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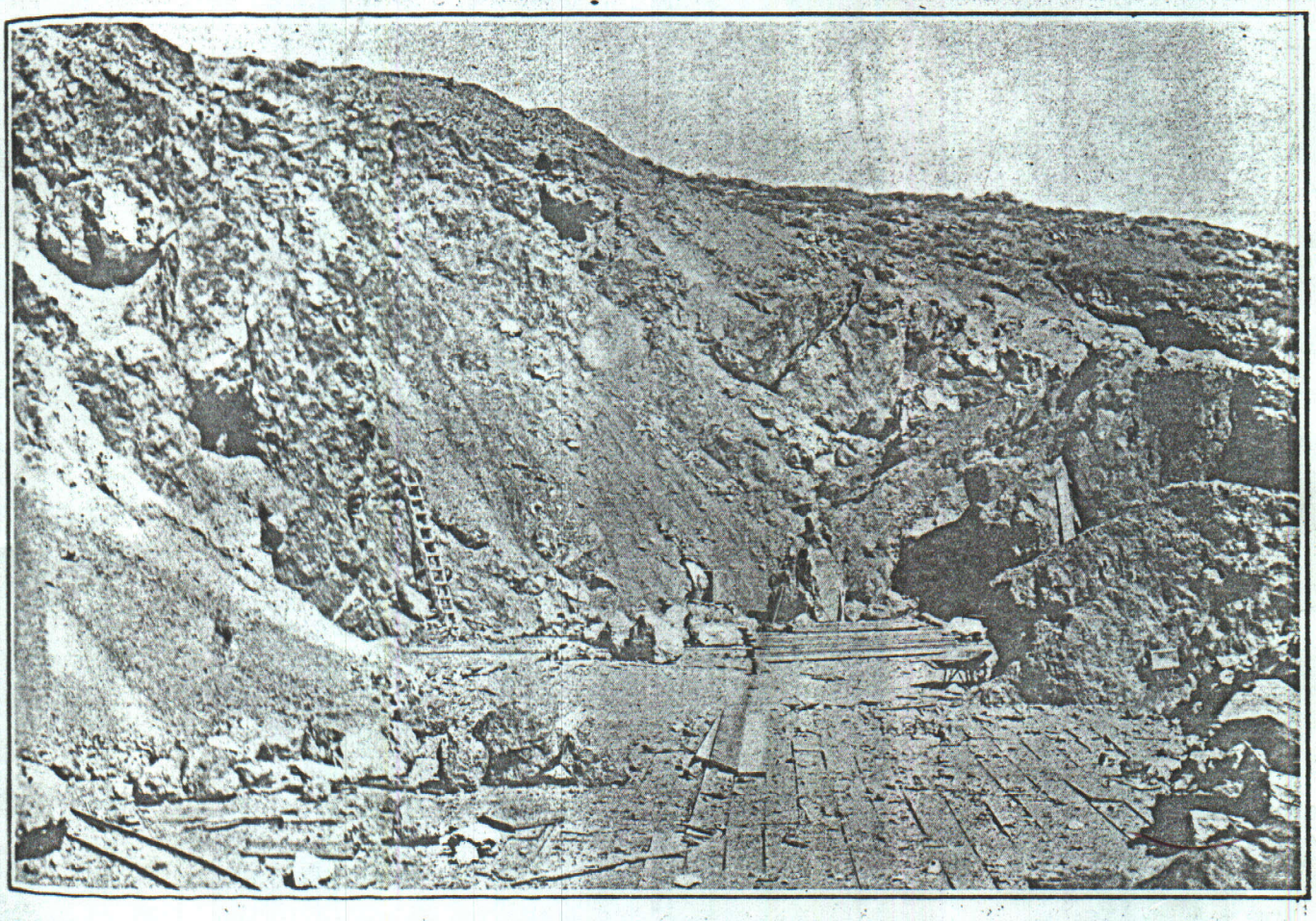
The Silver-lead Mines of Eureka, Nevada

A Famous Old Mining District That Is Now Being Reopened. Interesting Geological Problem of the Continuance of Ore with Depth

BY WALTER RENTON INGALLS

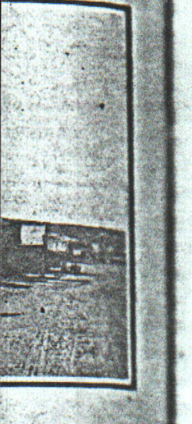
The first important mines of silver-lead ore in the United States were at Eureka, Nevada. It is now nearly 40 years since they were opened, nearly 25 years since they receded largely in production, and fully 15 years since anything worth mentioning has been heard of them until recently. But from 1869 to 1879, when their star paled under the superior brilliancy of Leadville, they were the largest domestic supply of pig lead and they are of peculiar interest because of their romantic history in the early days, because of the uniqueness of their geology and the famous litigation which arose respecting them because of the richness and easy mining of the remarkable orebodies, and because at Eureka many mining engineers and metallurgists who subsequently became eminent received their first practical experience. Eureka is properly considered the birthplace of the American silver-lead smelting industry. In view of all these things and especially the brilliant record of the old mines there is peculiar interest in the reopening of them, undertaken about two years ago by the Richmond-Eureka Mining Company, which was a virtual consolidation of the historic old "Eureka Con." and Richmond companies, two neighboring concerns that were at loggerheads for 30 years. There are some who think that their mines were abandoned prematurely and that well planned and persistently executed explorations will disclose new orebodies as rich as those which formerly were mined. There are others who think that the mineral bearing formation of Ruby Hill was exhausted by the thorough exploitation of the old companies, that the mines were bottomed and have no further ore to yield, i.e., silver-lead ore; of course there is no question about the low-grade iron ore that was left behind in the old stopes. Before discussing this difference of opinion with any detail, it is worth while to relate briefly the history of the mines.



