 2 Hearth	800 - 850°F.
Heat input, BTU per ton	400,000
Rabbling - speed r.p.m.	1
- teeth per hearth	in hearth - 12 out hearth - 12
Exhaust gas volume, actual cubic feet per minute	5,000

Roasting

Increasing demand for molybdenum in the form of its trioxide has resulted in the recent conversion of a 16 foot dryer to a roaster. The 16 foot roaster combined with the 18 foot roaster will roast 90% of concentrator production. Both roasters are similar in structure and design to the 10 foot dryer.

Control of temperature, air, and heat input at the various points of the roasting process is very important to produce a low sulphur calcine. Air plays the dual role of coolant and oxidant. Since oxidation of molybdenum sulphide to trioxide is exothermic, adjustment of the amount of air input can be used to raise or lower the hearth temperature thus regulating the rate of any particular step in the overall roasting process.

Most of the heat required in roasting is supplied by the oxidation of molybdenum sulphide to trioxide. A modest amount of external heat input is required to initiate roasting, and to maintain sulphur removal when sulphur content in the feed drops too low for roasting to be autogenous. In the 18 foot roaster, burners are placed in pairs in each of No. 1 and No. 9 hearths, and in foursomes in each of No. 10, 11 and 12 hearths. In the 16 foot roaster burners are placed in pairs in No. 7 hearth and foursomes in each of No. 1, 8, 9, and 10 hearths.

Roasting of molybdenum concentrate in the 18 foot roaster can be broken down into four steps. The two burners of No. 1 hearth provide heat to remove the last trace of moisture, to vaporize and initiate combustion of collector oils in the feed. Heat given off by the oil burning is sufficient to sustain complete removal of water and oil in the top two hearths.

When concentrate reaches No. 3 hearth, its temperature is high enough to initiate oxidation of molybdenum sulphide to dioxide. Air is introduced to No. 4 and 5 hearths to provide oxygen for roasting. The roasting reaction is exothermic and a well adjusted air input maintains the reaction temperature.

The second stage of oxidation to trioxide takes place in No. 6 to 9 hearths. The reaction is again exothermic and oxygen is required.

To ensure a product of less than 0.10% sulphur, a total of 14 burners are located on the bottom four hearths which remove the last remaining traces of sulphur, which amounts to 1% in No. 9 hearth. The process control criterion is the hearth at which "tail-out" occurs. Tailout is said to take place when the load stops glowing and appears a yellow colour. Tailout on No. 10 or 11 hearths is usually an indication of acceptable calcine.

Roasting in the 16 foot roaster follows a similar sequence. Drying of the molybdenum sulphide concentrate and burning of the flotation oils are complete in No. 2 hearth. Oxidation to dioxide proceeds from No. 3 to 5 hearths. Final transformation to trioxide takes place in No. 6 and 7 hearths to give a tailout in No. 8 hearth. Final removal of sulphur below 0.10% is accomplished by the time the calcine leaves No. 10 hearth.

Data

Diameter		18 Feet	16 Feet
Hearth	- Number	12	10
	- Area in sq. ft.	2,255	1,306
Feed Rate	- Lb. Mo/day	40,000	
	- Lb. Mo/day/sq. ft.	11.2	
Temperature °F.	- Highest	1,200 No. 3 Hearth	1,300 No. 3 Hearth
	- Tailout	1,000 No.10 Hearth	1,000 No. 8 Hearth
Product Sulphur Content		Maximum 0.10%	
Heat Input	- BTU/day	38,400,000	12,900,000
	- BTU/lb. Mo	1460	
Rabbling	- Speed in r.p.m.	0.5	0.5
	- Teeth for in hearth	27	22
	- Teeth for out hearth	29	23
	- Furrows/hour	10,000	6,600
	- Furrows/hour/sq.ft.	4.8	4.8
Recovery		90	
Product Size Control		Minus 10 mesh (Tyler Screen)	

SULPHUR DIOXIDE REMOVAL

The sulphur dioxide removal plant was designed to handle 45,000 ACFM of flue gases at 500°F., containing approximately 1.4% sulphur dioxide by volume, from two roasters and one dryer.

