State Mining Bureau.

HENRY G. HANKS, State Mineralogist.

CONTRIBUTIONS

TO THE

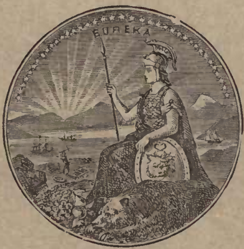
Geology and Mineralogy

OF

CALIFORNIA.

ON THE MILLING OF GOLD QUARTZ,

By MELVILLE ATTWOOD, F. G. S.



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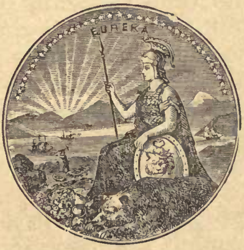

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On the Milling of Gold Quartz.

HENRY G. HANKS, *State Mineralogist:*—

DEAR SIR: My last paper to the State Geological Society on "The Milling of Gold Quartz," wherein I tried to describe the process of simple amalgamation of the raw pyritic matter in wooden barrels, appears from the great number of letters that I have received respecting it, after its publication in the Mining and Scientific Press, to have attracted considerable attention, and has, therefore, encouraged me to resume the subject, but this time as a contribution to the State Mining Bureau; you having kindly offered to allow the specimens accompanying this paper, and intended to illustrate what I have stated, to remain for a short time at the rooms of the Mining Bureau, to give those who feel interested in the matter a chance of examining them. You have also promised to put some very important and interesting specimens from your private collection with them.

I can only now repeat what I have stated on a former occasion, that at the present time I think scarcely anything can be of greater importance to the mining interests of this State, than a simple and cheap mode of extracting the gold from low grade veinstone, and the determination of the true condition of the ores associated with it.

THE "FREE GOLD,"

As it is called, can easily be saved; indeed, the language of the old mill-man, "only give it a chance and it will take care of itself," is very true, particularly so when met with, as it is in some of the Bodie veins, carrying scarcely any pyritic matter. The difficulty in the concentration of the sulphurets (I use the Californian term, which, as I stated before, was, I think, first applied in Nevada County, in 1859, to the pyritic matter associated with the quartz in the gold-bearing veins of this State), appears now to be, in a great measure, overcome by the use of the "Frue concentrator," which, with comparatively little attention, and at one operation, makes very clean work. I have served a very long apprenticeship in the "dressing" of different kinds of ores, but in all my experience never remember any machine which pleased me better than the "Frue." The rubber surface of the revolving cloth appears to greatly assist the operation.

The question of concentration being now so far solved, it renders it desirable, indeed necessary, for isolated mills to have some cheap and easy mode, which they can use at their own works, to extract the gold from the concentrations.

TREATING PYRITES FOR THE EXTRACTION OF ITS GOLD.

The following is a copy of a paper on "Iron Pyrites," read before the Royal Society of New South Wales, in 1874, by J. Latta, Esq., which contains much valuable information :

MR. PRESIDENT AND GENTLEMEN : At the request of some of the members of the Royal Society, I have ventured to occupy part of your time this evening in describing the method of treating pyrites for the extraction of its gold, as carried out by the Port Phillips Company, at Clunes.

In 1861 I was engaged by that company as their chemist and assayer, with special instructions to devise, if possible, a process for profitably extracting the gold from their pyrites, which was then but little better than a waste product. Except processes inapplicable to our circumstances, such as smelting, etc., the only known means for extracting gold from such mineral was that practiced in South America and the United States—"of exposing the auriferous sulphides to the action of air and moisture for a year or so, whereby a portion of the mineral became oxidized, liberating the gold previously inclosed by the sulphides; the mineral was then passed through the stamping battery with quartz, and whatever portion of the sulphides remained undecomposed was retained, as well as the then rude machinery for that purpose admitted, to undergo another term of oxidation, and so on whilst any remained." I scarcely need to point out how extravagantly wasteful of time and gold such a process must have been. Yet even at the present time this process is occasionally practiced in Victoria. At some claims the blanketings—that is, the pyritous sand, with a little free gold caught upon the blankets—are, after a time, again put through the batteries with the quartz, for the purpose of extracting its gold. Any one practically acquainted with the treatment of mineral containing fine gold by the battery process, will at once recognize the impossibility of retaining a fair proportion of such minutely divided gold as oxidized pyrites affords; by far the larger portion would be held in suspension by the water, and be carried away by it through all the appliances devised for its retention. In addition to the difficulty of retention arising from the fine state of division which gold so obtained possesses, most of these particles would be

COATED WITH IRON OXIDE,

and other products of the decomposed mineral, thus offering another hindrance to its chance of amalgamating with the mercury. This latter difficulty deserves careful consideration, where fine gold has to be dealt with, as from its fineness it escapes the scrubbing which the larger grains receive from contact with the quartz whilst crushing, whereby their surfaces are cleaned, and thus rendered extremely sensitive to the influence of mercury placed for their detention. In reference to the condition of the gold in pyrites, it has come to be pretty generally admitted that 'nearly, if not quite, all the gold exists in the metallic state.'"

