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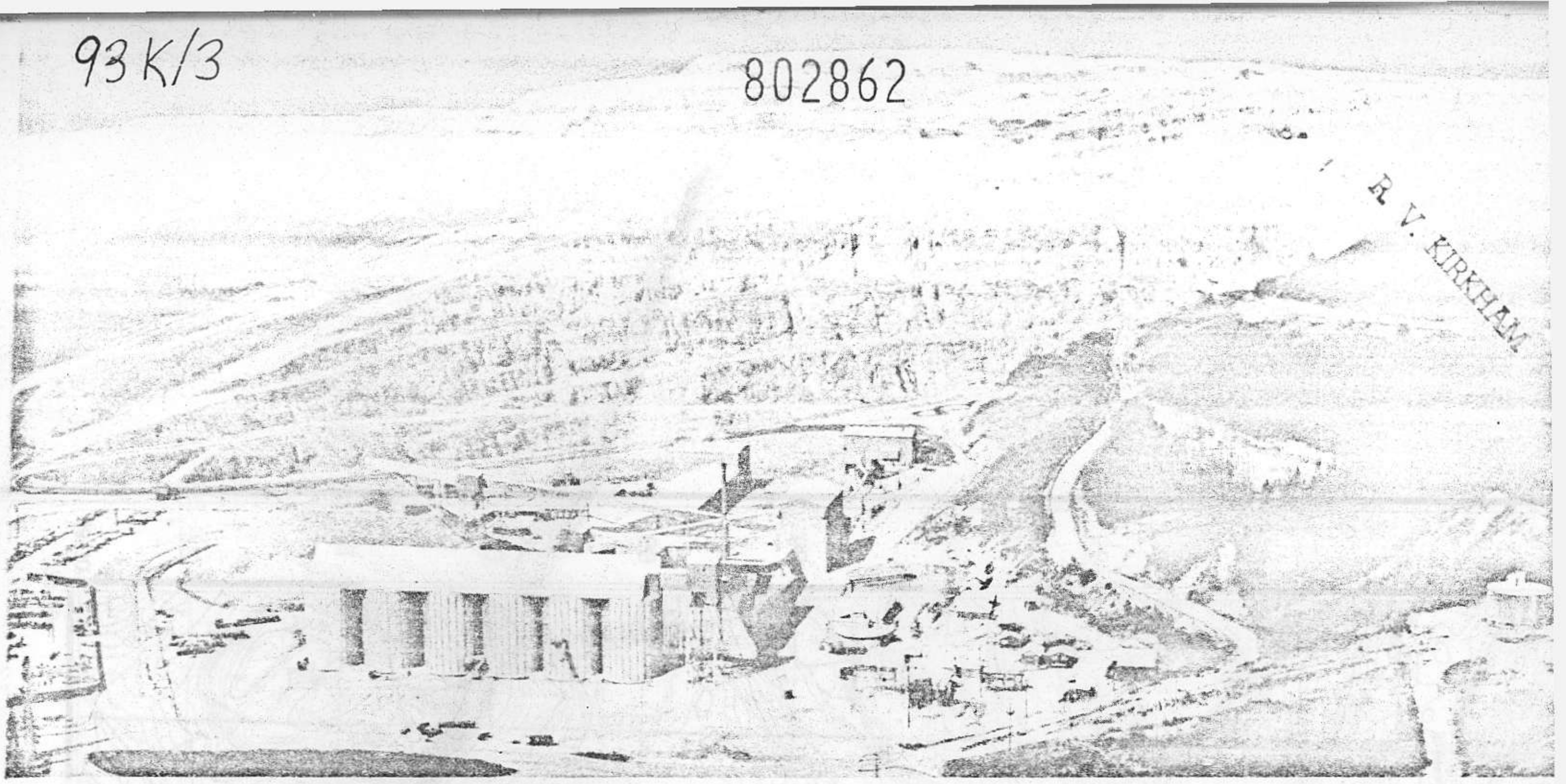
R. V. KIRKHAM



Endako: Overlooking the mill area

Endako

The Endako Mines Division of Canex Placer Limited operates a large molybdenum mine in central British Columbia. Since its opening in 1965, the operation has expanded considerably

The Endako molybdenum deposit lies some 100 miles west of Prince George, central British Columbia; the crest of the open pit is at elevation 3500 feet (Endako village, six miles away is at 2200ft). Temperatures range from −40C (occasionally in winter) to an average of 10C in summer, rising to 35C at times. Annual precipitation is about 20in, of which half is snow.

