Asbestos Mining at the Jeffrey Mine

By K. V. LINDELL



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An aerial view of the Jeffrey open-pit mine, looking south, showing pit with truck road to 580-level, as at July, 1950.

Asbestos Mining at the Jeffrey Mine

Introduction

CANADA has long been recognized as the largest producer of asbestos in the world. It is also well known that nearly 100 per cent of this Canadian production comes from a serpentine belt running through the Eastern Townships of Quebec to the Vermont border. However, until very recent years, Canadian Asbestos has come to be almost entirely associated with the Thetford Mines district. This district does produce a large proportion of the Canadian production, but the largest asbestos mine in the world—producing over 50 per cent of the Canadian production—is situated at the Town of Asbestos, 90 miles east of Montreal.

This is the Jeffrey mine of the Canadian Johns-Manville Company, who have operated it for many years to supply the raw material for the many and varied asbestos products manufactured in the company factories.

The Mineral Asbestos

The mineral asbestos has been known since very early times for its fire-resistant qualities. However, it was not until well into the nineteenth century that this quality was put to commercial use, rather than being treated only as a curiosity.

The name asbestos covers a wide variety of fibrous minerals which may be classed into two major groups — the amphibole group, and the serpentine group.

The amphibole group, made up of a number of silicates of magnesium iron and calcium, are very resistant to fire and acids. Serpentine is a hydrous silicate of magnesium, and the highly fibrous variety is known as chrysotile

The author of this article on the Jeffrey asbestos mine is vice-president of Canadian Johns-Manville Company, Ltd., and general manager of the company's Asbestos Fibre Division. He was formerly mine manager of the mine about which he writes so authoritatively.

Mr. Lindell, a graduate of the Michigan College of Mines in 1928, joined the Johns-Manville company in 1945 as mine superintendent at the Jeffrey, later being appointed plant engineer and, in January, 1950, mine manager. Prior to 1945 he had been associated with International Nickel Company of Canada, Ltd., at the Frood mine and Copper Cliff general headquarters. He was made assistant to the general superintendent of mines for Inco in 1943 and that year was sent to Petsamo to develop a programme for opening a nickel mine.

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asbestos. This constitutes by far the largest proportion of the world's production of the mineral. Chrysotile asbestos is usually found in various shades of green, but may occur in light yellow or cream. No matter what colour it may appear when found, however, the fibres when pulled apart are white and when fluffed up closely resembly wool in appearance. The Jeffrey mine production is of this chrysotile variety of the mineral.

Geology

The deposits at Asbestos are due to serpentinization of peridotite with the development of chrysotile as cross-fibre veins predominating, though slip-fibre in veins and slip-planes also occurs.

The fiberized extent, or orebody of the Jeffrey mine for the sake of simplicity may be considered to be cylindrical in shape, tilted on its long axis and dipping from north-east to south-west. There is no regularity to the fibre occurrence. Barren and fiberized masses are found both horizontally and vertically throughout the mine. About 25 per cent of the orebody is barren rock. On the north side the orebody is in contact with a slate foot-wall, striking north 60 deg. and dipping south-east at approximately 45 deg. On the east and west sides the ore fades irregularly into unaltered peridotite and non-commercial fibres. Towards the south the orebody appears deeper than boreholes in that area.

History

As nearly as can be determined asbestos was first discovered in Quebec as early as 1862, but this discovery was not in any of the present producing areas. During 1876 asbestos was discovered at Thetford and mining proceeded rapidly. In the meantime, near Danville, a natural phenomenon was puzzling the settlers of that district. The phenomenon was masses of long silky fibres apparently growing within the rock and was locally known as "Webb's Ledge" since it occurred in a hillside out-cropping on the farm of Charles Webb.

Even though asbestos had been recognized as such in Thetford, only 60 odd road miles away, the phenomenon of Webb's Ledge remained only a local curiosity until seen by Evan Williams, a Welshman, visiting his brother, who recognized it for what it was. Williams tried unsuccessfully to interest local farmers in the out-cropping, and eventually journeyed to Richmond, 16 miles from the deposit, to try to interest W. H. Jeffrey. Jeffrey, an Englishman, apparently of considerable substance and a shrewd old gentleman, became interested and opened the mine on a royalty basis in 1881. Thus the Jeffery mine came into being, and the village of Asbestos took form and expanded with the mine.

Jeffery operated the mine for about 13 years selling his product, which consisted solely of crude, to the H. W. Johns Manufacturing Co., in Manhattan, N.Y. In time, however, he became hampered by contracts and other matters, failed to pay the royalties and lost a lawsuit to Webb. He also became deeply indebted to his miners and creditors and eventually went into bankruptcy. The property then passed into the hands of Messrs. W. Farwell and F. C. Thompson, who almost immediately sold it to Messrs. G. Boas, J. N. Greenshields and B. Marcuse. These men, who were operating a nearby slate quarry, formed the Asbestos and Asbestic Co., which



The concrete headframe, 127-ft. 6-in. high, was "poured" in one continuous pour taking nearly 15 days.

rapidly developed the property. During this time, about 1897, the Asbestos and Danville Railway was built to connect the mine with the Grand Trunk Railway (now the C.N.R.) at Danville.

In 1950, T. F. Manville became interested in the Asbestos and Asbestic Co., and gradually accumulated stock until he held the controlling interest. When this company went into liquidation in 1916 the property was taken over by a company formed for this purpose and named Manville Asbestos Co. Ltd., backed by American capital. In 1918 the company was re-organized under the name of the Canadian Johns-Manville Co. Ltd. and shortly after Mr. Manville's death in 1925, his heirs disposed of the greater part of their holdings. Of the original Manville family, one, H. E. Manville, Jr., a nephew of T. F. Manville, retains an active interest in the company.

