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

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TOMBSTONE MINING DISTRICT
Cochise County, Arizona
Area of Mutual Interest
General Articles

BLAKE 1882

work is expected of American chemists. The presence of arsenic is so rare in American irons that it is hardly necessary to mention the fact that where it is present the precipitation with molybdate must be made in a cold solution. My attention was lately drawn to this element by finding 0.05 per cent. in an iron sent out by chemist L. for the purpose of comparing results by different methods. My result on this iron was reduced from 0.180 per cent. to 0.152 per cent. of phosphorus by taking the above-mentioned precaution.

To sum up, I find of three chemists working the acetic and citric acid methods in list A, two are wrong. Of four who worked the direct molybdate method three are wrong, and the fourth has a variation of 0.010 per cent. in the method as regularly worked by him. Of three working the modification of the molybdate-magnesia method, in which there is a large quantity of chlorides present with the nitric solution when phosphorus is precipitated, all are wrong, and of ten working the method so that there is only nitric acid and ammonium nitrate present with the iron solution, nine are within the limits of error.

THE GEOLOGY AND VEINS OF TOMBSTONE, ARIZONA.

BY WILLIAM P. BLAKE, F.G.S., NEW HAVEN, CONN.

THE mining district and the town of Tombstone are situated in Cochise County, Arizona Territory, at the northwest end of the Mule Pass range of mountains, in longitude 110°, and latitude about 31° 40′ N., upon the right bank of the San Pedro River, from which the town is distant 9 miles east. It is also 24 miles south of Benson station on the Southern Pacific Railroad of Arizona, and about 40 miles north of the Mexican line. Its altitude above the sea is 4600 feet. The Dragoon Mountains rise across a valley to the northeast, and the Huachuca Range similarly upon the southwest. The country is open, without timber, and the surface, where the mines are opened, is in general gently rolling, and accessible to wagons by natural roads.

The first locations were made in the year 1878 by the Scheffelin brothers and Richard Gird, the latter being well known among the pioneers of Arizona as a surveyor and miner, who contributed largely to our knowledge of the geography of the Territory in early days,

when the dreaded Apache dominated the region. There are now, probably, over one thousand locations or claims in the district, and upwards of 2500 inhabitants.

The output of the precious metals, gold and silver, up to the first of January, 1882, aggregates $7,359,200, and over $3,000,000 have been disbursed in dividends. This product is distributed among the following-named mines and mills:

Production of Tombstone Mines and Mills.

Tombstone Mill and Mining Company,	$2,704,936 33
Contention Consolidated,	2,703,144 39
Grand Central,	1,050,875 30
Head Centre,	191,520 52
Vizina,	526,716 98
Ingersoll,	15,000 00
Sunset,	15,000 00
Corbin Mill,	40,000 00
Boston Mill,	112,007 83

Dividends.

Tombstone Mill and Mining Company,	$1,100,000
Contention Consolidated,	1,375,000
Grand Central,	600,000
Vizina,	80,000

This will suffice to show the importance of the locality for mining, and to indicate at the same time the principal claims.

GEOLOGY OF THE DISTRICT.

In going from the railway at Benson to the mines the traveller rises from the post-pliocene deposits along the San Pedro to a granitic plateau. The rock is gray and highly crystalline, and is apparently eruptive. It weathers in places into gigantic rounded blocks and masses, lying one upon another as if piled there by some Titanic force, rather than by the gentle and gradual effects of irresistible decay. This rock extends to within a mile or two of Tombstone, where stratified formations occur overlying the granite.

These stratified beds consist of quartzites, limestones, and shales, with frequent repetitions in an ascending series several thousand feet thick, but all conformable and dipping generally at a low angle from 20° to 45° to the eastward. The fossils which have been found in the middle and upper beds, consisting chiefly of *Productus* and cyathophylloid corals, show them to be *Paleozoic*, and probably

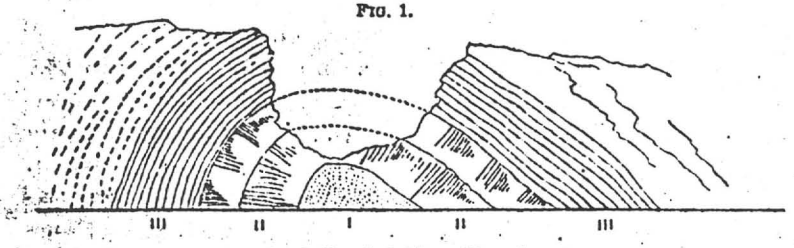
Lower Carboniferous. The lower strata are probably older. A small shell, like *Lingula*, occurs in the shales of the Contention mine.

In addition to the stratified formations we find intrusive porphyritic dikes cutting through the strata indiscriminately, nearly at right angles, and trending approximately north and south, or a little east of north. This is the direction of the general rift or breaking of the country and of the mineral veins.

In the central portion of the district, covering the claims known as the Toughnut, Goodenough, Way-Up, Vizina, and others, erosion has exposed the outcropping edges of many strata of limestone, shales and "quartzites." Both the shale and so-called quartzite beds are of deep-sea origin, being very fine and compact in texture, with scarcely any signs of granular structure. The latter, particularly, is flint-like and very hard, and is more exactly described as a novaculite or honestone. In places it passes insensibly into limestone, apparently forming beds of silicious limestone. It is, no doubt, largely organic in its origin, and is a very fine sediment, totally different from the typical quartzites, with granular structure, found in the higher parts of the series of strata. It evidently, in forming, accumulated slowly, beyond the influence of currents, at the sea-bottom. An abundance of iron pyrites in fine crystalline grains, disseminated through the layers of this rock, gives evidence of its organic origin in part, at least. This rock has special importance from the fact that the miners in the Toughnut and Goodenough claims find it *below* the chief ore-bearing limestone. It is regularly and evenly stratified for a thickness of about 110 feet, and rests upon a thickly-bedded dolomitic limestone below. The beds above it consist of dark, black or blue limestones, and of thick beds of dark argillaceous shale, alternating with black silicious shales for nearly half a mile to the eastward. The black limestones above the novaculite are the chief repositories of the bedded masses of rich silver ore, as will be presently shown.

The whole series of beds in this central part of the district is thrown into folds, being regularly plicated in a series of wave-like flexures, the steepest and sharpest folds being on the northwest of the Toughnut and Goodenough claims facing the granitic region in that direction. These folds may be traced, but with difficulty, upon the surface, but are best seen in the crosscuts of the mines and along the drifts. In the open cut upon the Toughnut there is a good exposure of some of the beds at the crest of an anticlinal fold presenting an appearance in section, along a northeast and southwest cut, nearly as shown in the annexed drawing:

FIG. 1.



Anticlinal fold. Toughnut.

I. Novaculite—under the limestone.
II. Limestone—bending over the novaculite.
III. Shales—bending over the limestone.

This little section is along the upper level known as the "adit." It is directly below the place on the surface where ore was found cropping out, mixed with soil and vein-stuff. At another place, upon the western end of the Goodenough, we find a series of plications, up and down, at about the angles shown, and with rich ore lying in the folds. These folds are not large, covering only a few hundred feet in extent, but are beautifully regular and well defined. As we pass up the hill, rising higher in the series of strata to the eastward, the dip becomes more regular, and coarse-grained quartzites, in thicker beds, take the place of the finer-grained deposits.

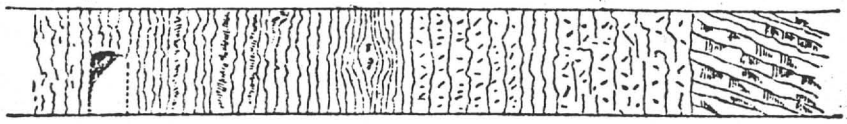
All of the formations named have not only been uplifted as described, but have been much broken and faulted either at the time of uplift or at long periods later. This is shown by the number of fissures and lines of fault, as well as by the outcrop of dikes of porphyry, and the dissimilarity of the stratified beds on either side of them, and the disjointed outcrops of the limestone beds.

THE CONTENTION MINE.

The chief fissure and ore-bearing vein of the district traverses the Grand Central and the Contention claims. These claims were located in a north and south direction upon the somewhat obscure croppings of a dike of dioritic porphyry carrying ore, in, through, and alongside of it. This location was made by Messrs. White and Parsons. The croppings were not remarkably well defined, consisting of the porphyry and a confused mixture of porphyry, chert, and quartz, with masses of porous quartzite alongside; none of these rocks rising high above the soil. There was, however, a considera-

ble discoloration of the soil by iron-rust along the line, and a little digging revealed good ore near the surface. The harder parts of the dike were the most prominent, and its direction governed the direction of location of the claim. This dike varies in width from a few feet to 50 feet or 70 feet, and dips to the westward at an angle of from 55° to 65°. It cuts indiscriminately through shales, quartzites, and limestones, and is evidently of igneous origin. The contact, however, with the abutting edges of the disrupted beds is not always marked by any great change in their appearance or composition, though in places there is obscure metamorphism, impregnations of silica, and some modifications of structure. The dike itself has a distinct vertical lamination or structure through most of its substance, and is more or less penetrated by veinlets of quartz. In some portions it is highly crystalline and nearly barren, and in others consists chiefly of a feldspathic base, in which the feldspar crystals are obscure. It passes into a felsite, which, in the decomposed portions of the dike, and when slaty in structure, might be mistaken for the partly decayed shales or quartzites. Large portions of the dike are so penetrated by quartz as to consist largely of it, and might be called quartz, although close examination will show the presence of feldspar.

FIG. 2.



The accompanying cross section (Fig. 2) of the chief part of the dike taken on the first level of the Head Centre mine, upon the Contention lode, will convey a better idea than can be given in words. It shows the vertical structure, and the general distribution of quartz in vertical seams or layers, and in one place a vug, or cavity, in which there are distinct quartz crystals. In general, however, combs of quartz crystals are wanting; the quartz being in an amorphous, subvitreous state, or in the form of chert. The lamellar arrangement of this quartz near the central part of the section is shown by the little cut of full size (Fig. 3) of a fragment ground down to a plane surface. The lines represent the layers of quartz; the intermediate spaces are filled with feldspar. This lamination is typical of the vertical structure of the dike. Another fragment, with less quartz, taken at a distance of about two feet from the first,

FIG. 3.

consists chiefly of a felsite base with obscure crystals of feld-par sparingly distributed. Examination shows it to be penetrated irregularly by veinlets of quartz, as shown by the accompanying sketches from ground and polished surfaces. (Figs. 4 and 5.)

FIG. 4.

FIG. 5.

There is also a considerable amount of mineralization of the dike by iron pyrites disseminated irregularly in its substance in cubical crystals, most of which have dissolved out and left the cavities only to indicate their former presence, making in some places a spongy mass of porphyry or of quartz. Although the mine has been worked to a depth of 600 feet, and there are some 12 to 15 miles of drifts, levels, and winzes in the Contention and adjoining mines, the undecomposed ores below the water-line have not yet been reached and mined, and all the ores above are in the decomposed and oxidized condition common to surface ores. A large part of the ore is highly charged with red oxide of iron, to such an extent that the clothing of the miners becomes saturated with the rouge-like powder, and the tailings at the mills are blood-red.

There has been an extensive decomposition of the porphyry, especially along the upper 300 feet of the dike, resulting in the formation of quantities of white clay, kaolin, sometimes perfectly snow-white and pure, but generally more or less mixed with red oxide of iron. This kaolinization extends in places to the adjoining shales, and there are some white, claylike, interstratified beds which may, on further examination, be found to be altered felsitic offshoots from the dike. It is not yet possible to say what the exact nature of the ore below the water-level will be found to be. The only metallic contents so far found, with the exception of the pyrites and some galenite and lead carbonate, are gold and silver in a comparatively free state; part of the gold, if not all, being free, and the silver occurring chiefly as chloride, or horn-silver (with probably some iodide), in crusts and films, also occurring in minute crystals upon

cleavage surfaces. The average value of silver and gold in the ores worked last year was about $70 per ton. The gold has of late increased from 20 to 25 per cent. of the value of the product, the rest being silver.

GOLD IN PORPHYRY.

One very interesting fact is the occurrence of free metallic gold, together with chloride of silver, in the midst of the porphyritic rocks, at a distance of many feet from the portions of the porphyry carrying quartz in veins, and disseminated. This gold is found chiefly in a portion of the rock apparently dioritic, containing finely-disseminated hornblende. In decomposing, this porphyry becomes steatitic, and in places appears to be changing to serpentine. The gold is found in thin sub-crystalline flakes and scales, chiefly in and along thin seams and cracks in the mass of the rock, as if it had been infiltrated and deposited from solution. This is probably the fact, and the magnesian nature of the rock has no doubt exerted an important influence in its deposition. Free gold is also found in quartz in the usual manner of association, but even in such specimens the crystalline feldspar of the dike is found.

METALLIZATION OF THE DIKE.

The time and manner of metallization of the dike may be considered as open questions, for a solution of which we must wait until the mining extends below the permanent water-level of the formation. It seems most probable that the rock, at the time of its intrusion, was pyritous, and the strata adjoining it no doubt were. It is not impossible that there may have been a concentration of the precious metals in the dike from the surrounding beds, the result of the decay and change of the pyrites diffused in the strata. On the other hand, we may suppose that the dike has been the source of the silver and gold we find in and about it.

In either case the vertical laminated or stratiform structure parallel with the walls has been an important factor in the distribution of the metals, and in the changes and modifications of the original condition of the dike. We may readily conceive of such vertical planes of structure affording planes or lines of least resistance to vertical movements, while the abutting ends of the strata, in contact with the walls of the dike, would offer great resistance by friction. The condition of the dike along a great part of its course seems to sustain and verify this hypothesis. There has evidently been considerable movement of parts of the dike upon itself, resulting in the formation of heavy clay seams and brecciated layers of porphyry and quartz, sometimes occupying a medial position along the dike, sometimes at one side or the other, and again along the line of contact with the country rocks. Such seams and brecciated ground are sometimes wanting, and the structure and condition of the dike remain unchanged.

The whole of the dike with the adjoining strata have been subjected to extensive movements and displacements, shown not only by breaks of continuity, but by the brecciated cross-courses and seams traversing both the igneous and stratified formations. One of these faults resulting in a throw of the northern portion of the Contention lode 150 feet to the west, and partly outside of the west side-line of the claim, has recently led to expensive litigation. The faulting seam or break has been drifted upon between the two ends of the disjointed dike. It consists of a heavy breccia of fragments of the adjoining strata, together with a strong clay wall, marking the plane of greatest movement and slip. Its direction is southwest and northeast.

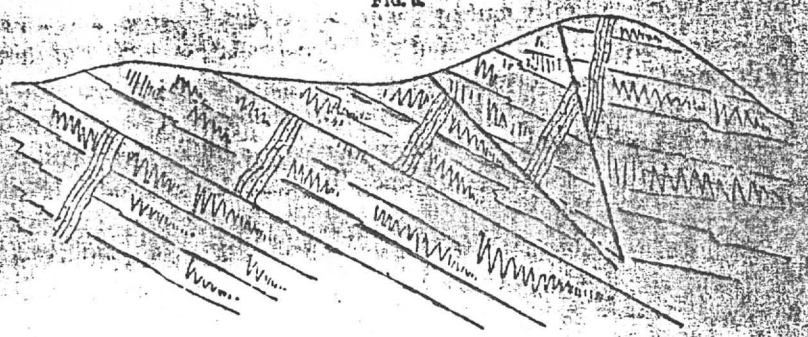
In addition to the lateral movement there have been extensive vertical displacements, and it is probable that the lateral shifting may be referred to them. It would be premature to attempt an exact description of the numerous faults and mechanical changes to which the dike has been subjected. They require further study and surveys. Mr. Isaac E. James, so long and well known upon the Comstock lode as an accomplished mine engineer, is now in charge, and has the subject under investigation. We owe the first determination of the nature and position of many of the vertical faults and throws to his careful observation and surveys. Without now entering into precise descriptions of particular displacements, it will suffice to give a sketch indicative of what has occurred, producing such a confused recurrence of ore upon certain levels of the mine, as to lead at one time to the supposition that there were several dikes of porphyry and ore over a breadth of five or six hundred feet.

The movement appears to have been from the west eastward and downwards, the top of the dike being carried off in successive blocks by the sliding of masses of the stratified formations partly upon the planes of deposition of the beds (these dipping eastward and affording surfaces of easy movement), and partly upon steeper planes of fracture generally dipping eastward, as shown in the outline sketch section, which may be taken as typical.

This disruption of the dike, with its attendant fracturing and

brecciation of the country rock, accompanied by the movement of the dike upon itself, and the formation of heavy clay seams, has provided favorable places for the accumulation of ore. It is generally found in the softer and most broken portions of the dike, coincident, no doubt, with the regions of greatest original metallization and subsequent movement, attended by clay seams. Such clay seams, with the accompanying ore, have by some been considered as marking

FIG. 6.



the limits of a second or subsequently-formed vein, following the dike and independent of it. This theory, formed under the inspiration of the necessity of narrowing down the vein and throwing it as far west as possible, in order to secure a greater length of it upon the Head Centre ground, would be more defensible, if in the stopes any vein structure referable to a later deposition could be found. Instead of the fragments of broken porphyry, shale, and quartz being cemented together by quartz, they are loosely aggregated, and show clearly that the formation is due to mechanical force and attrition. The clay seams are also not certain boundaries of the ore; it occurs on both sides of clay seams. The clay cannot, therefore, be taken as separating ore from waste. The seams, moreover, are not continuous, but give out, and in some parts of the dike are absent.

The only place upon the lode where water has been reached is upon the Sulphuret claim. At this point the lode intersects strata of limestone, and there is a bedded layer of ore following the stratification and connected with the dike. This ore is chiefly galena and iron pyrites. Very little has yet been taken out. So also in the Head Centre ground, at a higher level, where the dike intersects limestone, a bedded or interstratified layer of ore occurs. But the best examples of bedded deposits in the district are in the Toughnut and Goodenough claims before referred to.

BEDDED ORE DEPOSITS.

These also are associated with dikes and vertical fissures nearly parallel with the Contention lode. One of the longest and best defined is the West-Side lode, which may be traced for about two miles, until it passes into the underlying granite. Its northern prolongation appears to cut across the Toughnut claim, and to connect with the vertical fissure and quartz croppings at the Discovery shaft on the Goodenough.

A second line of fissure cuts across the anticlinal line of the formations at the open cut on the Toughnut, and crosses the whole breadth of the Goodenough into the Way-Up claim beyond. This has been followed on ore from the open cut to the Way-Up, and is connected with the chief lateral bedded deposits. A lode has also been followed in the same general direction from the claim called the "Defiance," across the Toughnut into the Goodenough. This lode is marked by very heavy croppings of quartz and flinty boulders lying above the limestone on the surface.

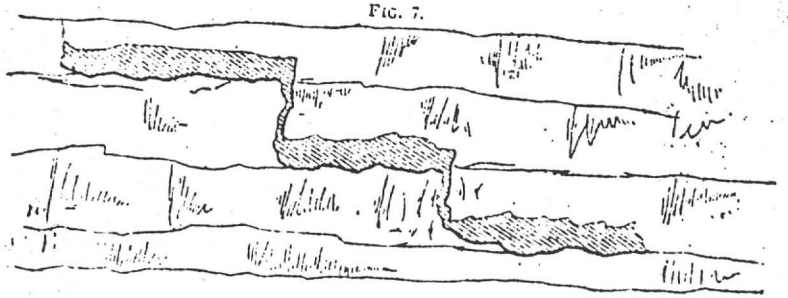
In the figure extending into the Way-Up claim the ore was found in layers and bunches following the plane of the vein, extending upwards and downwards along its course in nearly vertical shoots or ore-bodies, but breaking off into the adjoining strata in flat bed-like layers, particularly where the vein intersects the lower limestone resting on the novaculite beds. These bedded offshoots from the vein are often of considerable lateral extent, following the planes of stratification on either side. We cannot yet state with confidence what the exact origin of these bedded deposits is. They may be due to the decomposition of nodular masses, but they are generally deposited in the limestone as if by replacement. They may be regarded as filling irregular cavernous spaces eroded from the strata by metalliferous solutions, and without any regular boundaries. These bedded masses do not have a symmetrical arrangement of the ore, except such as may be referred to stratification or deposition by gravity.

It is to be observed that these bedded masses of ore occupy the limestones rather than the silicious or argillaceous strata, as we might expect from the greater solubility of the limestone. Inasmuch as these limestone strata are folded and turned up in different directions, the intersection of the limestone with the vertical plane of the vein is an irregular line. At such intersections the walls of the fissure are corroded away and are obliterated, or are further apart than where the fissure cuts the silicious beds, the shales, or the quartzites.

In this respect the formations are similar to many abroad. Moissenet* represents bodies or shoots of ore corresponding in their pitch to the intersection of strata with the plane of a vein. Wallace describes a series of strata in the North of England consisting of limestones and shales traversed by lodes productive in the limestone, but poor when passing through shales. Other examples might be cited.

In extent, the bedded masses of the Goodenough and Toughnut claims have been much greater than the ore-bodies of the vertical fissures, and it may be said that the greater part of the production has been from the beds or flats. They extend irregularly between the two fissures a distance of about 400 feet, measured diagonally along the dip. It is noteworthy that they follow the stratification, and then suddenly break across it vertically, following a crack or break of the bedding, and then expand again horizontally for some distance to another, dropping down by a series of steps from one layer to another in and between the limestones.