The molybdenite deposit was discovered and staked in 1927 by two local hunters. Work was sporadic until the 1960s when a program was followed by diamond drilling in 1962. Endako Mines was incorporated in October 1962, and Canadian Exploration Ltd (subsidiary of Placer Development) entered into exploration. Following initial work 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-ton/day mine plant and development of the open pit began in June 1964. The mine was officially opened on 8 June 1965. Modifications to the plant during the first two years allowed mine production to be gradually increased to a throughput of 17,500-tons/day (t/d). A major mill expansion to increase milling capacity to 25,000t/d was completed in November 1967.

Mill throughput is currently rated at 26,500t/d at average ore grade of 0.15% MoS_2. Two products, molybdenum disulphide and molybdenum trioxide are produced. Estimated mineable ore reserves at 31 December 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, 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.

The orebody in plan is roughly an elongated cigar-shaped zone of stockwork. Mineralization is simple and consists of molybdenite, pyrite, magnetite, and minor chalcopyrite. Calcite and chalcedony are late vein minerals.

As the benches are mined, the pit geologist continually records the geology. This adds to diamond drilling data, helps to project reserves to subsequent benches, and helps to locate areas from which a good blend of rock types and metal grade can be taken.

The pit geologist also monitors the pit walls for slope movement and delineates structures which might produce zones of weakness or instability.

PROPERTY OPERATION

The Endako mine operates with six departments under the administration of a resident mine manager. At 31 May 1976 the distribution of people involved (hourly rated plus staff): administration (4); employee relations (21); accounting (34); mine engineering (32); mining (146); mineral processing (123); plant maintenance (244); for a total of 604 (474 hourly rated; 130 staff).

Much of the long-range planning at Endako is done via a Univac 1106 computer at the Placer Development head office in Vancouver. Threedimensional pit design programs, reserves calculations, and long-range scheduling are handled.

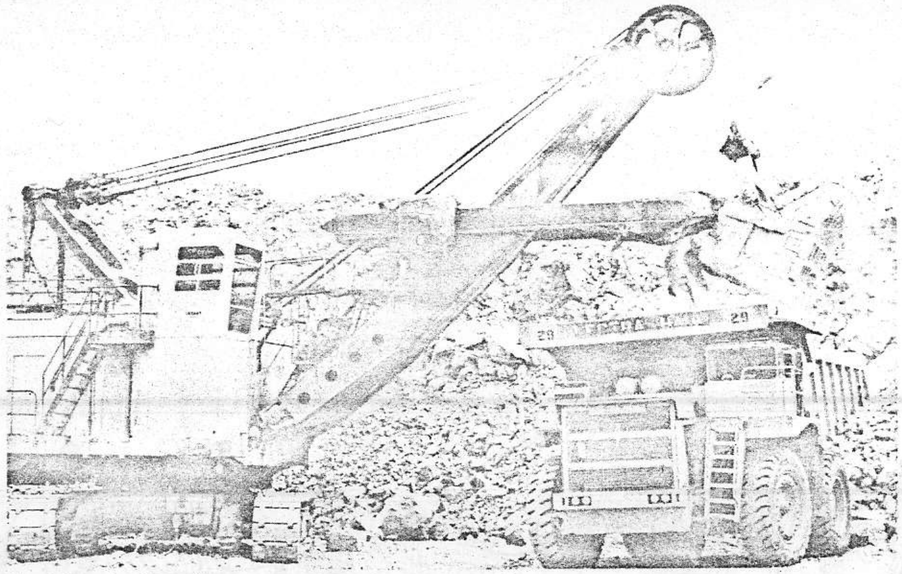
The present open pit excavation involves some 200 acres and goes to 600ft deep. Daily mine production rate is 61,000t/d of which 26,500t/d is mill feed.

Pit parameters are: Overburden bank slope 34°. Safety berm at base of overburden 40ft wide; bench interval height 33ft; safety berms in rock 30ft wide every second bench; working face slope 68°. Haul roads 80ft minimum width and 10% maximum grade. Minimum pit wall curvature is not less than 75ft radius, and the working floor is flat.

