

THE  
MINING MAGAZINE  
AND  
JOURNAL OF GEOLOGY,  
Mineralogy, Metallurgy, Chemistry, and the Arts,  
IN  
THEIR APPLICATIONS TO MINING AND WORKING USEFUL ORES AND METALS.

EDITED BY

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SECOND SERIES.

VOLUME ONE.

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NOVEMBER, 1859, TO JULY, 1860.  
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NOVEMBER, 1859.

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ART. I.—SILVER AND COPPER MINING IN ARIZONA,\* WITH A  
MAP.

THE proposed new Territory of Arizona, better known as the Gadsden Purchase, lies between the thirty-first and thirty-third parallels of latitude, and is bounded on the north by the Gila River, which separates it from the territory of New Mexico; on the east by the Rio Bravo del Norte (Rio Grande), which separates it from Texas; on the south by Chihuahua and Sonora, Mexican provinces; and on the west by the Colorado River of the West, which separates it from Upper and Lower California. This great region is six hundred miles long by about fifty miles wide, and embraces an area of about thirty thousand square miles. It was acquired by purchase from Mexico, during the mission of General Gadsden, at a cost of ten millions of dollars. At that time there was scarcely any population, except a few scattering Mexicans in the Mesilla Valley, and at the old town of Tucson, in the centre of the Territory. The marauding Apache Indians had gradually extirpated almost every trace of civilization in what was once a thriving and populous Spanish Province.

\* Compiled for the *Mining Magazine*, from the various Reports and Statements of Messrs. Brunckow, Ehrenberg, Poston, Mowry, Parke, Emory, Bartlett, Parry, Schott, Gray, Blake, Ward, Wilson, and others.

Much interesting information upon the early history of this comparatively little known part of the United States, was obtained from the archives of the Mexican Government, by Capt. C. P. Stone, late of the U. S. Army. It appears that as early as 1687 a Jesuit missionary from the province of Sonora, which, in its southern portion, bore already the impress of Spanish civilization, descended the valley of Santa Cruz river to the Gila, which he followed to its mouth, now the site of Fort Yuma. From this point he ascended the valley of the Gila, the Salinas or Salt River, and other branches. Proceeding east, he explored the Valley of the San Pedro and its branches, reached the Mimbres, and probably the Rio Grande and the Mesilla Valley. Filled with the enthusiasm of his sect, he procured authority from the head of the order in Mexico, and established missions and settlements at every available point. In a report to the Viceroy of Spain, made during the early settlement of the Province, we find the following statement: "A scientific exploration of Sonora, with reference to mineralogy, along with the introduction of families, will lead to a discovery of gold and silver, so marvellous, that the result will be such as has never yet been seen in the world." A map of this and the adjoining territories was drawn by some of the Jesuit missionaries in 1757, and dedicated to the King of Spain.

The reports of the immense mineral wealth of the new country made by the Jesuits, induced a rapid settlement. The sites of more than forty towns and villages, some of them of considerable size, are indicated on the map. These settlements and missions were founded by the side of streams and springs in fertile valleys, which produced luxuriant crops of wheat, corn and beans, and in many parts grapes and other foreign fruits were cultivated. In the western part of the territory were the missions of St. Pierre, St. Paul, St. Matthias, St. Simond, St. Francisco Merci; the ranchos of Eau Cheri, Eau de la Lune, and others; on the Santa Cruz, the missions of San Xavier del Bac, Santiago, San Cayetano, and San Felipe, the towns of Tucson, Tubac, Reges, San Augusta and many others. San Xavier del Bac is still in existence. It is a mission Church of great size and beauty, magnificently ornamented within; forty thousand dollars worth of silver being used to adorn the altar. Upon the San Pedro river were the missions of St. Mark, San Salvador, Santa Cruz, and the

towns of Quiduria, Rosario, San Fernando, and others. To the east, some small settlements were found in the Valle del Sauz, on the Mimbres, at the copper mines north of the Mimbres, and to the south the immense grazing and stock-raising establishment of San Bernardino, where hundreds of thousands of cattle and horses have since been raised. The Indians in the vicinity of the missions were reduced first to obedience by the Jesuits, and then to slavery by the Spaniards.

The missions and settlements were repeatedly destroyed by the Apaches, and the priests and settlers massacred or driven off. The Indians, at length thoroughly aroused by the cruelties of the Spaniards, by whom they were deprived of their liberty, forced to labor in the silver mines with inadequate food, and barbarously treated, finally rose, joined with tribes who had never been subdued, and gradually drove out or massacred their oppressors. Civilization disappeared before their devastating career, and in its place we now find, with few exceptions, only ruins and decay, fields deserted, and mines abandoned. The mission of San Xavier del Bac, and the old towns of Tucson and Tubac, are the most prominent of these remains. The mission of San Xavier del Bac is a grand old structure, which, from its elegant masonry and tasteful ornaments, must have been erected in times of great prosperity.

From 1757 down to 1820, the Spaniards and Mexicans continued to work many valuable mines near Barbacora, and the ancient records and notes mention many silver mines, most of which contain a per centage of gold. Among them were the Dolores, San Antonio, Casa Gordo, Cabrisa, San Juan Batista, Santa Ana, (which was worked to the depth of three hundred and sixty feet), Rosario, Cata de Agua, Guadalupe, Connilla, Prieta, Santa Catarina, Guzopa, Hurstano, Arpa, Descuhidora, Nacosare, Arguage, Churinababi, Huacal, Pinal and a great number of others.

The most celebrated modern localities are Arivaca, (also anciently famous as *Aribac*), Sopori, the Arizona mountains, the Santa Rita range, the Cerro Colorado, the entire vicinity of Tubac, the Del Ajo, or Arizona copper mine, the Gadsonia copper mine, and the Gila river copper mines. As late as 1820, the *Mina cobre de la Plata*, (silver and copper mines,) near Fort Webster, north of the Gila, were worked to great advantage; and so rich was the ore that it paid for transportation on mule-back, more than a thousand miles, to the city of Mexico.

