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FIELD MUSEUM OF NATURAL HISTORY

CHICAGO

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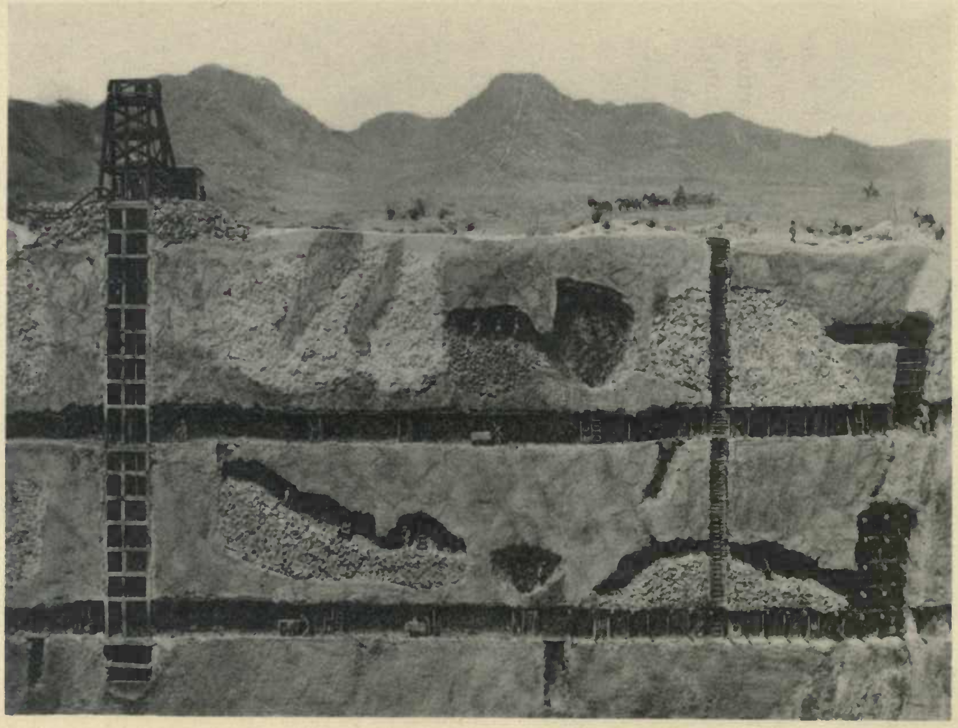

MODEL OF AN ARIZONA GOLD MINE.

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DEPARTMENT OF GEOLOGY
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Model of an Arizona Gold Mine

This model represents a small gold mine of medium richness in a vertical quartz vein six feet wide. The vein and mine workings are presented in section, that is, as they would appear if they were cut through along the center of the vein and one-half removed.

This model is intended to illustrate the ordinary features present in some form in the great majority of all metal mines and to show the orderly manner in which mines are developed and the ores extracted.

Great diversity in the nature and structure of ore deposits compels a corresponding variety in the details of workings by means of which the ores of these deposits are extracted.

However diverse these details may be, they all may be grouped as parts of major features which are common to nearly all metal mines.

In this respect these excavations resemble the more familiar structures on the surface. As buildings, however much as they may differ in appearance, are all built up of units, as walls, floors, windows and doors, so these underground workings are composed of groups of such units, as drifts, cross-cuts, stopes, raises, etc.

There are some exceptions to this rule. The great open-cut mines of the Great Lakes Iron Ranges, for instance, are merely great quarries. In certain developments of caving systems of mining some features of the ordinary type are nearly unrecognizable or quite absent. Coal mines and mines worked along the lines of coal mines have developed a nomenclature of their own for many of these features.

The mine represented in this model is a small one in a vertical vein in hard rock. The rock is very firm at the left near the shaft and becomes less solid to the right, where the vein is intersected by another one in a weaker and more broken rock which tends to cave and fill any openings made in it. The mine is in a region where timber is expensive and where there is but little water. Electric current developed by water power is available for power. The methods of mining employed are those suited to these conditions.

The vein forms the entire vertical front of the model. Its intersection with the surface of the ground is its OUTCROP. Near the shaft and for the greater part of its length, the outcrop is covered by soil. Towards the right of the model the outcrop of the vein appears above the soil in two places, where it can be distinguished from the surrounding rock by its darker color. This dark brownish-red color is due to the presence of large quantities of oxides of iron which are residues left from the destruction by weathering of some of the original vein minerals. Such an iron-stained outcrop is called an IRON HAT.