The plant is a three stage process consisting of two cooling stages and one absorption stage. Exhaust gases from the dryer and the two roasters enter the primary cooler, which is a mild steel vessel lined with lead, and an acid resistant brick. A water spray is introduced through three spray assemblies to cool the gases from 500°F. to 100°F. Some of the water vaporizes to saturate the gases, and any liquid left settles to the bottom and drains to the secondary cooler. Water consumption is approximately 100 USGPM.

The secondary cooler is a fiberglass reinforced polyester tower, partially packed with 3 inch polypropylene "Intalox" saddles which provide large amounts of surface area for gas and liquid heat exchange. Primary cooler exhaust gases enter the secondary cooler through a nozzle in the bottom and rise up the tower becoming cooler as they come into contact with water percolating down through the packing. Water is introduced through a distributor at a rate of 700 USGPM to cool the gases to 45°F.

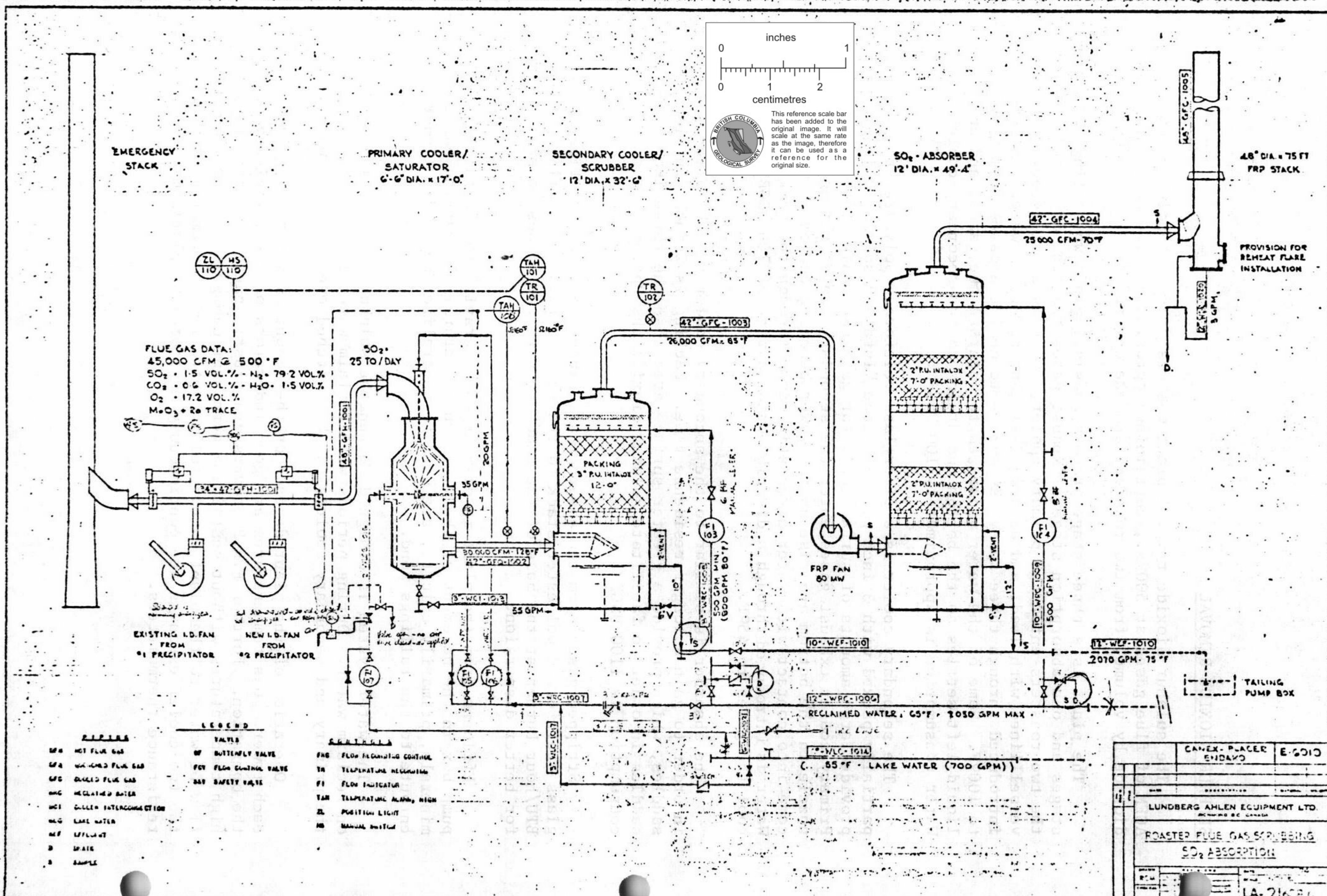
The absorber is similar to the secondary cooler though taller, in order to gain a longer residence time. Packing is 2 inch "Intalox" saddles, which provide a greater surface area than the three inch saddles in order to facilitate sulphur dioxide absorption. Water consumption is 1100 USGPM.