SURFACE WORKINGS ON RUBY HILL

The History of Eureka

The first locations at Eureka were made in 1864, but such ores as were found were not then considered of value. There were remarkably prominent exposures of iron ore on Ruby Hill, which must have been observed by the early prospectors, but it is equally certain that such ore was abso-

lutely destitute of value to them under the then existing conditions. After the rich discoveries in 1869, at White Pine, 40 miles east of Eureka, which were made in a limestone formation, attention was redirected to Eureka, and a smelting furnace was erected by C. A. Stetefeldt, already an eminent metallurgist, in which he smelted ore from several of the mines. The process was not quite successful because of the large proportion of gangue in the ore delivered to the furnace, necessitating a proportionately large quantity of flux, while pecuniary embarrassment prevented even the completion of the works. Dr. Raymond, in writing of Eureka in 1869, said: "The deposits are frequently large, but occur irregularly in limestone. They contain smelting ores, which, for cheap reduction ought to be dressed before they reach the furnaces. The ores assay well and probably average better than those from the base range at White Pine."

In 1869, Col. G. C. Robbins built a small furnace at Eureka and demonstrated that the ores could be successfully smelted. About the same time, Col. David E. Buel and associates leased the McCoy furnace (which had been erected by Mr. Stetefeldt) and bonded the Buckeye, Champion, and Sentinel mines. After Colonel Buel had satisfied himself of the smelting qualities of these ores, he resolved to build a large smeltery and together with Messrs. Bat[illegible]n, Allen, Ingoldsby and Farren, formed a company called the Bateman Association. A combination was soon af[illegible]rward made with Wm. Lent, who had ac[illegible]red valuable property in the district, a[illegible] the Eureka Consolidated Mining Co[illegible]y was organized.

[illegible] de[illegible]lopment of Eureka was rapid, a[illegible] 1870 the mines came into great [illegible]ence. The ores were at first easily [illegible] once the requisite knowledge [illegible]quired, and were easily mined. [illegible]t orebody in the Champion [illegible]cropped as a 3-in. crack in the [illegible] filled with limonite. The lime[illegible] the ore proved to be only 6 or [illegible] This and other deposits in the [illegible]re dug out in open cuts. The [illegible]arthy lead carbonate and was so [illegible]ined with pick and shovel alone [illegible]ne man could take out 10 tons per [illegible] and two miners actually supplied two smelting furnaces.

The Beginning of Smelting

At the end of 1870 there were 14 furnaces, all in or close to the town of Eureka. According to Guido Kuestel, the ores smelted at that time averaged 40 to 48 per cent lead, $60 to $80 in silver and $15 to $20 in gold per ton. Three and a half tons of ore yielded one ton of pig lead. The latter averaged about $170 in silver and $80 in gold per ton. The yield of the Eureka mines in 1870 was not less than $1,200,000 in value.

From 1870 onward Eureka poured out a constant stream of base bullion until the great ore deposits were exhausted. The Eureka Consolidated Mining Company was always the largest producer; the Richmond Consolidated was a good second. In 1871 the works of the Eureka Consolidated comprised five furnaces, which had an aggregate capacity of 120 to 148 tons of ore per day. In that year about 19,000 tons of ore were mined and smelted, which cost $5.52 per ton for the mining and $19.60 per ton for the smelting. The total production of the Eureka district in 1871 was 5665 tons of bullion valued at $2,035,588. In 1872 the production of base bullion was 6780 tons. In that year the cost of mining and delivering the ore to the furnaces was $7.84 per ton, and 8.42 tons of ore produced one ton of bullion. The reason that there was not a larger increase in the production of the district this year was litigation between the Eureka and Richmond companies, which checked the output of the latter. This litigation was the beginning of hard feeling between these two companies which lasted until the death of some of the prominent figures concerned in it. However, there was a great increase in the production in 1873, when the output of base bullion aggregated 12,000 tons, which was furnished by eight smelting works with a total of 17 furnaces. In 1874 the Richmond company erected a refinery, and in 1875 the Eureka & Palisade Railway was completed, giving the district connection with the Union Pacific Railway at Palisade.

In 1875 the mining and smelting industry of Eureka fell more and more into the hands of the two large companies, which made increasing outputs up to about 1880 and paid large dividends. In the early 80's, however, the old bonanzas began to be exhausted and the production of lead dwindled, falling to about 4000 tons in 1884. The reduction in mining and smelting cost was insufficient to compensate for the impoverishment of the ore, for although the cost of smelting was reduced somewhat, the cost of mining increased because of the necessity of operating at greater depth and other unfavorable conditions. In 1883 the cost of mining to the Richmond company was $13 per ton, while smelting cost $11.66 per ton.