FIG. 7.



The ores found in these bedded deposits in the limestones are much more plumbiferous than the ore of the feldspathic dikes. Galenite, blende, and iron pyrites are abundant in masses, which, within the reach of oxidizing agencies, are largely converted into oxides and carbonates.

Bedded ores of this nature are also found in the limestones of the Blue Monday claim contiguous to the vertical fissure in the westward prolongation of the West-Side lode, or vertical ore-bearing fissure. This contiguity of the bedded deposits of the camp to the vertical fissures and dikes, and the occurrence of bedded ores where the dikes intersect limestone strata, lead me to the opinion that the

* Annales des Mines (6) 9, p. 10.

metallization of the district is due to the igneous intrusions, and that these intrusions, with the accompanying impregnations and ramifying veinlets of quartz, are the true lodes, or "leads," that may be followed with confidence in the search for ores.

THE GOLD FIELDS OF THE SOUTHERN PORTION OF THE ISLAND OF SAN DOMINGO.

BY RICHARD P. ROTHWELL, NEW YORK.

IN the year 1881, I visited San Domingo, in the interest of French capitalists, to examine and report upon certain "concessions" of gold-bearing gravel and quartz veins, on the Isabella and Jaina rivers and their tributaries.

This district is periodically reported to be extraordinarily rich, and there is cast around it the glamour of the mysterious shipments of gold, credited, in romance and in more or less romantic history, to Columbus and the Spaniards of the fifteenth and sixteenth centuries. Since considerable sums of money and several valuable lives have been lost in the unsuccessful search for its profitable mines, it seems desirable to place on record some of the information collected concerning the value of these famous gold fields, with the hope of facilitating the work of those who may hereafter be called on to investigate these claims, and of preventing the unnecessary waste of capital.

It is needless to add that the capitalists for whom my investigations were made abandoned the enterprise they had in view, although no doubt similar schemes will be brought forward many times in the future, as they have been in the past, under the fervent advocacy of too sanguine enthusiasts.

Since the time of the Spanish occupation of the Island of San Domingo, in 1497, when Columbus found the natives wearing ornaments of gold, more or less of the precious metal has been obtained annually by washing the gold-bearing sands of several of its streams. It is said that during the Spanish domination, when the native Indians were held in the most abject servitude, a certain amount of gold was *required* of each one as the result of his labor. Under this

BLAKE 1902

Tombstone and Its Mines

Tombstone
and its
Mines

A Report upon the *Past* and *Present*
Condition of the

MINES OF TOMBSTONE

Cochise County, Arizona
to the
Development Company of America

By
WILLIAM P. BLAKE
Mining Engineer

Hon. E. B. Gage

New York
1902

New Haven, *July* 28, 1902

The Development Company of America
New York City

Gentlemen :—

I have the honor to submit a Report upon the Geology and Mines of Tombstone, Cochise County, Arizona.

Respectfully yours

William P. Blake
Mining Engineer

Tucson, Arizona
and
New Haven, Conn.

Arranged and printed at
The Cheltenham Press
New York

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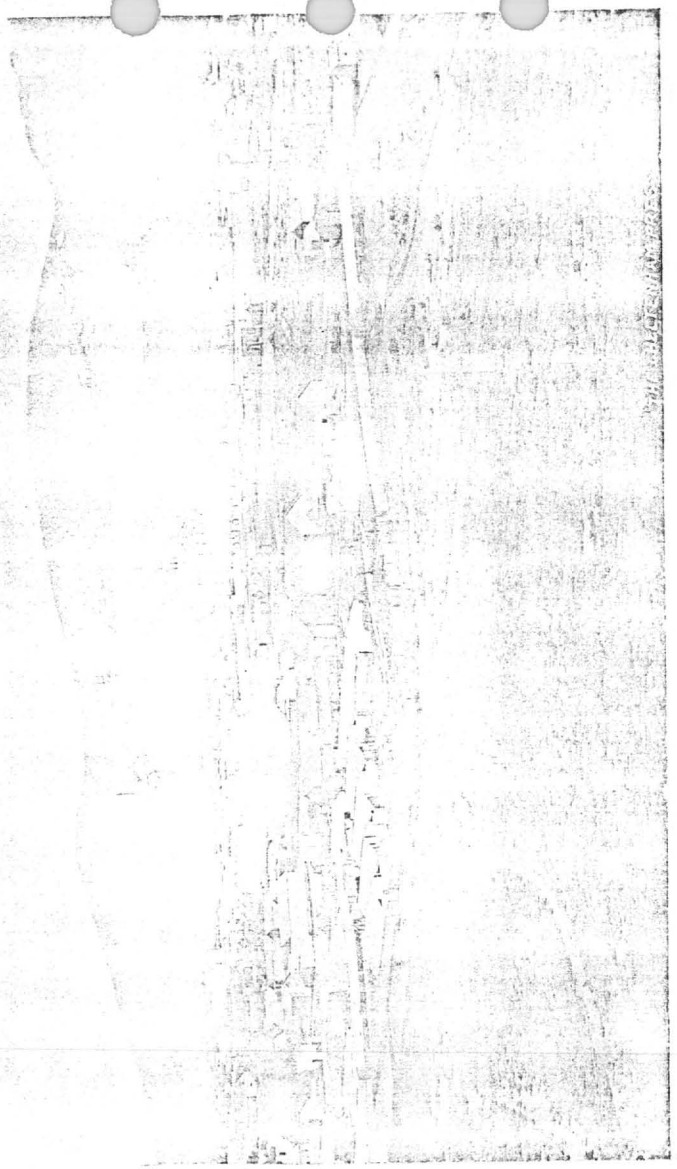


CITY OF TOMBSTONE
Showing, in the background, Grand Central, Contention, and other important mines now owned by The Tombstone Consolidated Mines Co., Ltd.

The Veins and Mines of Tombstone, Arizona

Chapter One—Introductory

Location and History

THE mining district of Tombstone is in Cochise County, Arizona, in the Mule Mountains, known, also, as the Mule Pass Range. It extends from the San Pedro River eastwardly towards the Dragoon Mountain range and has a general altitude of from 4400 to 4600 feet above tide water. The city of Tombstone, including the chief mines, is in latitude 31° 40′ and longitude 110°. It is about 40 miles north of the international boundary line—24 miles south of Benson, on the Southern Pacific trans-continental road, and is 9 miles east of the San Pedro River at the place known as Fairbank, upon the two lines of railway extending southward from Benson, one line being the International, from Benson to Guaymas via Nogales; the other, the Arizona and Southeastern, extending from Benson to Bisbee via Naco Junction, and now extended to Douglas and points eastward towards Deming and El Paso. The surveys have been made and the grading has commenced for a branch

road from Fairbank to Tombstone and beyond. This branch will supersede the nine miles of staging between Fairbank and Tombstone and will give all rail connection with the overland trunk lines. Even now passengers leaving Tucson in the afternoon reach Tombstone early in the evening, but when the road is completed from Fairbank to Tombstone the trip will be much shortened in time and will be by rail for the entire distance.

The grading for this road is progressing rapidly, and it is expected that trains will be running to Tombstone by the end of the year. It is being built by the owners of the El Paso & Southwestern, generally understood to be the firm of Phelps, Dodge & Co., of New York.

Mr. F. M. Murphy, President of the Development Company of America, who has been specially connected with the development of railway communication in Arizona and is President of the Santa Fé, Prescott & Phœnix Railway, has projected a line to extend eastward from Phœnix by way of Florence and the valley of the San Pedro to Benson, where it will connect with the Southern Pacific and with the El Paso & Southwestern, leading to Fairbank, Tombstone, Bisbee, Naco and Douglas. This line, when completed, will place Tombstone in rail connection with the Santa Fé system via Phœnix and Prescott.

The Tombstone Consolidated Company up to the middle of the year 1902 had hauled from Fairbank and erected at the mines an aggregate weight of five hundred tons of machinery and supplies, including four great boilers, each weighing twenty-five tons. These required a specially constructed wagon, a considerable expenditure upon the road, and a team of thirty-four horses.

The position of Tombstone relatively to the railways and to other prominent mining camps is shown upon the accompanying small map of the region (Fig. 1, p. 13).

This map shows the two north and south valleys of the Santa Cruz and of the Santa Pedro, each having its source in Sonora, Mexico, and flowing northwards to the Gila of Arizona.

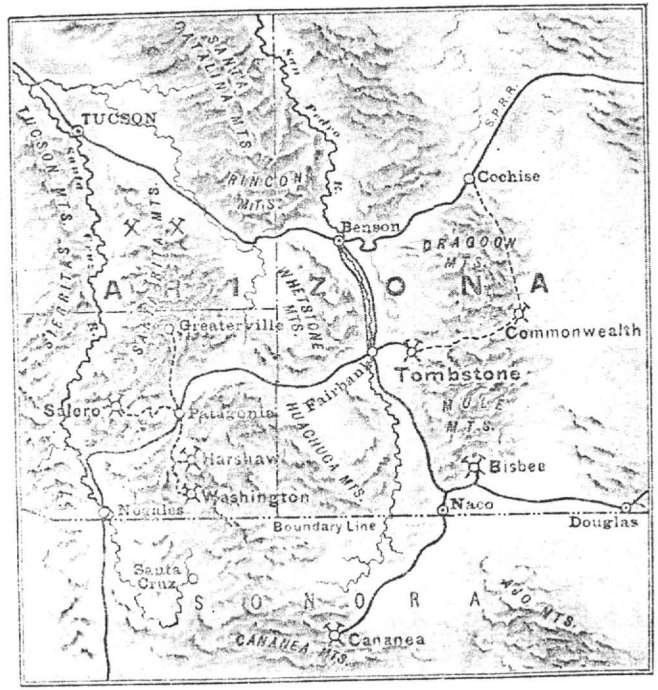


FIG. 1. *Sketch Map to Show Position of Tombstone.*

Discovery by Schieffelin

Up to the years 1877 and 1878 the Tombstone District was a comparatively unknown and unexplored region. It was infested with the murderous Apache savages, and few prospectors dared to go there. Being nearly in the center of known and promising mineral-bearing districts it excited the hopes and expectations of prospectors, but was not explored until Edward L. Schieffelin, braving the danger from the Indians, penetrated to its center and discovered its hidden riches.

Schieffelin had found evidences of mineral wealth in a remote part of the region as early as 1877, and in the spring of 1878 he started from Huachuca with the intention of thoroughly prospecting the Mule Mountains, in which he felt sure great deposits of the precious metals would be found. His expedition was considered a very hazardous one, and Schieffelin was advised to take his tombstone with him. His enterprise and courage were rewarded by finding a heavy outcrop of rich ore at the very surface of the ground. The profusion of ore lying nearly flat, and the absence of any well-defined linear outcrop, it would appear, were somewhat puzzling to him; for he located a claim transverse to the trend of the mineralizing vein and called it the *"Toughnut,"* and to the district he gave the name of *"Tombstone."* Returning with his samples to the settlements he persuaded his brother, Albert E. Schieffelin, and Richard Gird to join him in locating and working other claims.*

Edward L. Schieffelin

*Edward L. Schieffelin was born in the year 1848 in Western Pennsylvania, and moved with his father to Rogue River valley in Oregon. At the age of twenty-two years he went to the State of Nevada, where he worked for a time in the mines and then went prospecting, which was his favorite occupation. He reached Northern Arizona, and as far south as Signal and Wickenburg, on the Hasayampa. Here he joined a party of Indian scouts going to Camp Huachuca, on the west side of the San Pedro, where he left them and crossed the valley to prospect the Mule Mountains, then one of the most dreaded haunts of the bloodthirsty Apache Indians. Making his way alone between the hills he

ese locations and the splendid r lts of mining era-
tions, adding millions of wealth to the country, m a
sufficiently enduring monument to the memory of Schieffe-
lin. His remains, in accordance with his dying request,
were interred at the summit of the Granite Hill, near the city
of Tombstone, and are surmounted by a massive monument
of granite bowlders, a view of which from a photograph
will be found at the end of this report.

Within four years after the discovery over one thousand
claims had been located. The richness and extensive char-
acter of the ore-bodies attracted widespread attention, and
development was rapidly extended until Tombstone became
generally known as one of the most important mining dis-
tricts of the country. Mines were opened in all directions,
the hills were dotted with hoisting works, mills were erected
on the San Pedro; a city of thousands of inhabitants sprang
up, water was brought in from the tops of the distant
Huachuca Mountains, and the greatest mining activity pre-
vailed.

camped the first night near a small rivulet of water, among the granite bowlders, about seven miles east of the river. His prospecting was rewarded by the discovery of the rich ore on the claim which he staked off and called Toughnut. He took samples with him back to the settlements, some say to Globe and others to Tucson, where his brother Albert was working and Richard Gird was assaying. The results of the assay of the samples being highly satisfactory a partnership was formed and the three went to the claim and commenced the development which soon made Tombstone famous in the annals of mining.

Later, in 1880, the Schieffelin Brothers and Gird sold their interests. Gird removed to the Rancho del Chino, California, Al Schieffelin died of consumption and Edward resumed the life of a prospector, reaching as far north as Alaska, but made his home with his mother in Alameda, California. He was on a prospecting tour at the time of his death, about the 14th of May, 1897, alone in his cabin twenty miles from Canyonville, Oregon. All suspicions of foul play or suicide were removed by the evidence. His watch and money were found upon the body, also business papers and his plans for the immediate future.

On May 17, 1897, his brother, Charles L. Schieffelin, telegraphed to Tombstone a request of his brother that when he died he should be buried on the top of the granite hill about three miles west of Tombstone, where his body was laid to rest on Sunday, May 23, 1897, with impressive services. The wife, the mother and his brother were present. The funeral address was given by Colonel William Herring.

W. P. B.

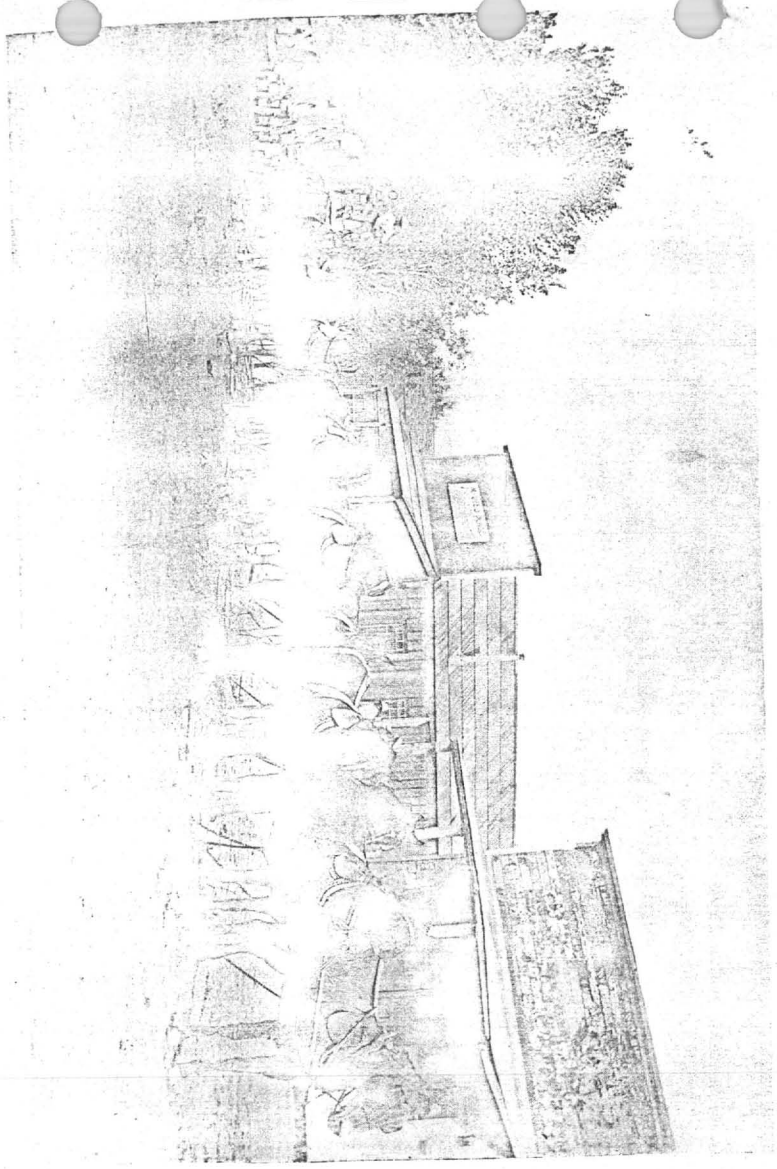
Construction of Mills

Mr. W. F. Staunton writes:*

"Phenomenally rich ore in great abundance led to the speedy construction of mills, and by June, 1879, the Gird 10-stamp mill, the first in the District, and the machinery for which was hauled over 300 miles in wagons from Fort Yuma, on the Colorado River, then the terminus of the Southern Pacific Railway, was started. The ore averaged over $100 per ton in value, and the tailings about $25. Other mills followed quickly, and there were soon 150 stamps dropping on Tombstone ore. It was a dry camp. There was no water available for milling near the mines, and the mills were all located on the San Pedro River, at distances ranging from eight to ten miles away and involving an expenditure of $3.50 per ton for hauling the ore. Wages and supplies were very high; railroads were hundreds of miles away, and the new camp was beset with difficulties of all kinds; but such was the richness of the ores and their abundance that, notwithstanding the difficulties and the fact that treatment of the ores was not at first understood, a large part of the values passed into the tailings.

"Mining was vigorously prosecuted with every prospect of continued success in the numerous claims until a vast body of water was found at the same general level and it became necessary to erect large pumping plants. Two were installed, one upon the Grand Central Claim and one upon the Contention. These powerful pumps steadily lowered the level of the water, showing that it could be controlled. It was also made evident that the surrounding mines were so connected by subterranean passages below the water-level that they could not be independently drained, and that concerted united action would be necessary to an equitable division of the expense.

* Letter of June 29, 1901, to the Development Company of America.



The camp was almost a desert one and the mills were located on the river, thus involving the necessity of expensive wagon haul. There was little in the appearance or surroundings of the camp to suggest the existence of water, and when it was struck in the Sulphuret shaft, at the comparatively shallow depth of 500 feet, it was a surprise to all. Other shafts, including the Contention, Grand Central, West Side, Head Center and Empire, reached the water soon after, and demonstrated that it was to be found at practically the same level throughout the District. The mines at this time were still working in high-grade ore bodies far above the water, and no doubt was felt as to easily pumping it out and continuing down when it should become necessary. The Grand Central Company installed a line of direct-acting steam pumps capable of raising 500,000 gallons in 24 hours; but, to the surprise of all, the withdrawal of this amount of water produced no appreciable effect. The Contention Company then put in a plant of 12-inch Cornish pumps at an expense of about $150,000, and capable of raising 1,000,000 gallons in 24 hours, and again the attempt to sink was made, but it soon became evident that the combined capacity of the pumps was inadequate. The Grand Central then put in a line of 14-inch Cornish pumps of 1,500,000 gallons capacity, and at a cost of in the neighborhood of $200,000, and together the two Cornish plants gained steadily on the water and sinking below began. But much valuable time had been lost, and from a lack of appreciation of the seriousness of the problem the rate of dividends had gone on undiminished, without retaining an adequate reserve for contingencies. Furthermore, there was a lack of harmony among those concerned which prevented the attainment of the best results.

The Water Controlled

"A depth of 100 feet below water-level was reached, and it was demonstrated that the water could be controlled; that it was, in fact, a basin which, once exhausted, could be held in check with a moderate expenditure for pumping. Other mines than the Grand Central and Contention took advantage of the recession of the water and began pushing down, proving the continuance of the ore below the water and its excellent grade. Both the Grand Central and the Contention shafts were vertical, and it was necessary to cross-cut for the ore-bodies. This was going on and very rich ore found—that in the Contention assaying about $100 per ton in gold. Up to this point (May, 1886) the situation was good. The mines were still working in ore above the water, and it had been conclusively shown that the water could be controlled and mining go on indefinitely when a disastrous fire utterly destroyed the fine Grand Central hoisting works and pumping machinery. There is no doubt that the Contention pumps could have held the water in check alone after this disaster until other machinery could have been put on the Grand Central, but differences arose between the companies and pending the settlement of these the pumps were stopped and the shafts allowed to fill. Finally, through the carelessness of a watchman, the Contention plant took fire, and its complete destruction postponed indefinitely the working of the mines below the water."

After this succession of disasters several unsuccessful attempts to effect a consolidation of the various interests were made, and meantime deep mining at Tombstone was suspended. For years past some of the mines have been worked only in a small way on ore-bodies remaining above the water level.

Consolidation of Interests

The Tombstone Consolidated Mines Company, Lt., recently organized, has succeeded in accomplishing the long desired consolidation of the mines, and has secured over seventy claims in the district, including all the more important mines, the superficial area of the claims so secured being, approximately, two square miles.

The list of claims in this consolidation includes:

The Contention Consolidated Mining Company, four claims.
The Grand Central Mining Company, twenty-six claims.
The Tombstone Mill & Mining Company, eighteen claims.
The Head Center & Tranquillity Mining Company, four claims.
And other claims of different companies, together with all mills, millsites, buildings and machinery.

