QUICKSILVER.[1]

By F. L. Ransome.

INTRODUCTION.

Mining for quicksilver[2] (mercury) in the United States began in California in 1848, and the total production to the end of 1917 is 2,305,130 flasks, valued at $108,708,078. Large as this sum is it is only about one-ninth of the value of the lead produced in this country to the end of 1915, or about one-sixteenth of the value of the silver, one thirty-third of the value of the copper, or one thirty-fifth of the value of the gold mined prior to 1917. Thus quicksilver mining is a comparatively small industry in this country.

Up to 1882 the mines of California supplied all the quicksilver produced in the United States. Texas, which began production in 1899 with 1,000 flasks, now ranks as the second quicksilver mining State in the Union, with an output of 10,791 flasks in 1917. Nevada, which now holds third place, began production in 1903, reached its acme with 2,550 flasks in 1912, and yielded 997 flasks in 1917. Oregon, with 388 flasks in 1917, ranks fourth, and much smaller quantities are obtained from Arizona, Idaho, and Washington. From 1903 to 1907 considerable quicksilver was produced in Utah, the annual output from that State amounting to 1,133 flasks in 1905, but Utah now produces no quicksilver.

The world's production of quicksilver in 1917 is estimated at 122,592 flasks, of which the United States produced 36,159 flasks, Italy 29,300 flasks, Spain 25,133 flasks, and Austria-Hungary probably about 27,500 flasks.

USES.

As everybody knows, quicksilver is used in thermometers and barometers, but the quantity consumed annually in the United States in the manufacture of such instruments is less than 2 per cent

[1] The chapter on quicksilver for this bulletin was originally undertaken by Mr. H. D. McCaskey. Finding, however, that other duties were preventing its completion, he turned over the task to me in September, 1918, with such notes as he had prepared for his manuscript.—F. L. R.

[2] "Quicksilver" and "mercury" are two names for the same metal and to some extent are interchangeable. "Quicksilver," however, is the term commonly used in mining and commerce, while "mercury" belongs particularly to the language of science and especially of chemistry. In the industrial arts the two words have nearly equal currency.

of the total quantity produced. Mercury is a constituent of many drugs and chemicals, including calomel and corrosive sublimate, and mercuric oxide and mercury salts are used in the manufacture of certain chemicals of which the mercury itself does not form a part. For example, in one process of producing glacial acetic acid acetylene is oxidized with mercuric oxide, the same lot of mercury being used repeatedly. Mercury is used also in making phthalic anhydride and phthalic acid, organic compounds which are employed in the dye industry but which themselves contain no mercury. The use of mercury fulminate as a detonator has expanded enormously with the increase in the variety and efficiency of the high explosives now manufactured for industrial and military purposes, and, although primers have been made of other materials, especially for small arms, no substitute has found general acceptance. Quicksilver is now used extensively in the manufacture of antifouling ship-bottom paint. The consumption of quicksilver in gold-dredging and other placer operations is still large. In gold-quartz mills, however, the amalgamation process has been largely supplanted by cyanidation. Among the varied uses to which quicksilver is put may be mentioned also its employment in dental amalgams; in the manufacture of laboratory air pumps and other scientific instruments; in thermostats, gas governors, and similar appliances; in mercury-vapor electric lamps; in compounds for preventing scale in steam boilers; in cosmetics; in certain electrolytic processes for the manufacture of chlorine, caustic soda, and picric acid; in primary batteries, electrolyzers, rectifiers, and other electrical equipment; and in felt making.

ORES.

Most quicksilver ores are of rather simple mineral composition. About 25 mercurial minerals are known, but most of these are rare, and some of them contain quicksilver only as a minor constituent. Over 95 per cent of the quicksilver produced in the United States comes from the bright cochineal-red sulphide of mercury, known in its natural form as the mineral cinnabar. Pure cinnabar contains 86.2 per cent of quicksilver. Minor sources of quicksilver include metacinnabar, which has the same composition as cinnabar but is dark gray or black, and native quicksilver, which generally occurs in little globules but in some mines fills cavities of considerable size. The cinnabar in quicksilver ores is usually associated with pyrite or marcasite and less generally with the sulphide of antimony, stibnite. The commoner nonmetallic constituents of the ore are quartz, chalcedony, opal, calcite, mixed carbonates of calcium, magnesium, and iron, and barite. Many quicksilver ores contain also small quantities of an oily or asphaltic hydrocarbon, and some carry free sulphur.

