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OPEN PIT METHODS AT BETHLEHEM COPPER CORPORATION LTD.

BY

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(MANAGER - MINE PRODUCTION AND STAFF).

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ABSTRACT:

The Jersey Open Pit Mine is the second of a number of copper deposits which will be mined by Open Pit Methods at Bethlehem Copper Corporation Ltd., operation in South Central British Columbia.

This paper describes the geology, pit design, and the mining equipment used, as well as some of the problems encountered in operation.

INTRODUCTION:

The Bethlehem property is located in the Highland Valley area about 28 miles southeast of Ashcroft, B.C. It consists of 256 mineral claims covering an area in excess of 10,000 acres. The open pits and milling installations are located at an elevation of approximately 4900 feet above sea level in an area of gently rolling hills, characterized by moderate snowfalls in winter and moderate amounts of rainfall and pleasant temperature in summer.

Copper mineralization in the Highland Valley has been known since the turn of the century. In the year 1899, a group of mineral claims was staked in the area now known as the Snowstorm Zone. In 1915 - 16, several tons of highgrade were shipped.

Although exploration was carried on in the area off and on, it failed to demarcate any economical ore bodies.

In 1954, the McLallen-Reynolds-Huestis Syndicate did some prospecting work in the Highland Valley area and staked about 100 mineral claims in an area covering Snowstorm Iona-Jersey Zones. Bethlehem Copper Ltd., was incorporated in 1955 and the claims

staked by the Syndicate were transferred to the Company. Persistent efforts of this Company to bring the property into production, backed by the faith of its originators, Mr. McLallen, Mr. Reynolds, Mr. Huestis, were finally rewarded in 1962 when the first shipment of copper concentrates was produced by Bethlehem and shipped to Japan. Today, Bethlehem operates one of the largest open-pit copper mines in B.C., and is among the major copper producers in Canada.

GEOLOGY:

The property occurs near the center of the Guichon batholith of lower Jurassic age. The batholith is about 40 miles long in a North-South direction and about 16 miles wide. The rock is a massive, coarse textured, grey quartz diorite which is locally called the Guichon or older quartz diorite. Locally the quartz diorite has been intruded by granite, quartz monzonite, several porphyries, and a distinctively younger quartz diorite. Associated with these varied younger rocks are several bodies of breccia. The origin of this breccia is not definitely known, but there are several possibilities-----

1) Explosion
2) Intrusion
3) Intrusive.....

both the breccia and the younger intrusives are host rocks for mineralization. The mineralization consists of chalcopyrite, bornite, molybdenite, and minor pyrites which occur as disseminated grains, fracture fillings, lense deposits, and as irregular coarse blebs.

Geologically several ore zones are located close to the contact between the Guichon batholith and the younger intrusives, where breccia may or may not be found. The important point is that the mineralization is structurally controlled. Not all structurally disturbed rocks are mineralized, but most of the mineralization is found in dislocated and disturbed rocks. In the brecciated areas, the mineralization is of the highest grade and more uniformly distributed than in the non-brecciated rock.