This control and ownership permits of the adoption of a general plan of working to the best advantage, and the reopening of the mines at the most important and desirable points.

New Shaft and Pumps

The Company has already located a new general shaft and has completed it to the water-level. This shaft measures 7 feet by 22 feet in the clear and has four compartments, two for hoisting and two for pumping. A substantial double engine flat-cable hoist is now being erected, and every modern desirable appliance is being added to insure rapid and economical work.

The American Bridge Company has supplied a steel headframe 79 feet high and 30 feet wide. The shaft house will be constructed of steel and made fire-proof.

The pumps are supplied by the Prescott Steam Pump Company of Milwaukee. They are of the direct acting type, triple expansion, with steam cylinders in pairs, of 39 in.,

23 in. and 15[illegible] diameter. [illegible]ameter of w[illegible]r plunger 13 in., stroke 24 in. These pumps are 33 ft. 7⅜ in. in length, 9 ft. 8 in. wide and more than 6 ft. high. These powerful pumps will throw 1,750 gallons of water per minute, which is nearly 60 per cent. more than the combined pumping capacity of the old Grand Central and Contention pumps. They will be placed at the water-level in chambers excavated for them, and two will be laid down there, one to be in reserve.

Other pumps of the same type have been ordered and are under construction, that are proportioned to a 1,000 foot lift and will be ready to install when that depth is reached. All the above will be stationary and the falling water-level will be followed down by four movable pumps called sinkers. These will have 14 in. steam cylinders, water cylinders 8 in. and a stroke of 12 in. Each will throw 800 gallons per minute, an excess that is necessary to provide for moving them in succession without stopping the discharge of water.

There will be four 200 horse-power boilers of the Morrison corrugated internal furnace type, each 10 feet in diameter and 15 feet long. Crude oil will be used for fuel.

This pumping plant will be one of the finest in America. It is of large capacity, but the lift required will be quite moderate. There is a large territory to be drained, for the seams and areas of crushed rock give the water access from one part of the District to another.

The weight of all this material is above a million pounds, exclusive of the hoisting engines, which are already on the ground. The machine shop of the Contention and Grand Central mines has been refitted and is now in use.

The great advantages resulting from the consolidation of interests, aside from the necessity of united centralized effort for the unwatering, are evident. There is not only a great saving in the cost of administration but of working. Instead of independent hoisting works, each with a corps of engineers, firemen and attendants, with the cost of maintenance

of in[illegible]pendent shafts, one central he[illegible]ing plant su[illegible]es for several claims. Instead of separate underground workings without connection or unity the mining can be projected and carried forward on one comprehensive plan. The office work is lessened and centralized, and fewer large salaries have to be paid. Thus the cost of production per ton is greatly lessened. Costly and vexatious litigation is avoided.

The rapid development of such great stores of mineral riches made every foot, indeed every inch, of length upon the lodes of great value. It is not surprising, therefore, that in the complexity of end lines and side lines, fractional claims and irregularities of locations all under different ownership, differences should have arisen which could be settled only by the courts.

Extent of Workings

Important and costly suits were instituted, involving questions not alone of territorial right but of the nature and extent of the lodes, requiring the most careful underground surveys and the services of experts in mining and mineral deposits. We are indebted largely to this costly and animated litigation in 1882 for suites of elegant naps and sections of the mines and for the intimate knowledge gained of the structure, direction and value of the lodes and deposits. Since the consolidation of interests and the merger of properties and values in the new company their maps and data have become common property and are now deposited in the office of the Company at Tombstone. Dividing lines have ceased to be lines of contention and waste of energy.

The many miles, said to be over twenty, of galleries, drifts, cross-cuts, shafts and winzes in the several properties of the Contention-Grand Central Lode, especially those of the lower levels, are in good condition to-day and have become the property of the new Company. These workings are of great value, giving as they do immediate access to

different p[illegible]s of the pro[illegible]ty, saving h[illegible]dreds of thousands of dollars which would otherwise have to be expended in exploration preparatory to deeper work.

This combination is one of the notable examples of the value to the laboring man, and to the community at large, of the consolidation of interests. Without such unison the mines would lie idle to-day as for nearly two decades past, but by united effort they are re-opened; Tombstone is resurrected—repeopled—and is connected by rail with the great trans-continental lines.

This beneficent condition has been largely brought about by the personal influence and energy of Hon. E. B. Gage, now the President of the Tombstone Consolidated Mines Company, whose likeness from a photograph appears as the frontispiece of this Report.*

Mr. Gage has changed his residence from Prescott to Tombstone and now occupies the home and offices formerly the headquarters of the Tombstone Mill & Mining Company. He will give his direct personal attention to the work of development and operation of the consolidated properties, and will be aided by W. F. Staunton, M.E., General Manager of the Company, and formerly Superintendent of the Tombstone Mill & Mining Company's mines, and also by

* Mr. Gage was born in Pelham, New Hampshire, Oct. 2, 1839. He was educated in boyhood at the Common School, and at the age of fifteen entered the Preparatory School at Phillips Academy, Andover, Massachusetts, and went from there to Dartmouth College, where he was graduated in the Scientific Department in 1858. In the winter of the year 1877 he went to Arizona, and in April of 1878 he purchased an interest in the Grand Central Mines, then recently opened, and has been connected with that property ever since as President and Superintendent.

In the year 1892 he took up the matter of the purchase of the Congress Mine in Yavapai County for himself and his associates, and has since been connected with the property as the President of the Congress Company. For the past five years Mr. Gage has been the President of the Phœnix National Bank of Arizona, and one of the directors about the same length of time. He has served the Territory officially for four years as one of the Prison Commissioners, and was President of the Capitol Commission during the time of the erection of that building. He is now one of the directors of the Santa Fé, Prescott & Phœnix Railway, one of the branches of the Santa Fé System.

W. P. B.

H. J. Gray, all of whom are successful men in the mining business, with wide experience in mining generally, and have a thorough personal experience in, and knowledge of, the mines held by this Company.

The relative position of the more important claims and mines are shown upon the map which accompanies this description. It is on a scale of 666 feet to the inch and exhibits at a glance the chief underground workings marking the course of the Contention Lode and of the several extensive bedded deposits of ore pitching towards the Contention.

Water Supply

Tombstone is supplied with water from the Huachuca Mountains some 25 miles away, across the valley of the San Pedro. This water is gathered from the brooks of the higher canons in the pine forest region. It is derived largely from the melting of the winter snows and is excellent in quality, clear, cold and very pure and soft. It is received in small reservoirs and conducted to a seven-inch wrought iron pipe, through which it flows down the mountain across the valley over rolling hills and elevations to the distributing reservoir on the hill above the Grand Central mine, from which the water is delivered to the mines and the city, under high pressure. This reservoir is cut in the solid rocks and cemented, and is 365 feet higher than the corner of Toughnut and First Street. The principal streets have water mains and fire hydrants at the corners. These water works are said to have cost nearly half a million of dollars, and are in good condition to-day. The possession of such a water supply is of great economic value to the mines and reduction works and greatly facilitates the resumption of active work besides its importance to the health of the place and the protection it affords against destructive fires.

Climate

Tombstone enjoys a most salubrious climate. It is considered one of the most favored places for residence in the mining region of Arizona. The heats of summer are tempered by the elevation and dry air. The nights are always cool. The coldest days of winter are not severe, and outdoor work can continue without interruption from frosts or snow.

Chapter Two—Geology

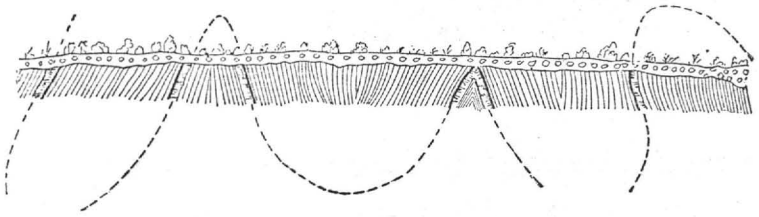
BRIEFLY stated, the rock formations of Tombstone consist of ancient sedimentary strata of limestone, shale and quartzite of Palæozoic age, probably Carboniferous, flanked by granite rock of igneous intrusion and uplift, by which, or from other causes, these strata were thrown into wave-like folds. These folded beds are cut across by a system of plutonic dikes and mineral veins.

Folded Strata

The folded strata present a succession of anticlines and synclines on a small scale as compared with the mountain-making flexures of the Appalachian and other mountain chains, but of the same general form and nature. These folds are locally known as "rolls," and they may be traced along the chief arroyo or dry water course, where they are cut across by erosion, and also in some of the mines. They may be likened in form to the waves of the sea, or to a series of wrinkles, for the larger folds have still smaller subordinate foldings upon them. Some of the anticlines are rounded and arch-like, others are sharp and angular and broken. The amplitude varies from a few feet to many yards. Erosion of these folds brings to view at the surface double lines of outcrop converging to a point, or diverging, according to the pitch of the fold and the angle of the surface cutting. A sketch, vertical section, representing folds visible in the side of the Tombstone arroyo below the Northwest shaft will serve to indicate the nature and form of these

flexures in the limestone and shales of the chief mineral-bearing formation of the camp.

FIG. 3. *Section to Illustrate Rock-folding.*



These folded strata have special importance in the distribution of one of the forms of ore deposit, for ores have been extracted in greater quantity from the upper or arched portions of the anticlines than from the troughs, or synclines.

The folded structure of the Tombstone strata, as also the occurrence of ores in the veins, and in bedded deposits, were described by me in a communication to the American Institute of Mining Engineers in the year 1882.*

The original discovery of ore by Schieffelin, as already noted, was at the outcropping crest of one of such folds on the Toughnut claim, where the anticline came up to the surface, and the upper layer had been worn away, revealing an ore deposit of broad extent following the bedding of limestone in the form often described as "blanket deposit."

The crests of such folds or anticlines are not horizontal, but have a decided pitch or plunge below the surface downwards, distinct from the dip. In the Contention-Toughnut series this downward pitch is towards the course of the Contention lode workings.

It is found by a careful study of the underground works of the different claims that there are several parallel anticlinal folds, locally termed "rolls," traversing the ground

* The Geology and Veins of Tombstone, Arizona, by William P. Blake, F.G.S. Transactions of the American Institute of Mining Engineers, Volume X, pages 334-345. February, 1882.

west of the Grand Central, Contention, Lead Center, Tranquillity and Empire, and pitching towards these claims at such an angle as to intersect the dike and lode traversing these claims at a considerable depth below the water-level. These phenomena are more fully described and illustrated in the chapter relating to porphyry dikes and lodes, to which reference is made. See pages 52-55.

In addition to the granite and the stratified beds, so bent, crumpled and folded, there are intrusions of porphyry in the form of dikes coming up from unknown deep-seated sources, filling great clefts and fissures across the beds, and bringing with them, especially along the Grand Central and Contention claims, deposits of the precious metals—gold and silver. There is also a system of veins, marked by outcrops of quartz, cutting the strata in a general east and west direction transverse to the axes or direction of the folds of the beds and making a slight angle with the general direction of the igneous dikes.

Three Groups of Strata

There appear to be three distinct groups or series of stratified formations in the Tombstone District. It will at least be convenient to so divide them for purposes of description:

1. The Contention and Toughnut Series.
2. The Manganiferous or Luck-Sure Series.
3. The Emerald Series.

Each of these groups presents some radical differences of composition, structure, position, or age, justifying their separate consideration. All the strata have been uplifted at different angles, and all have been subjected to more or less breaking and dislocation. The phenomena of plication and folding are shown chiefly in the first or Contention Series of formations, in which the more extensive mines of the District are found. The solid formations are much hidden

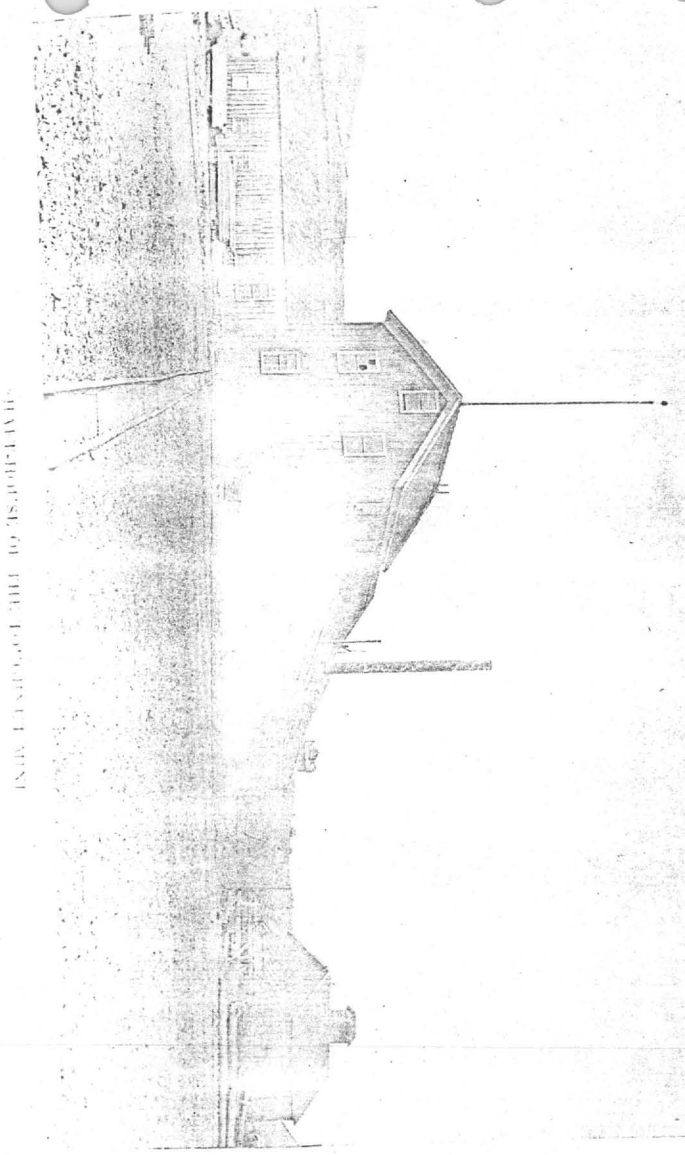
from view by superficial accumulations of broken fragments spread over the surface and generally known as "wash." This wash is often several feet deep, especially along the course of the larger arroyos.

This surface accumulation as well, also, as the form of the surface; the hills and depressions, show that there was a vast amount of erosion of the rocks; a cutting away of the formations since their uplift, and since the formation of the deposits of ore. This has important economic significance, as will be shown when the relation of the water-level to the ores is discussed.

These three groups of formations will now be considered in succession:

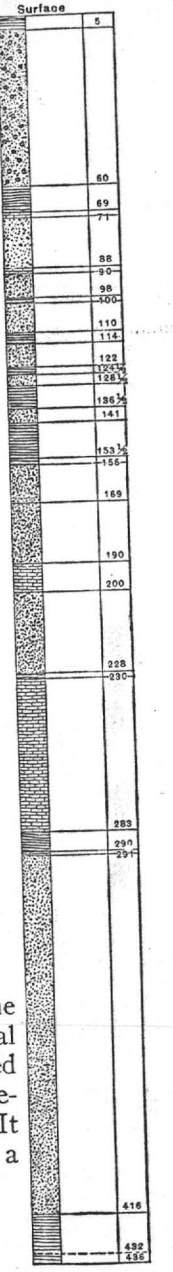
I. Contention—Toughnut Series

The nature and succession of the beds of the stratified formation can be seen in partial sections along the chief ravines and partly in the drifts, tunnels and shafts of the mines, but the best continuous section of a part of the series was obtained by boring with a diamond drill at a place where the strata were least disturbed, at the corner of Seventh and Fremont streets, in the city of Tombstone, to a total depth of 436 feet. Water was reached at the depth of 432 feet from the surface. The underlying "White Limestone" was penetrated by the drill twenty feet, but its thickness was not determined at that point. It is much thicker than the heaviest bed of blue limestone and is the lowest formation yet reached in the mining operations upon this group of rocks. It is dolomitic. The blue limestones are totally different in appearance and are fossiliferous, but the fossils are confused and broken and are not recognizable specifically but are apparently Carboniferous in type.



Formation.	Thickness.	Total Depth
1. Soil and "cement"—Caliche..	5	5
2. Detrital, Clay with loose rock of limestone and quartzite.	55	60
3. Shale, loose and broken.....	9	69
4. Blue Limestone.....	2	71
5. Broken Shale and Quartzite...	17	88
6. Blue Limestone.....	2	90
7. Grey Quartz, iron stained and broken.....	8	98
8. Black Shale, broken.....	2	100
9. White Quartz, iron stained...	10	110
10. Black Shale, broken.....	4	114
11. Grey Quartz, iron stained, broken.....	8	122
12. Black Shale.....	2½	124½
13. Quartzite, Grey.....	4	128½
14. Black Shale.....	8	136½
15. Quartzite, Grey.....	4½	141
16. Black Shale.....	12½	153½
17. Shale with calcareous seams..	2½	
18. Quartzite, brown stained.....	13	169
19. Quartzite, hard blue, with pyrites at bottom.....	21	190
20. Blue Limestone.....	10	200
21. Hard Quartzite, iron stained.	28	228
22. Black Siliceous Shale.....	2	230
23. Blue Limestone.....	53	283
24. Black flinty quartz, limestone and quartzite (assay 3.2 oz. silver).....	7	290
25. Blue Limestone.....	1	291
26. Quartzite, Novaculite.....	125	416
27. White Limestone.....	—	—
Water-level		432
Bottom of Hole.....		436

The so-called quartzites of this part of the Section are very fine in grain without the usual granular structure, and may be properly called novaculites, or hone-stones. This is true especially of the lower bed, 125 feet in thickness. It is a white, compact, dense rock, breaking with a conchoidal fracture and without visible grains.

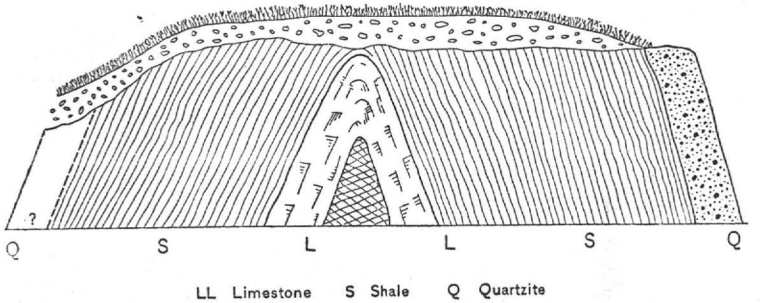


The series of formations represented by this Section is surmounted or overlaid conformably by shales and quartzites, the quartzites being the highest rocks in the series. They are largely developed on the Contention Hill and at the Grand Central mine, where they form the outcropping rocks dipping easterly. They are grey in color, the sandy grains are distinct; diagonal or cross stratification is found, and they might properly be described as sandstones, not being so firmly consolidated and vitrified as typical quartzite. Similar sandstones crop on the Tranquillity claim, and they may be found in most of the cross-cuts on the different levels of the Contention mine and elsewhere. It will be noted that shale beds form an important part of the total thickness of the series of beds perforated by the drill. The shales are generally thinly bedded, and are siliceous rather than argillaceous or calcareous. The outcrops are generally fissile, rusty and much broken, but in depth the color is much darker and often almost black. There is doubtless a general distribution of iron pyrites and perhaps of organic matter in these shales. By weathering, the pyrites are decomposed and the outcrops assume a rusty brown color and break up into fragments.

The hills and slopes lying west of the Contention and Grand Central are underlaid by this shale formation, while lower down at the Toughnut and Goodenough the limestones appear at the surface and are succeeded by the novaculite and the lower limestone, or dolomite, which crops out near the Combination Incline and is again found cropping out along the lower portions of Tombstone gulch towards the granite contact near Fisher's Mill. It is often referred to as the "lower lime" or lower "white lime" and also as the dolomite, to distinguish it from the upper beds of blue limestone, where the chief bedded masses of ores occur. There does not appear to be any well exposed outcrop of this lower limestone in depth, and its exact thickness is not made evident. In tracing out the structure along Tombstone gulch, several outcrops are found below the Defence Hills and are supposed to be portions of this lower series of rocks.

The well-formed crest of a single anticlinal is a good example of folding and at the same time shows a thick body of shale overlying a stratum of siliceous limestone, probably magnesian. It crops out in the lower part of Tombstone gulch not far from the contact with the granite near Fischer's Mill and is no doubt a lower member of the lower white limestone series. The crest or saddle of the bed is occupied by a crushed up body of siliceous rock,—probably a siliceous shale. A bed of grey sandstone crops on the right and is probably repeated on the left but is covered by the overlying wash. The shales are blue and brown in color and are siliceous. The portion of the rocks shown by the section represents only a part of a succession of folds of siliceous limestones, shales and sandstones, and it is fair to conclude that deep explorations on the Contention Lode will eventually penetrate this series of strata.

FIG. 5. *Example of an Anticlinal Fold.*



II. Manganiferous Limestone

Under this designation I place a series of thickly bedded massive limestones in which ore-deposits characterized by large amounts of manganese ore are found, and from which manganiferous silver ore has been produced in quantities.

