Schroeter

888138

COMINCO LTD
SULLIVAN MINE
KIMBERLEY, B. C.

(Latitude 49° 42'N., Longitude 116° 00'W., Elevation 3900 feet)

LOCATION

The Sullivan mine and concentrator are located within the City limits of Kimberley, B. C. in the Purcell range of southeastern B. C. The mine is located on Mark Creek, approximately two miles north of the City centre, and the concentrator two miles south of the City centre. The holdings include 680 Crown-granted claims and fractions and 582 recorded claims.

CLIMATE

The air temperature ranges from a January minimum of minus 20°F. to a June maximum of 89°F., measured in 1973. Freezing conditions commence in October and persist for the ensuing six and a half months. Snowfalls account for 12.24 of the 21.20 inches of annual precipitation, with the fallen snow cover reaching a maximum thickness of 41.5 inches during late March at the Sullivan snow station. This is located 5100 feet above sea level on the surface above the Sullivan Hill.

HISTORY

The two original claims, the "Hamlet" and "Shylock", of what was later to develop into the Sullivan Mine, were located by four prospectors, Pat Sullivan, Ed Smith, John Cleaver and Walter Burchett, in August 1892, following a 37 day trek overland on foot from Kootenay Lake to St. Mary's Prairie. One of the partners, Sullivan, was killed in the Coeur d'Alene district of Idaho in the winter of 1892, but the remaining three continued work on their claims at intervals, when finances permitted, until 1896.

In that year the partners were bought out by the Sullivan Group Mining Company, formed by a group of Spokane men who were also interested in the Le Roi Mine at Rossland. The Sullivan Group Company also built a smelter at Marysville, which was completed in 1903 but, beset by financial and metallurgical problems, was shut down in 1907.

The mine was purchased in 1909 by the Federal Mining and Smelting Company which formed a subsidiary, the Fort Steele Mining and Smelting Company. The Consolidated Mining and Smelting Company (Cominco) took a lease and option on the property in December 1909. The following year the Company commenced the purchase, which was completed in 1913.

Development work for the next few years was directed at finding sufficient lead ore which would be low enough in zinc for smelting in the Company's plant at Trail.

This method of selective mining was extremely profitable and by 1914 the Sullivan had become the largest producer of lead in the British Empire, production in that year being 35,500 tons of ore containing 12,000 tons of lead and 500,000 ounces of silver. At the same time, development and diamond drilling programs had proved up a considerable tonnage of what was then considered as low grade lead ore because of its high zinc content.

Although at this stage, the froth flotation process had been developed, the problem with the complex Sullivan ore was one of selective flotation.

In 1917, Mr. R. W. Diamond took charge of what had become an intensive investigation of the various methods for separating this complex ore into three sulphide products - lead, zinc and iron. As a result of this investigation and at a time when zinc prices were falling rapidly, a differential flotation process was successfully achieved in 1919. The following year, large scale testing - in Trail - proved the process to be economical.

This technological discovery in the mineral processing field also led to a radical change in mining methods at the Sullivan Mine.

Selective mining was no longer necessary and a more systematic method of mining the hitherto low grade ores could be commenced.

The information and experience obtained from this test work was immediately used to design a concentrator which was to be built in Kimberley.

In the spring of 1922, construction of the Sullivan mill commenced on the Chapman Camp site 3 miles from the mine portal. It commenced operation in August 1923 at a daily rate of 3000 tons. The size of the concentrator was increased in steps until by 1949, when the sink-float plant was introduced, the capacity was 11,000 tons per day.

In the interval between August 1923 and December 31, 1973, the concentrator has treated about 109,736,000 tons of Sullivan ore. The total production from the approximate date of its acquisition by the present owners to December 31, 1973 is about 110,735,850 tons of ore.

GEOLOGY

The orebody is 7,000 feet long, from several feet to 300 feet thick, and roughly resembles an inverted saucer. The strike is north-south, and the dip averages about 30° to the east, gentle in the upper part of the mine, steepening in the central portion, and flattening along the eastern edge.

The orebody occupies one limb of a north-plunging anticline, the crest of the anticline coinciding approximately with the western margin of the orebody. It occurs in the lower Proterozoic Aldridge formation, which in the Kimberley area is composed of at least 15,000 feet of alternating argillites, siltites, and dirty quartzites. The Aldridge is the lower member of the 35,000 foot thick Purcell group of sediments. It contains a high proportion of turbidite-type beds and is thought to represent the early basin filling of the Purcell geosyncline.