No quicksilver ores that are mined on a large scale consist exclusively of pure cinnabar. The richest that are extensively worked are those at Almaden, Spain, where the average yield in 1917 was slightly less than 7 per cent. Probably the lowest tenor in ores that are successfully mined is found on the Pacific coast of the United States. The average yield of the California ores during the last two years was 0.38 per cent.

METALLURGY.

The ores of quicksilver, unlike those of most metals that are won by smelting, are without exception in this country treated at the mines, and the liquid metal is shipped as a finished commercial product in iron bottles or flasks containing 75 pounds each. A moderate heat, about 360° C., is enough to vaporize and decompose cinnabar, and the quicksilver is obtained directly by condensation in suitable chambers through which the fumes from the furnace are conducted. There are two classes of reducing apparatus—furnaces and retorts. In most furnaces the ore is exposed to the direct action of the flame, the volatile products of combustion, with more or less dust, mingle with the vapors of sulphur and mercury driven from the ore, and all pass together through condensers. The operation is in general continuous. In retorts, on the other hand, the ore is heated in a closed iron vessel, out of contact with the flame, and only those volatile constituents that are released from the ore pass into the condensing apparatus. In most retorts the operation is intermittent.

FORM OF QUICKSILVER ORE BODIES.

Quicksilver ore bodies are notoriously irregular in form, and probably for no other group of metalliferous deposits is prediction or quantitative estimation more difficult. By far the greater number of quicksilver ore bodies that have been or are being worked in the United States are irregular lenses, pipes, or podlike masses with few or no definite surfaces of demarcation separating them from the inclosing rocks. Where several ore bodies occur they are usually arranged along a principal zone of fissuring and may have one distinct wall, generally marked by a seam of claylike material, or gouge, produced by the crushing and grinding of the rock along one of the fissures. The ore masses may consist of porous rock through which the cinnabar or other quicksilver minerals are scattered in small crystal particles, or may be made up of rock that is traversed by many irregular veinlets or stringers, in which occur most or all of the valuable minerals, the rock between the stringers being barren.

OCCURRENCE.

The ores of quicksilver, like those of most other metals, show on the whole a close association with igneous rocks and with zones of fissuring. Their deposition, more commonly than that of other metals, with the possible exception of antimony, was associated with volcanism as opposed to plutonic igneous activity and occurred comparatively near the surface. It follows that quicksilver deposits as a rule are found in regions of Tertiary and Quaternary volcanic activity which have not been subjected to long and deep erosion, that they are more likely to occur in the younger geologic formations than in the older ones, and that as a class they do not extend to great depth. It must be noted, however, that there are some conspicuous exceptions to these generalizations. Although most quicksilver deposits are in regions of geologically late volcanic eruptions, it is probable that ores of quicksilver were deposited also during or soon after epochs of similar igneous activity in the older geologic periods but that many of them have been removed by erosion. Some of the deposits which are in the older rocks and which do not appear to be related to Tertiary or later volcanic eruptions may have had such earlier origin.

It is entirely in accord with the general association of quicksilver ores with volcanic activity that the quicksilver deposits of the United States are found in the western part of the country, where the products of Tertiary and later vulcanicity abound and where numerous hot and thermal springs testify to the comparative recency of much of the igneous activity.

In California the principal deposits occur in the Coast Ranges within a belt about 400 miles long that extends from Santa Barbara on the southeast to Ukiah on the northwest. The maximum width of this belt is about 75 miles. The known deposits within this area are numerous. About 25 of these are at present productive, but it is estimated that at least three times that number of mines which were productive in the past are now idle. A comparatively small number are prospects, from which no production has yet been recorded.