The silver mining region of Arizona is, in fact, the north-western extension of the great silver region of Mexico. The mountain ranges are the prolongations of those which southward in Sonora, Chihuahua, and Durango, have yielded silver by millions for centuries past. The general direction of the mountains and the veins, is north-west and south-east, and there are numerous parallel chains or ranges which form long and narrow valleys in the same direction. Like most mineral regions, Arizona is of small value for agriculture, possessing in comparison with its extent but little arable land, and in many parts is nearly destitute of water, and desert-like. Much of this forbidding and arid surface would, however, prove fertile if irrigated.

In March, 1856, several gentlemen who had spent several years in Sonora and the Gadsden Purchase, formed an association in Cincinnati, Ohio, for the purpose of sending out a small party to secure by purchase or discovery one or more of the old deserted mining ranches. Col. Chas. D. Poston, of Kentucky, with Mr. Ehrenburg and Mr. Frederick Bruncow, and a party of frontiersmen, were fitted out, and after several months of exploration, purchased the Arivaca ranche, near Tubac, and established the head-quarters of the company at the old mining town of Tubac, on the Santa Cruz river, and near the Santa Rita mountains and the northern spurs of the Arizona or Arizuma Range. This ranche, in addition to all its mineral wealth, contains twenty thousand acres of agricultural land, with permanent water, wood, and grass. It contains twenty-five silver mines, or openings, which were worked by the Mexicans previous to the Apache war, and became famous for their rich ores. The best known were Mina San José, Santa Margarita, Basura, Blanca, Arenias, Tajitos, Amado, and La Purissima. Titles were also acquired to many veins of silver ores in the Santa Rita mountains, among which were the old mines of Salero and Ojero.

Seven miles north-east of the Arivaca ranche, on the Cerro Colorado, other interesting and important mining localities were found, among which were the Heintzelman, Mina Carlos, Maria Cesario, Puertozito, Guadalupe, Amarillo, and Mina Longorenia. These results led to the permanent organization of the company known as the Sonora Exploring and Mining Company, of which Major S. P. Heintzelman, of the United States Army, who was several years stationed at Fort Yuma, was elect-

ed President. As the Heintzelman vein, which had been discovered by the party, afforded some very rich specimens of silver ore, attention was specially directed to it, and it was soon found expedient to concentrate all the labor there, and to temporarily suspend operations in the Santa Rita and Cajetano mountains. In August, 1857, the vein had been opened to a depth of fifty feet, and a pile of ore estimated by assay to be worth twenty thousand dollars for the silver, thrown out. The Salero mine was opened and cleared to a depth of eighty feet, and silver-bearing galena was being extracted in quantity from the Arenias mine. Samples of the ore from the Heintzelman, which were sent to New York and San Francisco for assay, gave results confirming those of the mineralogists and metallurgists at the mine. Prof. John Torrey, of the United States Assay office, found silver in the ratio of 237 ounces to the ton of 2,000 lbs., and 33 per cent. of copper. The combined results are given in the following table :

ASSAYS OF SILVER ORES FROM HEINTZELMAN MINE.

	<i>Grains per lb. Av.</i>	<i>Value per lb. Av.</i>	<i>Value per ton.</i>
Assays by Prof. Booth.....	247.80	\$0.67	\$1,342 00
“ “ .....	87.64	0.2375 ;	475 00
“ Prof. Torrey.....	51.99	0.16	322 94
“ “ Locke.....	70.10	0.2150	428 46
“ E. Kinsey.....	239.40j	0.6488	1,296 60
“ “ .....	525.00	1.4218	2,843 60
“ Min. Eng. at Tubac.	345.83	0.9350	1,870 40
“ “ “ “ .....	520.00	1.4075	2,816 60
<hr/>			
Total 8 Assays.....	2096.26	\$5.6913	\$11,395 60
Average.....	262.03	0.7114	1,424 45

Assays of selected portions of the ore have given much higher results, even \$20,000 worth of silver to the ton of ore. Recent assays of samples, by Dr. Jackson of Boston, showed the presence of from thirteen to sixteen per cent. of silver, and thirty-seven to thirty-eight per cent. of copper. He regards the ore as *Stromeyerite*, or sulphuret of silver and copper. Many of the specimens from the mine consist of a mixture of vitreous copper (sulphuret) and argentiferous minerals, the external characters of which are not well defined. Mr. Brunckow recently reports finding some very fine specimens of iodid and bromid of silver, and a silver amalgam. Native

or *virgin* silver, is also reported to exist in the vein. Twenty-two tons of ore sent to San Francisco and smelted in a reverberatory furnace yielded \$450 a ton, but it was found that a large part of the silver had been lost in the furnace and residues; this, with other experiments, led to the adoption of the barrel amalgamating process for the greater part of the ores, while some were best adapted for smelting, and the poorer and clayey portions for the primitive and simple *patio* process as followed in Mexico. After many delays, from the difficulty of transportation and erection of the requisite machinery in that isolated region, two barrels have been set in motion, each capable of receiving 1060 lbs. of ore. The last reports of Mr. Kustel, superintending the amalgamation-works, under date of May, 1859, state that 35 tons of the ore yielded \$5189 53 in silver, or an average of \$148 to the ton. A part of this ore, 6 tons, was very poor, and best adapted to the *patio* process.

Mr. Ehrenberg explains this result, and makes the following estimate of the general or average richness of the ore, based upon the results obtained from the commencement of reduction of the ore, at the mine and elsewhere.