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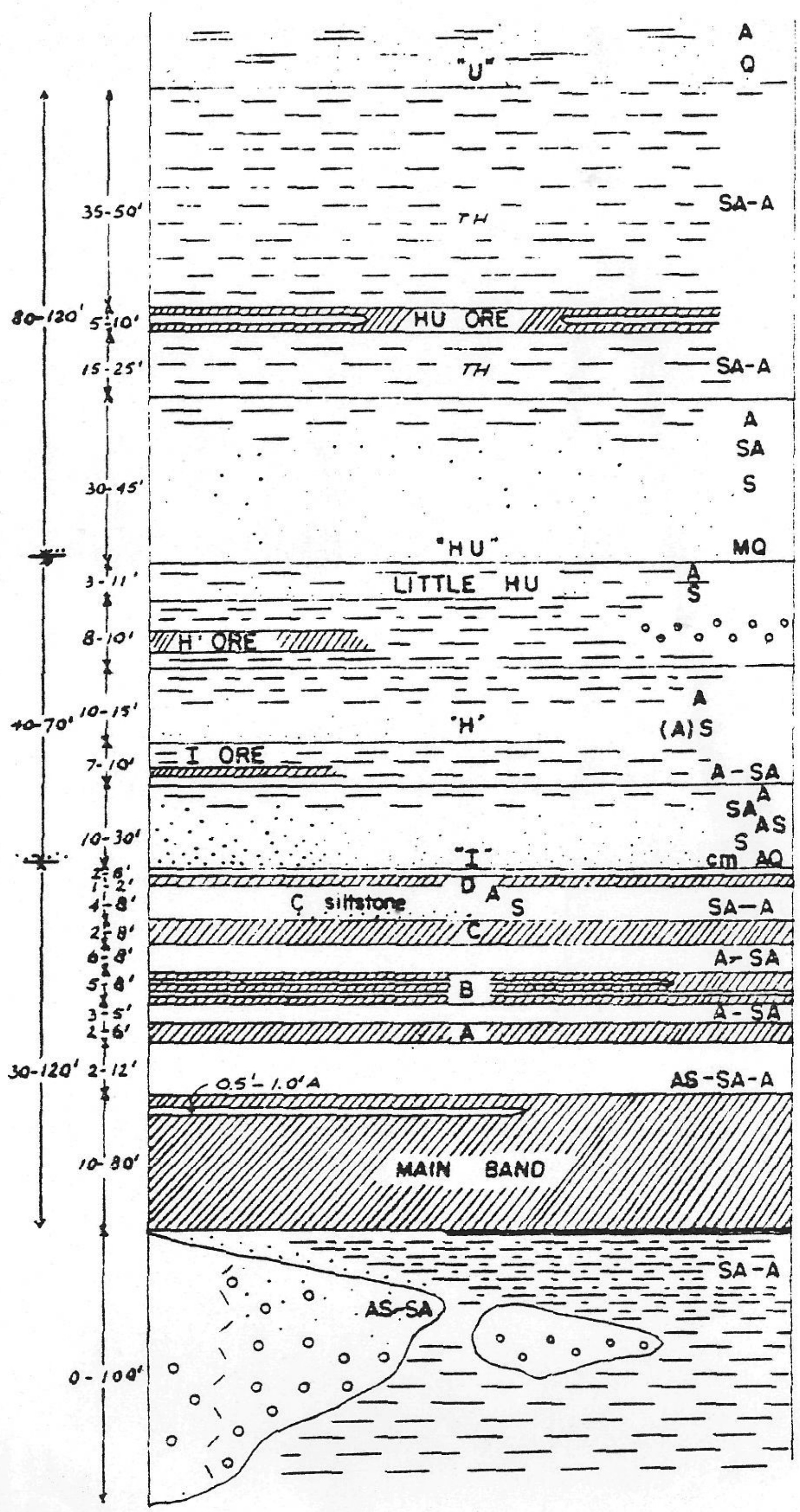
SULLIVAN MINE, KIMBERLEY, B.C. — IDEAL GEOLOGY SECTION



UPPER QUARTZITE
quartzite with argillite partings
base not recognized as definite horizon

THIN BEDDED HANGINGWALL
beds, fraction of inch to several feet –

HANGINGWALL UPPER ORE ZONE

HANGINGWALL UPPER SILTSTONE
prom. Q or AQ base with Q grains for several feet

LITTLE "HU" SILTSTONE

HANGINGWALL CONGLOMERATE
recog. south and east of mine

HANGINGWALL SILTSTONE
Q grains rarely conc. at base.