Stripped gases from the absorber are exhausted through a fiber-glass reinforced polyester stack to the atmosphere. A two million BTU/hour burner at the base of the stack reheats wet exhaust gases for better dispersion.

Effluent from the plant is discharged by gravity to the tailings pump box in the basement of the mill, where naturally occurring basic minerals, primarily calcite, are used to neutralize the acidic liquor enroute to the tailings pond.

The water system is designed to run the sulphur dioxide plant on reclaim water. During periods when reclaim water is in short supply, the primary and secondary coolers can be switched over to fresh water.

Operation of the plant depends on the amount of water going into each tower. Gas temperatures are good indicators of the efficiency of the operation. Further F.R.P. towers and plastic packing cannot stand high temperatures without sustaining permanent damage. Therfore, the flow of water to the plant is carefully controlled and temperatures of the two cooler exhausts are continuously monitored by platinum resistance thermometers.



EMERGENCY STACK
PRIMARY COOLER/ SATURATOR 6'-6" DIA. x 17'-0"
SECONDARY COOLER/ SCRUBBER 12' DIA. x 32'-6"
SO2 - ABSORBER 12' DIA. x 49'-4"
48" DIA. x 75 FT FRP STACK
PROVISION FOR REHEAT FLARE INSTALLATION
FLUE GAS DATA:
45,000 CFM @ 500 °F
SO2 - 1.5 VOL.% - N2 - 79.2 VOL.%
CO2 - 0.6 VOL.% - H2O - 1.5 VOL.%
O2 - 17.2 VOL.%
MoO3 + Zn TRACE
SO2 - 25 TO/DAY
42"-GFC-1004
25 000 CFM - 70 °F
42"-GFC-1003
26,000 CFM - 65 °F
30,000 CFM - 128 °F
42"-GFQ-1002
34"-42"-GFH-1001
PACKING 3" P.U. INTALOX 12'-0"
2" P.U. INTALOX 7'-0" PACKING
FRP FAN 80 MW
EXISTING I.D. FAN FROM #1 PRECIPITATOR
NEW I.D. FAN FROM #2 PRECIPITATOR
200 GPM
35 GPM
55 GPM
500 GPM MIN. (800 GPM 80 °F)
1500 GPM
2070 GPM - 75 °F
10"-WEF-1010
12"-WEF-1010
12"-WRC-1006
TAILING PUMP BOX
RECLAIMED WATER, 65 °F - 2050 GPM MAX
65 °F - LAKE WATER (700 GPM)
LEGEND
CANEX - PLACER ENDAKO
E-6010
LUNDBERG AHLEN EQUIPMENT LTD.
ROASTER FLUE GAS SCRUBBING
SO2 ABSORPTION
LA-216

Product Packaging

Molybdenite (MoS_2) concentrate production is marked as molybdenite concentrate in 33 US gallon drums, or molybdenum trioxide (MoO_3) concentrate in 33 US gallon drums and small pails, or as pitch bonded briquettes.

Because of its low unpacked bulk density, molybdenite concentrate is packed with a force feed auger to give a packed density of 110 pounds per cubic foot. Drums are not filled to constant weight, but a range of 400 to 460 pounds of molybdenite concentrate per drum is maintained. Drums are strapped four to a pallet for shipping to Vancouver by truck.

Molybdenum trioxide is packed at a constant weight of 463 pounds or 210 kilograms per drums. A manual fast fill on a vibrating table is followed by a photo-electrically controlled stage of topping up. Oxide drums are packed and shipped in a similar manner to sulphide.

Small cans are filled on a vibrating table by a photo-electrically controlled feeder. Manual adjustment is occasionally required to give a constant weight of 10 kilograms of contained molybdenum.