Not all veins develop an iron hat, but most of them present at their outcrops color contrast with their surroundings by which they may be readily traced wherever they are not covered by soil.

THE ORE in the upper part of the mine is a weathered and iron-stained quartz. The values lie in minute particles of free gold disseminated through this quartz. In the lower levels this ore is replaced, as is usual in such deposits, by a cleaner quartz, which contains no free gold, but encloses quantities of the sulphides of the heavy metals, principally iron and copper. The two principal sulphides in this vein are the bright, yellow, glittering pyrite or iron pyrite composed of iron and sulphur and the similar but deeper yellow chalcopyrite, composed of iron, copper and sulphur.

The gold in this part of the mine is thinly disseminated in invisible form through the sulphides. The quantity of gold is very small. On the average, two ounces of gold will be scattered through a ton of the sulphides. Any substance of ordinary value so thinly distributed would be worthless, as the expense of blasting and raising the ore would much exceed what it could be sold for. The value of gold is so great, however, that even the small quantity in a ton of sulphides is worth forty dollars, a value that well repays working.

THE GANGUE is the barren quartz which encloses the ore. In practice the terms ore and gangue are somewhat loosely used. Thus one may describe this material as sulphide ore in quartz gangue and another may describe it as a quartz and sulphide ore. Also the sulphide mineral with such quartz as is extracted with it in the ordinary process of mining is commonly referred to as the ore and only that quartz which is extracted separately or is free from the sulphides is called the gangue. The gold is not equally distributed through the sulphides. In some places the sulphide will contain much more than the average quantity of gold and in other places it will carry little and in some places none. The sulphides without value are not spoken of as gangue. They are called poor or barren ore. In the upper levels, where the sulphides are absent, the ore is that part of the quartz which contains free gold, while the valueless portions of the quartz form the gangue.

One of the objects of a good miner is to extract as much of the good ore as possible and at the same time to leave as much as possible of the worthless material behind, for it costs as much to mine and raise gangue as it does to mine and raise ore.

If the sulphides are worth forty dollars a ton and it is necessary to mine three tons of quartz with each ton of ore, then the material mined is worth only ten dollars a ton, a value that in so small a mine in so remote a region will barely pay expenses of mining and treatment, although larger mines find such ore very profitable.

When, as is the case here, the ore can be so mined that with each ton of sulphide only one ton of quartz must be mined, the material hoisted is worth twenty dollars a ton and yields a good profit.

As the ore is not distributed equally in all parts of the vein, there must be certain areas where the ore is richer than elsewhere. These areas are likely to have some regularity of form and distribution. The laws controlling their distribution are frequently very obscure, so that in many mines the discovery of these enriched areas before the workings actually cut them is very difficult and often impossible. They frequently assume very elongated forms, and are then called CHUTES or SHOOTS or sometimes CHIMNEYS. These may run in any direction in the veins. In some mines the richer portions take the form of patches of limited area called POCKETS. A very rich pocket in a gold mine is usually called a GLORY HOLE. Often ore chutes cannot be distinguished by appearance from the rest of the vein and their location and limits can be determined by assay only. There may be one such chute or a number of them in a mine.

When the segregations of rich ore take an elongated form, thick at the center and tapering toward each end, they are called LENSES.

This mine is on a large ore chute. After the vein had been found, the prospector explored it along its length until he found a place where it was unusually rich. This was the outcrop of a chute. As the mine grows deeper the bottom of the shaft, while still in the vein, will leave the ore body. The working faces of this mine at these deeper levels will be off to the left and will be connected to the shaft by a long gallery.

In the upper part of the vein, called the OXIDIZED ZONE on account of the nature of the minerals contained in it, the distribution of the gold is much more irregular than it is in the SULPHIDE ZONE below. In the oxidized zone the ore in the main ore chute is again segregated into minor chutes. Three of these are plainly shown by the worked-out areas pitching downward and to the left which appear in the upper part of the model.

Entrance to the mine is through the SHAFT which appears at the left. This is a vertical shaft. To suit other conditions, shafts in many mines are inclined. Such shafts are sometimes called INCLINES. In still other mines it has been found better to run a nearly horizontal gallery into a hillside. This, which is practically a shaft laid on its side, is a TUNNEL. The shaft in the model is divided into two COMPARTMENTS and is hence a two-compartment shaft. To the right is the HOISTING COMPARTMENT through which the ore is raised and through which entrance and exit are ordinarily made. The smaller compartment to the left is the LADDER-WAY. In this are placed the various pipes and electric wires which enter the mines, as well as ladders for emergency use. In this mine the ladders are continuous. This is unusual. In most mines the ladder-way is interrupted every thirty feet or so by a platform to minimize the danger of falls.