This quite agrees with the results of some experiments carried out by myself in conjunction with Mr Daintree, late of the Victoria geological staff. Our researches ended in obtaining but the barest possible evidence of

GOLD EXISTING IN A MINERALIZED STATE IN PYRITES.

As a matter bearing somewhat in support of this result, and whilst engaged in these investigations, I had the good fortune to come across some fine specimens of cubical pyrites, which upon examination with a pocket lens, seemed to indicate the presence of gold; upon transferring them to a good microscope, gold was distinctly seen upon the planes of cleavage, and upon dissecting the crystals, every cleavage face was found distinctly gilded. Now, from the fact that the presence of gold could only be determined by the aid of a good microscope, and that only as a fine gilding, some notion may be formed of the excessively fine state of its division, and how unsatisfactory would be the task of separating such liberated films from water in motion.

Guided by these considerations it became evident that any attempt to mechanically separate gold from pyrite—unless aided by the previous decomposition of its enveloping sulphides—must prove ineffective from the impossibility of reducing it to its ultimate atoms, for so long as a cluster of sulphide atoms remain unbroken, they might reasonably be imagined to enclose those of gold. Again, it was equally clear that, when such gold was liberated from its envelope, water concentration alone was inapplicable. To test the correctness of these conclusions, each of them was made the subject of rigid experiment on an extended scale, before receiving them as fundamental truths to guide us in determining the best method suitable to our requirements. Two parcels of pyrites of twenty tons each—one roasted, the other unroasted—were ground in one of the best arastras known, with mercury; a constant stream of water flowing through to carry off the finely ground sand, which was then carried through mercury boxes and over blankets. Each parcel received the same amount of grinding and treatment in every detail. The results are as follows:

Twenty tons raw sand containing 3 oz. 6 dwts. per ton:

Gold obtained	29.21 per cent.
Gold in tailings	42.84 per cent.
Gold carried off in water	27.95 per cent.

Twenty tons roasted sand, 1 oz. 7 dwts. 10 grs. of gold per ton:

Gold obtained	51.57 per cent.
Gold in tailings	27.21 per cent.
Gold carried off by water	21.22 per cent.

Here it will be observed that, with the raw sand, only a small portion of the gold was obtained—a very much larger was left in the tailings, although finely ground, and a large proportion was carried off with the water as slime. With the roasted mineral more than half the gold was obtained; the tailings were much poorer than those from the raw sand, but still very rich, and a large quantity was carried off by the water.

After carefully considering the merits of the various methods suggested for extracting gold from pyrites, our first problem to solve was how to best destroy the enveloping sulphides and arsenides, so as to get rid of the deleterious action of these minerals upon the mercury used for amalgamating and detaining the liberated gold; and, secondly, the best method of extracting the gold from the decomposed pyrites. After a number of experiments on a large scale, it was decided to effect the decomposition of the pyrites by a roasting process. To effect this economically, I devised, and, in conjunction with Mr. H. A. Thompson, patented, in 1862, the inclined roasting furnace, which is now used in many places throughout the Colonies. It consists of an inclined roasting hearth, usually about 30 feet long by 5 feet wide; the fire-hole for heating the hearth on the lower end of it, and is separated from it by the fire bridge; between the latter and the hearth is a channel for conveying into the store-pit the sand when roasted. In the foot wall of the furnace are 6 tubes, from 1½ to 2 inches diameter, for supplying heated air to the roasting sulphides; scarcely any air is admitted through the fire bars, the gaseous vapors from the fuel being completely burned by the great excess of air passing over the fire for oxydizing the pyrites. Along each side of the furnace are five working doors, for the workmen to turn and rake down the mineral. Above the upper end of the furnace a large hopper is constructed, capable of holding 24 hours' supply of sand; in the floor of this hopper is a trap for supplying mineral to the hearth; the hopper is filled by trucks communicating with the puddles by a tramway to the stamp-house. The whole of the furnace is carefully braced with vertical, longitudinal, and transverse ties. The present furnace has been working about ten years, and, with fair treatment, will last many years more. In working this furnace the whole of the hearth is covered with pyrites to the depth of between 2 and 3 inches, kept at a gentle red heat, with frequent stirring, until the mineral nearest the fire, and about 6 feet beyond it, is found no longer to give off sulphur fumes. An experienced workman can determine when this condition has been attained by its appearance in the furnace. It is then raked into the discharge channel and the mineral lying upon the hearth immediately above that removed, is brought into its place; again, that still further up is brought a stage lower, until the whole has been shifted, when the vacant place at the upper part is refilled from the hopper. The sulphurous and arsenical vapors, together with the products of combustion and dust from the pyrites, pass into a tunnel between 200 and 300 feet long, 4 feet high, and 3 feet wide, carried up the side of a hill, terminating in a chimney 30 feet high. Nearly all the sand and dust carried over by the draft is deposited within 40 feet of the furnace, and is periodically removed for retreatment, as it contains a notable quantity of gold; beyond 40 feet the sand is worthless. From the size of the tunnel the vapors move slowly onward, and have, consequently, time to deposit any heavy particles; continuing their course, the vapors pass through 6 cellular brick screens, down which a powerful spray of water passes; here they get cooled and scrubbed, the sulphurous and sulphuric acids dissolved out, whilst the arsenious acid is deposited on the floor of the tunnel, scarcely anything escaping from the chimney but the foul vapors. Some alarm was felt by the Town Council lest any

