CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the Grover Heinrichs Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

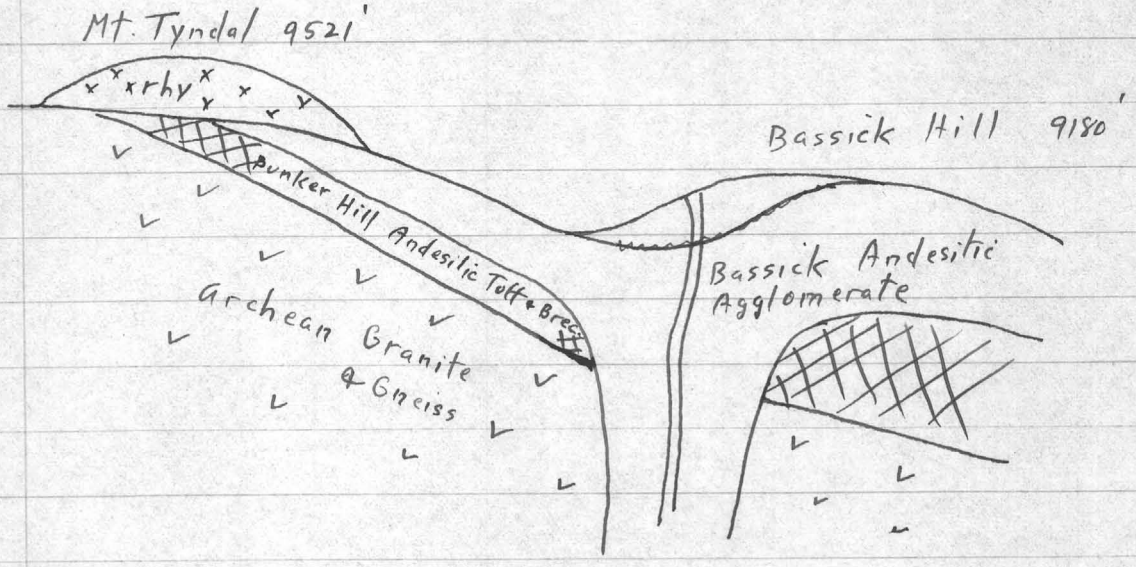
The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

Custer Co., Colo.

Silver Cliff Plateau. Small rhyolite plateau, poured into lake basin; now 1 x 2 mi., steep front on S edge. This front is black rhyolite, 30-50' high, resting on Archaean. Ore in rhyolite in little cracks & fissures. Mineral matter mostly MnO_2 & Fe_2O_3 + horn silver in flakes & films.

Mineral zone 30-50' wide. Hard to tell limits

Bassick Mine, near Rosita, Custer Co.



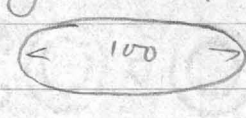
The agglomerate is locally silicified at Bassick Hill & the ore-bodies outcrop here. Rock a true volc. agglomerate, fragments 1/2" - 3',

sub-angular or rounded. The local silific. has caused the prominence of Bassick Hill

Agglom. has a white matrix, mostly SiO_2 & Kaolin. The agglom. may have fissured & the ore developed along one of the fissures.

While the ore has been devel. along a fissure vein, it is not a fissure deposit at all.

Ore body elliptical in horizontal section.



It descends into the agglom. nearly vert., but winding. Grades insensibly into agglom. Values highest in center, diminish as periphery nears. Minerals

ZnS
PbS
Jamesonite
Tetrahedrite
Pyrite
Chalcop.
Smithsonite
Calamine
Fre Au
Au telluride.
Quartz

Minerals disposed in successive coats, or shells about boulders of agglomerate. In the same region of the cross section, the minerals are deposited in definite sequence & in about the same amt., but the max dep was in center.

Usually 3 shells on a boulder.

Inner Sulfides of Zn, Sb, Pb, paper - 5 mm.

Dark

2nd More Pb, Au, Ag - 150-200 oz Ag
- 100 oz Au } ton

Light.

(figures apply to shells alone, not core)

3rd Sphalerite 5-50 mm. Most val. due to thickness. 60-120 oz Ag
15-50 Au } ton

Outer shell rough on outside.

Sometimes a 4th shell of chalcop., 10-30 mm. shell

5th shell - thin sprinkling of FeS_2 cryst.

Shells thin out on margin of ore-body, & one passes out into region of no shells.

(No quartz, $CaCO_3$, barite, etc found in shells.

765' down charcoal was found in the ore & country. Some charcoal was silicified, some soft & showed grain of wood.

Some filled with FeS_2.

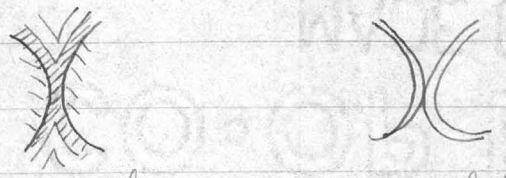
This ore body a volcanic pipe - throwing boulders in air - time from surface involved

3/14/17.

Bassick Hill cont.

Volcanic activity often lies dormant for a sufficient time for timber to grow in the vent.

The shells of ore are no thinner where the boulders are in contact than elsewhere.



Not like this But like this

The boulders are thoroly decomposed & bleached. Basic silicates have disappeared - feldspars turned into Kaolin, giving the boulders in the pipe a dec. appearance.

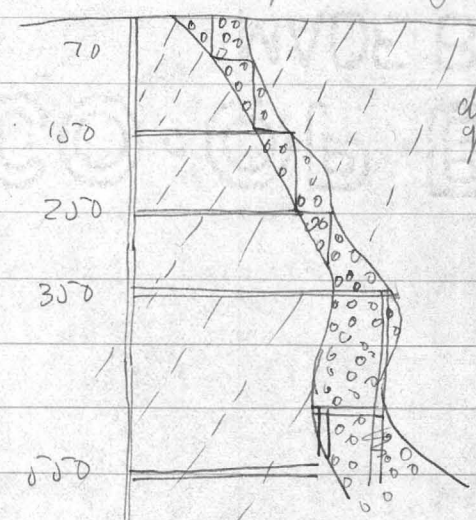
Genesis of the Ore.

The ore clearly occupies the vent of a volcano - Evid. - materials, relation to surrounding rocks. Remarkable is the absence of minerals separable to water deposition.

We have some of these minerals depositing in certain fumaroles, & this deposit seems to be due to gaseous emanations connected with 2nd any volcanic activity. (Deposition by sublimation.

Bull Domingo Mine, Custer Co., 3 mi. from Ag. Cliff.

In a region of gneissic rocks (+ syenite & granite). The ore body is a pipe descending into the gneiss. The pipe is 50' in diam., & is full of boulders of country rock.



The boulders are coated with mineral matter & this constitutes the ore. Sim. to Bassick, but the boulders are derived from the country - mostly gneiss, some granite & syenite. These boulders are also rounded, & the syenite boulders are least rounded. The boulders are decomposed; size 2-3" - 1' in d. The material between the boulders has the same comp. The coats are chiefly PbS & ZnS; gangue chiefly $CaCO_3$, $MgCO_3$, $FeCO_3$ (prob. dep. from water), SiO_2 (chalcedony also present). Shell usually ½" - 1" thick, laminated concentric with boulder. Regular sequence of dep.

Inner 1. Crypt. Galena or PbS + ZnS.

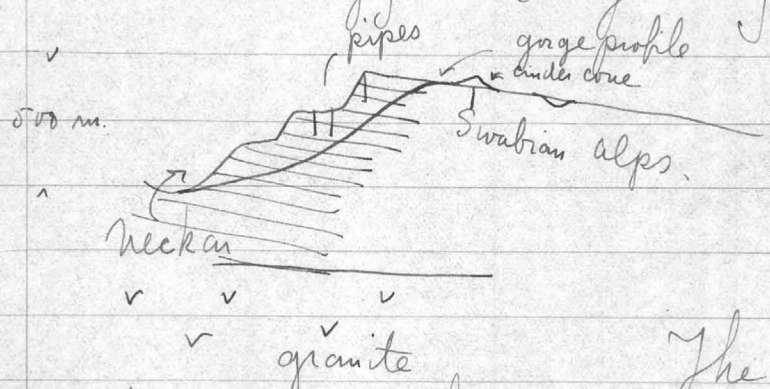
2. Dull galena; dolomite.

Between 3 boulders we have anglesite, calcite, siderite etc.

JAC

Fault breccia ? ??

Analogy – S. Germany



In the gorges, on the scarp, & on the face of the plateau are fd. volcanic vents – cones, depressions, pipes.

The pipes vary from 30-40' in diam. up. Their contents vary from wholly sed. (country rock, to wholly volc. material. Fragments of the top strata are fd. in pipes down by the stream; granite is fd. in the upper pipes.

When volc. activity commences, a hole is punched thru the crust, & when the hole reaches the surface, the churning continues; sometimes volc. material comes up, forming a cinder cone, sometimes not.

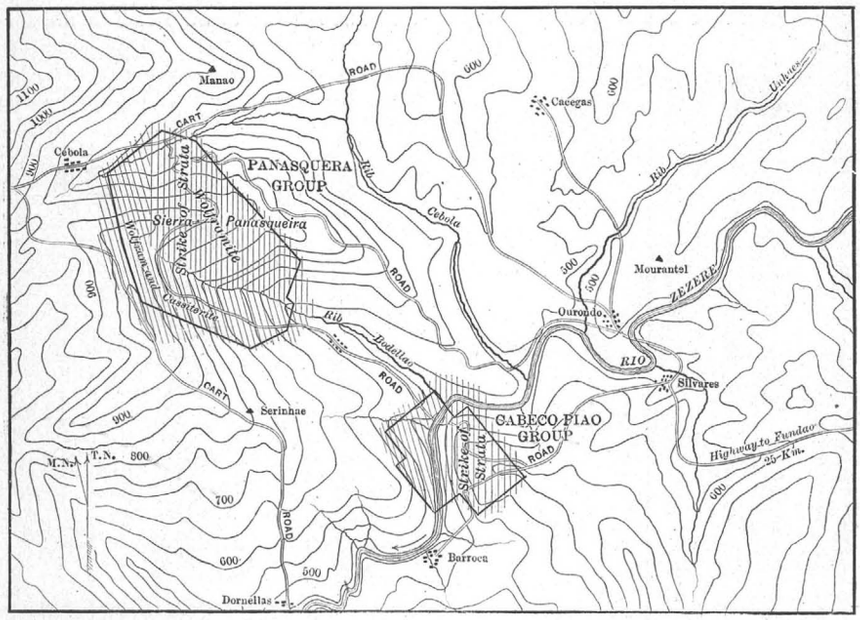
The Dom. mine may be one of these embryonic volcanoes, the activity dying down, leaving only a path of circulation for waters carrying mineral matter.

