

ART. III.—*Notes on the Quicksilver mines of Almaden, Spain.*
Condensed from a MSS. Report made to the New Almaden
Company of California, by C. E. HAWLEY, M. E.

THESE mines, which, according to Pliny, were worked 700 B. C., and in his time annually sent 10,000 pounds of cinnabar to Rome,* are still productive to a remarkable extent.

The geological position of the Almaden mines has been shown to be Upper Silurian by the researches of Don Casiano de Prado, the predominating rocks being slates which usually form the walls of the veins and are sometimes impregnated with cinnabar. The matrix or gangue stone of the ore ground is a hard fine-grained sandstone, so hard at times as to be confounded with quartz. These sandstone beds form the so-called veins, and appear to have been impregnated with the vapors of cinnabar at the time of their metamorphosis, and so evenly are they charged with the ore, that in mining very little waste rock is taken out. There are three veins of ore at present worked in this mine. 1st, the San Diego and San Pedro; 2d, San Francisco; and 3d, San Nicholas. These are separated by masses of slate and sometimes enclose thin layers of slate in the ore. The linear extent of the mine is only about 600 feet, and near the surface, was much less. The mine is divided into ten different floors or levels, separate from each other by an average of about 90 feet, the lowest level being 921 feet from surface.

* Pliny, lib. 33, chap. 7.

The veins in the upper workings appear to have been very indistinctly defined, but have increased in power and in quality of ore steadily as greater depths have been reached. They were fully developed in their true character only on the 5th floor, while now in the bottom of the mine at the 10th level the richness and abundance of the ore in sight exceeds all before known. The following tabular statement illustrates this progressive increase in the extent and width of the three veins at the several levels commencing with the fifth.

Level.	San Diego.		San Francisco.		San Nicholas.	
	Length.	Width.	Length.	Width.	Length.	Width.
5th,	164'	14·5'	426'	13'	98'	9·6'
6th,	264	16·5	363	49·5	214·5	10·7
7th,	495	15·3	511	15·3	412	13·2
8th,	561	26·4	594	14·5	610	18·1
9th,	495	21·5	478	9·1	561	9·2

The 10th level is not yet sufficiently worked to determine the length or thickness of the veins, but the ore is of fine quality. The veins stand nearly vertical and are opened by vertical shafts. Their course is in general N.W. and S.E., and they are separated from each other by slate and sandstone. The linear extent of these veins is far from being completely proved. Work has been suspended where the ground became comparatively sterile. But it is well known that the mine, extensively opened in the 17th century by the Fugger Counts, exists in close proximity on the N.W., while a few yards of exploration in that direction, or to the S.E., may show the veins restored to their fruitfulness. The great mine worked by the Fuggers, and after them until the great fire of 1755, though in close proximity to the present mine, is now unknown, although the records prove its great yield and that it was worked to a depth of 825 feet.

The mode of extraction of the ore with the securing of the mine is by leaving alternate pillars of the solid ore 4 varas wide, the space left void between which, after the ore is removed, is filled by masonry, or by broken stones supported upon arches of masonry. The galleries of the mine are also turned in masonry. This system was adopted in 1804 on account of the scarcity of timber and with a view to the greater permanency of the work. The reserves of ore thus accumulated, equal nearly to all that has been removed, have been left untouched since 1804 until within the past 6 years, since which time very limited quantities of them have been removed, the spaces left being filled with much less care than the first set of pillars. Timber is used only for temporary purposes; the stone required for the masonry being quarried in the adjacent hills.

The mechanical appliances of this great mine are of the most primitive description. The ore is raised through the Teodoro shaft by 8 mules working a whim with an effective force of about 3 horses (steam standard). The amount of water in the mine is very small and appears to have varied but little in a century. The system of pumping is slow, expensive and barbarous. An antique machine of the last century, notable only for its age and inefficiency, demands for its aid the constant additional force of 30 to 40 men employed in pumping by hand.

The cost of extraction of the metric quintal of 100 lbs. of ore is as follows, given in reals (=5 cents U. S. coin.)

Excavation in ore and dead ground	7.40 reals	
Interior transportation	1.24	"
New timber, refuse rock, etc.	0.55	"
Tools, 0.92, whim, shops, etc., 1.17	2.09	"
Rock for fortifying mine, 1.57 mortar and brick, 1.02,	2.59	"
Masonry, 1.25, timbering, 3.67, carpentry, 1.11	6.03	"
Draining the mine	4.47	"
Laborers at mine, shaft, yard, etc.	2.86	"
Various expenses, 0.78, salaries, 1.48	2.26	"
	<hr/>	29.49
Transportation to furnaces,	0.17	"
Cost of metric quintal of ore at furnace,		29.66

This is equal respectively to 67.8 c. and 68.2 c. of U. S. coin.

Much doubt seems to rest over the amount of metal obtained from the ore and respecting the relative merits of various modes of distillation. The most trustworthy observations, however, appear to be those made between 1851 and 1855, from which the average per centage obtained was 6.9, at the following cost per quintal (100 Spanish pounds.)