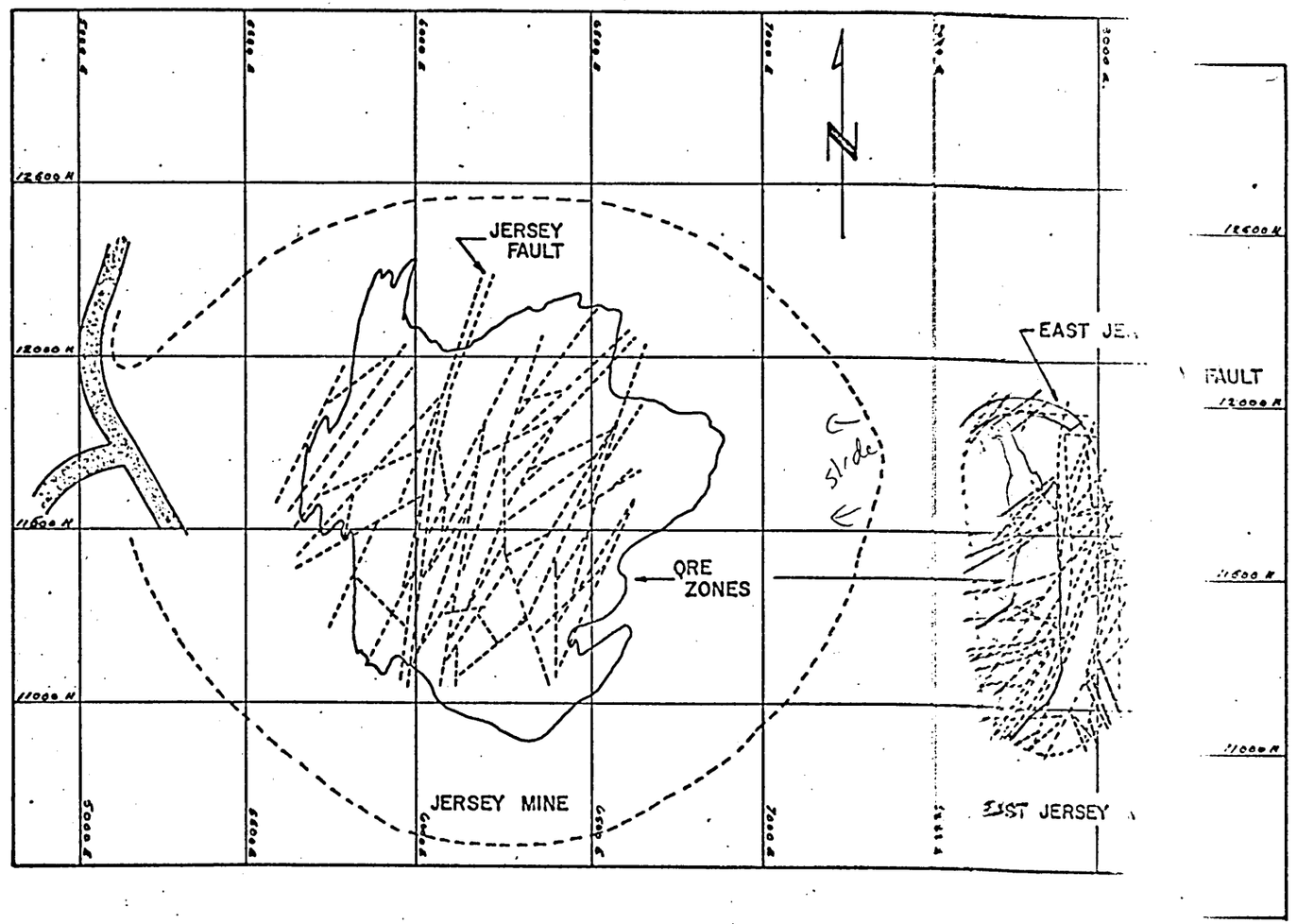


FIGURE 1. Showing Geology of the Jersey and East Jersey [illegible].

Figure 1., shows the pertinent faults of this system in both the Jersey and East Jersey Mines. Noteworthy is the slight elongation of the Jersey orebody parallel to the Jersey fault. In the East Jersey the orebody appeared to be fault controlled as it is stretched along the footwall of the East Jersey fault. The main tonnage of the Jersey orebody is on the hanging wall of the Jersey fault; however; the ore is considerably further from the fault. Figure 1., does not illustrate the true density of faulting, as there are many faults that were mapped and not shown.