Waning Production—The Grand Total

By 1880 the workings in the principal mines had attained considerable depth, the Richmond having a shaft 1000 ft. deep. Up to this time the mines had been dry, but in 1881 the Eureka company encountered water in its new shaft at a depth of 756 ft. In the same year the great suit between the Eureka and Richmond companies was decided by the Supreme Court of the United States in favor of the former. This suit was brought in 1877 on account of the Richmond company having crossed its line and worked out the famous Potts chamber whereby the Eureka company claimed to have lost $2,000,000. In 1882 the deep shaft of the Eureka was drowned out, and henceforward pumping was a serious difficulty.

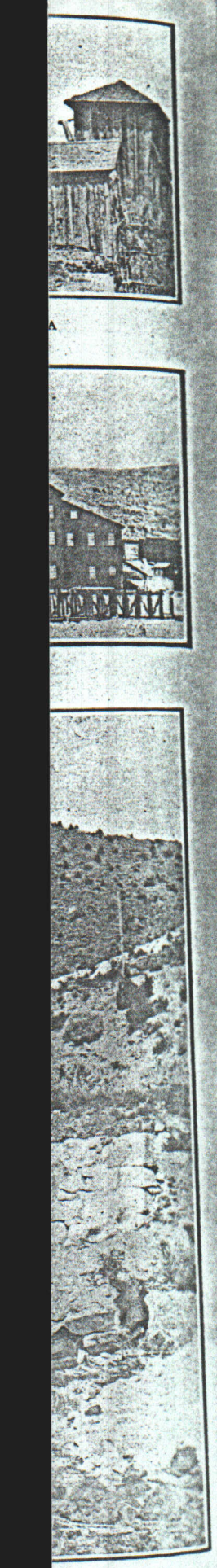
From 1884, mining at Eureka continued to fall off, the output dwindling to a comparatively low figure, being largely the product of tributers, to whom the upper portions of the mines had been given over. As early as 1885 most of the ore production of the Eureka Consolidated was from its tributers. In 1889 the total lead production of the district was only 1489 tons. In the early 90's all operations came practically to a standstill. The feud that arose between the two big companies over early disputes, which became the subject of litigation, was still alive and prevented harmonious action when such was especially needed. In 1893 the production of the whole district was 14,515 tons of ore. In 1897 the output of the mines of the Eureka Consolidated was only 1121 tons of ore.

Up to the end of 1882 the production of the district, according to Curtis, was about 225,000 tons of lead, $40,000,000 worth of silver and $20,000,000 of gold. From the statistical records in Raymond's reports, in the "Mineral Resources of the United States" and elsewhere, I am unable to account for more than 178,000 tons of lead actually shipped from the State of Nevada, of which, of course, all but an insignificant amount came from Eureka. From 1882 to the end of 1890 the lead production was probably about 25,000 tons, and from 1891 to the end of 1900 I surmise it may have been about 12,000 tons. Probably the output of Eureka up to the end of 1900 was about 210,000 tons of lead and doubtless 90 per cent. of that was derived from the two big mines.

The Eureka & Palisade Railway

To go to Eureka, one leaves the main line of the Southern Pacific at Palisade. From that point the Eureka & Palisade runs almost due south to Eureka, a distance of about 80 miles. The country traversed is unfertile, unsettled and uninteresting. There are occasional stations along the road, but nothing that can be called a village by any stretch of the imagination. At present there are two trains a day. One of them is exclusively a freight train. The other is chiefly a freight train, but by virtue of carrying a single combination car, with seats for 12 or 15 passengers, is by courtesy called a passenger train. This makes the journey of 80 miles in about six hours. Previous to the reopening of the mines there was only one train every other day.

The Eureka & Palisade railway presents a rather unique survival of what railroading in the West used to be. The road was built just 30 years ago and operates today with the same equipment that it had at the beginning. The road is narrow-gage, laid with 40-lb. rails. The construction would be pronounced easy by any mountain railroad builder, the grades over Garden pass, which is the worst place, being only a lit-



ND DUMP

tle more than 2 per cent., but the feeble and worn-out locomotives of the line have great difficulty in negotiating even that gentle ascent. In coming down from Eureka with a train of five gondola cars, loaded with a total of about 100 tons of ore, and the little combination car at the end of the train, we finally came to a standstill in puffing up a 2 per cent. grade. The solution of the difficulty was to split the train, the locomotive going off to the summit with three cars, and putting them on a siding, returning for the three cars left back on the line. With a railway operated in this manner, the trials and tribulations of a mine operator at Eureka in shipping out his ore and bringing in his coal, etc., can readily be pictured. At Palisade the miniature freight cars, which carry each from 15 to 20 tons of ore, are pushed up an incline, and dumped into elevated pockets, from which the standard-gage cars of the Southern Pacific are loaded.

The Town of Eureka

Descending from Garden pass the railway crosses Diamond valley and enters one of the gently sloping ravines, characteristic of Eastern Nevada, in which—a short distance from the entrance—is situated the town of Eureka at an altitude of about 6500 ft. above sea-level. The terminus of the railway is below the town, a quarter of a mile or so. Just above the railway station was the smelter of the Eureka Consolidated, which company was always referred to as the "Con." Then comes the town and at the upper end of the town the Richmond smelter. There were smaller smelters near the Con and near the Richmond, but with a single exception nothing remains of these save the slag-dumps, and indeed the same is true of the two big works.