ARSENICAL VAPORS

Should escape and prove injurious to the inhabitants, as the works were close upon the township, and they placed the matter in the hands of Mr. Johnson, the Government analytical chemist, for investigation, who reported as follows: "I drew five gallons of the vapors from the chimney of the roasting furnace, and, by the application of one of the most delicate tests known to science, viz., Reinck's test, discovered but the merest trace of arsenic." I may remark that when this investigation took place we were condensing over two tons of arsenic per month in the tunnel. I have dwelt somewhat lengthily upon this part of my subject, as I am desirous to show that, with due precautions, such operations can be safely carried on in the neighborhood of habitations.

In carrying out the roasting operations the work is divided into three shifts of eight hours each, one man being able to attend a furnace, and finally to cover up the hot sand discharged with damp sand and spray it with water. This quenching was found to be a matter of some importance, as the quartz sand—always found with the pyrites—is thereby broken up and rendered friable, by which the after process of grinding is greatly facilitated. The quantity of sand which a furnace of the above-mentioned size can treat, will average 4 tons per 24 hours, with a consumption of 3-10 of a cord of wood per ton. Having determined upon a

MECHANICAL PROCESS FOR EXTRACTING THE GOLD

From the roasting mineral, it became necessary to discover the best condition for accomplishing it. In this, also, we were greatly assisted by the knowledge gained of the physical condition of the gold in pyrites. Consequently, after our earlier experiments already mentioned, we carefully avoided a current of water, and ground with mercury without an overflow until it was considered the gold had become amalgamated. By cautiously varying the experiments, and ascertaining the proportion of gold obtained in each case, we were led up to the present method of working. From the results of a great number of experiments, it was shown that the quantity of water used in the grinding process was a matter of considerable importance, the success of the operation to a great extent depending upon the sand being in a damp condition only; by this means the mercury becomes thoroughly diffused, and every grain of sand has a particle of mercury in contact with it; consequently there is afforded abundant opportunity for the gold to amalgamate. On the other hand, if sufficient water has been used to convert the mass into a semi-fluid state, the mercury remained at the bottom of the mill, the surface only being in contact with the sand; consequently the opportunity for amalgamation was considerably lessened, and the quantity of gold extracted very much less than when working damp sand only. As the result of these experiments, the following process has been adopted: The sand, after being roasted, is ground—only moderately damp—with an equal weight of mercury for three quarters of an hour, under the rollers of an ordinary Chilean mill; water is then allowed to flow into the basin, the mill still revolving, until nearly all the finely ground sand has been carried off in the overflow to the concentrator; the mill is then stopped, the water drained off from the unground sand and mercury, again started, and recharged with fresh sand, and so on until it is necessary to clear out the amalgam—generally once a week, depending upon the richness of the mineral treated. The finely ground sand passed into the concentrator is kept slowly stirred for a quarter of an hour, to keep the sand in suspension in the water, and allow the mercury and any amalgam which might have been carried over from the mill to gravitate through it; the water with its sand is then slowly run through a smaller concentrator, to retain any valuable particles which might have escaped the first, and is then considered sufficiently impoverished to be allowed to run away.

The quantity of roasted mineral the company treat by this process, when working, averages 18 tons per week—the duty of two mills worked in eight-hour shifts, one man attending them, alternately changing and discharging.

