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Mining methods at the Arevalo Mine, El Chico, Hidalgo, Mexico

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Department:

MINING METHODS

at

THE AREVALO MINE, EL CHICO, HIDALGO. MEXICO.

By

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A

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THE AREVALO MINE

LOCATION:

The Arévalo Mine of the Cia.de Real del Monte y Pachuca is located nine kilometers north of the City of Pachuca,Hidalgo, México. It is reached by an excellent automobile road from Pachuca. Several different branches of the Mexican Railway System place Pachuca within easy access of the different entries of México. It is situated on the eastern slope from the Central Plateau of Mexico in the midst of a large government forest preserve and at an altitude of 2200 meters above sea level. An abundance of hydroelectric power is provided from Necaxa, Puebla, a distance of 120 km.

GEOLOGY:

The El Chico District, in which the Arévalo Mine is located, is separated on the north from the Pachuca district by a range of mountains, rising to an elevation of 3000 m. The intervening surface rock between the two districts consists mostly of andesitic conglomerates. Underneath the conglomerates are found andesites and dacites.

At the point where the Arevalo Mine is situated, there is an east-west rhyolite dike which outcrops on the surface. There has been a great deal of faulting during different periods along this dike, some of which has been post-

mineral. The country to the north has been upthrown with respect to the south of the dike. Up to the present time all ore has been found in a dacite, being a block approximately 2000 m. long and with a varying width up to 40 m. The post-mineral faulting has limited the lateral extent of this dacite containing the ore, and so mining has been restricted to the dacite.

Underneath the surface conglomerates to the north of the dike is found a black andesite which usually marks the footwall of the ore bearing dacite. The footwall had been prospected by means of a 2000 m. adit, and 56 different veins have been cut. All of these veins are narrow and contain base sulfides in varying quantities with small amounts of AgS and Au. These small veins are found in an andesite of a lower horizon than the dacites. And for this fact it is considered that the block of andesite has been uplifted with respect to the rock on the south side of the dike. The occurrence of base sulfides in the veins instead of AgS and Au ore indicates that the mineralization of these veins was probably formed at a greater depth than the mineralization of the AgS and Au ore that was formed in the block of dacite -- to the south of the dike.

To the south of the dike, surface conglomerates are found in a 800 m. crosscut on the 390 m. level. This evidence again shows that the country to the north of the dike

was upthrown with respect to the country to the south of it.

This block of ore bearing dacite is located north of the dike and with the black andesite on the footwall of the dacite. The dacite is in a zone of intense faulting and facturing due to post-mineral movements. The dacite was in this way shattered and has caused the ground to be heavy for mining.

The ore occurs in this dacite as small stringers of quartz and calcite with AgS and small quantities of basic sulfides. Or sometimes the sulfides are found in the dacite without the presence of quartz nor calcite. The ore is usually richer when associated with quartz than when with calcite. The calcite predominates in the upper levels and the quartz in the lower levels. The ore is very irregular and spotty due to the post-mineral faulting and shattering of the ore bearing dacite. The ore contains approximately.9 gm. Au to 100 gm. Ag.

The rhyolite dike has a varying width of one to five meters. Several dikes or variations of the rhyolite are sometimes found. There is a varying thickness of gouge on both sides of the dike.

In the lower levels very basic ore, PbS,ZnS, with a small amount of CuS and AgS, is found to be on the footwall of the AgS ore. The basic ore has a possible commerical value and perhaps can be mined should sufficient tonnage be found.

The basic ore is separated from the AgS ore by a smooth slip which makes a distinct contact between the minable AgS ore and the basic ore which is left on the wall. It is believed that this basic ore was not formed at the same time as the silver ore because the smooth slip shows a decided contact and not a graduation from the silver ore to the basic. The two different ores probably came from the same ore magma and are evidently products of segregation of that magma.

