STEEL HARDENING METALS

STEEL HARDENING METALS.

By Joseph Hyde Pratt.

Under the head of steel hardening metals are included those metals used or experimented with in the hardening of steel, although some of them are used more generally for other purposes in the form of compounds. The metals belonging to this class are nickel, chromium, tungsten, molybdenum, titanium, uranium, and vanadium. The statistics in this report relate to the production of the ore from which these metals are obtained, except that the figures for nickel and cobalt are for the matte made at the mines. In the mineral classifications, chromium appears as chrome ore, nickel as nickel and cobalt, and titanium as rutile. Manganese naturally comes under the head of steel hardening metals; but, on account of its comparatively large production, it is treated separately. Nickel and chromium have been presented separately at former censuses, but the statistics of the remaining metals have not been previously shown.

The statistics collected at the census of 1902 for the steel hardening metals are summarized in Table 1.

Table 1.—*Summary: 1902.*

	Total.	Tungsten.	Uranium and vanadium.	All other steel hardening metals.[1]
Number of mines	12	4	3	5
Number of operators	12	4	3	5
Salaried officials, clerks, etc.:				
Number	3	....	2	1
Salaries	$3,740	....	$3,500	$240
Wage-earners:				
Average number	26	2	19	5
Total wages	$20,911	$1,260	$17,040	$2,611
Contract work	$825	....	....	$825
Miscellaneous expenses	$735	$120	$490	$125
Cost of supplies and materials	$3,652	$210	$3,010	$432
Product:[2]				
Quantity, short tons	4,444	184	3,810	450
Value	$83,717	$5,975	$48,125	$29,617

[1] Includes operators as follows: Chrome ore, 1; molybdenum, 1; nickel and cobalt, 2; and rutile, 1.

[2] The United States Geological Survey does not report the value of tungsten and molybdenum, nor does it under this classification present the other metals. The report for nickel is for the refined; for cobalt, the oxide prepared from the ore; while Census figures are for the nickel and cobalt matte at the mine.

Besides the mines reporting a production during 1902, 7 were idle. These have been worked to some extent during the past few years, some of them becoming producers, while at others the work has been that of development to prove the existence of ore in quantity. The uncertainty of the demand for most of the ores has been the principal cause of their nonproduction. These idle mines were distributed, by states, as follows: Arizona, 1; California, 1; Colorado, 3; Nevada, 1; and Wisconsin, 1. They were owned by 5 individuals and 2 incorporated companies.

The total number of mines operated in 1902 was 12, distributed among 7 states, as follows: California, 1; Colorado, 6; Connecticut, 1; Missouri, 1; Oregon, 1; Virginia, 1; and Washington, 1. Of these 12 mines, 4—3 in Colorado and 1 in Connecticut—produced tungsten, and 3—all in Colorado—produced uranium and vanadium. Where there are less than 3 operators mining any one ore they are included in "all others." Of the 12 operators engaged in the production of these metals, 8 were individuals, 1 a firm, and 3 incorporated companies.

The total value of the outstanding capital stock of two of the incorporated companies was $200,000, with no bonded indebtedness. The entire authorized stock, all of which is common, has been issued, the shares numbering 1,001,000.

Of the three incorporated companies, one which produced nickel and cobalt, is not included in this table, for the reason that lead was its principal product, nickel and cobalt being merely by-products, and accordingly all statistics for this company, with the exception of the quantity and value of the nickel and cobalt produced by it, are included in the report on lead.

Production.—The total production of these various ores reported in 1902 was 4,444 short tons, valued at $83,717. Of this production 85.7 per cent of the quantity and 57.5 per cent of the value consisted of uranium and vanadium, the remainder being about 1 part tungsten and 3 parts "all others." In quantity the production of chrome ore was second, or next to uranium and vanadium, but in value was fifth. Tungsten ranked third in quantity and fourth in value; rutile, fourth in quantity and sixth, or lowest, in value; nickel and cobalt, fifth in quantity and third in value; while molybdenum, ranking lowest in quantity, was second in value.