This series of limestone beds is developed chiefly in the western and southern part of the District in the higher and more hilly region west and south of U. S. Mineral Monument No. 2, and upon the mineral claims formerly known as the Lucky Cuss, Luck Sure, Wedge, Sunset, Knoxville (Stonewall), Anchor and the Grand Dipper.

The limestone crops out boldly at the Lucky Cuss shaft and west of it to the contact with the granite, along and near which the rock is changed to a white crystalline limestone. This limestone extends around the end of the ridge surmounted by the United States Mineral Monument No. 2 and gradually rises to the top of the ridge, and as the distance from the granite increases the blue color replaces the white. And at the summit of the ridge southwards the limestones are nearly black and are much seamed with small veins of white calcite. The general trend of the strata is east and west. An observation near the summit of the ridge some distance south of the monument gave N. 8° W., dip West, 72°.

Further south the strike and dip change somewhat, with evidences of a curve or bend towards the Emerald Series. In these dark colored and massive beds opposite the Emerald and north of the Emerald arroyo one of the beds is characterized by the presence of innumerable minute encrinal stems visible only upon weathered surfaces where the stems stand out a little and give the rock a peculiar rough feeling to the touch. These little fossil encrinal stems are less than a millimetre in diameter. A freshly fractured surface does not show the presence of fossils, but is fine, granular and subcrystalline. Chemical tests show the presence of only a small quantity of magnesia in this rock, and it cannot be classed as a dolomite. An analysis of the Knoxville limestone, a blue and compact sample from the west end of the mine, gave 90.75 of lime carbonate, 2.85 of magnesia carbonate and 5.20 per cent of silica. This and the following analyses were made by Mr. Frank C. Earle for Mr. Goodale.

The limestone from the main working shaft of the Lucky Cuss near the contact with granite, a white and crystalline rock, gave only a trace of magnesia and 6 per cent. of silica. A sample representing the general character of the limestone of the Luck Sure belt was also without magnesia and had only 2.41 per cent. of silica.

The chief mines in this series of rock are the Knoxville, Lucky Cuss and the Luck Sure. These have been liberal producers of manganiferous silver ore. This ore occurs in irregular seams and bodies in the midst of the altered limestones.

Mr. Charles W. Goodale, who for several years was general manager of the Knoxville Mine, has directed special attention to the silver-bearing manganiferous ores of the Lucky Cuss, Knoxville, Luck Sure and Wedge mines, named in the order of their importance. At the date of his paper, July, 1887,* these mines had produced over 750,000 ounces of silver.

The limestone belt in which the Knoxville ore-bodies occur is about 1680 feet wide and rests on granite on the north.

The same authority states that in cross-cutting the limestone from the mine a great variation in its character was observed, some portions were so siliceous as to approach the nature of quartzite, but the greater part of the rock contained 94½ per cent. of lime carbonate. No certain evidences of stratification in these Knoxville limestones were observed.

The ores occur in these rocks in close association with the

* Transactions of the American Institute of Mining Engineers, Volume XVII, page 767. July, 1887.

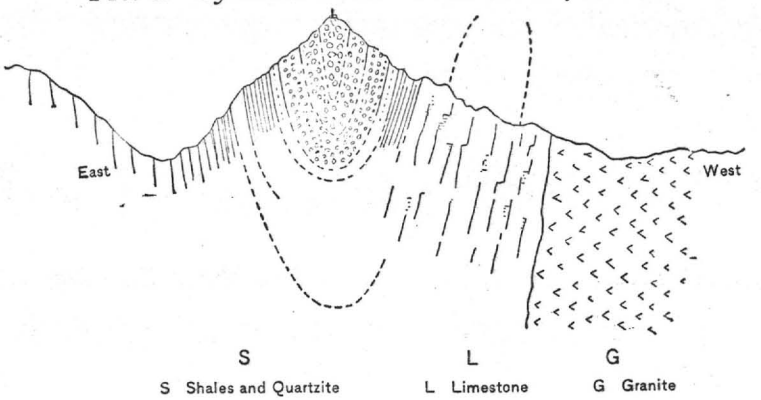
oxides of manganese in the form of irregular pipes, which are more particularly described in the chapter devoted to the description of the veins or lodes, in which also a discussion of the probable origin of the manganiferous ores will be found. See Chapter III, p. 43.

Massive Conglomerate and Breccia

By crossing the limestone ridge from the Luck Sure claim in a southeasterly direction into the valley of Lucky Cuss gulch a very different group of rocks is found in a double line of croppings of massive conglomerate standing nearly on edge. It extends in a general southeast direction from the U. S. Mineral Monument No. 2 across the Luck Sure, the C. O. D., Mizzen Top, Anchor, Telephone and Grand Dipper claims to the Rattlesnake claim where it disappears under the thick deposits of the Emerald Gulch.

For the greater part of this distance, especially where the croppings are near to the heavy croppings of limestone, this broken formation is made up of well-rounded pebbles and bowlders of limestone, mingled with pebbles of quartz and pebbles and bowlders of feldspar-porphyry. There are also intercalated layers of sand, the whole appearing to be a stratum of coarse and sandy conglomerate, such as would be formed along a coast by wave action—a regular beach shingle. As, however, we trace out this conglomerate reef to the top of the hill above the Lucky Cuss and reach the vicinity of the quartzites and novaculite, the fragments of the reef change in character and are made up largely of the adjoining rocks, thus indicating an origin by shearing—a shear zone. But there are bowlders of more distant origin, making it difficult to give an explanation of the origin of this peculiar breccia and conglomerate, which requires further study.

FIG. 6. *Synclinal Fold. U. S. M. M., No. 2.*



This ridge thus gives evidence of a strong, sharp, synclinal flexure, terminating, or running out, just above the Lucky Cuss. It is either a synclinal fold or a double shear zone, and in either case forms a strongly marked division between the heavy croppings of the Lucky Cuss and Luck Sure limestones on the west and the hills which are believed to be formed of the Contention-Toughnut series on the east. The fold extends nearly parallel with the Luck Sure limestones for a part at least of its course and terminates in a bluff-like hill above the Lucky Cuss while the croppings of the novaculites or siliceous shaly beds bend around the hill, parallel with one or more thin beds of limestone lower down the hill. This strongly developed change of formation leads me to question the supposed conformity of the Contention series with the manganiferous series. There seems to be a break in the continuity of the strata along the eastern side of this synclinal fold. But this is not clearly made out, and the relations of these formations are admitted to be extremely obscure and difficult to unravel, requiring further study and accurate mapping. The structure so far as it could be determined is clearly synclinal, with the axis of the trough pitching southeasterly. The northern highest end forms the top of the hill overlooking the Lucky Cuss. The novaculites and

one, at least of the beds of limestone appear to underlie the conglomerate and to pass in V-like outcrops each side of the ridge. The limestone on the west side, adjoining the granite, is possibly folded upon itself.

The limestone largely developed at the Lucky Cuss is interstratified with white novaculite (generally called "quartzite" in the camp.) These beds with the limestone are generally regarded as the equivalent of the white limestone underlying the Contention and Toughnut beds. It is supposed that this lower limestone is here uplifted from below the series of blue limestones and shales and that these blue limestones and shales rest conformably upon the limestone of the Lucky Cuss, which in its turn is supposed to rest conformably upon the next underlying series I have designated as the Emerald Series, which includes the heavy quartzites of the Ajax Mountain. In other words, all the formations mentioned are regarded as lying in parallel beds from the upper sandstone of Contention Hill to the base of the Ajax quartzite and even lower. This appears to be the view held by Mr. Staunton, Mr. Gray and Prof. Church. It greatly simplifies the subject and may be the correct interpretation of the phenomena. It may be the correct solution of what I believe all of these careful, close observers regard as a difficult problem, especially as it is presented along the eastern base of the Lucky Cuss hill, between the blue limestone series and the Lucky Cuss limestones.

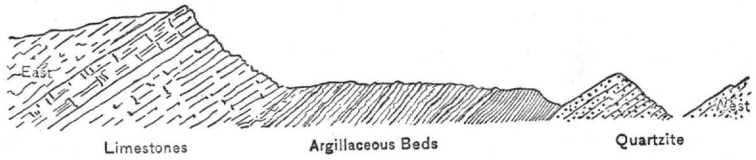
Professor Church, in a recent communication to the Institute of Mining Engineers,* represents in a section entire conformity of the formation from the Randolph limestone at the base upwards through the Ajax quartzite, the Emerald limestone and the Lucky Cuss limestone and Herschel quartzite to the Contention series.

* The Tombstone, Arizona, Mining District, by John A. Church. Transactions of the American Institute of Mining Engineers. New York and Philadelphia, meeting February and May, 1902.

III. Emerald Series

In the western part of the District, beyond the manganiferous series from a deep gulch on the Ecstasy Claim eastward to and across the Emerald Claim, there is an interesting series of beds of limestone shales and quartzites cropping with extreme regularity and all dipping eastward at an angle of about 30°, north and south strike. The upper members consist chiefly of massive limestone weathering with a rough rugose surface forming the mass of the mountain back of and south of the Emerald mine. This limestone rests on a series of argillaceous limestones with many shaly partings forming sharply defined linear croppings. Then under a bed of shales there is a foundation of regularly bedded clean quartzites of vitreous even grain, somewhat colored red with oxide of iron, and over 400 feet thick. These quartzite beds resemble those of the Huachuca Mountains. They are regularly and evenly bedded. They do not resemble in composition or position the sandstone beds of the Contention series. They are apparently lower in geological horizon and older.

FIG. 7. *Sketch Cross-section of the Emerald Series.*



The rough rugose limestone and dolomite of the Emerald is very different in its appearance from the limestones of the Luck Sure, which last are darker in color, often quite black, like coal, and traversed by innumerable small seams of white calcite. This kind of limestone is largely developed on the ridge south of the U. S. Mineral Monument No. 2 and it is

in strong contrast with any of the beds of the Emerald series. This of itself indicates a difference of horizon and that there is a wide separation in age between the rocks of the two series. Moreover the strike or trend of the Emerald series is very different from the trend of the limestones of the Luck Sure, and there appears to be a line of break or demarcation between the two groups following the general course of Emerald Gulch. The lines of strike of the two series of beds here make an included angle of about 120°.

It is also to be noted that the great beds of regularly stratified quartzite cropping in the Ecstasy Claim if prolonged on their line of strike northward, would pass through or under the Luck Sure limestones and the well-defined croppings of the Lucky Cuss without the probability of conformity.

It thus appears that there are great lithological and structural differences between these two series of rocks.

I therefore conclude that the Emerald series is entirely distinct from the Luck Sure series and that the two systems are separated by a great dislocation in an approximately east and west direction.

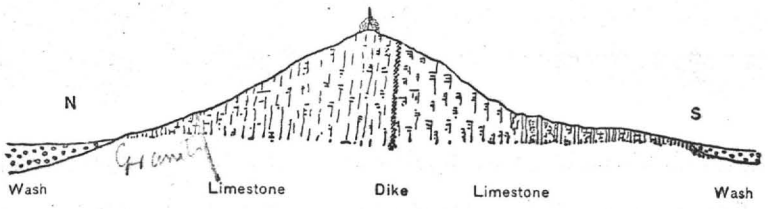
Comstock Hill

An elevation a short distance north of Tombstone consists of a remarkable series of stratified limestones generally in thin layers alternating with siliceous beds all standing on edge and much altered by the underlying granite uplift and by plutonic dikes. This alteration consists in the loss of color of the limestone, it being changed from blue to white and in the formation of crystalline silicates, especially of idocrase (vesuvianite).

There is a thin dike of diorite on the south side of the summit showing at intervals, and on the eastern slope of the hill a cropping of similar rock some ten feet or more in width. The direction or strike of the beds is generally nearly east and west (N. 85°—90° W.) at the summit, but this

section changes on the eastern end until the strike is nearly N. 45° W., there being apparently a curve in the beds due to folding.

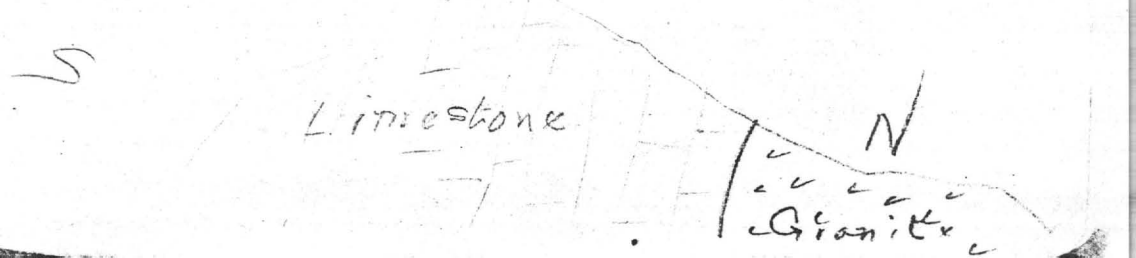
FIG. 8. *Sketch Cross-section of Comstock Hill.*



The accompanying sketch cross-section of the hill will give an idea of its general form, and of the strata, which disappear on all sides under the gravelly accumulations of the plain, the "wash," which conceal the contact with the adjoining granite. This hill is surmounted by the United States Mineral Monument No. 5.

These Comstock Hill strata appear to me to be the equivalents of the similar series of beds observed at the Emerald Claim and west of it. They do not resemble the ore-bearing series of limestones of Central Tombstone, with which there does not appear to be any connection. I am not able to correlate the two groups of strata nor to show the correlation of the Comstock Hill series with those of the Emerald except by similarity of lithological characters and stratification.

The bordering granite sweeps around from the contact above Fisher's Mill to the foot of Comstock Hill and appears to have been the chief agent of metamorphism of the series of limestones as a whole, while local metamorphism is due largely to the intruded dike. These Comstock Hill dikes do not appear to have any special significance regarding the ore deposits of the camp, and so far have not been found to be ore-bearing.

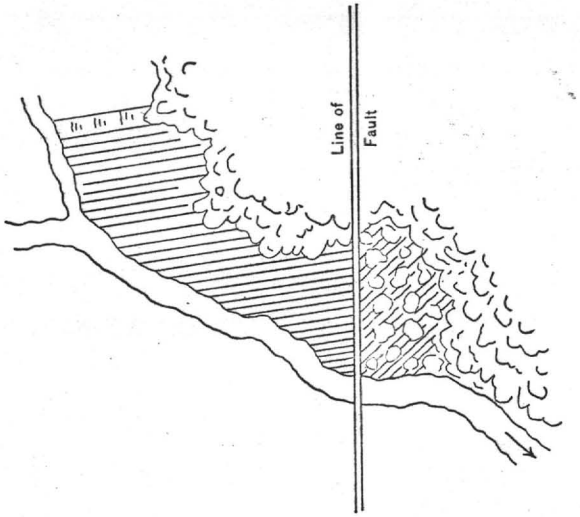


Faults and Dislocations

The Contention-Toughnut series appears to have been a region of considerable faulting of moderate extent. The surface of the region near the Toughnut workings, and those of the Goodenough and Way Up presented abundant evidences of dislocation. So also the upper levels of the Contention mine developed the presence of several faults by which the normal dip and position of the strata were much disturbed. The shifting of a block of the Contention lode to the westward on the Head Center gave cause of costly litigation. It gave the appearance of two parallel veins. And at other points the dislocation and overlapping of the parts of the lode give, practically, the effect of two or more lodes on the same level. This condition was discussed in my paper of 1882.

Among other interesting phenomena of the formations of the Contention and Toughnut series there is a remarkably well-defined break and fault plane across the strata far beyond the lode showing in the left bank of Emerald gulch some distance from the south end of the Grand Central ground between the Grand Dipper and the Bunker Hill claims. It shows in one side only of the gulch. One side of the break consists of a body of shales standing on edge, of a dark color but hard and siliceous. These are cut off at nearly right angles by the slip or break. The other side of the break is formed of a nearly vertical wall of rocky fragments, the result of the crushing movement, cemented together by infiltrated lime-carbonate, like caliche. It makes a firmly cemented mass of large and small blocks and fragments of limestone, shales and quartzite, evidently the crushed-up strata through which the movement took place. The blocks are angular. The full breadth of this crushed zone is not shown as the cemented mass passes under and is covered by the wash. An attempt has been made to show the break in plan by the annexed illustration.

Fig. 9. *Plan of Faulting Plane Crossing Emerald Gulch.*



The outcropping beds are cut diagonally across by the gulch, showing a succession of siliceous shales, quartzite and a red and green schistose rock to a bed of hard blue limestone about sixty paces up the gulch. These beds trend N. 76° to 80° West magnetic, and are nearly vertical. The trend of the fault-plane is North about 10° to 20° East, magnetic, and its dip is 82°-83° eastwardly. The extent of the throw could not be determined as the detrital material of the surface covers the strata from view. The movement may have been vertical as well as horizontal.

This faulting plane gives every evidence of being of considerable extent. If prolonged northward in the direction seen at its only exposure in Emerald Gulch it would pass through the series of locations lying east of the Grand Central and the Contention, and would be approximately parallel with the Contention dike. In the other direction, northward, it would intersect the Bunker Hill and Rattlesnake claims toward U. S. Mineral Monument No. 6. Other

examples of faulting are described and illustrated in the following Chapter II upon the ore-deposits.

Rhyolite

An area of rhyolite is found on the State of Maine claim. This is far outside of, and west of, the other claims and groups. The ore-deposit, or vein, is also in a very different group of rocks, being in a plutonic mass of syenitic quartz porphyry of a grey color and fine grain and very hard. The XXX Mine adjoining is in similar rock, and is opened by an incline at an angle of 30° dipping westward. The strike of the quartz vein is nearly magnetic north and south.

East of the line of these claims there is a belt of rhyolitic rock in vertical layers, tufaceous and fragmentary, trending N. 20° East, and still further east, a second belt of quartz porphyry and of rhyolite 200 to 300 feet wide. Granite does not appear, but the contact of these rhyolitic and porphyritic plutonic rocks with shales is found near to the Last Chance house on the Charleston road.

Granite

This is a compact homogeneous fine-grain granitic rock without stratiform or gneissic structure, and is no doubt intrusive. It crops for some miles in the direction of Fairbank and forms an abundance of large rounded bowlders of disintegration. This rock has a pleasing grey color, is easily worked into good building blocks and was used for the Schieffelin monument and for the foundation blocks of the hoisting and pumping engines.

It appears to have risen into the midst of the Tombstone formation and forms a broad belt, or dike-like mass, west of the Lucky Cuss and Old Guard claims. It is bordered on the western side by conglomerates, shales, quartzites and limestones, the relation of which to the stratified formations on the east of the granite cannot be ascertained without further surveys and a good map.

Chapter Three—The Ore Deposits

TWO distinct classes of mineral deposits are represented in the Tombstone District: 1. Veins or lodes. 2. Interbedded or Blanket Deposits.

The original discovery was made upon the outcropping of a blanket deposit found in close association with the main bed of blue limestone and, in fact, replacing a portion of the original bed.

The deposits in veins will be first considered.

Porphyry Dikes and the Veins

The sedimentary and folded strata are cut nearly at right angles by a succession of plutonic dikes trending a few degrees east of north and south of west. Five such dikes have been recognized: the Contention, Empire, Hawkeye, Quarry and the Northwest. These dikes cut the country in nearly vertical planes. They occupy fissures or breaks in the stratified rocks and are found traversing the granite rocks also. They undoubtedly extend to great depths in the earth.

Veins and impregnations of quartz are associated with the dikes. In some of them the quartz is closely intermingled with the mass of the dike, in others the quartz is formed in distinct but parallel veins or forming an acute angle with the trend of the dikes. From these facts and others we may justly conclude:

(1) That the veins or dikes were formed together, or in near sequence of time, and that the siliceous deposits represent emanations from deep-seated, probably thermal sources.

The chief dike of the District, generally known as the Contention dike, will be first described.

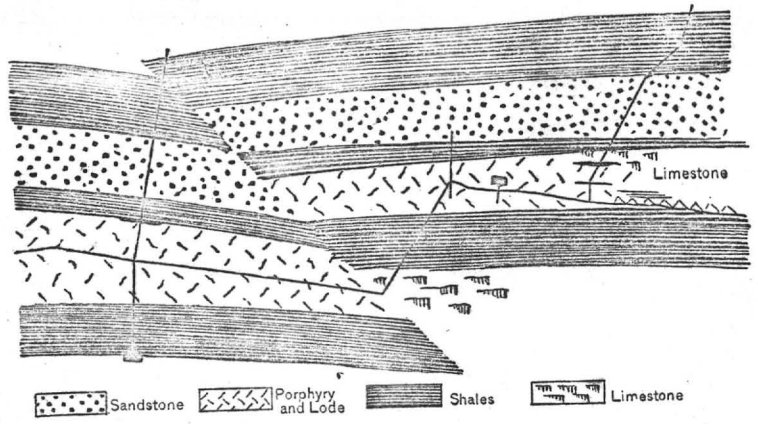
Contention—Grand Central Lode

The porphyry dike of the Grand Central and Contention mines extends not only through these claims but through the Head Center into the Tranquillity and beyond into the Empire. It may be regarded as the one great leading vein or lode of the District. While the dike is a crystalline igneous rock which has broken through and disrupted all the stratified beds in its path, it is so closely connected with siliceous layers and impregnations and with the deposits of gold and silver which are found not alone in quartz alongside of the dikes but in the substance of the dike itself as to permit of its being regarded as the lode.

