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Mining Camps of North America:

Tonopah, Nevada's Best-known Silver District

Complex Geology an Interesting Feature

By Herman D. Budelman

[redacted]

Geological Survey published Professional Paper No. 42 the trachyte, and is sometimes intrustive into it, and its

fissures in which the veins were formed, these faults were probably post-mineral and occurred at dif-

In the west-central and western areas of the district

dividend paying mines has been forced to close down, but without new developments or a rise in the price of silver their probable life is problematical.

timbered to prevent dilution of the ore. Narrow stopes are stulled, and wide stopes are square-setted. The flatter veins are worked by footwall crosscuts and

raises, the spacing of the raises being an economic problem depending on width of vein and other factors,

was later changed to a sand-leaching and slime-agitation plant, and later to an all-slime plant.

Tonopah Belmont surface plant

This shaft is 1,700 ft. deep, but practically all production has come from above the 1,400 level. The mill has a daily capacity of more than 500 tons, but is now idle.

The Geological and Physical Condition of the Tonopah Mines,
Walter P. Jenney, EMJ 1-1-1910.

Veins are larger and more regular when traversing the earlier ~~rhyol~~ andesite, contract in width or pinch out when entering the rhyolite. Latter is largely qtz, breaks with a fine-grained, splintery fracture, color light greenish gray. It is an intrusive sheet. St veins pass into rhy with no change.

Ores are qtz, with argentite, pyragyrite, polybasite etc, with some copy etc. Ratio is 90-100 oz silver toone ounce of gold.

Tonopah.
Spurr, Ore Magmas. p 299 ff.

Country Rock. Oldest rock a trachyte flow; horizontal faulting along transition zone of main trachyte body and its glassy lower portion; here an andesite intrusion penetrated; renewed fissuring along same zone, glassy trachy- alaskitic intrusion followed immediately above the andesite; same plane again reopened, second trachy-alaskite intruded just above the other. Later copious surface andesite flow, then series of rhyolitic and alaskitic flows and intrusions.

Veins. Main veins formed after trachyte eruption, before any others. Second imp set of veins after 2nd trachy alask intrusions, and before the succeeding andesite flow. This set in 4 periods: a, large typically barren qtz veins; b, tungsten veins; c, barren qtz-adularia veins; d silver-gold qtz veins similar to first group. 3d group of veins formed after last rhy-alask flows and intrusions, carrying occasional lead zinc and copper sulphs, but not gold and silver. (Veins in rhy tks of same age are rich in gold and silver at Goldfield and Divide.) All these veins formed at nearly the same depth below the surface. Therefore pressure had nothing to do with formation of the different types. Therefore temp fluctutaed up and down the whole range of ore deposition. As tungsten, copper zinc and lead are sparse, these critical Ts were only briefly sustained; main dep was silver-gold ore in qtz- T and P conditions for this type were normal. Only difference between this dep and the normal silver zone overlying the lead zone is the gold. Thinks gold represents separate low-temp zone overlying the rich silver zone; this gold zone distinct from the two other deep-seated gold zones: 1st below the copper zone-gold-qtz zone; 2nd above the copper zone-pyrite-arsenop. zone. (Silver also shows two recurrences in the deep zones: 1st below the lead-zinc zone, in the py-arsenop zone, and the sec above the lead-zinc zone.

But in a telscoped dep like Tonopah all three gold zones may be represented, since all major zones appear to be.

Thinks temperatures were high in these deps; qtz is finer-grained than that at depth, but this means quick crystallization, like the fine-texture of associated volcanic rks, and not initial temp. Calcite, another typical gangue, is found thruout the whole range of ore-dep in depth. Adularia is found in the copper zone at Matehuala; in deep gold-qtz veins in Calif; copper deps of Mich, CM mineral in Norway with ores of copper, zinc and molyb.

Vulcano crater (silceous rhy) fumaroles have deposited compounds of tin, bi, co, Cu, zinc and lead, or nearly the whole range of metallic deps.

Alteration. Near the veins: sericite and adularia, qtz, py and siderite; at a distance: calcite, chlorite, py siderite. Sericite and qtz of the vein walls indicates fluorine disengaging itself on the opt of qtz, together with CO_2 and H_2S (as indicated by the py and siderite); but at a distance from the vein only CO_2 and H_2S were left. This corresponds with recorded succession of gases from fumaroles: hottest contain clorine, fluorine, boron, which disappear when T sinks. S emanations persist to much lower T, while CO_2 persists from hot T to low T.

Tonopah.

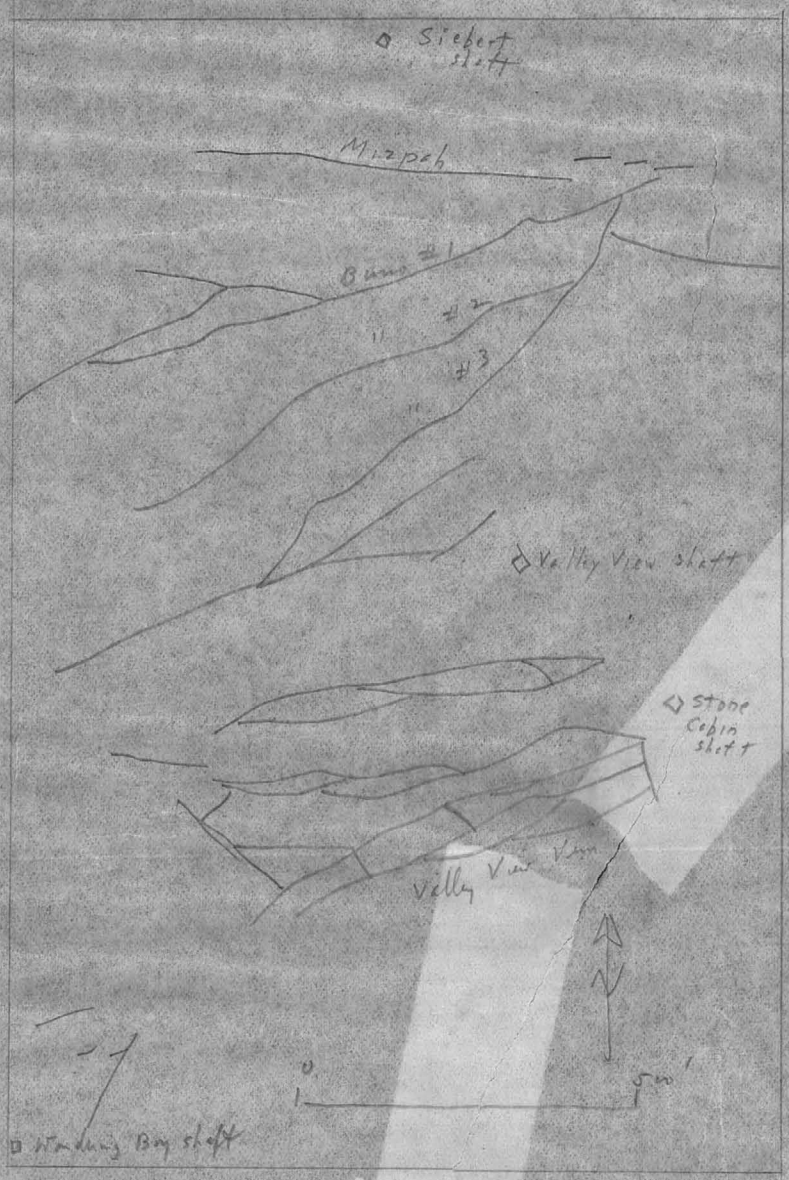
Spurr, Ore Magmas, p 152 ff.