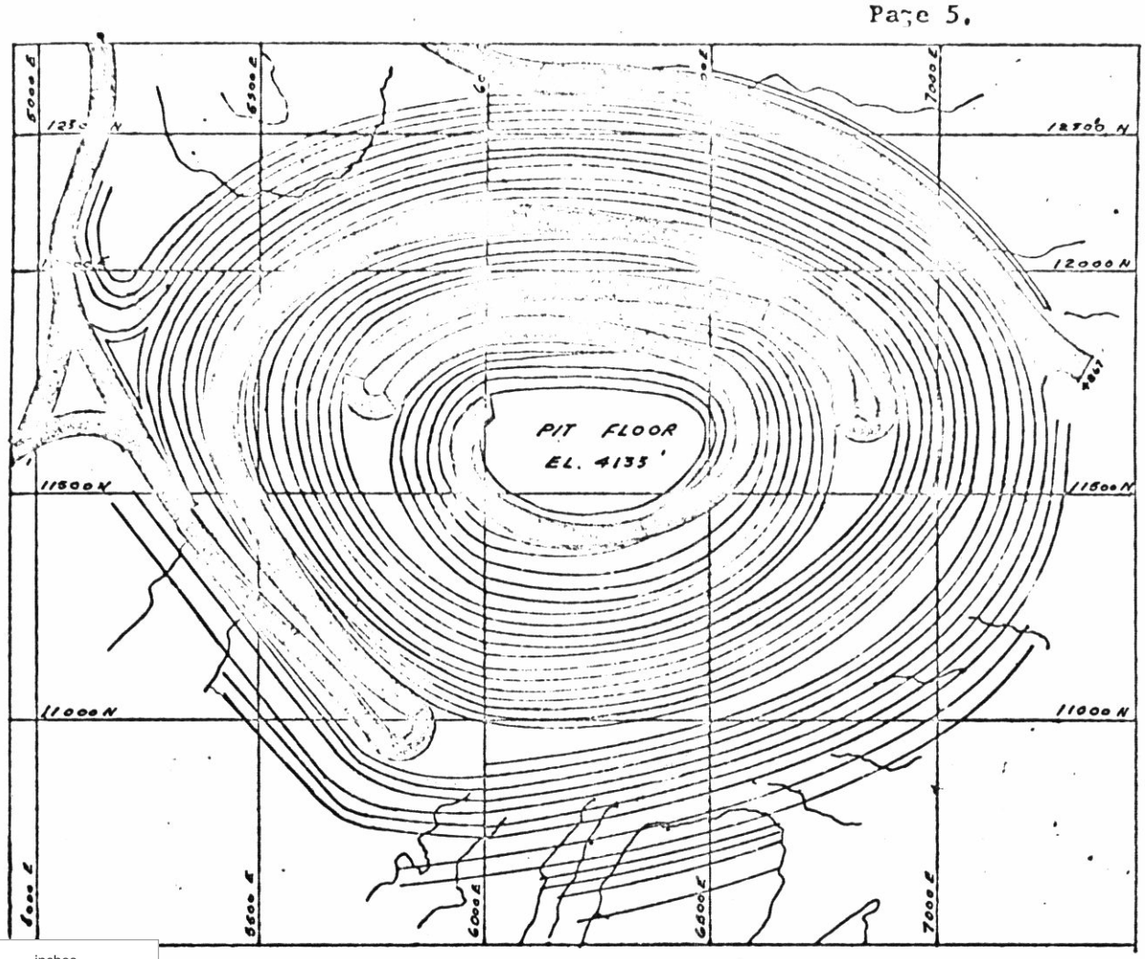
ORE RESERVES:

The cutoff grade for the ore reserves calculations is 0.35% copper. Any material below this cutoff grade is classified as waste. This material is stockpiled in large waste dumps or used in the construction of the tailings dam. The waste removed is not susceptible to leach due to the extremely high carbonate content. The Jersey Pit is presently being mined. As of January 1st, 1968, the remaining reserves were:

Ore:	34,050,540 Tons @ 0.60% copper.
Waste:	14,185,601 Tons.
Waste/Ore:	0.416/1

PIT DESIGN:

The Jersey Pit is about 2400 feet long and 1900 feet wide. Maximum depth of the Pit at completion will be about 1050 feet. Mining is done in 33 foot benches. Pit walls are sloped at a 70° angle and a 25 foot safety berm is left every second bench to catch any falling rock and to give added stability to the Pit wall. Extra wide berms are provided where necessary because of structural or operational consideration. The Pit is designed at an overall slope of 48°, although individual wall slopes vary considerably because of the location of haul roads.



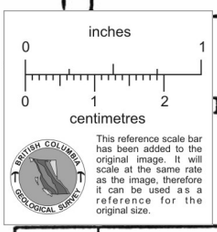


FIGURE 2. Jersey Open Pit, Bethlehem Design #3-S.

