1927

Fluorspar mining and milling in southern Illinois

Henry William Hurst

FLUORSPAR MINING AND MILLING IN SOUTHERN ILLINOIS.

BY

HENRY WILLIAM HURST.

A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree Of

ENGINEER OF MINES.

Rolla, Missouri.

1927.

Approved by C.R. Forbes

Prof. of Mining

TABLE OF CONTENTS.

TABLE OF CONTENTS.

General Statement.

Fluorspar is fully as necessary a material in certain phases of steel manufacturing as the metal that enters the furnace. Without it, the basic open hearth practice probably would not have reached its dominant position among steel-making methods. Of the entire output of fluorspar, 80 to 85 percent is used in basic open-hearth and electric furnaces as a flux and detergent and there is today no known substitute.

The mining of the ore on a large scale requires extensive underground workings, much the same as is found in metal mines. Since high extraction can not be accomplished the milling of the ore is very easy.

Small scale operations are rapidly disappearing as the ore near the surface is mined out. Deep mining necessitates a large investment in expensive equipment.

Three large companys now practically control the output of this district. One of these, the Hillside Fluorspar Mines, has the newest mine and mill emboding the latest mining and milling methods, and therefore will be used as the source of information for the following pages.

Location of the District.

The Illinois fluorspar district is geographically located in the extreme southern part of the state. Geologically it is a part of what is generally known as the Kentucky-Illinois fluorspar field which covers part of Hardin and Pope counties in Illinois, and Crittenden, Livingston and Caldwell counties in Kentucky.

History of the District.

The first record of mining in the district goes back to 1842, when fluorspar and galena were mined in the now well known Rosiclare Vein. Fluorspar, however, was of little value at the time and all efforts were directed to the mining of galena. The galena, in most cases, was found in pockets or thin veins along the walls of the vein. This necessitated the removal of much fluorspar for which no market could be found. Heavy flows of water, inadequate equipment for mining and milling and practically no market for fluorspar effectually prevented any real development of mines until nearly 1880.

History of the District.

The adoption of the basic open-hearth process of treating steel by the steel industries marked the turning point, upwards, in the consumption of fluorspar. The greater demand for fluorspar lead to a systematic development of the mines. Production was fairly steady until 1907. Since 1907 there has been a steady increase in the production except during slump years when the production of steel fell off. The years 1914 to 1919 mark the most properous period in the life of the district, followed by a depression from 1919 to 1923, and a gradual revival toward normal operations from that to the present time. Importations of fluorspar now supply more than half of the normal tonnage required by the industries and thereby work a hardship on the domestic producers of fluorspar.

Ores and their Occurrence.

The ores of economic value are given in the order of their importance.

Fluorite: CaF_2, a non-metallic mineral commonly known as fluorspar is the predominating

Ores and their Occurrence.

mineral and the only mineral found in sufficient quantities to permit profitable production on a large scale. It occurs in glassy transparent cubes, cleavable masses and in lens. The masses or lens vary from 6 to 30 feet in width, 50 to 300 feet in height and up to 600 feet in length. Less commonly the ore is grandular or fiberous in structure, and occasionally occurs as banded spar. It has a specific gravity of 3.2, is brittle, has a hardness of 4 and can easily be scratched by a knife. Chemically it consists of calcium and fluorine in the proportion of 51.1 to 48.9. In color fluorspar ranges through all of the colors of the rainbow, varying according to the degree of purity, from a clear colorless glossy substance, optical spar, to a dark purple or green mass.

Galena; PBS, lead sulphide is found throughout the vein. Commercial quantities of it, however, are sometimes found in pockets or irregular masses in the fluorspar and calcite vein material. Small seams of galena often occur along the walls of the vein in the lower levels.

Ores and their Occurrence.

Cerussite: $PbCO_3$, occurs in small quantities in the upper levels, insufficient, however, for commercial consideration.

Sphalerite: ZnS, is found in large quantities in the southern end of the Rosiclare Vein. Zinc ore has not been found in the Hillside mines to date.

Calcite: $CaCO_3$, is found in large quantities as a vein filling material throughout the veins and is commonly classed as gangue. Some attempts have been made to utilize it as a fertilizer and as a grit for chickens. In present day milling practice it is all sent to the dump.

Grades and their Uses.

Gravel spar constitutes the bulk of the mill product and is sold on a basis of not less than 85 percent calcium fluoride and not over 5 per cent silica at an average price of 18.60 dollars per ton.

The steel industry consumes over 85 per cent of the gravel spar produced in the United States as a flux for the basic open-hearth steel process. This flux is valuable principally for giving fluidity to an otherwise viscous slag and at the same time aiding the slag in the absorption of such impurities as sulphur and phorphorous.

Gravel spar is also used in the enameled and sanitary ware industries; as a flux in some blast furnace operations and in iron and brass furnaces; and in the bond constitutents of emery wheels.

Acid Lump spar is second in importance, due to its higher selling price. Average market price is 30.00 dollars per ton on a basis of not less than 98 per cent calcium fluoride and not more than 1 per cent silica per ton. Lump spar is sometimes shipped as lump for use in some foundries, or ground to pass through 30 mesh as required in enamel manufacture, glassware and porcelain glazing and like uses. It is ground to pass through 55 mesh for the production of hydrofluoric acid, sodium fluoride and other chemicals. All ground spar sells at higher prices, varying from 2.50 to 7.00 dollars more per ton then lump spar. Foundry Lump, a distinct grade differs from gravel spar in that it contains no fines. The chemical

Grades and their Uses.

analysis is the same as for gravel spar but it sells for 2.00 dollars more per ton. As the name implies most of this grade is used by the foundries. The enamelware industries use small tonnages of this grade.

Small amounts of fluorspar are used in the smelting of gold, silver, and copper ores; in the refining of copper, antimony and lead; in the bond of carbon electrodes; in the extraction of potash from feldspar and from the flue dust of Portland cement works.

Strategrahy and Structure.