“According to the estimate of Mr. Lathrop, and the different engineers, the ore brought to the surface from the Heintzelman vein, amounted in quantity to 225 tons. I assume this to be correct, but think it low, but have based on it the following calculations. It was and is distributed as follows, and yielded in silver the amounts noted :

	<i>Tons.</i>	<i>Yield.</i>	<i>Total value.</i>
1. Shipped to San Francisco . . . . .	22	\$450 00	\$9,900 00
2. Smelted at Cerro Colorado . . . . .	7	900 00	6,300 00
3. Ore stolen and sold in Sonora, at least	11	900 00	9,900 00
4. Middling and poor ore amalgamated	35	148 00	5,180 00
5. On hand yet . . . . .	150	150 00	22,500 00
Total,	225		\$53,780 00

“Which gives an average of \$238 13 per ton of ore. This result, however, is not quite correct, as the ore sent to San Francisco was reduced by parties who had neither knowledge or material to do it properly. They themselves allowed that nearly \$5000 in silver was still in the bottom of the furnace, the slag, and some other unknown places, of which we were to get 75 per cent. The ores shipped to them were first

selected as the richest to produce a large working capital soon. All subsequent selections could not have been better, and still the latter yield at our own furnace at Cerro Colorado, \$900 00 per ton. It is then but fair to assume this, at least, of equal value. Corrected thus it stands as follows : ”

	<i>Tons.</i>	<i>Yield.</i>	<i>Total value.</i>
1. Smelted at San Francisco . . . .	22	\$900 00	\$19,800 00
2. “ “ Cerro Colorado . . . .	7	900 00	6,300 00
3. Ore stolen and sold in Sonora . . .	11	900 00	9,900 00
4. Amalgamated in Arivaca . . . .	35	148 00	5,180 00
5. Ore from which No's. 1, 2, and 3, were picked and now on hand . . .	150	150 00	22,500 00
	Total	225	\$63,680 00
True average then per ton ore, \$283 02.			

The first bar of silver from these works, was produced in March of this year, since which many of different values have been sent in or found their way to the mints through the channels of trade. The largest bar yet made, weighed about 930 ounces, amounting in value, at \$1 28 the ounce, to twelve hundred dollars. At the last accounts from the mine, two of the barrels, worked four days in the week, yield about 1200 ounces of silver, and the smelting furnace some 300 or 400 ounces more.

According to Mr. Brunckow, the vein traverses strata of metamorphic clay slate obliquely, and has well defined walls. The engine shaft is now 100 feet deep, and a cross-cut at 60 feet from the surface, showed the vein to have a width of from three to five feet ; above, on the 30 foot level, the width is from two to three feet.

The motive power at the amalgamation works is insufficient, and good results cannot be obtained with the barrel process without regularity of motion, which it is difficult or impossible to have with mules. There is besides, much injury and loss occasioned by stopping to rest or change the animals. Arrangements for erecting steam engines, and additional barrel machinery have been made, and the mining operations will be vigorously prosecuted.

SANTA RITA SILVER MINING COMPANY.

This company was organized in 1858, to work several of the veins of silver ore in the Santa Rita mountains, discov-



ered by the exploring parties of the Sonora Exploring and Mining Company. These veins and mines include the Salero and Ojero, Asugarero, Bustillo, and others east of the Santa Cruz river. Some of these mines were worked long ago, and large amounts of silver taken out. The Salero is a vein of some three feet in width, and an old shaft has been cleared to a depth of 80 feet without reaching the bottom. The Ojero was a mine of great reputation among the Mexicans, and was abandoned on account of the caving in of one of the walls. The Bustillo was opened more recently than either of the others, and has been mined only twenty-five or thirty feet. The ores from these mines are chiefly argentiferous galena, and are best adapted to smelting or mingling with other ores. The pine forests of the Santa Rita mountains are visible from the mines, and will afford lumber and fuel. One of the veins has been traced by old workings, for a quarter of a mile.

#### PATAGONIA, COMPADRE, AND OTHER MINES.

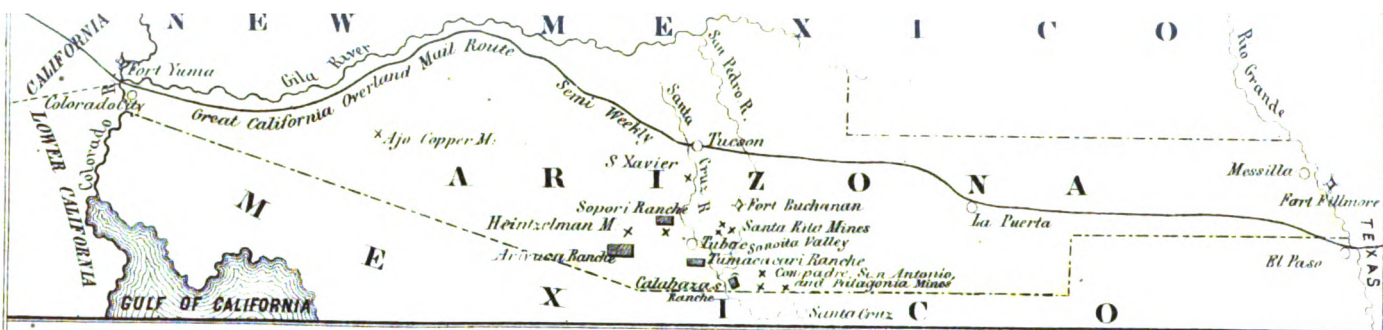
The Patagonia vein near Fort Buchanan, is composed chiefly of argentiferous galena, yielding from forty to eighty ounces of silver to the ton of ore. It exists in considerable quantity, and is easily mined and smelted. The locality is being prospected and worked under the direction of Captain Elwell and Mr. Brevort.

The Compadre and French mines are now being worked, under the direction of Col. Titus and company. Furnaces for melting are being erected about ten miles from the fort.