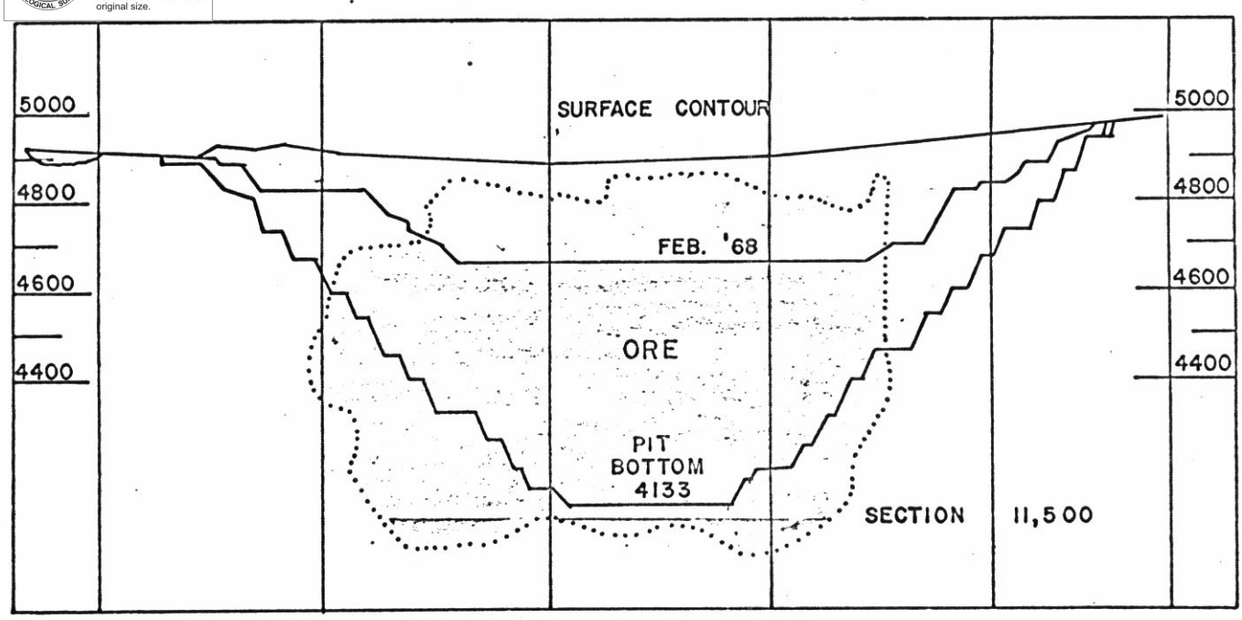


FIGURE 3. A Typical Section Through the Jersey Open Pit.

Figure 2., shows a plan of Jersey Pit design #3-S. Figure 3., shows a typical cross-section through the Pit and it also shows the location of ore and waste areas.

All haul roads are designed on a 10% grade. Originally the roads were designed to spiral to the ultimate bottom. As the pit developed, the south wall was found to be relatively incompetent because of major faults. The pit was redesigned and a series of switch backs on the haul roads were put in to relocate the road system away from the South wall of the Pit.

MINING EQUIPMENT:

Exhaustive cost studies were made with various size and type of equipment to select the most productive and economic machines. Diesel shovels and drills were purchased to obtain the maximum mobility and flexibility in scheduling production. Although two larger shovels could have provided the required production, three Bucyrus-Erie 88-B shovels with 5 1/2 cubic yard buckets were selected. Three smaller shovels were selected so as to achieve more uniform blending of ore from different areas of the pit, and a greater flexibility in scheduling production. Major mining equipment is as follows:-

1	Bucyrus-Erie 45-R Rotary Drill
1	Gardner-Denver Airtrac Drill with a PR123 3" Drill
1	Gardner-Denver 900 cfm Compressor
3	Bucyrus-Erie 88-B Shovels with 5 1/2 cu. yd. bucket
15	WABCO Haulpak Model 50 (Ton) Rear Dump Trucks
1	Caterpillar - 988 Front-end loader with 6 1/4 cu. yd. bucket.
1	WABCO - 777 Grader
1	Caterpillar - D8H Bulldozer with Ripper
1	Komatsu - D80 Bulldozer
1	Caterpillar - D4 Bulldozer.
1	Rubber Tired Dozer - Michigan 180
1	Sanding Truck - converted to Water Truck during summer, Mercury T-800.
1	Fuel Truck with a 1500 Gallon tank. (G.M.C.)
1	P & H Model 218-C Crane - 18 Ton capacity.

There is a well equipped shop on the property where all necessary repairs can be made to any equipment.

PIT DEVELOPMENT:

Although the Jersey Pit is designed for an over-all waste/ore ratio of 0.655/1, a major portion of this waste is concentrated on the upper benches. In order to obtain the desired ore production at the average pit grade, it has been necessary to schedule production at a W/O ratio of 2/1 or more for the first few years. A temporary road system had to be designed so that ore production could be obtained from lower benches while waste from the top benches is removed. Mining of ore and waste has to be closely planned and tight schedules have to be maintained.

As a result, we expect that by the middle of 1969, the major tonnage of waste will have been removed. After this period the W/O ratio will be 0.25/1 or less. At that time we plan to utilize the extra capacity to strip other proven ore zones, such as the Huestis and Iona.