The strata of this region have been folded to form an immense dome. The subsequent intrusion of igneous dikes and sills caused further rock deformations with differential settlings of large blocks, accompanied by the formation of large fissures and faults. These fissure and fault planes provided channels through which the mineral bearing solutions circulated, depositing fluorite, galena, sphalerite and calcite where conditions were favorable. Not all of the fissures contain ore, nor are all of the ore deposits in fissures. The main fissure, now known as the Rosiclare Vein, is producing about 85 per cent of the fluorspar mined in this district. The dip of this vein is to the west but is so small that it may be considered vertical as far as mining operations are concerned. The strike is Northeast Southwest, the surface being covered by overburden.

The total movement along this fault has not been determined though displacements of more than a 1000 feet have been noted. Due to the extensive movements along this fault,shear zones are common and minor or relief faults often occur at some distance from the

Strategrahy and Structure.

main fault. These lesser faults or fissures often contain ore bodies of commercial importance.

It is believed that calcite was the first mineral to be deposited in the fissure. Changes in the character of the circulating waters and often a further series of rock movements then caused the calcite to dissolve and be replaced by fluorite accompanied by lead and sometimes zinc.

Clearly defined slickensides within the ore bodies in many places prove that post-mineral movements took place. Much of the lead ore is found along these post-mineral fault planes, indicating a secondary deposition of mineral.

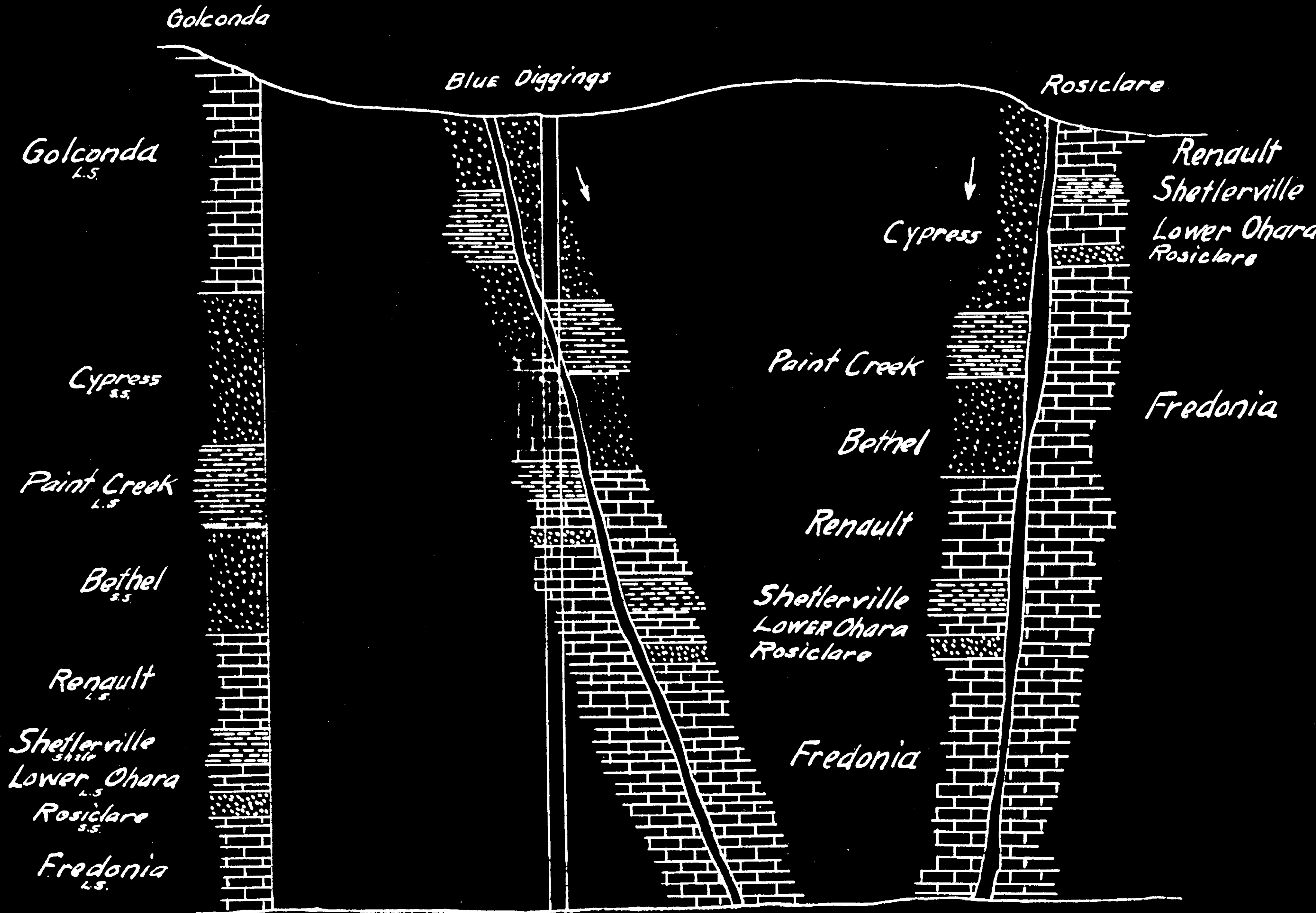
System	Group		Formation	Thickness in Feet	Names of Members
Mississippian	Chester	Middle	Glen Dean Ls	50-70	
			Hardinsburg SS	30-100	
					Unconformity
			Golconda Ls & Shale	150	
			Cypress SS	80-100	Unconformity
		Lower	Paint Creek Shale	40-50	Unconformity
			Bethel SS	50-100	
					Unconformity
			Renault Ls	50	Unconformity
			Shetlerville Ls & Shale	30	Unconformity
	Meramec		Ste. Genevieve Ls	20-50	Lower Ohara Ls
				15-30	Rosiclare SS
				150-200	Fredonia Ls
			St. Louis Ls	350	
			Warsaw Ls	250	

A PART OF THE GENERALIZED SECTION OF THE ROCKS OF HARDIN COUNTY

FROM BULLETIN NO 41, PLATE 1 ILLINOIS STATE GEOLOGY SURVEY.