General Geology. Shallow complex veins formed in late Tertiary volcanic complex of flows and sills. Veins of several periods.

Main Period. Silver sulphs, copy, blende, gangue qtz and adularia; gold.

Later Period. Same metallic and gangue minerals, with abundant rhodochrosite. Also barren qtz veins, st with adularia.

Chief ore-veins have formed mainly by replacement of crushed and sheetd fissure zones; many of the barren qtz veins are clean fissure veins, no evidenve of replacement. Sharp clean line between vein and wall.



1st Period Veins

No enrichment at junctions.

Star Route
Garden Valley, Calif.

November 26, 1962

Mr.Laurence H.Beal, Mining Geologist
Mackay School of Mines
University of Nevada
Reno, Nevada

Dear Larry:

I am greatly obliged to yourself and Vern for helping me out on Tonopah by sending the Nolan paper. I am greatly interested,also, in what you say about Nolan's maps being there. Block diagrams are a highly useful adjunct to geologic reports,but they should not be the sole illustrations. I have used them frequently as auxiliaries; but one cannot make vertical sections from them directly,and because of what I call the Babylonian stone quarry mode of construction ,a structure in which you are interested suddenly disappears under the nearest quarry bench. Another gripe is that Nolan presents his western quarry viewed from one angle,his eastern from another.

Don't laugh at an old man now,but I have been changing his 60° axial angles to 90°,a long,painful job!this was because I didn't know how to get hold of the original plans. Now you say these are available,I think I shall continue,mainly because to do so keeps me constantly hep to the structural picture,so far as it goes.

Unforunately it doesn't go quite far enough:too incomplete,scratchy on account of the stone quarry.For example,where Nolan's faults or veins traverse a vertical quarryman's bank,you can get the dip;but elsewhere,where you see it on the horizontal bench,you don't know the dip.

I now live closer to Reno than to Berkeley;what I think I should do is complete my rectification of "Nolan's Folly" and then come to Reno with the results and consult his plans and sections. At that time I can have copies made of the critcal parts of the plans,and of the cross sections.

As for results of my epithermal studies,whether anyone publishes them or not,I should be highly pleased to show them to you.

Thanks again

Sincerely

Edward Wisser

UNIVERSITY OF NEVADA
RENO, NEVADA

MACKAY SCHOOL OF MINES
NEVADA BUREAU OF MINES

November 13, 1962

Professor Edward Wisser
Star Route
Garden Valley, California

Dear Ed:

Dean Scheid asked that your request be taken care of over here. Under separate cover, I sent you a complimentary copy of Nolan's publication. It occurred to me that in addition to the bulletin you might be interested in our colored photostatic copies of Nolan's underground maps (these were used to develop the block diagrams in the report). The underground workings are shown at 1":200' and in all include about ninety plates. Unfortunately we have only one office set, but I would be happy to arrange for a set of copies or copies of critical areas and cross sections. Positive photostatic copies are about $1.20 each.

I am looking forward to the results of your study of epithermal ore deposits.

My best regards,

Very sincerely yours,

Larry Beal

Laurence H. Beal
Mining Geologist

LHB:hm

MINING 111B 3A-2. Tonopah Envirnment.

References: Geology of Tonopah Mining District, J.E. Spurr, USGS PP 42, 1905. T.B. Nolan (1) UG Geology of W part of Tonopah District, Univ. Nevada Bull. vol. 24, 1930, No. 4 (2) UG Geology of Tonopah Mining District, Nevada, Ibid. vol. 29, 1935, No. 5.

Rock Formations:

Post-ore rhy. Dikes, lenticular masses.

Post-ore Fraction breccia member of Esmeralda formation. Volcanic breccia that unconformably overlies OBs and their wall rocks. (May not be post-mineral-cf. Glance cgl., Bisbee). Extensively silicified, locally pyritized/

ore West End rhyolite: sills to 600' thick, intrusive into older rks.

ore Extension breccia: tabulat intrusive mass; in W half of district only.

ore Mizpah trachyte: flows 2000' thick originally, much of this removed by erosion locally.

Sandgrass andesite: dark lavas, interlayered with Tonopah formation.

Tonopah formation: IB tuffs, breccias, flows, conformably overlain by Mizpah trachyte. 1000' plus.

Regional structure:

District lies on a west-dipping monocline, presumably W flank of a N-S uplift, although source of rocks enclosing OBs thought derived from igneous center to the W. Extension Breccia intruded as tabular mass along Tonpapah-Mizpah contact. West End rhyolite intruded, same contact, but more sill-like. Both pinch E.

Earliest faults N-S, dip flat E (opposed to beds, antithetic faults connected with the uplift). Halifax fault zone. In far E part of district. E dip ave. 37. One member ends Belmont vein E; other members cut E-W Halifax vein into several segments. A little min. and ore along Halifax fault zone. Pre-mineral movement 2000' plus.

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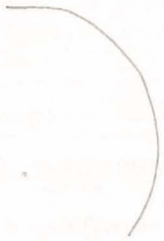

3/9/49

Either contemporaneous with or slightly later than this early Halifax faulting there came the compound Tonpah fault. Three similar major fractures ;all convex E in plan, convex upward in section. Axes of curvature of all three on same E-W line, plunge flat E. No comparable deformation in wall rocks, so not due to folding. Displacement along each of the three branches 500-1500', HW relatively down. Thought due to uplifted footwall segment, probably an igneous cupola. (W side of Halifax fault also thought to have been uplifted). Lies W of Halifax, uplifted area possibly a cupola on top of the general uplifted mass.

Uplift succeeded by "collapse": NW, N-S faults. Progressively greater uplift along Halifax fault zone (W side) explains N dip of most of the E-W veins.

p.39-40: In pre-Esmeralda time present site of Tonopah was uplifted, earliest uplift along Halifax zone, rocks in FW pushed up, tilted to present west dip. This early uplift progressively greater to N.

Then Tonpah fault cupoloa uplift. "Concomitantly with the formation of the major fractures, several minor fractures developed along the crest of the curved Tonipah fault segments, possibly as a result of the stretching in the HW blocks due to the increase of the volume of rock in the uplifted FW block."

