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Abstracts of Institute Papers

The following papers were presented at the San Francisco meeting September, 1922, and will be printed in full in pamphlet form.

A copy of any of these papers complete will be sent free to members on application, for which a request blank is furnished on page 20 of the Advertising Section. Discussion of papers is invited.

The Aztec Mine, Baldy, New Mexico

By Charles A. Chase, Denver, Colo., and Douglas Muir, Simon, Nev.

THE Aztec mine is not widely known by reason of its isolation and the relative insignificance of its tonnage; but financially it has an enviable record and geologically it is extremely interesting. The paper describes the geology and mineralization of the district, the mining and milling methods, and the costs.

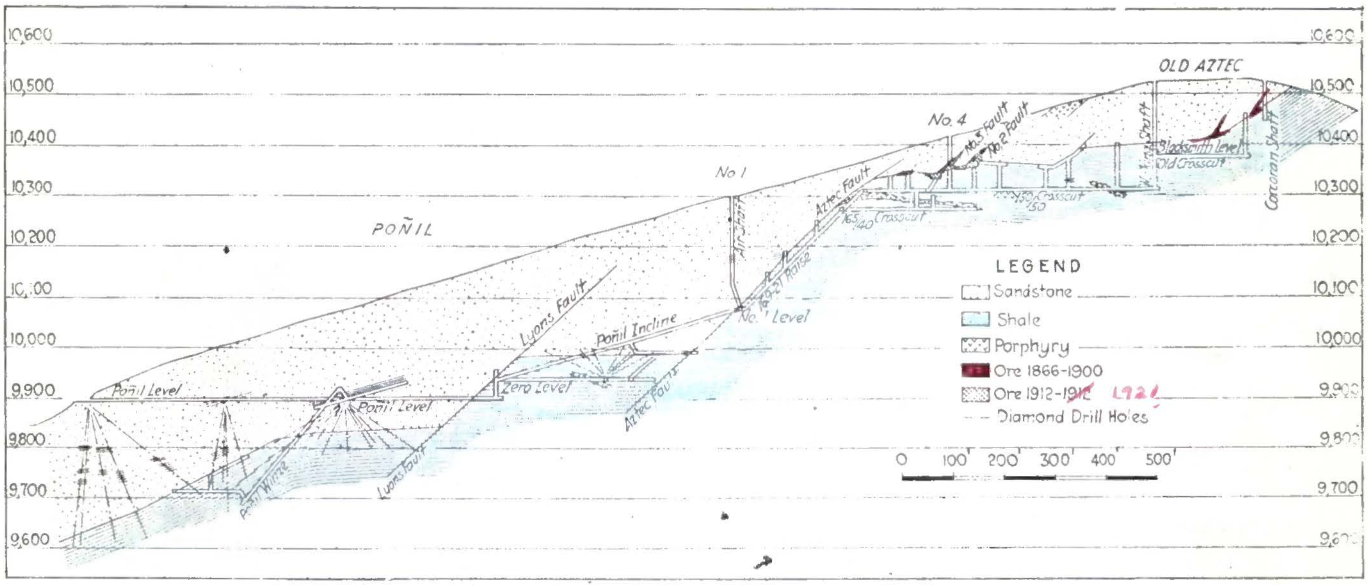

Fig. 1.—Northeast-southwest section of Aztec gold mine.

The town of Baldy, Colfax County, the mine camp, at an elevation of 10,000 ft., is 8 mi. west of Ute Park, the terminus of a branch of the A. T. & S. F. Ry.

Rich copper float was found in 1865, and discovery work was begun the next year. At the same time, gold placers were found on Willow Creek. Gold washing lasted many years. In 1867, placer gold was found also on Ute Creek, the tracing of which to its source led to the locating of the Aztec mine in the following year.

The early production came from the contact of shale and sandstone or from sandstone immediately above the contact. Exact record of production is lacking, but L. C. Graton gives estimates ranging between $1,250,000 and $1,500,000 of which about $1,000,000 was taken out in the first four years.

After the exhaustion of the early bonanza, production continued intermittently until 1909, when systematic development was begun.

Late in 1911, the southeasterly orebody on No. 4 level was reached. This was typically silicification and enrichment of flat-lying beds of sandstone from narrow and steep fractures; shaly layers in the sandstone seemed to account for vertical localization of the enrichment. The type was like that of enrichment in flat beds in the Black Hills of South Dakota, except that the verticals were fainter and the beds less subject to replacement.