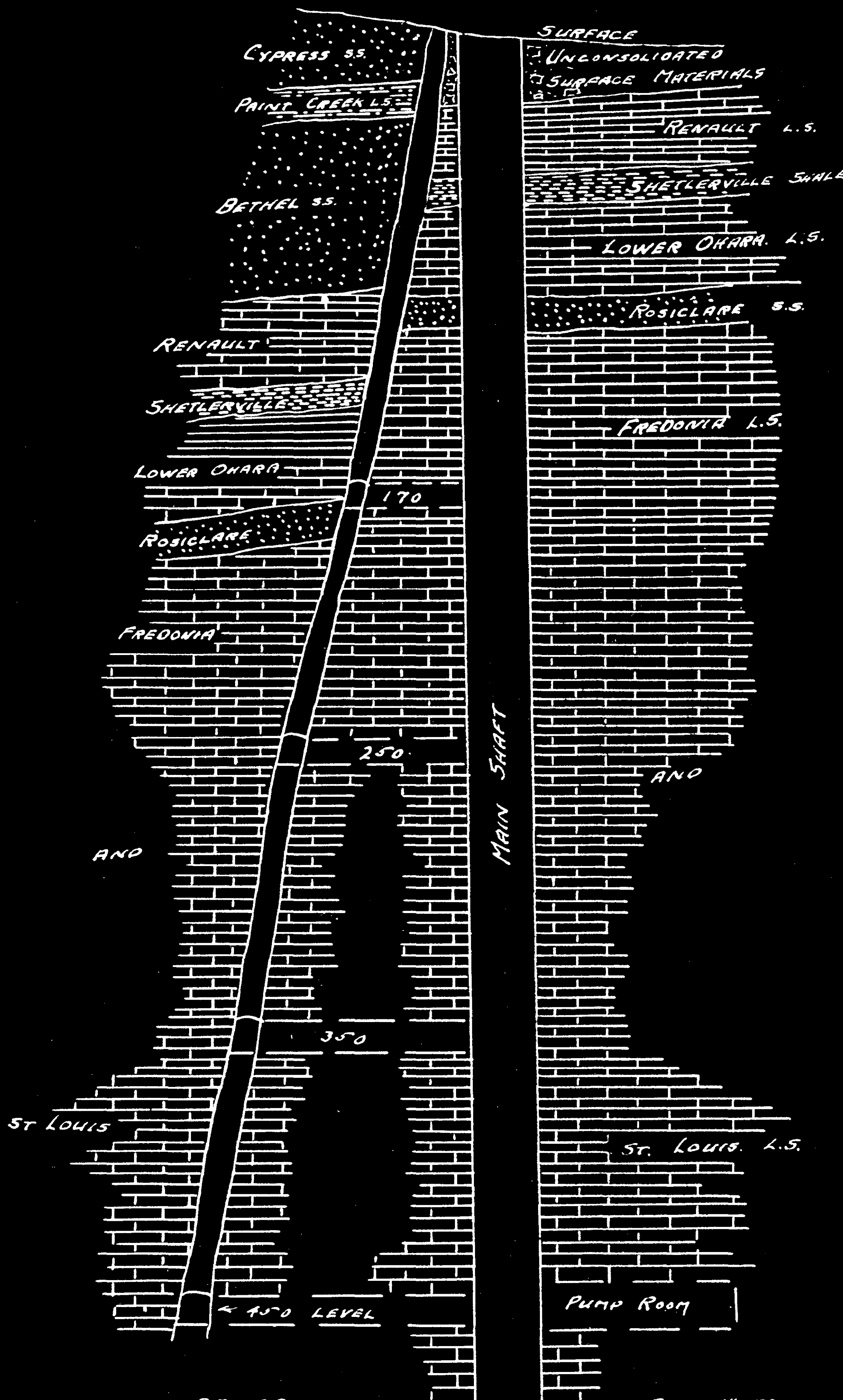
General Section E & W showing Known Faults

Scale 1" = 100 FT.



Idealized geologic section to show vein relationship.

G-1A



GEOLOGIC
SECTION THRU
HILLSIDE SHAFT & VEIN

SCALE 1" = 50 FT

G-1

Location and Description of Mines.

The three largest mines, the Rosiclare Lead and Fluorspar Mining Company, the Franklin Fluorspar Company and the Hillside Fluorspar Mines, are located within the city limits of Rosiclare, Hardin County, Illinois and are within a radius of one mile of the Ohio River. Up to the year 1919 the Ohio River was the only means of transportation and Hardin County was one of the two counties without a railroad connection of any kind. In that year the railroad was extended from Golconda to Rosiclare and all shipments are now made by rail.

Method of Development.

In many cases the continuity of the vein is assumed and projected through the property to be developed. Diamond drill holes are then put down at frequent intervals on an angle calculated to cross the vein. This is continued until the vein has been definitely located, and the thickness of the ore determined. The shaft is then sunk on the footwall side of the vein.

Shafts.