Its general course or direction is north and south. It cuts the rocks indiscriminately, but in places follows the bedding of the disrupted strata. It is thus bordered in places by shales, by quartzites, or by limestone.

There are dislocations by faulting which give the semblance of two or more parallel dikes, as for example, on the 207-foot level of the Contention, equivalent to the first level of the Head Center, a representation of which is given in the annexed plan of a portion of the ground between the North Shaft of the Contention to and including the cross-cut drift north of the Head Center Shaft. Shales, quartzites (or sandstone) and limestone are here shown traversed by the Contention dike (Fig. 10, p. 45).

FIG. 10. *Porphyry Dike with Adjacent Beds—Dislocated.*

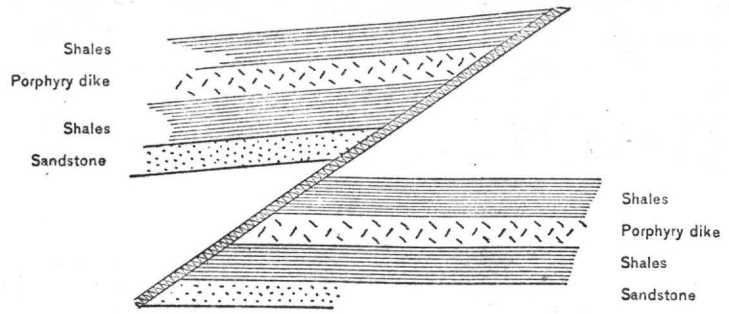


The breaks and throws of the dike may be further illustrated by a second example found on the 258-foot level in the long cross cut from the South Shaft westward into the Flora Morrison, where there would appear to be three dikes nearly parallel to each other. The chief faulting plane here trends north 25° to 30° west and dips to the northeast. It is marked by a heavy belt of crushed material of a bright red color. The distance of the throw appears to be not less than 250 feet.

The dip of the strata is eastward at an angle of 45 to 50 degrees (Fig. 11, p. 46).

The thickness of the Contention dike is variable. In the cross-section westward from the shaft shown in the plan it measures 68 feet from one wall to the other. About 500 feet north it suddenly diminishes to a few feet from side to side. This is indicated at the extreme right hand or north end of the plan (Fig. 10) where, also, a bed of limestone comes in between the porphyry and the shale. It is possible that there is a second break or dislocation at this place. Four hundred feet further north there is a sudden expansion of the dike on both sides of a mass of shale.

FIG. 11. *Northwest and Southeast Dislocation.*



The dominating importance of the Contention lode in the Tombstone District is convincingly shown by the number and extent of the workings upon it, as represented on Map Fig. 2—The Contention Lode, page 22. These workings extend for a great distance through the many claims and, in the aggregate, number many miles, and all above the water-level.

Origin of the Ores

This dike, with its accompanying quartz veins and ore-bodies, is the great leading source of the ores, and is followed by the miner in his search for paying ore-bodies. It was so followed in the Grand Central, the Contention, the Head Center, Tranquility and others, and may be followed at the present day with every promise of success to great depths below the water-level. Indeed, there is no reason to question the probability of the ore-bodies extending as far downward as in lodes in other districts. It is more than probable that the porphyry dike of the Contention group, was charged with mineral sulphides at the time of its intrusion, and that the adjoining beds were also mineralized by the contact. Or, if the metals were distributed in the mass of the sediments the dikes produced the conditions favorable to the concentration and deposition of the ores. The question of the origin of the ores permits of much theoretical discussion, but little practical or economical significance aside from the facts of the presence and distribution of the ores. That the paying ore-bodies were found alongside of and in the dike is a familiar fact to the miners and engineers who worked and explored the mines along its course. The opinion and conclusions regarding the existence of paying ore-bodies in depth below the water are based not alone upon the mode of occurrence or form of such ore-bodies in the extensive group of mines worked to the water-level but, also, and convincingly, upon the known ascertained existence of bodies of ore below the water-level. For a further discussion of this subject see beyond under Chapter V, The Lodes in Depth.

A few theoretical details and considerations respecting the origin of the impregnation of the rocks and lode with the noble metals may have some interest and practical application. Reference may be made to my description of the lode read at the Washington meeting of the American Institute of Mining Engineers in February, 1881, from which the following extracts are made:

"The dike has a distinct vertical lamination or structure through most of its substance and is more or less penetrated by veinlets of quartz. In some portions it is highly crystalline and nearly barren, and in other portions it consists chiefly of a feldspathic base in which the feldspar crystals are obscure. It passes into a felsite, which in the decayed portions of the dike, and where it is slaty in structure, might be mistaken for the partly decayed shales or quartzites. Large portions of the dike are so much penetrated by quartz as to consist largely of it, and the mass might be called quartz, although close examination shows the presence of feldspar. . . .

"There is a considerable amount of mineralization of the dike by iron pyrites disseminated irregularly in the mass usually in cubical crystals, most of which have dissolved out, leaving cavities only, indicating the former presence of the

pyrite, making some places a spongy mass of porphyry or of quartz."

The quartz veinlets appear generally to be later in origin than the dike (though they now seem to be an integral part of it) and they may have been coincident in origin. The extensive decomposition and kaolinization of the feldspar seen on all sides may have yielded the silica.

Again quoting from the description in 1881:

Metallization of the Dike

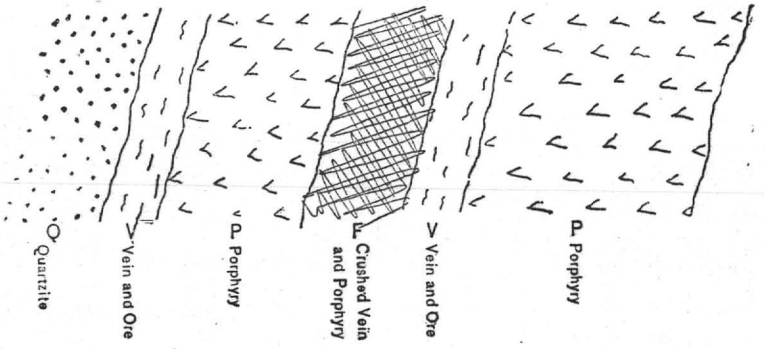
"The time and manner of metallization of the dike may be considered as open questions, for a solution of which we must wait until the mining extends below the permanent water-level of the formation. It seems most probable that the rock, at the time of its intrusion, was pyritous, and the strata adjoining it no doubt were. It is not impossible that there may have been a concentration of the precious metals in the dike from the surrounding beds, the result of the decay and change of the pyrites diffused in the strata. On the other hand, we may suppose that the dike has been the source of the silver and gold we find in and about it.

"In either case the vertical laminated or stratiform structure parallel with the walls has been an important factor in the distribution of the metals, and in the changes and modifications of the original condition of the dike. We may readily conceive of such vertical planes of structure affording planes or lines of least resistance to vertical movements, while the abutting ends of the strata, in contact with the walls of the dike, would offer great resistance by friction. The condition of the dike along a great part of its course seems to sustain and verify this hypothesis. There has evidently been considerable movement of parts of the dike upon itself, resulting in the formation of heavy clay seams and brecciated layers of porphyry and quartz, sometimes occupying a medial position

along the dike, sometimes at one side or the other, and again along the line of contact with the country rocks. Such seams and brecciated ground are sometimes wanting, and the structure and condition of the dike remain unchanged."

That the dike has suffered extensive movements since its consolidation is shown on most of the levels of the mines; in addition to the lateral dislocations by faulting, as already shown, there have been sliding movements along the walls of the contact with the sedimentary beds, and portions of the dike have slid back and forth upon themselves, resulting in the formation of extensive bodies of soft clay or flucan, like the gouge or selvage of mineral veins. There is also extensive fracturing of the abutting edges of the stratified beds shown by a crushed bordering mass of breccia several feet thick, by which the original bedding is obliterated. And when this fracturing passes through beds which have been previously mineralized there is a mingling of ore with the fragments of the wall rocks—ore which is already crushed and can easily be mined. In the upper levels large quantities of such already crushed ore were found. The presence of much highly-colored red hematite in such crushed zones is a good indication of paying ore. At many places on the 600-foot level the smooth slickensided walls of the dike are

FIG. 12. *Section of the Contention Dike and Lode.*

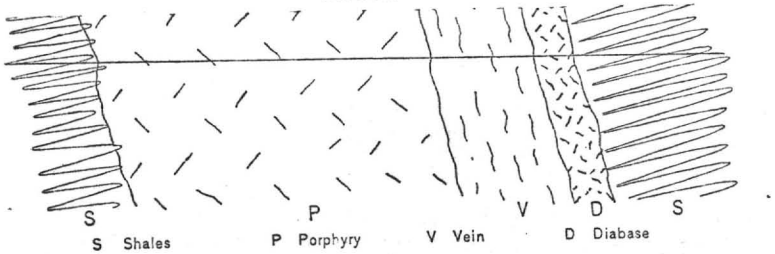


colored a brilliant hematite red and may be regarded as contiguous to important ore-bearing ground below.

The structure of the dike at two distant points is shown by the annexed drawings of places where ore occurs both alongside of and in the dike (Figs. 12 and 13).

The Contention dike, or rather the fissure which it occupies, appears to have been opened a second time, permitting of a parallel intrusion of another variety of plutonic rock of a darker color and finer grain containing hornblende or augite. It is probably a diabase. It may be seen cropping at the surface on the west side of the feldspar porphyry dike south of the Grand Central pump shaft. A similar rock has recently been noted by me in a short cross-cut to the west from the main dike on the 600-foot level of the mine, near the bottom of the Sulphuret Shaft, in close association with rich ore lying between it and the feldspar porphyry, as shown in the section, Fig. 13.

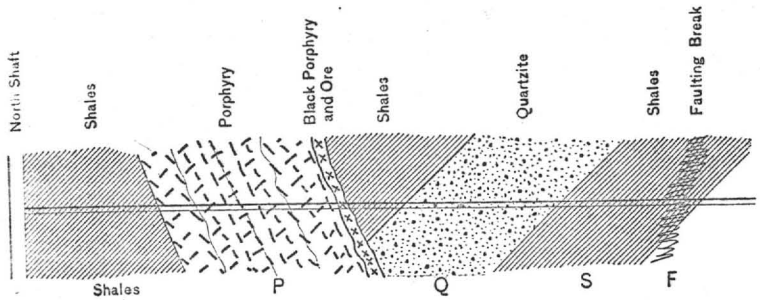
FIG. 13. *Section of the Contention Lode on the 600-foot Level.*



Again, I find recorded in my notes of 1881 a dark colored "black" porphyry at two places on the west side of the dike, on the third or 207-foot level of the Contention, and in each place accompanied by bodies of ore. The notes also show that this was upon the 309-foot level (206 feet of Head Center), a dark colored rock containing gold; "a compact, fine grain, dark green rock or hornblendic porphyry with scales of gold in it, and chloride of silver in yellow crusts and patches." The rock seemed partially altered to steatite.

The valuable ores of the Contention lode were not confined to the limestone contact with the porphyry alone, but were found also at the contact with shales and with quartzites. On the third level north in the Head Center ground, ore was found in 1882 next to the contact of the porphyry and shale, with ore, also, in the shale, which at that point was quartzose and schist-like, as if altered by the dike and the accompanying siliceous emanations, or infiltrations.

FIG. 14. *Section of the Contention Lode from the North Shaft Westward on the III Level.*



This cross-section shows the intersection of different beds by the dike, and a brecciated seam, or broken up zone, in the midst of a mass of shale.

The West Side Vein

The West Side vein has been extensively worked and has produced a large amount of ore, as may be seen from the tabular statements of production. From the original discovery on the Toughnut claim the fissure was followed westwardly leading to the second roll, or anticline, and following the fissure eastwardly it led to the other roll, or anticline, in the Way Up Claim. In parts of its course it is barely more

than a "crevice" similar to many in the lead and zinc regions of Wisconsin, large enough to permit of the flow of solutions of the ordinary and noble metals for ages, by which heavy deposits have been made not alone on the walls of the fissure but in the adjacent limestone. It has been worked to a depth of 500 feet or more.

The vertical longitudinal section following the West Side vein, herewith presented, serves to show not only the succession of anticlines and synclines cut by this fissure, but the distribution of ore in the fissure as marked by the portions stoped out, indicated by the shading (Fig. 15, p. 53).

It should be noted, first, that Shaft No. 3 reaches to the water-level through a continuous chimney or body of ore deposited opposite the shales and limestones. Second, that another shaft reaches ore-bodies formed opposite the "quartzite" and on the top of the white limestone; thus showing that the ore-deposition on the plane of the vein is not confined to any one kind of wall-rock, although the limestone appears to have been most conducive to the deposition of ore.

Bedded Ores—Blanket Deposits

But while the porphyry dike of the Contention group, with its impregnation of quartz and the precious metals, is the important constant source of value, it has been noted from the first that the contiguity of beds of limestone has had an important influence upon the mineralization. Limestone, as usual in metalliferous deposits, has here acted as a precipitant. And in this District it appears to have acted not only chemically but mechanically, by its form, or position, with respect to the vein-system.

The bulk and greatest value of the bedded or blanket ores are found along the crests or anticlines of the limestone. And the ores are deposited in greater quantity at and near to the

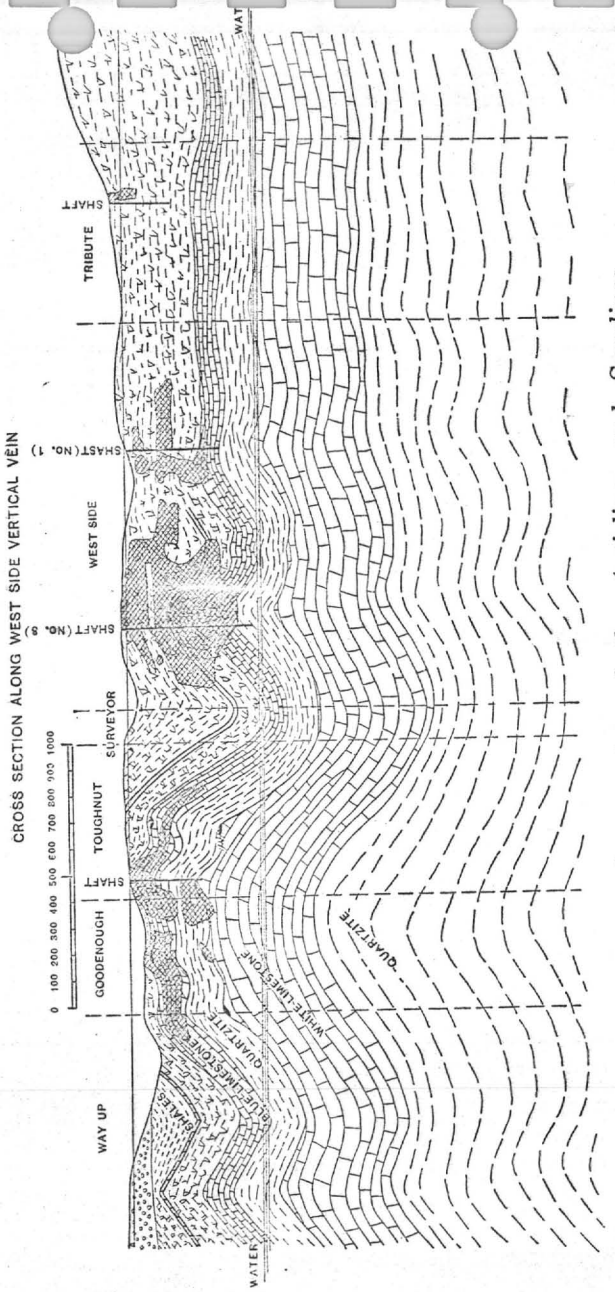


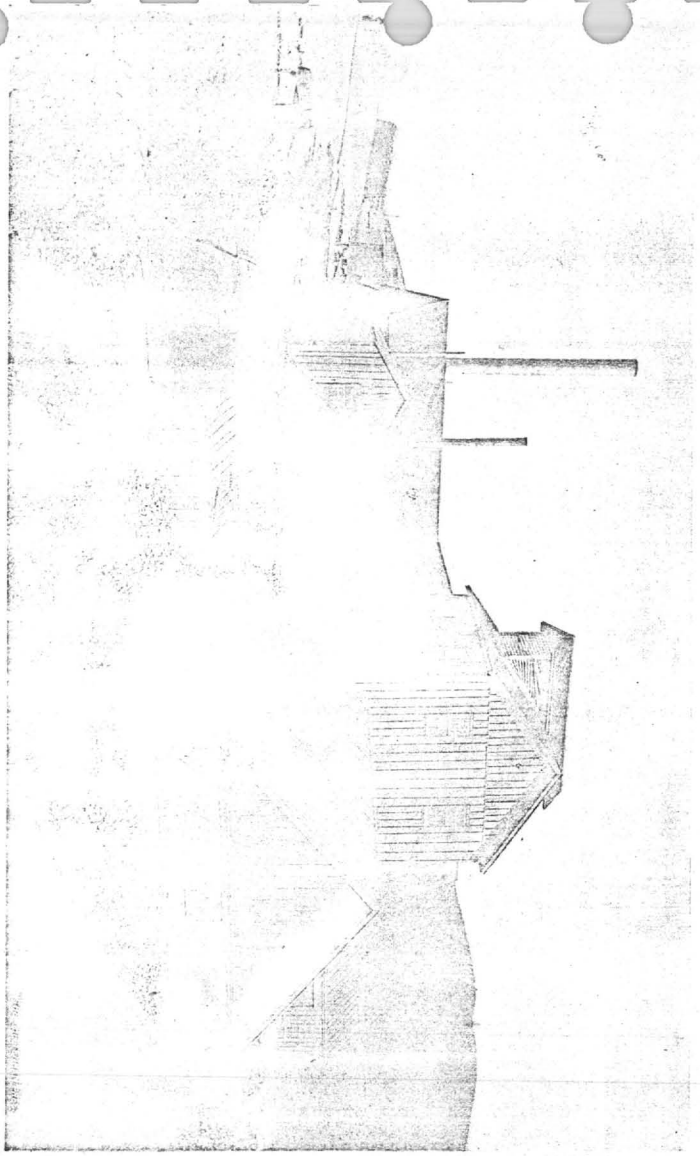
FIG. 15. *Cross-section of the Anticlines and Synclines Crossing the West Side Vertical Vein.*

veins, as if solutions had flowed outward from the fissures and had followed the pitch of the crest of the folds downward. This was shown in a striking way in the Toughnut mine, where the ores were in greater quantity on the down-hill side of the intersection of the folds or "saddles" with the vein. The ores also extended in workable masses for a greater distance from the vein on the lower side than on the other, or up-hill, direction of the pitch.

It appears also that each vein, fissure, or crevice crossing the folds of the rocks has contributed to the formation and maintenance of the deposits of ore in the arches of the rock—the anticlines or saddles—along the line of the pitch from one side of the District to the other. Reference is here made to the map and sections, particularly to the map (No. 2) showing the extent and direction of the stoped ground on the Toughnut and Goodenough claims extending eastwardly from the Defence fissure to the West Side and the Way Up fissure, and from thence into the Girard, Hawkeye and Little Wonder towards the Contention lode.

The accumulation of paying ores in the crests or saddles of the folds having thus been shown to be general in the District, and it likewise having been found that there is local enrichment and deposition at the points where these folds are intersected by dikes or lodes it becomes of great practical importance to determine the number and the direction of the folds. To this end numerous observations have been made by Messrs. Staunton and Gray upon the form and pitch of the ore-bodies. The results have been carefully plotted upon a series of sections following the crests of the main folds and showing their downward pitch to and under the water-level down to the point of intersection with the Contention lode, where it is expected to find heavy accumulations of ore, and such accumulations not alone in the bedded rocks but in the lode itself.

It is interesting to note that the accumulation of ores in the crests of the folds or anticlines of rocks is found to a remark-



SHAFT-HOUSE OF THE WEST SIDE MINE

le degree in the gold mines of Bendigo, Aus ia, described by Rickard.*

Such deposits are there known as "saddle reefs," the ores being accumulated in the saddle-like folds of the beds.

It is noteworthy that the ore deposits in Australia are not confined to one layer but that they occupy successive layers one under another, but always in the crest of the arch and below it rather than above, or on the sides of the folded beds.

The shaded or hatched areas upon the map show the portions which have been worked out chiefly upon the claims formerly controlled and worked by the Tombstone Mill & Mining Company. It is not supposed that any important masses of ore remain in or near these stopes, but in their extreme downward extension, to and below the water, other similar ore bodies may be found. It is also possible that other blanket deposits may be found in the but partially explored region northeast of the old workings.

Taking the stoped areas of the chief blanket deposits as marking the chief lines of flexure (anticlines or rolls), the general direction of the longer axes is found to be N. 60°-80° W. Four main lines of flexure or saddles are strongly marked. If some of the lesser flexures are enumerated the number would be increased.

1. Anticline through the Defence, Intervenor, West Side, Sulphuret, through the Flora Morrison (near the new shaft) into the Contention. Approximate direction N. 68° W.