THE AVERAGE PROPORTION OF GOLD EXTRACTED

During the last year, from 294 tons of pyrites, amounted to 95.19 per cent. of the assays, the sand averaging 4½ ounces of gold per ton. Some of the parcels returned as high as 98 per cent. during that period. The cost of extraction amounted to £2 2s. 4d. per ton, without estimating wear and interest on capital. The above charge is rather high, as fuel during that period was unusually dear, and the furnace being but 4 feet wide, instead of 5 feet, increased the labor cost, as less work is done at the same cost than would be incurred in working a larger furnace. Another element in the cost is the mercury which is lost, amounting to 1 pound and 13 ounces per ton—a large proportion of which, I think, might be saved by improved appliances for that purpose, together with the gold contained in it. The immediate cause of this loss of mercury is the severe trituration to which it is subjected with the sand. This was found indispensable, for whenever, through oversight or experiment, a less degree of trituration was applied than that now used, or the sand ground too wet, the return of gold was invariably diminished by several per cent.

In carrying out these operations, I found that a large proportion of galena in the mineral seriously interfered with the extraction of the gold, but a small proportion of the sulphides of copper, zinc, or lead produced no appreciable effect.

Taking the process as it stands, we have been unable to find one that would at less cost extract the same proportion of gold, or could be safely trusted in unskilled hands with only occasional supervision.

Mr. Thompson also read the following return:

Returns of pyrites treated at the Port Phillip Company's works, Clunes, since October, 1866. Minerals treated: 1867, 215 tons, 17 cwt.; 1868, 366 tons, 9 cwt.; 1869, 401 tons, 11 cwt.; 1870, 431 tons, 9 cwt.; 1871, 561 tons, 2 cwt.; 1872, 368 tons, 6 cwt.; 1873, 294 tons. Gold, contents per ton, per assay: 1867, 4 ozs. 16 dwts. 6.93 grs.; 1868, 3 ozs. 18 dwts. 6.56 grs.; 1869, 4 ozs. 1 dwt. 19.15 grs.; 1870, 3 ozs. 11 dwts. 4.34 grs.; 1871, 4 ozs. 7 dwts. 10.99 grs.; 1872, 5 ozs. 18 dwts. 19.36 grs.; 1873, 4 ozs. 10 dwts. 16.30 grs.

Total gold obtained: 1867, 960 ozs. 13 dwts.; 1868, 1,322 ozs. 13 dwts.; 1869, 1,515 ozs. 11 dwts.; 1870, 1,370 ozs. 4 dwts.; 1871, 2,290 ozs. 1 dwt.; 1872, 2,031 ozs. 9 dwts.; 1873, 1,268 ozs. 17 dwts. 12 grs.

Gold extracted, per ton: 1867, 4 ozs. 9 dwts.; 1868, 3 ozs. 12

dwts. 4 grs.; 1869, 3 ozs. 15 dwts. 11.60 grs.; 1870, 3 ozs. 3 dwts. 12.60 grs.; 1871, 4 ozs. 1 dwt. 15.20 grs.; 1872, 5 ozs. 11 dwts. 22.56 grs.; 1873, 4 ozs. 6 dwts. 7.63 grs.

Percentage of gold extracted: 1867, 92.43; 1868, 91.71; 1869, 92.28; 1870, 89.24; 1871, 93.34; 1872, 94.22; 1873, 95.19.

The results obtained by Mr. Latta appear to have been exceedingly close and satisfactory, though rather costly—about ten dollars per ton—which, I think, could have been much lessened had the stuff been reduced finer, and the concentration been carried a little further, so as to have freed the pyrites from the excess of gangue or quartz sand previous to calcination.

It is now generally admitted by metallurgists of any note, that the gold in pyrites exists in a metallic state, and it is with no little pleasure that I am enabled to practically corroborate the statements of Mr. Latta on this subject, having procured for your inspection a number of crystals, and fragments of crystals, of auriferous pyrites, obtained from different parts of this State. They are mounted on glass slides for microscopic examination, as with a common lens the presence of the gold can hardly be detected; but with a good microscope, using an inch or half inch objective, it will be found that the faces of some of the crystals are, in places, most finely and beautifully gilded, and that here and there are seen little specks or drops of gold partially imbedded in the pyrite. The mill-man, after looking at these specimens, will not be surprised at the loss sustained in the wet stamping of auriferous pyrites.

SAMPLING AND ASSAYING GOLD QUARTZ.

In Phillip's Metallurgy, pages 166 and 167, very good directions are given for sampling and assaying gold quartz. For assaying, he says: "The most accurate results are obtained by carefully washing a four-pound sample in the batea. After having in this way concentrated the gold in about an ounce of sand and pyrites, this residue may be either subjected to assay, or the sulphides dissolved by nitric acid, and the gold extracted by amalgamation with mercury, which is subsequently volatilized, and the gold weighed. In either case, calculations are made on the four-pound sample, and when the residue has been subjected to fusion, very accurate results are obtained."

BARREL AMALGAMATION.