With a few exceptions the deposits of the main quicksilver belt in California are in rocks of the Franciscan formation, probably of Jurassic age, or in the serpentine which is so abundant and characteristic an associate of these rocks. Probably the greater number are in the serpentine. Others are in sandstone, generally near the serpentine, and still others are in thin-bedded siliceous rocks known as radiolarian chert.

The most productive mine in California at present is the New Idria, in San Benito County, which in 1917 yielded 11,000 flasks out of a total for the State of 23,938 flasks and for the United States of 36,159 flasks. The total production of California to the end of 1917 is 2,210,852 flasks, valued at $102,851,913.

In Oregon cinnabar is widely distributed, but only one deposit, a metallized fissure zone in andesite at Blackbutte, in Lane County, is at present commercially productive.

In Washington cinnabar has been found at a few localities in Chelan, Kittitas, and Lewis counties. None of the deposits has yet proved to be of economic importance.

Nevada contains many widely scattered deposits of quicksilver ore, no one of which has yet been worked on an extensive scale, although a few of them have been fairly productive for short periods. The Nevada quicksilver ores occur in rhyolite of Tertiary age and in limestones or associated sedimentary beds of various ages from Paleozoic to Mesozoic. The production in 1916 was 2,198 flasks, valued at $276,706, and in 1917 it was 997 flasks, valued at $105,004.

In Arizona most of the known quicksilver deposits occur in zones of fissuring or shearing in pre-Cambrian schist.

In Texas the principal deposits are in the Terlingua district, in Brewster County, about 75 miles south of Alpine. The ore occurs along fissure zones in Cretaceous limestones and shales, generally in proximity to bodies of intrusive rock. These mines yielded in 1917 10,791 flasks of quicksilver, valued at $1,136,508, and in 1916 6,306 flasks, valued at $793,862. The production of Texas from the beginning of operations to the end of 1917 is 76,200 flasks, valued at $4,680,295.

STATISTICS OF PRODUCTION, PRICES, IMPORTS, AND EXPORTS.

The tables which follow have been taken from the Geological Survey's report on the production of quicksilver in 1917, which the reader should consult for more detailed information than can be presented in this summary.

Quicksilver produced in the United States, 1850–1917.

[In flasks of 76.5 pounds to June, 1904; subsequently in flasks of 75 pounds.]

Year.	Flasks.	Price per flask.	Value.	Year.	Flasks.	Price per flask.	Value.
1850	7,723	$99.45	$768,052	1885	32,073	$30.75	$986,245
1851	27,779	66.93	1,859,248	1886	29,981	35.50	1,064,325
1852	20,000	58.33	1,166,600	1887	33,825	42.375	1,433,334
1853	22,284	55.45	1,235,648	1888	33,250	42.50	1,370,625
1854	30,004	55.45	1,663,722	1889	26,484	45.00	1,191,780
1855	33,000	53.55	1,767,150	1890	22,926	52.50	1,203,615
1856	30,000	51.65	1,549,500	1891	22,904	45.25	1,036,406
1857	28,204	48.73	1,374,381	1892	27,993	40.71	1,139,595
1858	31,000	47.83	1,482,730	1893	30,164	36.75	1,108,527
1859	13,000	63.13	820,690	1894	30,416	30.70	933,771
1860	10,000	53.55	535,500	1895	36,067	37.04	1,335,922
1861	35,000	42.05	1,471,750	1896	30,765	34.96	1,075,544
1862	42,000	36.35	1,526,700	1897	26,691	37.28	995,040
1863	40,531	42.08	1,705,544	1898	31,092	38.23	1,188,647
1864	47,489	45.90	2,179,745	1899	30,454	47.70	1,452,656
1865	53,000	45.90	2,432,700	1900	28,317	44.94	1,272,566
1866	46,550	53.13	2,473,202	1901	29,727	48.46	1,440,570
1867	47,000	45.90	2,157,300	1902	34,291	43.20	1,481,371
1868	47,728	45.90	2,190,715	1903	35,634	45.29	1,613,864
1869	33,811	45.90	1,551,925	1904	35,315	43.50	1,536,203
1870	30,077	57.38	1,725,818	1905	30,534	36.22	1,105,941
1871	31,686	63.10	1,999,387	1906	26,083	39.50	1,030,279
1872	31,621	65.93	2,084,773	1907	21,554	39.60	853,538
1873	27,642	80.33	2,220,482	1908	19,752	44.17	872,446
1874	27,756	105.18	2,919,376	1909	21,075	45.45	957,859
1875	50,250	84.15	4,228,538	1910	20,601	46.51	958,153
1876	72,716	44.00	3,199,504	1911	21,256	46.01	977,989
1877	79,395	37.30	2,961,434	1912	25,064	42.05	1,053,941
1878	63,880	32.90	2,101,652	1913	20,213	40.23	813,171
1879	73,684	29.85	2,199,467	1914	16,548	49.05	811,680
1880	59,926	31.00	1,857,706	1915	21,033	85.80	1,804,631
1881	60,851	29.83	1,815,185	1916	29,932	125.89	3,768,139
1882	52,732	28.23	1,488,624	1917	36,159	105.32	3,808,266
1883	46,725	28.75	1,343,344				
1884	31,913	30.50	973,347		2,305,130	....	108,708,078