The usual practice of large companies is to sink

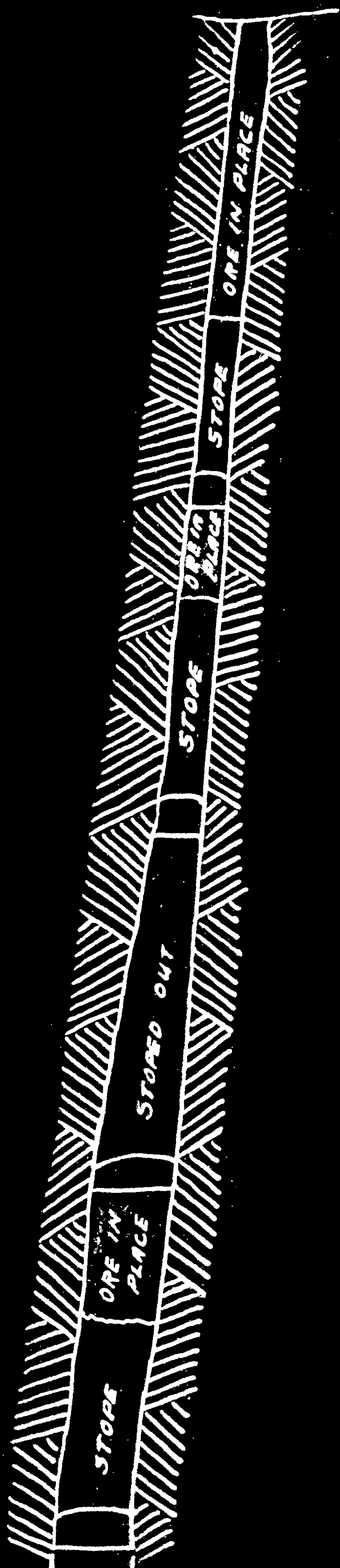
Shafts.

the shaft deep enough to open several levels at 100 foot intervals, and large enough to finish inside the timbers about 15 feet by 5 feet 6 inches. This gives ample room for two compartments for the skip and cage with a third compartment for a ladderway, air, water and power lines. The shafts are usually concreted down to the solid rock which is limestone and stands well. Square sets are not necessary, the guides are supported by divider timbers set into hitches cut in the rock.

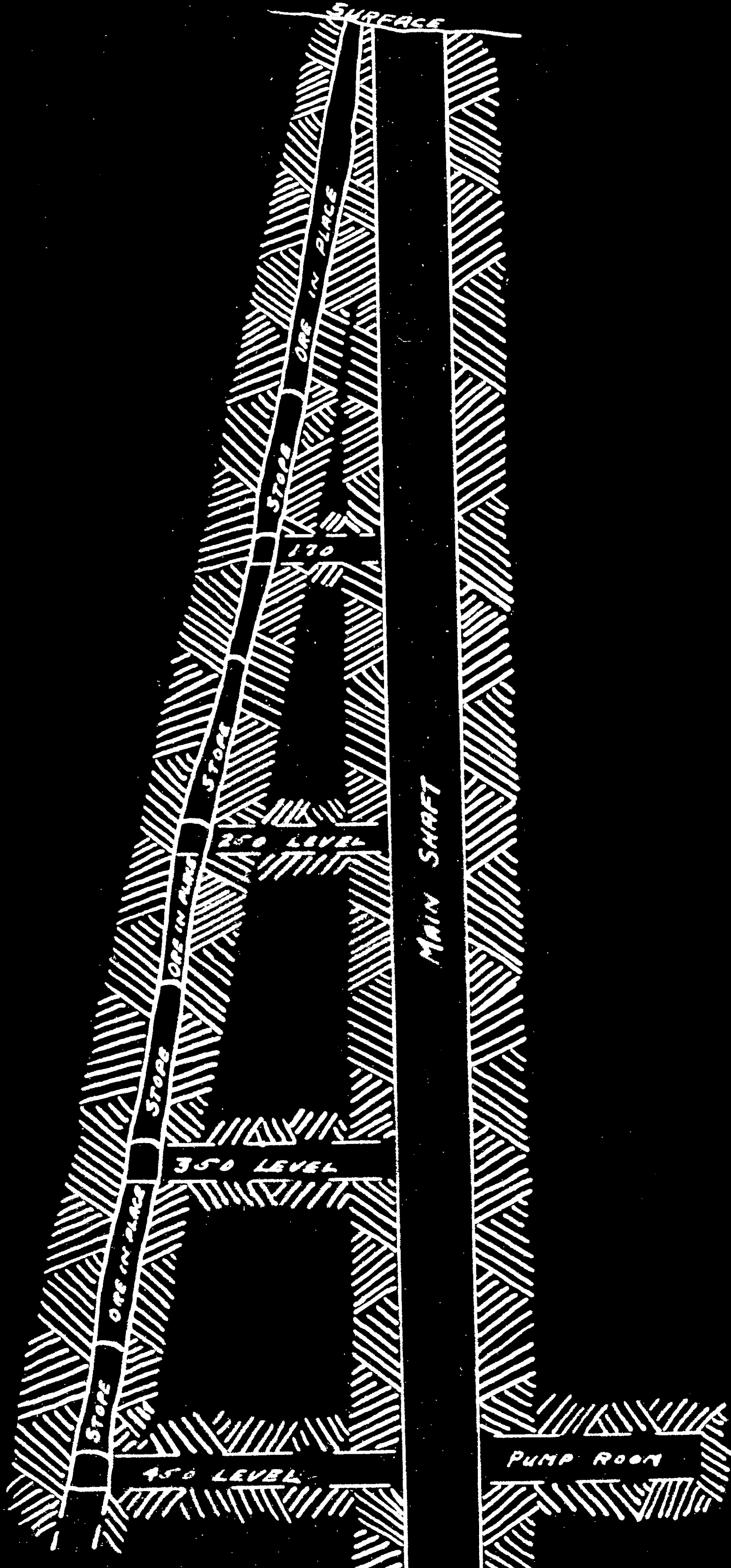
Drifts and Levels.

Drifts from the shaft are driven to cross the vein and are usually 12 feet wide by 7 feet high. This gives ample room for double track, necessary water, power, and air lines, also a drainage ditch. These drifts are usually in limestone, like the shaft they require no timbering. Rock that works loose, due to exposure to the atmosphere, is barred down from time to time without any interruption of the normal operation of the mine.

Levels are driven in the vein in both directions from the crosscut drifts. (See plan or stope section)



SECTION
THRU
STOPE—N. 1800



SECTION
THRU
HILLSIDE SHAFT & VEIN

SCALE 1" = 50 FT.