INTERMEDIATE SILTSTONE
Q grains usually prom. at base

color zone fine P and Zn. lams in soft argillite between D and I

"B" band triplets – two 2-12" A bands separated by three narrow sulphide bands.

MAIN BAND ORE
massive to laminated sulphides

FOOTWALL "SLATES" 6" to 1.0'

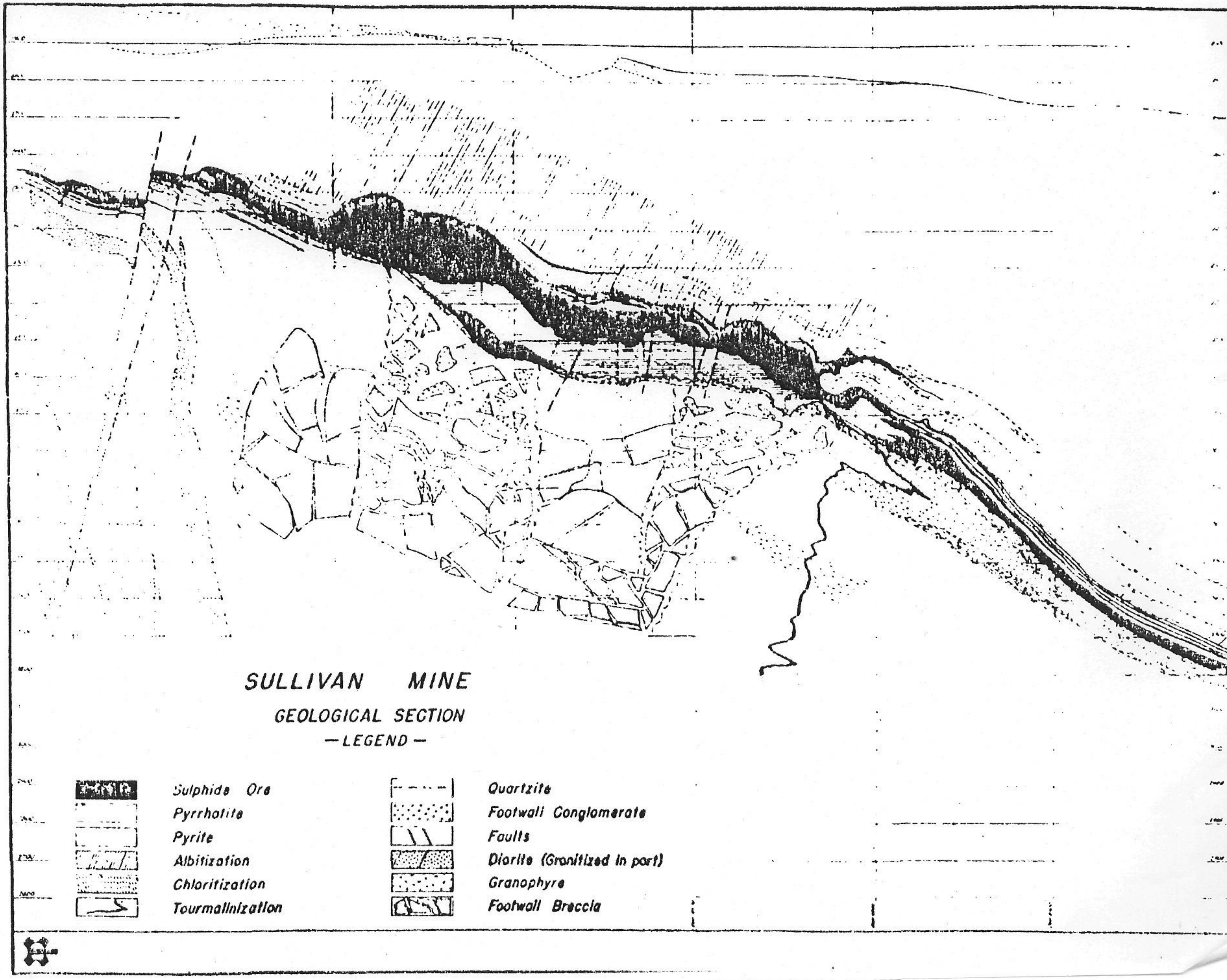
FOOTWALL LAMINATED ZONE

FOOTWALL CONGLOMERATE

FOOTWALL THIN BEDDED SERIES

Q - Quartzite S - Siltstone A - argillite AQ - argillaceous quartzite
AS - argillaceous siltstone SA - silty argillite
c.m.f.g. = coarse, medium, fine grained