Quicksilver imported and entered for consumption in the United States, 1908–9117.[a]

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1908	15,113	$8,216	1913	171,653	$75,361
1909	15,968	8,203	1914	614,869	271,984
1910	667	381	1915	421,884	282,752
1911	471,944	251,386	1916	424,396	515,919
1912	82,706	39,920	1917	390,494	449,032

[a] Prepared by J. A. Dorsey from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Quicksilver exported from the United States, 1906–1917.[a]

Year.	Quantity (flasks of 75 pounds).	Value.	Year.	Quantity (flasks of 75 pounds).	Value.
1908	2,996	$124,960	1913	1,140	$43,574
1909	6,802	266,243	1914	1,446	70,753
1910	1,923	91,077	1915	3,372	225,509
1911	291	13,995	1916	8,880	670,475
1912	310	13,360	1917	10,778	998,470

[a] Prepared by J. A. Dorsey from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Prices of domestic quicksilver at San Francisco, 1915–1917.

[Per flask of 75 pounds.]

Month.	1915	1916	1917	Month.	1915	1916	1917
January	$51.90	$222.00	$81.00	July	$95.00	$81.20	$102.00
February	60.00	295.00	126.25	August	93.75	74.50	115.00
March	78.00	219.00	113.75	September	91.00	75.00	112.00
April	77.50	141.60	114.50	October	92.90	78.20	102.00
May	75.00	90.00	104.00	November	101.50	79.50	102.50
June	90.00	74.70	85.50	December	123.00	80.00	117.42

FUTURE OF THE QUICKSILVER-MINING INDUSTRY IN THE UNITED STATES.

An appraisal of the quicksilver resources of the United States based on actual measurements and estimates of the quantity of ore available in individual deposits presents insuperable practical difficulties. The best that can be done is to reach some rough conclusion from the history of the industry and from general knowledge and impressions of its present status and of the condition of known deposits. It is also necessary to take into account the probability of the discovery of new deposits and of improvements in metallurgy.

Records show that quicksilver mining in the United States has generally declined since 1877, when the domestic production reached its acme, with 79,395 flasks. The output sank in 1914 to 16,548 flasks. Although not uniformly retrogressive, the decline was on the whole fairly regular and on this account the more ominous. The price has not declined at the same rate as the output. In 1877, the year of maximum yield, quicksilver was worth only $37.30 a flask. In 1890 it had risen to $52.50 a flask, and in 1914 it was $49.05 a flask. Production has failed to respond to the stimulation of moderate increases in price, and the conclusion that the supply of ore has on the whole been decreasing in tenor and available quantity since 1877 appears to be warranted by the historical record. It is true that under the influence of unprecedented high prices during the recent war years the production rose to 36,159 flasks in 1917. This increase, however, was not accompanied by the discovery of any large new sources of supply, and that the domestic output of quicksilver must decline from the point reached in 1917 appears inevitable.