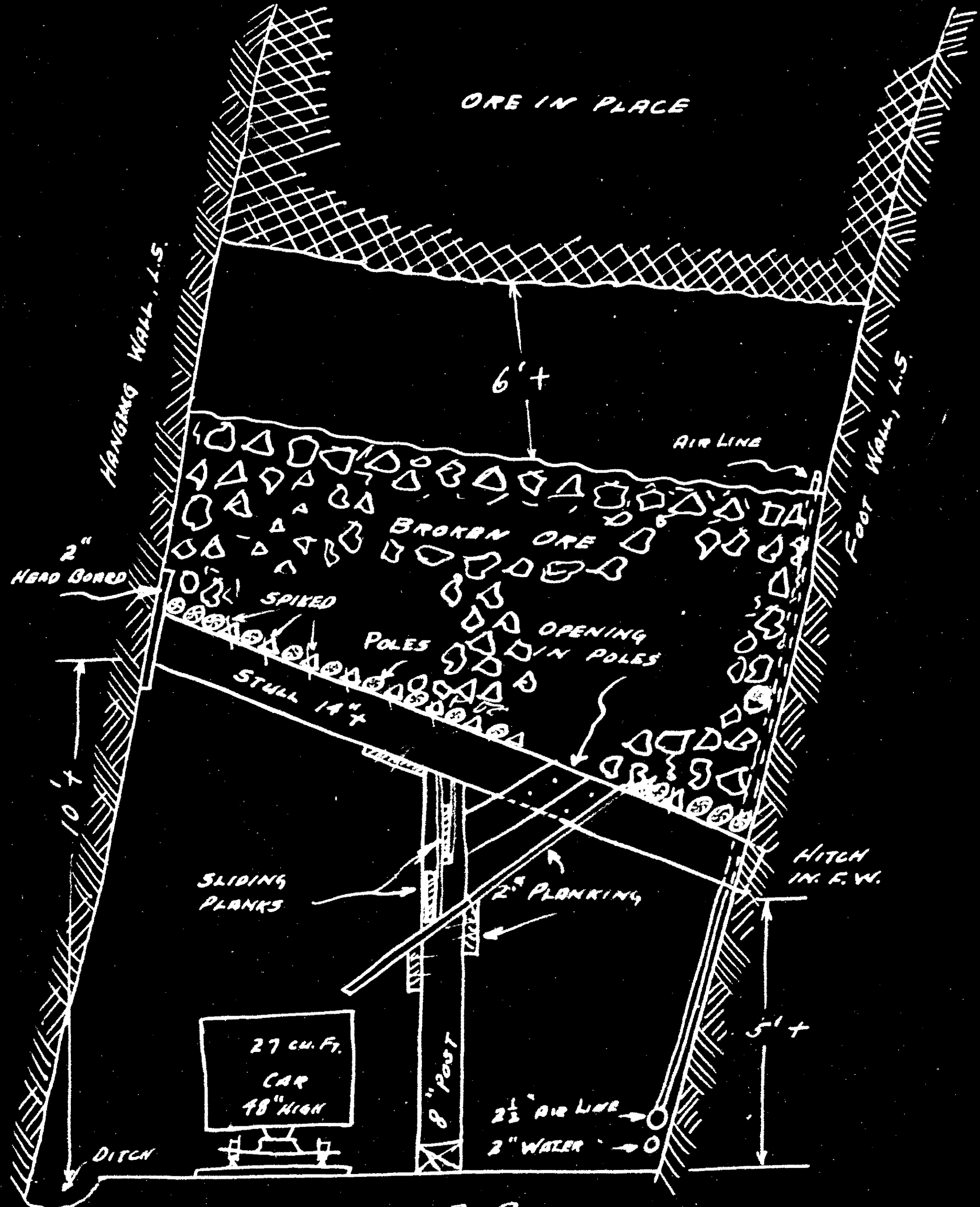
V-2

Development of Level.

When in ore the levels are driven the full width of the ore and 12 feet high on a 1 per cent up grade from the shaft. The heighth of the level gives the necessary headroom for the stulls that are later put in. Hitches are cut in the footwall at intervals of 6 feet and about 5 feet above the floor of the level, and the stulls are placed across the level heading against the hanging wall about 10 to 12 feet above the floor of the level. See sketch U-3. The heighth of the head and diameter of the stull are determined by the width of the level at each respective point. The stulls are then covered with poles.

The latest practice, however, in development is to drive the level the width of the ore and about 7 feet high. Then raises, on 25 foot centers, are driven up about 20 feet and connected by a sub-level. This method, see sketch No. U4, leaves an arch between chutes and between the level and the broken ore above. It also elliminates the replacing of broken stulls, caused by fall of wall rock after the stope has been drawn out.

When the older method is used much additional



STOPE SECTION A-A

SKETCH. NO SCALE.

Development of Level.

expense is added to the mining cost when a mud or water pocket is encountered in the stope. The mud and water act as a lubricant along the walls of the stope, reducing the friction and transferring all of the weight down on the poles and stulls with resulting disaster. When this happens stulls must be doubled and many broken stulls replaced. The practice of leaving arches is, therefore, rapidly gaining favor.