Ore bodies: Replacement veins following faults or minor fractures; commonly without well-defined walls. Argentite, polybasite, As-pyragyrite etc. Qtz., early; fg pink carbonate, contrmp. with ore; barite.
Main ore control Tonopah fault. Known OBs limited to thin shell, apex in central part of district; elongated dome E-W; median line of shell coincides with crests of the three major branches of the Tonopah fault. Ore shoots in W part restricted to parts of the two lower branches of the flt. In E half, to the subsidiary E-W fractures connected with the fault.

Stresses notion that qtz was early, sealed many fractures; at time of

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INSERT.

Alteration Environment: Albitization of feldspars almost universal in the district,unlike Pachuca where it is more closely confined to veins. Earliest effect. Next most widespread is chloritization,everywhere,to varying degrees,except in central part.Most intense near flts. Carbs.py,with chl. Qtz-sericite-adularia,central area.Hard,bleached rk/Applies to Mizpah trach. Qtz-sericite-adularia alteration most intense in Tonopah fault area,coinciding almost exactly with highest contours of productive zone. Would have been an ore guide.

Gold-silver ratios of OBs coincide with contours of central zone:central area 1:85,decreasing to 1:115.5 on outskirts. By plotting such ratios and drawing isobars thru them,central area would have been delineated. More later.

Nolans Suggestions for Prospecting:Segments,unexplored,of known veins, within the productive zone. Sample walls of veins for low-grade. Try for new veins,at greater depths in E,W parts (see section).

Since Halifax uplift,according to Nolan,continues N,suggests prospecting for another local uplift,such as the one that made Tonopah,farther N. But covered by younger rocks.Might map the few scattered OCs of pre-Esmeralda rocks to try to get hunch on structure,then drill if favorable.

Illusrtates: (1) Use of contours to show areal extent,top and bottom of productive zones.(2) silver-gold ratio contours. (3) attempt to duplicate known ore structure.

metallization only fractures then opened received ore. Renewed ,persistent movement again.

Qtz deposition largely confined to E-W, N-dipping fractures (progressive uplift to N, fan pattern).

I do not understand the mechanics of the Tonopah fault;it might possibly represent a concentric shell in rock surrounding a cupola, formed by shrinkage due to cooling,whereafter the congealed boss was shoved up,stretching the rocks,as Nolan says,above the shell-fracture. Spurr's vein map,p.84,PP 42,suggests a radial pattern away from this dome. He says the channels were fracture zones rather than open fissures. Mineralized sheeted zones. Then to stock work,finally whole qtz vein like Pachuca.Replacement between the outer walls domiant. Solution abras like Pachuca.

Valley View vein, S of Mizpah,has vertical feather joints.

Have been unable to get a clearer picture of Tonopah owing to the block diagrams.But turning again to general terms,we find: uplift,formation of major faults,this time of a freak variety,and renewed uplift persisting thru the time of metallization.

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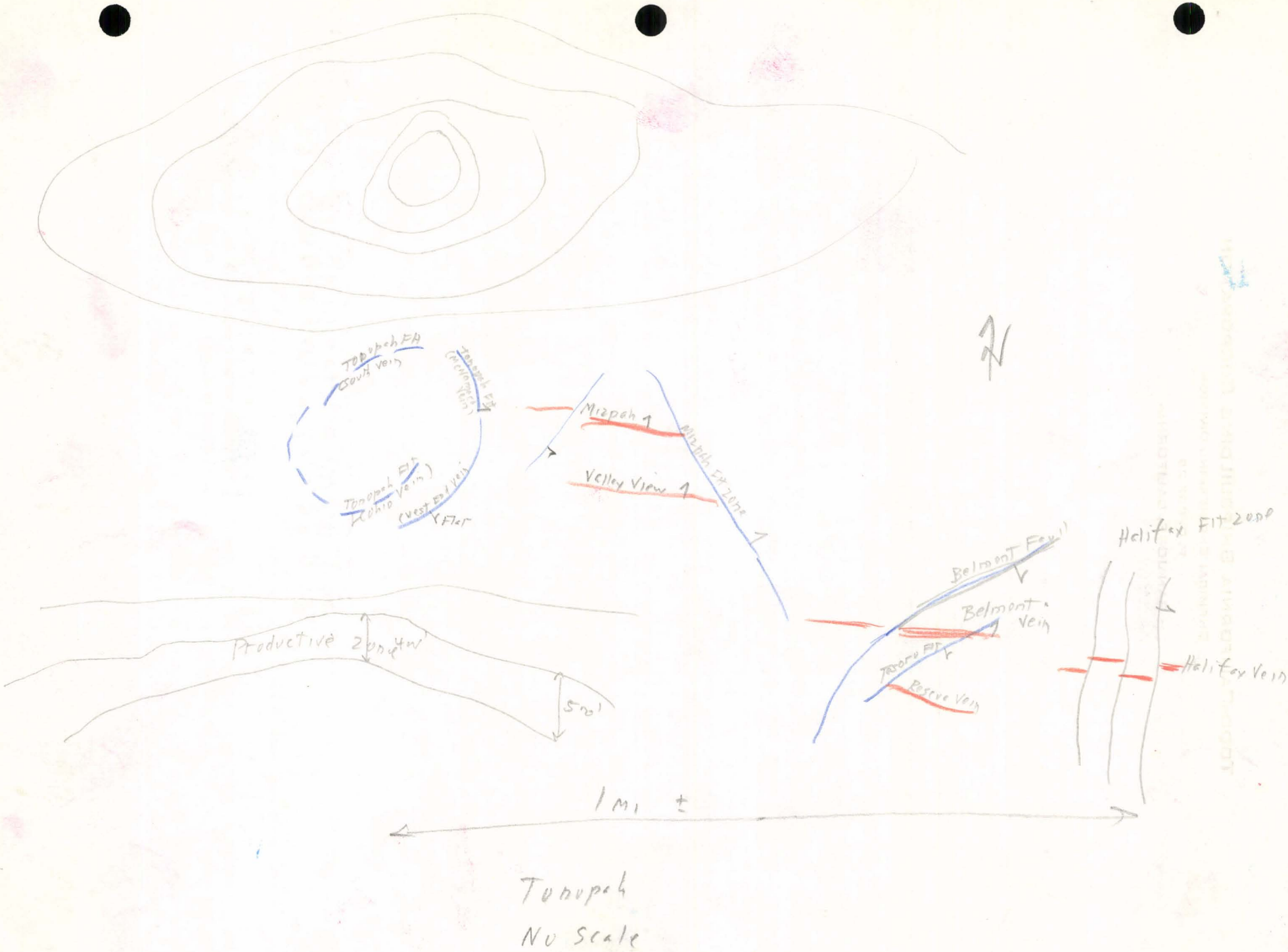

Tonopah

No Scale

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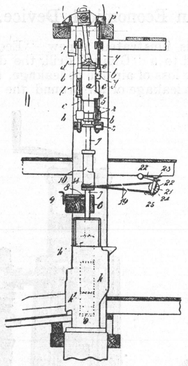
STRATHMORE BOND
RAG CONTENT U.S.A.