A wide survey of the known quicksilver deposits of the country confirms the conclusion drawn from historical and statistical data. The deposits, with few exceptions, are not large, most of them probably do not extend to great depth, and many of them are decidedly of superficial character. Even if the ore at certain localities does continue to a depth of 1,000 feet or more, some of the deeper ore bodies, in consequence of their irregularity and lack of continuity, are likely to remain undiscovered. Some of the mines that are at present the most productive have in all probability passed their period of greatest yield, although there is still a possibility that the discovery of new ore bodies may restore them temporarily to something like their former activity.

There are in California a large number of old quicksilver mines which have been productive but which have lain idle for years and which even the unprecedented prices obtainable for quicksilver during the last three years failed to revivify. Some of these are probably exhausted. Others contain ore bodies or at least material that carries some quicksilver; and these mines will some day be reopened. For most of them, however, this is not likely to happen in the near future under any conditions that can now be foreseen. They will probably remain undisturbed until the higher grade and more accessible deposits of the world are exhausted.

During the last 20 years comparatively few new quicksilver deposits have been found, and only four or five of these have produced more than a few hundred flasks each. Of the total domestic production of 36,159 flasks in 1917 less than 600 flasks came from new mines opened during the war period, and not one of these promises to develop a production of 1,000 flasks or more annually. The exploitation of the Terlingua district represents a notable modern addition to the known quicksilver resources of the country. Other regions capable of as great or greater production may be awaiting discovery, but as years pass the possibility is diminishing, and it is now hardly probable that any other locality with the potential productivity of the Terlingua district will be discovered in the United States.

It appears on the whole that quicksilver mining in the United States must be regarded as a declining industry, in which, however, there is still opportunity for individual success not only in working known deposits but in discovering and developing new ones. During the next 10 years the annual output may be expected to fall to 15,000 flasks or less. Prices of course will affect the output, but they can not change the physical conditions upon which production fundamentally depends. The high prices obtainable during the war nearly tripled the annual output, but the same or even higher prices could not again produce the same result.

The price of quicksilver in the United States during the next few years will depend upon so many uncertain factors that prediction is extremely hazardous. Among the determining conditions may be mentioned changes in the uses of quicksilver, the cost of labor and supplies, the quantity and price of foreign quicksilver available, and tariff legislation. The decline of our own production, of course, makes for higher prices. With the coming of peace there will be less quicksilver required for war purposes, although some of the modern applications that sprang from the exigencies of war are likely to persist. It is believed that the industrial consumption of quicksilver will be greater after the war than it was before and will continue to increase until diminishing supply and rising price force the extensive employment of substitutes. Quicksilver can undoubtedly be produced more cheaply abroad, especially in Spain, than in the United States, but it is doubtful whether this country will in the near future be deluged with foreign quicksilver to the extent feared by some domestic producers. Self-interest alone on the part of importers and foreign dealers would seem to preclude an attempt to lower the price in this country to anything near the cost of production in Spain.

The plan of attempting to maintain the quicksilver-mining industry in the United States by a high duty on imported metal has many advocates among the quicksilver producers, whose representatives at a hearing held by the Tariff Commission in San Francisco in June, 1918, asked for a duty of $35 a flask in addition to the present 10 per cent ad valorem. Such a duty would increase the profits of some of the larger mines but would not transform a declining industry into a growing and self-supporting one. It is doubtful whether there is any wisdom in attempting to foster quicksilver mining by a high import duty whose effect would be to levy a tax on all users of quicksilver for the benefit of a small group of producers, and it is still more doubtful whether the people of the United States would submit to this tax. It has been urged that as quicksilver is essential in warfare the mining of quicksilver should be stimulated by tariff protection. This might be an excellent argument were our quicksilver supplies without limit, but inasmuch as they are in process of exhaustion it is difficult for one who looks at the question impartially to see why the Government should hasten the approach of that day when there shall be no more quicksilver ore to mine rather than purchase quicksilver where it can be bought cheaply, store it as an immediately available reserve supply against the next war, which it is hoped may never come, and rely as a final resource upon those mines in which some ore, that would have been taken out under sufficient governmental encouragement, may yet remain to be of service in a great emergency.