∴ Quartzite ∵ Siltstone //// Ore ═ Thin bedded
═══ Laminated ∘∘ Conglomerate


SULLIVAN MINE
GEOLOGICAL SECTION
—LEGEND—
Sulphide Ore
Pyrrhotite
Pyrite
Albitization
Chloritization
Tourmalinization
Quartzite
Footwall Conglomerate
Faults
Diorite (Granitized in part)
Granophyre
Footwall Breccia

In the lower section of the mine, stratigraphy in the ore zone is very regular, with bands of sulphides interbedded with bands of barren rock, and sedimentary structures are preserved in great detail. In the upper portion of the mine, this delicate layering is only present in very small areas, large areas of massive ore occur, and there are large zones of essentially pure iron sulphide with little or no lead or zinc. The upper zone also varies broadly from place to place, with confused streaking or banding in some locations and no internal structure in others. The principle sulphides are pyrrhotite, sphalerite, galena, and pyrite. Chalcopyrite and arsenopyrite are minor constituents.

Magnetite is fairly common in some parts of the orebody, and cassiterite is present in small amounts. In the oxide zone, cerrusite and pyromorphite are common.

Concepts of the ore gensis of the Sullivan orebody have evolved with time, with major difficulties in interpretation arising due to regional metamorphism and to the striking difference in the mode of mineralization from one part of the orebody to another. Any syngenetic theory based on the finely preserved sedimentary features in the lower orebody must explain the massive concentrations of metal in the upper orebody. On the other hand, conventional hydrothermal replacement theory fails to explain the apparently sedimentary nature of deposits in the lower mine. Neither theory alone fully accounts for the complex structure of the orebody, and it is possible that a more complete explanation of the genesis of Sullivan ore will be forthcoming when regional metamorphism in the Kimberley area is better understood.

While ore reserves for the mine have not been released by the Company, Cominco's annual report for 1973 states a combined figure for the Sullivan and HB mines of 62,000,000 tons with a lead-zinc content of 6,700,000 tons. The HB mine accounts for less than 10% of this.

MINING

Development of Mining Methods

Early mining at the Sullivan was by open stoping in very competent ground. Pillars left in this part of the mine were quite irregular due to the selective mining of high grade lead ore. A more orderly stoping pattern was adopted after development of differential flotation permitted extraction of mixed, lower grade lead-zinc ores.

Open stoping using short hole percussion drills for benching continued as the proven ore reserves increased, leaving extensive openings in the mine and large unsupported areas. As a safety measure against extensive hanging wall collapse, and accompanying air blasts, and as an aid to future pillar recovery, backfilling operations using surface gravel were commenced in 1935 and continued until 1961.

The sinking of Nos. 1 and 2 inclined shafts in the 1940's and early 1950's gave access to the lower, more uniform, part of the orebody. Systematic stoping advanced downdip with stopes mainly 50 feet wide on 100 foot centres, with some variations in pillar dimensions when ground conditions dictated. The 1940's also saw the start of the changeover from short hole drilling to longhole drilling. Both diamond and percussion longhole drilling have been used for stoping and pillar mining since, and currently, other than for development longhole drilling is used throughout the mine.

Backfilling of the lower, more regular stopes, using the float reject from the sink-float plant at the concentrator, started in 1949. For several years pyrrhotite tailings from the concentrator were added to the floatfill in order to cement and consolidate it. This practice was discontinued when problems of oxidation and production of excessive heat and sulphur dioxide gas arose. Subsequent filling of stopes using untreated float continued until 1973. Fill placement was by means of gravity, except in those areas flatter than the angle of repose of the crushed waste. Several methods of filling such areas have been tried - electric scrapers, large-diameter boreholes, and various mechanical and pneumatic stowing devices - but none have been completely satisfactory. Experiments to stabilize this fill by cement injection are underway.