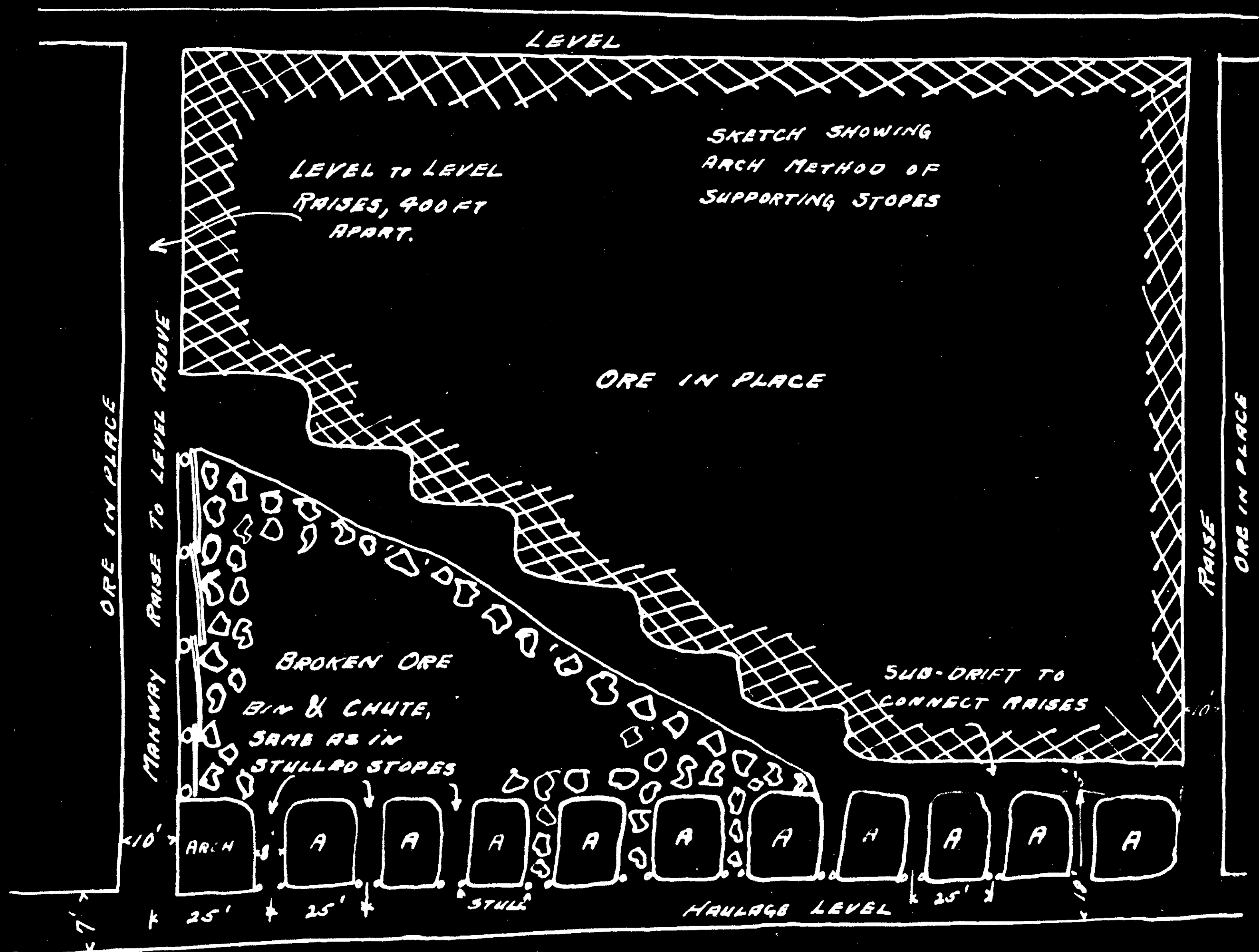
Bins and Chutes.

Where stulls are used bins and chutes are built between alternate pairs of stulls. The bins are built of round timbers and sawed planking with movable gate pieces. The lip of the chute extends over the tram track and clears the top of the cars at least three inches. See sketch No. U-3.

Where raises are driven for opening a stope a bin and chute is built in each raise. See sketch No.U-4.

Raises.

Raises are driven from level to level at the end of each stope. They serve as manways to the stopes, as a bulkhead and ladder extends from level to level. After the stope has mined out the raises serve as ore


LEVEL
SKETCH SHOWING
ARCH METHOD OF
SUPPORTING STOPES
LEVEL TO LEVEL
RAISES, 400 FT
APART.
ORE IN PLACE
ORE IN PLACE
MANWAY RAISE TO LEVEL ABOVE
RAISE
ORE IN PLACE
BROKEN ORE
BIN & CHUTE,
SAME AS IN
STULLED STOPES
SUB-DRIFT TO
CONNECT RAISES
10'
ARCH
A
STULL
25'
HAULAGE LEVEL
7'

U-4

Raises.

passes and at all times as air ways. Most of the raises are driven on contracts of a stipulated amount per foot of raise, the company furnishing all equipment and explosives.

Stoping.

As soon as a sufficient number of bins and chutes have been constructed, stope work is started by taking a light cut the length of the completed bins. The first cut of stope must not be too deep or shot very hard. Carelessness at this point will result in many broken poles, bins and sometimes stulls. After a cushion of ore is formed on the poles, there is no danger of breaking through by subsequent shots. The miners, using Ingersol-Rand stopers, then work the length of the stope, always striving to maintain a uniform level of broken ore if possible, while the broken ore is being drawn out through the chutes. A distance of 6 feet between the back and the top of the broken ore is considered the best working condition. The stope is worked up to within a few feet of the level above. Here an arch is left to protect the level above. The

Stoping.

thickness of the arch is determined by the width of the stope and the level above and varies considerable, as some of the stopes vary from 6 to 35 feet in width. See sketch No. U-4 and U-5.

Tramming.

As a general rule electric and gasoline motors are used for tramming the cars. The type and size of motor used in this district is capable of handling five loaded cars. Two types of ore cars are used; the side dump, 40 cubic foot capacity mounted on ball-bearing trucks and the swivel bodied, end dump, 27 cubic foot capacity mounted on ball-bearing trucks. The smaller car is used in all cases where hand tramming is practiced.

The cars are stopped under the chutes and filled with ore by raising the chute gates. Large boulders often clog the chute and require bull-dozing, while a free running chute will fill the car and drift if care is not exercised by the trammers. A few cars of ore are drawn from each chute thereby allowing the stope to settle uniformly.