MINING:

The mine at the time that it was taken over by The Cia. de Real Del Monte y Pachuca in 1921 was producing a very small tonnage of high grade ore. The mine had been worked for years. The upper levels were well developed and most of the ore removed from these levels. The lower levels had not been thoroly developed nor had the bottom of the ore been reached in depth. So after a thoro examination, sufficient ore reserves and possibilities were found to warrant the purchase of the mine, the necessary development work, and the building of a 9 Km. tramline to Pachuca for the milling of the ore in the company's central cyaniding plant of 2400 tons daily capacity, later increased to 4000 tons capacity.

The mine at the time of acquisition was developed by various surface entrances and levels to a depth of 390 m. The levels were spaced approximately 50 m. apart and most of

the ore had been worked out to the 290 m. level. From the 290 m. to the 390 m. level some stopes were working and with subsequent development along the vein more ore was found. The ore was extracted thru an interior shaft and chutes to the 240 m. level where it was trammed thru an adit to a mill located at a distance of 3 Km. This mill cyanided as high as 200 tons per day, but due to the small tonnage and excessive cost of transportation from Pachuca it was decided to abandon the mill and build the 9 Km. tramline to Pachuca with a maximum capacity of a 1000 tons per day.

At the same time it was necessary to provide additional hoisting equipment A new shaft was sunk from the surface in the solid footwall to a depth of 530 m. The work was done rapidly as it was possible to raise from each level above the 390 m. level. The shaft is 18'6" long by 6' 4" and consists of manway, a compartment for a two deck man cage, and two compartments for hoisting in balance.

Only a small amount of ore was found below the 490 m. level. The ore has decreased in value and extent on the 490 m. level with an increased of the basic sulfides. An interior shaft is now being sunk 100 m. below the 490 m. level, so as to determine if ore exists in depth.

The fractured zone to the west has been explored by means of a drift on the 390 m. level to a distance of 1200 m.

from the shaft. No ore was found; the ore bearing dacite terminating 300 m. west of the shaft. A drift has also been driven 900 m. to the east of the shaft on this level with only spotted values and mineralization. A 2300 m. crosscut was driven to the north of the ore body also on the 390 m. level; a number of veins were cut containing basic sulfides and unpayable quantities of AgS.

The choice of mining methods was limited to cut-and-fill in solid ground, and to squaresets in heavy ground. The daily tonnage is approximately 800 of which two thirds is produced from the cut-and-fill stopes and the balance from squareset stopes.

Top-slicing nor caving methods were not applicable to the upper levels due to the scattered condition of the stopes at the time that the mine was acquired and also due to the fact that the top levels could not be abandoned, due to surface buildings. Otherwise top-slicing would have been adopted.

SQUARESET STOPES:

All squareset stopes are very heavy and require close timbering and filling. The payable portion of the vein was originally 5 to 8 m. wide. On the hangwall of the ore is the gouge and decomposed dike. In the center and on the foot-wall of the ore are found irregular workings, some filled and some partly open where the vein was worked years ago.

On the hangwall and sometimes in other portions of the stopes slickensides are found which increase the tendency of the fractured and shattered ore-bearing dacite to cave. The dip of the hangwall is approximately 65° and is determined by the dike which limits the ore on the hangwall.

So between the broken up pillars of ore, the old filled stopes, and the extremely soft hangwall, difficult ground for successful mining was found.

In opening up a squarset stope, 25 m. is considered the most economical length. This size stope permits a fairly rapid cut and at the same time provides enough different working places so that timbering, filling, mucking, and ore breaking may go on simultaneously. A waste raise is run to the level above in the center of the 25 m. stope; one manway and one chute are then spaced on both sides of the waste raise. Should other chutes be found desirable they are made later from a counter drift below.