The nickel and cobalt ores were concentrated into a matte which was valued at $352 per ton, of which value about five-sevenths was due to the cobalt contents and two-sevenths to the nickel.

The average value per ton received for the chrome ore in 1902 was $14.50. A standard chrome ore contains 50 per cent of chromic oxide (Cr_2O_3), but for every unit above this there is an increase in value of from 75 cents to $1 per ton; while, on the other hand, there is a much greater deduction for every unit below 50 per cent. For some uses, as in the lining of furnaces, chrome ores as low as 40 per cent of chromic oxide can be used.

The reported value of crude tungsten ores varied from $4.68 to $45 per ton. Before this ore is put on the market it is more or less concentrated. An ore containing from 60 to 70 per cent of tungstic oxide will bring in the general market, from $102 to $200 per ton.

Molybdenum ores have been valued at from $100 to $1,500 per ton, but the actual market value for these ores, when they are in constant demand for manufacturing purposes, will be nearer $100 per ton for a 50 to 55 per cent ore free from copper.

The value of uranium and vanadium ores is about $12.63 per ton for crude ore, which averages from 5 to 9 per cent of the oxides. When concentrated, these ores will bring as high as $320 per ton, the prices varying with the percentage of uranium and vanadium oxides.

The titanium reported at the census of 1902, which was all in the form of rutile, was valued at $12.50 per ton, this representing a crude product which had not in any way been concentrated or selected.

Table 2 shows the production of nickel and cobalt oxide in the United States from domestic ores from 1889 to 1902; also imports and exports of nickel oxide and matte. Most of the imports are from Canada, in the form of matte, the refining being done in this country. The exports are largely to the United Kingdom.

TABLE 2.—PRODUCTION OF NICKEL AND COBALT OXIDE FROM DOMESTIC ORES, AND IMPORTS ENTERED FOR CONSUMPTION: 1889 TO 1902; ALSO EXPORTS: 1894 TO 1902.

[Compiled from tables of United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR ENDING DECEMBER 31—	PRODUCTION FROM DOMESTIC ORES.			IMPORTS ENTERED FOR CONSUMPTION.					EXPORTS, NICKEL OXIDE AND MATTE.	
	Nickel.		Cobalt oxide.	Total value.	Nickel, nickel ore, nickel oxide, alloy of nickel with copper, and nickel matte.		Cobalt oxide.			
	Quantity (pounds).	Value.	Quantity (pounds).		Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
1889	[1]252,663	$151,598	13,955	$238,663	367,288	$156,331	41,455	$82,332	....	....
1890	223,488	134,093	6,788	439,481	813,870	376,279	33,338	63,202	....	....
1891	118,498	71,099	7,200	364,351	10,600,655	321,163	23,643	43,188	....	....
1892	92,252	50,739	7,869	488,129	4,487,890	428,062	32,833	60,067	....	....
1893	49,399	22,197	8,422	429,434	12,427,986	386,740	28,884	42,694	....	....
1894	9,616	3,269	6,763	340,438	9,286,733	310,581	24,020	29,857	[2]1,235,588	$247,568
1895	10,302	3,091	14,458	669,749	20,355,749	629,910	36,155	39,839	1,061,285	239,897
1896	17,170	4,464	10,700	656,637	23,718,411	620,425	27,180	36,212	2,756,604	600,833
1897	23,707	7,823	19,520	816,256	27,821,232	781,483	24,771	34,773	4,255,558	997,391
1898	11,145	3,956	6,247	1,583,507	60,090,240	1,534,262	33,731	49,245	5,657,620	1,359,609
1899	22,541	8,566	10,230	1,285,100	44,479,841	1,216,253	46,791	68,847	5,004,377	1,151,454
1900	9,715	3,886	6,471	1,272,535	57,500,800	1,183,884	54,073	88,651	5,869,906	1,382,727
1901	6,700	3,551	13,360	1,983,828	117,364,337	1,849,620	71,969	134,208	5,869,655	1,521,291
1902	5,748	2,701	3,730	1,588,764	33,942,710	1,437,649	79,984	151,115	3,228,607	924,579

[1] Includes 35,000 pounds of nickel from Canadian mattes.