Open Pit Mining

In 1881 when the mine was first opened by Mr. Jeffrey all work, including drilling, was done by hand. The deposit, being on a hillside, was first worked as a sidehill cut by hand steeling a 15-foot hole and blasting with black powder. The fibre was then chiselled from the broken rock. Soon three pits or sidehill cuts were in operation on different sides of the hill. Hand, then horse-powered, derricks were used to raise the rock as the pits deepened. Eventually the three pits joined and became so deep that the derricks were replaced by aerial tramways supported on first wooden and then steel towers.

The aerial tramway system was in general use throughout the asbestos mining areas of Quebec and was developed to a high degree of efficiency. However, as the span increased due to the increasing width of the workings, more and more trouble was encountered. In the case of the Jeffery mine this trouble was mainly in the form of cable breakage, even though two-inch special steel cable was being used to span the 2000-ft. width.

With the failure of the aerial tramways system threatening in the near future the mine management decided to change its mining method. The Spiral benching system was adopted. This method consists of mining with power shovels outward and laterally from the sinking cut on the various levels which are 35 feet apart vertically and connected by an inclined approach.

Primary drilling is done from the top of the bench by means of drills mounted on steel derricks. Holes are collared 15 feet back from the face and sunk at an angle of 10 to 15 deg. off the vertical, sloping towards the face. They are spaced from 3 to 6 feet apart, according to rock conditions. All holes are sunk to about four feet below grade, thus requiring 40-foot length of steel for the standard 35-foot benches.

Blasting is done by means of instantaneous electric caps and special low-freezing nitroglycerin. Holes are loaded with 30 to 50 pounds of 2-in. by 16-in. dynamite sticks and a maximum of 3000 lbs. of explosives per blast is maintained. All blasting is done by 220-volt A.C. current from a blasting cabin equipped with an approved type blasting switch. The amount of rock broken per blast varies from about 3,000 tons up to 25,000 tons.

Long asbestos fibres are hand picked at the loading faces. The bulk of the rock is loaded out by electric shovels equipped with caterpillar treads and operated under their own power, supplied with 2,200 volts A.C.

Originally, transportation of rock and dirt was carried by means of steam or electric locomotives and side-dump 20- and 30-cu. yd. steel cars. This equipment operated on a standard gauge railway, tracks being laid on steel ties to facilitate shifting as required by the expansion of benches.

This haulage system in the open pit was gradually replaced in 1951 by 22½-ton diesel trucks operating on an eight per cent ramp leading directly from the bottom of the pit to the mill slip. This change makes for easier manoeuvering rendered necessary by the coming into production of the new underground mine. It also makes available larger quantities of ore in the open pit, thus extending its life through some 12 years.

The mine is adequately lighted for full-scale night operations by means of electric floodlights mounted on steel towers in strategic locations. Compressed air is delivered and distributed for usage in the mine at regular intervals on the operating levels. Pumps, telephones and safety cabins are suitably located to give ample service to the mine operations.

Mining Transition

With the deepening of the open-pit mine and the attendant constriction of the lower levels, the necessity of preparing for another type of mining within the mine limits became more and more acute. Several systems of vertical expansion were actively studied and in 1942 management adopted the underground block-caving method. This mining method had already been successfully used in the Thetford mines area. In this system the ground to be caved is first undercut and then broken by natural forces acting upon the same.

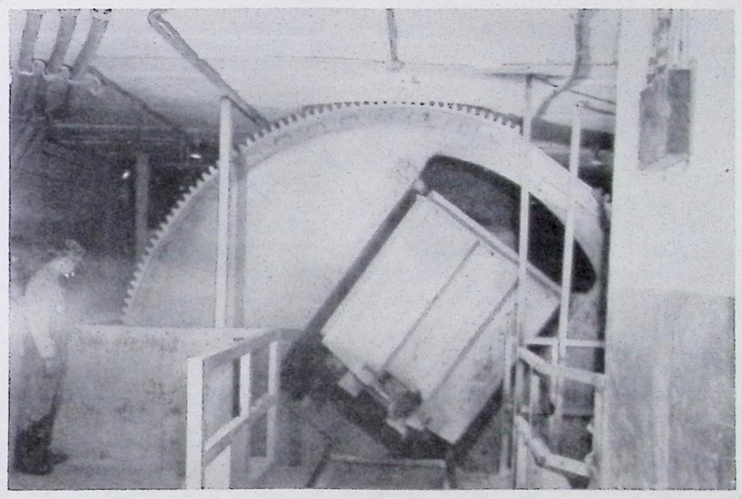
First development work started in July, 1944, with the sinking of a shaft and, on February 22nd, 1950, the underground mine effectively came into production with the blasting of the first quarter of the undercut of this first block.

Underground Mining

The underground operations are laid out to produce 12,000 tons per day using scram drifts. 125 h.p. slusher hoists and 72-inch scrapers load into 200-ft. tipple cars hauled by 15-ton combination trolley and battery locomotives controlled by a dispatcher by means of two-way radio. Track is 36-in. gauge with 85-lb. rail laid on steel ties. The main haulage is a continuous loop, and ore is dumped by a two-car rotary tipple into either the waste or ore dump, which feed three 48-inch by 60-inch jaw crushers. Feed to the crushers is controlled by vibrating grizzly feeders. Crushed material passes either to waste or ore passes of 350 tons live capacity each. These feed into a common loading pass, delivering through guillotine-type gates to measuring pockets of 10-ton capacity for skip hoisting.