The first operation consists in driving a single line of squaresets the full length of the area to be stoped on the footwall so as to form a permanent haulageway; The manways and chutes are all located in this counterdrift. After the full length has been opened up, or simultaneously with it, crosscuts are started from the drift in the stope towards the hangwall. These cross cuts are usually started every fourth or fifth set, depending upon the con-

ition of the ground. The idea being to leave a pillar of ore between the different crosscuts so as to help to hold up the back. After these crosscuts are finished and the ore removed they are immediately filled with waste and the back of the sets caught up securely with timber on top of the waste in such a manner that the weight of the back of the stope rests on the fill and not on the squaresets. At the same time that these crosscuts are being filled, new crosscuts are being started always leaving a pillar of ore or at least a filled set between two crosscuts, The pillars of ore are eventually removed by subsequent crosscuts, by this time the first crosscuts will have been filled and so again the back will be supported on either side of the crosscut, either by a filled set or by pillars of ore which will be taken out later. Spiling is very frequently necessary in order to drive the drifts or crosscuts. When the old pillars are not broken timber is sometimes omitted. The ore chutes and manways are built up with round oak cribbing and have a width of one meter. The chutes are lined with three inch pine boards. Round timbers cut to a standard size on the surface are used for squaresets.

As a cut nears completion, another cut is started from the other end of the stope if possible from a waste raise. The production of ore is maintained constant by working several faces at the same time. It is usually planned to have two

faces breaking ore and placing timber while fill is being placed in sets already finished. It is absolutely necessary that the sets be back filled immediately as otherwise the broken back would cave even with the support of pillars or filled sets on either side.

Twelve to fifteen men are usually employed in a stope like this.

CUT-AND-FILL STOPES:

In the portion ofthe mine where the vein has not been worked before cut-and-fill mining has been successful. The lengths of the stopes are usually 40 to 80 m. long. Waste raises are spaced at 25 m. intervals. Ore chutes are placed at ten meter intervals and manways connected with both the level above and below. The stopes vary from one to eight meters wide, the average is four meters. The cuts are invariably started at one of the waste raises and then continued the length of the stope. Fill is carried as close as possible behind each cut so as to catch up the back with cribs and to prevent the possibility of slabs falling off the walls. Formerly all filling was done with wheel-barrows but double drum air hoists were later substituted with great success and economy. This permits greater speed and eliminates the large number of men that were formerly used for this work, Under proper conditions it has been found that two men with a scraper can do the work that 10 to 20 men were doing with wheelbarrows and much quicker.

The scraper has not been found practial so far for use with the ore in the stopes due to timber interfering.. Where cribbing is used to hold up the back this has prevented the use of the scraper to advantage. At present seven Waugh 300 double drum hoists are in use in various of the larger stopes. The depreciation and initial cost of these hoists make them expensive but they are much more economical than the former method of using wheelbarrows. All stopes are heavy and require the use of numerous cribs to hold up the back. The back has a tendency to slab off with horizontal slips, so in connection with the soft hangwall and with slickensides on the footwall the ground is very heavy The cuts are carried low, never over two meters high, so that the back can always be barred down andthe men protected in this way from loose rocks. The fill is also carried close to the cut for the same reason as the back becomes heavy if left unsupported for any length of time. The fill is carried to within one meter of the back. Numerous cribs are placed before filling and afterwards; a portion of this timber is recovered.

WASTE SUPPLY

Waste is supplied chiefly from glory holes on the surface and from development work in the mine.

Several large glory holes on the surface are in use. During the dry season the surface dirt is obtained and used as much as possible as it can be broken cheaply with black

powder. During the rainyseason it is necessary to use as much rock as possible for the surface dirt becomes very wet and difficult to handle. The glory holes are drawn by a number of chutes and then the waste is trammed by mules to different winzes connecting to the 240 m. level where it is drawn by motors and then trammed for distribution to the stopes below. Whereever possible an effort is made to dump the waste from the motors directly to the place where it is to be used so as to obviate unnecessary tramming. This supplies all of the waste for use in the stopes down to the 390 m. level, and by use of the same system of raises it may be used to the 490 m. level in case of necessity altho this requires rehandling at the 390 level by motor.