[2] Last six months; not separately classified prior to July 1, 1894.

The production of metallic nickel, from 1889 to 1902, in the principal producing countries of the world is given in Table 3. The French manufacturers obtained the ore from New Caledonia, Oceania, and the German from New Caledonia and Norway.

TABLE 3.—*Production of nickel in Canada, France, and Germany: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	CANADA.		FRANCE.		GERMANY.	
	Quantity (pounds).	Value.	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.
1889	830,477	$498,286	330	$324,900	282	$279,680
1890	1,435,742	933,232	330	317,300	434	436,430
1891	4,626,627	2,775,976	330	319,200	594	644,480
1892	2,413,717	1,399,956	1,244	1,174,580	747	698,630
1893	3,992,982	2,076,351	2,045	1,175,720	893	774,630
1894	4,907,430	2,061,120	1,545	1,175,720	522	449,350
1895	3,888,525	1,360,984	1,545	1,033,220	698	575,890
1896	3,397,113	1,188,990	1,545	875,330	822	666,900
1897	3,997,746	1,399,137	1,245	704,425	898	710,980
1898	5,517,690	1,820,838	1,540	887,800	1,108	670,482
1899	5,744,000	2,067,840	1,740	1,003,600	1,115	669,517
1900	7,080,000	3,327,707	1,700	1,020,000	1,376	946,884
1901	8,882,000	4,707,460	1,800	1,440,000	1,659	1,184,263
1902	10,693,410	5,025,903	....	....	....	....

Small quantities of tungsten ore (wolframite) and of tungsten iron, valued at $7,046, were imported during 1902.

The uranium and vanadium ores are mostly exported. Salts of the metals to the value of about $15,000 have been annually imported. The value of these imports for 1902 was $12,491.

Employees and wages.—The aggregate number of all classes of employees and wage-earners, as given in Table 5, was 29, who received $24,651 in salaries and wages. Of these, 3 were classified as salaried employees, receiving $3,740 in salaries; and 26 as wage-earners who were paid $20,911 in wages. Included with the 3 salaried employees was 1 foreman, employed underground, who received $1,500 salary. Of the 26 wage-earners, 15 were employed underground, all of whom were classified as miners. To this number of underground workers should be added the foreman classified as a salaried employee, which would make the total number of underground employees 16.

The wages received by these 26 wage-earners varied from 75 cents to $3.24 per day; 17, or 65.4 per cent of the total number, received from $3 to $3.24 per day. That relatively high wages were paid to these wage-earners is due to the fact that most of the mining of steel hardening metals was in the Western states. The month in which the largest number of wage-earners was employed was July, when the number reached 42. The minimum was in January, when only 15 were employed.

The production of chrome ore in the United States and the imports of chrome ore, chromate, etc., from 1889 to 1902, inclusive, are given in the following table:

TABLE 4.—PRODUCTION OF CHROME ORE IN THE UNITED STATES, AND IMPORTS OF CHROME ORE, CHROMATE, ETC.: 1889 TO 1902.