The Shaft

The shaft is steel-timbered, measures 18 ft. by 13 ft. 6 in. inside the steel and has five major compartments. There are two skip compartments 6 ft. 6 ins. by 6 ft. 6 ins., a cage compartment 13 ft. 6 in. by 7 ft., a cable, pipe and cage counterweight compartment 3 ft. 6 ins by 6 ft. 6 ins., and a manway compartment 3 ft. 6 ins. by 6 ft. 6 ins.. The steel sets are 6-in. H-beams at 22.5 lb. per foot, hung on six feet centres by means of angle studdles. The shaft is concreted for its total depth, flush with the inside of the steel sets.



The rotary tipple, capable of dumping two 200-cu. ft. cars into either a 130-ton waste bin or a 260-ton ore bin.

Surface Plant

Headframe

Completion of the shaft was followed by the construction of a concrete headframe due to steel shortages. The design is unique in the mining field inasmuch as the headframe proper was constructed by means of a single sliding form complete with all compartment walls in a continuous operation. The main structure of 796 cu. yds. was poured in one continuous pour taking 14 days 16½ hours, with a sliding form.

The headframe is 115 ft. 6 ins. in height plus a 12-ft. penthouse. It is 30 ft. in diameter with 12-inch outer walls and 5-inch partition walls. Before the headframe was built the existing shaft collar was reinforced to carry it by pouring a concrete plug to fill the void between the cylindrical concrete collar and the inside of the shaft sets. The plug was securely dowelled to the collar, and the headframe dowelled to the surface slab and this plug.

The headframe houses two 10-ft. diameter skip rope sheaves and two 10-ft. diameter cages, and cage counterweight sheaves. The two sets of sheaves are mounted on separate concrete slab decks 100 ft. and 74 ft. respectively above the collar elevation. One of the empty segments of the 30-ft. diameter circle on the north side, outside the shaft proper, houses a stairway and elevator well. The segment on the south, or collar house side, serves as a hoistway for raising or lowering sheaves, etc., to the sheave decks, and the one on the east or hoist house side serves as an entrance to the manway of the shaft.

Surge Bin

A circular reinforced concrete surge bin of 300 tons live capacity is erected on the west side of the headframe at a distance of 35 ft. centre to centre. The bin is 20 ft. in diameter and is provided with 12-in. circular shelves spaced to build up an inner lining of rock fines to protect the walls of the structure against impact and abrasion. It has a basement, which contains a vibrating feeder and tail end of a conveyor installation. It also has a concrete housing over it at the skip dump position. A mastic joint is provided where it joins the headframe as

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it was built independent of the headframe on a floating concrete slab, using stationary forms.

Transfer Belts

A 36-in. wide conveyor belt of 750 tons per hour capacity inclined at 15 degrees 43 minutes, and 272 feet long, is used to convey waste and mill rock from the basement of the surge bin to the top of the surface bins. This belt, which is 580 ft. in actual length, is housed in a conveyor gallery constructed of structural steel enclosed with Corrugated Transite walls and roof.

The first belt discharges into a two-way hopper which feeds the material directly into the waste bin, or to the ore bin by means of a 29-ft. long conveyor with a 36-in. belt.

Surface Bins

The two surface bins, located 286 ft. 9 ins. centre to centre from the surge bin, were also poured of reinforced concrete using a sliding form. They are twin cylinders, built siamese, 30 feet in diameter, with 9-inch walls. This pour took 6 days 11 hours. They are 54 feet high from the foundation to the picking house floor, with the ore bin having a live capacity of 1000 tons and the waste bin a live capacity of 650 tons. The waste bin has been constructed to permit loading directly into standard railway cars, with provision in the foundation to pass material from the bin directly to the conveyor tunnel to the mill, if it is desired to use the waste bin for ore. The ore bin feeds directly to the mill conveyor tunnel. Two vibrating feeders, located in the tunnel, control the flow of material onto the belt.

Collar House

Following the completion of the headframe, a collar house was constructed. It is a steel frame building, 119 ft. by 47 ft. 6 in., with 30 ft. clearance to the bottom of the trusses, covered with Corrugated Transite. Both standard and 36-in. gauge tracks enter this building and a 10-ton electric crane is provided for handling heavy material.

Change House

At the same time as the collar house was being built, the change house was being erected. It is a structural steel frame with brick and concrete block walls and partitions, and a Corrugated Transite roof. The change room is of the hang-up and locker type, with a capacity of 500 men. Ventilation is provided by an 8600 cu. ft. per minute fan.

Both showers and Bradley type wash fountains are provided. Provision is made for the installation of sun lamps in the shower section. The building also contains a 30-locker foremen's dry, an 8-locker officials' dry, a first aid room and offices. Heating and hot water are supplied by an automatic oil-fired 85 h.p. boiler located in the basement.