In 1914, work opened a bonanza, consisting mainly of altered shale enriched with free gold to a value of $50 to $100 per ton; 80 to 90 per cent. of the gold could be amalgamated and another 5 to 10 per cent., with a little pyrite, was readily caught on a Wilfley table. Although this new orebody was only 500 ft. distant from the old workings, its discovery, by downward prospecting along the contact, would have been delayed by the presence of folds and water-bearing fissures in the intervening barren ground. Subsequent development of this orebody has failed to find the slightest continuity with any other ore, and it shows no indication at the surface.

From 1912 to 1920, the mine produced $1,680,718 in bullion, varying from 856 to 889 fineness in gold and 105 to 142 in silver, and $243,079 in concentrates. Shortly after the discovery of the bonanza, the cost of producing gold was as low as $2 per ounce, but in 1919 it rose to $13.50 because of the large amount of timbering required and other operating difficulties. L. C. Graton studied the district, in 1905, for the Geological Survey. In 1916, Edward H. Perry and Augustus Locke reported on the geological conditions at the mine. In 1918, O. H. Hershey made a study of the faulting systems and the ore occurrence. This paper, in addition to recording the observations of the authors, has drawn freely from the written reports of these engineers.

Structural Geology and Types of Ore Deposits

The original plane of division between the sandstone series and the Montana shale, in places, remains in its original condition, but generally there has been slipping of the rigid sandstone over the soft shale, producing at the top a thin gouge or selvage of 6 to 8 in. of soft crushed shale. Where there has been no actual displacement, that is cutting across of the beds, the contact is regarded as original. Two main periods of faulting are recognized. The first period produced a group of faults of relatively small displacement. While they fault the sandstone, they do not penetrate deep into the underlying shales, but curve to low dips and practically follow the original contact. The second period contains two notable faults of large displacement, called the Aztec and the Lyons fault. The former dips northeastward from 20° to 45°, generally about 35°. Nearly everywhere it has a thick, soft gouge under a hard sandstone roof. The shales under it have been partly crushed to a depth of several feet. In places the disturbed zone contains large fragments of sandstone under the main gouge. The displacement on the plane of the Aztec fault has been about 550 ft. The Lyons fault, as exposed in the Poñil workings, is accompanied by a black gouge and dips northeastward at 35°. It is a normal fault and appears to have a displacement of 450 feet.

Mr. Hershey distinguishes three types of ore deposits, probably formed at three distinct periods. The first is the so-called "shale ore." This is remarkable for its high gold content, whereas contact metamorphic ore deposits usually carry gold in relatively small quantities. A somewhat similar deposit appears to occur at the Ajax mine on the southwestern slope of Mt. Baldy. There the gold is distributed through a dark, heavy, finely granular rock, consisting of nearly colorless pyroxene, amphibole, epidote, magnetite, a little zoisite, scapolite, and specularite.

The second type of mineralization is that accompanying faults Nos. 2 and 3. Its essential minerals are calcite and pyrite. The ore occurs in seams and bunches scattered through a zone of broken ground accompanying the fault gouge. Other carbonates, such as rhodochrosite, may be present and probably a little quartz. Much of the pyrite is coarsely crystallized and there may be a small amount of chalcopyrite with it. The gold content runs from $8 to $50. The metal is fine grained and not visible. Where these fault veins lie at low angles, practically coinciding with the shale-ore lenses, the gold content is relatively high. Good ore continues up along the fault into the sandstone but gradually weakens. Fault veins that do not touch shale ore are not likely to carry commercial ore; and if a fault vein is found to carry commercial ore, it may indicate the presence of shale ore somewhere down along the dip.

The third type of deposit is genetically connected with Aztec, Lyons, and other faults of that system. It occurs almost exclusively in sandstone and its most characteristic mineral is chalcopyrite. The gold content is relatively low, and free gold is rarely or never visible. Movement along the fault fractured the relatively brittle sandstone, forming little fissures in which the solutions circulated. The resulting mineralized zones vary from a few inches to many feet in thickness.

The orebody at the extreme northwest that was commercially important seems to be of a different type from those described. It was extremely high-grade ore having the characteristics of contact metamorphism. It lay just between the contact of shale with overlying sandstone partly altered to quartzite, and though seemingly a part of neither, it extended a short distance upward along the steep, small fractures, fading away into the sandstone. Beside masses of coarse and fine native gold, this ore contained quartz, limonite, garnet, pyroxene, and other silicates, a little pyrite and chalcopyrite and always an appreciable amount of bismuth telluride.

Mining and Milling

Timbering was by square sets, where the ground was heavy, or soft; and by posts or stulls, where it was hard. At times, waste from development served in large part to fill the sets, but frequently waste raises into the overlying sandstone were necessary; these served also to prospect the sandstone: they never found ore. Much of the ground was heavy, requiring careful timbering. Some of the best ore was overlaid by material that required spiling before the ore could be drilled and blasted. Timbering was by far the largest single item of expense in the extraction of the ore, though the cost of timber was reduced by the operation of a sawmill, a few miles from the mine.