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR ENDING DECEMBER 31—	PRODUCTION.		IMPORTS.						
			Chrome ore.		Chromate and bichromate of potash.		Chromic acid.		Total value.
	Quantity (tons).	Value.	Quantity (tons).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	
1889	2,000	$30,000	5,474	$50,782	1,580,385	$137,263	....	$2,974	$191,019
1890	3,599	53,985	4,353	57,111	1,304,185	113,613	....	634	171,358
1891	1,372	20,580	4,459	108,764	755,254	55,897	634	203	164,864
1892	1,500	25,000	4,930	55,579	496,972	94,055	772	204	149,838
1893	1,450	21,750	6,354	58,629	976,706	78,981	3,708	641	138,251
1894	3,680	53,231	3,470	38,364	1,483,762	125,796	5,680	837	164,997
1895	1,740	16,795	5,230	82,845	2,045,910	181,242	2,083	414	264,501
1896	786	6,667	8,669	187,400	952,794	80,538	2,429	387	268,325
1897	....	....	11,570	187,439	1,329,473	108,497	71,220	5,457	301,393
1898	....	....	16,304	272,234	1,160,710	86,134	5,329	1,758	360,126
1899	....	....	15,793	284,825	1,130,965	73,510	33,134	6,360	364,695
1900	140	1,400	17,542	305,001	111,761	7,758	35,452	7,232	319,991
1901	368	5,790	20,112	363,108	430,996	29,224	53,462	10,861	403,193
1902	315	4,567	39,570	582,597	....	....	90,817	11,115	593,712

The total amount paid for supplies and various other expenses was $5,212. Of this amount $3,652 was for supplies and materials, and $735 for rent of offices, taxes, etc. The balance of $825 was paid for contract work.

The total amount of mechanical power used in the production of the ores of these steel hardening metals was 310 horsepower, 250 of which was furnished by 6 steam engines and 60 by water wheels. All the water-power was rented.

A detailed summary showing the statistics of the production of steel hardening metals during 1902 is given in Table 5.

DESCRIPTIVE.

CHROME ORE.

Chrome ore, or chromite, which contains the metal chromium, was the first of the minerals containing any of these steel hardening metals to be mined in the United States for commercial purposes. The discovery of chrome ore in this country was made about 1820[1] by Isaac Tyson, jr., at Bare Hills, Md., 7 miles north of Baltimore, but the deposit, being scanty and poor, was soon abandoned. He afterwards found the mineral at Soldiers Delight, about 15 miles northwest of Baltimore. In 1827 his attention was attracted by the appearance in the market place of Baltimore of a man from back in the country who had in his wagon several lumps of a heavy black mineral which he was using to keep a barrel from rolling about in his cart.[2] Upon testing these lumps, Mr. Tyson found the mineral to be chromite and learned that it was from Harford county, about 27 miles from Baltimore. This was the beginning of chrome mining in this country and of the chrome industry of the Tysons, which was later supplemented by manufacturing processes and has continued down to the present time. In the next year, 1828, chromite was discovered in Lancaster county, Pa., and the control of this property was also obtained by Mr. Tyson. It was afterwards developed into the famous Wood mine, which has produced about 95,000 tons of chromite. Chromite mining in Maryland and Pennsylvania continued for a great many years until many of the deposits or pockets of chromite were worked out. About the time the ore began to grow scarce in these states, it was discovered in California, and for a few years a number of thousands of tons were shipped to Baltimore. When, however, the importation of chrome ore began, about 1884, the chrome mining industry in the United States began to decline. There are known deposits of this mineral in quantity in California and North Carolina, and probably deposits exist in Pennsylvania and Maryland; but, on account of the low price at which the foreign ore can be landed at Baltimore, but a small portion of that used in the United States is mined here. New uses for chromium and the construction of railroads through some of the chrome fields will

[1] The Mineral Industry, Vol. II, page 151.

[2] Transactions of the American Institute of Mining Engineers, Vol. XXV, page 487.

undoubtedly cause an increase in this industry during the next few years.

The uses of chromite, at present the only source of chromium, can be readily divided into three heads:

1. As a mineral: In the manufacture of bricks as hearth linings for basic, open-hearth furnaces, and for water-jacket furnaces in copper smelting. For these purposes ores carrying as low as 40 per cent of chromic oxide can be used. It is also probable that chromite can be used to advantage in other furnaces, especially where it is desirable to use fluorspar as a flux.