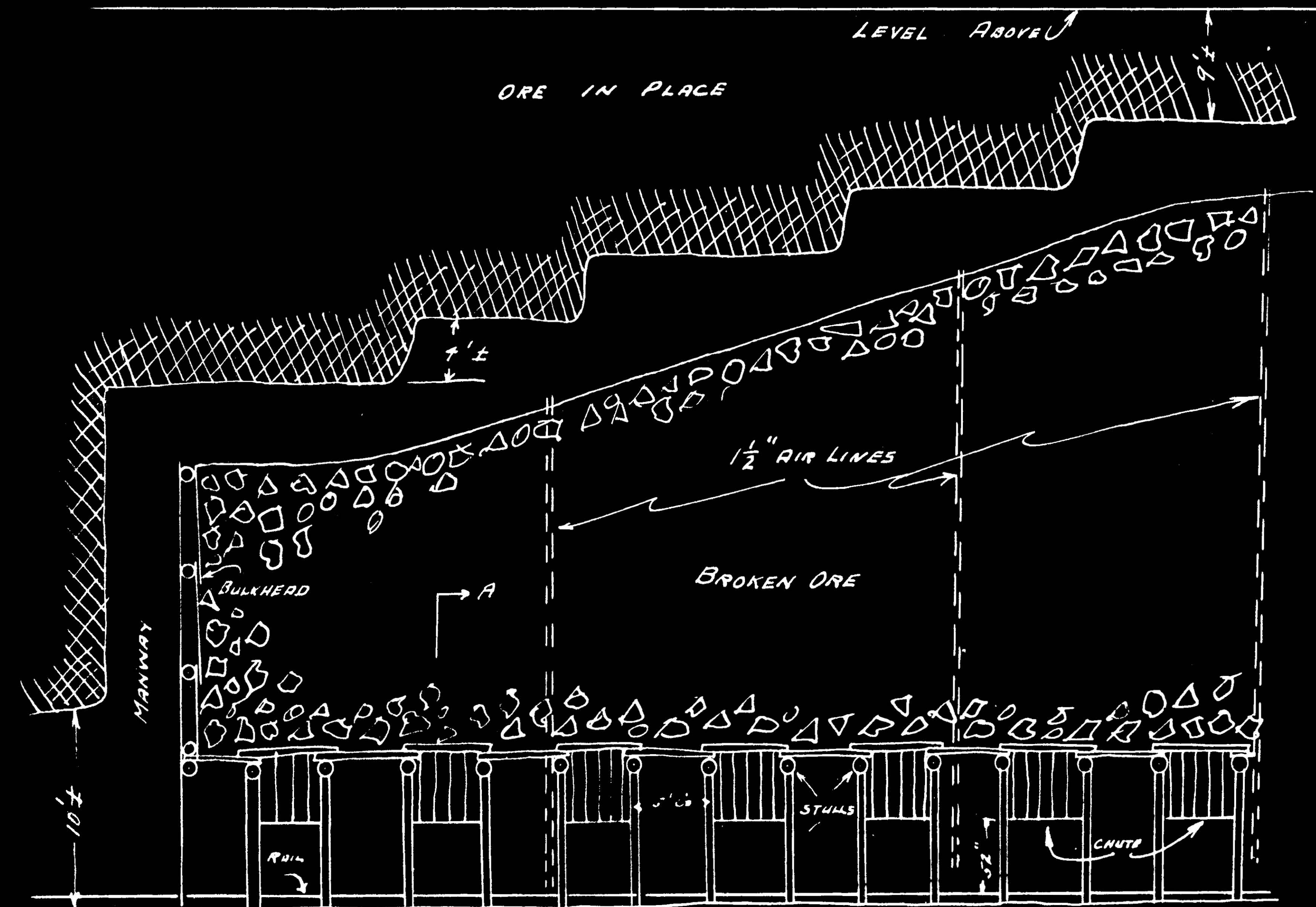
Tramming.

When drawing from raise bins there are no restrictions as the ore is being dumped into the raise on the upper levels with the idea of getting it to the main tramming level.

All ore is dumped through a grizzley into the shaft ore pocket. The grizzley has 9 by 12 inch openings. Here much of the waste rock, that too large to go through the grizzley, is picked off, later to be hoisted in cars to the surface and dumped. Ore too large to go through the grizzley is pounded through with sledge hammers.

Hoisting.

The ore is hoisted in a self-dumping skip which is loaded from air controlled gates in the shaft side of the ore pocket. A 5 ton skip is operated in balance with a cage by a Nordberg, double drum electric hoist. This hoist has cylindrical drums 5 feet in diameter, hydraulically operated post brakes, and Lilly safety controllers and is geared through herringbone gears to a 150 hp., 2300 volt General Electric Co. induction motor. A rope speed of 600 feet per minute is sufficient for the tonnage required.



SKETCH OF SECTION IN PLANE OF STOPE.

Drainage.

Large flows of water are encountered in normal mining operations which necessitates constant pumping. Ditches are shot out near one wall of the drifts and levels, and all water is directed to a main sump near the shaft. Massive concrete bulkheads are constructed in the cross-cut drifts leading from the shaft to the vein. When a large water pocket is encountered, or an unusually large flow of water takes place these bulkhead doors may be closed and the flow of water to the pumps regulated by the valves and pipes that extend through the bulkhead. The normal flow of water at Hillside is about 250 gallons per minute; other mines in this district have had as much as 6000 gallons per minute.

Experience has shown that the triplex plunger type of pumps are well adapted to the waters of this district. The water is usually clear and contains no acid and is used throughout the mill and power plant. Porcelain plungers are now being used in the pumps and are giving excellent results.

The large flows of underground water, and auxiliary air shafts assure good ventilation and an even temperature in the mine.

Mill Building.

The newer mill buildings are constructed of reinforced concrete and structural steel; they have a large area of window space in the side walls and many skylights in the roof, with a special glass roof over the picking belts. Mechanical equipment, electrically driven, is provided for all milling operations and is so carefully located that the ore moves in a logical sequence with no unnecessary handling or elevating.

Operation.

The importnt feature of the newer mills is that each piece of milling equipment has an individual motor drive; and in case of a choke-down or breakage it is not necessary to shut down the entire mill or department in which the trouble occurs. Exhaust steam from the power house is used for heating purposes, and live steam is used only for the dryer.