It is interesting to visit some of the old mining camps, which acquire a picturesqueness in their decay and dilapidation that savors of more years than they actually possess. But Eureka is not exactly dilapidated. On the contrary it exhibits rather a trim appearance in spite of the rows of shops with shutters closed on doors and windows since many years ago, bearing mute testimony to the fact that the 1000 inhabitants of today do not require so much as the 9000 of 30 years previous. Indeed, it is a mystery how the town has lived so well during the long years of stagnation in mining and has supported the many excellent retail stores, and two hotels—one particularly good—which it has to-day. Even now the number of miners in the district is only about 200, most of whom live at the mines and being chiefly foreigners do not spend their money in the old-fashioned, reckless American way, so that the tradespeople and saloon-keepers say that business is not materially better than before the mines were reopened.

However, Eureka is the county-seat; there are some ranchmen up and down Diamond valley who come to it for trade; until the Nevada Northern railway was built it was the railway station for Ely; and it is still the supply point for Hamilton—another famous old mining camp of the '60s, that is now so dead that the saloon is open only one day in the week, although some mining is going on and there is hope that it also may experience a rejuvenation.

Eureka is agreeably situated, its site being sufficiently roomy and the hills on either side being not very steep, and looking north there is a fine outlook over broad Diamond valley. There are some trees in the town and with the aforesaid shops and other conveniences it is not a bad place as mining camps go. In its various vicissitudes the town has been several times partially washed away by floods, once ravaged by small-pox, and twice almost completely destroyed by fire, but if not so prosperous as once it remains today a respectable shadow of its pristine self with fond hopes that somewhat of its former activity may yet return.

Ruby Hill and Its Mines

The principal mines of Eureka are situated on Ruby Hill, which rises to an elevation of about 7300 ft., two miles west of the town. On this hill, going from southeast to northwest, are the Jackson, Phœnix, Eureka Consolidated, Richmond and Albion mines, following in the order mentioned. Ore was found in each of these properties, but only in the Eureka Consolidated and the Richmond were the deposits of great magnitude. The geology of the Eureka district, including Ruby Hill, was described by Joseph S. Curtis in "Silver Lead Deposits of Eureka, Nevada," which was one of the earlier monographs published by the U. S. Geological Survey, and ranks still among the best. Mr. Curtis' field work was begun in July, 1881, and concluded late in 1882; the book was published in 1884. Unfortunately, even when the field work was begun, the mines had passed their prime, and when the monograph was published their production had run down to a comparatively small figure. However, the report is of superlative value at present, when the mines are being re-opened.

I shall not attempt to go much into detail in describing the geology of Ruby Hill By reference to the accompanying vertical cross-section it will be seen that there is a wedge of crushed limestone lying on the southwest side of the Ruby Hill fault, the wedge lying between the Ruby Hill fault and a secondary fissure which joins the main fissure at about the 12th level of the Eureka Consolidated mine, or rather joins it at about the 12th level on the line of this particular section. However, by reference to the elevation on a longitudinal plane, it appears that the line of junction of the two fissures increases with depth in going northwest, *i.e.*, from the Eureka Consolidated into the Richmond. Consequently, in going in that direction the vertical cross-section of the crushed limestone increases both in width and in depth. The Ruby Hill fault is a fissure of remarkable persistency and sharp definition. The faulting of the formation thrust upward the Prospect Mountain quartzite, immediately underlying the ore-bearing limestone, upon the southwestern side, so that the quartzite and crushed limestone are now in contact at the secondary fissure. At the junction of these two fissures they appear to cross each other and at great depth there is probably another wedge of limestone in reverse position.

Form of the Orebodies

In the upper wedge of crushed limestone the ore occurs in deposits of very irregular form, sometimes resembling lodes, sometimes "stocks," and sometimes beds. According to Curtis the orebodies of any size were always capped by caves, or in some way connected with such openings in the rock and with fissures. This connection of orebodies with fissures is universal in the district. Curtis believed that the caves were formed subsequent to the deposition of the ore, partly by the action of water carrying carbon dioxide and partly by the shrinkage of the ore in its decomposition. The origin of these caves, whether before or after the deposition of the ore, is a highly important point. Since the decomposition of the original ore, the latter has in many instances been redistributed by the flow of underground water.

The ore above the water level is principally composed of galena, anglesite cerussite and mimetite, with very little quartz and calcite, the gangue being for the most part hydrated oxide of iron The ore carries both gold and silver Below the water level the ore is chiefly composed of pyrite, arsenopyrite, galena and blende.

The description of the ore deposits of Ruby Hill as occurring in forms resembling lodes, stocks and beds, is undoubtedly scientific, but I doubt if it conveys a thoroughly good idea of the occurrence of these orebodies. They occur as large masses, sometimes more or less ellipsoidal in form, in the crushed limestone But what really constitutes the orebody In the early days it was only the miner high in lead that was considered to be ore; lead and silver bearing limonite was "gangue." At present the former "gangue" is ore.

Considering all the mineralized matter to be ore, which is proper from the present standpoint, the ore-deposits of Eureka consist of masses of oxidized silver-lead mineral, of irregular form, imbedded in larger masses of limonite containing comparatively little gold, silver and lead the ultimate form of which is unknown

because the iron ore was not extracted in the former working.