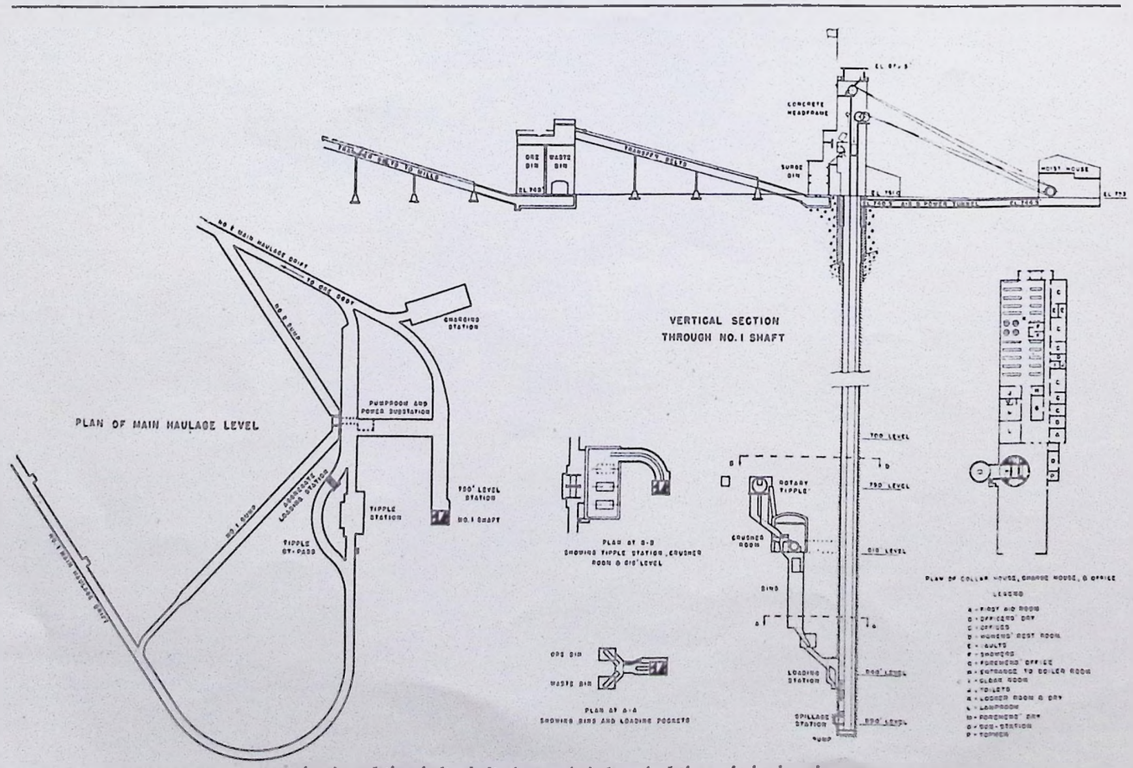
Hoist House

While the shaft was being sunk, the permanent hoist house was under construction and hoists were being installed. This building, 113 ft. by 62 ft. 9 in., is of brick and reinforced concrete construction with a Corrugated Transite roof. In addition to the hoisting equipment, a 2800 cu. ft. air compressor has been installed in the building, with space provided for the installation of two additional similar units.

Two electric cranes service the building. A 20-ton unit serves the front bay in which the hoists are installed, and a 10-ton unit the rear bay, which houses the compressor and electrical equipment for both hoists and compressor.

Mine Hoists

Hoisting equipment at the No. 1 shaft consists of two Ward-Leonard amplidyne controlled hoists, one a 200 h.p. cage hoist, the other a 1000 h.p. skip hoist. The hoists have all the equipment normally associated with Ward-Leonard hoists, with the addition of amplidyne and electronic controls. These two controls, working together, give control over maximum voltage or speed, over maximum current and torque, and over rate of change of acceleration. Thus it is possible to throw the controller from full hoist to full reverse without tripping any circuit breakers or causing any serious discomfort to those riding in the cage or skips. Both the cage and the skips are equipped with pneumatic guide rollers, rather than the conventional slippers.



A drawing of the shaft, shaft plant and shaft end of the main haulage loop.

Man Hoist

The man hoist is a 200-h.p. unit with a single 10-ft. diameter drum grooved for 1⅝-in. wire rope. It is capable of hoisting the 50-man, 12,000-lb. cage with a 13,000-lb. load and an 18,500-lb. counterweight at a normal speed of 500 f.p.m. At a reduced speed, and by increasing the counterweight to 25,000 lbs., it will handle a 26,000-lb. locomotive. Elevator control of the cage is made possible by the above-mentioned amplidyne and electronic control, since manual control of acceleration is unnecessary.

Ore Hoist

The ore hoist is a 1000-h.p. unit with two 10-ft. diameter drums grooved for 1⅝-in. rope. One drum is fixed and the other clutched. The hoist is capable of handling two 12,000-lb. skips in balance, one carrying 21,200 lbs. of material. Each trip requires, at a maximum speed of 1200 f.p.m., a total time of 75 seconds, out of which 10 seconds is allowed for loading.

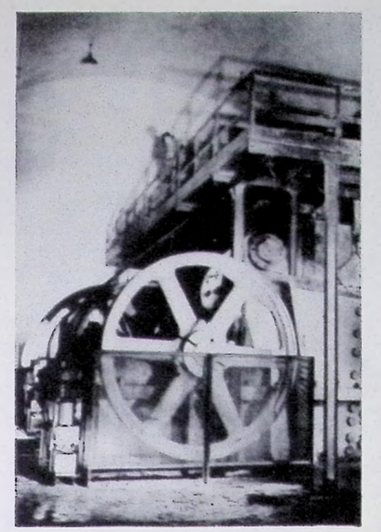
Underground Plant

Rotary Tipple

At the No. 1 shaft end of the 750 level main haulage loop is the rotary tipple capable of dumping two 200-cu. ft. cars into either a waste or an ore bin. The tipple, with its control panels, is installed in a concreted station 41 ft. 6 in. by 23 ft. by 9 ft. 6 in. high. In actuality the tipple consists of two independent 1-car tipples, each with its own drive and controls, placed end to end and spaced so that cars centred in each section need not be uncoupled. When the tipple rotates to one side it dumps into a 130-ton waste bin, and to the other into a 260-ton ore bin. Both bins are lined with steel plate anchored in concrete.