Of the operations upon these mines, and several others now being prospected in the territory, there is as yet but little information. Much labor and time in that new and remote region is necessary to prepare for systematic working, and to develop the extent and character of the different veins even upon and near the surface.

#### STEPHENSON MINE.

One of the oldest and best known mines within the limits of the proposed territory, is that in the Organ mountains, about fifteen miles from Fort Fillmore, on the Rio Grande, generally known in the States as the Stephenson mine. It has yielded large amounts of silver, but has not been worked



MAP OF  
**ARIZONA**  
 or the  
**GADSDEN PURCHASE**  
 with the Position  
 of its  
**SILVER MINES**  
 as now worked  
 1859.



for two or three years. The ore is an argentiferous galena, with small quantities of copper pyrites, which in all probability is auriferous, as gold is found in the silver extracted from the ore. The mine has been worked very rudely in the primitive Mexican style, and the ore was taken to the banks of the Rio Grande to be smelted. It was melted on a rudely constructed hearth, and the lead oxydized by a blast of air from blacksmiths' bellows worked by mule power. The ore yields from 40 to 100 ounces of silver to the ton, and is found in great abundance. A part or the whole of the lead in this ore might be saved by adopting other processes for extracting the silver. It is believed also, that in the form of pig-lead with the silver combined, it would bear the cost of transportation to New York where the separation could be more economically effected. The ore is also valuable in Arizona to mix with other ores poor in lead, which require smelting to obtain the silver. A company—The Fort Fillmore Mining Co.—has recently been formed in New York to work this mine on an extended scale.

It is hardly necessary to refer to the extreme richness of the mines of silver in the south-eastern prolongation of the Arizona mountains into Sonora. Both Ward and Wilson, in their valuable works upon Mexico, have given a mass of the most important statistics upon these mines and their extraordinary richness. Of Sonora, Wilson states that it is "a region of country which combines the rare attractions of the richest silver mines in the world, lying in the midst of the finest agricultural districts, and where the climate is as attractive as the mineral riches. But its richest mineral district is near its northern frontier, and is almost inaccessible, and can never be advantageously worked without an abundant supply of mineral coal for smelting; nor can any of its mines or estates be successfully worked without greater security for life and property than at present exists. The capitalists of Mexico will not invest their means in developing the resources of Sonora, and in consequence, the finest country in the world is fast receding to a state of nature." He gives "the following record in evidence of the masses of silver extracted at Arizuma. Don Domingo Asmendi, paid duties on a piece of virgin silver, which weighed 275 pounds. The king's attorney brought suit for the duties on several other pieces which together weighed 4033 pounds. Also for the recovery, as a curiosity, and

therefore the property of the king, of a certain piece of silver of the weight of 2700 pounds. This is probably the largest piece of silver ever found in the world, and yet it was discovered only a few miles distant from the contemplated track of our Pacific Railroad."

#### COPPER LOCALITIES AND MINES.

Copper ores of the richest description are known to abound in Arizona. When the overland emigration to California by the Gila route commenced, the emigrants frequently brought in masses of rich ore which they had picked up along the road. These specimens were chiefly native copper, very pure, invested with a crust of red oxyd of copper and of green carbonate, the whole yielding by assay about 90 per cent. of copper. It was for a long time believed by some that this ore contained a large percentage of gold, a fallacy which was dissipated by a thorough and expensive trial. One of the most important localities of this ore is in the Sierra del Ajo, 135 miles west of Tubac, where the red oxyde and green carbonate occur in large quantities, and have long been in use by the Indians for painting their bodies.

A company—the Arizona Copper Mining Company—has been formed to work these mines, and at an expense, it is said, of over \$100,000 have supplied their mines with an abundance of water, erected buildings, smelting furnaces, and raised over a thousand tons of ore, a part of which was shipped to England and sold there to great advantage. It costs, delivered at Swansea, \$125 a ton, and is worth from \$200 to \$375 per ton. The mines are one hundred and thirty miles from the mouth of the Gila River and about sixty miles south of it.

Another locality of rich copper ore varying from 30 to 70 per cent. is immediately upon the Gila river, and only twenty-five miles from its mouth. The ores can be loaded from the mine directly into flat boats and transported down the Colorado river, to the Gulf of California, where they may be transhipped to England or to the Atlantic ports.

The Mimbres Copper Mine, is another important locality, and is regarded as one of the richest yet opened in the Territory. About two hundred men are now employed in working it, and the copper is sent to the mint at Chihuahua, and to the Atlantic States. Mr. Brunckow, the mineralogist of the Sonora

Exploring and Mining Company, who has visited the place, followed the vein about eight miles northward and did not find any indications of its disappearing. It is associated with silver ore, and iron ore is found in abundance in the vicinity.

Lieut. Mowry makes the following statement respecting the agricultural resources of the Territory:—"The agricultural resources of Arizona are sufficient to sustain a large mining population, and afford abundant supplies for the great immigration which will follow the development of its mineral resources. The whole valley of the Gila, more than four hundred miles in length, can be made, with proper exertion, to yield plentiful crops. The Pimos Indians who live in villages on the Gila, one hundred and seventy miles from its mouth, raise large crops of cotton, wheat, and corn, and have for years supplied the thousands of emigrants who traverse the territory en route to California. These Indians manufacture the cotton into blankets of fine texture and beautiful pattern, which command a high price. They also grind their corn and wheat and make bread. In fact the Pimos realize in their every-day life something of our ideas of Aztec civilization. A town will probably grow up just above the Pimos villages, as there is a rich back country, and the streams afford valuable water power for running mills."