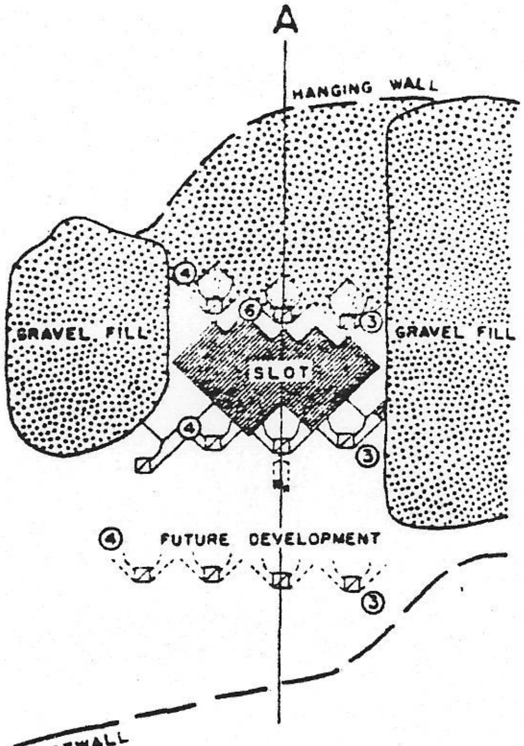
Pillars currently account for 99% of the Sullivan's production and as a result of the great variety of shapes and sizes, detailed planning is required for each pillar.

The recovery of pillars has been fairly systematic since the early 1960's when the "Northwest Retreat Front" was established. This retreat front was defined as a result of a compromise between optimum retreat directions based on rock mechanics principles and production flexibility requirements. It incorporates controlled caving to the surface of hanging wall waste into stoped-out areas.

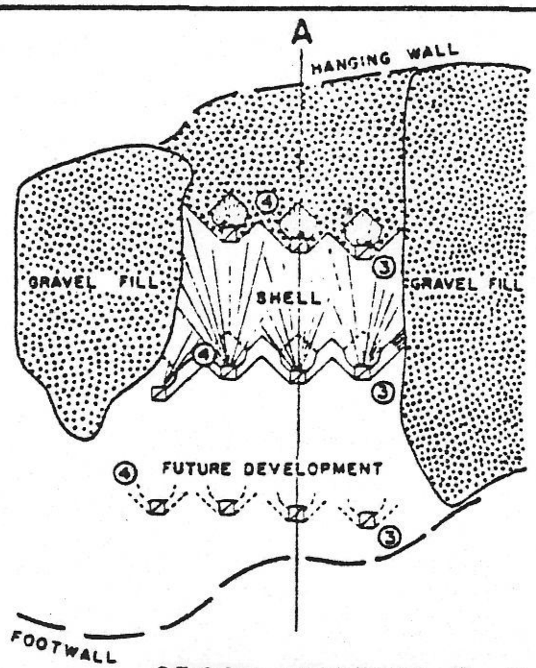
Because the pillar size and the mining environment vary greatly throughout the mine, a number of mining methods have been tried over the years. These range from a single slot and shell to a multi-stage slot, core and shell, and to a method of successive slot and shell stages.

Large scale multi-stage mining, however, resulted in large tonnages of broken ore remaining within the pillar while subsequent stages were being developed and drilled. With ores of certain mineral compositions, this prolonged exposure to air and confinement within the pillar, together with the presence of ground waters, was conducive to rapid oxidation and heating of the ore.

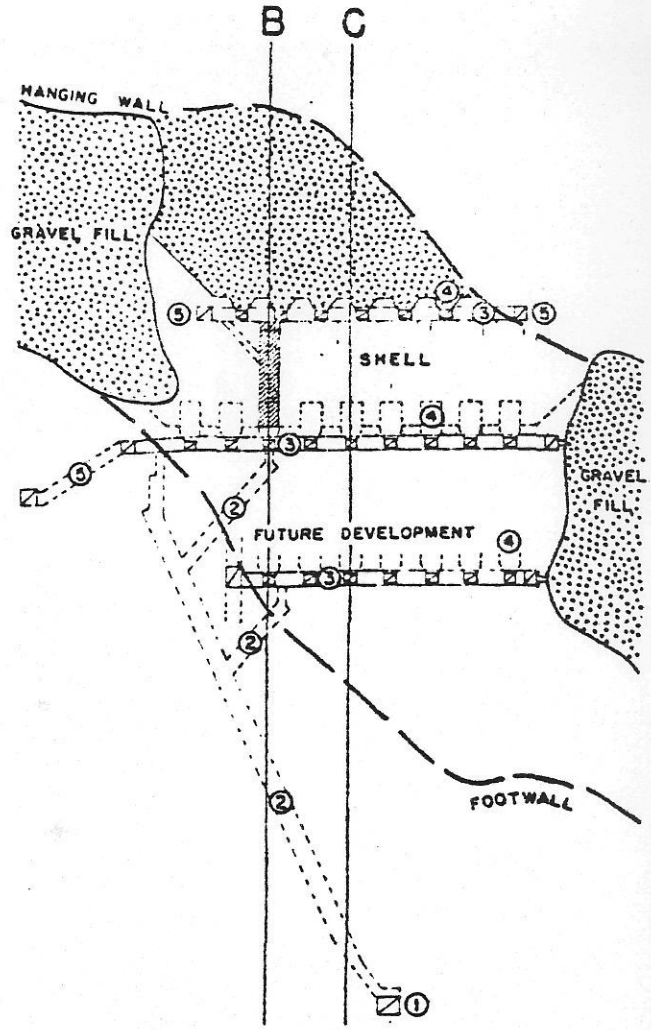
Current mining methods are aimed at eliminating this problem by reducing the scale of operation such that each stage can be developed and extracted independently. This has the advantage of reducing the time of exposure of the broken ore to circulating air, and also enables production to commence immediately following the completion of development, drilling, and blasting.