The mill is a ten-stamp amalgamation and concentration combination and by it a recovery of 85.81 per cent. has been obtained in later years. Water for power was available during one month in the spring of the year. Upon development of a considerable supply of ore and need for power expansion, the semi-Diesel type engine was selected and Muncie units 30- to 80-hp. were placed in the mill to furnish power for all purposes.

Costs

On a basis of 30 tons, daily, mined and milled during the years 1918–1920, inclusive, the following costs prevailed.

Mining	$4.91 per ton
Milling and marketing	3.54 per ton
General	1.62 per ton

The total cost of power was $0.0396 per hp.-hr. Fuel oil cost $0.151 per gal. and lubricating oil, $0.967. Fuel oil was used at the rate of 0.708 lb. per hp.-hr. and lubricating oil, 0.041. Trucking 16 mi. the round trip, with practically no back haul, cost $6.86 per ton of freight hauled. The mine is 2500 ft. higher than the railroad.

During the years 1918–1921, inclusive, the cost of mine development, including direct and indirect charges, was $15.89 per ft. over 9883 ft. of work. Of this amount, $7.59 was the cost of explosives, labor of breaking ground, mucking and placing timbers. Diamond drilling 18,276 ft. cost a total of $4.59 per ft., distributed as follows:

Direct charges:	
Drilling, only	$3.10
Pipe lines and stations	0.37
Power	0.66
Water	0.12
	$4.25
Indirect charges:	
Assaying, surveying, sampling and supervision	0.34
Total cost	$4.59

The shortest hole was 40 ft. and the longest 748 ft. An average length of 237 ft. was obtained in 77 holes drilled.

Metal-mine Ventilation in the Southwest

By Chas. A. Mitke, Bisbee, Ariz.

After describing ventilation systems and their need, especially in deep mines containing high sulfide ores and in mines where caving systems of mining are used, the paper deals with allaying rock dust, and the relation of mining methods to ventilation systems.

In the Southwest, mechanical ventilation of metal mines has been receiving consideration for many years. Thirteen copper-mining companies, with an aggregate tonnage, when operating at approximately 50,000 tons a day, have installed mechanical ventilating systems in their mines. All these mines are within a radius of 200 miles, the largest copper-producing area in the world.

The capacities of mechanical ventilating installations in these mines range from 100,000 to 300,000 cu. ft. of air per minute, depending on the size of the mine, character of the workings, tonnage produced, etc. The latter varies from 300 to 20,000 tons per day. The mines include both high- and low-grade deposits, the greatest depth of the former, at present, being approximately 2500 ft.; and of the latter, 1200 ft. The volumes of air at present being coursed through the mines are from 60,000 up to 225,000 cu. ft. of air per minute, which, in their relation to the underground working force, range from 200 to 800 cu. ft. of air per man, per minute. While not to be taken as criteria, these figures are indicative of the character of the ventilation furnished.

The operators in the Southwest have long realized that efficient ventilation goes hand in hand with low operating costs, principally through the large saving effected in the use of compressed air and the higher efficiency displayed by the men.

Ventilation Systems

Every large mine is ventilated by a primary and secondary ventilating system. By the *primary ventilating system* is meant the use of a limited number of large units, advantageously located, to ventilate as large an area of the mine as possible. This should approximate 70 to 100 per cent. of the mine workings. The air, in many cases, is drawn down through large concrete shafts, which constitute the main intakes, and are fireproof and have a smooth surface.

The *secondary ventilating system*, consisting of compressed-air jets, booster fans, and small portable blowers with ventilating pipe (some of which are mounted on trucks), is not brought into use until all the possibilities of the primary system have been entirely exhausted.

Ventilating systems for mines in which sulfide orebodies exist, especially if the sulfide is comparatively soft, oxidizes rapidly, and caves readily when stoped, should always have sufficient capacity to remove the additional heat generated from this source, also to take care of emergencies. By such provision, mine fires may be averted or speedily controlled.

During recent years, the introduction of the caving systems have brought new problems in ventilation. When it is considered that in such mines shots are fired as frequently as one every minute (and sometimes oftener), also that every shot pulverizes a certain amount of rock, producing a large quantity of very fine dust, which rises simultaneously and moves with the powder smoke, the necessity for a most efficient ventilating system becomes evident.

In such mines, it is not so much the reduction of excessive temperatures, or high relative humidities, as it is the removal of the smoke and gas produced by blasting, and the fine dust created through continuous mining operations, that is of prime importance. In