Mining and Metallurgical Patents.

PATENTS ISSUED MARCH 29, 1904.

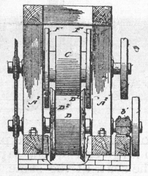
Specially Reported and Illustrated for the MINING AND SCIENTIFIC PRESS.

STAMPING APPARATUS FOR CRUSHING ORES, ETC.—No. 755,686; D. B. Morison, Hartlepool, England.



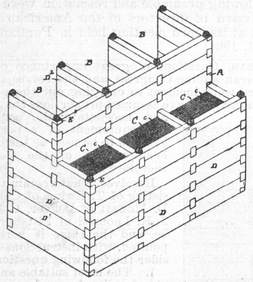
In stamping apparatus, combination with stamp stem of means for holding same in raised position comprising block of less width at bottom than at top, means for supporting block adjacent to stem but leaving it free to tilt, and means for moving block so that its wide part comes into contact with stem and for holding block in that position, but allowing it to tilt.

ORE CRUSHING MILL.—No. 755,725; E. A. Wall, Salt Lake City, Utah.



Combination with frame and lower roll mounted in fixed bearings therein, of upper driven crushing roll having free vertical movement toward and from upper side of lower roll, to crush material passing rolls, and independent driving means for rotating upper roll in opposite direction to lower roll and at same rate of speed.

JIG TANK.—No. 755,749; G. T. Cooley, Oronogo, Mo.

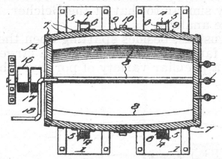


Jig tank constructed of separate side timbers, having interlocking tongues to form corner joints, tongues having one of interlocking surfaces beveled in planes of one of meeting sides and other surface beveled in planes of other meeting side, held together by draw bolts passing through tongues.

CONVERTING MATTES.—No. 755,557; R. H. Aiken, Jerome, Ariz.

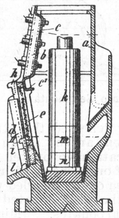
Process of converting mattes by subjecting charge of molten matte in a converter to an oxidizing blast, and meantime adding to charge, at rate approximately corresponding to rate of formation of oxide, material, proper for fluxing charge, at temperature approximately that at which slag forms from products of particular matte and fluxing materials.

APPARATUS FOR TREATING ORE.—No. 755,871; T. A. Helm, Salt Lake City, Utah.



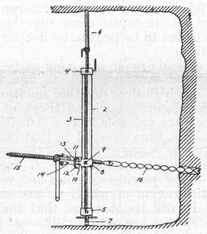
Apparatus for treating pulverized auriferous ores, comprising rotatable cylindrical tank, radially depending blades in tank extending length thereof, circular brace frame disposed between inner ends of radial blades, air pipe leading into tank, faucets to draw off liquid from tank, and means to rotate tank.

MORTAR BOX FOR STAMP MILLS.—No. 755,913; D. B. Morison, Hartlepool, England.



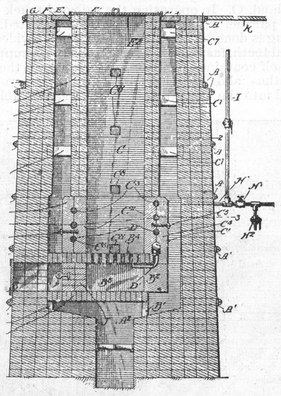
Mortar having two-part removable front, comprising lower screen section of usual design, and stiffened sheet-metal section detachably supported by box frame inside plane of screen, each section being independently removable.

COAL AND ROCK DRILLING MACHINE.—No. 756,028; L. K. Koontz, Allegheny, Pa.



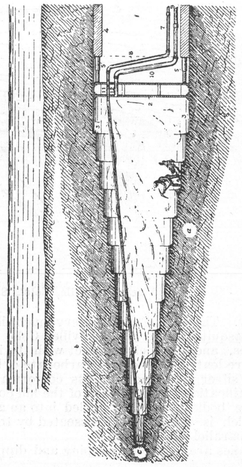
Supporting means for drilling mechanism, comprising vertically reversible post having separated uprights, and disconnected drilling mechanism sustaining devices, one on each post upright, each of devices having reversely disposed sustaining points.

METALLURGICAL APPARATUS.—No. 755,867; G. W. Gesner, New York, N. Y.



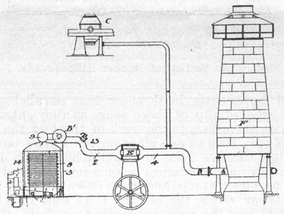
In apparatus for manufacture of alloy, or analogous use, combination of upright retort C surrounding flue and adjacent furnace arranged to discharge its products of combustion through such flue, pipe coil D partially exposed within fire brick to heat of flue, with open end of pipe discharging into retort, connection for introducing fluid to other end of pipe, chamber B^3 so material will descend by gravity from retort into chamber, provisions for opening and closing chamber, and grate B^4 of refractory material separating chamber from retort and tight floor B of refractory material separating chamber from furnace, arranged to allow descent of fine material only.

METHOD OF CONSTRUCTING TUNNELS, SHAFTS OR OTHER EXCAVATIONS.—No. 755,956; C. Sooysmith, New York, N. Y.



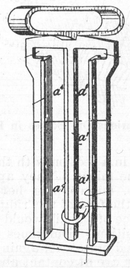
Method of tunneling which consists in constructing freezing chamber in material to be excavated, freezing surrounding material, advancing shield in rear of freezing chamber and completing tunnel lining.

METHOD OF EXTRACTING MOISTURE FROM AIR FOR BLAST FURNACES AND CONVERTERS.—No. 756,110; J. Gayley, New York, N. Y.



Method of feeding air blast to blast furnaces or converters, which consists in cooling air artificially, thereby causing its moisture to be reduced to small percentage, feeding dried air to blowing engine by initial pressure of relatively small degree sufficient to overcome in whole or in part friction of air current in apparatus, increasing its pressure at blowing engine to degree above that to which it was initially subjected and feeding dried air therefrom under compression into furnace or converter and maintaining it under compression from time it leaves the blowing engine until it enters furnace or converter.

FILE OR CARRIER FOR MINERS' PICK BLADES OR LIKE TOOLS.—No. 756,093; J. Beeton and J. Wardall, Hucknall, Torkard, England.