The Panasqueira Tungsten District, Portugal

By Wilhelm Preus*

Among the most important tungsten mines on the Iberian peninsula are the Panasqueira mines in the province of Beira Baixa, Portugal. They are divided into the Panasqueira group and the Cabeco Piao group, shown in the accompanying map. These two groups comprise about 1000 hectares of steeply sloping country, showing signs of existing mineral deposits, as outcrops and float.

The ore deposits consist of quartz beds, varying from 0.10 m. to 0.60 m. in thickness, containing the minerals wolframite, cassiterite, oxide of iron, iron pyrites, mispickel and mica. There are numerous beds situated in Cambrian schist.



TOPOGRAPHY OF THE PANASQUEIRA TUNGSTEN DISTRICT, PORTUGAL

Location

The mines are situated almost in the center of a large sedimentary bed about 11 km. from the nearest igneous rocks. This I think noteworthy, as most tungsten deposits in Spain and Portugal are either within igneous rocks, especially granite, or on the contact of igneous and sedimentary rocks. The strata vary in direction from true north to south to magnetic north to south (16 deg. west—true north.) This fact suggests some influence upon the mineral concentration or deposition of the beds. Those in the schists with strike true north contain wolframite, oxide of iron, pyrites, mispickel, little mica, but no cassiterite or carbonate of copper. The northern part of the Panasqueira group and the eastern part of the Cabeco Piao group have beds of this sort.

In the southern part of the Panasqueira group and the western part of the Cabeco Piao group the strata strike magnetic north. Here the beds contain wolframite, cassiterite, oxide of iron, mica, a small amount of carbonate of copper and iron and arsenical pyrites.

The deposits are well defined, both walls being sharp limits of the quartz. The beds in the Panasqueira group are almost horizontal, dipping 5 to 10 deg. to the South; in the Cabeco Piao group they dip 35 deg. to the North.

Faults

There is more or less faulting, the faults being almost vertical, and mostly striking north and south or east and west; they are 0.10m. to 1m. wide, are composed of crushed shale, and are very permeable by water. The faults are generally compensating and the displacement very slight, being nil in the Cabeco Piao group, and two to three meters in the Panasqueira group.

The mineralization is rather erratic and although faults appear to have had some influence, this is difficult to determine. Nevertheless it has been noted that when three or four faults cross each other forming a triangle or a trapezoid the part of the bed limited by the faults as a rule is richer than other parts of the same bed. A bed recently opened yielded 110 kg. tungsten concentrates per square meter from a space within three faults, and several lumps of pure mineral weighing 30 to 100 kg. were found; another bed found within triangular faults yielded about 90 kg. tungsten per square meter. Such cases frequently occur.

Panasqueira Group

Exploitation has been going on for about 10 years in the Panasqueira group on the north slope of the Panasqueira Sierra, where an incomplete concentration plant has been put up. There are 15 proved quartz beds on the north slope and corresponding beds have been found on the south slope. Only four of these have been exploited to any extent. The proprietors of the mines have in 10 years exploited, concentrated and sold 600 metric tons of tungsten concentrate (68 to 71 per cent. WO_3) which cost, including freight to Fundao, about $130, Portuguese currency, per ton. The prices obtained during the last three years have varied between $5.25 and $10 per unit ($365 to $700 per ton) c.i.f. Continental ports.

About 30,000 sq.m. of quartz beds have been stoped out during these 10 years, yielding 25,000 tons of ore for treatment at the plant. The mill has been slightly improved but about 25 per cent. of the wolframite is still lost in the dumps; the mines are at present producing at the rate of 200 to 250 tons of concentrates (68 to 71 per cent. WO_3) per year.

The Cabeco Piao Group

In the Cabeco Piao group exploration has proved the existence of 10 beds, and in four of these about 60,000 sq.m. of quartz beds have been laid bare with very little work; these will average 25 kg. of wolframite (68 to 71 per cent. WO_3) per square meter. Simultaneously some development was done and during two years about 50 tons of wolframite were sold. This ore was obtained with a very incomplete manual washing plant.

In the district containing cassiterite only exploration work has been done.

It appears that these mines would be capable of producing 1500 to 2000 tons of wolframite per year at a cost of $80 to $100 per ton, and at this rate they would be able to dictate the European price; but to do this a rational development of the mines and the installation of a modern and effective concentrating plant would be necessary, which is not likely to take place.

*Mining engineer, Estacion Vacar, Prov. de Cordoba, Spain.

Livache and Potain have made a series of experiments on the substitution of zinc white for white lead both as paint, and as a priming composition for porous surfaces. For a satisfactory paint, zinc white requires one-fifth more oil than white lead, but will then cover one-fifth more surface, and by adding to the oil 1 per cent. of manganese resinate and a sufficiency of oil of turpentine, zinc white paint will dry in practically the same time as white lead. As a priming composition, a mixture of 1000 parts of zinc white, 1500 of whiting, and 633 of linseed oil containing 2—4 per cent. of manganese resinate is equal, both as regards applicability and rapidity of drying, to one consisting of equal parts of white lead and whiting, while costing only about 10 per cent. more.

A Curious Deposit of Cerussite in Colorado

The Ore in the Terrible Mine, at Ilse, Custer County, is Not Associated with Sulphides and Other Minerals Usually Found with Lead

BY ROBERT B. BRINSMADE*

In the Terrible mine, at Ilse, Custer county, Colorado, there is an unusual deposit of cerussite. First discovered about 1880, it has passed through varying fortunes. At present it lies idle. During its working life the mine produced some 250,000 tons of ore from which over $500,000 worth of lead concentrate was extracted and shipped. A few tons of ore were rich enough to sort and smelt direct, but the greater part was handled as concentrate with 60 to 70 per cent. lead.

Peculiar Method of Manufacturing Litharge

The old concentrator had crushers, sizers, jigs and tables like the orthodox arrangement for galena, but the process of making litharge, adopted by the Crystal Lead Company, the last operators, to utilize the rare nature of cerussite concentrate, is worthy of note. The litharge furnace was a small brick reverberatory. By raising the concentrate to a heat sufficient to free the CO_2, the PbO dropped through the perforated iron grate of the hearth, leaving only a cinder of silica fused with a small percentage of PbO. The furnace had a capacity of 6 tons per day. By grinding the furnace product in an Abbé tube mill and then bolting through a 200-mesh silk screen the litharge became ready for shipment in 150-lb. canvas sacks.

A ton of concentrate averaged a yield of 1500 lb. of litharge containing 90 per cent. PbO, the balance being silica. In spite of the impurity, this litharge was superior to the usual kind for use in vulcanizing rubber, owing to its freedom from shots of metallic lead.

The Mine

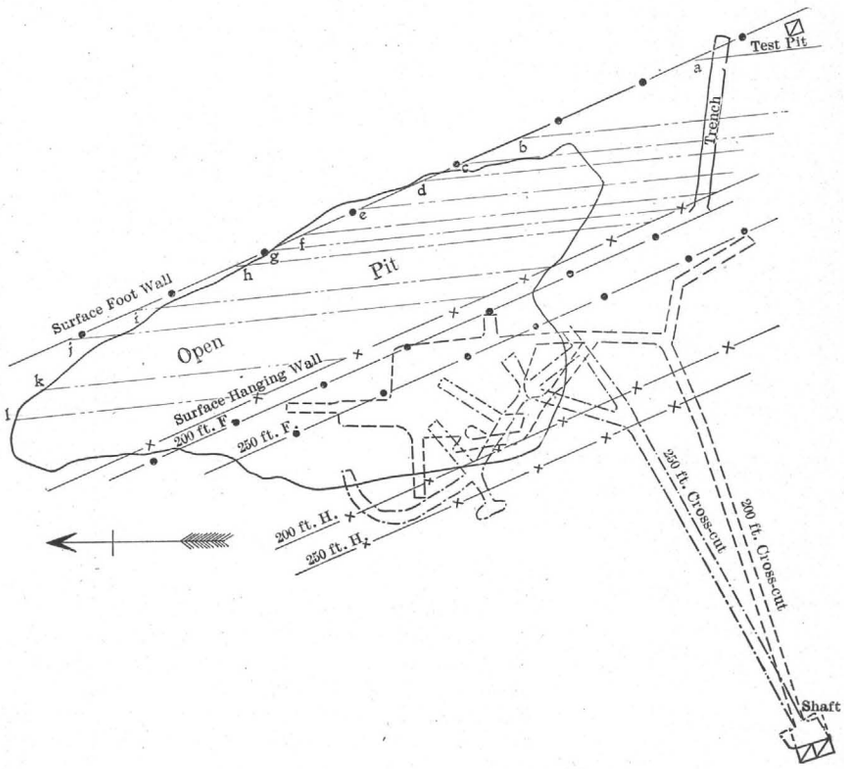
The mine lies in Oak Creek valley in the Greenhorn mountains, 25 miles south of Florence, Colorado. The valley, for the 20 miles of its length observed, was apparently eroded in metamorphic schists along the axis of an ancient anticlinal fold. Ascending the creek from the Arkansas valley through a rugged cañon till within 10 miles of the mine, when the bounding hills take a gentler slope that is covered with soil and brush, it exhibits only occasional outcrops of the schist. Here, too, the creek bottom becomes broad enough to permit of considerable agriculture.

The old mine now has the appearance of an open quarry, about 450 ft. long by 100 ft. wide, filled with water to within 50 ft. of the surface. The local theories of the deposit were either that it was an impregnated igneous dike or a great fissure vein in gneiss. On first sight the iron-stained, decomposed and shattered mineralized material that shows around the pit sides may have been either a dike or a vein, and it required close study to find evidence that these theories were untenable.

Features of the Deposit

The striking feature of the east side of the quarry is the hanging wall, a parting plane on a dip of 67 deg., which is well marked and doubtless first gave rise to the vein theory. This parting plane, however, is filled with a layer of finely divided blue clay 6 to 12 in. thick, which indicates a fault of considerable movement. How far this fault extended horizontally, it is not possible to trace, without trenching, as the valley soil covers the fault outcrop to a depth of several feet. Three miles south along the valley, at Leadhills, was found, some 20 years ago, a pocket of a cerussite in similar rock and 80 tons of concentrate from a hand jig was shipped; but there is little or no showing in the old pits there at present, and no evidence of the hanging wall fault was seen.