Crusher Room

The crusher room located on the 816 level, is separated from the shaft by a 35-ft. pillar and is 70 ft. by 32 ft. by 38 ft. high. It is of reinforced concrete construction, three walls and the arched back being a minimum of two feet thick, and the fourth wall, which has the three crusher feed openings, a minimum of three feet. Access to the room may be gained either by No. 1 shaft through the 816 station or down a manway raise from the tipple station on the 750 level. There are both telephone and bell signal communication between the crusher room and tipple station.



Floor-level view of crusher room showing No. 2 crusher in the foreground.

Installed in the crusher room are two 48 in. by 60 in. jaw crushers with 200 h.p. drives, fed by vibrating grizzly feeders from the tipple ore and waste bins. Provision is made in the room for the installation of a third similar unit.

The No. 1 crusher feed comes from the tipple waste bins, and the by-passed fines and crushed material discharge into the waste bin below the crusher.

The No. 2 crusher feed comes from the tipple ore bin, and the by-passed fines and crushed material may be discharged either into the waste bin beneath No. 1 crusher or the ore bin beneath the location of the proposed No. 3 crusher. The No. 3 crusher, which will be installed when required, draws its feed from the same tipple ore bin as the No. 2 crusher, and will discharge only into the ore bin beneath its planned location. A 20-ton electric travelling crane is set up to service all three crushers.

The excavation of an opening roughly 75 ft by 36 ft. by 40 ft. high presents an interesting problem in any ground, but when in peridotite which has to be supported, and within 35 feet of a 12 ft. by 14 ft 6 in. shaft, it becomes even more so. The crusher room was first perimetered from the floor level up to and including the arch at the roof by means of square setting. The rock was excavated far enough outside the square sets to allow for the minimum concrete required plus 9 inches for forms, for bracing and blocking. The walls and arch were then poured in three separate horizontal pours, the third of which included part of the side walls and 8 feet of the roof arch. A horizontal slice conforming to the arch of the roof was then taken starting at both ends of the room, forms set, and the complete arch from side to side poured in sections. In all, five such sections were excavated, formed and poured to complete the roof from end to end.

When the pouring of the walls and roof was completed a central pillar of rock was left standing within the square sets. Leaving the forms on to protect the concrete, this central pillar was then excavated by under-handing it, the crusher pits excavated, and the floor and pits concreted.

Ore and Waste Bins

The ore and waste bins are identical bins 12 ft. by 16 ft. by 56 ft. high, set on a 29-foot centre to centre distance beneath the No. 1 and No. 3 crusher pits. They have a live capacity of 350 tons each, are steel timbered, lined with vertical 65-lb. rail on 1-ft. centres, and concreted flush with the wearing surface of the ball of the rail. Out of the bottom of each bin is a short steel-lined slide at 45 degrees, ending with an undercut arc gate actuated by an air cylinder, which conducts the crushed material to the top of a common steel-lined loading pass at 40 degrees. This loading pass delivers either waste or ore to the measuring pockets.

Measuring Pockets

Two 10-ton capacity measuring pockets are installed in a concreted station on the 940 level. Flow into these pockets from the common loading pass is controlled by air actuated, undercut guillotine gates. Discharge from the pockets to the skips is by air actuated, quick acting hinged gates and 5-foot manganese lined chutes at fifty degrees.

Spill Pockets

A spill pocket of 35 tons capacity is formed in each skip compartment by lining the compartment with steel plate for 24 feet beneath the skip loading position. Discharge from each pocket is controlled by a chute and gate on the 990 level. A small station is cut on the 990 level, in which a transfer carriage is installed which enables one 2-ton rocker dump car at a time to be pulled off the cage, transferred to a short length of track laid on a permanent bulkhead in the skip compartments, and pushed under the discharge gates. Spill is hoisted to the 750 level.

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Auxiliary Underground Plant

Electric Power

Power is taken underground at 2200 volts A.C. by means of four 3-conductor, 250 M.C.M. armored cables in parallel in the shaft. These leave the shaft at the 750 station and run to a main bus in the 750 pump room, which is a concreted room 75 ft. by 15 ft. by 10 ft. 6 in. high, containing the main mine pumps, a transformer vault, and control panels.

The three main breakers in the pump room control the following 2200 volt A.C. power:

1. To the pumps in the pump room.
2. To the crusher room and 1000 k.v.a. 440 volt transformer in the vault.
3. To the two 250 M.C.M. cables carrying power into the orebody.

The 440 transformer supplies all 440 requirements such as the motor pump on the 990 level, and chargers, overhead crane, etc., in the charging station. The two 250 M.C.M. cables controlled by the third breaker run up No. 2 main haulage through No. 1 crossover and up No. 1 main haulage with take-offs as required for the D.C. substation, unit substations for the slusher hoists, and No. 2 service shaft hoist.

Compressed Air and Water

Compressed air is taken underground from the compressor in the No. 1 shaft hoistroom via an 8-inch air line down No. 1 shaft, and from the open pit via a 4-inch line in No. 1 service shaft. It is distributed throughout the mine by means of 6-inch, 4-inch, and 2-inch pipes. Service water enters the mine via No. 1 shaft through a 4-inch pipe and is distributed by means of 4-inch, 2-inch, and 1-inch pipes.