The Surface Workings

An excellent idea of these orebodies is obtained from the surface workings, which are shown in some of the engravings from photographs that accompany this article. All of these photographs were taken on the western side of Ruby Hill, where there were enormous outcrops of iron ore, and also toward the top of the hill. These form, I believe, one of the most extensive iron outcrops ever known in North America. (The iron outcrop at Leadville, Colo., was more extensively covered by surface gravel.) There was little or no lead ore showing in the original outcrop at Eureka, but certain seams, which were followed down, rapidly swelled into great bodies of ore, and at the present time in the old quarries may be seen small seams of yellowish lead ore, ramifying into the red iron ore, which were overlooked by the tributers. The great excavation represents lead ore extracted, together with iron ore that was taken out incidentally, but the quantity of the latter apparently was not proportionately large, because the old dumps show comparatively little. However, there is at least one dump of iron ore which looks good enough to ship, while there are other dumps containing a mixture of iron ore and non-mineralized waste which probably it will never pay to rework.

Underground Prospecting

The conditions underground are similar to, indeed I may say identical with, those exemplified at the surface. Some of the surface deposits, in fact, extended right into the hill, one of them developing into the famous Hicks stope underground, and there are workings which go clear through Ruby Hill, coming out on the eastern side at what is the 100-ft. level of the Locan shaft. The ore that is now being mined at the surface on the western side of the hill is dumped down through one of the old shafts to this level through which it is trammed to the bins at the eastern side of the hill.

The great orebodies throw out branches, veinlets, and streamers, so to speak, for long distances, the form being comparable to that of a cuttle-fish, with a large central body and tentacles extending in many directions. This made prospecting comparatively easy because the drifts driven on any level, if reasonably close together, were fairly sure to strike some tentacle of an orebody if any existed. In following up such a leader the main orebody was found sooner or later. We find this same kind of prospecting going on at present, under the new regime, but alas! with some extremely vexatious results, as will be presently pointed out.

Operations Under the Tribute System

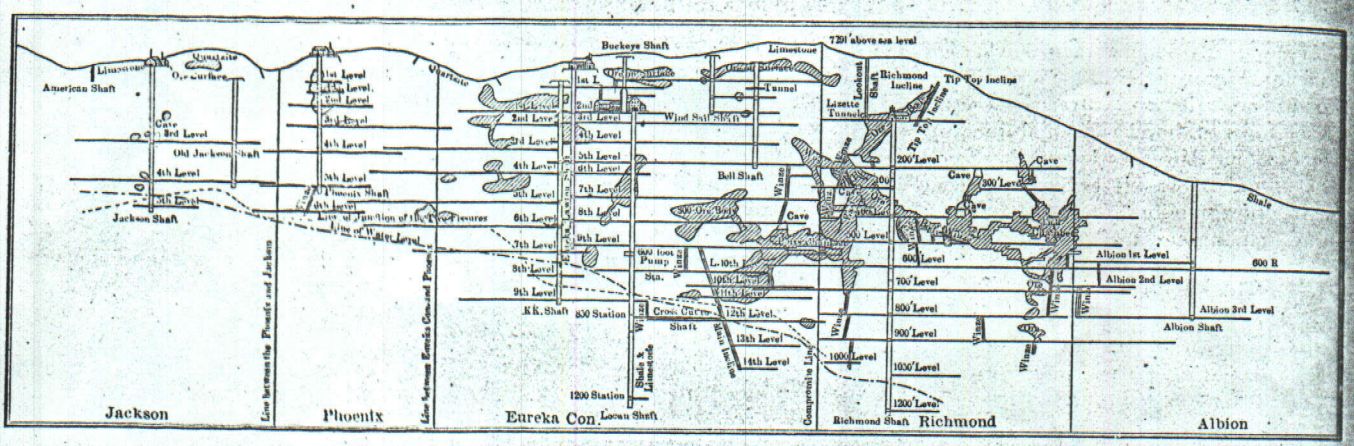
As early as 1878 the older workings of the Eureka mine contained considerable ore, which had failed to be extracted either through oversight or improper mining. Many small orebodies also had been passed over as too poor or insignificant to be worth mining and there was reason, moreover, to believe that undiscovered orebodies of small size existed, as indeed turned out later to be the case. To make a clean sweep of the ground, in that year T. J. Read, then superintendent of the mine, introduced the tribute system, dividing up the ground into blocks. A little later the tribute system was introduced in the Richmond mine, and in that as well as in the Eureka, it was found to work very well. As the companies gradually finished their operations in the lower levels, tributers were put in them also, and eventually tributers were in possession of the whole mine in each case, especially after the influx of water had driven the companies out of the extreme lower levels. Subsequent to 1885 or 1886 the bulk of the production in the Eureka was made by tributers, and since about that time no maps were kept up by the companies.

It is almost unnecessary to say that the tributers put the mines in wretched condition, because that is always what they do when they are not carefully supervised, and in almost all cases supervision which at first may be effective gradually becomes lax and eventually there is no supervision at all. The tributers in Ruby Hill burrowed, gouged and gutted, filled up some old workings and allowed others to cave in. Probably it never will be known fully how and where they went. But the annoyance of present prospecting is that in discovering and following a promising leader of ore, it always is found to end not in a substantial and desirable nucleus, but invariably in a stope opened and exhausted by some tributer coming from a different direction. One can not help admiring the industry of the former tributers, but it is to be remarked that in 30 years they had ample time to dig far and thoroughly.