Sorting.

A reciprocating feeder feeds the mine run ore into a revolving washing screen made of punched plates with 3/4 inch holes from which the oversize goes to the picking belt and the undersize to a

Sorting.

Leahy vibrating screen. See the flow sheet for the complete path of the ore. The three compartment picking belt has a speed of about 18 feet per minute and passes between two rows of waste pickers. The pickers near the head of the belt remove the coarse sizes of waste, limestone and calcite, throwing it into a bin beneath the belt from which it is drawn out into cars and trammed to the dump or into trucks for use on the roads and streets. The other pickers remove the various grades of lump spar wanted at the time, and place it in the middle compartment of the belt, from which it goes direct to storage bins.

Crushing.

The ore remaining in the two side compartments of the picking belt is discharged into a 24 by 12 inch Blake jaw crusher from which it is passed to a set of 36 by 18 inch rolls and into a 50 ton bin. A second set of rolls, 24 by 12 inch, over the same bin receive the oversize of a revolving scalping screen, 4 by 12 feet, punched plates with 5/8 inch holes. A third set of rolls, 24 by

Crushing.

12 inch are used for crushing the lead middlings. These middlings do not return to the main mill feed circuit as will be seen on the flowsheet.

Sizing.

From the crusher bin the ore passes through an automatic feed gate to the main elevator, which has 18 by 8 by 8 1/2 inch buckets and travels 140 feet per minute, and empties into the above mentioned scalping screen. The oversize material, plus 5/8 inches, returns to the rolls for further crushing, while the undersize material goes to the trommels for further sizing. No 1 trommel, 42 by 96 inches has 7/16 inch holes, oversize goes to a jig set to operate efficiently on that particular size of ore. The undersize goes to trommel No. 2, same size, but with 1/4 inch holes. Again the oversize goes to a jig and the undersize goes to No. 3 trommel, same size, but with 1/8 inch holes. The oversize for this trommel also goes to a jig while the undersize goes to No. 4 trommel. No. 4 trommel has 2mm holes, the oversize goes to a jig and the undersize goes to the table department for treatment.

Concentration Methods.

The general practice is to use jigs for the coarse sizes of materials and tables for the fine sizes. The Harz 5 compartment type jig is in use throughout the district. Each jig receives its feed from its respective trommel and produces a hutch and a drawoff concentrate, the tailings go directly to the dump. If the ore is high in lead, as the Hillside ores are, each Harz jig is preceded by a Richards pulsator jig which takes the entire feed from the trommel, removes the lead and passes the rest of the feed to the Harz jig. The Harz jigs are constructed of reinforced concrete. See the flowsheet for sizes,and etc,

Tables are used for all sizes of feed below 2mm., with very good results. Each table produces a lead concentrate and a spar concentrate, middlings, which go to secondary tables, and tailings. Butchart, Plat-O and Diester-Overstrom tables are used interchangably with good results. Each mill works out a plan for riffling tables to best meet the requirements of its particular ore. And since each mill ore varies from the rest no set plan can be used. Jigging, however, is uniform.

Drying.

All lump spar that is picked off the belt to be treated in the fine grinding department must be dried before it can be crushed. To obtain the right dryness, the receiving bins, usually of rectangular steel construction with hopper bottoms, are partially lined with steam pipes. After the bins are thoroughly heated a steady stream of dry spar is drawn off through the gates in the bottom of the bins.

Fine Grinding.

The lump spar drawn from the dryers goes to a 9 by 15 inch Blake Crusher, then through a No. 1 Sturtevant Ring Roller Mill for final grinding. The product from the roller mill goes to a 36 by 60 inch Hummer separator, which removes all spar that has been ground to the required mesh. The screens used in the Hummer separator vary from 20 mesh to 60 mesh, though the use of a 52 mesh is the general practice. The oversize from the screen returns to the roller mill for regrinding, the undersize goes to storage bins, later to be sacked, put in barrels or shipped in bulk as the trade may demand.

Power.

A well equipped power house furnishes electrical power for all mining and milling operations. The boiler room equipment is as follows: four Erie City 150-hp. horizontal return tubular, 72-in. x 18-ft. 150-lb. suspended setting, hand-fired boilers, set in two batteries and equipped with balanced draft. Two Cameron horizontal plunger boiler feed pumps, 12 x 6 x 18 inch and a feed water heater.

The engine room equipment is as follows: one Chuse non-releasing 18 x 21 inch Corliss engine, direct-connected to a General Electric 210 kva. 2300 volt, 3 phase, 60 cycle, 200 r. p. m. alternator, and one Chuse non-releasing 23 x 28 inch Corliss engine, direct-connected to a General Electric 450 kva., 2300 volt, 3 phase, 60 cycle, 150 r. p. m. alternator, both units have belted exciters. Two steam-driven Ingersoll-Rand Co. air compressors supply 2950 cubic feet of air per minute, one is a type X.P.V.3 with a capacity of 650 cubic feet per minute and the other a No.10, 2 stage, with a capacity of 2300 cubic feet per minute.

The pump house contains two 1000 g. p. m. motor-driven centrifugal pumps. These pumps lift water to a 50,000 gallon tank which supplies the mill, power

Power.

house, and all dwellings and fire hydrants with water.

Shipping.

The Golconda branch of the Illinois Central Railroad serves this district with two trains each way daily.

A spur track serves each mine, coal and other supplies are brought to the plants and all concentrates are loaded direct from the storage bins to the cars by belt conveyors. When the ore is stored in piles in the open, clam-shell shovels are used for loading into railroad cars.

The bulk of the gravel fluorspar shipments are made in open coal cars, which have a capacity of 50 to 55 tons. Acid lump, ground or sacked spar is shipped in boxcars.

Bibliography.

Geology.

Illinois State Geological Survey Bulletin No. 41.

The Geology of Hardin County and the adjoining part of Pope County, by Stewart Weller.

INDEX