Pumping

The 750 level is drained by concrete ditches running along the drifts and crosscuts and draining into two sumps. Water is pumped by two Mather and Platt Plurovane units, powered by 150-h.p., 2200-volt A.C. motors, and having a capacity of 500 g.p.m. at a combined head of 828 feet. Water collected at the bottom of the shaft is pumped to the 750 sumps by means of a float controlled motor pump on the 990 level.

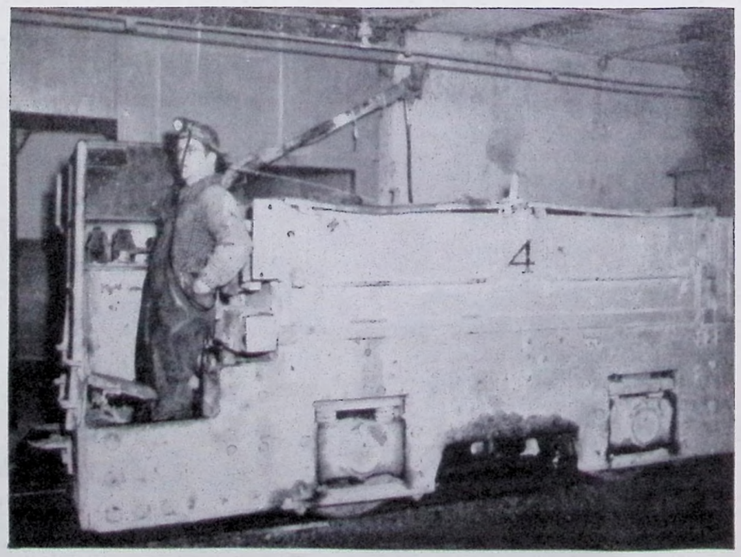
Ventilation

Ventilation is provided by a 60-inch axivane fan with an adjustable aluminum blade, capable of 85,000 c.f.m. at 3.65 ins. W.G., powered by a 75-h.p. 2200-volt A.C. motor. It draws foul air out of each slusher drift and exhausts it to the first sub-level, thence to No. 1 service shaft and to surface. Fresh air is drawn down No. 1 shaft, up the haulage ways and into the slusher drifts via the loading openings.

Concreting Plant

The plant consists of the following:

1. Ten compartment batch cars, equipped with a discharge belt.
2. A concrete mixer, powered by a 10-h.p., 250-volt D.C. motor.
3. A concrete conveyor, carrying the mixed concrete from the mixer to a pumpcrete machine.
4. A pumpcrete machine capable of pumping concrete through a 6-inch pipe a distance of 800 feet horizontally.
5. An aggregate storage raise, running from the 700-level to the aggregate station near the tipple on the 750-level. An automatic batcher, installed at the raise discharge, weighs out any set amount of sand and/or stone, one batch at a time.



One of the 15-ton locomotives used underground, showing the trolley takeoff and the radio unit by which communication is maintained with the dispatcher.

General Layout of 750 Level

The main haulage level is made up of a continuous loop system of drifts and crosscuts, each 8 ft. 4 in. wide by 9 ft. 6 in. high inside the steel or concrete. The No. 1 and No. 2 main haulage drifts run parallel on 100 ft. centres through a central pillar in the ore body with crosscuts normal to them every 200 ft. These in turn are all joined at their most remote points from the shaft by a drift which perimeters the orebody. The grade in all headings is plus one-half per cent leaving the No. 1 shaft.

Between No. 2 and the orebody safety bays are provided every 100 feet in both haulage ways where no other point of refuge is available. Within the orebody and in the central pillar, No. 1 and No. 2 service shafts bottom on this level. Also in the central pillar are located the necessary stations to service the mine equipment and men, such as a storeroom, fitters' shop, D.C. substation, and lunchroom for 160 men complete with tables and benches. Within the orebody, but outside the central pillar, are unit substations for the slusher hoists, powder and cap magazines, an oil storage room, fan station and ventilation drifts and crosscuts. On the edge of the orebody, at the junction of No. 1 main haulage and 1-3 crosscut is the dispatchers' station, and in the No. 1 shaft vicinity are the pump-room and sumps, tipple station, aggregate station and charging station complete with overhead crane and pit to service the electric locomotives.

Main haulageways are driven by means of twin-boom hydraulic drill jumbos mounting Leyner drills, 1-inch quarter octagon drill steel and detachable bits. The broken muck is normally loaded into 10-ton tipple cars by means of an electric powered Conway loader, but two air-driven model 21 Eimco rocker shovels and 2-ton cars are also available. Stations are normally driven using the above equipment, or by means of an air driven self-propelled Drillmobile mounting a single hydraulic boom, and scrapers where track is not available.

Headings on this level are left untimbered but gunited where possible, timbered and gunited, or timbered and concreted where necessary. The two main haulage ways are 100 per cent concreted from the sumps to the D.C. substation due to the nature of the ground outside the orebody, and gunited or timbered and gunited within the orebody.

Haulage System

Haulage is carried out on the 750 level on 36-inch gauge track of 85-lb. rails laid on steel ties. Equipment consists of six 15-ton combination trolley and battery locomotives to haul trains made up of ten 200-cut. ft. (10-ton) capacity solid body tipple cars equipped with rotary couplings, two 3-ton battery locomotives to handle the 40-cu. ft. (2-ton) capacity rocker dump cars with link and pin couplers, 5 passenger cars, and miscellaneous flat cars, powder cars, etc.