2. In chromium alloys: Chromite is used to a considerable extent in the preparation of a ferro-chromium alloy. The preparation of this alloy, which is used in the manufacture of armor plates and armor-plate-piercing projectiles, has become a very important industry. The ferro-nickel alloy is also used in the manufacture of armor plate. It is generally made by the addition of these two alloys of iron to molten steel before it is cast into the ingot; they produce a more or less homogeneous triple alloy.

3. In chromium salts: The first use of chromite was in the preparation of the salts, chromate and bichromate of potash, used in dyeing, tanning, and in the manufacture of pigments; this continues to be its chief use. It was about 1800 that the value of these salts as pigments was discovered, but it was not until the discovery of deposits of chromite that they were used commercially. Some chromium salts are also used for medicinal purposes.

NICKEL AND COBALT.

Nickel and cobalt mining in the United States began probably in 1863 with the opening of the Gap mine, in Lancaster county, Pa. This mine was worked almost continuously and very extensively from 1863 until 1880, and was the only nickel mine then worked on the American continent. With the discovery, however, of the nickel deposits in the Sudbury district, Ontario, Canada, and the moderate prices which prevailed for nickel, work at this Gap mine began to decrease, and about 1891 ceased altogether. It is very probable that there are still good deposits of nickel ore in quantity in this mine and that in the near future it will again become a producer. Since 1891 most of the nickel and cobalt produced in the United States has been at Mine Lamotte, Mo., where it has been obtained as a by-product in lead mining. Attempts were made to mine nickel in North Carolina about 1890, and although the mineral genthite, a nickel silicate, was found in some quantity at a number of places, there was only one place—near Webster, Jackson county—that gave any indication whatever of containing it in commercial quantity. Considerable work was done, but in 1891 the mine was closed and remained so until 1902, when the shafts and drifts were reopened and several carloads of ore were shipped for experimental purposes. There has also been some development of nickel deposits in Oregon and Idaho, and a few tons of ore have been shipped for experimental purposes, but none of the mines can be called producers.

The first general use of nickel commercially was probably in the manufacture of German silver or albata, an alloy of zinc, copper, and nickel. Articles made of iron and plated with nickel have to some extent replaced those made of German silver. Another of the earlier uses of nickel was for coinage, which is yet carried on quite extensively by the United States and many of the European countries. With the introduction of nickel in the manufacture of a special steel the demand for it has largely increased, so that this use of the metal has become the most important. Large quantities of nickel steel are used in the manufacture of armor plates, turrets, propeller shafts, crank shafts, etc. Another use that has received favorable consideration is in the manufacture of nickel-steel rails, which were first used by the Pennsylvania Railroad Company, and evidently gave entire satisfaction.

Cobalt is put on the market as the oxide and used almost entirely for coloring glass, porcelain, and similar substances.

TUNGSTEN AND MOLYBDENUM.

The mining of tungsten and molybdenum ores in the United States has become an established industry within the past few years only. Tungsten ores were mined in Colorado and Connecticut, and molybdenum ores in Washington.

Until lately the uses of these metals were few, requiring a comparatively small amount of their salts to satisfy the demand. The salts of tungsten were used as a mordant in dyeing and printing and as fireproof material for wearing apparel, while the principal use of molybdenum was in the manufacture of ammonium molybdate, used by chemists in the determination of phosphoric acid. A small amount of molybdenum salts is used in the preparation of blue carmine or molybdenum blue in the coloring of porcelain. The use, however, of these two metals in the preparation of ferro alloys has led to an increased demand, especially for tungsten, which, when added to steel, increases its hardness and toughness, and is believed by some to make it superior for certain purposes to any other manufactured. Tungsten steel is also used in the manufacture of tool steel, spring steel, and sounding plates and wires for pianos, where hardness and strength are especially desired. Molybdenum steel, the beneficial properties of which are similar to those of tungsten, is beginning to be used, but in much smaller quantity.

RUTILE.