2. Anticline through the Toughnut, Girard, towards the Tranquillity, Head Center and Contentment. Approximate direction N. 68° W.

3. Anticline. Goodenough into Hawkeye and Little Wonder. The major axis of this blanket, if prolonged, would pass through the Empire and Silver Thread to the North Point claim. Approximate direction N. 70° W.

* T. A. Rickard. Transactions American Institute of Mining Engineers. And recently in the Engr. Min. Journal. March 29, 1902. Volume LXXIII, page 440.

4. Vizina through corner of Goodenough and Gilded Age and the western end of the Way Up. N. 77° W.

Other flexures to the westward of No. 1, the "Defence Roll," are known to exist, notably at the Tribute, Bob Ingersoll and Blue Monday, but are not sufficiently opened up to permit of a particular description.

The rock of the whole intermediate region is no doubt in a flexed or crumpled condition, but the flexures are hidden from view by the heavy surface accumulations of "wash."

The line of pitch of the chief blanket deposits, or in other words, of the anticlinal folds to which the deposits conform, is invariably toward the Contention lode or its prolongation; and the angle of pitch, or the inclination to the horizontal water level, varies from 10° to 15°.

The section given on page 80 (Fig. 19), drawn on a scale of 400 feet to 1 inch, and following the West Side anticline, shows this inclination, or pitch, and the distance to which the blanket deposit has already been worked out, and the distance remaining on the pitch down to the intersection with the Contention lode, in which distance, or area, ore may be found. The portions worked are indicated by heavy black lines. It will be noted that for a part of the distance there were three superimposed beds following three layers of limestone.

The section shows, also, the probable depth to which the prolongation of these deposits, or of the limestone beds in which the deposition occurs, would extend below the present water level at the Contention lode. Assuming that the same pitch continues beyond the explored portion this depth should be from 150 to 250 feet. Other sections give similar figures, assuming that the angle of pitch remains constant.

Inasmuch as there has been found at the places where the anticlines have been intersected by veins an enrichment by greater deposition on the lower side of the planes of intersection it is not unreasonable to expect to find similar conditions on the lower or eastern side of the Contention lode if the

limestone beds are continuous the[re] without fault[ing] or displacement.

It appears, also, that the rolls or anticlines pitching under the Empire and Silver Belt and adjoining claim towards the northern end of the Contention lode have been less explored than the others, and that they perhaps intersect the lode at a greater depth, and may form important ore-bodies yet to be reached when the water is removed.

Knoxville Mine

This mine in the southwestern part of the District beyond the Lucky Cuss and Luck Sure is in the limestone of the Lucky Cuss and Luck Sure series. It had been opened up in the year 1887 to a depth of about 375 feet, as shown by a longitudinal vertical section given by Superintendent Goodale in his paper in the Transactions of the Institute of Mining Engineers.*

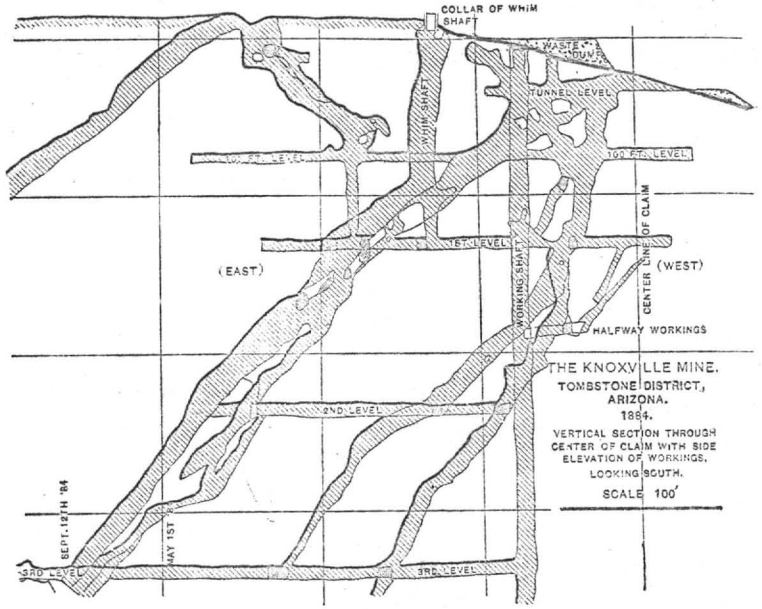
This section exhibits a series of pipe-like ore-bodies or "chimneys" extending from the surface diagonally downward, eastwardly from the surface to and below the third level. There are four of these chimneys or ore-chutes which, as far as then explored, had produced over 12,000 tons of ore containing at least 7,000 tons of manganese oxides. These ore chimneys pitch eastwardly at an angle of about 45°, or from 40° to 50°, and follow a crevice, or plane of cleavage, having an easterly and westerly strike, thus conforming to the direction of the structure of the beds of limestone which is found to be about N. 78° E. magnetic. Four of these ore-bodies or chimneys were more or less united near to the surface. Three of them were developed to a depth of 400 feet and the fourth to 150 feet.

The plane of the crevice was a sure guide to the ore-bodies,

* Volume XVIII, page 911.

though "its width was not appreciable," and there was nothing in the crevice like clay or gangue. The conditions were thus very similar to those seen in the lead and zinc regions of Wisconsin, and which conditions, in fact, occur in the limestones on the Way Up and other claims in the Contention and Toughnut series in the heart of the Tombstone District. Mr. Goodale describes the filling of these chutes or chimneys as follows:*

FIG. 16. *Section of the Knoxville Mine.*



"There were no indications of ore until the drifts were within a few feet of the ore-bodies, where the walls of the crack were stained with black oxides of manganese and some carbonate. Small detached pockets of pure manganese oxide also indicated proximity to the chimneys, but these small bodies carried very little silver. The filling of the chimneys

* Transactions American Institute of Mining Engineers, Volume XVII, page 768.

included, in a great variety of forms, pyrolusite, wad and psilomelane. It is not improbable that a searching examination would have discovered the rarer oxides; braunite, manganite and hausmannite. The gangue was quartz and calcite, galenite, cerussite, pyromorphite, cuprite, melaconite and malachite were occasionally observed, and the assay showed a little gold."

Origin of Manganiferous Ores

The question of the origin of these manganiferous ores in deposits apparently the result of the decomposition and replacement of the enveloping limestone by solutions has excited much interest and considerable discussion. After a somewhat hasty visit to the mine while it was being worked by Mr. Goodale I formed the opinion that the manganese was derived from portions of the limestone containing protoxide of manganese similar to the massive beds of pink limestone bordering or associated with the Franklinite and red zinc ores of Sterling Hill and Mine Hill, Sussex County, New Jersey, which, after being quarried and exposed to the weather, gradually assume a brown and even a black color. This view was strengthened by finding fragments at the Knoxville mine of pink colored limestone, which, on analysis, gave me 0.1 per cent. of manganese, a small quantity, but enough possibly to form large bodies of manganese ore if the solution and segregation was sufficiently extensive.

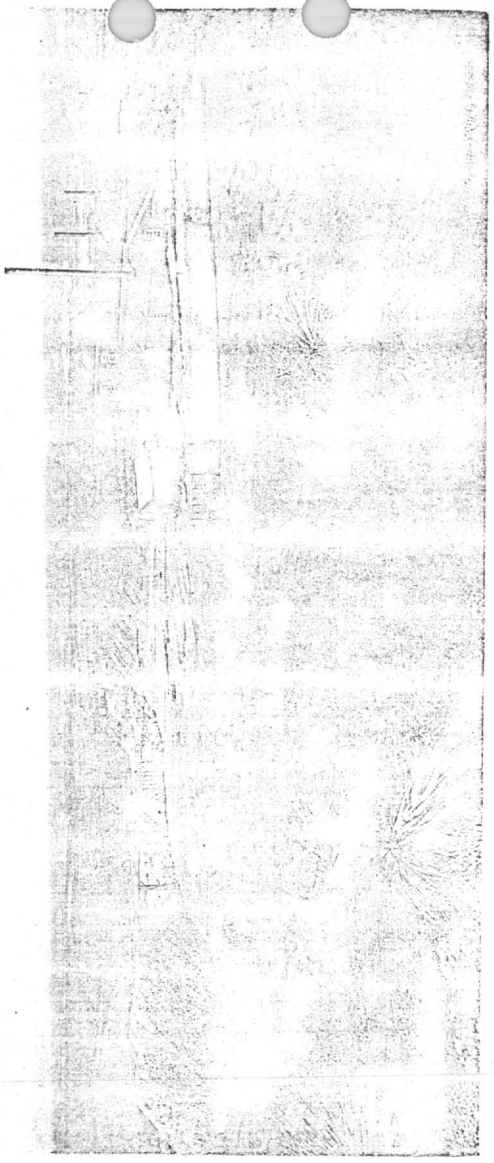
At the time of my recent visit to the claim (1902) I looked in the waste piles for evidence of quantities of such limestone in the mine and was not successful. It is probable that the samples I had were from some masses of secondary deposition. Since, also, the operations upon the Lucky Cuss Claim disclosed a body of manganese sulphide—the mineral species Alabandite—the mystery to me is solved. Alabandite is the sulphide of manganese, and I have no doubt that the original included masses or kidneys of this sulphide, formed

In the midst of the limestone, are the source, by decomposition and precipitation, of manganese ores of the pipes or chimneys, the solutions having spread laterally and downward along the crevices, enlarging them by the corrosion of the walls with the formation of the pipe-like ore-bodies of manganese oxide, and, in places, the deposition of calcite, snow-white in part, and in other places possibly containing manganese oxide.

This explanation of the origin of the manganiferous ores would make clear the origin of the peculiar and irregular forms in which the ores are found. They occupy irregular crevices without the tabular form characteristic of the filling of deep-seated fissures. It may be safely assumed that the extent of such ores, laterally or in depth, depends upon the magnitude of the original bunch or pocket of sulphide which has undergone decomposition. Deep mining below the water may be expected to encounter, as in the Lucky Cuss, unchanged masses of manganese sulphide. Masses above the water and exposed to atmospheric influences have undergone oxidation with the formation of oxides precisely as is the case with sulphide of iron. The source of the silver and gold in the manganiferous ores is no doubt the original manganese sulphide with which they are combined or closely associated. Analyses of the alabandite will throw light upon this question.

From tests and analyses made at the Massachusetts Institute of Technology it was concluded that the portion of the silver in the ore (not in the sulphide) which was not in combination with chlorine was united with copper, antimony and sulphur as in the mineral species grey copper, or tetrahedrite. Analyses of milling ores showed from 42 to 74 per cent. of sesqui-oxide of manganese, and from 18 to 25 per cent. of silica, in round numbers, with various other constituents in small quantities, including the precious metals.

All of the chimneys yielded ore assaying from 30 to 50 ounces of silver per ton near the surface.

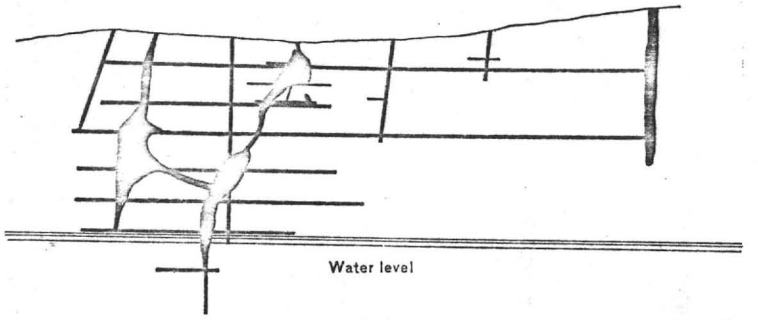


HOISTING WORKS, LUCKY CUSS MINE

Lucky Cuss Mine

The Lucky Cuss Mine, situated a short distance below U. S. Mineral Monument No. 2, is the deepest mine in the camp as respects the water-level and the geological horizon. It is opened on or adjoining the contact of limestone with the granite, and also on the line of one of the veins crossing the series of anticlines and synclines and prolonged beyond the limestone into the granite, where the fissure can be plainly seen, and has been explored sparingly by a succession of pits from which ore can be taken.

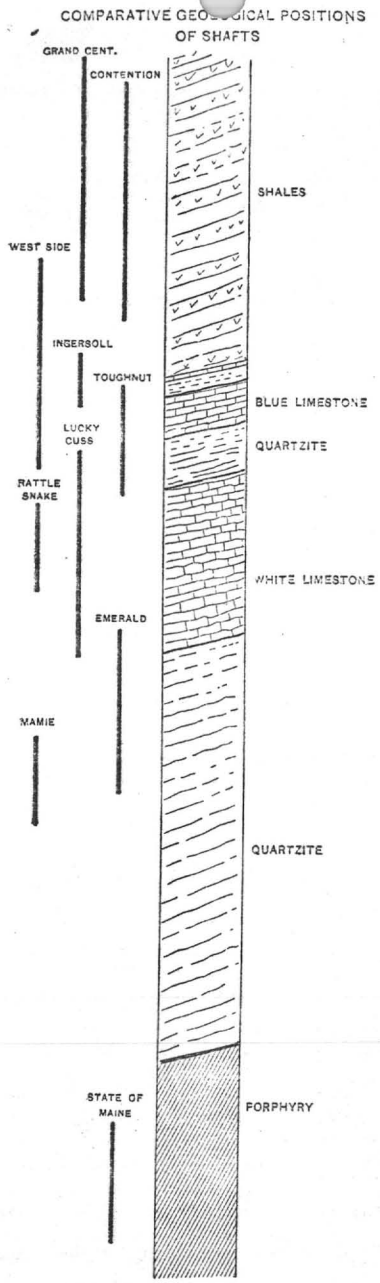
FIG. 17. *Section of the Lucky Cuss Mine.*



At a depth of 490 feet in the shaft water was encountered. This mine has yielded over $400,000 in value of ore. The ore was good to the water level and below it. It assayed well in gold and silver and lead. Free gold has been found and a telluride is reported. The ores are manganiferous, and a considerable amount of manganese oxide has been taken out. The interesting mineral—the sulphide of manganese "Alabandite"—occurs here in the limestone under one of the intruded tongues of granite or dike rock.

The accompanying drawing represents the mine in longitudinal section. It shows the form of the ore deposits, and the several shafts and levels extending to and below the water (Fig. 17).

FIG. 2



Comparative Geological Position of Shafts

A very interesting illustration has been prepared for me by Engineer Staunton showing the comparative geological position of the chief shafts of the District as respects the geological horizon penetrated in each case. The vertical section of the formation is in accord with the view held by Mr. Staunton and others that the manganiferous limestones underlie the Contention and Toughnut series conformably. It shows at a glance that ores have been found and mined in all the formations.

Chapter Four—The Production

THE value of the aggregate production of gold and silver from the mines of Tombstone is placed by competent judges at not less than $34,000,000. This is partly from records of yield and is partly from estimates.

Table of Production to 1882

At the time of the publication of my paper upon the Geology and Veins of Tombstone in the year 1882,* the output of the precious metals, gold and silver, up to the first of January, 1882, aggregated $7,359,000, and over $3,000,000 had been disbursed in dividends. This product was distributed among the following-named mines and mills:

Tombstone Mill & Mining Company	$2,704,936.33
Contention Consolidated	2,703,144.39
Grand Central	1,050,875.30
Head Center	191,520.52
Vizina	526,716.98
Ingersoll	15,000.00
Sunset	15,000.00
Corbin Mill	40,000.00
Boston Mill	112,007.83

Dividends.

Tombstone Mill & Mining Company	$1,100,000.00
Contention Consolidated	1,375,000.00
Grand Central	600,000.00
Vizina	80,000.00

It is the opinion of Mr. J. W. Dean that the Tombstone District has yielded at least $40,000,000 in value that can be accounted for.

* Transactions of the American Institute of Mining Engineers, Volume X, pages 334-345. May, 1881, to February, 1882.

Mr. A. L. Grow, who has been familiar with the mining operations of camp since discovery i[n] statement made to me some years ago, before the consolidation, says:

"About 1887 it was reported that the Tombstone District had produced something over $34,000,000. Official records show that the Grand Central gave $7,000,000 ($2,000,000 dividends) and a large amount for improvements and purchase of other mines. The Contention gave $6,030,142—$2,575,000 in dividends. The Tombstone Mill & Mining Company gave about $8,000,000, but have no data as to dividends.* The Head Center & Tranquillity Company took out over $600,000, but spent all in improvements and litigation. The Vizina, $700,000; Watervale Company, $600,000; Telephone Company, $200,000; other mines that we have no record of, about $7,000,000."

These figures show the relative importance of the chief properties at that time as producers. Corroborative data from other sources and some further historical notes may here be presented relative to the three leading groups of mines; the Contention Consolidated; the Grand Central and the Tombstone Mill & Mining Company.

The Contention Consolidated

Patrick Hamilton, in his Resources of Arizona, published in 1884, wrote of the Contention property, that it was first incorporated in 1880 as the Western Mining Company, which, about the close of the year 1881, on the consolidation of the property with the Flora Morrison and 600 feet of the south end of the Sulphuret, was changed to the Contention Consolidated Mining Company.

"In 1882 the company extracted a total of 25,017 tons of

* Mr. W. F. Staunton, formerly superintendent of the Tombstone Mill & Mining Co., states that the net earnings of this company were over $2,000,000, of which $1,500,000 was paid in dividends and the balance absorbed in litigation and purchase of property.

ore an average of 2,086 tons per month. That produced 632 bars of bullion, valued at $1,676,705.96.

"In the first five months of 1883 the ore saved and treated amounted to 13,652 tons, which produced 205 bars of bullion, valued at $553,085.91."

At that time there were five levels opened; the depth of the main shaft was 600 feet, and the amount of underground workings on all of these properties in the consolidation, including drifts, cross-cuts, winzes, raises, intermediary levels, etc., measured twenty miles.

The following tabular statement shows the value of the yield of the Contention Company for one year (1882):

January	$121,886.33
February	128,726.01
March	148,704.15
April	126,152.69
May	116,820.03
June	166,041.22
July	148,017.43
August	154,511.64
September	152,173.74
October	139,328.39
November	144,226.84
December	133,766.31
Total	$1,678,354.68

The Grand Central Mining Co.

The first claim of this group was one of the earliest located and one of the largest producers of the District. It adjoins the Contention on the south and is one of the group consisting of the Grand Central, the Grand Central South Extension, the Naumkeag and the Leviathan. Also the Emerald and other claims were under the same ownership and control. As early as the year 1882 the shaft had reached a depth of 600 feet, and the principal levels and openings had been connected with the Contention. Full reports of the value

of the production are not obtainable, but the amount for a period of eight months and thirteen days up to December 31, 1881, was $1,061,520; and during the last six months of that period monthly dividends of $50,000 each were paid, aggregating $300,000. During the same time an equal amount ($300,000), advanced to erect the company's mill and plant, was repaid.*

The 30-stamp mill was located on the San Pedro River, about two miles above the Contention mill. About 90 tons of ore were raised daily and worked at this mill.

This large mining property and milling plant was from the first under the able and conservative management of Mr. E. B. Gage, who resided on the property, and directed its operations. Some interesting facts recently communicated by Mr. Gage regarding the ore-chutes of the Grand Central Mine will be found under the head of Chapter V—The Lodes in Depth (page 75).

Tombstone Mill and Mining Co.

The several properties of this Company were for many years under the efficient management of Professor John A. Church, whose systematic and complete reports upon the progress of operations and on the weight, fineness and value of the bullion produced permit of the presentation of figures in detail for several years of the most active operations. Some of the latest figures are from the annual reports made by Mr. W. F. Staunton, while superintendent. These tables all have special value as concise records of what the mines produced from the blanket or interstratiform deposits.

The mines of the Tombstone Mill & Mining Company reached the greatest productiveness they have ever known during the year April 1, 1881, to March 31, 1882, the total yield having been:

* Report of the Director of the U. S. Mint upon the annual production of Precious Metals in the United States. Pages 314-315.