The stopes below the 390 level are usually supplied with waste from the development work above this level. All development work on the 490 level,the bottom level, that is in waste is hoisted to the 390 level in cars and then taken by motor and dumped to the stope where needed. No waste is ever hoisted to the surface if it can be avoided.

In case of a shortage of waste, a glory hole is made to the footwall of the stope needed and the waste supplied direct. The soft gouge prevents the hangwall from being used to supply waste as it would cave the stope in subsequent cuts.

A caving station for the supply waste was tried but not successful as the rock where available was not suitable for caving.

SAMPLING METHODS.

All development work in vein matter is sampled at 1.5 m. intervals. Each sample is one meter wide, A,B,C, etc. being used to denote the samples taken across the working place. All stopes are sampled frequently, the high grade stopes only occasionally.The low grade stopes at least once a month. The ore is easy to distinguish when fairly high grade as the sulfides are plainly visible. But in the low grade stopes the sulfides are not so easily distinguishable, especially as PbS is present and is apt to be deceptive as to the silver content.

The samples are cut by moil and hammer in groves about 4 inches wide, the surface of which is chipped. A special crew of sample men under the direction of the engineer take all of the samples. Each month the Engineering Dept. prepare blue prints showing the assay plans of the levels, a vertical section, and stope assay plans which enable the Mining Dept. to keep a close check on the different working places.

In the square set stopes the samples are taken the full width of the sets instead of one meter. The assays are then plotted on cross-section paper so that each square represents a square set. The assays are then placed in these squares.

This enables a selection to be made in mining the next cut.

The ore is very irregular in value, one stringer may run several kilos of Ag while the vein on either side may have only a few grams. So it has been found to be best that in computing the value of any block of ore to leave the high samples in the average, and not discard them. The general average of the mine is calculated in this way for a month, taking in consideration the tonnage produced from the different working places. This average has been found to be 10% higher than the mill head for this same period. So in the final calculation of ore reserve a sample correction of 10% is applied with good results.

LABOR:

The men at the mine consist of Indians and mestizos. The Indians are seasonal workers alternating their work in the mine with ranch work. The Indian labor forms the lowest class and they occupy usually the least important jobs. They are docile and rather easy to handle if their ways are understood. They are not over energetic and are not capable mentally nor physically of any great task. Simplicity is their keynote. The mestizos form the greater part of the miners. Their inteligence and physique are greater than the pure Indian. The mestizos occupy the most important jobs and very capable men are frequently found among them.

The men live in small villages near the mine. Like most Mexican communities the sanitary conditions are poor and a great deal of sickness of all kinds is found among them, especiallyin the dry season.

The task system has been found to be most successful among all miners. From this a bonus system has been developed where possible in this mine. This has lowered the costs and increased the production in many working places.

It has been found that in the stopes, the most successful way to produce and maintain tonnage is to establish a certain number of cars per shift from the stope as standard. This is determined by experience, considering the number of men in the stope, whether square set or cut-and-fill, and any other special conditions that affect ore production. The stope boss then receives his standard day's pay regularly and for each increase of five cars over his standard production he receives a bonus. The men in the stope receive nothing from the company in addition to their regular pay unless the stope boss sees fit to give them a part of his bonus for their work. The advantage is that the stope boss keeps pushing his men and strives to get the most work possible with the number of men that he has. The trammers also receive a bonus, depending upon the number of cars trammed. Car checkers are on duty at each ore pass so that an accurate check is maintained daily from each stope of the ore produced. It is found that ten to twenty men are as many as can be handled by one man in a

stope. The production from each stope varies from 1.5 to 4.5 tons per man in the stope, depending upon the method of working and other conditions.