The foot-wall faulting, on the contrary, is less well defined and the line by which it is marked on the map indicates a series of irregular slips marking the eastern boundary of the ore. Between foot and hanging there is no porphyry or true-vein matter visible in the deposit, but only metamorphic strata with bedding planes at the surface, represented by *a, b, c* on the map, parallel to the strike of the surrounding country rock. These strata are alternate layers of granulite (quartz and orthoclase) and gneiss (mica, quartz and plagioclase felspar), in which weathering and movement has obscured, in many cases, the original bedding planes.



MAP OF MINE ON THE CERUSSITE DEPOSIT

The strata of the profitable ore extend between bedding planes and are practically all granulite, forming a solid mineralized block, thrown into this position by the hanging- and foot-wall faulting, and having gneiss for both walls. Just beyond the thick gneiss strata, north and south of *b* and *l*, are more granulite layers containing cerussite, but not found in sufficient quantity for mining.

*Mining engineer, Lawrence, Kan.

Nature of the Rocks

The granulite is a hard, brittle rock and when shattered by earth movements the resultant cracks appear to have remained open until filled by solutions. The gneiss, on the contrary, is more decomposed and so soft that small cracks could be easily closed by slight pressure. It is therefore not surprising to find the cerussite confined to the cracks of the granulite, while the gneiss is practically barren.

The cerussite layers are usually 1/16 to ⅛ in. thick and the proportion of ore depends upon their number. In some places the granulite averages 10 per cent. lead, but the general average as mined yielded 4 to 5 per cent. of metallic lead in the mill. Occasionally the cerussite has formed considerable masses. One weighing 115 lb. was exhibited at the Portland Fair. These masses are crystalline druses, appearing casually like white, opaque vein quartz, and only shown the crystal habit along occasional planes on their periphery. The cerussite is dull white, translucent, brittle and easily detachable in small plates from its rock matrix. It is free from metallic impurities and is easily distinguishable from calcite in its thin sheets by giving no effervescence with dilute HCl.

Genesis of the Deposit

There is little doubt that the ore is of secondary origin, for primary lead ore habitually comes up in the form of sulphides. It is true that at Steamboat Springs, Nevada, the minerals deposited by the rising hot water contain a small proportion of cerussite, but it is only in association with ten times as much galena, and at the Terrible no galena has ever been detected.

It therefore appears probable that this deposit has been formed by descending waters. The clay selvage in the fault would stop the lead-bearing waters from penetrating further west and the fault would thus be the hanging wall; while the foot-wall boundary was caused by minor slips, more or less parallel with the hanging wall, shutting off the open cracks of the gneiss and forming a dam on the east side that prevented any considerable penetration of the cerussite into the foot-wall.

There are two possible sources of the lead: beds in limestone or small veins in the schists. No limestone was observed in the vicinity, but small galena veins are found in schists on the hillsides within a mile of the Terrible, and a sufficient number of them in the eroded anticlinal arch could have furnished all the lead in the mine.

With the help of heat and oxidation the two simplest equations for changing PbS to $PbCO_3$ are:

I. $PbS + 4O = PbSO_4$.

II. $PbSO_4 + Ca(HCO_3)_2 = PbCO_3 + H_2CO_3 + CaSO_4$.

Sufficient lime for the reaction in the absence of adjoining bedded limestone could easily have come from the lime felspars of the gneiss. The solutions may have entered the cracked granulite as $PbCO_3$ dissolved in the hot H_2CO_3, and the $PbCO_3$ may have been crystallized out by the cooling of the carrying solution.

In view of the fact that the granulite cracks north and south of the orebody contain calcite instead of cerussite, another method of ore origin is tenable. The lead may have entered the cracks as $PbSCO_4$ dissolved in hot H_2SO_4 and replaced the previously deposted calcite by the reaction of equation II. But this would set free considerable $CaSO_4$ within the orebody, and as no gypsum is to be observed in the pit, this theory of cerussite deposition seems less likely than the first.

It is probable from the method of origin that the ore does not reach a great depth. The rock cracks would tend to close up as depth was gained from the rising pressure, and they would also be smaller as the stress, and consequently also the shattering, is greatest at the top of the anticlinal arch. In the lowest workings on the 250-ft. level the cracks were smaller than at the surface, which seems to corroborate this theory.

Sampling Ores Containing Metallics

F. A. Thompson, *Western Chemist and Metallurgist,* Vol. III, has submitted the results of sampling an ore, containing metallics, not to show the proper method of sampling, but to show the difficulties attending the operation. The ore was porphyritic, the feldspar being pretty well kaolinized and in places was heavily iron stained. The gold and silver was present almost entirely as metallics, flakes of gold being visible to the naked eye; sometimes pieces of gold as large as grains of rice were visible.

The whole lot weighing about 10 tons was crushed to 0.5 in. size, and 1/5 cut out with a Vezin sampler. This two-ton cut was roll-crushed to about 0.12 in., and carefully riffled twice on a Jones sampler, having riffles 1 in. wide. This 500 lb. sample was put through smaller rolls to about 0.06-in. size and cut once with the riffle sampler. Each half was treated separately, being called original and duplicate, by cutting once with the riffler and rolled to about 0.025 in. size, and again cut to about 10 pounds.

The 10-lb. sample was passed through a coffee mill grinder several times, and riffled down to approximately 2 lb. and sifted on a 100-mesh sieve, about 90 per cent. passing through without further grinding. The oversize was bucked on a board until the metallics, which often showed up as ribbons of gold on the board, passed through the sieve. The pulp was mixed, coned and quartered, and divided into samples for the mine and sampler.

Results of the Assay

Sample	*Oz. gold per ton*
Sampler Original	9.29
Mine Original	11.22
Sampler Duplicate	12.60
Mine Duplicate	13.74
Average	11.71

The results on each sample being the average of at least four assays of ½ assay ton each, which upon the sample differed at times as much as 0.5 oz., it was decided to resample as the differences evidently lay there. The resample was started with the 1/5 portion of the original sampling, and the operation from that point to the division into original and duplicate repeated with more care if possible than at first. The sample now instead of being divided into two parts was divided into four and each part treated separately and reduced as before. The four final portions were ground in the coffee mill and the pulp weighed before screening. The metallics were then sifted out on a 100-mesh sieve, wrapped in lead foil and assayed, two by the mine and two by the sampler, each accepting the other's results. The through-screen portion was divided up into samples for the mine, sampler and umpire:

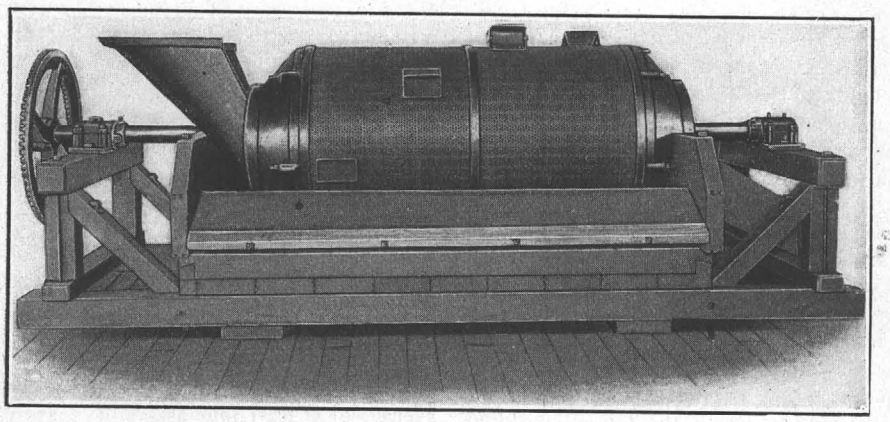
Result of Second Assay, Oz. Gold per Ton

	Pulp			Metallics		Final
	Mine	*Sampler*	*Average.*	*Mine*	*Sampler*	Results
First original	10.23	10.00	10.11		2.23	12.34
First duplicate	15.88	14.36	15.12	3.20		18.32
Second original	16.80	14.24	15.52		7.04	22.56
Second duplicate	16.90	15.23	16.07	2.39		18.46
Average						17.92

The settlement was made on this basis, and the experiment stopped. In the first sampling it is evident that metallics remained on the bucking board and muller, but in either case the results are not conclusive, and it is a question whether an accurate sample can be obtained on such material. The ratio of weight of sample to size of particles is well within the limits prescribed by sampling authorities.

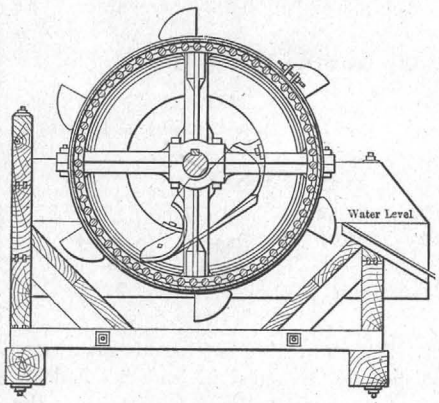
New Century Disintegrating Screen

The New Century Disintegrating screen, manufactured by the American Concentrator Company, Joplin, Mo., is a washing and disintegrating machine for the preliminary treatment of ore, barytes or other substances imbedded in stiff clay, mud or soapstone. It is a cylindrical screen protected within by round iron bars, and provided with a series of elevator buckets on the outside, the whole revolving in a tank of water.



NEW CENTURY DISINTEGRATING SCREEN

The material, which may include lumps of ore or boulders 10 in. in diameter, is fed into the revolving cylinder through a cast-iron hopper and is separated and washed by the action of the iron bars and the water. The bars are separated by one-inch spaces. The material which passes this revolving grizzly falls upon the screen and if sufficiently fine passes into the tank whence it is elevated by the buckets and discharged upon an apron and thence by launders to any desired point.



CROSS SECTION OF SCREEN AND TANK

The coarse material, after being rolled over and over in the machine, is discharged by means of a suitable casting.

The screen and revolving grizzly are supported by heavy spiders constructed in two parts so that they may be replaced without disturbing the central shaft. The machine is driven by countershaft and pinion with either bevel or spur gear, placed as desired.

The machine is furnished in different sizes and with screen perforations varying from 50 mesh to 1½-in. holes. The water required varies with the material treated; usually a 1½- to 2-in. pipe under a 3-ft. head furnishes an ample supply.