Ore	29,[illegible] tons
Number of bars	478
Crude Bullion	[illegible],390,763.00 ounces
Fine Gold	2,462.84 "
Fine Silver	1,198,118.92 "

Approximate market value:

Of Silver	$1,325,040.23
Of Gold	51,006.90
Total	$1,376,047.13

One ton of ore has yielded on the average:

Of fine Silver, 41 ounces	market value,	$45.60
	assay "	53.02
Of fine Gold, 0.084 ounce	"	1.74
Total market value per ton		47.34
Total assay value per ton		54.76

Ore Production

October 1, 1881, to March 31, 1882

	No. 6 Tons	Combination Tons	Main Shaft Tons	North West Tons	West Side Tons	Total Tons
October	Merged in combination.	1,361.25	852.04	368.87	83.64	2,665.80
November		1,147.56	1,023.04	248.77	45.31	2,464.68
December		1,264.97	1,021.70	264.01	88.80	2,639.48
Jan., 1882		1,496.25	1,470.94	261.00	66.60	3,294.79
February		1,442.95	1,136.80	181.24	54.73	2,815.72
March		1,564.83	1,324.72	167.78	44.78	3,102.11
Second 6 mo.		8,277.81	6,829.24	1,491.67	383.86	16,982.58
Total		11,946.35	12,792.68	2,600.56	508.02	29,211.66

Bullion Product

April 1, 1881, to March 31, 1882

	Net Value	Silver Ounces	Fineness Silver	Gold Ounces	Fineness Gold	Base Metals	Percent. Base
April, '81	$83,554.78	70,942.83	859	263.00	.003	11,288.17	14.1
May	92,806.69	79,170.76	898	268.29	.003	8,723.57	9.9
June	135,496.08	118,781.64	885	192.28	.001	15,203.08	11.33
July	123,245.31	107,617.97	887	201.56	.001	13,582.47	11.19
August	151,279.15	133,199.12	896	178.25	.001	15,223.63	10.25
Sept	111,495.97	97,520.04	877	172.16	.001	13,557.80	12.19
1st 6 mo.	$697,877.97	607,232.36	...	1,275.54	....	77,578.72	.....
October	$114,229.70	97,694.96	851	174.06	.0015	17,015.79	14.8
Nov	112,092.73	97,789.62	829	183.74	.0016	20,386.19	17.3
Dec	130,730.26	114,387.44	825	170.84	.0012	23,970.16	17.3
Jan., '82	130,156.05	112,272.52	922	257.19	.002	11,910.75	9.6
Feb	116,165.52	99,732.68	860	254.91	.0022	15,875.91	13 7
March	79,084.74	68,909.34	740	146.56	.0016	24,039.68	25.9
2d 6 mo.	$682,459.00	590,886.56	...	1,187.30	.....	113,198.48	.....
Total	$1,380,336.97	1,198,118.92	862	2,462.84	0.0017	190,777.20	13.72

Number of bars	478
Gross weight	1,390,763
Average fineness, Silver	861
" " Gold	1.7
" percentage Base Metals	137.2

The product from April 1, 1882, to March 31, 1883, was:

Ore mined	21,991.02 tons
Ore milled	21,474.00 "
Fire clay and limestone mined for furnace	60.67 "

The mill produced:

Number of Silver bars	232
Crude Bullion (Mint weight)	642,830.02 ounces
Fine Silver	532,372.03 "
Fine Gold	1,813.00 "
Base Metal	102,823.82 "
Market value of Silver, deducting discount, freight and shortage	$565,790.67
Market value of Gold	37,474.71
Total	$603,265.38
The furnace produced	2,708 bars
Containing fine Silver sold	40,883.57 ounces
" " Gold "	298.81 "
" Lead "	263,333.00 pounds
Market value of furnace product, deducting freight and charges	$55.062.31
Base Bullion on hand	6,000.00

The total marketed product of the year's work was:

Silver,	573,255.60 ounces	value,	$609,960.85
Gold,	2,111.81 "	"	43,487.93
Lead,	131.67 tons	"	4,878.91
			$658,327.69

Bullion Product

April 1, 1882, to March 31, 1883

(By Mint returns)

	No. of Bars	Gross Weight Ounces	Silver Ounces	Gold Ounces	Base Metal Ounces
April, 1882	40	112,864.30	75,258.24	257.58	37,348.48
May	30	76,017.30	35,631.71	102.55	40,283.04
June	18	49,140.70	47,649.62	42.39	1,448.69
July	20	54,020.90	51,154.01	50.08	2,816.81
August	15	42,021.90	41,146.04	50.64	855.22
September	18	49,357.35	48,755.54	97.04	474.77
First 6 months	141	383,422.45	299,595.16	600.28	83,227.01
October	16	44,983.10	43,551.95	163.42	1,267.73
November	16	43,032.00	38,297.24	202.00	4,532.76
December	14	39,717.50	35,364.61	157.83	4,195.06
January, 1883	12	34,449.10	30,072.01	169.45	4,207.64
February	14	38,845.70	36,375.10	219.55	2,251.05
March	19	52,559.00	49,115.96	300.47	3,142.57
	91	253,586.40	232,776.87	1,212.72	19,596.81
Total for year	232	637,008.85	532,372.03	1,813.00	102,823.82

Average fineness, Silver	8
" " Gold	
Percentage, Base Metal	161.41
	1,000.00

Ore Production

April 1, 1882, to March 31, 1883

	Main Works Tons	Combination Tons	West Side Tons	Lucky Cuss Tons	Defence Tons	Northwest Tons	Total
April, 1882	1,211.67	1,393.12	61.55	....	....	144.06	2,810.40
May	1,187.72	1,390.84	53.02	....	...	143.28	2,774.86
June	108.23	1,469.21	177.32	....	....	.....	1,754.76
July	104.02	1,522.05	257.46	....	....	.....	1,883.53
August	367.75	1,334.53	198.57	....	....	.....	1,900.85
September	366.52	895.81	533.08	78.20	....	.....	1,873.61
First 6 mos.	3,345.91	8,005.56	1,281.00	78.20	....	287.34	12,998.01
October	504.65	460.03	746.87	148.84	....	Limestone and Fire Clay	1,860.39
November	481.70	463.04	764.58	164.53	50.00	11.05	1,923.85
December	494.21	373.95	766.17	152.83	Tribute	11.05	1,787.16
January, 1883	336.32	61.80	635.90	133.00	....	37.50	1,167.02
February	230.37	63.20	570.30	17.35	50.78	12.12	932.00
March	257.48	45.68	768.90	185.53	65.00	.....	1,322.59
Second 6 mos.	2,304.73	1,467.70	4,252.72	802.08	165.78	60.67	8,993.01
Total for year	5,650.64	9,473.26	5,533.72	880.28	165.78	348.01	21,991.02

The operations of the year, April 1, 1883, to March 31, 1884, were as follows:

Ore mined	17,410.79 tons
Limestone mined	109.73 "
Ore milled	16,042.67 "
Tailings concentrated	16,969.00 "
Ore and Flux smelted	1,527.85 "

The mill produced:

Number of Silver bars	169
Crude Bullion	466,395.05 ounces
Fine Silver	402,063.89 "
Fine Gold	1,896.27 "
Base Metal	62,434.89 "
Market value of Silver, deducting all charges but transportation	$431,739.92
Market value of Gold, deducting Mint charges	39,195.91
Total	$470,935.83
The furnace produced	11,851 bars
Weight of product	654.47 tons
Containing fine Silver sold	193,560.70 ounces
" " Gold "	1,178.60 "
" Lead "	645.84 tons
Market value of furnace product, deducting charges	$254,267.22

The whole record of the Tombstone Mill & Mining Company and its predecessors in the mining of ore and production of metals is as follows, the table including only the marketed product:

	Ore Tons	Gold Ounces	Silver Ounces	Lead Tons
June–September, 1879	2,025.00	284.86	129,215.81	.....
October, 1879–March, 1880	3,733.00	450.60	137,375.06	.....
April–September, 1880	7,242.00	745.70	392,017.11	.....
October, 1880–March, 1881	9,363.05	1,099.42	474,831.77	.....
April–September, 1881	12,229.08	1,275.54	607,232.26	.....
October, 1881–March, 1882	16,982.58	1,187.30	590,886.56	.....
April–September, 1882	12,998.01	600.28	299,595.16	.....
October, 1882–March, 1883	8,993.01	1,212.72	232,776.37	131.67
April–September, 1883	8,545.12	1,734.54	299,297.75	266.48
October, 1883–March, 1884	8,975.39	1,340.34	296,326.84	379.35
Total	91,086.24	10,931.30	3,459,554.69	777.50

Ore was mined and marketed from the Lucky Cuss and West Side claims as follows:

	Dry Weight Tons	The Ore Contained: Silver Ounces	Gold Ounces	Lead Pounds
Lucky Cuss, Apr. 1, '88, to Apr. 1, '89	2,566.423	107,978.66	1,519.27	68,501
" " Apr. 1, '89, to July 1, '89	687.264	25,706.94	355.66	....
West Side, Apr. 1, '88, to Apr. 1, '89	480.796	40,674.03	893.49	70,298
" " Apr. 1, '89, to July 1, '89	150.797	12,663.89	240.63	13,980
Total	3,885.279	187,023.52	3,009.05	152,779

Ore was mined and marketed during the year July 1, 1889, to June 30, 1890, as follows:

	Dry Weight Tons	The Ore Contained: Silver Ounces	Gold Ounces	Lead Pounds	Average Grade per Ton: Silver Ounces	Gold Ounces
Lucky Cuss	2,487.532	110,953.63	1,161.03	61,193	44.60	0.466
Sulphuret	500.319	42,411.44	966.35	44,828	84.77	1.931
Northwest	274.367	23,895.48	38.71	58,674	87.09	0.141
Total	3,262.218	177,260.55	2,166.09	164,695	....	....

Shipments to the smelter for the year ending June 30, 1891, were as follows:

	Dry Weight Tons	Contents: Silver Ounces	Gold Ounces	Lead Pounds	Average Grade per Ton: Silver Ounces	Gold Ounces
Lucky Cuss Mine	2.270.865	124,681.89	1,681.87	145,313	54.905	.74
W.Side-Sulphuret Mine	1.105.252	81,004.58	1,526.90	316,136	73.29	1.38
Northwest Mine	458.002	30,751.46	98.69	116,836	67.14	.215
Assay Office, Clean-up	14.884	773.96	8.18	2,082	52.00	.55
Charleston Slag Dump	42,406	2,589.91	23.67	6,066	61.07	.56
Total	3,891.409	239,801.80	3,339.31	586,433	61.625	.853

Shipments to smelters the year ending with June 30, 1892, were as follows:

	Dry Weight Tons	Contents: Silver, Ounces	Gold, Ounces	Lead Pounds	Average Grade per Ton: Silver Ounces	Gold Ounces	Percent. Lead
Lucky Cuss Mine	2,683.63	116,973.40	1,253.53	280,606	43.58	.46	5.24
West Side-Sulphuret Mine	1,489.77	99,025.61	1,688.87	381,912	66.47	1.13	12.82
Northwest Mine	1,413.06	124,061.79	500.94	262,407	87.79	.35	9.30
Toughnut Mine	1,101.69	97,455.42	603.29	248,956	88.45	.55	11.30
Assay Office, Clean-up	16.97	899.35	8.82	2,476	53.00	.52	7.30
Charleston	322.70	22,090.17	152.35	86,469	....	....	....
Total	7,027.82	460,505.74	4,207.80	1,262,826	65.52	.598	8.98

Shipments to smelters for the year ending with June 30, 1893, were as follows:

Mines	Dry Weight Tons	Contents: Silver Ounces	Gold Ounces	Lead Pounds	Average Grade per Ton: Silver Ounces	Gold Oz.	Percent. Lead
Lucky Cuss	3,728.93	93,801.93	430.63	193,328	25.15	.11	2.59
West Side-Sulphuret	1,183.89	57,547.92	971.12	179,659	48.61	.82	7.58
Northwest	1,427.35	124,253.19	256.82	288,990	87.05	.18	10.12
Toughnut	2,095.62	116,200.58	1,288.68	541,208	55.45	.61	12.91
Charleston	16.59	361.55	2.98	1,824	21.80	.18	5.50
Total	8,452.38	392,165.17	2,950.23	1,205,009	46.39	.35	7.12
Total previous year	7,027.82	460,505.74	4,207.80	1,262,826	65.52	.598	8.98

Value of the Ores

There are two classes of ore produced at the Tombstone mines—the milling ores and those best adapted to smelting. Both classes are high grade. They yield gold, silver and lead. The average value of the ore worked by milling in 1881 was reported as $70 per ton. It is said and believed by competent judges familiar with the yield of the ores of the Tombstone District that the general average value was $45 per ton, being the highest average value ever reached in any important district on the Pacific Coast. Averages of samples and the certificates of returns from the smelters sustain that claim. The figures given in the preceding pages may be consulted for detail of the returns from large quanti-

ties of ore, both milling and smelting, and from different mines.

A recent assay of a sample taken by me from the lode on the 600-foot level of the Contention, a few feet above the water level, showed the presence of 47.07 ounces of silver and 2.31 ounces of gold, worth $47.74 per ton, or a total value of about $76 per ton, estimating the silver at 60 cents an ounce. Samples taken by Mr. Gray, selected ore, ran as high as 3.2 ounces gold and 98 ounces of silver. Examples might be multiplied, but returns on large lots as shipped are more satisfactory. Reference is made to the description of the Contention lode, in Chapter V, for a report of the result of more recent assays. See p. 78.

The lot of ore from the Tranquillity Mine shipped in April, 1902, 40,224 pounds, yielded per ton gold 2.4 ounces; silver, 98 ounces, and contained 14 per cent. of lead, making a very desirable ore for smelters. According to Mr. J. W. Dean, one of the former owners, the smelting ores shipped from Tombstone in 1899 averaged in value from $4,000 to $6,000 to the car load; assuming the car load at 20 tons this would be from $200 to $300 per ton in value. Such ores were selected so as to justify the great cost of hauling and transportation, but with a railway connection, and possibly a smelter in the camp, ores of a much lower average would be worked profitably.

Increase of Gold Relatively to Silver in Depth

The bullion produced from the ores, especially from those of the Contention lode, consisted largely of gold. The relative amount of gold and silver varies with the different mines and ores. In the year 1881, at the Contention, the gold formed 20 per cent. of the total value, but as greater depths were reached the value of the gold increased to 25 per cent.

This relative increase is good for other mines and for the blanket deposits as well as for the veins.

In the Toughnut and Goodenough claims the ores carried a little gold at the surface, but in depth they carried $30 per ton in value in the ore-chutes pitching towards the Empire claim.

An increase in the amount of gold relatively to silver in the lower levels of the Grand Central was noted in 1882. It is said that the value in gold at that time ranged from $85 to $112 per ton.

In the West Side claim the ore in the upper levels carried about $7.66 per ton, with an increase of $13 per ton in the ores from the lower levels. The ores from the deep workings on the Sulphuret claim carried about $20 in gold per ton.

In the Contention the gold content increased as compared with the silver, as already indicated, and it is reported that at 75 feet below the water-level mining was carried on in an extensive body of ore that averaged $100 per ton in value of gold.

Perhaps the most notable example of increase in the amount of gold relative to the silver was found at the Lucky Cuss mine opened in the manganese-bearing limestone. Starting at the surface with only a trace of gold in the ore, at the water level the average value was $35.14 in gold in car load lots. The increase was almost in a direct ratio with the depth as shown by the returns from the smelters. In some shipments the value of the gold was as high as $51 per ton.

It is not to be inferred from these examples that the ratio of the gold to the silver, or the increase in the value of the ore, will increase with depth indefinitely. The augmentation is believed to be confined to the surface ores, or to ores lying above the permanent water-level. Below this level there is no reason to expect a constant increase in value with depth, for the ores may be assumed to have their normal condition where covered permanently by water.

The decompositions and recompositions incident to atmos-

be considered as sufficient to affect the amount of gold at different distances from the surface.

At the Contention mine in 1882 flakes of native gold were common in the seams and surfaces of the porphyry, and it occurs at the present time in the ores of the Tranquility mine in visible grains, making rich and handsome cabinet specimens.

Second Class Ores

Large quantities of ores extracted from the Contention and from the Grand Central and other mines upon the Contention lode, in which the average content in gold and silver was not sufficient in value to justify carting to the mills on the San Pedro have been profitably treated by the cyanide process.

The erection of mills at the mouth of the mines, or the rapid and cheap transportation which will be provided by the railway will permit of working ores to advantage that formerly had to be left on the dumps.

Nature of Ores Below the Water

It is to be expected that in this Tombstone camp and its mines, as in all other mines, the ores below the permanent water-level will be more pyritic—will contain more sulphur—than the oxidized ores above the water. We may, in short, look for ores that are not oxidized. The values will be there, but the method of treatment for the extraction of the values will be different from the treatment of ores from above the water. It is not yet possible to state what process will be best adapted to the end. It may be that roasting and chlorination will be resorted to, or it may be best to smelt. The smelting furnace will no doubt be the proper destination for such ores as are heavily charged with lead, as is now the case with some of the ores from the bedded deposits in the limestone and in the stopes of the Tranquillity.

Chapter Five—The Lodes in Depth

Contention Mine

IN the winter of the year 1882 I made an extended and careful study of the various workings of the Contention, Head Center and the Tranquillity mines in company with the late Mr. Isaac E. James,* the engineer and surveyor, and have notes of the lode and ore-bodies and stopes. I was able to trace these ore-bodies from the surface to the 600-foot level, just above the water line, and to note their continuity and the satisfactory evidences of the downward extension of the lode and its ores into and below the water. I was not present when the water was lowered by pumping, but in company with Mr. James had previously been to the lowest winze on the lode and saw a strong lode of quartz extending into the water. It had the appearance of being leached out at the water level and for a few feet above it, as if by the seasonal changes of water-level the ores had been removed, leaving a cellular skeleton-mass of white quartz. The inference was unavoidable that greater depth under the water would show good ore in the lode.

* "Ike" James, as he was familiarly known by the miners and intimate friends upon the Comstock Lode, and later at the Contention, was an accomplished surveyor and draughtsman. He was thoroughly familiar with the workings of Tombstone mines, especially of the Contention, and made beautiful and accurate maps of the lodes and a model of the whole mine. He made the earliest maps of the Ophir and other mines on the Comstock Lode. After the fire which destroyed the pump and hoisting works of the Contention, Mr. James was engaged for a time at other mines and then went to San Diego, California, where he died. He was a most genial, intelligent and charming companion in my underground investigation of the Contention Lode.

W. P. B.

The [illegible] census of opinion and statement by competent observers and judges at the time, and since, is that ore values will be maintained in depth. This is my belief also. It is based upon the knowledge gained as above stated and upon the fact that I have recently visited different parts of the 600-foot level of the mine, where winzes have been sunk to and into the ground now covered by water and have seen good ore there.

Other points at which ore has been shown to extend to and below the water were visited by me in the extreme east workings of the Contention on the 600-foot level, where two winzes show ore of good grade.

It is interesting to take note of the experience in deep mining at the celebrated Commonwealth, at Pearce, one of the nearest precious metal mines of great extent. The ores at that lode were in an oxidized state above the permanent water line, and it was supposed that on mining below the water only sulphuretted ores would be found. But the oxidation has extended to a greater depth and no radical change of treatment of the ore has been found necessary. The ore is as rich below the water as above. This fact alone is sufficient, if there were no other evidences, to relieve any doubts regarding the downward extension of the ores in the Tombstone Camp.

At the several points where mining operations on ore-bodies have reached water-level the evidences of continuity have been highly satisfactory. It would be an anomaly in mining if the ores so liberally formed above the water did not extend with equal value below its level. It is geologically certain that the present surface level of the country is now much lower than it formerly was, this lowering or cutting away being the result of the mighty erosive agencies to which Arizona has been subjected. The ancient surface was probably some hundreds of feet higher than now and the ancient water level was correspondingly higher than now, so that the ore deposits we have been able to mine were once below the

water. And if we now lower the water artificially we may expect to uncover ores as rich or richer than those uncovered by the gradual subsistence of the water level from natural causes.

This question of the continuity of ore below the water has been much discussed. That ore should so continue, theoretically, has already been sufficiently stated and shown. But it is now a matter of *fact* rather than of theory. While not present when the two great pumps were in action, one at the Grand Central, the other at the Contention, I am most credibly informed that the water was drawn out enough to permit of winzes being sunk at intervals below the 600-foot mark for the purpose of testing the lode. Owing to the broken character of the ground, the water receded at points quite remote from the shafts almost as fast as in the shafts. The shafts themselves were extended downward for approximately 100 feet below the water-level, an important fact, showing that the water can be controlled by proper pumping.

High grade gold ore was found in the winze upon the east ledge, about 400 feet north of the Contention pump shaft. A letter from the then president of the Contention Company stated that at a depth of 75 feet in this winze "a drift was run for a distance of 140 feet, and that the ore taken therefrom averaged over $100 per ton in gold." Ore of excellent grade was found in the other winzes, but this winze was the only one in which any considerable amount of drifting was done.

In a recent letter from Engineer Staunton (Sept. 4, 1902) he says: "We are now running a drift on this east ledge northward from the top of the winze on the 600-foot level, and are getting a good showing of ore, an assay from which, received that morning, showed 22.6 ounces silver and 2.9 ounces gold, or a total value of $71.24, figuring silver at 50 cents an ounce. Another assay received to-day also shows the same strikingly high proportion of gold to silver, which we are finding to be the rule on the water level. It is from

one of a number of bunches of ore found in the country rock east of the west ledge, where we are excavating a station for a hoisting engine to be used in sinking the winze and running drifts when the water is lowered. The assay was 7.4 ounces silver and 2.2 ounces gold; a total value of $49.57, of which $45.87 was gold and $3.70 was silver."

The influence of wall rocks upon ore deposition is a factor not disregarded. It has been pointed out fully that the ores of the Contention were deposited not only where the lode intersected limestone beds but also where the walls were of shale and of sandstone or quartzite. It is therefore just to expect ore deposition along the walls formed by the lower formations, especially where these formations are the downward prolongation or extensions of beds known to be peculiarly ore-bearing above the water. The structure of the beds, as already shown, gives evidences of an extended area of such contacts along the deeper parts of the Contention lode now submerged, but which will become accessible when the water is sufficiently lowered.

Grand Central Mine

In regard to the extreme south portion of the Contention lode the following facts are important.