Future Prospects

This may well take us to the question, "What are the future prospects of the mines? In the first place, as to the upper wedge of limestone, it has evidently been nearly completely prospected. The ground in the Eureka mine has been prospected rather exhaustively clear to the bottom. However, in lower levels there are some blocks of 200 or 300 ft. square, which may be found to contain bodies of ore not yet discovered, although the chance for this would not appear to be extremely brilliant. In the Richmond mine the wedge of limestone is deeper and wider and the lower part of it has by no means been cut up so thoroughly as in the Eureka Consolidated. It is true that such exploratory work as has been done in the lower part of the Richmond mine has not resulted very successfully, but this may be due rather to bad luck than to the non-existence of orebodies. Nevertheless, it must be acknowledged that the mineral bearing country in both these mines has been well prospected, and the production from any new orebodies that may be found in the upper wedge of limestone is unlikely to be more than a tithe of those which previously have been mined out. Recognizing this, it must be admitted that the chances are better for the Richmond mine than for the Eureka.

As to the lower wedge of limestone the prospects are uncertain. They are the same today as when Curtis made his report, and consequently Curtis' views are important. He says in concluding his re-



ELEVATION ON LONGITUDINAL PLANE THROUGH RUBY HILL

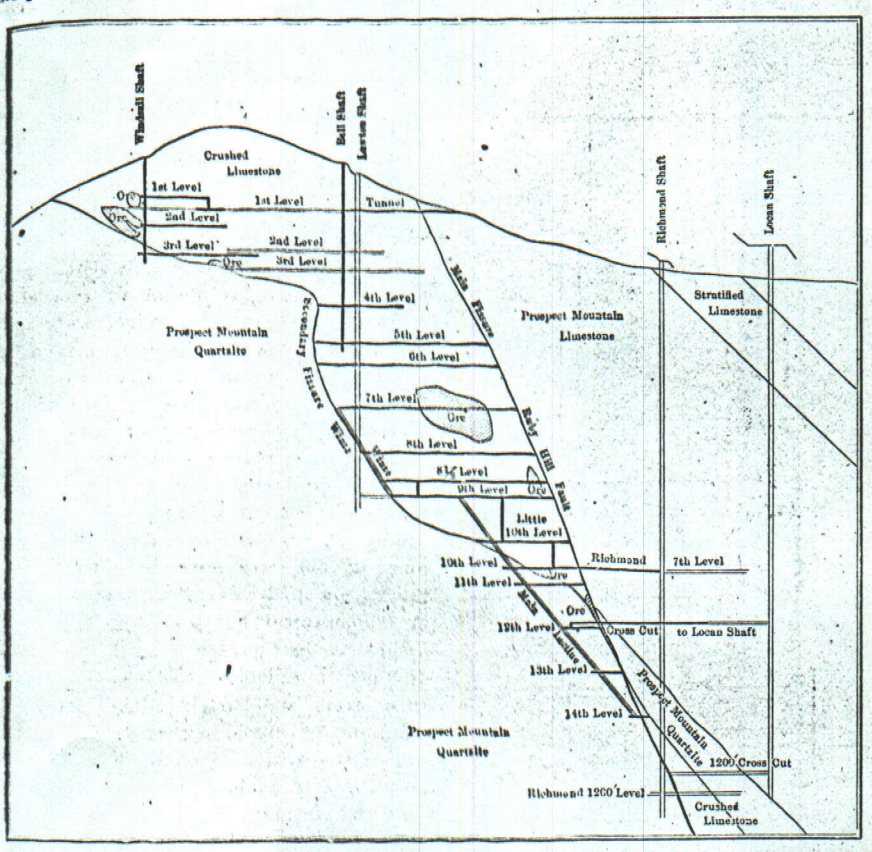
port: "The probability of finding ore in the lower wedge of limestone depends in a great measure upon the validity of the theory of substitution. If this theory is the true one—and the proofs favoring of it are strong—there seems to be no reason for doubting the presence of ore below, provided that the limestone was in a fit state to admit the ore-bearing solution during the period of deposition. That this was the case is indicated by what has been thus far observed in the lower limestone and by the fact that ore was found in the Ruby Hill fault-fissure when it was laid bare by the cross-cut from the 1200-ft. level of the Locan shaft. On the other hand, if the orebody were dependent on the prior formation of caves they will not be found below the water level, as cave formation could not take place much below that plane."

It may be remarked here that Curtis himself rather strongly favored the theory of substitution. He continued as follows: "Whether the extraction of the ore in the deeper workings will prove profitable will depend upon the flow of water, size of orebody, value of ore and facilities with which it can be reduced. Water may prove a serious impediment, but it is not necessarily one which should be fatal to the exploration of these mines. As to the size of the orebodies no satisfactory predictions can be made. No great change in the value of the ore as regards to silver need be feared, though it is possible that the contents in gold may be decreased."

Whatever may be learned with respect to the lower wedge of limestone, its exploration is certain to prove one of the most interesting problems in mining geology. Up to the present time no active move has been made in this direction, although the equipment for bailing out the Locan shaft is already on the ground.

Recent Developments

The activity of the Richmond-Eureka Mining Company so far has been confined to re-opening the old mine for the extraction of iron ore. This has been a costly, dangerous, troublesome and tedious work, the old stopes having largely caved in, so that it has been necessary to retimber them entirely with square sets. The shafts also, had to be retimbered.