In PROSPECTS, that is, preliminary workings to determine the value and nature of an ore deposit, the shafts usually have but one compartment and in some districts of small mines one compartment shafts are common. On the other hand larger mines usually have more than two compartments. Three and four compartment shafts are usual.

The shaft is strengthened by a skeleton lining of heavy timber. Horizontal rectangular frames spaced at frequent intervals are firmly held in place against the rock by wooden wedges. These frames, called SETS, are connected as a continuous framework by upright posts at the four corners. Other uprights mark the division between the compartments. Cross timbers in each set complete the timbering and separate the compartments.

Near the surface, where the shaft passes through soil and broken rock, further protection is necessary. This is provided by LAGGING, which is a plank lining to the shaft.

In the hoisting compartment is the CAGE. This is an elevator much like the elevator of an office building. On this cage, the cars of ore are raised and access to the workings is provided for supplies and men. Over the top of the shaft is the HEAD-FRAME. This carries at its summit a pulley over which the cable from the cage passes to the HOISTING ENGINE housed in a building at the rear. At the bottom of the model the shaft is continued to form a kind of cistern called the SUMP in which the mine waters collect. On the lower level of the mine to the left of the shaft is the PUMP driven by an electric motor. This takes the water from the sump and delivers it to the COLUMN, a large pipe in the ladder-way, through which it passes to the surface.

THE LEVELS. When the shaft had been sunk fifty feet a small chamber called a STATION was excavated at the right. From this station a long gallery called a DRIFT was excavated along the length of the vein. A drift differs from other passage ways in mines in that it always runs lengthways of the deposit.

This drift and the workings connected with it constitute the FIFTY FOOT LEVEL, so called because its drift is fifty feet below the surface.

When the shaft had been sunk a hundred feet at a point near the base of the model, another station was cut and another drift started. This drift and its workings constitute the HUNDRED FOOT LEVEL.

On the hundred foot level to the right of the shaft is a gallery running directly into the model. This is a CROSS-CUT, so called because it cuts across the deposit. This cross-cut runs through the vein and into the country rock behind. It was driven to find out if there was another vein parallel with the one worked.

From the lower level two shaft-like openings extend downward. From the upper level a similar opening extends down to the left. These are WINZES which were driven where some features of the vein suggested that exploration in this direction might be of value.

Near the right of the model a vertical, shaft-like opening extends from the lower level to the surface. This is a RAISE, so called because it was excavated from below upwards. The reason for driving it from below is that in mining it is much cheaper to work from below than from above. This raise is lined with CRIBBING, that is, logs built up log-house fashion. The raise has two objects. By providing a second opening to the surface it permits a circulation of air and furnishes much needed ventilation. It is also the final stage of blocking out the ore that lies between it and the shaft. It will be seen that the block of ore lying between the hundred and the fifty foot levels and between the shaft and the raise has four of its six faces open for examination. Experience has shown that when four faces of a body of ore can be examined, a very fair estimate may be made of the quantity and value of the ore. Such ore is said to be BLOCKED OUT or ORE IN SIGHT. On this model two such blocks are shown, one from the surface to the fifty foot level and the other from the fifty foot to the hundred foot level. The mine workings described, shafts, drifts, cross-cuts, raises, etc., constitute DEVELOPMENT WORK which must be done before the extraction of the ore in a large way can be undertaken. It is customary to carry development considerably ahead of the mining proper so that it may be known what may be expected of the mine for some time in the future.

Some ore is extracted during development but at a cost much greater than that of the average cost of mining.

The larger part of the ore is taken from chambers called STOPES.

The principle on which mining is carried out in this mine and in the great majority of all metal mines, is to so conduct the operations that the ore always moves downward to the shaft and no lifting of the ore is performed except at the shaft. Ore moves downward by its own weight, but to raise it, effort, human or mechanical, must be employed. It is economical to concentrate all this application of power in one operation at the shaft. Stopes worked along these lines are called OVERHAND STOPES.