The rest of the oxide production is marketed in the form of cylindrical briquettes with pitch as the binder. According to the molybdenum content of the oxide concentrate, the weight of the briquette is varied to give a constant weight of 2.5 pounds of contained molybdenum for the domestic market or one kilogram for foreign consumption. The amount of pitch in the briquette runs about 10%. Overall sulphur content is kept below .15%.

Tailings Disposal

Mill tailings are pumped from a combined tailing pump box to two separate tailings disposal areas: No. 1 pond covering 531 acres and No. 2 pond covering 327 acres.

No. 1 line of 31,000 feet of 22 inch and 24 inch wood stave and steel pipe feeds No. 1 pond and extension. No. 2 line of 13,000 feet of 27 inch wood stave and steel pipe feeds No. 2 pond. In most cases piping is laid at a down grade of 0.5% between cylindrical drop tanks of steel.

Tailings are trapped behind dams built up by spigotting tailings behind a berm of sand pushed up ahead of time by small bulldozers.

Water is reclaimed from the two tailings ponds at a rate of about 6,500 US gallons per minute by pumps mounted on barges near the shore of each pond. Make up water, which amounts to 20% of mill discharge, is pumped from Francois Lake at a rate of 1,500 US gallons per minute.

Assaying and Research

Atomic absorption technique was implemented by the assay laboratory of Endako to perform fast molybdenum analyses of samples with molybdenum content below 3%. The spectrophotometer currently in service is a "Techtron" model AA 5. For higher grade samples, the standard lead molybdate gravimetric method is used.

Trace elements such as copper, lead, bismuth, and iron in the calcine are analysed with atomic absorption method. Phosphorous content is determined by wet chemical method. Sulphur level of calcine is analysed with the "Leco" combustion apparatus.

Calcium content is determined because it is closely related to the residual sulphur content of calcine. Atomic absorption technique proved to be well suited for the low concentrations involved.

The research department is equipped to conduct tests in flotation, grinding, leaching, and roasting. The sulphur dioxide removal plant was designed on the basis of pilot plant work conducted by research personnel.

Along a more routine vein, research department is responsible for sub-sieve sizing of samples down to 10 micron range. A cyclosizer is used for this purpose and proved to be a valuable tool in controlling the grade of final concentrate. Dust loss measurement in the crusher, roaster and dryer are checked frequently on a regular basis in an effort to control the amount of dust exhausting to the atmosphere. Air borne dust count is also checked regularly in the crushing plants.

PLANT DEPARTMENT

Planning

The planning section requisitions parts and materials, and schedules and co-ordinates work for the plant department through a work order system.

These work orders, which can be initiated by any individual or from past history in scheduling, servicing and preventative maintenance, are also used for recording maintenance history.

On present performance, approximately 40% of all work is planned.

Pit

The pit section, operating under a master mechanic and out of a central shop, maintains all mobile equipment. This includes production equipment, shovels, drills, and some 60 mobile service vehicles.

Plant

Again, acting under a master mechanic, this section is split into mill, plant and shop areas. Nearly all work carried out in this section is scheduled during day shift with the exception of emergency repairs which are covered by 8 shift mechanics scheduled on continuous shifts.

Electrical

Operated under a chief electrician, this section is split into electricians (20) and instrument electricians (5). The electrical section maintains all plant electrical installations including the pit equipment. Any major electrical installation is usually contracted out from the design stage.

Surface

Responsible for maintaining all buildings, roads, transportation, etc. the surface section employs carpenters, painters, equipment operators and labourers. Seasonally, this section is increased in size during the summer to maintain and relocate where required the 7 miles of tailings line.

Equipment

The plant department operated and maintains all services. These are basically:

Electrical Power	69 KV supply, connected load 25,000 H.P. Distribution through 69 KV to 4,160 and then 600 volts.
Fresh Water Supply	From adjoining Francois Lake. Supply rate 2,500 gpm max.
Buildings	Most buildings are of Butler design and are heated from a gas fired centrally located hot water system.

Personnel

Employees may be upgraded within the plant department either by gaining local experience and being classified as repairmen in varying degrees, or through the apprentice program. The latter is run in conjunction with academic training at a Provincial school, and while under the program, the apprentice will receive practical training in various aspects of the plant.

There are normally between 55 and 60 apprentices employed by the plant department.

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