In development work a similar system has been found to be simple of application and has given good results. All men have a standard day's pay which they receive irrespective of the meterage produced. But by experience with work in certain kinds of rock it has been determined the meterage that should be produced under average conditions, considering the kind of rock, the number of men working in the face, the number of machines, the distance necessary to tram the broken rock and anyother factor that might influence the advance. The man in charge of the face is then payed on a meterage basis for his own services only, a fair day's work is considered average and so receives a bonus on all advancement which is above the average standard. Of course almost every working place has different conditions which must be considered in fixing a small sum weekly depending upon the advance made, altho this entirely depends on the man in charge of the face. Frequently he does not give his men any bonus money if the advance has been poor, but if it has been good and he, himself, has made a bonus then he will reward his men from his own bonus which will be sufficient for this purpose.

In shaft sinking a bonus is being successfully applied for the meterage over 6 meters per week, each man in this way

sharing in the bonus directly.

Of course there are exceptions to all rules and sometimes a bonus is not applicable, the men then receiving their standard day's pay. The above systems have been evolved due to the special characteristics of the Mexican miner. The average miner cannot be relied upon to do anything unless he receives a great deal of individual attention and pushing by someone constantly at hand. He naturally has the desire to do as little work as possible and requires a great deal of supervision, hence the limited number of men working with each boss. Instructions must be given with great detail and repetition. The miner is frequently like a child in his mental capacity and habits. The men in charge are of different type and are often energetic, willing and good workers.

The law is also very explicit and it is found to be necessary to see that all men receive their day's pay irrespective of the work done, A regular contract including labor and supplies has not been found feasible and we have found this improvised bonus system successful. This gives the man in charge of a working place an incentive to push his men and at the same time guarantees all men their daily wage. It is also simple of application.

The following is the wage scale:

Stope bosses	8.00--1200 Pesos per day
Timbermen	3.00-- 2.00
Drillers,turbro	3.50
Drillers helpers	2.50

Drillers, stopers	2.50 Pesos
Motormen	3.00
Muckers	2.00
Trammers	2.00
Hoistmen	7.00
Blacksmiths	4.50 - 6.00
Drill Sharpeners	4.00
Native Shift Bosses	40.00 - 110. per wk.

The stope bosses and men in charge of development work average about 10.00 pesos, Mexican Currency, per day. As can be seen from above the miners in the Pachuca District are receiving pay much above the average of any other district in Central Mexico.

Since the adoption of the Constitution of 1917 there have been a great many labor troubles and difficulties which have been forced on industry by the government in applying radical laws. The basic ideas in many of these laws are good.

Boards of Arbitration and Conciliation are provided in all districts, consisting of an equal number of members appointed by Syndicates and by industry with an odd member appointed by the government. The government appointee is nearly always a Labor man and so naturally most decisions are one-sided.

The men in the mines were unorganized until a few years ago when agitators started the movement. At the Arévalo Mine the majority are not members of the Syndicate but the minority is the powerful element and forces its will over the others. The mine is run similar to a "closed shop mine" in many respects altho nominally the idea of an open shop prevails. Each mine has its own syndicate who elect their officers. These officers act as a grievance committee and meet regularly

with the mine captain in an effort to arrange the difficulty. In case the matter can not be settled, then it is sent to the company's main office where every possible method is made to end the matter, frequently compromising. If no arrangement is then made, the matter goes to the Board of Arbitration and Conciliation.

EQUIPMENT

The electric current is received from Pachuca at 20,000 volts and reduced at the mine to 6000 volts for use of the compressor and 1000 volts for the hoist. It is reduced still further for lighting and some of the shop motors.

Two Ingersoll-Rand Compressors are in use. One of 3500 cu. ft. per min. cap. used with a synchronious motor, and the other a small 600 cu. ft. per min. capacity for use during peak loads.

Two Nordberg hoists are in use. One two-drum hoist with a 290 H. P. motor, rope speed 1600 ft. per min. Hoisting is done in balance. The capacity of the Skips is 2.5. tons. The other hoist is for use of the men and supplies. It is a single drum hoist with a 290 H. P. motor, rope speed 1200 ft. per min. It is equipped with a double deck cage. The cage is designed for the hoisting of two one-ton cars should it be necessary.