Travel in the main haulage loop is in one direction only at a one-half per cent grade in favor of the load.

All train movements are controlled by the dispatcher from a concreted station 12 ft. by 9 ft. by 10 ft. 6 in. high. This station is located at the main diamond crossover of the haulage system situated at the intersection of No. 1 main haulage drift with 1-3 crosscut and No. 2 crossover. Communication between the dispatcher and the 15-ton locomotive is by means of two-way radio telephones, each locomotive having its own set, powered from the batteries, mounted above the controller in the cockpit. There are telephones installed at strategic locations in case of radio failure and for the use of the 3-ton locomotives, which have no radios.

Development of a Block

The first step in the development of a block, which is 200 ft. by 200 ft., is to provide a ready means of access to the sub-levels which are 40 feet apart vertically. To accomplish this, service shafts are provided at strategic locations throughout the orebody, each shaft servicing a group of blocks. At present there are two such shafts in operation, both within the central pillar in the orebody. These shafts are steel timbered, concreted where necessary, and have three compartments with a cageway for a 10-man cage.

Fringe Drifts

From the service shafts, 4 ft. by 7 ft. sub-levels are driven every 40 feet vertically to the block to be developed. The 200-ft. by 200-ft. block is then perimetered on these levels. Drilling is done by jackleg machines using chisel bit ⅞-in. hexagonal steel, and the broken muck is scraped by 36-in. scrapers pulled by air-driven 10 h.p. slusher hoists to 4 ft. by 4 ft. raises



One of the self-propelled single-boom drill jumbos used in most drifts throughout the mine, except in the main haulageways where twin jumbos are used.

driven by diamond drills on each corner of the block. Approximately 33 per cent of these headings must be supported by steel timbers, but 95 per cent of this is recovered before the block is caved. Powder used in blasting the fringe drifts is about equal amounts of 1⅛-in. by 8-in. Forcite and 70 per cent Driftite. In raising by diamond drills 1⅛-in. by 8-in. 55 per cent Stopeite is used. Electric detonation is used throughout. The corner raises terminate in chutes located in the 750 level crosscuts, from which either 10-ton or 2-ton cars may be loaded. Fringe drifts will only be used for initial caving after which panel caving and modified free caving will be applied.

Slusher Drifts

Each block has eight slusher drifts, four on the north and four on the south sides, spaced on 50-foot centres along the crosscuts. Slusher drifts are spaced in blocks on opposite sides of the crosscuts so that although they are on 50-foot centres for any one block they are on 25-foot centres along the crosscuts—the Nos. 5, 6, 7 and 8 of one block on one side, and the Nos. 1, 2, 3 and 4 slusher drifts of another block on the other side of the crosscut. The first step towards the development of slusher drifts is to see that existing steel sets in the crosscut are properly lined and placed to correspond with gangway sets to be put in. The gangway is then excavated, muck is removed, gangway posts and caps stood and a checkered plate floor laid over the crosscut caps. As the excavation advances, slusher stations are cut and timbered, slusher drift lip plates set in place and the gangway and slusher stations concreted.

Slusher drifts are driven normal to the haulage crosscuts from the lip plates at plus one per cent to approximately half way across the block. Excavation is by means of jacklegs, working off the muck for the top half of the round, 10 h.p. air-driven slusher hoists and 36-inch scrapers loading over the lip plates into 10-ton cars. The excavation is a minimum of 10 ft. wide by 13 ft. high, enough to provide 18 inches of concrete in the walls, one foot in the floor and three feet in the back around a finished drift 7 ft. wide by 9 ft. high. Drifts are driven raw if possible, 60-lb. rails laid with their tops on plus one per cent grade from the lip plates and on one foot centres parallel to the length of the drift, the tail pulley post and two H-beam bumper posts stood in place, and the concrete floor poured flush with the top of the rails. These rails have their ends bent down at 45 degrees so that they cannot be torn up by the scrapers. Steel pins are set in the floor along the sides to tie in the walls and floor, and short rails or I-beams stood as posts opposite each drawpoint to hold horizontal bumper rails for the scraper. Slusher drifts are of two lengths. The Nos. 1, 2, 3, and 4 on the south side of a block have only five drawpoints and are 103 feet long, while the Nos. 5, 6, 7 and 8 on the north side have six drawpoints and are 120 feet long.

After the floor is poured the first round is slashed out of each drawpoint and the ventilation stub excavated at the end of the drift. Drawpoints are on 35-ft. centres on the same side of the drift or staggered on 17 ft. 6 in. centres from side to side, the No. 1 drawpoint being 12 ft. 6 in. from the centre line of the crosscut. When this muck is cleaned out, the drift is ready to have the walls and back concreted. Panel and truss type aluminum forms

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with quick-acting clamps to join them are used to concrete the slusher drifts. The 12-inch battery in the top corners of the drifts is built in the forms, and recessed boxes and hanger bolts for the return cables are placed as the forming proceeds. The ventilation stub is formed, the drawpoints bulkheaded off at least 18 in. oversize on all sides, and the walls and back poured.

Draw Points

After the forms have been removed from the slusher drift walls and back, the drawpoints are excavated, using stopers, to a point approximately 12 feet vertically above the slusher drift floor and for a distance of 16 feet along the 45 degrees footwall. This much of the drawpoint is then poured after restanding 7 trusses of the drift forms and clamping aluminum drawpoint forms in place. The finished drawpoint opening is 8 ft. long by 4 ft. 6 in. high.