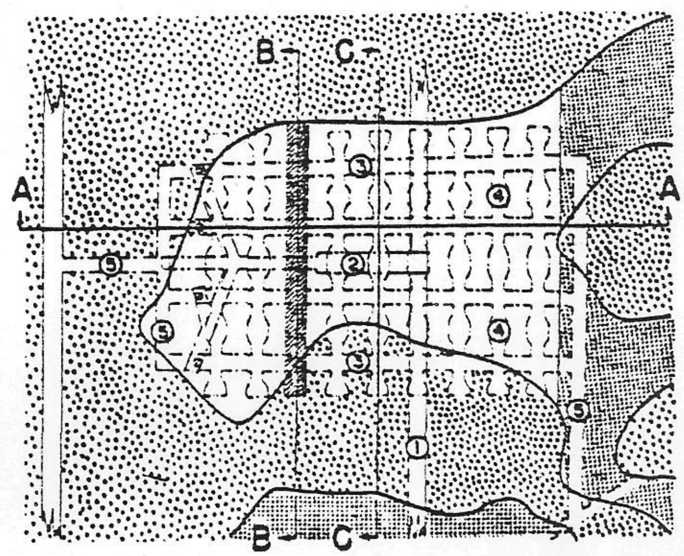
CROSS SECTION B - B



CROSS SECTION C - C



SECTION A - A

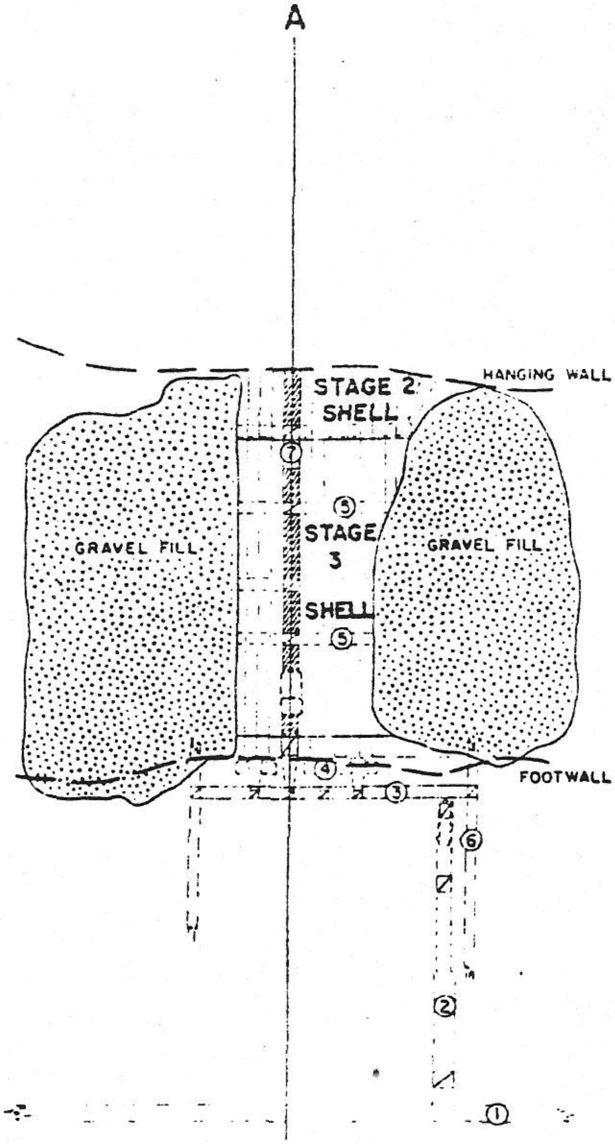


PLAN

TYPICAL SINGLE-STAGE PILLAR LAYOUT

① HAULAGE DRIFT, ② MUCK RAISE, ③ SLUSHER SUBS, ④ DRAWHOLES, ⑤ MANWAYS, ⑥ TEMPORARY CROWN PILLAR (BLASTED WITH SHELL).