Notwithstanding the amount of information already gained of the mineral riches of Arizona, it is evident, from a moment's consideration, that our knowledge of the number and extent of veins and localities of both silver and copper is extremely limited. The country has never yet been systematically explored for minerals, and large portions of it are completely unknown to us. Except along the lines of travel and the routes of the surveys for a railroad route the country is, for the time, almost inaccessible, and must of necessity remain unexplored, in detail, until strong parties are organized for the purpose. The developments already made, great as they are, may be regarded as indications, merely, of what may be expected when geological and mineralogical explorations are pushed forward with energy into the cañons of the Sierras, and capital and skill follow to seize upon and develop the many valuable mineral localities which will inevitably be discovered. Until now, the Anglo-American mind has scarcely been directed to the systematic and thorough working of silver mines and the metallurgical treatment of the ores; and we may rea-

sonably look for great improvements in both departments, whereby the cost of producing silver will be greatly lessened, and permit even the poorest ores to be advantageously worked.

Silver mining in Arizona possesses some great natural advantages over silver mining in Central Mexico, where that business has been mostly carried on. Many of the mines in that part of Mexico are in the midst of lofty mountains, hundreds of miles from the sea-coast; only to be approached on the backs of mules, by almost inaccessible paths, or over roads constructed at immense expense, thus greatly enhancing the cost of supplies. Heretofore, the expense of transportation to the mines of Arizona has also been so great as to seriously retard their development. A desert without water intervenes a part of the way between Tubac and the coast of California, so that freight from San Francisco to the mines has in some instances amounted to hundreds of dollars to the ton. This has been imperious from the political, not *geographical* position of the country, for a good wagon road connects Tubac with the Mexican port of Guyamas, 325 miles distant. Lobos, in Sonora, it is expected, will eventually become the seaport of the mining region of Arizona, from whence it is distant but 175 miles, over a level country, with good pasturage.

By the laws of Mexico, the transportation of *machinery* through its territories is free. The basis of a treaty is now preparing between the agents of the Mexican and American governments, which is to permit the free transit of merchandise across the State of Sonora to Arizona. This treaty will probably be soon completed, and a new impulse thereby given to mining operations, in the comparatively low cost of transportation; Guyamas and Lobos each being of easy and cheap access, by water, from San Francisco and New York—the latter place via the Isthmus of Panama.

The establishment of the great semi-weekly overland mail between St. Louis and San Francisco, greatly increased the facility of access to this interesting region, and continues to afford regular communication with the Atlantic cities and San Francisco on the Pacific. The route traverses the entire length of the Territory from east to west, placing it within 16 days of St. Louis and 7 of San Francisco. But the wealth and latent prosperity of this and adjoining regions demand more than this—the long-talked-of Pacific railroad must be built—the apathy of the American people on this subject

must give way before that necessity which the events of every month render more apparent. It requires no prophet to foretell that Arizona is to become the great field of American mining enterprise, and as famous for its silver and copper as California for its gold.

A sanguine calculator estimates the future annual yield of Arizona in silver, at one hundred millions of dollars. Mexico, the great silver-bearing country of the world, has never yet exceeded an annual yield of thirty-five millions: it is not therefore probable that the dream of this Arizonian visionary will soon be verified. But when we perceive with what rapidity our population, in its advance to the Pacific, spreads over new territories—the energy with which it overcomes untold obstacles—the avidity it shows in launching upon novel enterprises, be they but promising—it is not perhaps too much to look for an honest measure of prosperity to that long, narrow strip of mineral bearing territory, purchased by Mr. Gadsden for us, of our Mexican neighbors, as a route for a railroad to the Pacific; which in a spirit of anticipation has already received the dazzling appellation of the “SILVER STATE OF ARIZONA.”

#### DISTANCES TO PROMINENT POINTS IN THE TERRITORY AND SONORA.

The two principal towns in the mining regions are Tucson and Tubac—the first on the line of the overland mail route; the latter 52 miles south of it, and each containing a few hundred inhabitants. Tubac is the head-quarters of the Sonora Exploring and Santa Rita Silver Mining Companies. From Tubac to points of interest in the vicinity, the distances are as follows:—Heintzelman Silver Mine, at Cerro Colorado, 22 miles, six miles south of which on the Arivaca Rancho are the amalgamation works of this mine. Santa Rita Silver mines, 10 miles; Tumacacari Rancho, 3 miles; Sopori Silver mine and Rancho, 11 miles; Calabazas Rancho, 15 miles; Fort Buchanan, (garrisoned by United States troops) 40 miles; San Xavier Silver mine, 35 miles; Patagonia Silver mine, 48 miles; Ajo Copper mine, 135 miles. Distances from Tubac to prominent points out of the Territory, by the travelled routes, are as follows:—San Francisco, 1074 miles; San Diego, 510 miles; Fort Yuma, (built by Major S. P. Heint-

zelman, U. S. A. in 1851,) 330 miles ; El Paso, 389 miles ; Saint Louis, 1770 miles. Towns in Sonora, Mexico—Santa Cruz, 54 miles ; Magdalena, 51 miles ; Altar, 95 miles ; Hermosillo, capital of Sonora, 229 miles ; Guyamas, port of entry of Sonora, 329 miles ; Lobos, on the Gulf of California, 175 miles.

LIST OF MINING COMPANIES IN ARIZONA AND VICINITY.

Four of the mining companies in Arizona are incorporated under charters from different States. *The Sonora Exploring and Mining Company* was organized in 1856, under the laws of Ohio ; capital, two millions of dollars ; office of the Company, No. 88 Wall Street, New York. *Directors*, Samuel Colt, Hartford, Conn. ; Wm. T. Coleman, New York City ; Chas. D. Poston, Elizabethtown, Ky. ; Augustus Belknap, New York City ; W. M. B. Hartley, Hartford, Conn. ; Chas. S. Brown, Boston, Mass. ; Henry Howe, Cincinnati, Ohio. *Officers*, Samuel Colt, President ; Wm. T. Coleman, Vice President ; Chas. D. Poston, Acting Sec'y ; S. H. Lathrop, Director of mines ; Richard W. H. Jarvis, Treasurer at the mines ; Guido Kustel, Frederick Brunckow and T. Methner, Mining Engineers. Head-quarters, Tubac, Arizona ; Mines near Cerro Colorado, Arizona ; Reduction Works, Arivaca, Arizona. S. H. Lathrop, Director. Capital, \$2,000,000, in 20,000 shares of \$100 each. First silver ore reduced in July, 1858. Number of Mexican Peons employed, 140.