CROSS-SECTION THROUGH RUBY HILL

As a preliminary to the present operations all of the leases in the mine were cancelled.

Operations are now going on in the surface workings on the western side of Ruby Hill, on the first, second and ninth levels of the Eureka and on the sixth level and elsewhere of the Richmond. The operations are resulting in the production of about 130 tons of ore per day, which averages about 3½ per cent. lead, 30 per cent. excess of iron, 0.18 to 0.2 oz. of gold and from 2 to 3 oz. of silver per ton. The value of such ore is probably about $10 per ton at the mine. In its production 160 men are employed. Drill runners are paid $4 per day, miners, $3.50, muckers and trammers, $3. Timber is very expensive, costing $80 per thousand. It is probable that the requirements will be reduced later on by the introduction of the top-slice system of mining in certain portions of the mine. The reopening of the mine has been done in a highly skilful manner, which reflects great credit upon Andrew S. Mayberry, the superintendent. The work has not yet by any means been completed, and gradually without doubt the cost of mining will be reduced, but even under the most favorable circumstances, it is difficult to see how there can be any great profit from $10 ore which has to stand transportation charges of 380 miles to the smelter at Salt Lake City. That there is any profit must be due to a favorable smelting contract with the U. S. Smelting, Refining and Mining Company, which owns a large interest in and manages the Richmond-Eureka. The ore from the latter furnishes a necessary and valuable flux to the smelter.

Smelting

Eureka was the real birthplace of silver-lead smelting in the United States. It had been tried a few years previously at a few other places, but the operations were ephemeral and unsuccessful, except at Cerro Gordo, Cal., and left no stamp on metallurgical practice. At Eureka, on the contrary, several important improvements were introduced, but of more importance was the training which many metallurgists received in a successful practice of the art. The two large smelters of Eureka were in operation for 20 years. The Richmond was closed in 1890; the "Con" in 1891. When the Richmond was built, in 1871, it was the finest thing in American lead-smelting practice. Doubts were expressed as to the justification of so much perfection in view of the uncertain life of the mines. This is, of course, amusing, when we read the later history of the latter.

Now, nothing much remains of the old works except the huge slag dumps which are shown in photographs accompanying this article. On the Richmond site there is standing a small cupola furnace and a few pieces of rusty dismantled machinery that it was not worth while to remove. On the "Con" site there are a few dismantled sheds. The sites of the smaller works are stripped equally clean.

However, there is at Eureka one relic that should be carefully preserved as a monument of the past. This is the Matamoras smelter, just above the "Con," which is shown in one of my photographs. Its stone furnace surmounted by a strange piece of iron-work is a prominent sight upon arriving at Eureka. The building in which it stood has fallen down and been carried away for lumber, but the furnace has withstood the action of wind, weather and vandals, and remains today a fine example, and the only example, of how smelting used to be done at Eureka. The date of its erection I am unable to say, but it must have been early. The fur-

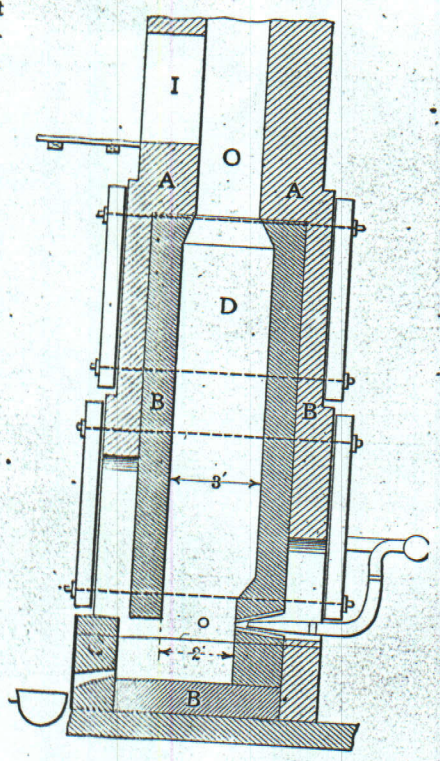
place is constructed of the "firestone," a refractory, easily cut sandstone which was used in all of the early furnaces at Eureka. Indeed, the Eureka Consolidated did not abandon this construction and substitute water-jackets until 1884. The entire shaft of the Matamoras furnace is constructed of this stone. The breast is open—a sump-furnace. The curious structure on top of the furnace is a dust-catcher. It is of sheet iron lined with brick. In the top there is a circular hole, about 18 in. in diameter, for escape of the gas. At the bottom a steam pipe, bent upward, was evidently to promote the draft. The idea was that the dust carried upward from the charge would be checked in the inverted pyramid and would slide down the sides of the latter into the furnace again. To our modern eyes this is an amusing contrivance, but at that time, be it remembered, dust-collecting flues had not been introduced. Alongside of the furnace is the Sturtevant fan which furnished the blast, then the little engine which drove the fan, and finally the boilers, set also in firestone, which produced the steam. These are shown quite clearly in the photograph. Smelteries of equal primitiveness are to be found in Mexico today.