JMM
SULLIVAN MINE PLANNING



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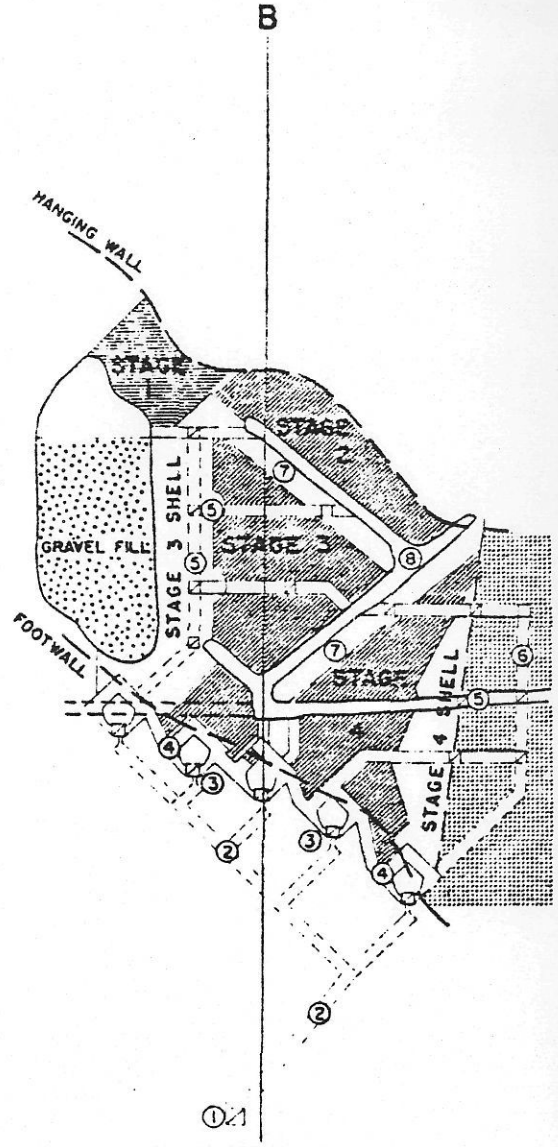
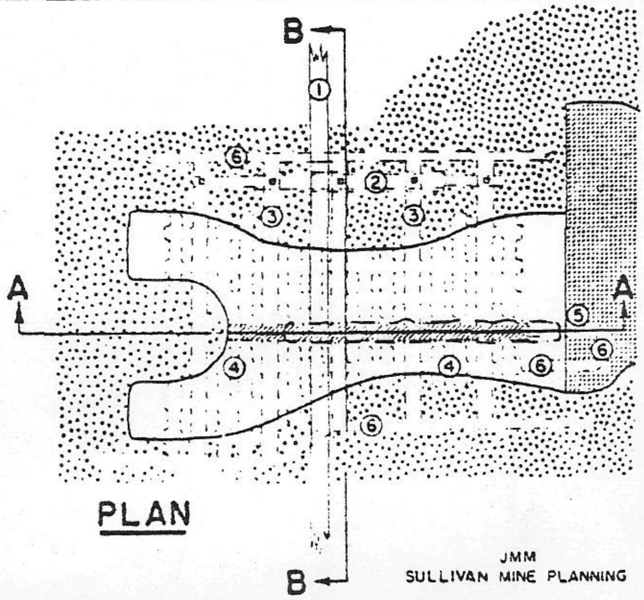


SECTION A-A

LEGEND

1. HAULAGE DRIFT
2. MUCK RAISE
3. SLUSHER SUBS
4. DRAWHOLES
5. DRILL SUBS
6. MANWAYS
7. TEMPORARY CROWN PILLAR (BLASTED WITH SHELL)
8. OLD DEVELOPMENT

TYPICAL MULTI-STAGE PILLAR LAYOUT



PLAN

JMM
SULLIVAN MINE PLANNING

Services

The mine is serviced by the main tunnel on the 3900 Level. The tunnel extends from a portal near the mine offices 6000 feet to the fringe of the orebody and another 6000 feet to the farthest working place.

The levels below the 3900 Level are serviced either by No. 1 Shaft, located at the south end of the orebody or by No. 2 Shaft located near the centre of the orebody.