The only titanium mineral mined for commercial purposes is rutile, a titanium oxide. Titanium was formerly considered one of the very rare metals, but it has now been proved to be one of the commoner elements and is very widely distributed. In the future, besides rutile, the chief commercial source of titanium will be the mineral menaccanite (ilmenite), a titanium iron oxide. Rutile has been produced at Roseland, Nelson county, Va., and in Chester county, Pa. Only a small quantity is required to satisfy the demand, and the product does not amount to much over 100 tons of the crude ore per year.

The uses of rutile are principally in the ceramic industry for coloring porcelain and in the manufacture of artificial teeth. The titanium oxide will, under favorable conditions, impart a fine yellow color to the porcelain, and it is also capable of being used with other substances to produce secondary colors. The amount of titanium oxide used in the manufacture of artificial teeth is from five-tenths of 1 per cent to 2 per cent of the total materials used in making them.

At the present time no titanium is used commercially, as far as known, in the manufacture of titanium steel, although irons have been made containing a considerable percentage of titanium, the result of using ores for their iron contents rather than their titanium. Considerable work has been done, however, experimentally in regard to the use and value of titanium steel and with a great deal of success. It is probable that the introduction of this kind of steel into the general market is not far distant. Its properties of special interest are elasticity, and greater elongation and ductility than ordinary carbon steel.

URANIUM AND VANADIUM.

The production of uranium and vanadium ores during 1902 was all in Colorado. They have been mined in small quantities for a great many years, some of the salts of uranium being used to produce a pure black glaze on porcelain, while other salts are used in the decoration of glass and china ware, giving permanent colors. Vanadium salts are used in the coloring of glass, but principally in the preparation of vanadic acid, as a mordant, for aniline black in dyeing. The use of uranium and vanadium in the manufacture of special steels is still in the experimental stage, but enough has been done to prove that they increase tensile strength.

TABLE 5.—*Detailed summary: 1902.*

	Total.	Tungsten.	Uranium and vanadium.	All other steel hardening metals.[1]
Number of mines	12	4	3	5
Number of operators	12	4	3	5
Character of ownership:				
Individual	8	4	3	1
Firm	1			1
Incorporated company	3			3
Salaried officials, clerks, etc.:				
Total number	3		2	1
Total salaries	$3,740		$3,500	$240
Superintendents, managers, foremen, surveyors, etc.—Number	2		1	1
Salaries	$2,240		$2,000	$240
Foremen, below ground—Number	1		1	
Salaries	$1,500		$1,500	
Wage-earners:				
Aggregate average number	26	2	19	5
Aggregate wages	$20,911	$1,260	$17,040	$2,611
Above ground—Total average number	11	1	5	5
Total wages	$6,727	$540	$3,576	$2,611
Engineers, firemen, and other mechanics—Average number	2		2	
Wages	$1,200		$1,200	
Miners—Average number	9	1	3	5
Wages	$5,527	$540	$2,376	$2,611
Below ground—Miners—Average number	15	1	14	
Wages	$14,184	$720	$13,464	
Average number of wage-earners at specified daily rates of pay:				
Machinists, blacksmiths, carpenters, and other mechanics—$2.00 to $2.24	2		2	
Miners—$0.75 to $0.99	1			1
$1.75 to $1.99	4	1		3
$2.50 to $2.74	2	1		1
$3.00 to $3.24	17		17	
Average number of wage-earners employed during each month:				
Men 16 years and over—January	15	3	9	3
February	17	3	11	3
March	23	3	17	3
April	25	3	19	3
May	25		22	3
June	36	3	27	6
July	42	9	27	6
August	33		27	6
September	33		27	6
October	22		19	3
November	21		12	9
December	20		11	9
Contract work:				
Amount paid	$825			$825
Number of employees	7			7
Miscellaneous expenses, total	$735	$120	$490	$125
Rent of offices, taxes, insurance, interest, and other sundries	$735	$120	$490	$125
Cost of supplies and materials	$3,652	$210	$3,010	$432
Product:				
Quantity, short tons	4,444	184	3,810	450
Value	$83,717	$5,975	$48,125	$29,617
Power:				
Total horsepower	310	280		30
Owned—Engines—Steam—Number	6	4		2
Horsepower	250	220		30
Rented—Horsepower	60	60		

[1] Includes operators distributed as follows: Chrome ore, 1; molybdenum, 1; nickel and cobalt, 2; and rutile, 1.