The Carpenter shop is equipped with modern saws and timber-framers thus handling a large amount of timber economically. All timber is cut to standard sizes on the surface.

A small machine shop with lathes, drill presses, pipe cutters, etc. enables all minor repairs to be made at the mine. A large machine shop is maintained in Pachuca for work such as can not be done at the mine.

An up-to-date blacksmith shop is maintained near the mouth of the shaft. Two IR No. 5 and one IR No. 50 sharpeners are used for sharpening the steel.

The mine is equipped with Turbro drifters; automatic rotating stopers and hand stopers; several types of jack-hammers are in use. The automatic rotating stopers, have proved to be very expensive in their upkeep and are objectionable for that reason. All stopers are used dry.

The shaft is placed to the footwall of the vein, the rock is solid and stands well. A great economy was made in equipping the shaft with fabricated steel sets. The higher initial cost has been offset many times by the longer life obtainable from the steel.

Hoisting is done from the 240 and 490 levels. Air controlled gates are used for loading. The idea being thru-out the mine to drop the ore to the 240 or 490 levels.

On the two main haulage levels, 240 and 390, storage battery 10-ton locomotives are used.

The surface buildings include offices, supplyhouse, a mess house and bungalows for the foreign employees, A large change house for the men has been built.

CONTRACT METHODS:-

From time immemorial the task system has been used in Mexico with the best results for obtaining a certain standard of work. Due to the characteristics of the greater part of the men a boss is essential with each group and naturally it is found that the best results can be obtained by working thru the boss rather than trying to supervise the men directly. Several different methods have been evolved for handling the situation, some on the bonus basis, some on a contract being given to one individual, and others on the group contract system. A few of the merits and demerits of the various ideas will be given, however, the ultimate choice must depend upon local conditions and perhaps upon radical labor unions.

The writer believes that, where possible, the bonus system is the best if local conditions permit. A modified bonus system was used at the Arévalo Mine with good results. Past experiences indicates that even better results would have been obtained if the payment was extended to include all of the men instead of the contractor only, thus presenting the fact to the men that they could make extra money by additional effort and not look directly to the contractor for this extra payment as frequently the contractor does not pass any money along to the men. Bonus systems require more intelligent supervision and are of easier application in smaller mines.

The straight contract now prevails in most of the mines. In this form the contract is given to one man. It has the

advantage that the contractor is supposed to take greater responsability for the work. When the contractor's earnings are sufficient he gives a small amount of it to the men. So far the disadvantage of this system has been to create a powerful click of contractors who are sometimes trouble-makers in many labor disputes. It is found difficult and sometimes unwise to cut prices even when they are excessive. The contractor usually gets too much money for the work he does. The contractor has a tendency to do poor work. To correct many of the disadvantages of the straight contract system, the group contract is being implanted in many cases. In this form a contractor is named who receives a standard wage higher than his men. Then the earnings are divided pro ratio among all the men and the contractor according to their standard pay, the pay of the contractor and his night boss are considered fifty to one hundred percent higher in calculating their share of the earning. This system has proved to be an improvement over the straight contract, as the men receive extra money weekly, if the breakage or meterage is good, directly from the company and not thru the contractor who perhaps would give them less or nothing at all under the straight contract system.

In conclusion, it is believed that the bonus system would be best for use in smaller mines, otherwise the group contract. Local conditions, labor unions, and the type of the miners determine what can be used, although not always the ideal system.

CONCLUSIONS.

Now that the Arévalo Mine has been finished, the payable ore exhausted, the equipment removed and the surface buildings abandoned, the author would like to express a few personal opinions that would perhaps be worth considering under similar conditions in the future.

It is believed that all men entering the service of a company should be subject to medical examination before being employed. This would keep out those that are not in good health or that have physical deformities that would be a hinderment in their work. This is especially important in view of the very stringent labor laws providing for indemnization for injuries and professional diseases. Due to the inherent likelihood of many of the men for the contraction of tuberculosis with the frecuent association of silicosis and the corresponding indemnities provided by law, it would behoove any employer to try to weed out the most unfit before employment.