In the Bluefields gold district in Central America machines of this type are used having screens as fine as 60-mesh, while for washing carbonate zinc ores in Tennessee 1½-in. perforations are used. At the works of the American Sapphire Company, in Montana, the holes vary from 3/16 to ⅝ inch.

California and Nevada Mining Wages

SPECIAL CORRESPONDENCE

Fifty members of the senior class of the College of Mines, University of California, have gone to visit the mines at Tonopah, Nevada. Field surveying and examination of prominent mines will comprise the work of the trip. It is notable that a large number of University men are now scattered throughout the newer mining camps of southern Nevada. There are representatives of Yale, Harvard, Stanford, California, Pennsylvania, Princeton, Michigan, Northwestern, Chicago, Virginia, Cornell, Georgetown, Brown, Oxford and Heidelberg, in the city of Reno alone, and they are about to form the Nevada University Club with headquarters in that city, where a club house will be built. These graduates have been attracted to Nevada by the opportunities to make money in mining and other occupations.

In this connection it may be said that numbers of practical miners are leaving the mines of California for the better wages offered in the Nevada camps. For this reason there is a shortage of miners in most of the California mining countries. In one of the San Francisco dailies of April 3 there are advertisements for miners to work in California, among them one which calls for 82 machine men at $3.50 to $4 per day; 36 single and double hand drillers $67.50 to $90 per month; 26 muckers $75 to $80 per month; 60 carmen, $60 to $75 per month; 168 drillers for mines and quarries $67.50 to $90 per month. This gives a fair idea of the California wages. The underground miners get $3 to $5 per day according to the section of the State, the former price being the general average. In Nevada wages are much higher, being nearer $4.50 per day on the average and this accounts for so many leaving for that State.

Navigation and Mining in California

SPECIAL CORRESPONDENCE

The California Débris Commission has made a report which may be summarized as follows:

1. That it is advisable to attempt to divert the Bear or American rivers into the tule lands.

2. That it is inadvisable to construct settling basins and restraining barriers in the lower courses of the Bear and American rivers.

3. That it is now time to commence the work of restoring the navigable conditions of 1860 in the Sacramento and Feather rivers.

4. That the most feasible and advantageous method of accomplishing this is by dredging.

In pursuance with these conclusions, and in compliance with the requirements of the Act of March 1, 1893, the commission recommends as follows:

1. That an appropriation of $400,000 be made by Congress contingent upon a similar appropriation being made by the State of California, part of this sum to be devoted to the construction of two hydraulic dredges of high power, and the remainder to their operation and maintenance, in accordance with the general terms of the report on improvement of navigation of the Sacramento and Feather rivers, and for disposing of the mining débris brought into those streams by their tributaries.

2. That these funds be expended by the California Débris Commission under the direction of the Secretary of War, all rights of way and easements for levees and spill banks to be furnished free of cost to the United States.

The River Improvement and Drainage Association of California, which organization has been working for the betterment and improvement of the conditions of the rivers of California has done much to bring about harmony in the interests of the various industries involved in the question of hydraulic mining.

Important Mines Near Deadwood, S. D.*

Written for the MINING AND SCIENTIFIC PRESS.

There are no mines within the corporate limits of the city of Deadwood, although a good portion of the town is built on worked-out placer mines which paid handsomely during the years from 1876 to 1878. Though surrounded by large and rich mines and ore deposits, none of these occur, so far as known, within half a mile of the town, the nearest being the Montezuma and Whizzers, operated for the iron pyrite which occurs abundantly in the great lode on which these claims are located. These mines have been extensively drawn upon to furnish sulphide material for the pyritic smelter of the Golden Reward Co., in which are treated the siliceous ores obtained from mines near Terry Peak. These flux mines are owned by J. T. Gillmore & Co. of Deadwood. The ore deposits occur associated with a heavy reef of quartzite, which can be traced for many miles over the hills to the southeastward from Deadwood creek, but which passes beneath the lower member of the overlying Cambrian rocks half a mile away to the northwestward. This zone is 40 to 100 feet in width and carries chiefly pyrites, with a little chalcopyrite in the quartz gangue. The inclosing walls are mica schist, hornblende schist, etc.

Although there are represented within the city limits of Deadwood all of the several geological horizons at which ores occur in the Cambrian, Silurian and Carboniferous formations, within the Black Hills, there are no ore deposits of value known to exist in these rocks in this town. The Cambrian exposures are complete from the basal quarzite to the upper quartzite, distinguished by the abundant appearance of the fossil Scolithus. The Cambrian formation has a thickness here of about 450 feet, but thins out southward until in the southern Black Hills, near the south fork of Castle creek, it is not over 50 feet in thickness.

Overlying these Cambrian quartzites, shales and glauconitic sandstones are the calcareous shales and limestones of the Silurian and Carboniferous. The presence of the Devonian has been questioned, but the writer is of the opinion that fossils found on the eminence just east of Deadwood, locally known as White Rocks, identify the Devonian horizon.

It is in these sedimentary beds that the gold, silver and lead-bearing deposits which have attracted so much attention of late years occur, and which are generally referred to as the "siliceous ores," to distinguish them from the ore found in the Archæan schists upon which these sedimentaries rest.

All about Deadwood, particularly to the east, north and west, eruptive rocks of several types have been intruded into the Archæan and overlying sedimentaries, but these occurrences, known to be favorable to mineralization and the formation of valuable ore bodies, are not always accompanied by deposits of ore of commercial value. To the eastward of Deadwood, however, in Spruce gulch and on the divide between Spruce gulch and Two Bit creek, there are extensive and valuable ore deposits occurring at several horizons in the Cambrian and later formations. In the basal member, the Quartzite, occurs lead-silver ore; about 200 feet higher, lead carbonate ore is found in glauconitic red sandstone, and gold also is found in loosely coherent coarse sand rock, and in a dense, hard siliceous limonite. Ore deposits are known in and near the upper quartzite, and a chimney of gold-bearing iron ore is found in the carboniferous limestone on Lexington hill. Beside these several ore-bearing horizons, there are numerous zones in which occur "stocks" of iron oxide (presumably oxidized pyrite) in the porphyry intrusions. Ore deposits of this class are numerous on the divide between Spruch gulch and Two Bit, and similar occurrences are known near Galena and in the Bald mountain district.

The Spruce gulch section is rugged, and, owing to the numerous faults and porphyry intrusions, the geological structure is somewhat complicated, and an understanding of it is rendered more difficult by the large amount of talus which often obscures the rock formations. In this region one of the principal properties is that of the Lexington Hill Gold Mining Co. Originally this company owned the single claim known as the Old Lexington, at the summit of Lexington hill, on the divide between Spruce and Two Bit gulches, a mile and a half east of Deadwood. The Lexington Hill Co. consolidated the properties of five separate corporations, and their holdings are now among the most extensive controlled by a single company in Lawrence county. The area of mining ground thus consolidated is 350 acres. The greater portion of the ore is found in the Cambrian shales and quartzites. Thus far, five separate ore-bearing horizons are known. The formation is much disturbed in places and the ore beds are found lying at all angles, from nearly horizontal, as in the Champion mine, to about 60° pitch, as in the Annie. In the early days of the district the Champion was the most extensively worked of any of these mines, and many thousands of tons of good ore were milled in an ordinary stamp mill in which simple amalgamation was the only practice. This was done in the years about 1879 to 1882. There were frequent stoppages, when neither mine nor mill were operated for months at a time. This is not surprising, for the mill men were at their "wits' end" how to save the gold. Cyaniding was unknown, and chlorination, though commonly practiced elsewhere, had never been introduced in the Hills. The old mines are a labyrinth of shafts, winzes, levels and irregular excavations from which the ore was taken. Much of this ore was high grade, running from $15 to $200 per ton. The average, however, was much below this. Ore from $5 to $20 per ton is abundant. The development work was done in a random, haphazard fashion, in search of high-grade ore, but the present company has introduced a system of development which will greatly facilitate mining and cheapen its cost.

The accompanying illustration is that of the Lexington Hill mill in Spruce gulch, about a mile from Deadwood by road. A tunnel has been driven into the hill back of the mill, as shown in the illustration on the front page. This tunnel is started below the lowest Cambrian stratum, and will be run 3000 feet to a point under the crest of Lexington hill. This cheapens mining, as all ore broken above the tunnel level can be handled by gravity.

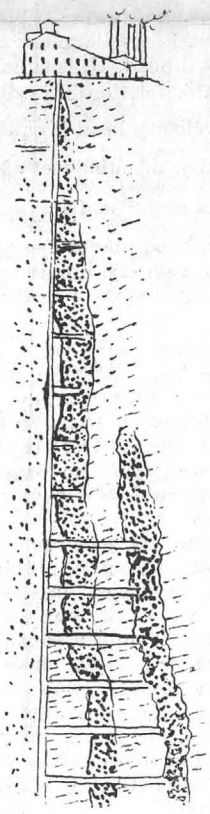
The milling process is by amalgamation, concentration and cyaniding tailings. The average value of the ore is stated to be $6 per ton.

*See illustration front page.

The Bassick Mine, Querida, Colo.

One of the most interesting mines in Colorado is the Bassick, near the town of Querida, in Custer county. The remarkable ore shoots of this property occur in an agglomerate of andesite within a rudely elliptical fissure, or vent, which at the surface was 20 to 30 feet in width and 100 feet long. It extends downward almost vertically, but winding somewhat. It is a typical pipe or chimney. It is practically without walls, and there is no line of demarkation between ore and barren country rock, the values disappearing by gradual transition from rich silver-gold ore to that which is commercially worthless.

Within the zone of fracture which some presume to be a volcanic vent, though this is unlikely, the fragments of the breccia or agglomerate range from that of pebbles to boulders 2 to 3 feet in diameter. These



Ore Shoots Bassick Mine, Custer County, Colo.

fragments are rounded, or subangular, few having sharp edges. Its condition varies from soft, earthy and crumbling, to dense, hard and flinty. At times boulders of the secondary silica are found embedded in masses of kaolin. The remarkable fissure has maintained its structural characteristics to a depth of nearly 2000 feet from the surface outcrop.

The richest ore occurs in the central portion of the deposit, the values generally lessening as distance from the center of the mass increases. It is a curious fact, also, that the average size of the fragments of rock (andesite), at the center are larger than those in the zone surrounding it.

The mineral composition of this unusual type of ore deposit is as peculiar as its structure is uncommon. There is in this deposit neither calcite, heavy spar, nor any other of the spar minerals that are generally found associated with ore deposits. The minerals occurring in the deposit are chiefly the sulphides of zinc, and lead, antimony and copper, with the secondary minerals resulting from their alteration in the upper or oxidized portion of the deposit. These minerals are the carbonates and silicates of the base sulphides, together with tetrahedrite (gray copper), silica, gold and silver.