DRILLING:

Primary drilling is done with the 45R Rotary Drill drilling 9 7/8" diameter holes. 33-Foot benches are drilled with 40 ft., holes giving a sub-grade of 7 feet. The Jersey Pit rock is relatively easy to drill. Practically all drilling is carried out with steel tooth Tri-cone bits which are equipped with tungsten carbide buttons on the outside of the shirt tails for gauge protection. Penetration rates of 60 to 80 feet per hour are achieved with the average at about 64 feet. Holes are drilled on a 28' x 28' pattern except in the vicinity of the Pit walls where the burden on the hole is cut down almost to half. The lighter burden permits lighter explosive charge in the hole and thus minimizes damage to the pit walls. The pit walls are trimmed with 3" percussion holes, where needed. The holes are staggered on succesive rows to avoid toes between holes.

Experiments with wider pattern drilling are now in progress. The Plans are to keep with this burden but to increase the spacing between holes. The drill reamer-stabilizer at the bottom of the Drill stem is equipped with a water separator for wet drilling. Nonetheless we do not find it necessary to use water for drilling for a major part of the time. Water is used for drilling in summer when the dry weather creates dust problems.

BLASTING:

Ammonium-nitrate - fuel oil mixture is used for blasting in all holes except in very wet ground. The ANFO mix is supplied by C.I.L. at the hole. The ammonium nitrate and the fuel oil is carried on the truck in separate tanks and is mixed as it is fed into the hole. The hole is primed near the bottom and detonating cord is used through the complete length of the hole.

Short period electric blasting caps are used in blasting. In starting a new bench, extra holes are drilled to start the bench as illustrated in Fig. 4.

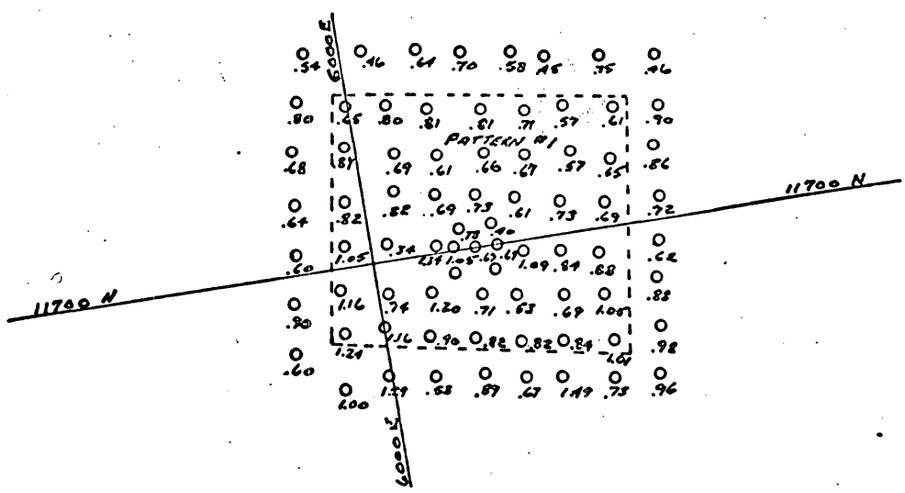


FIGURE 4. Showing Drill hole pattern used for the first Blast on 4667-ft. Bench.

The holes are delayed away from an open face or broken rock. The usual practice is to blast behind a previously broken muck pile whenever possible. This method has several advantages:

(1) Better fragmentation and less fly rock.

(2) There is little lateral movement of the broken material; the rock remains essentially in its original position, avoiding mixing of ore and waste.

(3) When shovelling, the face of the broken muck pile remains nearly vertical; thus, the sorter knows at all times where the face is in relation to ore or waste holes.

Effort is made to pump out the water from the wet holes, insert a plastic liner and use ANFO for the explosive charge. Two submersible electric pumps with an overall diameter of 5 3/8" (Prosser Series 1300) are used in tandem to pump out the holes. A portable generator, the pumps and the discharge hose are carried on a pick-up truck which is backed right up to the hole for pumping. A plastic liner is lowered into a hole as soon as it is pumped and the ANFO charge is loaded. If the hole is excessively wet and cannot be pumped, it is loaded with a metallized slurry (hydromex in 8"dia. cartridges), primed with a pentamex primer. Since hydromex is almost 5 times as costly as ANFO, all efforts are made to keep the hydromex consumption to the minimum. Generally we use very little of the metallized slurry during summer. In the extreme cold weather during winter, pumping of holes is not very practical and slurries have to be used. A non-metallized slurry, Hydromex - T3, is now under trial. This new slurry provides the advantages of water proof blasting agent with comparable speed of detonation at a lower cost.