Carrier for miners' pick blades and other like tools consisting of body provided at one end with handle and at other end with base plate, body being formed with tenons or dovetails down and into which pick blades (having the usual recess) are adapted to slide and engage, and means for locking the blades in place.

tion is something enormous, and the time of the decantation very great. To diminish this, suppose I go to the extreme limit and have only two tons of solution to one ton of ore. If I let that settle I draw off one ton. I have one-half left. The second time I have one-half of the half, or a quarter. The third time one eighth, the fourth time one-sixteenth, and the fifth time one-thirty-second. That is, there would be 3% of the original solution left in the ore in five decantations in this case. But here I would use the first time one, the second two, the third three, and the fifth time I would have five tons of the solution which I would have to precipitate. So you can see if I make my decantation co-efficient small, that is one-tenth, I get quick removal of the solution, but I have a large quantity of the solution to handle, and to precipitate. I have generally found that a decantation co-efficient of about one fourth is practicable. That is, I would have four tons of solution to one ton of ore. I decant off three tons each time, and that way I would bring it down to about 1½% in three decantations, and would have only nine tons of solution to precipitate per ton of ore.

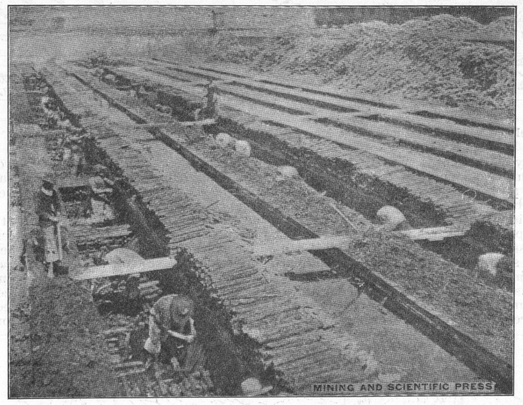
(TO BE CONTINUED.)

Wet Methods of Extracting Copper at Rio Tinto, Spain.*

NUMBER II.—CONCLUDED.

Written by C. H. JONES.

Each series consists of three tanks in parallel arranged so that the liquor can be divided up and passed along as many tanks as necessary, depending on the quantity of liquor that is being run through and on the varying temperature of the liquor with different seasons, the hotter the solution, which in summer reaches 100° F., the faster the rate of precipitation. Each tank is about 320 feet long, 5.5 feet wide by 2.25 feet deep, and has a slope varying from 2 per 1000 in the first series to 11 per 1000 in the last, the reason for the increase in slope being, that as the liquor becomes impoverished in copper, the free acid present is more active in wastefully dissolving the pig iron—an action which is considerably diminished by increasing the velocity of the liquor by means of the increased slope of the tanks. The tanks themselves are made of 9x3-inch boards attached to wooden frames set in cement, the space between parallel tanks being filled in with stone and cement, constituting a wall supporting the sides of the tanks.



The Method of Removing the Cement-Copper from the Precipitating Tanks.

The accompanying engraving shows the method of removing the cement copper.

No metal is used in the construction, hard wooden pegs being employed to attach the boards to the frames. The spaces between the boards are carefully calked with oakum and pitch in order to render the tank water tight. At each end of the tank is an arrangement by which a door can be dropped in and luted so as to cut out that particular tank, and there are also wooden plugs that can be removed so that the liquor from that tank can be run off, thus allowing for the removal of the precipitated copper. A few old boards are placed on the bottom of the tanks for their protection and on these are piled up the pigs of iron which are laid across the tank at the bottom, the next layer being at right angles to the first, and so on until the tank is filled; each foot-length of the tank contains about one ton of iron. The liquor is allowed to run through the system of tanks and needs no attention except to remove the precipitated copper and to add fresh iron. The "salida" liquor containing from 15 to 20 grams of copper per cubic meter is allowed to run to waste, for the reason that about this copper content the amount of iron required to precipitate the copper equals the value of the copper recovered. Daily some of the tanks are cleaned out by being closed as described above, the liquor meanwhile passing down the other tanks of the series; the liquor is run off into settling tanks, any copper in suspension being there recovered; all of the iron is removed from the tank and piled on to the dividing wall, at the same time the copper adhering to the iron is knocked off and thrown back into the tank. The dirty looking precipitate is then transferred to the cleaning and concentrating plant, the iron is replaced in the tank and the liquor again allowed to run through it. This crude precipitate, containing about 70% copper, is thrown, a little at a time, on to a perforated copper plate placed at the head of a long launder or tank and is washed through the plate by a strong stream of water from a small nozzle. The material that does not pass through the screen consists of leaf-copper and small pieces of iron; this material is thrown into a heap and afterwards sorted over by girls who remove the pieces of iron. The precipitate that passes into the launder is repeatedly turned over against the stream of water and by this simple means a concentration is effected.

The first few yards of the launder contain a red precipitate known as "No. 1 precipitate," containing 94% copper and less than 0.3% arsenic; following this is "No. 2 precipitate," containing 92% copper and between 0.3% and 0.75% arsenic, while below is the "No. 3 precipitate;" this is in a state of very fine division and contains on an average 50% copper and 5% arsenic. This last named portion, which carries all the graphite from the pig, contains the bulk of the antimony and bismuth that is also precipitated from the liquors. Classes Nos. 1 and 2 are removed to the drying sheds and are bagged for shipment to the refinery; the No. 3 precipitate is removed, moistened with acid liquors, made into balls by hand and dried in the sun. These balls become cemented hard and can be readily transferred to the smelter, where they form part of the charge for the blast furnaces and are run down to matte to be subsequently bessemerized, thus effectively removing the arsenic, antimony and bismuth that they contain.

The reactions that take place in the cementation tanks are given in equations 5, 6 and 7.

The first reaction that occurs in the liquor running over metallic iron is the reduction of the ferric sulphate to ferrous sulphate, the final result being in accordance with the equation:

$$(5)\quad Fe_2(SO_4)_3 + Fe = 3FeSO_4.$$

This action causes the consumption of the pig iron without any corresponding yield in copper, and consequently should be avoided as far as possible by having all the iron in the ferrous state.

The second reaction is the precipitation of the metallic copper, brought about by galvanic action. The iron becomes coated with copper, and thus the iron and copper in the acid liquor constitute a galvanic couple with a considerable difference of potential. It is due to the electrolytic action that the copper and all other metals present that are electro-negative to iron will be precipitated. The ultimate action of the precipitation may be chemically expressed by the following equation:

$$(6)\quad Fe + CuSO_4 = FeSO_4 + Cu.$$

Besides the reactions above mentioned there is one which causes the liberation of hydrogen, as evidenced by the bubbles of gas that may be observed to arise in the tank liquor. This action, which causes a wasteful consumption of the iron, may be expressed as a final result by the following equation:

$$(7)\quad Fe + H_2SO_4 = FeSO_4 + H_2.$$

These three equations constitute the main reactions that take place in the precipitating tanks.