These minerals were found arranged in concentric shells or layers, around the boulders of the deposit. The shells are of about the same thickness and follow each other in the same order on all of the boulders, there being generally three and sometimes four separate layers observable. From within outward, they occur as follows:

First. A thin layer of the sulphides of antimony, zinc and lead, black in color, with metallic lustre and crystalline structure. This layer varied from a thin line to $\frac{1}{5}$ inch in thickness, and carried from 1 to 3 ounces gold and 60 ounces silver per ton.

Second. A layer of lighter color, in which there was a larger amount of lead, silver and gold than in the layer underneath it, and running sometimes 100 ounces gold and 150 to 200 ounces silver per ton.

Third. A layer of crystallized zinc blend, containing also some iron and copper. It was from $\frac{1}{5}$ inch to 2 inches thick, carrying 15 to 50 ounces gold and 60 to 120 ounces silver per ton. Owing to its relative abundance, this layer constituted the most valuable source of revenue in the mine.

Fourth. When it was present, this fourth shell consisted chiefly of chalcopyrite. In thickness it varied from a few grains scattered on the outer surface of the blende to $\frac{1}{10}$ inch. It contained 50 to 100 ounces gold and silver.

Fifth.—Outside of this there occasionally appeared a thin sprinkling of pyrite. Strangely, this mineral, usually so abundant in ore deposits, occurs sparingly in the Bassick mine. Among the larger boulders the filling was generally kaolin. The mineral comprising the first, or inner shell, of the larger masses was always found present, as it covered the smaller pebbles and cobbles, whether the other shells occurred or not. It is a combination of antimonial lead. The zincblende layer, which is so pronounced in the heart of the ore body, is entirely absent in the outer portions of the deposit.

The gray copper was always found associated with quartz and outside of the shells in the interstitial spaces between the boulders. Quartz is also found in the open spaces between the boulders and never as a portion of the shells.

A curious fact in connection with this mine is the finding of fragments of charcoal to a depth as great as 765 feet. The charcoal often was found to have fine crystals of pyrite scattered throughout its pores.

Charcoal is also found in some portions of the Comstock Lode hanging wall, at Virginia City, Nev., and in the mines of Bodie, Cal.

These several occurrences of charcoal several hundred feet from the surface have been thought to be due to the fact that there have been several periods of eruption of the andesites, and that the interval between them was sufficiently long for trees to either grow on the surface of the flow or tufa deposit, or to be carried there by some means, and that the tree was enveloped in the next succeeding flow or deposit, to be, in time, converted to charcoal. This theory, if accepted, indicates the probability that the Bassick ore deposits have occurred at the joining plane of two separate deposits of fragmental andesite, or that the wood from which the charcoal was formed was involved in the andesite tuff or breccia in some manner, to be later turned to charcoal.

The origin, or genesis, of the Bassick ore deposits has been the subject of much speculation and a great deal has been written on the subject. Among the theories advanced are that of an "active volcano," where the rocks were ejected, falling back into the vent only to be again ejected, thus, in time, becoming rounded, like washed boulders.

This explanation will not account for the several peculiar structural phenomena observed. Had the rocks been ejected as suggested, only to fall back to be again ejected, until they finally came to a state of rest by reason of decrease of volcanic force from below, they would have lain in immediate contact with each other. This is not the case, however, as the boulders do not touch, and no known force could have kept them suspended in air, as it were, until the sulphide mineral shells had been deposited to fill the spaces between.

The more reasonable supposition is that the deposition of mineral is due to thermal springs rising from depth and carrying the minerals in solution found in the deposit. This mineralization took place along a line of fracture, somewhat illy defined, it is true, but probably having a direction common with the major axis of the ore body. The rings or shells of mineral deposit seem to be due to the concentric decomposition of the andesitic boulders themselves, a phenomenon not at all uncommon in the weathering or alteration of many massive rocks. The concentric shells were replaced by the mineral solutions, in much the same manner as metasomatic replacement occurs, in bands within fractured zones, elsewhere. As to the relative age of the several shells, that seems more difficult of solution. The natural inference is that the outermost shells, being the first to suffer alteration, were also the first to be replaced by the minerals of the sulphides coming from below.

It seems, without doubt, that the ore deposits of the Bassick mine are due to the last active evidence of volcanic action in the form of a fumarole or hot

CONCENTRATES.

RUBBER packing for gaskets and other purposes cuts much more readily if the knife be frequently wet during the progress of the work.

A GOOD speed for a driving belt is 3000 to 4000 feet per minute. In leather belts the direction of driving should be with and not against the laps in the belt.

THE strike of a vein is its direction horizontally. The trend of an ore shoot is its dip along the strike of the plane of the vein. The dip of the vein is at right angles to the strike.

WHEN a ton of quartz or other rock contains $20 in gold, the gold represents one part in 29,166 parts, and if the value be but $2 per ton, the gold represents but one part in 291,660 parts.

SOME mill men tie the wedges around the shank of a shoe with a string, others have the wedges tacked to a strip of cloth in order that they may be promptly adjusted when required.

FLUORSPAR is sometimes used in the manufacture of Portland cement. It is claimed to facilitate the semi-fusion of the finely ground material, thus forming what is known as "clinker."

IT is no more economical to run an engine with an underload than it is to run one with an overload. It is always wise to provide ample power, but the installation can be easily overdone.

CEMENT acts as a protector to iron and steel used in its reinforcement. Steel bars so used have been found with practically no sign of rust after having been embedded in concrete for over twenty years.

A CROSSHEAD for shaft sinking may be made of angle iron, and it would probably be as serviceable if not better than one made of wood. The plates could be riveted by the blacksmith. If the material is at hand it would probably be cheaper than wood.

NEARLY all copper ore deposits occurring at or near contact of limestone with other rocks contain garnet in abundance. The idea that the appearance of garnet is a sign of a poor mine is a fallacy, for some of the largest and most profitable copper mines are accompanied by abundance of garnet.

THE appearance of scattered but rich small pockets of ore in a large rock mass is not a safe indication that these deposits will be found to increase in size and number until a large, solid body of ore is formed in depth. Numerous stringers appearing at the surface sometimes unite to form a solid vein below.

THE frequent earthquakes being of late recorded in California are supposed to be due to the interior cooling of the earth, and the consequent shrinkage results in compensating movements of the outer crust of the earth—the rocks which may be seen in the hills and mountains in the workings of mines. All regions are likely to be similarly affected. Seismic disturbances occur in all parts of the world and are practically of daily occurrence.

A FATHOM is 6 English feet. Mine workings are not usually measured in fathoms except in Cornwall and a few places in the United States, where the custom has been introduced from England. A vara is a Spanish yard—32.8748 inches. It is often used to denote the extent of mine workings, and also of the superficial measurement of mining ground. In California, the legalized vara is 33.372 inches, and the legua (league) is 5000 varas, or 2.6335 United States miles.

THERE is a great difference in the manner in which different men fire a boiler. A careful man who has been properly taught, or who has learned from experience, will use much less fuel than another who either does not know or is careless, and consequently extravagant. Coal should be fired frequently and in even thin layers. Too heavy a charge will cause a prompt and decided lowering of temperature with a great increase of temperature as soon as the coal gets to burning brightly.

TO lay ½ mile of track (5280 feet of rails), using twelve-pound rails, will require about nineteen tons of rails beside fish plates, bolts, nuts, spikes, etc. If sixteen-pound rail is used, twenty-five tons of rail will be required. It is not necessary to use fish plates underground. Thousands of feet of track are in use in mines where no fish plates are in use. If the ties are heavy enough to use good-sized spikes, no fish plates are required. Where heavier tramming is done on the surface it is advisable to use fish plates on permanent tracks.

FUSE is known as single, double and triple tape, cement fuse, gutta percha fuse, etc. Each fuse is made in much the same manner—a thin and continuous string of powder surrounded by a wrapping of hemp or other material and covered on the outside by a single, double or triple thickness of tarred tape tightly wound. In the case of cement fuse a composition impervious to water is substituted for tape, and gutta percha is only another variety of covering. In wet places or under water the best varieties of fuse should be employed.

THE duty of the miner's inch (1.5 cubic feet per minute) of water in moving gravel is variable, depending on the head and volume of the water used, and to a great extent upon the character of the gravel, and the grade, which may facilitate or retard the clearance of the gravel from the working place. The miner's inch varied so greatly in quantity, by reason of the variable head employed in measurement, that the California and Montana Legislatures fixed the amount at 1.5 cubic foot. Under a head of 6½ inches—that is, 6½ inches from the surface to the center of the orifice—1.53 cubic foot of water will flow in one minute through an aperture 1 inch square.

LOCOMOTIVE BOILERS are frequently seen about small mines, and sometimes at large ones. A boiler of this type is convenient, particularly in the smaller sizes, and is often mounted on wheels in order that it may be moved readily from place to place. For prospecting purposes, they are much in favor. The locomotive or firebox boiler is as extravagant of fuel as it is convenient, but its usefulness may be greatly increased if the feed water be heated and a damper be placed in the stack, in order that the combustion of the fuel may be controlled somewhat. This kind of boiler can be used to run hoists, pumps, quartz mills, saw mills and other machinery not requiring too great power.

THE largest number of stamps in operation under one roof is 300, in one of the mills of the Alaska-Treadwell Gold Mining Co., Douglas Island, Alaska. This company has another mill of 240 stamps. The gold output of Venezuela is difficult to arrive at, owing to high export duty, which acts as a sort of premium to smuggle gold out of the country. Official reports credit that country with a production of 41,200 ounces to as high as 49,000 ounces within the past ten years, with a probable average of about 43,000 fine ounces annually—or about $8,600,000 during the past ten years. The annual output of Venezuela was considerably higher about twenty years ago, when the great Lode El Callao was being vigorously worked.

IN pumping against a closed valve with a multi-stage turbine pump, or any other kind, the gauge should indicate a pressure equal to the total head necessary to raise the desired quantity of water. This depends upon the length of the pipe, L, its diameter, d, and coefficient of friction. The total head, H, is equal to the sum of the vertical lift, h, the friction head, h_1, and the velocity head, h_2. The velocity head is equal to $\frac{v^2}{2g}$ where v is equal to the number of cubic feet discharged divided by the cross-sectional area; the friction head is $f_1 \frac{L}{2g}$ where f_1 is the frictional head for 100 feet of pipe of given diameter and for given velocity, obtained experimentally and given in hydraulic tables. The formula is $H = h + f_1 \frac{L}{2g} + \frac{v_2}{2g}$.