It is believed that all drilling machines used in the mine should be wet or used with the newer dust collectors. This would have a tendency to reduce silicosis. Recent laws have now obliged mining companies to adopt wet machines. However, it is also believed that wet machines will give a much better performance over dry machines from the economy point of view as well as the improvement in health standards.This is accomplished in wet drilling by more footage per steel and of course less wear on the bit with a corresponding lower labor cost per hole.

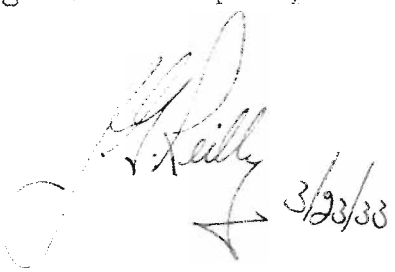
Another factor that has been found to be an advantage would be the more liberal use of fans to insure better ventilation. This would be shown indirectly by having a tendency to reduce silicosis and directly by having a tendency to increase the output per man with better ventilation.

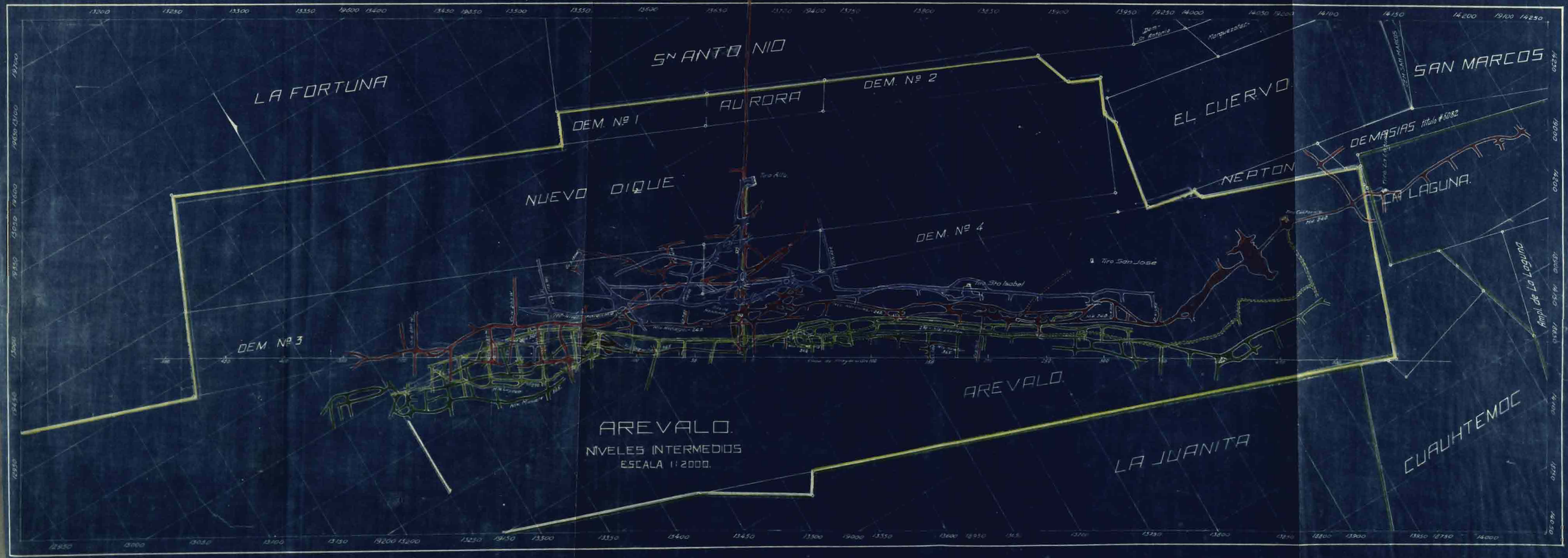
Experience has shown that certain improvements might be made in the installation of haulage equipment. The mine was equipped with small storage battery locomotives which were evidently originally supplied with the idea that they would be used for gathering purposes. They were perfectly suitable for gathering. But as the conditions were they had to be used for main haulage on the two principal levels. In a similar case in the future larger, trolley equipped locomotives would be an economy due to the use of less labor, longer trains and over capacity in design. A small portable battery locomotive would probably have been an advantage to have had in other of the levels, provided that the cost of same and repairs could compete with the low priced labor.