While the liquor is fairly strong in copper, the copper is mostly precipitated in a coherent form, but in the later stages as the liquor becomes impoverished it is precipitated in a powdery state—a condition which is more effective in its galvanic action with the iron, and thus unfortunately causes a larger precipitation of arsenic and other impurities than in the earlier stages. In the later stages also the "solution reaction" of iron in sulphuric acid as given in reaction No. 7 goes on to a proportionately greater extent than does the precipitation of copper, and consequently the cost of pig iron in precipitating the copper varies inversely as the quantity of copper in the liquor.

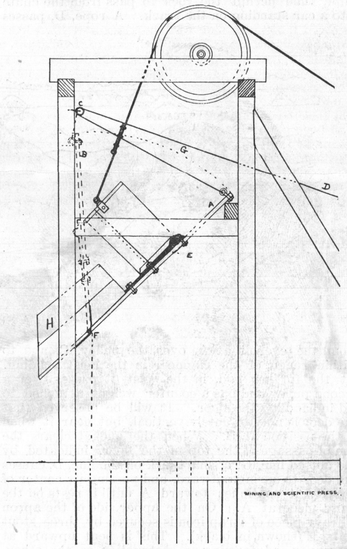
By keeping careful watch on the reduction as far as possible of the ferric iron before the liquor enters the tanks, and by giving it sufficient velocity through the tanks, a strongly acid liquor such as given above during a year's working will not consume more than 1.4 units of pig iron (containing 92% iron) to 1 unit of copper precipitated. A valuable check on the iron being consumed can easily be kept by the laboratory, by analyzing the liquors before entering and after leaving the tanks, and from these analyses the quantity of iron that is being consumed can be calculated.

This description of the methods of leaching and precipitation that are now used at Rio Tinto is offered in the hope that it will prove of interest and value, especially so in view of the fact that most of the information heretofore published pertaining to these methods has become obsolete.

*Abstract Trans. Am. Inst. Min. Engs.

An Automatic Bucket Dumping Device.

About many small mines the problems of economy are closely studied, and the inventive faculty of the superintendent is taxed to find ways and means of doing things economically. At a mine where shaft sinking only is in progress, or a small number of men

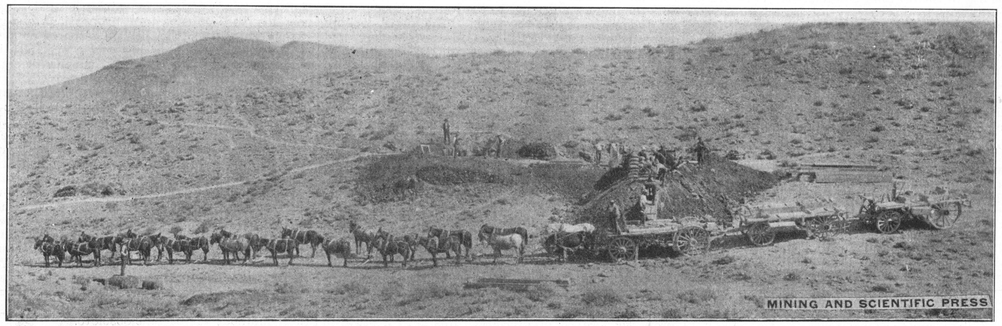


Bucket Dumping Device.

are employed underground, there are sometimes several hours when the hoisting engineer is idle, but he cannot leave his post, for at any minute the signal may come from below to "hoist," "send down tools," "send down timbers," or some other requirement, and he must be at or near his post. He has abundant time to keep the engine clean and to prepare during the day for his partner of the night shift. In such a situation it is obviously extravagant to have an additional man on top who one-half of the time will be unemployed, or if he hustle in wood from the outside pile, clean the lamps for night, level off the dump, help in the blacksmith shop, or do other odds and ends about the place, it only affords additional leisure to the engineer. There are mines, however, where one man on top attends to the entire work to be done. He is hoisting engineer, carpenter, timber-framer, blacksmith, carman, fireman and general roustabout, and sometimes adds to these duties the responsibility of superintendent. To accomplish this is only possible by the employment of mechanical devices to take the place of men. The accompanying sketch shows an arrangement whereby a man at the hoist may raise the bucket filled with rock, dump it, and send the bucket back into the mine without leaving his post at the throttle. After the bucket has gone below he goes out and trams the car to the

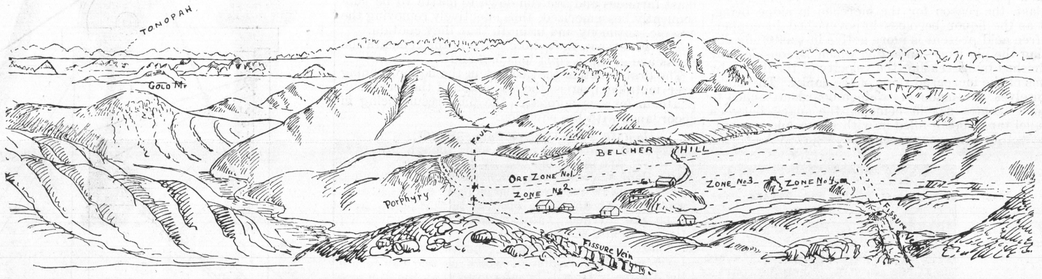
waste dump or ore pile, dumps it and trams it back to the shaft ready for the next load.

The sketch shows the operation of a simple contrivance for accomplishing this. A door, or apron, is made of strong planks, and fixed on a hinge, F, flush with the line of the inside of the shaft. This apron, when not covering the shaft, inclines backward, and the upper end rests against a cross piece



Loading Ore at the Tonopah-Belcher Mine, Nevada.

in the head frame near B. When a bucket is hoisted it is raised to clear the dotted line, G (though in the drawing there is not sufficient room allowed by the draughtsman for this purpose). This is an important part of the arrangement, and the head frame should be sufficiently high to permit this, and at the same time permit the rock to pass from the chute into a car standing on the track. A rope, D, passes



A Sketch of Tonopah-Belcher Mine and Vicinity, Lone Mountain, Nevada.

from the eyebolt at A, over the pulley, C, and to within reach of the engineer in the hoist building. At the further end, in the hoist, it passes over a second pulley and has a counter weight attached to aid in handling the door. It will be observed that the door is not absolutely vertical, but near it when in the position at B. When the bucket clears the line of passage of the top of the door, indicated by the dotted line, G, a smart jerk on the line, D, causes the door to spring outward, and passing its center of gravity it continues toward A until it rests on the cross piece at A. On the upper side of the apron a heavy piece of strap iron is secured by three stout bolts, E (shown in black). This is bent upward at the upper end, forming an obstruction on the otherwise comparatively smooth surface of the apron. The bucket is one of the straight sided kind, having a strengthening band top and bottom, with chimes $1\frac{1}{2}$ inch deep on the under side. The bucket is lowered by the engineer. When it strikes the apron it slips downward a short distance, and the upper edge of the chime of the bucket engages the buckeled strap of iron, and unable to slip downward further as the cable is slacked by the engineer the bucket overturns and dumps its contents into the chute, H, whence it passes to a car which should be placed to receive the rock. The bucket is hoisted above the apron, the engineer again gives the string a vigorous pull and the door assumes its former position at B, and the bucket is again sent below.