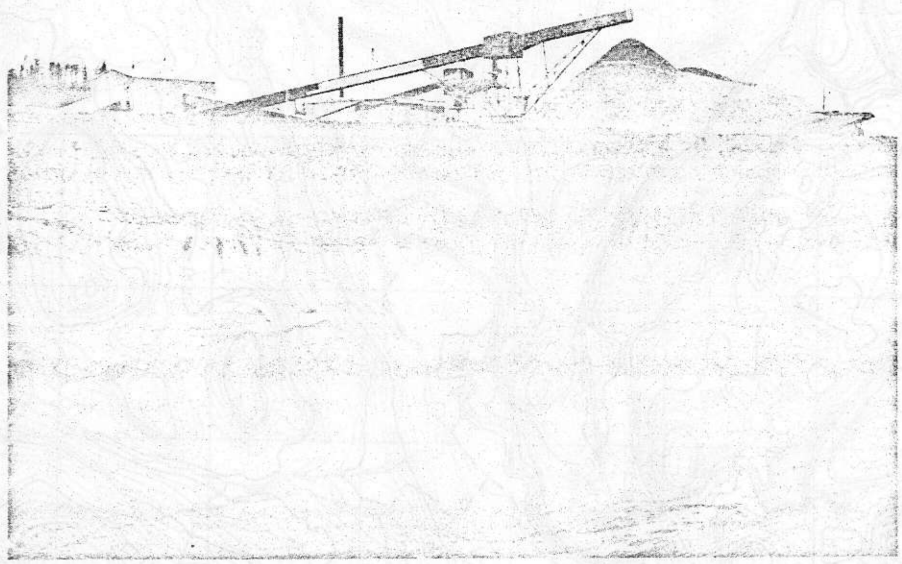
Blast hole spacing: 9in and 9⅞in diameter holes with 20x20ft to 22x22ft pattern; subgrade drilling 7ft. Powder factor is 0.50lb/ton.

Production for the year ending 31 December 1975 was (million tons): waste rock 8.7; low grade 3.8; mill feed 9.5; for a total of 22.0-million tons mined. From the start of operations in May 1965 through December 1975, production (million tons) was: waste rock 29.2; low grade 30.6; mill feed 82.3; overburden removed totalled 6.1-million yd³.

The year's operations to 31 Dec'75 consumed: for blasting, 9.8-million lb ANFO, 2.4-million lb slurry, 39,000 primers, 1.9-million ft detonation cord. Also: diesel fuel 1,097,000 gal; haulage truck tires $662,000; electric power 8728MWh; and 174 drill bits.



Endako: In the pit



Endako: Below the mill area

PRODUCTION EQUIPMENT

For blast hole drilling there are four electric units: three Bucyrus-Erie 40R (9in dia) and a Marion M4 (9⅞in). One 40R and the M4 operate each shift (three shifts a day).

For rock loading there are three 13yd³ shovels operating each of three shifts a day: a P&H 2100B electric and P&H 2100BL, and a Marion 191B electric. There are also an 8yd³ B-E 150B electric and a P&H 1400 electric shovel.

Rock is hauled by ten 85-ton and eight 100-ton Unit Rig Lectra Haul trucks.

For dump maintenance, shovel clean-up, and road maintenance there are three tracked D-8 Caterpillar dozers; Caterpillar tired dozers; and three road graders, together with watering and sanding trucks.

MINERAL PROCESSING

The Endako concentrator was put into production with a nominal capacity of 10,000t/d of mill feed. Shortly after start-up throughput was increased above normal capacity to reach 17,000t/d 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 26,500t/d.

Primary crushing: One gyratory crusher operating in open circuit. Pit run ore is dumped 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 1000-tons/hour.

Dust control in the primary crusher building is performed by a bag-house 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 1600-tons/hour; mantle life 3,500,000-tons mill feed; concave life 4,000,000-tons mill feed.