The Old Slag Dumps

The question naturally arises, Can any part of the old slag dumps be shipped profitably under present conditions? In so far as slag proper is concerned the answer is probably not. The old metallurgists were fairly skilful and the ores were of easy smelting character. Consequently the slags are not very rich; certainly not rich enough to rework. They are said to contain from 2 to 3 oz. silver per ton and 1 to 2 per cent. lead. However, there are large accumulations of speiss, which may some day be a source of value. The formation of this compound, due to the arsenic in the ore, was always a great trouble to the Eureka metallurgists. They could not cleanly extract its gold, silver and lead, and cast it aside in cones, which glisten brilliantly on the dumps today. I was informed by an official who had long been connected with the Eureka Consolidated company that the amount of the speiss in the Eureka and Richmond dumps is probably between 130,000 and 200,000 tons, and that it contains 30 per cent. arsenic, 3 per cent. lead, 2 per cent. copper, and 2 to 3 oz. silver and $3 to $4 gold per ton. If these figures are approximately correct, there is in these dumps a great resource of arsenic, enough to supply the domestic consumption for many years. The high percentage of arsenic noted in the bag-house fume at the United States smelter at Salt Lake undoubtedly comes from the smelting of the Eureka ore.

Other Prospecting

Outside of Ruby Hill a little prospecting is going on in the Eureka district. A Philadelphia company is sinking a shaft on the flat to the north of the hill, looking for a continuation of the mineral zone of the latter. If the work of the United States Geological Survey be correct, and there is no good reason to doubt it, the outlook in this direction is not flattering. Steps are also being taken to reopen the old Ruby-Dunderberg mine on Prospect mountain, which in the early days was a rather large producer, in fact the only producer of note outside of Ruby Hill, although its output was far inferior to that of Ruby Hill. According to the study of the United States Geological Survey the Ruby-Dunderberg occurs in a different formation, which is not to say, however, that it was not, or may not yet be, a good mine. (I did not visit it.) But



THE SMELTING FURNACES OF 1870

A. Outer wall of porphyry. *B.* Inside lining of sandstone. *C.* Front of hearth of composition. *D.* Shaft of square horizontal section. *O.* Shaft of circular horizontal section. *I.* Charge hole.

Ruby Hill seems to have been unique, and the great concentration of its mineral value was unquestionably within the Richmond and Eureka lines.

A note in the *Min. Journ.* says that the employment of aluminum in metallurgy to prevent blisters and fissures in steel ingots gives excellent results. Suppression of blisters is due to the fact that aluminum has so great an affinity for oxygen that when it is thrown into a crucible of melted steel it absorbs all the oxygen, free or combined with iron, disengaging such heat that the metal is kept extremely fluid; about 0.01 per cent. aluminum suffices.

Aluminum Instead of Carbon for Safety Explosives

A new explosive designed to secure safety in blasting in a gassy atmosphere and to do away with the noxious products of the discharge, has been invented by Jean A. Fürstenhoff, and is described in *Revue des Produits Chimiques* (Oct. 15, 1907). Safety explosives of the liquid-air type give off carbon monoxide upon their detonation and the liberated gases are injurious to workmen, forcing them in many cases to return to the use of dynamite. The new explosive is prepared from material which cannot give rise to the formation of any toxic substance. To this end carbon and all other organic matter containing this element is replaced by a metal or mixture of metals which will react with liquid air or oxygen and so prevent the formation of an oxide of carbon. For example, it is known that aluminum forms explosive mixtures with substances which readily give up oxygen. In order to attain this result with liquid air or oxygen, aluminum in powdered form is placed in a cartridge, preferably metallic, and air or liquid oxygen is added just before the explosion is desired. In order to increase the rapidity of the reaction a varied quantity of metallic hydrate or a mixture of hydrates may be added, their composition depending upon the result desired. Hydrate of calcium, or any other alkaline hydrate, answers this purpose, but care must be used not to select any hydrates which are unstable at temperatures but little above the ordinary as their presence is likely to produce an unreliable explosive.

In using the cartridge the powdered aluminum is mixed with a certain quantity of the hydrates (obtained by heating an alloy of calcium and sodium in a current of hydrogen), the cartridge is put in place and then the requisite quantity of liquid air or liquid oxygen is introduced. The necessary detonation is given by fulminate or by a flame from a ribbon of magnesium. No noxious products are formed and there is no flame. Aluminum may be replaced by magnesium or any other suitable metal or alloy, and the hydrates may be those of any other suitable metal or metals.

The total production of limestone and dolomite for flux in the United States in 1906 is reported by the United States Geological Survey at 16,077,202 long tons; an increase of 689,311 tons over 1905. The total value in 1907 was $7,612,692, the average value at quarry being $0.47 per long ton. The larger outputs were 6,396,765 tons in Pennsylvania, 3,096,346 in Ohio and 1,019,931 in West Virginia. Dolomite is used chiefly in Alabama.

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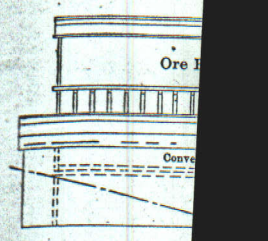

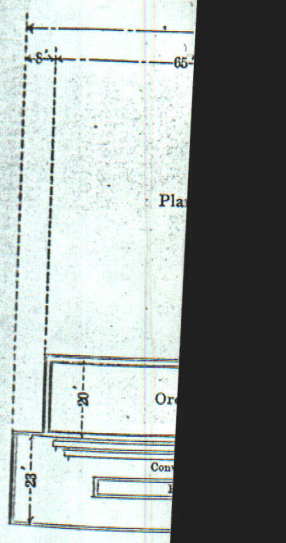

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