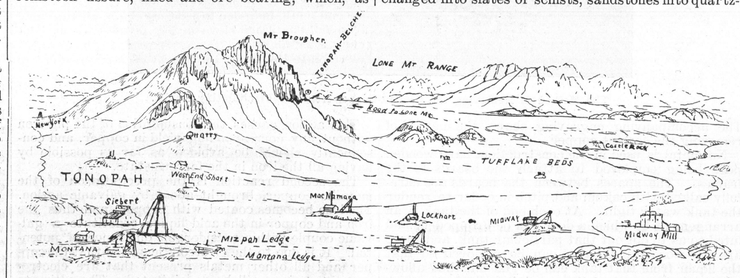
IT seems strange that laws should be required to make the equipment of mine shafts with safety devices compulsory; but such is the case. And, worse still, in many cases the law is neglected and has become a dead letter. It is the part of wisdom for every mining company to avoid accident, not only to insure the safety of employes, but it is economy and good business to avoid the expense incident to a breaking cable, a wrecked shaft or a ruined skip or cage, which inevitably always follows a case of overwinding where no safety appliances are provided, or which fail to operate if they have been put in.

The Lone Mountain District, Near Tonopah, Nev.

Written for the MINING AND SCIENTIFIC PRESS by A. LAKES.

The region at the eastern base of the Sierras from the line of the Central Pacific Railroad at Reno, for 300 or 400 miles south, to Tonopah and Goldfield, is one that bears every evidence of great mineralization. It is essentially a volcanic region, all the rocks, with exception here and there of some outcrops of Cambrian and Silurian limestones, are volcanic. The eruptions are mostly of Tertiary age, consisting of andesite, dacite, rhyolite and diorite, with some later overflows of basalt. Volcanity seems, in Nevada, to increase as we approach the base of the Sierras, and may be connected with that great uplift. The evidences of mineralization show it to be both recent and ancient.

A few miles below Reno we have the Steamboat Springs issuing in puffs of steam and hot water from a series of long parallel fissures near a hill of basalt. Some of these fissures have already been filled with quartz and vein stuff, forming true veins; others are in process of filling with gelatinous silica. Here we have modern fissure veins in process of formation. A few miles further southeast we have the great Comstock fissure, filled and ore bearing, which, as



The Lone Mountain Range from Tonopah, Nevada.

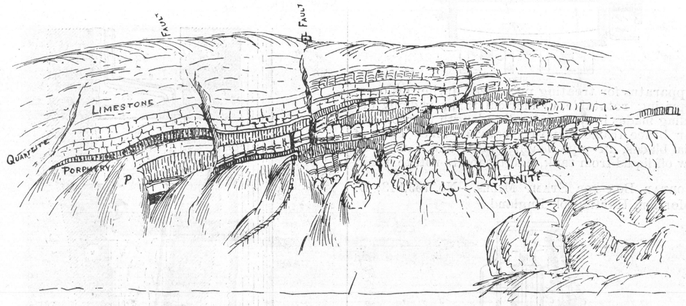
the hot deeper workings show, is following down a retreating hot spring that filled the fissure with gold and silver ore in the same way as at Steamboat Springs.

South again we come to the mining district of Candelaria, where there are fissures in volcanic rocks, and still further south to Tonopah and Goldfield, with their mineralized, fissured zones in andesitic rocks. About 20 miles southwest of Tonopah, at Silver Peak, is a well-defined crater and modern lava flow, while Tonopah itself, like Cripple Creek, Colo., is located on the site of numerous volcanic vents. Tonopah has been described by J. E. Spurr and other writers, so we will not dilate on it here, but pass to one of the districts not far from it which has hitherto had less notice.

LONE MOUNTAIN.—On leaving Tonopah and going west we pass over a prairie-like region underlaid by thick beds of stratified volcanic tuff, which to an unknown depth overlies and obscures the ore-bearing andesites of Tonopah. This volcanic tuff, derived from finely comminuted material, shot up in the air from some of the volcanic vents in the vicinity, fell in showers upon the bed of a lake and was stratified by its waters. It contains occasional fossil imprints of leaves and terrestrial vegetation. Continuing west we pass occasional bluffs and tables of tuff capped with basalt. About 20 miles west of Tonopah is a group of hills around a central peak called Lone mountain. This peak is of massive granite, and against it recline, usually at steep angles, a thick series of uptilted slates, schists, quartzites and metamorphosed limestones, and marbles of Cambro-Silurian age, interpenetrated by sheets, dikes and intrusive masses of andesite and other eruptive rocks, the heat of which, doubtless, metamorphosed the sedimentary beds. The evidences of this metamorphic action are very pronounced—shales are changed into slates or schists, sandstones into quartzites, and limestones into white marble; while various minerals, characteristic of metamorphic action, appear in the rocks at contacts with the igneous dikes, such as epidote, which is particularly abundant. We have here all the acknowledged geological conditions for mineralization, nor are the precious metals wanting.

Near Lone mountain are the remains of an old arrastra showing that some primitive miners found gold and worked it. Numerous large fissure veins, striking about north and south from the peak, traverse the volcanic rocks and the sedimentaries alike. These veins have as yet been little opened or proved, but they show on the surface unmistakable signs of mineralization.

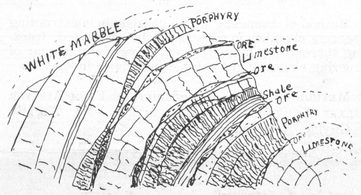
At the Tonopah-Belcher mine, south of Lone Mountain peak, a long ridge called Belcher mountain is composed of tilted, or rather folded limestones, marbles and slates, with intercalated intrusions of



Cliff near Leadville, Colo., Showing Intrusion of Porphyry into Sedimentaries.

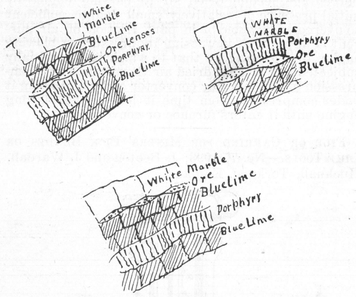
porphyry. The formations are very much like those of the Mosquito range at Leadville, Colo. In the limestones, and at their contact with the intrusive sheets, are lenticular bodies of carbonate of lead ore, carrying silver, lying more or less conformably with the stratification. The strata of the hill containing these ore bodies has been folded into an anticlinal arch which is truncated or dissected by the ravine running parallel with the hill.