THE efflorescence appearing on the face of concrete walls is due to the seepage through the wall of moisture, carrying lime or other minerals in solution, which are deposited on the wall upon the evaporation of the water. This is usually observable along approximately horizontal lines, which represent the several stages of the successive days' work. It has been suggested that this may be presented by giving the upper surface of each separate layer placed in the wall, a backward slope toward the rear of the wall and sprinkling a layer of neat cement on this upper, but unfinished surface. This forms a layer almost impervious to water and when moisture percolates downward through the concrete, on reaching these several impervious inclined planes, the water will be trained backward to the rear of the wall instead of to its face, and, in time, the soluble minerals will be completely dissolved and removed from the concrete.

THE thawing of nitro powder is always attended with danger, and too much care cannot be taken in this matter. When warmed, nitroglycerine oozes from the absorbent, and if it collects in a drop this drop is dangerous, for, falling on any heated object, will explode in the great majority of instances, and this explosion is likely to have the effect of exploding the main mass. Dynamite may be safely thawed in several ways. One, said to have been employed on the Croton Aqueduct work, was that of placing a cubical box 30 inches square within a box 48 inches square, the space between the boxes being filled with green stable manure packed hard. The boxes were set in a hole in the ground and filled round with 18 inches of loosely packed manure, the floor of the thawer being filled to a depth of 10 inches with tightly packed manure. The space above will hold conveniently fifty pounds of nitro powder. The cover had a stovepipe ventilator 3 feet high, and was provided with a sliding cover, to make access to the interior convenient. The sticks of dynamite were laid in loosely, the lid closed and green manure piled over it to the depth of a foot. The powder would thaw in from three to eight hours, depending on the degree of the temperature outside. This method of thawing frozen nitro powder is safe; no rapid changes of temperature occur, and it is inexpensive.

GEOLOGICAL STRUCTURE has often a decided influence on the topography of a region. A fault may produce a cliff extending sometimes many miles. The contact between two formations often results in the erosion of a canyon along this line. Hard rock strata often produce ridges, and bosses of hard rock, rounded or rugged, isolated hills. Synclinal folds usually produce valleys, though not always, as the compression of rocks in a synclinal trough may render them so hard as to make them better able to resist erosion. The axis of an anticlinal is often indicated by a valley, as the rocks are fractured and thus rendered more easy of removal by erosion. The course of a vein is as often indicated by a line of depression as by a bold outcrop. The reason for this is due to the fact that the walls of a vein are often impregnated with the sulphide of iron which is disseminated in grains throughout the rock, often to a considerable distance on either side of the fissure. This renders the country rock much more easily susceptible to decay and oxidation of the sulphides, which facilitates erosion. Many other instances might be mentioned to show that geological structure has a very important influence on surface topography, like flows of lava over the country, which usually result in producing long, flat-topped ridges or table lands.

THE probable value of the ore which may be found at a greater depth than that exposed in a copper mine would be a difficult matter to satisfactorily determine. The engineer may be able to form a very fair judgment from what he can see of the probable continuity of the ore downward, but its value can only be guessed at. In many important copper mines the gossan is practically destitute; in the zone next below the iron capping the ore is abnormally rich, and in depth (in the normal sulphide zone) the ore is a low-grade mixture of copper and iron sulphide and gangue, and often also pyrrhotite and other minerals. The climatic conditions and topography of the country have much to do with the oxidation of the sulphide ores and the position of the various alteration products as related to the surface. Thus in a country where oxidation proceeds more rapidly than erosion a heavy iron gossan is not infrequently seen on the surface, while in a desert region, while oxidation may be more rapid than in a comparatively moist region, the rate of erosion is even more rapid and the iron capping is thinner or it is accompanied by the oxides and carbonates of copper, under which are found the enriched sulphides of which chalcocite (copper glance) and bornite (peacock copper ore) are examples. Beneath the zone in which these ores occur is the normal sulphide zone, but this may be deep seated, as at Clifton, Ariz. In many regions the normal zone is found within 200 feet of the surface. Although the greater portion of the zone of mineralization is above 1000 feet from the surface, there are places where the zone of enrichment extends to greater depth and many hundred feet below the level of the ground water of the district. In some mines there is practically no zone of oxidation or enrichment, which is probably due to climatic and topographical conditions.

CYANIDE SOLUTIONS are decomposed to a greater or less extent by many mineral substances commonly occurring in ores. The solution affects almost all of these substances more or less, and is itself affected by them, but the success of the process is based upon the fact that gold and silver in minute particles are more readily affected than are the other minerals usually occurring with them. Pyrite affects cyanide to a slight degree. Metallic particles of iron and steel which result from the crushing of the ores are disseminated throughout the mass of ore treated and dissolve slowly in cyanide solutions. Metallic copper is also slightly soluble in the solution. Copper sulphides usually accompany gold and silver ores, being present from a trace up to rich ore of copper. All the copper sulphides are soluble in cyanide solutions, but some more so than others. The presence of other mineral substances often facilitates the dissolution of copper ores in the cyanide solution, as many interesting reactions take place. The best way to determine the amount of cyanide consumed by the presence of particular substances is by test. Chemical analysis only cannot be relied upon to give the desired information. Mispickel (arsenical iron sulphide) is acted upon by cyanide, but very slowly. Some gold ores containing abundant arsenical sulphide have been successfully treated by the bromo-cyanide process. Stibnite (antimony sulphide) decomposes cyanide readily, and is one of the most objectionable substances with which cyanide operators have to deal. Owing to the reactions which take place in the solutions, gold and silver are sometimes rendered practically almost insoluble in cyanide solutions. Mercury, which is usually present in tailings, is soluble in cyanide. Some operators claim this metal aids in the process, others say it is a detriment. This must be considered as representing the individual experience of these several operators, and neither statement accepted as positive in all cases. Zinc sulphide is not considered as very disadvantageous if the mineral is fresh from the mine and has not had long exposure to oxidizing influences. Galena (lead sulphide) is similar in its action to zinc sulphide, and is not particularly objectionable to the cyanide operator. In each of the instances here mentioned special tests must be made to determine the amount of decomposition of cyanide by these several minerals.

spring, possibly accompanied by hot water and the escape of steam at the surface.

The peculiar mineralization of the deposit may be due in part to secondary causes. There are other deposits in that portion of Colorado not wholly dissimilar, and these occurrences throw much light upon the origin of ore deposits in zones of fracture and brecciation.

The Genesis of the Copper Deposits of Clifton-Morenci, Arizona.

NUMBER II.

Written by WALDEMAR LINDGREN.

The Longfellow limestone, though somewhat irregularly altered, is, next to the contact, generally transformed into a coarsely granular rock of garnet, epidote, diopside, magnetite, pyrite, zincblende and chalcopyrite, and there is a most decided change of composition, chiefly consisting in additions of silica and iron. Other parts are less altered, but contain much magnetite, together with the sulphides mentioned, disseminated through a medium-grained crystalline mass of the carbonates of lime and magnesia. The development of magnetite, metasomatically, is a most pronounced feature of the process. Looking at the formation as a whole, sulphur, iron, copper and zinc have certainly been added, and probably also silica and magnesia. Large masses of magnetite, locally used as a flux, have been mined at this horizon.

The Morenci shales have suffered a change to dense, greenish hornfels with a development of amphibole and, in places, also muscovite. Pyrite and magnetite are also present, but on the whole the change in composition is probably slight.

The Modoc limestone, containing about 96% of carbonate of lime, has proved extremely susceptible, and over large areas at Morenci, as well as at Metcalf, is converted to a massive sheet of lime-iron garnet; magnetite is usually present; epidote and oxidized copper ores are also of frequent occurrence. This transformation, involving large additions of silica and ferric iron, is very noteworthy, as the evidence is entirely uncontrovertible.

The contacts of the sedimentary series and the porphyry are sharp and show no evidence of assimilation. All of the contact metamorphic rocks, when unaffected by oxidation, are very compact and hard, atmospheric waters finding great difficulty in attacking them. Considering that great amounts of carbon dioxide have been expelled during the metamorphism, it is clear that a great shrinkage of volume should have taken place if no additions of material had been received. Such a reduction of volume has evidently not taken place, and I believe that any loss has been fully balanced by gains from material contained in magmatic solutions.

Study of the Morenci contact zone proves conclusively that important accessions of substance have been received. The rocks inside the altered zone contain an enormous quantity of sulphur, iron, copper and zinc. Iron is contained in the unaltered rocks to some extent, but nothing like the quantities in the contact zone; sulphur, copper and zinc in noticeable amounts are absent from the unaltered rocks. Were they present, to the extent of a small fraction of the percentage contained in the contact-zone, direct observation and surface oxidation would expose their presence. The minerals in which these substances are contained were certainly formed contemporaneously with the ordinary contact minerals of the district, like garnet, diopside and epidote.

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

The metasomatic development of magnetite in pure limestones which has recently been questioned by Prof. Klockmann may be observed in almost countless localities at Morenci and Metcalf, both in the field and under the microscope. It is known that iron was not contained to this extent in the original rock, but to demonstrate its actual derivation in each case is, of course, difficult. The question becomes clear only when we compare the contact zone as a whole with the original unaltered rock.

It seems very strange than any one can doubt the possibility of such conditions and overlook what must happen when a magma in aqueous fusion is suddenly brought up to higher levels and strongly ionized water-gas above the critical temperature is largely released from its bonds. It must of necessity contain dissolved substances. Even at comparatively low temperature water is one of the most powerful solvents known, and its action, when a perfect gas, is probably far in excess of that at 100° or 200° C. It is well known that some rapidly congealed rocks, like the "pitch stone" from Saxony, contains up to 8% of water, which indicates an amount of water-gas which per cubic meter of magma would at + 4° C. correspond to from 250 to 300 liters. All magmas may, of course, not have contained this amount. The water-gas seems to have penetrated the limestones like a sponge, inducing extreme molecular mobility. Even should we deny any additions of substance, a most remarkable transferring of substance has certainly taken place in the rock, as shown, for instance, by large crystals of garnet developing in limestones of uniform composition containing far less silica than the amounts required by the newly formed mineral.