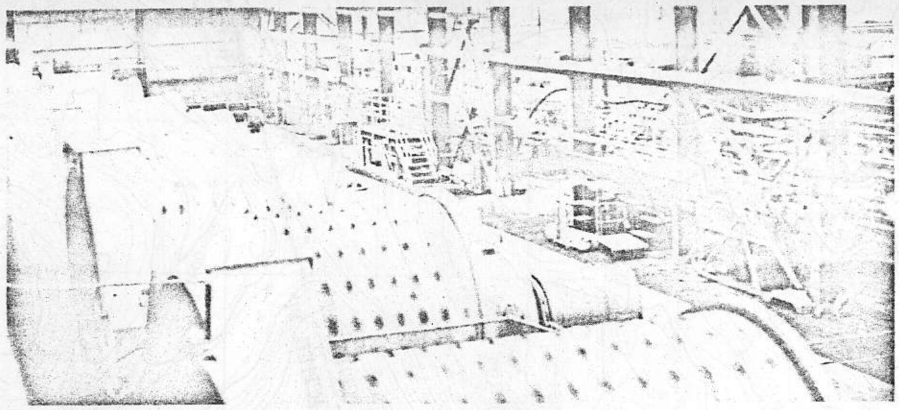
Secondary and tertiary crushing: Primary crusher product is first sized on a primary screen; undersize goes directly to the fine ore bins, while the oversize (plus 1 inch) goes to a stockpile which controls surges in primary crusher production. The normal 100,000 tons dead storage capacity of the stockpile can be raised to 200,000 tons with bulldozers.

Four in-line vibratory pan feeders reclaim ore from underneath the stockpile to feed the dual 13x84 Hydrocone secondary crushers. Secondary crushing is in open circuit, the product going straight to the tertiary crushing circuit.

Tertiary crushing is performed by dual 5x84 Hydrocone crushers in closed circuit with two double deck secondary screens.

Secondary screen undersize is the final product which is distributed among the six fine ore bins by a tripper. Each bin is 60ft high and 50ft in diameter, with a live load capacity of 4500 tons.

Most of the dust is controlled 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 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.


Endako: In the mill

Primary grinding
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 comprises 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 9.5x13ft 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 1250hp 240-rev/min, 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 1500hp motors.

The rod mills of the three original sections (No.1 to 3) are fed by twenty-four tube feeders. Belt speed under the tube feeders ranges 33-100ft/min. The conveyor has a variable speed drive, pneumatically controlled by the belt scale, which regulates 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.

Classification of discharge from each ball mill is performed by dual 30 inch cyclones, with standby units.

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.

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 preceding 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 is 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.

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.

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 60-70% at −9 microns. Each regrind stage is a ball mill in closed circuit with a rubber-lined cyclone.

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%.

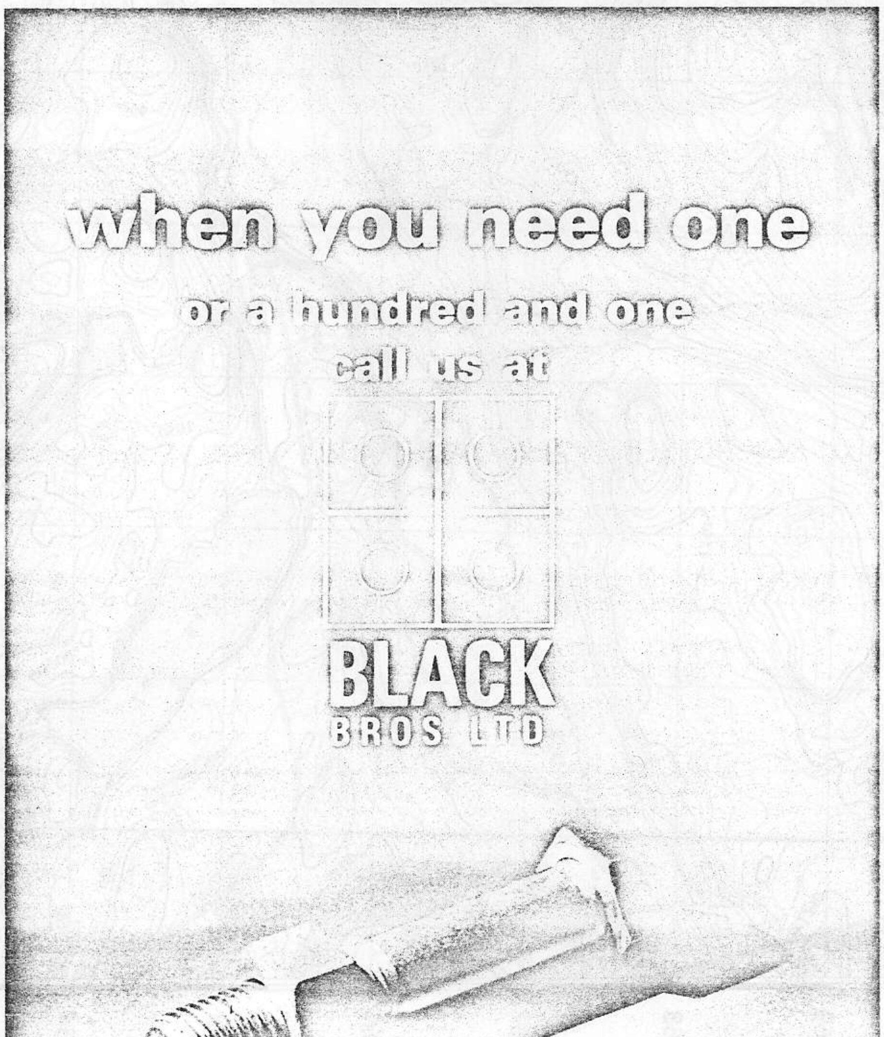
Dewatering: Final concentrate produced by the fourth cleaners is thickened to about 50% solids in a 20ft diameter thickener using Separan as flocculant. The underflow is pumped to a stock tank (20ft dia, 12ft high) with a 3x3 soft rubber liner (SRL) pump controlled by a preset on-off timer.