The *Santa Rita Silver Mining Company* was organized in the year 1858, under the laws of Ohio ; capital one million of dollars ; office, 167 Walnut Street, Cincinnati, Ohio. *Directors*, Dr. Geo. Mendenhall, Cincinnati ; Thos. Wrightson, Cin. ; Thos. H. C. Allen, Cin. ; John D. Park, Cin. ; Chas. D. Poston, Elizabethtown, Ky. ; Jas. O'Kane, Columbus, Ohio. *Officers*, Dr. Geo. Mendenhall, President ; Thos. H. C. Allen, Vice President ; Thos. Wrightson, Secretary ; Wm. Wrightson, Director at the mines. Head-quarters, Mission of Tumacacari, Arizona ; mines, Santa Rita Mountains, Arizona. Wm. Wrightson, Director. Capital, \$1,000,000, in 10,000 shares of \$100 each. Number of Mexican Peons employed, 90. First silver ore reduced May 7th, 1859.

The *Sopori Land and Mining Co.*, and the *Arizona Land and Mining Co.* were organized in June, 1859, at Providence, R. Island.



*Fort Fillmore (Stephenson) Silver Mining Co.*, at Fort Fillmore, New Mexico. Organized December, 1858. Major Jno. I. Sprague, U. S. A., President. Office, No. 34 Pine Street, New York. Mines in Organ mts., near Rio Grande. W. H. Rittler, Director and Engineer. Capital \$1,000,000, divided in 50,000 shares of \$20 each.

*Sopori Mining Co.* Organized August, 1858. Office, Providence, Rhode Island. Mines and land in Arizona. Welcome B. Sayles, Director. Capital \$1,000,000, divided in \$10,000 shares of \$100 each.

*"Setentrion Mines."* Organized as American and Mexican Mining Company, in June, 1859. President, George Davis. Office 34 Pine Street, New York. Capital \$2,000,000, divided in 100,000 shares of \$20 each. Mines located in Chihuahua.

*Mexican Pacific Mining Co.* Organized by charter from Pennsylvania, June, 1857, by E. L. Plumb. President, Geo. F. Allen. Office 92 William Street, New York. Capital \$4,000,000, divided in 40,000 shares of \$100 each.

*Patagonia Mining Co.* Private Association. Working mines near Sonoita River, Arizona. President, Capt. R. S. Ewell, U. S. A.

*Union Mining Company.* Working mines near the Sonoita River, Arizona, under direction of Col. Titus.

*Boundary Mining Co.* Private Company. Working mines near the boundary line of Sonora.

*Arizona Copper Mining Co.* Organized in 1854, in San Francisco, California, by Edward E. Dunbar. President, Major Robert Allen, U. S. A. Capital \$1,000,000, divided in 10,000 shares of \$100 each.

*San Xavier Mining Co.* Organized in San Francisco, in 1857. Mine near Tucson, Arizona.

*Cahuabia Mining Co.* A private company, working silver mines in the Papagueria, Arizona. President, Herman Ehrenberg. Director, William Brown.

ART. II.—PROCESSES FOR THE EXTRACTION OF SILVER, FOLLOWED AT THE REDUCING ESTABLISHMENTS OF THE HEINTZELMAN MINES, ARIZONA, AND THE REAL DEL MONTE MINES, MEXICO.

*(Compiled for the Mining Magazine.)*

THE processes now in use at the Reduction Works of the Sonora Exploring and Mining Company, for the extraction of silver from the ores, are essentially three, viz : smelting, amalgamation in barrels, and amalgamation in the open air, or the *patio* process. They are briefly described by Mr. Frederick Brunckow, who has recently returned from Arizona, in a report to a committee of the stockholders, from which the following is in part extracted :—

“The ores of the Heintzelman vein, as well as most of the Mexican ores, contain a considerable portion of quartz, which renders them difficult to smelt. The richest portions only are therefore selected for the smelting process.

“The lower part of the furnace is built of a fine-grained refractory quartzose sandstone, found in the neighborhood. The upper part and the smelting house are built of brick, dried in the sun and air, called *adobes*. The smelting chamber inside the furnace is twelve inches square, and the blast is produced by a double bellows constructed at the place and worked by one man.

“To each part of selected silver ore, three parts of lead ore from the Arenilla mines are added, and after complete fusion the contents of the chamber are allowed to run off into a basin on the outside. As it cools, a crust is formed on the surface, which contains to a large extent sulphurets of copper, lead, and the impurities. This is taken off from the lead below and kept separate. The lead is run into castings in the form of cakes, ten inches in diameter, weighing 75 pounds. Six of these lead cakes are put on edge, one near the other, upon two inclined iron plates, which nearly touch each other. Charcoal is placed around and between the cakes, so that they are enveloped, and after kindling it the lead cakes must be protected from draughts of air. The heated cakes commence to melt and sink, and the lead runs down the iron plates to a basin, from which it is run into pigs. This lead is free from copper,

and yields about forty pounds of silver to the ton. A skeleton of each lead cake is left behind on the iron plates, and is rich in copper, and yields some silver. In order to separate this from the copper, the skeleton is broken into fragments and passed the furnace in company with the crusts taken from the lead in the first place, and with some other lead ore. By smelting the skeletons and crusts, which contain sulphurets, etc., lead will result, which is put in castings in the form of cakes; these cakes are put again upon the declining plates, and pass through the process described before. The remaining skeletons this time contain very little silver; they are smelted in a copper refining reverberatory furnace and refined, and in the form of balls of metallic copper are delivered over to the amalgamation works, where they are required for the barrel process.