Ore bodies are found outcropping and dipping into



Ideal Cross-Section of Belcher Hill, Nevada.

the hill apparently in three or four parallel zones. The degree of dip of these zones as they enter the hill varies according to the part of the fold the erosion has cut; thus at one place on the upper part of the ridge the ore zone enters the hill with a dip of not over 15°, and continues in for a few hundred feet till it becomes steep and goes down with the anticline; lower down the hill the next zone dips in at 25° or 30°, and the next below that at from 40° to 60°. All these zones will, with depth, become very steep or nearly vertical. The intrusions of eruptive rock are, as at Leadville, very irregular and hard to



Position of Various Ore Bodies in Belcher Mine.

follow or portray in a section with the present slight development of the mines. They appear as brown, lenticular masses, outcropping here and there at various levels on the face of the ridge. No one section across the face of the hill would show them all in their relative position. Sometimes they are below a certain well-defined limestone, again they are above it, sometimes they are at contact above the ore, and the ore lies between them and the limestone; at others the ore is above the porphyry and below the limestone, or again the ore may lie between a blue limestone and a white marble, and the porphyry be absent. The intrusions of porphyry appear to occur in tongues or lenses dodging about and insinuating themselves between the bedding planes of the strata. The accompanying section of a cliff near Leadville, Colo., will exemplify the ramifications of intrusive sheets of porphyry in sedimentary strata, and in a manner very similar to that at the Belcher, to which it has a close analogy.

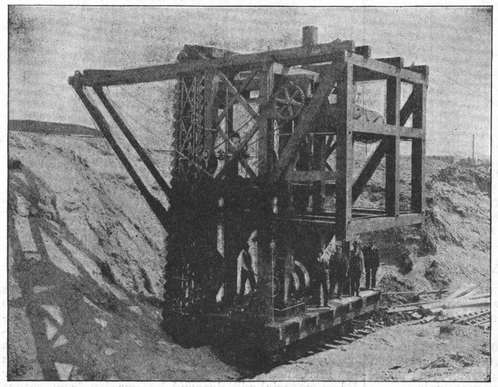
These intrusions, besides splitting open the strata, have locally faulted it. At one place a large massive intrusion of a peculiar variety of porphyry has come up and apparently deflected the strike of the limestones, bending them around at an elbow. At the sharp bend the strata have broken in a fault. The lenticular bodies of ore consist of masses of decomposed rock and iron oxide, mingled with lead carbonates, usually in the disintegrated form called at Leadville "sand carbonates." Mingled with these sand carbonates are abundant grains, kernels, nodules and small irregular bodies of galena, which are high grade in silver. The probability is that these scattered bodies of galena will increase in quantity with depth until the whole body becomes a sulphide, or a mass of silver-bearidg galena. It has been observed in other regions that these scattered nodules of galena are, near the surface, richer in grade than the galena body proves to be ultimately in depth. Whether or not the different zones of mineralization will, in depth, come together into one large body remains to be proven by deeper workings and crosscutting.

Carbonate of lead ores in large quantities are comparatively scarce nowadays, and, though low grade in silver, are much desired by the smelters to mix with their siliceous ores, such as those of Tonopah. They would be very valuable in case smelting works should be at any time erected in that camp, apart from the intrinsic value of the ores themselves with their lead and silver contents.

There are other promising mines and veins in this Lone mountain region of which no one can foretell the future. It will be observed that the Tonopah-Belcher ore deposits are entirely different in character from those found at Tonopah, as well as the rocks in which they are found. They remind one of the ore deposits of Leadville and Aspen, Colo., especially in the early days of those camps.

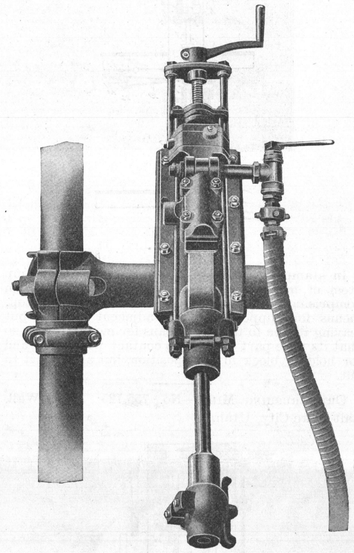
Sand and Gravel Digger.

Herewith is portrayed an automatic combined sand and gravel digger, elevator and grader, designed and constructed by the C. O. Bartlett & Snow Co., Cleveland, O. In operating the railroad track is laid along parallel with the bank to be excavated. The digging is done by heavy steel buckets, provided with special teeth, fastened to a strong chain, all supported by a self-contained elevator leg pivoted at the head end, thus allowing the lower end to be gradually forced into the bank by means of heavy cables attached to the bottom of the elevator leg and running up over sheaves at the outer end of the projecting arm of frame, then down to a drum which is geared to the engine shaft. By this means the lower end of the elevator is to be gradually forced into the bank, digging and elevating the material up to an angle of 70°, commencing at the bottom and gradually digging its way up. The steel buckets are designed to dig the gravel, sand or other similar material and elevate it as fast as dug, discharging it at the top onto a belt conveyor, delivering it to a revolving screen on the opposite side from the elevator.



An Economical Device.

Herewith is illustrated a new "Economy" air cock attached to a "Giant" drill, the design being to obviate the loss of air due to leakage, and do away with constant leakage of air around the taper plug.



This air cock is so arranged that the pressure of the air on the bottom large end of the taper plug keeps the plug fitting the seat, at the same time allowing it to be freely operated. To compress air is costly at best, and, it being desirable to avoid all leaks, this device is presented by its makers—the Compressed Air & Machinery Co., 24-26 First St., San Francisco, Cal.—as effectually preventing loss of air in the operation of rock drills.

The American Mining Congress.

The following preamble and resolution were passed by the board of directors of the American Mining Congress at its third meeting held in Portland, Or., March 21, 1904:

WHEREAS, Questions of great importance confront the American Mining Congress, and the correspondence and clerical work incident to carrying out the purposes of its organization have assumed proportions that justify and necessitate the acquisition and equipment of a permanent location to be used as the business headquarters of the Congress; therefore be it

Resolved, That a committee consisting of T. Ewing of California, D. Moffatt of Denver, Colo., and J. R. Leonard of Pittsburg, Pa., be, and the same is hereby appointed, with instructions to consider the following questions:

1. The most suitable and available locality for such permanent headquarters.
2. The amount of money necessary to acquire a suitable site.
3. The cost of constructing suitable structures on such site.
4. The expenditure necessary to properly equip such structures for the purposes intended.
5. The annual cost of maintaining such headquarters.

And to report recommendations thereon at the next session of the Congress in August, 1904.

The next meeting of the American Mining Congress will be held in Portland, Or., August next, 23d to 27th, inclusive.