ASBESTOS

ASBESTOS.

By Joseph Hyde Pratt.

Two distinct minerals are included in these statistics as asbestos, one being a variety of amphibole and the other the fibrous variety of serpentine known as chrysotile. It is the latter that is the more valuable and for which there is the greater demand. In the United States, however, it is, thus far, principally the amphibole variety that has been mined. The low value of this mineral and the uncertain demand have caused a wide variation in production. The first census statistics for asbestos were reported in 1880, when, among minor minerals in the Report on Mining Industries, 7 mines were shown to have been operated—4 in Maryland and 1 each in Georgia, New York, and South Carolina. The number of employees reported was 17, who received $1,400 in wages. There was no cost of supplies or materials given. The production of asbestos was 150 tons, valued at $4,312. The company operating in Georgia was incorporated with a capital of $10,000.

At the Eleventh Census there was no record of the number of mines or establishments. The capital represented was stated to be $42,600; the employees, including foremen and office force, were 12; and the wages paid, not including office force, but including $1,900 for development work in Wyoming, were $2,700. The cost of supplies was $525. The production for that year (which was entirely from California) was only 30 tons, valued at $1,800.

Because of the lack of uniformity of the statistics of these two years, they can neither be compared with each other nor with those for 1902, except as regards the quantity and value of the production.

Table 1 is a summary of the statistics for 1902.

Table 1.—*Summary: 1902.*

Number of mines or quarries	4
Number of operators	4
Salaried officials, clerks, etc.:	
Number	7
Salaries	$2,628
Wage-earners:	
Average number	23
Wages	$8,250
Miscellaneous expenses	$1,758
Cost of supplies and materials	$8,233
Product:[1]	
Quantity, short tons	2,505
Value	$46,200

[1]The United States Geological Survey reports 1,005 short tons, valued at $16,200, which is the product marketed. Census figures represent the product mined.

Detailed statistics of this industry can not be published by states without disclosing the business of individual establishments, for, of the 4 mines or quarries reported, 1 each was located in Connecticut, Georgia, Massachusetts, and Virginia. Fifteen properties that were developed or prospected for asbestos in former years were idle in 1902. Three each of these were situated in Georgia, North Carolina, and Vermont, 2 in California, and 1 each in Pennsylvania, Virginia, Wisconsin, and Wyoming. Among the owners were 4 incorporated companies, with an authorized capital of $2,500,000, of which $1,655,070, all common, had been issued. Many of these properties, as those in North Carolina, Vermont, and Wyoming, contain the chrysotile variety, and it had been expected that some of these, especially those in Vermont, would report a marketable production for 1902.

Capital stock of incorporated companies.—Of the 4 operators in the asbestos industry, 3 were incorporated companies, 1 each of these being located in Connecticut, Georgia, and Virginia. In Table 2 are shown the details of their capital stock.

Table 2.—*Capitalization of incorporated companies: 1902.*

Number of incorporated companies	3
Capital stock issued	$2,010,000
Total authorized—	
Number of shares	1,400,000
Par value	$2,300,000
Total issued—	
Number of shares	1,110,000
Par value	$2,010,000
Common—	
Authorized—	
Number of shares	1,100,000
Par value	$2,000,000
Issued—	
Number of shares	975,000
Par value	$1,875,000
Preferred—	
Authorized—	
Number of shares	300,000
Par value	$300,000
Issued—	
Number of shares	135,000
Par value	$135,000