The argentiferous lead, free from copper, is put in a cupellation furnace, and passes the well-known oxydating process; the silver remains and is refined. The resulting oxyd of lead is added to the lead and silver ore, and again passes the blast furnace.

#### THE BARREL AMALGAMATING PROCESS OF REDUCING SILVER ORE.

To prepare the ore for amalgamating in barrels, it is crushed by stamps, and passes three sieves. The siftings of the first sieve are put under the stamps again. The sifting of the second sieve is as fine as the grain of wheat, and the total sifting is delivered to the ore-mill, Arastra, where it is ground with water, to a very fine powder; then it is dried and crushed. The sifting of the third sieve gives a powder fine as flour. This powder and the obtained fine-ore powder of the arastra mill is mixed with 8 per cent. common salt, put in a reverberatory roasting furnace, and roasted till all the metals are formed into chlorides; this process is completed in five hours. Eight hundred pounds of this powder are put into the amalgamation barrel, together with a certain quantity of water and 75 pounds of the copper balls from the smelting furnaces. The barrels are then made to revolve, so that the whole mass in the barrel will form, after a certain time, a paste so stiff that the 400 pounds of quicksilver now added, will not remain in a separate mass at the bottom, but

will be divided through the whole body of ground ore in minute globules, unseen by the naked eye. The barrels are now made to revolve for 22 hours. The formed chloride of silver will be precipitated into metallic silver by the presence of the metallic copper; chloride of copper will be formed, and this will be lost. The silver in the metallic state in contact with the quicksilver then forms the amalgam. The copper exists in the roasted mass as chloride of copper; it has no influence in the amalgamation process, and is lost in the residue. After 22 hours, more water is put in the barrels, in order to thin the paste, and to accumulate the minute globules of quicksilver and the formed amalgam in a mass. This will be accomplished in two hours, by allowing the barrels to revolve slowly. The barrels are now opened, and the quicksilver and amalgam runs out in troughs, from whence it is put into strong canvas bags. The surplus quicksilver is pressed through the bags by its own weight, the remaining stiff amalgam is retorted, the silver, not being volatile, remains, and is melted, and cast into bars. The bars are marked with the Company's stamps, numbered, their fineness according to the assay, and their value in dollars marked upon them.

#### THE PATIO AMALGAMATING PROCESS.

In different places in Mexico the method of amalgamation called the Patio process, is employed. This method of amalgamating differs entirely from the one just described, and can only be successful with a certain class of ore. The ore is crushed and ground to a very fine powder in the *arastra* mill, and without first roasting, mixed with salt, moistened, and piled up on a floor in equal piles. This floor, or *patio*, in Mexico is generally a large inclosure walled in and paved with blocks of stone. The piles of ore are formed in circles about forty feet in diameter, and are generally from a few inches to a foot in depth. Mules or horses are then driven violently around, and on the heap, until the salt and the powdered ore are thoroughly commingled. The whole is then allowed to remain for several hours, when a portion of copper or iron pyrites, called *magistral*, is added and thoroughly mixed with the mass, by mules, as before. This *magistral* serves to effect chemical changes in the ore, and must be added in different proportions, according to the quality of the ore and the temperature.

Quicksilver is then added, and the mass kneaded and stirred by the treading of mules, they being urged forward around the circle by a man standing in the centre of the heap. This is repeated from day to day, with additions of mercury, and the complete decomposition of the ore, and the amalgamation, is generally effected in the warm season in the course of two or three weeks, in the cold season much longer. The mixture is then transferred to a tub or vat, where the amalgam is separated from the earthy residues and impurities by washing. The excess of quicksilver is strained off; the amalgam is formed into cakes, retorted, and the resulting silver cast into bars.

It is estimated that to reduce 10 tons of ore, each twenty-four hours, at the Heintzelman mine, fifteen stamps, two arastras and twelve barrels will be required, seven tons of the ore being amalgamated in the barrels, and three by the patio process. The condition of the works in May last, owing to insufficiency of power, mules alone being used, did not permit the reduction of more than four tons a week. Three barrels were in operation part of the time in May. These were capable of receiving 1,060 lbs. of roasted and prepared ore, which is equal to 1,100 lbs. unground ore, the loss in weight being due, in part, to mechanical loss in stamping and manipulating and to calcination. The consumption of wood is one and a quarter to one and a half cords to every ton of ore. To decompose the chloride of copper which remains after amalgamation, from three to four per cent. of the weight of the ore is required. Eleven barrels, yielding 119 pounds of silver, showed a loss of 59 pounds of quicksilver. This is four ounces to the marc of silver. Much better results may be expected when steam power is substituted for mules.

OPERATIONS AT THE REDUCTION ESTABLISHMENT OF THE  
REAL DEL MONTE COMPANY, MEXICO.

The following data are from a Report made by Mr. Buchan, the manager of the Real del Monte Company, in 1854, and the notes of Mr. E. L. Plumb, taken while on a visit to the mines in 1857. In a letter to Col. Poston, accompanying the statistics, Mr. Plumb observes:—

“They show what cannot usually be easily got at—the cost in detail of the actual working operation (so far as the reduction of ores is concerned) of a large Company.

“The Real del Monte Company is one of the most important mining companies in Mexico, and is under excellent management, as can well be inferred from the system with which every branch of expenditure is looked after. Nothing more reliable, or based upon a larger experience, can be had anywhere. Their ores, I may also say, are of the hardest and most refractory character. You will perceive, however, that they are not losing money.”