GRADE CONTROL:

The average ore grade in the Jersey Pit is 0.60% copper and the cut off grade between ore and waste is 0.35%. With this close margin between the ore and the waste grade it

is very important to establish a reliable method of grade control. All of the following factors form a basis for this control:

1. Geology is utilized in selective sorting by prediciting the location of contacts, dykes, and waste ore boundaries.
2. Representative samples are taken from the blast hole cuttings. These grades are marked on stakes located on the muck pile with a plane table. Ore and waste areas are demarcated by different coloured ribbons.
3. The cuttings are sampled with a 4" diameter piece of iron pipe. A number of cuts are taken from the pile of drill cuttings after the cuttings from the sub-grade drilling are pushed off. The cuts are combined to make one sample and then riffled to a convenient size for assaying.
4. In order to minimize any lateral movement of rock, blasting is done behind broken muck as much as possible.
5. Personnel is trained to visually estimate the value of low grade ore blocks.

The effectiveness of this method of grade control is reflected in a comparison of the reported shipping grade and the mill heads. This is generally within one percent at Bethlehem.

EXCAVATING AND HAULING:

The broken muck is loaded by Bucyrus-Erie 88-B shovels equipped with 5 1/2 yard buckets. Two shovels work in each shift and are supplemented with a Caterpillar 988 front end loader. The loader is used for berm cleanup, loading in tight working areas and developing good shovel faces after blasts.

An extra shovel is available in case of breakdowns of the scheduled shovels as well

as during maintenance and service work. The three shovels are so placed about the pit that large moves for the shovels are generally not required.

All hauling is done with a fleet of 15 - 50 ton Haulpak rear dump trucks. A shovel generally works with 4 to 5 trucks and the front end loader with two to three depending on the haul distance, as well as the speed of loading. Idle time on equipment is cut to a minimum and the supervisors pickups are all radio equipped; therefore a maximum mobility of the equipment and operations can be realized.

About 10 to 11 trucks work on any one shift and two normally spare units are available if needed. The two or three trucks are generally in for servicing and maintenance. As the fleet works 24 hours a day, 7 days per week, we find it essential that each unit is serviced once in a 24 hour period.

PIT, DUMPS & ROAD MAINTENANCE:

In order to obtain equipment efficiency and low tire costs, all effort is made to maintain the Pit floors and haul roads in a first class shape. A grader is kept on the haul roads constantly along with four dozers, a packer, a water truck, and other subsidiary equipment needed to keep the pit floors and waste dumps in shape. A rubber tired dozer is used to get a greater mobility in cleaning up around shovels and moving between the various dump areas.

REPAIRS & MAINTENANCE:

A heavy equipment maintenance shop equipped with the latest type of tools and equipment capable of effecting all repairs and complete overhaul of any unit on the job, is available at the Minesite. Service and repair crews work around the clock although major repairs and overhaul jobs are concentrated during the day shift.

All equipment is regularly serviced and is thoroughly checked by mechanical crews according to a preventative maintenance schedule. A 100% percent working of the scheduled operations is aimed for and to date we have been successful in obtaining this

goal.

COST:

The ultimate test of a commercial operation is in the cost of production. Records of production cost at Bethlehem are kept in complete detail. Estimates of cost are made each week and any variations in costs are analyzed to point out the areas where results might be improved. Direct costs of mining per ton moved, including the charge for an accelerated depreciation as well as reserve account to cover major maintenance costs, range between 24 - 26 cents per ton with the following rough break-down.

Drilling	~ 1.5 cents
Blasting	~ 1.8 cents
Loading	~ 4.9 cents
Hauling	~11.0 cents
Pits, Dumps & Road Maintenance	~ 3.8 cents
Supervision, Engineering, Misc.	~ 2.0 cents
TOTAL	~25.0 cents

A major portion of the waste is used to build up the tailings dam. This extra haul has been estimated to cost 3.2 cents per ton and is included in our mining cost.

ACKNOWLEDGMENT:

Before I leave, I would like to express my thanks to the Management of Bethlehem Copper for permission to present this paper.

REFERENCES:

Coveney, C.J., "Bethlehem Copper Corporation: Geology", Western Miner, Vol. 36, January, 1963.

Coveney, C.J., Stevens, D.C., and Ewanchuk, H.G., "Grade Control at Bethlehem Copper", C.I.M., Bulletin, Vol. 58, No. 640, pp. 823-826, 1965.

Ewanchuk, H.G., "Grade Control at Bethlehem Copper", C.I.M., Transactions, Volume LXX, 1967, pp 22-27.