A misapprehension of the character of contact deposits seems to exist in many quarters, in considering the presence of minerals containing boron, fluorine, etc , as necessary to prove the contact-metamorphic character of these deposits. The character of magmatic waters evidently varies greatly in different magmas. Some may carry large quantities of the substances mentioned, as shown by the presence of tourmaline, cassiterite and other minerals in the contact-metamorphic rocks, while others may be almost wholly deficient in them, and, instead, carry sulphur, copper, iron and other metals. In the Clifton group of deposits, I would be inclined to consider molybdenum a characteristic constituent, taking the place of tungsten in the tin deposits. Any attempt to reduce the wonderful variety in the contact-metamorphic deposits to a single pattern is doomed to failure.

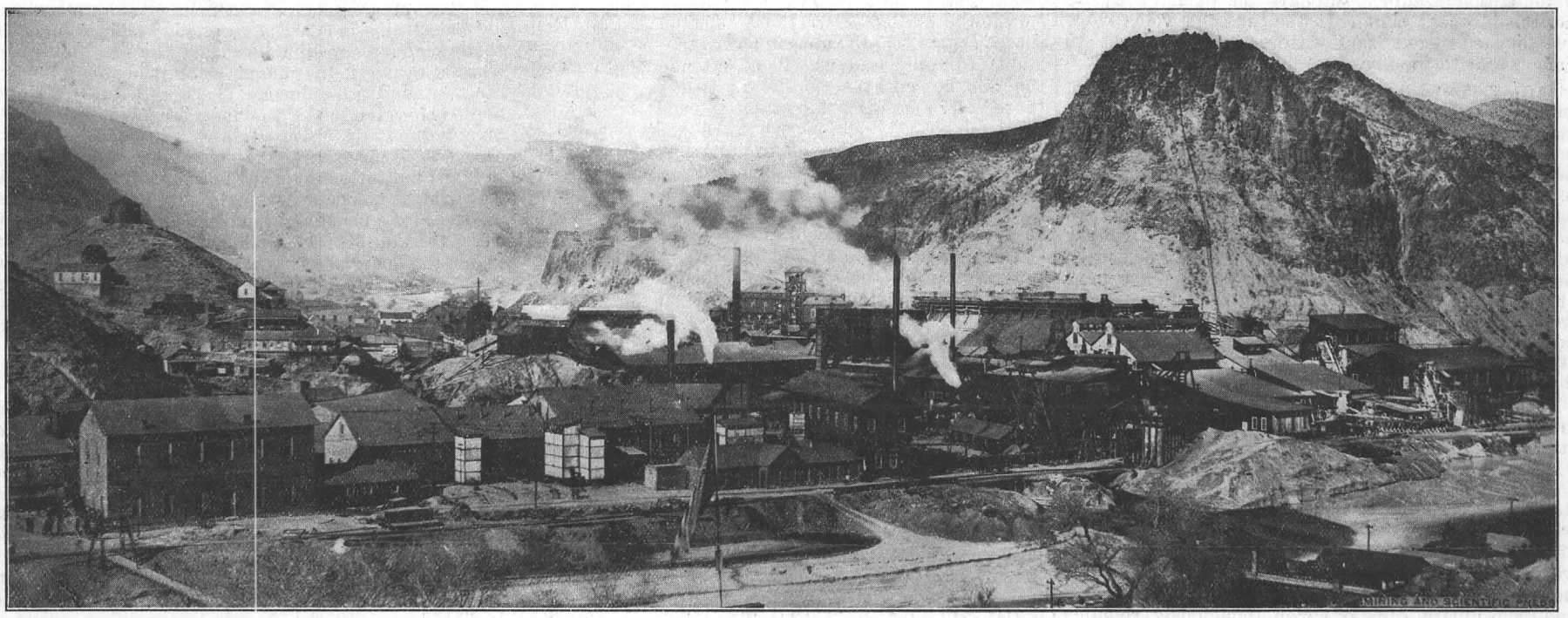
As the result of wide observations, we would state, as far as we know at present, ore deposits may occur several hundred or even 2000 feet away from the contact. In fact, disseminated sulphides and magnetite occur at Morenci up to 2000 feet from the main contact.

A tabular form of deposits often noted is usually due to the strongly marked difference in susceptibility of the various beds. Wherever the deposits have been enriched by oxidation, the form may be more or less dependent upon these changes.

W. H. Weed has noted the tabular shape in contact deposits at Cananea, Mex., and makes the form a basis of classification. I do not believe, however, that distance from contact (within limits given above) and shape are at all essential, and can find no mineralogical difference between deposits varying in these respects.

HYDROTHERMAL METAMORPHISM.—Both the porphyry and the contact zone are traversed by fissure-veins, which carry pyrite with a small quantity of chalcopyrite, zinc blende and molybdenite, whenever oxidation has not changed these minerals. These pyritic veins are of low—generally unpayable—tenor; they consist of prevailingly granular or massive, very rarely crustified, minerals with a little quartz-gangue, and are believed to have been formed by pyritic replacement along well-defined fissure planes. In the porphyry these veins are surrounded by very wide zones, in which the rock is greatly altered by the introduction of sericite and pyrite, and this applies to Metcalf as well as to Morenci. At the latter place, almost the whole of Copper mountain, containing the most important lodes, is thus altered. The process, which in the complete report is elucidated by many analyses, produces bleached rocks of varying hardness, in which all of the feldspar has been replaced by sericite and some pyrite. The biotite and hornblende are transformed into chlorite and serpentine, while the silica of the rock remains almost constant. All of the lime and soda are eliminated, while potash is greatly increased; no carbonates form during this process.

RELATION OF CONTACT AND HYDROTHERMAL METAMORPHISM.—The alteration of limestone along fissure-veins to tremolite (or diopside) with magnetite and sulphide is, as far as I know, a novel one. Ordinarily, limestone alters next to fissure-veins to dolomite or quartz or jasperoids. The addition of silica and iron and the mineralogical result of the hydrothermal process at Morenci undoubtedly connects it in some way with contact metamorphism. It is also probable that an alteration of this kind took place at high temperature comparatively soon after the solidification of the porphyry.



Arizona Copper Co.'s Works, Clifton, Ariz.

The vein alteration produces dull, earthy rocks from the limestone, while contact metamorphism results in hard, compact and granular rocks. On the other hand, there is undoubtedly a certain relation between the two processes, for amphibole (and pyroxine) occurs in the true contact-metamorphic rocks, and the intergrowth of magnetite and pyrite is characteristic of both. I should, therefore, conclude that after the completion of the contact metamorphism, properly speaking, and after the consolidation of the porphyry, an extensive fissure took place and solutions derived from the cooling porphyry, probably ascending and laterally extending from this rock, flowed through these fissures. Everything indicates that these solutions were closely related to those which emanated from the magma at the moment of intrusion and, in fact, similar in general composition.

PROCESSES DUE TO OXIDATION AND HYDRATION IN THE ALTERED ZONE.—Under influence of surface waters, but protected from direct oxidation, chlorite and serpentine form from the tremolite and diopside of the contact zones, while garnet is little altered. Under direct oxidizing action, garnet changes to limonite and quartz, while lime is probably carried away as carbonate. Tremolite and related minerals are similarly affected. Magnetite oxidizes to hematite and limonite, many large bodies of which are mined for fluxing purposes.

The veins are marked by siliceous outcrops, either entirely barren or containing small amounts of oxidized copper ores. No basic ferric sulphates have been seen either in the mines or on the surface. The waters percolating downwards must soon have lost their oxygen and, for the alteration at greater depths, ferrous sulphate and diluted sulphuric acid are probably the only reagents of importance resulting from the pyrite. It is clear that the upper part of the veins have not been formed by simple oxidation of pyrite and accumulation of limonite.

Direct oxidation of chalcopyrite yields cupric and ferrous sulphates, while the zinc blende produces zinc sulphate; both of these processes are in evidence wherever disseminated sulphides in the meta-

morphic rocks are exposed to oxidation. The general order of attack of oxygen is usually stated as follows: Arsenopyrite (most easily attacked), pyrite, chalcopyrite, blende, galena and, finally, chalcocite (most difficultly attacked). This rule is probably true only for one set of conditions as to mass, aggregate and character of solutions. Very marked exceptions from it occur at Morenci.

SULPHATE WATERS.—Descending waters from a lode of decomposing pyrite, chalcopyrite and zinc blende should contain chiefly ferrous, cupric and zinc sulphates, together with free sulphuric acid. The first two salts are easily soluble, but far more so is the zinc sulphate.

Cuprous sulphate is stable only under certain conditions and is not believed to be an important reagent, though it may form during subsidiary or intermediate reactions. Its presence in any mine waters has not been satisfactorily proved.

In this district, some moisture percolates the upper workings, as shown by efflorescences and stalactites of sulphates, but the mines are practically dry. In the porous porphyry, the moisture spreads easily, while the hard metamorphic rocks offer considerable resistance.

PROCESSES IN FISSURE VEINS.—Below the region of oxidizing influences, the veins consist of pyrite, chalcopyrite and zinc blende, while the upper few hundred feet contain chalcocite and oxidized copper ores. The most important action of the descending sulphate solutions has been a development of chalcocite by the action of cupric sulphate on primary pyrite ore; this process began at the time the veins were first touched by oxidizing waters, and continues to some extent to the present time.

OXIDATION OF CHALCOCITE —After a large part of chalcocite in the lode had been formed, there came a time when erosion and degradation, working faster than oxidation, began to expose the upper part of the chalcocite zone to active and direct attack by oxygen. Practically all of the veins are in this stage. The present zones of active oxidation are therefore due, not to direct oxidation of the primary lode, but to the destruction of the upper horizon of the chalcocite zone. As reagents, there are here ferrous sulphate, sulphuric acid, cupric sulphate and free oxygen. Any ferric sulphate present would soon be reduced to ferrous salt by the abundant pyrite. Chalcocite changes to cuprite and cupric sulphate, sometimes with an intermediate stage of covellite. Cuprite, partly reduced to metallic copper, is abundantly present in the upper limit of the chalcocite zone.

By some process not quite elucidated, chalcocite may, in places, change directly into native copper. The zone of cuprite and metallic copper has rarely great vertical extension, for the reason that both minerals are rapidly converted into cupric sulphate, brochantite, malachite, azurite and chrysocolla; but these products are soon dissolved by free sulphuric acid from pyrite, some of which tenaciously remains until the last, and descend as soluble sulphates to enrich the upper part of the chalcocite zone.