The mean cost of producing 3000 pounds of silver ore at the Real del Monte Company's establishment, and the comparative economy of the different establishments of Sanchez, Velasco, San Miguel, and Regla, for the year 1854, is shown in the following table :

TABLE SHOWING PRODUCE OF SILVER AND COST OF EXTRACTION AT THE ESTABLISHMENT OF REAL DEL MONTE COMPANY.

<i>At Sanchez, Velasco, or San Miguel, the Barrel Process is used: at Regla the Patio Amalgamation and Smelting.</i>	<i>By Barrel Amalgamation at</i>			<i>By Patio Amalgama- tion at</i>	<i>By Smelting at</i>
	<i>Sanchez.</i>	<i>Velasco.</i>	<i>San Mig.</i>	<i>Regla.</i>	<i>Regla.</i>
Stamping, mostly for labor,.....	\$00 64	\$00 59	\$00 60	\$00 26	\$00 30
Wear of Stamp heads,.....	24	25	88	28	28
Grinding in Arastras, labor mostly,.....	78	70	08	83	.....
Drying and lifting, mostly labor,.....	1 30	1 20	1 02	.....	.....
Calcination, mostly labor, (fuel below),.....	2 15	1 76	1 57	.....	.....
Amalgamation in Barrels and Patio, mostly labor,.....	1 41	1 04	88	3 98	.....
Smelting in furnaces, mostly labor, (fuel below),.....	.....	.....	.....	.....	17 80
Wear of Barrels,.....	35	30	21	.....	.....
Distilling Amalgams, casting Silver into bars,.....	08	10	07	05	04
Repair of Machinery, Furnaces, &c.,.....	33	60	50	48	3 90
Sundry costs,.....	55	30	40	40	3 40
Fuel, Wood,.....	3 79	3 31	4 27	.....	1 00
Fuel, Charcoal,.....	31	30	27	20	34 90
Salt,.....	6 70	5 87	6 60	3 64	.....
Sulphate of Copper,.....	.....	.....	.....	2 13	.....
Litharge,.....	.....	.....	.....	.....	21 50
Tallow and Oil, for Machinery,.....	33	37	29	10	.....
Quicksilver,.....	2 15	2 39	1 58	4 32	.....
Steam Power, mostly fuel,.....	1 91	4 23	.....	.....	.....
Animal Power, mostly forage,.....	2 14	.....	.....	.....	.....
Salaries, Expenses of Management, assaying, &c.,.....	1 31	1 14	1 03	1 09	6 80
<b>Total cost of reducing 3000 lbs. of Ore, .....</b>	<b>\$26 47</b>	<b>\$23 95</b>	<b>\$20 25</b>	<b>\$17 76</b>	<b>\$89 92</b>
<b>Mean produce of Silver per each 3000 lbs. of Ore,</b>	<b>92.88</b>	<b>94.80</b>	<b>62.40</b>	<b>65.92</b>	<b>518.40</b>
<b>No. of Cargas (of 300 lbs. each) of Ore reduced in 1854,.....</b>	<b>48.310</b>	<b>53.895</b>	<b>49.184</b>	<b>37.982</b>	<b>2.386</b>
<b>Ounces of Quicksilver lost per each \$8 00 of Silver produced,.....</b>	<b>4.79</b>	<b>4.97</b>	<b>5.28</b>	<b>12.71</b>	

The following may be taken as the average yield of ores from the Company's mines:—Rosario mine, 13½ marcs (\$8 00 each) of silver per monton (3000 lbs.) of ore; San Patricio mine 9.2 marcs per monton; poor and refractory ores, from the Santa Brigada and Santa Inez, 7½ marcs per monton.

Average yield of all ores reduced in 1849 to 1854, 9 75-100 marcs per monton.

Total amount reduced by the Company in 1849 to 1854, inclusive, 684,845 cargas, (of 300 lbs. each,) or 97,835 tons, producing \$5,858,330, or 5,352,600 ounces, being 54½ ounces to the ton of ore.

The amount of silver left unextracted by the several processes is as follows : Smelting, 6 per cent. ; Patio amalgamation, 15 per cent. ; at Velasco, by best barrel processes, 16½ per cent. ; and on the average of the three Haciendas engaged on this process, (barrel,) 19 to 20 per cent.

The salt used by this Company is brought from San Luis by a land carriage of three hundred miles, at a freight of \$42 per ton, and from Campeachy by shipping to Tampico and Tuspan. By either route it costs \$84 per ton. 1700 tons are annually required by this company.

The consumption of wood in 1854 was 60,000 tons, or 450,000 cargas. The Company's expenditure for fuel is at least \$150,000 per annum. All of it is brought a considerable distance on mules.

Mr. Buchan states, in his Report, (1854,) that "thirty stamp heads, fifty to eighty strokes per minute, can grind of our quartz ores 100 tons per week, to an exceedingly fine sand. To effect our annual grinding of 25,000 tons, not less than 60 tons of cast iron is worn away."

The following is stated as the profits and yield in silver of the Real del Monte Company's mines :

May, 1849, to December, 1852, . . . . .	\$327,160
Year 1853, . . . . .	582,328
" 1854, . . . . .	696,443
Total produce, 1854, . . . . .	1,811,882

In 1857 these mines were yielding to the Company \$60,000 per week in silver, or over \$3,000,000 per annum, of which over 50 per cent was net profit.

The engineer, in his Report to the Company at the close of the year 1857, says :

During the five years ending Dec. 31st, 1857, the Company's mines (four) produced in silver \$11,823,803. Yield in 1857 was \$3,039,616 00.

The same mines that are now worked by this Company have been worked more or less since an early period.

*Mineral Resources of the Rocky Mountains.*

Their produce from 1759 to 1781 was . . .	\$15,000,000
After death of 1st Conde de Regla to the Rev- olution, . . . . .	10,000,000
While being worked by the English, . . . .	10,481,475

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