During the time I was engaged in gold mining in Brazil, I stayed for some time at the St. John del Rey mine, and there witnessed the barrel amalgamation which I described in my last paper to the State Geological Society, and which is reproduced here:

Their process of amalgamation is nearly perfect, but the stamping and concentration very defective, the stamps doing but little duty—only 1¼ tons per head during the 24 hours; their plan of concentration being principally what is called "straking," consisting of a number of fixed inclined trays 30 feet in length and 18 inches wide, with a fall of one inch to the foot. The trays are covered for the first 16 feet with bullocks' skins tanned with the hair on them, and in lengths of 2 feet 2 inches; below these are series of blankets or baize cloths of the same length. The deposit of sulphurets on the first three skins contains nearly all the gold, and amounts to about 0.42 of a cubic foot per ton of veinstone stamped. It contains about 30 ounces of gold per ton, all of which, with the exception of one ounce, is in a free state; the ounce of gold being mechanically mixed with the coarser grains of pyrites.

It is estimated that in stamping and straking, 10 per cent. of the total amount of the gold is carried off in suspension by the water.

Their loss in amalgamation is comparatively trifling, as far as I can gather from their numerous reports, and will average less than 4 per cent.; the loss of mercury is 0.45 ounces per cubic foot of sulphurets amalgamated. The apparatus employed for amalgamation of the sulphurets consists of wooden barrels 4 feet in length and 2 feet 5 inches in diameter, having a capacity of 20 cubic feet. The charge of sulphurets for each barrel is one ton and a half, *free from decomposition*, and 60 pounds of mercury. There is also a sufficient amount of clean water at the same time introduced to give the slimes the necessary degree of fluidity to enable the globules of quicksilver formed to become properly incorporated, without allowing them to become sufficiently mobile to admit of the settling of the mercury and amalgam at the bottom. The barrels, when charged, are allowed to rotate from 20 to 30 hours, making 18 revolutions per minute, in accordance with the state of the atmosphere.

The contents of the barrels are afterwards washed in an apparatus called a "saxe," which is used to separate the gold amalgam from the refuse. In this country it might be perhaps better to employ separators the same as those used in the different pan mills.

In their report of 1880 the results of their trials of

Was anything but satisfactory; indeed, in the milling for gold that system appears to be too costly for low-grade ores, and not fit for the rich. It is better calculated for the treatment of veinstone which contains in the ton from five to ten ounces of silver, and that in a suitable mineralized condition as chlorides, etc.

The attempts to grind the sulphurets when they contain upwards of 50 per cent. of pyritic matter, and to amalgamate the mechanically combined gold inclosed in the particles of pyrites, at the same time and in the same pan, has not been attended with success from the earliest attempts, some of which I witnessed in Brazil in 1832, which was then made in an apparatus being a modification of the Hungarian bowl. The St. John del Rey sulphurets when ready for the barrel contain about 95 per cent. of pyritic matter, and are reduced so fine that 90 per cent. of it will pass through a sieve having 100 holes to the linear inch.

What I have tried of the California sulphurets the pyritic matter varies from 70 per cent. to 90 per cent., and about 75 per cent. of it will pass through a sieve of 100 holes to the linear inch.

The following analyses were made by John A. Phillips, F. G. S., and published in his Metallurgy of Gold and Silver. I lately received a letter from him, wherein he tells me he is going to publish another work on gold:

ANALYSES OF AURIFEROUS CALIFORNIA PYRITES CONCENTRATED FROM TAILINGS BY JOHN A. PHILLIPS.

	From Grass Valley.	From Near Sonora.	North Star, Grass Valley.
Sulphur	46.700	37.250	43.720
Arsenic	.310	8.490	1.360
Iron	41.650	36.540	39.250
Copper	trace.	trace.	.220
Lead	trace.	.400	trace.
Gold	.037	.302	.026
Silver	.036	Not determined.	.012
Cobalt	.036	Not determined.	.150
Silica	10.970	17.150	14.230
Totals	99.703	100.162	98.968

PER TON OF 20 CWT.

	Oz.	Dwt.	Gr.	Oz.	Dwt.	Gr.	Oz.	Dwt.	Gr.
Gold	12	2	0	93	13	0	8	10	0
Silver	11	16	0	--	--	--	3	18	0

By careful analysis their concentrations differ but little from those of some of the mines near Sonora, Tuolumne County, Cal., the amount of arsenic varying from one to ten per cent., though in the upper part of the St. John del Rey mine it did not contain so much arsenic as the following analysis, made by John A. Phillips in 1847, shows.