It was found that the concrete loading bins, such as used on the surface for the tram line to Pachuca, would have perhaps been more satisfactory if they had been lined with steel, or better still, constructed entirely of steel.

The mining methods were found to have been satisfactory due to local conditions and the cost was not found to have been excessive. However, in a future case it would be well to consider the possibility of top-slicing compared to square-setting. In the case of this mine, it would have been very incon-

venient due to the surface typography to have located the surface buildings elsewhere and for that reason top-slicing could not have been used, as the surface near the buildings would have caved. But under similar conditions underground, top-slicing could have been used in preference to square-setting at a lower and greater output per man.

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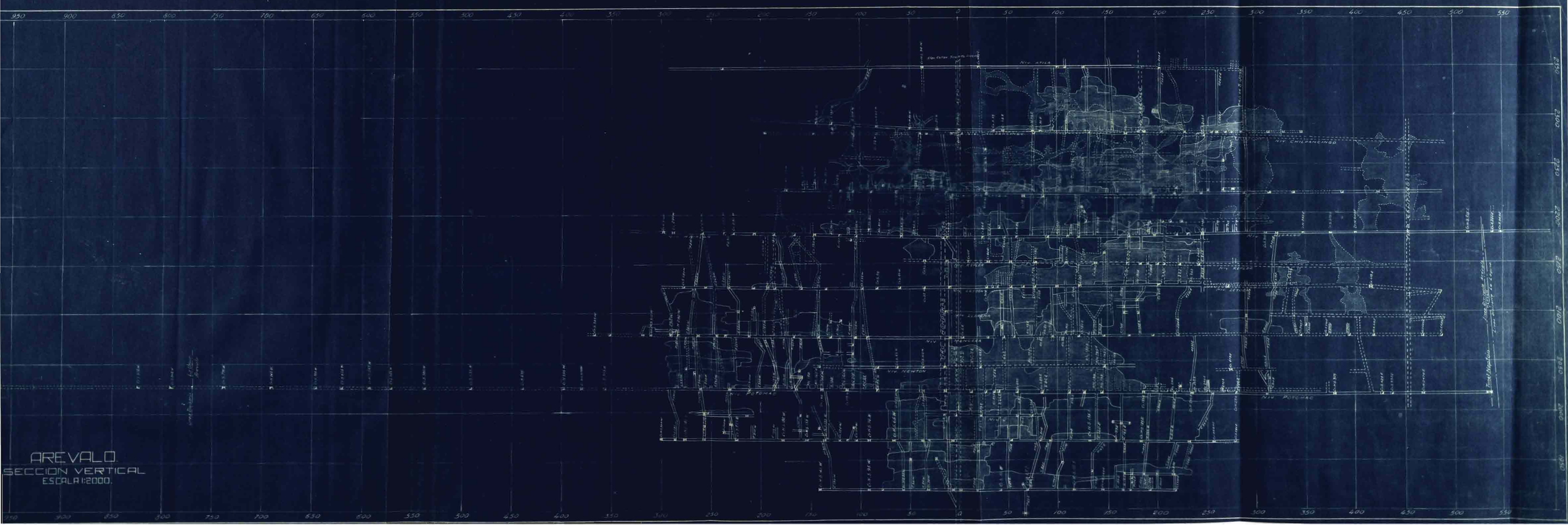
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