When the drawpoint forms have been removed the drawpoints are ready for the final stage in their development from the slusher drift. This consists of driving a slot 5 ft. wide by 25 ft. long on the centre line of the drawpoint, normal to the slusher drift, to the undercut level floor, using stopers. Normally at this stage of development the 125 h.p. slusher hoists have been installed in the stations and the 72-inch scrapers set up in the slusher drifts.

Undercutting

Simultaneously with the foregoing development on the sub-levels and from the 750-level, undercutting by diamond drilling is in progress on the first sub or undercut level. First, three 7-ft. by 8-ft. undercut drifts are driven 200 feet completely through the block directly above and parallel to Nos. 1, 2 and 3 slusher drifts. Diamond drills are then set up in the undercut drifts and fringe drifts to cut out a 200-ft. by 200-ft. slice 7 feet high and to shape the drawpoints bells. This entails drilling approximately 50,000 feet of 1⅝-in hole, some drilled by blasthole bits and some cored, depending on the ground.

The spotting and lining up of these holes must be done very accurately and requires careful and constant checking by the supervisory and engineering staffs. Both 1-ft. and 2-ft. rods are used in conjunction with air-driven 16-h.p. high-speed blasthole drills.



This photo shows a completed section of one of the slusher drift forms. It is constructed of truss-type panels made of aluminum and is clamped together for easy installation and removal.

Undercut Blasting

Just prior to loading the diamond drill holes each hole is carefully numbered with paint and blown out to free it of water or loose muck. If a hole is blocked, everything possible is done to open it up for its full length, but if this is impossible it is marked in the records. As the loading goes on a careful record is kept on the total loaded length of each hole, along with the number of sticks of powder compressed in that length. Powder used is 1⅛-in. by 8-in. 40 per cent Forcite, compressed to 2.25 sticks per foot of hole by sectional hardwood tamping rods. Holes are normally loaded to approximately 6 feet from the collar before priming, as the blasting caps used have 10 ft. length leg wires.

Priming is carried out to a carefully pre-arranged layout using C.I.L. short period delay electric caps numbered 1 to 15. These caps have a delay of only 25 mili-seconds between each cap of the first eight delays, and 75 mili-seconds between each of the remaining delays up to number 15. It is most important to follow the priming plan as the shot is planned to break the ground within the cone of each drawpoint and immediately above it as high as the undercut roof sideways, and downwards into the slot already excavated.

No connecting up is done until all loading and priming has been completed and the records checked to balance the series. Prior to connecting up No. 10 plastic covered flame seal wire is strung on insulators through the first sub-level drifts to the top of the ventilation raise into a safety switch. This switch is a double throw 60-ampere switch with one side shorted and is kept locked in the shorted position. From here the wire is run down the ventilation raise and into the D.C. Substation, where it terminates in a plug kept in a shorted socket, near the locked blasting switch.

Usually one-third to one-half of a block is shot at any one time. The amount of powder used for the normal shot is between 14,000 and 15,000 lbs. This is equivalent to 1.36 lbs. of powder per ton of rock broken in an undercut blast.

Production

Production is attained by loading direct from the slusher drifts into 200-cu. ft. tipple cars by means of 125-h.p. slusher hoists and 72-inch scrapers drawn by 1¼-in. steel cables. Slusher hoists have rope speed of 260 f.p.m., are equipped with electrically operated remote controls over air-actuated instantaneous clutches, and are powered by 125 h.p. 2200 volt A.C. motors. Both 72-in. rigid and 72-in. folding type scrapers, equipped with patented hitches for the ropes, are in use. The 1¼-in. return cable passes around an 18-in. tail pulley mounted on a vertical 14-in. reinforced H-beam tail post and protected by two 10-in. bumper posts, and back to the hoist. Between the hoist and the tail pulley the cable is held up to the back of the slusher drift by two 1-in. return rope idler pulleys.

Each slusher drift is illuminated by a sealed beam floodlight mounted in front of the slusher hoists. The loading point is the full width of the slusher drift and the steel loading lip projects 6 inches inside the near edge of the 200-cu. ft. tipple car positioned below. On the opposite side of the crosscut to the loading lip a steel spill door is suspended to deflect material which might otherwise overshoot the car, back into it. Cars are loaded to between 8 and 9 tons by two or three passes of the scraper in average material.

Secondary blasting of hang-ups and large chunks in drawpoints and slusher drifts is done as required. Drawpoint hang-ups are bombed by fastening a bomb of from 5 to 50 sticks of 1¼-in by 8-in. Forcite to the end of a rolled sheet metal blasting pole and placing it in the desired position up in the drawpoint. Rocks which have passed through a drawpoint but are too big to load are drilled and blasted in the slusher drift. Instantaneous caps and ordinary "A" batteries are used to detonate secondary blasts from the crosscuts. Secondary powder consumption in 1951 averaged .26 lbs. per ton of rock produced from the slusher drifts. However, as a larger area is opened up this figure shows a tendency to decrease.



A completed concrete slusher drift showing one of the drawpoints.

As mentioned previously, actual production began in February, 1950, when the undercut of the first block was blasted. From that date, underground production has been steadily increased and in August, 1951, the mine was producing to the present No. 1 shaft capacity of 12,000 tons per day. This has been made possible by accelerated development and consequent opening to production of other areas. At the time this article is written, ore is drawn from some 3½ blocks altogether.

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