Analysis of uncrushed ores from the St. John del Rey mines, made by J. Arthur Phillips, in 1847 :

Silica	16.87
Carbonate magnesia	12.17
Carbonate lime	3.01
Sulphur (iron pyrites)	16.78
Iron (iron pyrites)	14.65
Peroxide of iron	32.84
Peroxide of manganese	3.63
Arsenic and gold	Traces.
	99.94

N. B.—Gold per ton equal 1 oz. 2 dwt. 20 gr.

The reason I have said so much about these mines, and called your attention so frequently to them, is from the fact of their successful treatment of such a difficult veinstone for so many years. To properly understand the magnitude of the work, suppose we estimate the yield of the veinstone in California, from all the mines in pyritic matter, to be, say five per cent. of all that is worked (which is rather high), it will hardly equal that treated daily at the St. John del Rey works.

The results of years of experience in working such a mine ought to be interesting even if it were not exceedingly valuable, as it really is ; yet there are not wanting those who object to any information obtained from the reports of such as the St. John del Rey Company, on the (not very wise) grounds of the mine being worked in Brazil, and the reports printed and published in London ; and, may be worse than all, that the dividends are, and have been for the last forty years, paid there. In the

MILLING OF CALIFORNIA GOLD QUARTZ,

I would advise, for low grade rock, the stamping of it as coarse as such a machine as the "Frue," or other improved concentrator can treat to advantage. The size of the aperture in the screens should gradually increase, and be the largest in the upper part, which would in a great measure prevent what is termed "dead stamping," and, at the same time, add greatly to the duty of the stamps. Screens having 12 holes to the linear inch in the bottom and 10 in the upper part, are not too coarse for low grade rock. As a stamp-head weighing 8 cwt. will then, on an average, reduce 4 tons in the 24 hours, and those of 6 cwt. about 3 tons, and any trifling loss of free gold will amply be made up by what is saved in the sulphurets—*so that a "Ten Stamp Mill," with heads weighing 8 cwt., can be made to work to advantage 40 tons of rock per day.* The fineness of the stamping, however, is in part regulated by the position of the screen, that is, their horizontal distance from the stamp-head and the vertical height of the bottom of the screen above the level of the die. For example, the finest work is done by splash-stamping, that is, without using any screens, and allowing the pulp to be discharged over the front side of the mortar, which is purposely made lower than the back or feed part of the mortar.

The Port Phillip Company, in Australia, I believe, use them with 10 holes to the linear inch. Steel wire-cloth is the best and will, I am told, last better than any other.

Some years ago, in a communication to the State Geological Society on the subject, I recommended fine stamping for low grade rock containing a large proportion of sulphurets; but recent improvements in concentrators, and a closer examination of the condition of the gold in the iron pyrites, of which I find so large a proportion is in thin films, and which, with a rapid flow of water, would be carried away, and a greater part of it lost, have altered my opinion on this point.

It is not generally known, but nevertheless, from numerous and very careful tests, it is proved that in fine stamping, when the speed of the stamps is above seventy-five blows per minute, that the loss of gold, when blankets or raw hides are used, is much greater than at a speed of fifty blows per minute; though I am not aware that any tests have been made when the amalgamation was done in the battery. The system of

AMALGAMATION IN THE BATTERIES,

However, I have always considered a mistake and as entailing a great loss of gold, particularly so, when the rock contains a large proportion of sulphurets; besides, if precautionare not taken, a low degree of temperature will render the amalgamated silver plates nearly useless. To understand this correctly let the mill-man put two or three barrowfuls of rock very rich in sulphurets through the stamps and then watch the effect on the amalgamated plate, and at the same time collect some of the pulp after passing over the plates, and have it carefully tested, and he will then better understand why I prefer the blanket system.

Prof. W. W. Smyth, in one of his lectures on gold, with respect to stamping, says: "Take a large hammer and gently crack a nut with it, and you have an illustration of what a stamp ought to do; it ought, if possible, to crack the enveloping shell of stone, and set free the kernel of metallic mineral unbroken."

Or, for instance, take a piece of veinstone from the Bodie district—the same as marked No. 26—one half of it pound very fine, using a grinding action with the pestle, then wash out the gold in a batea, or horn spoon, and you will find that a large proportion of the gold will float away, in spite of every care, even using ammonia to destroy the grease on the ends of the fingers.

Then take the other half, pound it very coarsely, and in washing out the gold you will see very little float, and two or three turns of the batea will bring all the gold into the center.

IN THE BLANKET SYSTEM,

Where improved concentrators are used, after the pulp has passed over the blankets, only two lengths of trays of about four feet each, and two sets to each five stamps are required. They should be so arranged that the inclination can be altered, say from 3° to 5°, to suit the stuff being treated.