The beginning of a stope is shown about midway of the lower level, where a small opening appears above the drift. Here a narrow niche has been excavated to the side of the drift and a raise has been driven a few feet into the ore of the roof. A miner may be seen blasting out the beginning of a stope above this raise. Between this and the shaft appear two stopes in operation. These two have in the progress of the work run together, making one large stope. There are many ways of conducting mining operations in a stope and the methods employed must be adapted to the conditions in the mine. The method employed here is called shrinkage stoping and the stope is a SHRINKAGE STOPE. The ore is blasted from the roof and allowed to lie on the floor of the stope. As the broken ore occupies more space than it did when unbroken, if all were allowed to remain it would more than fill the stope. It is therefore drawn off from time to time from below but leaving enough behind so that miners standing on it may reach the roof conveniently. Standing on this broken ore they drill holes in the ore above them, using for the purpose a special type of air drill, called a stoper. The compressed air for these drills comes from an air compressor on the surface in a small building behind the shaft. It is led down the shaft and along the drifts in metal pipes. From these pipes it is conducted to the drills in the stopes by rubber hose. When the proper number of holes are drilled they are loaded with dynamite and after the men have left, the holes are fired, breaking more ore. In a small stope on the lower level, the holes have been loaded and a miner is preparing to light the fuses. The excess ore is then drawn from below and the operation repeated. Access to the stope is by a manway with ladders which is kept open through the broken ore by timbering. At the bottom of the stope near the entrance of the manway is a chute equipped with a gate through which the ore is drawn off into ore cars in the drift below. These ore cars run on a tramway to the shaft. At the shaft they are run on to the cage and taken to the surface. The broken ore in the stope not only provides a working platform for the miners but also serves in place of timbers to keep the sides of the opening apart. At the upper left corner of one of the stopes a small raise has been driven to the level above for ventilation.

When all the ore has been broken, the continued withdrawal of the broken ore from below would leave the stope empty. Left empty it would in time cave and the motion of the rock thus produced might disturb other workings of the mine. To avoid this after the stope has been completed, as fast as ore is drawn from below, waste rock is brought from the surface to the fifty foot level and fed into the stope through this ventilation-raise. The stope will thus remain full even after all ore has been withdrawn. On the upper level there are a number of worked out stopes which have been filled from the surface. Not all stopes are thus filled however, since in many cases conditions are such that caving will do no harm, and there are sometimes other reasons for leaving them empty. In some systems of mining caving is even invited and is so controlled as to be of great assistance to the mining operations.

On the lower level and against the raise are two stopes where on account of the value of the ore, none has been left to form a floor. Here the timbering of the drift has been made heavier and a floor of poles laid over it to hold the broken ore.

In one of the open stopes of the upper level the walls incline to bulge inwards so that broken ore left in the stope would bind and could not be drawn off. In this stope ore has been removed as fast as broken. The walls are kept apart by round cross timbers called

STULLS. The miners work on temporary wooden platforms laid on the stulls.

The drifts are made more secure by TIMBERING. As the rock is firm and as these levels are so near the surface that there is little pressure, not many timbers are necessary. For a long way from the shaft the drifts have no timbers whatever. Towards the right, where the rock is more broken, sets of timber designed to hold the roof of the upper level consist of two POSTS, one on each side supporting a CAP.

The corresponding place on the lower level is provided with full SETS of timber consisting of two POSTS, a CAP and a SILL.

Near the right of the model is a vein of another kind which runs at right angles to the face of the model. This vein carries silver and lead. In the upper part the ore is an impure carbonate of lead stained with iron oxides. In the lower part, it is the dark-colored sulphide of lead, galena. The silver content of the ore is disseminated in invisible form through the lead-bearing minerals. This vein DIPS to the left. The left wall overhangs the vein and is the HANGING WALL. The wall to the right is the FOOT WALL. This vein and its country rock are so broken that the method of mining employed on the gold-bearing vein cannot be used and exploitation must be by more costly methods.

On the upper level the stope runs upward from the drift and will eventually break through at the surface. The stope is left empty and is kept open by numerous cross timbers (STULLS). At the lower level the tendency to cave is too great to be resisted by stulls and an elaborate system of timbering called SQUARE SET is employed. This, which is often employed in deep mines and where the ground has much tendency to move, consists of a continuous system of hollow squares framed from heavy timbers. In this mine these squares are ten feet on edge but under worse conditions, they have to be made much shorter.

HENRY W. NICHOLS.

This model is exhibited on the second floor of the Museum in an alcove in Frederick J. V. Skiff Hall.