Mr. Gage, as president and manager of the Grand Central Mine was familiar with the ore developments, and at my request informed me regarding the indications at the south end of the property, where it is believed that thorough exploration will reveal bodies of ore yet untouched. He writes: "We found some very good ore-bodies near the southwest corner of the mine which I have no doubt will extend below the water level, as the ore continued as strong to the water-level as it did in the north end, but not in quite as large bodies. In fact we had three ore chutes in the Grand Central Mine. One was the extension of the same ore-body the Contention had in the south end of that mine. One to the south

of and near to the old working shaft, [illegible] the [illegible] near the southwest corner, which chute extended partly into the Naumkeag, a side line claim on the west of the Grand Central, and which the Grand Central owned."

New Shaft

At the bottom of the new Combination Shaft, on excavating for the pump station just above the water, a mass of heavy sulphide ore was found. This ore consists of pyrite and galenite, and it appears to occupy a saddle or roll of the beds. This mixture of galenite and iron pyrites is characteristic of the interstratified bedded deposits rather than of the ores of the dikes and veins.

Intersection of the Lode by Bedded Deposits

It is just to expect great results from the deep contacts of the limestone beds with the lode. Of the several sections upon the line of greatest extension of the workings upon the anticlinal folds carefully drawn to scale from the notes and sections of Mr. Gray and Mr. Staunton, one alone has been chosen as typical of the rest and as sufficiently illustrating the fact of the pitch of the rolls, the depth to which the stoping on ore has extended and the theory of the prolongation of the limestones and other beds with their accompanying blanket deposits of ore under the water-level to the Contention lode. This has already been discussed in Chapter III.

The section shows the succession of the strata from the surface down; the several dikes crossing the strata, and also the veins. The Contention lode is on the extreme east, where the shaft and the several levels are indicated. The general water level is shown by the horizontal line. The blanket ore deposits, so far worked, are indicated by the heavy black lines, dipping downwards toward the

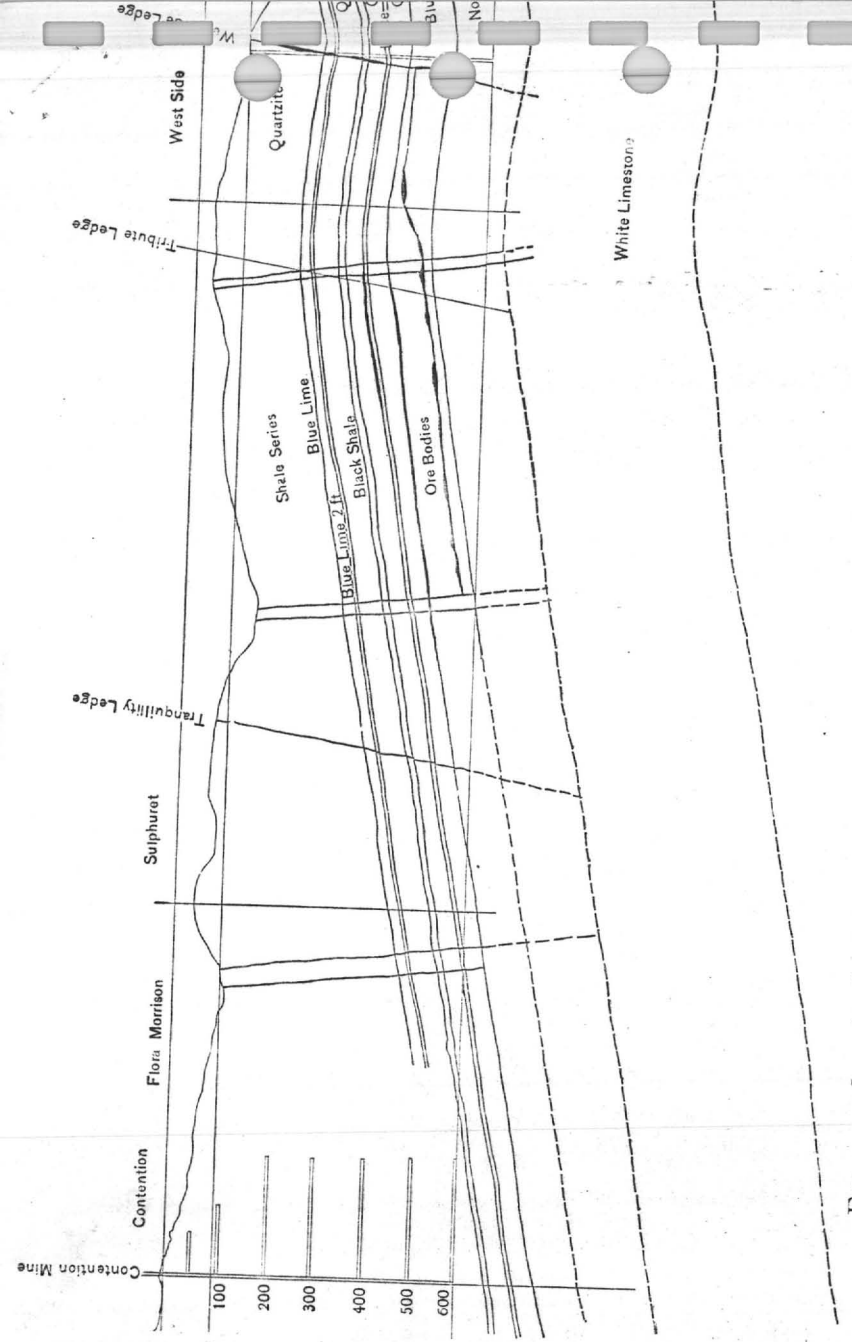


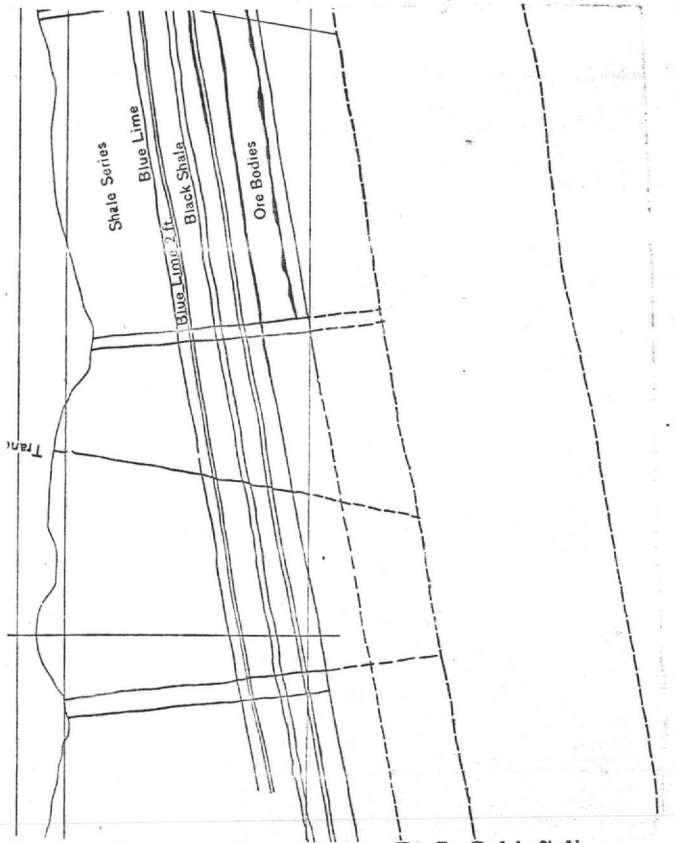
FIG. 19. *Longitudinal Section of the Blanket Deposits Following the West Side Anticline.*

Contention and extending near to the water line. I am indebted for the original of this illustration to Mr. H. J. Gray and to Mr. Staunton, who have made several such sections, following the crests of the different anticlinal folds. It will be noted that the prolongation of the ore-bearing ground downwards on the pitch if maintained unchanged would intersect the Contention lode about 200 feet below the 600 level (Fig. 19).

> the mines of the new Tombstone Consolidated Company and presented evidences of the nature and extent of the ore deposits, I do not hesitate to express the opinion based upon this evidence, and upon my experience of other localities, that paying ore-bodies will be found below the water-level on the Contention lode corresponding in value, extent, and distribution to those found on it above the water-level.

In the Tranquillity some excellent ore, showing free gold, is now being stoped out from bedded or blanket lodes by Mr. Grow. There are several places in this mine above water level from which ores of high grade can be extracted without

delay. The mine is well-equipped for immediate work, having levels opened, tracks laid and good hoisting works in running order. Ores have been regularly shipped from this property up to the date of its recent transfer to the Tombstone Consolidation.



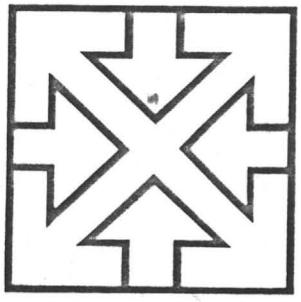
View of the Monument to E. S. Schieffelin.

In Conclusion

HAVING in the foregoing pages described the mines of the new Tombstone Consolidated Company and presented evidences of the nature and extent of the ore deposits, I do not hesitate to express the opinion based upon this evidence, and upon my experience of other localities, that paying ore-bodies will be found below the water-level on the Contention lode corresponding in value, extent, and distribution to those found on it above the water-level.

DRILL HOLE SUMMARY
TOMBSTONE DIST.

Consultants in:
• base & precious metals • uranium
• coal • geothermal • environment
• remote sensing • color aerial photography
• interpretation-image processing
• Worldwide Mobilization



4500 E. Speedway, Suite 14
Tucson, Arizona 85712
(602) 795-6097

James A. Briscoe, President
Registered Professional
Geologist

Southwestern Exploration Associates, Inc.

February 28, 1979

TOMBSTONE DRILLING SUMMARY

Drilling Group	Date	Drill Hole No.	Depth	Location
Bunker Hill	1936	DD-1	23'	T.D.C. Claims
Bunker Hill	1936	DD-2	75'	T.D.C. Claims
Bunker Hill	1936	DD-3	123'	T.D.C. Claims
Bunker Hill	1936	DD-4	151'	T.D.C. Claims
Bunker Hill	1936	DD-5	78'	T.D.C. Claims
Bunker Hill	1936	DD-6	20'	T.D.C. Claims
Bunker Hill	1936	DD-7	6'	T.D.C. Claims
Bunker Hill	1936	DD-8	40'	T.D.C. Claims
Bunker Hill	1936	DD-9	56'	T.D.C. Claims
Bunker Hill	1936	DD-10	180'	T.D.C. Claims
Bunker Hill	1936	DD-11	211'	T.D.C. Claims
Bunker Hill	1936	DD-11	75'	T.D.C. Claims
Bunker Hill	1937	CDH-1	380'	T.D.C. Claims
Bunker Hill	1937	CDH-2	75'	T.D.C. Claims
Bunker Hill	1937	CDH-3	460'	T.D.C. Claims
Bunker Hill	1937	CDH-4	430'	T.D.C. Claims
Bunker Hill	1937	CDH-5	385'	T.D.C. Claims
Bunker Hill	1937	CDH-6	295'	T.D.C. Claims
Bunker Hill	1937	CDH-7	506'	T.D.C. Claims
Bunker Hill	1937	CDH-8	298'	T.D.C. Claims
Bunker Hill	1937	CDH-9	295'	T.D.C. Claims
Bunker Hill	1937	CDH-10	385'	T.D.C. Claims
Bunker Hill	1937	CDH-11	400'	T.D.C. Claims
Bunker Hill	1937	CDH-12	215'	T.D.C. Claims
Bunker Hill	1937	CDH-13		T.D.C. Claims
Newmont	1954	DD-7	1650'	Silver Thread
Newmont	1955	DD-9	667'	West Side

Drilling Group	Date	Drill Hole No.	Depth	Location
Duval	1967	RDH-1	247'	T.D.C. Claims
Duval	1967	RDH-2	250'	T.D.C. Claims
Duval	1967	RDH-3A	250'	T.D.C. Claims
Duval	1967	RDH-3	108'	T.D.C. Claims
Duval	1967	RDH-4	80'	T.D.C. Claims
Duval	1967	RDH-5	50'	T.D.C. Claims
Duval	1967	RDH-6	250'	T.D.C. Claims
Duval	1967	RDH-7	219'	T.D.C. Claims
Duval	1967	RDH-8	148'	T.D.C. Claims
Duval	1967	RDH-8A	148'	T.D.C. Claims
Frankovitch	1959	DDH-1	230'	T.D.C. Claims
Frankovitch	1959	DDH-2	95'	T.D.C. Claims
Frankovitch	1959	DDH-3	51'	T.D.C. Claims
Frankovitch	1959	DDH-4	40'	T.D.C. Claims
Frankovitch	1959	DDH-5	270'	T.D.C. Claims
Frankovitch	1959	DDH-6	188'	T.D.C. Claims
Frankovitch	1959	DDH-7	90'	T.D.C. Claims
Frankovitch	1959	DDH-8	192'	T.D.C. Claims
Frankovitch	1959	DDH-9	125'	T.D.C. Claims
Frankovitch	1959	DDH-10	511'	T.D.C. Claims
Frankovitch	1959	DDH-11	287'	T.D.C. Claims
Frankovitch	1959	DDH-12	180'	T.D.C. Claims
Frankovitch	1959	DDH-13	146'	T.D.C. Claims
Frankovitch	1959	DDH-14	329'	T.D.C. Claims
Frankovitch	1959	DDH-15	350'	T.D.C. Claims
Frankovitch	1959	DDH-16	160'	T.D.C. Claims
Frankovitch	1959	DDH-17	205'	T.D.C. Claims
Frankovitch	1959	DDH-18	77'	T.D.C. Claims
71 Minerals	1976	RDH-1A	75'	Skip Shaft Area
71 Minerals	1976	RDH-101	55'	Skip Shaft Area
71 Minerals	1976	RDH-106	60'	Skip Shaft Area
71 Minerals	1976	RDH-107	60'	Skip Shaft Area
71 Minerals	1976	RDH-108	60'	Skip Shaft Area
71 Minerals	1976	RDH-109	60'	Skip Shaft Area
71 Minerals	1976	RDH-110	60'	Skip Shaft Area
71 Minerals	1976	RDH-111	60'	Skip Shaft Area
71 Minerals	1976	RDH-112	60'	Skip Shaft Area
71 Minerals	1976	RDH-113	60'	Skip Shaft Area
71 Minerals	1976	RDH-114	80'	Skip Shaft Area
71 Minerals	1976	RDH-115	60'	Skip Shaft Area
71 Minerals	1976	RDH-116	60'	Skip Shaft Area
71 Minerals	1976	RDH-117	80'	Skip Shaft Area
71 Minerals	1976	RDH-118	80'	Skip Shaft Area
71 Minerals	1976	RDH-119	80'	Skip Shaft Area
71 Minerals	1976	RDH-120	60'	Skip Shaft Area

Drilling Group	Date	Drill Hole No.	Depth	Location
71 Minerals	1976	RDH-120A	80'	Skip Shaft Area
71 Minerals	1976	RDH-121	60'	Skip Shaft Area
71 Minerals	1976	RDH-122	60'	Skip Shaft Area
71 Minerals	1976	RDH-123	73'	Skip Shaft Area
71 Minerals	1976	RDH-124	80'	Skip Shaft Area
71 Minerals	1976	RDH-125	130'	Skip Shaft Area
71 Minerals	1976	RDH-126	60'	Skip Shaft Area
71 Minerals	1976	RDH-127	80'	Skip Shaft Area
71 Minerals	1976	RDH-128	80'	Tranquility Shaft Area
71 Minerals	1976	RDH-129	70'	Tranquility Shaft Area
71 Minerals	1976	RDH-130	70'	Tranquility Shaft Area
71 Minerals	1976	RDH-131	65'	Tranquility Shaft Area
71 Minerals	1976	RDH-132	70'	Tranquility Shaft Area
71 Minerals	1976	RDH-133	73'	Tranquility Shaft Area
71 Minerals	1976	RDH-134	80'	Tranquility Shaft Area
71 Minerals	1976	RDH-135	80'	Tranquility Shaft Area
71 Minerals	1976	RDH-136	65'	Tranquility Shaft Area
71 Minerals	1976	RDH-137	55'	Tranquility Shaft Area
71 Minerals	1976	RDH-138	50'	Tranquility Shaft Area
71 Minerals	1976	RDH-139	50'	Tranquility Shaft Area
71 Minerals	1976	RDH-140	50'	Tranquility Shaft Area
71 Minerals	1976	RDH-141	50'	Tranquility Shaft Area
71 Minerals	1973	AT-1	55'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-2	50'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-3	75'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-4	65'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-5	50'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-6	80'	Unpatented T.D.C. Claims

Drilling Group	Date	Drill Hole No.	Depth	Location
71 Minerals	1973	AT-7	100'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-8	104'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-9	100'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-10	100'	Unpatented T.D.C. Claims
71 Minerals	1973	AT-11	100'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-1	50'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-2	45'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-3	48'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-4	10'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-5	10'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-6	10'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-7	48'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-8	48'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-9	48'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-10	48'	Unpatented T.D.C. Claims
71 Minerals	1973	TDC-11	48'	Unpatented T.D.C. Claims
71 Minerals	1973	RD-1	210'	Unpatented T.D.C. Claims
71 Minerals	1974	RD-1	608'	TMR Claims
71 Minerals	1974	RD-2	10'	TMR Claims
71 Minerals	1974	RD-3	185'	TMR Claims
71 Minerals	1974	RD-4	32'	TMR Claims
71 Minerals	1974	RD-5	500'	TMR Claims
71 Minerals	1974	RD-6	415'	TMR Claims
71 Minerals	1975	WWP-1	270'	State Of Maine
71 Minerals	1975	1-75	175'	Fox

Drilling Group	Date	Drill Hole No.	Depth	Location
Austral Oil	1968	DD-1	252'	West-Fox
Austral Oil	1968	DD-2	876'	West-Fox
Austral Oil	1968	DD-3	550'	West-Fox
Austral Oil	1968	DD-4	98'	West-Fox
Austral Oil	1968	DD-5	216'	West-Fox
Austral Oil	1968	DD-6	257'	West-Fox
Austral Oil	1968	H-1	300'	West-Fox
Austral Oil	1968	H-2	215'	West-Fox
Austral Oil	1968	H-3	500'	West-Fox
Austral Oil	1968	H-4	300'	West-Fox
Austral Oil	1968	H-5	250'	West-Fox
Austral Oil	1968	H-6	250'	West-Fox
Austral Oil	1968	H-7	250'	West-Fox
Austral Oil	1968	H-8	100'	West-Fox
Austral Oil	1968	H-9	140'	West-Fox
Austral Oil	1968	H-10	426'	West-Fox
Austral Oil	1968	H-11	250'	West-Fox
Austral Oil	1968	H-12	270'	West-Fox
Austral Oil	1968	H-13	250'	West-Fox
Austral Oil	1968	H-14	250'	West-Fox
Austral Oil	1968	H-15	250'	West-Fox
Austral Oil	1968	H-16	170'	West-Fox
Austral Oil	1968	H-17	285'	West-Fox
Austral Oil	1968	H-18	313'	West-Fox
Austral Oil	1968	H-19	490'	West-Fox
Austral Oil	1968	H-20	300'	West-Fox
Austral Oil	1968	H-21	270'	West-Fox
Austral Oil	1968	H-22	290'	West-Fox
Austral Oil	1968	H-23	207'	West-Fox
Austral Oil	1968	H-24	270'	West-Fox
Austral Oil	1968	H-25	290'	West-Fox
Austral Oil	1968	H-26	500'	West-Fox
Austral Oil	1968	H-27	200'	West-Fox
Austral Oil	1968	H-28	230'	West-Fox
Austral Oil	1968	H-29	235'	West-Fox
Austral Oil	1968	H-30	280'	West-Fox
71 Minerals	1973	HRD-1	265'	Seth Horn Claims
71 Minerals	1973	HRD-2	120'	Robbers Roost
71 Minerals	1973	HRD-3	120'	Robbers Roost
71 Minerals	1973	HRD-4	10'	Robbers Roost
71 Minerals	1973	HRD-5	10'	Robbers Roost
71 Minerals	1973	HRD-6	10'	Robbers Roost
71 Minerals	1973	HRD-7	35'	Robbers Roost

Drilling Group	Date	Drill Hole No.	Depth	Location
71 Minerals	1973	E-1	50'	So. Charleston Lead Mine
71 Minerals	1973	E-2	50'	So. Charleston Lead Mine
71 Minerals	1973	E-3	50'	So. Charleston Lead Mine
71 Minerals	1973	F-1	35'	So. Charleston Lead Mine
71 Minerals	1973	F-2	50'	So. Charleston Lead Mine
71 Minerals	1973	F-3	50'	So. Charleston Lead Mine
71 Minerals	1973	F-4	50'	So. Charleston Lead Mine
71 Minerals	1973	F-5	50'	So. Charleston Lead Mine
71 Minerals	1973	F-6	50'	So. Charleston Lead Mine
71 Minerals	1973	F-7	50'	So. Charleston Lead Mine
71 Minerals	1973	F-8	50'	So. Charleston Lead Mine
71 Minerals	1973	F-10	55'	So. Charleston Lead Mine
71 Minerals	1973	E-4	85'	So. Charleston Lead Mine