The trays should be about 16 inches wide, and the fall from the battery box to the head tray the same as from one tray to another, about 4 inches, with a board placed across the end that the fall of the water or pulp will be so broken as to strike the blanket in the tray below nearly at right angles. The blankets should be in 3-feet lengths, and made of coarse wool with a long nap. The double sets of trays are for the convenience of changing and washing the blankets. The blanket washings can be passed through a simple machine like that described in Phillips' Metallurgy (see page 185), and the tailings from it ground with the coarse concentrations in a Chilean mill.

It is not so much the length of the blankets that separates the gold from the gangue, but the fall, or jump, on them.

Where the mill has a limited supply of water, and they do not like to go to the expense of a number of concentrators, a coarse concentrator may be made with a "Tye Buddle," the plans and directions for the use of which will be found in "Phillips' Metallurgy of Gold and Silver," page 187.

The concentrations from the "Tye" can be passed over the "Frue," one of which would then be sufficient for a large mill; though I am not prepared to say by such means they can work as closely as by using the "Frue" alone.

In case the mill is not situated at a very great altitude, where the frost might interfere with this working,

AMALGAMATED PLATES,

In 3-feet lengths and 2 feet deep, on a fixed frame at an angle of about 3°, to which a slow lateral movement backward and forward of one foot, together with a slight shake, is given, in the same direction, with a sprinkling of clean water from a perforated pipe falling on the upper part above where the pulp strikes, might be placed with advantage between the blankets and concentrators.

THE CONCENTRATIONS

Should be sifted through a seive having 80 holes to the linear inch, and any particles that were not fine enough should be ground in a Chilean mill, the same as described by Mr. Latta, but without using the mercury; and afterwards charged into wooden barrels for amalgamation; but, before charging, the sulphurets should be soaked in water, to free them from all decomposition. I feel confident that larger results will be obtained by thus treating the raw ore than if it was roasted.

The great difference between a wooden surface and a metal one in amalgamation can easily be shown by washing out, say, about one dwt. of Bodie or Grass Valley gold in a batea and then adding, with a dropping bottle, just sufficient mercury for it to amalgamate with—too much or too little will lengthen the result; but if the proper quantity be used, by rubbing it with the finger in the center of the bowl it will amalgamate rapidly in less than a minute. Try the same experiment with an iron pan, and you will find how much longer it takes to get the same result. I would strongly recommend any mine adventurer, before erecting any quartz mill, or adopting any particular process, to have some 20 or 30 tons of the rock or veinstone stamped, and to save, during that operation, a fair sample of the battery pulp from it, which should be carefully concentrated in a batea, or any other utensil used for washing on a small scale. The condition and quantity of the gold, and other ores and minerals, should be tested and examined. The percentage of the sulphurets can also be roughly estimated at the same time, and all afterwards compared with the gross results from stamping.

TEST FOR TELLURIUM.

Mr. Edward Booth, analytical chemist, has kindly furnished me with directions for making a simple test for tellurium, in case telluric gold is suspected to be mixed with the sulphurets. It is as follows:

"Place in a test tube, or other vessel capable of resisting the action of acids, a small amount of the suspected material; which has been separated as thoroughly as possible from the accompanying gangue. Add enough sulphuric acid to well cover the sample and heat to boiling. If tellurium is present the liquid becomes colored a clear purplish red."

I have only found, as yet, telluric gold in two mines in Nevada County—one near Grass Valley, and the other, the Murchie mine, near Nevada City.

In my private collection I found a specimen marked "Meadow Lake Ore." I do not recollect who gave it to me, but it contains both gold and telluric gold.

REBELLIOUS GOLD ORES.

A great deal has been written and said about the so-called rebellious gold ores of the Meadow Lake District, and what the different *process-men* were going to do with them, but I never remember having heard of any careful analysis being made, either of the veinstone or the concentrations. I would therefore respectfully suggest to those who have any samples of the Meadow Lake ores to donate them to the State Mining Bureau, as the examination and determination of them would be of the greatest importance to the mining interests of the State. The mines were discovered, I think, in 1862, and in 1865 and 1866 eight quartz mills were erected; a large town built, estimated to contain 5,000 inhabitants. Now the place is quite deserted.

In the published reports of the Geological Survey, 1864, by Professor Whitney, no mention is made of the mines or district, so that little could have been known about them at that time.

THE PAN SYSTEM.

I can only now add, that had I years ago acted upon what I now suggest to others, I would have saved large sums of money for my partners and myself. For instance, what is the difference between the gold and sulphurets in the Mammoth lode, Mono County, and in the Sierra Buttes lode? Is not the gold in the latter much more difficult to save, and would not the Comstock soda, salt, and pan system, if introduced at the Sierra Buttes mine, soon close it up like the former? For my own part, I firmly believe that if the same pan system were used in the Victoria District, Australia, all the mines using it would soon cease to pay dividends; and, also, if the Idaho mines at Grass Valley were to try it, that their dividends would soon be reduced one half.