OXIDIZING PROCESSES IN LIMESTONE.—The processes which have resulted in the oxidized deposits now forming irregular or tabular masses in limestone or shale, and not connected with fissures, are materially different from those occurring in the lodes. In most cases the original material consisted of disseminated lean pyritic ores, containing pyrite, chalcopyrite, zinc blende and magnetite, locally more or less concentrated in irregular masses, or following certain strata or dike contacts. Free oxygen and sulphuric acid, ferrous and cupric sulphates, with an abundance of calcium carbonate, formed the reagents. Though oxygen and carbon dioxide may in part have produced limonite and malachite directly from pyrite and chalcopyrite, the most important reactions doubtless were those between calcium carbonate and sulphate solutions, partly derived from nearer the surface.

In the first case malachite, in the second azurite forms, together with gypsum. The latter mineral, though largely carried away in solutions, is not uncommon in these deposits at Morenci. Ferric hydrate will be produced from ferrous sulphate and calcium carbonate. Thus, in general, is explained the constant occurrence in these deposits of malachite, azurite and limonite. Crusts of replacing malachite and azurite frequently surround residual, rounded masses of limestone. The gangue of garnet and magnetite alters to ferric hydrate and quartz. Chrysocolla forms when silica is plentiful; zinc minerals are not uncommon in these deposits, and efflorescences of the zinc and magnesia sulphates sometimes cover the tunnel walls. During the process outlined above, lime is almost wholly eliminated, while alumina forms residual concentrations.

OXIDIZING PROCESSES IN SHALE.—Disseminated cuprite in beds of Morenci shale is a common occurrence, and some of the large ore bodies of the Manganese Blue mine were of this character. It occurs as flakes on the bedding planes, or in small replacement veins, sometimes accompanied by distinctly later malachite and by limonite.

Azurite also occurs frequently in shale, as shown by the second ore body in the Detroit mine. Large crystals of that mineral develop here, metasomatically, in a metamorphic shale, composed of sericite and amphibole. Cases have been observed where azurite envelops masses of undecomposed pyrite accompanied by a little limonite. During the oxidizing process, the alumina possesses considerable mobility. It is dissolved by sulphuric acid from clay shale and by decomposition of certain aluminous minerals, notably sericite. The aluminum sulphate formed is extremely soluble in water, and thus easily transported. At many places in the mines of Morenci, pure kaolin forms, together with azurite and malachite.

(TO BE CONTINUED.)

Water Rights in California.

NUMBER IV.

Written for the MINING AND SCIENTIFIC PRESS by SAMUEL C. WIEL.

HOW AN APPROPRIATION IS MADE (CONTINUED).—The mere diversion itself without the intent to apply the water to a beneficial use will not, of course, be enough; as where water is diverted merely to drain the bed of a stream so that it can be mined. (7 Cal. 261.) But when all requisites are present the right to the water dates back by relation, as we have seen, to the posting of the notice. (C. C. 1418). The actual application and use of the water may then follow, but need not do so immediately; the right is already complete, and the failure to make use of it within a reasonable time (130 Cal. 290 at 296) is only evidence of abandonment, to be considered hereafter. (115 Cal. 496, 60 Am. St. Rep. 806, note). There must, however, be apparent ability to apply and use it as intended; otherwise, though the construction work will be completed, there will be no bona fide intent to use it for a beneficial purpose, which, as we have seen, is also an essential. The absence of an apparent ability to use the water at completion is evidence against the bona fides of the intent (which must have a reasonable foundation), as in the case of gathering water in a reservoir for mere speculation. (15 Cal. 271.)

There having been a proper notice, a bona fide intention to apply the water to a beneficial use, diligence in the construction work, and an actual completion of it, the right is complete, and dates from the posting of the notice. (C. C. 1418).

EXERCISE OF THE RIGHT.—We now leave the questions arising out of the obtaining of water rights and take it as granted that a valid water right has been obtained by appropriation, as previously set forth. The inquiry now is as to the limits within which the water can be then used. The limitations to be considered are (1) those arising out of the nature of the right; (2) those concerning the manner of use; (3) concerning the amount used; (4) concerning the purpose for which used and the place of use.

1. The right is in the nature of a grant of favor or franchise from the Government to use the water (6 Cal. 548 at 558; 75 Cal. 464 at 483); that is, it is usufructuary solely. There is no property in the channel itself, nor in the water itself, nor in the natural flow. As there is no property in the channel itself obtained by appropriation, the same channel may be used by several appropriators, as where one man had appropriated water and a later comer above stream poured water into the channel and then diverted it again before it reached the former appropriator, thus using the channel as a link in a long ditch line (7 Cal. 46; 11 Cal. 143). The ownership of the channel remains with the Government. As, in the next place, there is no property in the water itself, the appropriator cannot sue for the value of water diverted by another, but only for the damage to his own use of it (57 Cal. 44). Nor can he set up any claim to water after it has left his ditch (3 Cal. 249), the water itself not being his, but only the use of it, which is what is expressed by saying that the right is usufructuary solely. As, finally, there is no property in the natural flow, it is held that, so long as one's ditch is filled, a later comer may change the amount of the natural flow by taking the surplus (13 Cal. 220), or an artificial flow is enough if one's ditch remains, nevertheless, filled as usual (113 Cal. 182 at 196)—without causing uncertainty, it should probably be added.

Though usufructuary solely, the right is in the nature of real estate. In 5 Cal. 445 the court says: "From the policy of our laws it has been held in this State to exist without private ownership of the soil, upon the ground of prior location upon the land, or prior appropriation and use of the water. The right to water must be treated in this State, as it has always been treated, as a right running with the land, and as a corporeal privilege bestowed upon the occupier or appurtenant to the soil; and, as such, has none of the characteristics of mere personalty." They held that a justice of the peace had no jurisdiction over an action for diversion of water, because it was an action concerning real estate.

It may become appurtenant to the land for which it is used, if any, and in such case passes with it as an appurtenance, if appurtenances are mentioned in a sale (47 Cal. 453; 93 Cal. 365; 75 Cal. 464), for "it can be transferred like other property" (13 Cal. 220 at 233). A sale of it requires a writing, because, being an interest in realty, it is within the statute of frauds (Griseza vs. Terwilliger, 28 Cal. Dec. 313). The statute of limitations concerning land applies to it (25 Cal. 504).

But the water right is not held like land, absolute, in the full sense; it is held subject to conditions owed to the Government, from whom it is at the start obtained, the chief of which conditions is that it must be continually used for a beneficial purpose. An illustration of this condition of beneficial use, under which a water right is held, occurred in the very recent case of Griseza vs. Terwilliger, 28 Cal. Dec. 113. It was there held that a verbal sale would not pass a water right, as it is an interest in land requiring a writing; but it was held, at the same time, that it would be taken as evidence of an abandonment, signifying an intention to discontinue applying it to a beneficial purpose oneself, as the Government requires. It was even hinted that it was an abandonment ipso facto, which harsh result is not one of the usual consequences of a parol sale of real estate, nor, for example, of a parol sale of an unpatented mining location (51 Cal. 258). If the head note, in the "Decisions," to the Griseza case correctly represents the decision of the court to this effect, then the statement in 13 Cal. 233, that it can be transferred like other property, must be taken with limitations, and the owners of water rights would be in danger of losing them entirely by a parol sale or a faulty deed. At all events, it shows again that there is no title to the water itself; but the right is usufructuary solely.

2. Manner of use: It has been said that the appropriator may use the water in any manner necessary to carry out the use for which it was appropriated (46 Cal. 218). It is a rule applying to all branches of the law of waters that whether the use is by water wheels, taking it by pumps, using it in steam boilers, etc., makes no difference (111 Cal. 473). Under Sec. 1415 civil code, the means by which water is diverted may be changed later, so long as others are not injured by the change. The only important limitation upon the manner of use is that the water must not be used wastefully, for then it is not all used, for a beneficial purpose, as is necessary (C.C. 1411; 132 Cal. 312; 112 Cal. 230). This is the same under the doctrine of riparian ownership, also; e. g., in one case a riparian owner built a dam, spreading out the water over a flat for cattle to wallow in, so that much was lost by evaporation. He was stopped by a writ of injunction (28 Cal. 340).

The use by means of ditches and flumes is, of course, the most usual, and using it in this way does not, by any means, make the appropriator an insurer of others against accident from breaking ditches or overflows. There is a famous English case (Fletcher vs. Rylands, L. R. 3 House of Lords, 330) declaring that a man builds a reservoir, etc., at his peril. But such is not the law in California (10 Cal. 413; 35 Cal. 679). Nor does such a break or overflow in itself prove that the ditch owner was negligent; or, as it is said, it is not a case of "res ipsa loquitur," and negligence is not presumed (7 Cal. 335). The owner is liable only if the break or overflow occurred through his negligence, a failure to use the care which an ordinary prudent man would have taken with that ditch (10 Cal. 541).

3. Amount of Water: Before the code the appropriator could take to the full capacity of his ditch, having a reasonable time, after its completion, to remove obstructions, rocks, etc., and to remove other things causing an irregularity of flow. (8 Cal. 443). He was limited to that, however, and could not take more later, unless by a new appropriation. (13 Cal. 33; 21 Cal. 374). Under the code he must state in his notice how many inches of water he appropriates, and will be limited to that (C. C. 1415), or, if he uses less than that, to the amount actually used. (112 Cal. 230; 120 Cal. 86).

The surplus over what he has appropriated may itself be appropriated by later comers. (13 Cal. 33; 120 Cal. 86).

4. Place and purpose of use: Under the code, the place and purpose of use must be stated in the notice (C. C. 1415). What constitutes a proper purpose has already been considered under the question of intention, and it need only be inquired here what changes can be made in place or in purpose of use, without a new appropriation.

As to change of place of use: It was early decided that the place of use may be changed without loss of priority. It was absolutely necessary in the early mining days, when new ground was being continually opened up. In 7 Cal. 261 it was held that branches could be run to new mining claims without loss of priority, and that the main ditch itself could be extended to new localities. In 15 Cal. 161 it was held that the point of diversion or taking of the water could likewise be changed. The only limitation recognized on change of place by these cases and the cases following them was that others must not be injured in making the change. These rules are now incorporated in the civil code, Sections 1412, 1415.

As to change of purpose: This was at the start treated as a distinct question from change of place (e. g. 7 Cal. 261). It was urged in several cases that the right was limited to the purpose for which first appropriated and that a use for a new purpose could be obtained only by a new appropriation. This view obtained some footing in the early decisions (e. g. 13 Cal. 33, 21 Cal. 374). But it never took a firm hold. In 13 Cal. 220 it was held that use for a saw mill