Concentrate is leached in the tank (to reduce calcite and ensure sulphur content of roasted concentrate can be reduced below 0.10%), and the leached product filtered to about 30% moisture in a 3-disc filter. Moisture is reduced to about 3% in a natural-gas-fired 10ft 4-hearth dryer.

Dried concentrate is conveyed to one of two 100-ton storage bins which hold feed for the canning line and roasters.

Roasting: A 16ft dryer was recently converted to a roaster to meet increasing demand for molybdenum as the trioxide; this unit, with the 18ft roaster, can roast 90% of concentrator production.

Air acts as coolant and oxidant; most of the heat required in roasting is supplied by the oxidation of molybdenum sulphide to trioxide. A modest amount of external heat is required to initiate roasting and to maintain sulphur removal when sulphur content in the feed drops too low for roasting to be autogenous.



Sulphur dioxide removal: A removal plant is designed to handle 45,000a.ft³/min of flue gases at 500°F, containing about 1.4% sulphur dioxide by volume, from two roasters and one dryer. There are two cooling stages and one absorption stage. Stripped gases from the absorber are exhausted through a fibreglass-reinforced polyester stack to the atmosphere. A 2-million Btu/h burner at the base of the stack reheats wet exhaust gases for better dispersion. The plant runs on reclaimed water, but fresh water can be supplied if needed.

Product packaging: Molybdenite (MoS_2) concentrate is packed in 33gal (US) drums; molybdenum trioxide (MoO_3) in drums and small pails or as pitch-bonded briquettes.

Tailings disposal

Mill tailings are pumped from a combined tailing pump box to two separate disposal areas: No.1 pond covering 531 acres; No.2 pond 327 acres. Feeds are by wood stave and steel pipe.

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

Water is reclaimed from the two tailings ponds at about 6500gal(US)/min by pumps mounted on barges near the shore of each pond. Make-up water (20% of mill discharge) is pumped from Francois Lake at 1500gal(US)/min.

Assaying/research

Atomic absorption (Techtron AA5 spectrophotometer) is used to make fast molybdenum analyses on samples with Mo below 3%. For higher grade samples the standard lead molybdate gravimetric method is used. Trace elements such as copper, lead, bismuth, iron are analysed by atomic absorption, as is calcium. Phosphorus is determined by wet chemical method; sulphur in calcine by Leco combustion apparatus.

The research department is equipped to conduct tests in flotation, grinding, leaching, and roasting. The SO_2 removal plant was designed from pilot plant work done by research personnel.

TRAINING

Employees may be upgraded within the plant department by gaining local experience and being classified as repairmen in varying degrees, or through the apprentice program, which is run in conjunction with academic training at a Provincial school. There are normally 20-25 apprentices employed by the plant department.