If the correct number of tons of mercury, soda, salt, and "other chemicals," as they are called, that have been sent to the Mono County mills were published, I am afraid it would appear to be very large.

It might be urged that the chemicals used in the Bodie mills were for the extraction of the silver from the ores. In that case, it would be exceedingly interesting to ascertain the expense, and see if it did not, as some think, cost $2 in coin for every $1 in silver so obtained.

CATALOGUE OF SPECIMENS.

The following is a catalogue of the specimens which I shall place in the State Mining Bureau to illustrate this paper:

No. 1—Crystal of pyrite on a glass slide. Some of the faces are very finely and beautifully gilded; so fine indeed that it requires an inch objective to see it to advantage. From the Eureka mine, Grass Valley.

Nos. 2, 3, and 4—Gold, in little drops or specks, imbedded in the pyrites. From El Dorado County.

No. 5—A specimen of arsenical pyrites with gold. From a mine near Nevada City.

Nos. 6 and 7—Sections cut from the same, in which the gold is easily recognized.

Nos. 8 and 9—Gold, with telluric gold.

No. 10—Section cut from same.

No. 11—Gold in carbonate of lime. Eureka mine, Grass Valley.

No. 12—Gold in talcose slate. Taquarilla mine, Brazil.

No. 13—Gold in talc. Placerville.

No. 14—Gold on talc. Brazil.

Nos. 15 and 16—Gold in Iacotinga (micaceous iron). Gongo Soco mine, Brazil. The Iacotinga veins are from a few inches to many feet in width.

Nos. 17 and 18—St. John del Rey veinstone; 18 is about the average of what was milled in 1866.

No. 19—Specimen of killas from St. John del Rey mine; a rock which forms the sides of the lode, but also contains considerable pyrites.

Nos 20, 21, and 22—Sections cut from St. John del Rey veinstone for microscopic examination.

Nos. 23 and 24—Sections cut from the killas.

No. 25—Yellow dusty matter mixed with gold, taken out of one of the richest pockets ever found at Grass Valley.

No. 26—Veinstone with gold. Bodie District.

No. 27—Gold in country rock (diorite). From Nicaragua.

No. 28—Gold in quartz crystal.

No. 29—Gold in syenite.

No. 30—Section cut from No. 29.

I have cut a great number of sections from the St. John del Rey veinstone, but could not detect the gold in any of them, and unless very great care is taken the batea test will hardly show any gold; notwithstanding which, on a large scale, they obtain better results from the amalgamation of the raw sulphurets than any other process I have seen tried.

THE TRIBUTE SYSTEM.

I have just received a copy of the report of the Port Phillip Company, Australia, published January 13, 1881, by which it appears the tribute system has been introduced there with great success. Too much can hardly be said in favor of such a system, as it places the hard working and intelligent miner on a much more respectable and independent footing; and though he in a measure shares the risks, but only so far as his judgment guides him, he gets the benefit of any discovery he may make. It also encourages him to study the peculiarities of the lode and inclosing rocks; besides which, by that system, all are jointly interested in the welfare of the mine. Many of the mines now idle in this State could be worked profitably under the system, particularly in the Bodie district.

In the Port Phillip report it says:

The number of tributes has averaged about 200 during the year, which shows no decrease when compared with the preceding year. The tribute system has been further extended by an arrangement with the tributers to drive the levels in the ground let to them, the company assisting them with driving timber and rails, and making an allowance per fathom until the yield reaches 6 dwts. per ton, when no further assistance is given; the company receiving half the gold obtained, and deducting from the allowance the cost of tramming. By this means a large amount of driving is done at a comparatively small cost.

The number of tons of quartz stamped on tributers' account for the year was 48,184 tons. The average yield of the entire quantity raised was 5 dwts. 5½ grains per ton (say $5).

Total receipts	£32,364 14s 7d
Expenditure	26,310 10s 7d
Leaving a profit of	£6,054 4s 0d

In conclusion, so thoroughly am I convinced of the great benefits that would result to this State by a more general introduction of the tribute system in an extended form, both to the placer as well as vein mining, that I wish particularly to call your attention to it, so that, through the influence of the Bureau, the subject may be brought in a proper light before the owners of mines or claims. A fair tribute will secure the *muscle* of the working miner, who, in too many cases, understands better than the Superintendent (generally a man of business) how to conduct trials for ore, and afterward to develop them. The *muscle* of the skilled miner is in every respect better than foreign capital.

There is no need of the hard-working miner to leave this healthy climate in search of employment, if those who own mines that are now idle would let the fact be known through the press, and at the same time offer a fair tribute for working them.