Mining and transportation	197.65 reals.
Cost of reduction in furnaces	22.35 "
Flasks	40.00 "
	<hr/>
	260.00

equals \$13 U. S. coin per quintal, or \$9.75 per flask, which sum is however raised to \$15.15, including cost of transportation to Seville and various incidental expenses. The average product of the five years named for both Almaden and Almadenejas we find at 16,582 quintals (=22,199 flasks), which cost in the aggregate \$304,535, or \$13.77 per flask. If the expenses and product of the Almaden mine are estimated separately, (Almadenejas being a small mine, raises the ratio of cost considerably), it is seen that its average annual yield was 21,468 flasks, costing \$268,214.53, or \$12.49 in Seville. This cost is apportioned as follows.

12 *The Quicksilver mines of Almaden, Spain.*

Mining, per flask,	\$6.53	or 52.25 per cent.
Reduction, “	0.87	“ 6.96 “
Flasks, “	1.50	“ 12 “
Flasking, “	0.09	“ 0.75 “
Transportation to Seville,	.70	“ 5.64 “
Administration,	2.58	“ 20.65 “
Extraordinary, etc.,	.22	“ 1.73 “
	<hr/>	<hr/>
Total per flask,	12.49	100.00

In the aggregate these expenses appear as follows, viz :

Administration,	\$8,188
“ superintendence, clerks, firemen, etc.,	21,117.80
Expense of warehouse at Seville,	2,459.50
Materials of shops,	1,121.85
Mining (less administration),	183,086.95
Reduction (furnaces),	17,544.20
Flasks, flasking and transportation,	39,951.70
Commission,	36,171.30
Transportation of funds, etc.,	1,880.55
Rents, \$189.95, charities, \$497,	684.95
Extraordinary and unforeseen,	4,687.75
Daily ordinary accts. of storehouses,	290.90
Hospital and church,	2,291.00
Laboratory,	160.00

\$269,636.45

Deducting \$2680.05, the profits of Almadenejas,

2,680.05

And the remainder of

\$266,956.40
very closely corresponds with the sum of \$268,214.55, the cost of 21,468 flasks at \$12.49 each.

The Bustamente furnaces in use at Almaden are extremely defective, depending on a series of small earthen ware cylinders, joined one to another and leading into a large chamber for the condensation of the mercurial vapors. Much mercury is lost from leaks in the joints of this apparatus.

In 1856 extensive and careful assays were made by two engineers employed by the Spanish government, of the ores accumulated for the burning of that year. The following deduction was made of the value of the different qualities of ore.

Metal or superior mercury,	38.576
Mediano (medium)	9.9
Bolas (cakes) of fragments of soot from condenser,	17.790
Bolas without soot,	5.110

Applying these figures to the five years, the results would be as follows, viz :

38,551 quintals "metal,"	= 38·576 p. c. = 14·872 quintals mercury.
143,969 " "mediano,"	= 9·904 " = 14·239 " "
5,109·5 " bolas with soot,	= 17·79 " = 908 " "
45,985·5 " bolas without soot,	= 5·11 " = 2·349 " "
Total quintals,	32·368
" " obtained,	16·101
Loss,	16·267.

This loss of 50·25 per cent is equivalent to 21,689 flasks; or, the ore contained, by the above estimate, 13·86 per cent and the amount of mercury obtained was 6·96 per cent.

Notwithstanding the cheap labor at Almaden, many items of cost are extravagantly high; at 78 cts. per ton of water raised, the enormous sum of \$17,541 is expended in pumping by hand! At least one-third the effective force of the mine-laborers is wasted in the toil of climbing up and down from the entrance to the bottom of the mine, want of ventilation making an additional heavy tax on the productive power of the miners. The cost of fuel for the furnace is extravagantly high and its quality the poorest.

The great feature of this mine, in contrast with other mercury mines, is the enormous body of rich ores always in reserve and ready for immediate extraction. A careful measurement shows that 36 per cent of the vein has been left untouched, equal to 2,012,600 cubic feet, which upon a moderate estimate must weigh 402,520,000 lbs. This at 7 per cent would give 375,685 flasks of quicksilver; at ten per cent it would yield 536,693 flasks, and at 14 per cent, 753,370 flasks of 75 pounds each. This estimate makes no account of the great body of extremely rich ores existing untouched between the 9th and 10th floors of the Almaden mine.

The very heavy expenses of fuel, pumping, transportation, hoisting of ores etc., might easily be reduced to at least one-half their present cost. Good coal exists in the great coal fields of Belmez, only 40 miles from the mine. With a safety cage for raising ore and the operators, good ventilation and drainage, and a proper system of railroads above and under-ground, the expense of many laborers might be saved. With these improvements and certain changes of administration, the author concludes that quicksilver can be produced at Almaden at a cost not exceeding one-third of that now incurred in the mines at New Almaden in California.

B. S.