As well as providing the supply function for men and materials, the No. 1 Shaft is also equipped to hoist waste from below 3900 to the surface. It extends from the surface at elevation 4,380 feet to the 2,400 elevation, a slope distance of approximately 3,200 feet. Hoisting is done by a Bertram-Nordberg 850 HP double-drum 12 foot diameter hoist, with a rope speed of 1,620 feet per minute. Total hoisting capacity of the shaft is 190 tons of waste rock per hour from the 2850 Level to the surface bin.

No. 2 Shaft is inclined at 40°, handles men and materials only. It extends from 3900 Level to 3350 Level. Hoisting is done by a Vulcan 500 HP double-drum hoist with a maximum rope speed of 850 feet per minute. The Levels above the 3900 Level are serviced by the 27 Raise in the South and the 30 Raise in the North. These are internal inclined shafts equipped to handle men and materials only. The two upper Levels, 4650 and 4500, have surface portals above the small inactive open pit at the outcrop of the orebody.

Electric power is delivered to the Sullivan Mine at 66,000 volts, at three surface sub-stations having a combined rating of 12,900 kilo volt amperes. Peak load requirement is 9,940 kilowatts, derived from a total connected load of 20,000 HP. All stationary motors underground are supplied with 550 volt, 3-phase, 60-cycle power, except for a 500 HP hoist motor and two 300 kilowatt motor-generator trolley sets connected at 2,300 volts.

The mine is served by a combined exhaust and forced draft primary system circulating 980,000 cfm of ventilating air from surface. The dust control from the crushing plants, conveyor transfers, and ore dumps form part of the return air. Fans on primary ventilation comprise six units on exhaust and five units on intake duty. There are also 125 fan units of various capacities on hand to operate the secondary ventilation circuits. The general ratio of air weight handled by the fans amounts to 5.0 tons of air per ton of ore produced.

Four of the intake fans have natural gas fired heating units which provide 840,000 cfm of heated air in cold weather and can provide 54 million BTU per hour at maximum output.

Compressed air for the Mine is supplied by seven electrically driven compressors totalling 4,700 HP with a combined capacity of 24,000 cubic feet per minute, compressing to 105 pounds per square inch.

Minor repair work is done underground in shops located at various central points throughout the Mine.

Although each pillar must be planned in detail, there are several design parameters which control the final layout. As a rule, every attempt is made to keep blast holes between 60 and 75 feet long. Slusher drifts are placed at about 40 foot intervals with drawholes every 20 feet.

Blast hole size depends upon ground type and ground conditions but in general 1 5/8" diameter diamond drill holes are used in soft sulphide ore and 2" diameter percussion holes in harder ground. Recently, diamond drilling up to 2 7/8" diameter blast holes has been successfully tried in fractured ground and has led to studies of hydraulic drills to further the practice.

The introduction of Atlas Copco ring drills for percussion long-hole drilling is planned to improve productivities and the working environment.

Blast holes are drilled on a 7 foot burden and a 7 foot toe spacing and are blasted using 75% gelatin, Cominco AN/FO, or, more recently, packaged slurry explosives. Loading techniques have been greatly improved by use of pneumatic loaders for both NCN explosives and packaged slurries.

Broken ore is scraped from drawholes beneath each broken pillar using electric scrapers, to muck raises and hence to loading chutes in the drift below.

Ore Handling

From the chutes, ore is loaded into either 86 cubic foot or 156 cubic foot side-dump Granby cars and hauled by trolley locomotives to ore passes. Currently, some trains are remotely controlled from the chutes during loading enabling the entire loading and hauling cycle to be operating by one man.

The ore from above the 3900 Level is handled on various intermediate levels and transferred through raise systems to the 3900 Level where it is hauled to a central bin above the main 3800 Level crushing chamber. Here it passes through primary jaw crushers and secondary cone crushers and is stored in the 3700 Level fine ore bin.

Ore from below the 3900 Level is transferred through a main ore pass system to either the 2850 Level of 2500 Level primary crushing chambers. After primary crushing it is conveyed on a multi-belt system at plus 17° at 450 tons per hour to the 3800 crushing chamber for secondary crushing.

Since completion in 1949 of the 3700 Level adit, ore from the 3800 Level crusher is hauled directly to the concentrator in 15 ton rotary dump cars loaded from the 15,000 ton fine ore bin. Train loading is automatic, using measuring pockets, each holding one complete car load.

Development waste from above the 3900 Level is hauled out of the mine via the main portal on that level, and waste from below the 3900 Level is hoisted to surface via No. 1 Shaft.