None of the companies showed bonded indebtedness and none reported dividends. Of the authorized capital stock, 87.4 per cent of the total value had been issued, of which 6.7 per cent was preferred stock. The capital reported for this industry is extremely large when compared with the value of the production for 1902 and with the production for any of the past years since the industry was started. This is due to the fact that most of the companies sending their statistics for 1902 were organized during the past few years, when the methods of incorporation in vogue have been for highly capitalized companies, regardless of the real value of the property or plant or of the magnitude of the business that could be built up. The companies have been organized supposedly with the idea that the amphibole asbestos can be mined and manufactured and used for the same purposes as the chrysotile asbestos. Were this the case the capitalization would not be so much out of proportion to the value of the properties as it is. The capitalization given in the above statistics does not refer to asbestos companies manufacturing products from chrysotile asbestos imported from Canada, but to those mining asbestos in this country and manufacturing products directly from it.

Employees and wages.—Of the total amount, $10,878, reported as paid for salaries and wages, $8,250, or 75.8 per cent, was paid to the wage-earners, and $2,628, or 24.2 per cent, to the salaried employees. There were 5.8 wage-earners, on the average, to a mine. The average number of wage-earners, as may be seen by reference to Table 6, was greatest (61) during October and least (7) in June. The dull months were from January to July, both inclusive. Table 6 also shows the average number of wage-earners at each specified daily rate of pay. Of the 23 employees, 17 were classed as miners or quarrymen. Of these, 13 received from $1 to $1.24 per day; 1 received from $1.25 to $1.49 per day; and 3 received from $1.50 to $1.74 per day. There were 2 machinists or blacksmiths, 1 of whom received the highest rate paid, which was from $2.50 to $2.74 per day. There were 2 firemen, each of whom received from $1 to $1.24 per day. One other wage-earner, who did miscellaneous work, received from $1.50 to $1.74 per day. The prevailing rate of pay was from $1 to $1.24, 16 having received this rate. These comparatively low rates of pay are due to the fact that most of the miners were employed in the South, where the rates of pay are much lower than either in the North or the West.

Supplies, materials, and miscellaneous expenses.—The principal item of expense, next to that for wages, was for supplies and materials, for which $8,233 was reported as having been expended. The miscellaneous expenses of $1,758 were incurred for rent of office, taxes, insurance, and other sundries. Thus, the total cost, including wages, salaries, supplies, materials, and miscellaneous expenses, was $20,869.

Mechanical power.—Steam engines with a total of 105 horsepower were used in producing the asbestos, this power being reported by 2 establishments—1 in Georgia and 1 in Virginia.

Production.—The total production of asbestos in the United States for 1902 was 2,505 short tons, valued at $46,200. This production of asbestos is the largest reported during the period beginning with 1880, in which year the statistics for this mineral were first obtained. Of this production, however, 1,500 tons represents the rock just as mined. The statistics do not, therefore, represent the total value of the asbestos as it is put upon the market. In some instances the asbestos was crushed, separated, and otherwise prepared at the mines. As in such cases the mining and the processes to which the mineral is subjected were conducted under the same management and with the same capital, it is impracticable to separate the statistics. The United States Geological Survey has published annual statistics of the quantity and value of asbestos, and these are shown in Table 3, for the years from 1889 to 1902, inclusive.

TABLE 3.—*Production of asbestos: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (short tons).	Value.	Average value per ton.
1889	30	$1,800	$60.00
1890	71	4,560	64.23
1891	66	3,960	60.00
1892	104	6,416	61.69
1893	50	2,500	50.00
1894	325	4,463	13.73
1895	795	13,525	17.01
1896	504	6,100	12.10
1897	580	6,450	11.12
1898	605	10,300	17.02
1899	681	11,740	17.24
1900	1,054	16,310	15.47
1901	747	13,498	18.07
1902	1,005	16,200	16.12

As is seen from the above table, there has been a very wide variation in the quantity reported from year to year, and also in the value. This is due, as stated above, to the uncertainty of the demand for this variety of asbestos. The highest prices were received for asbestos during the years from 1889 to 1893, when the values varied from $50 to $64.23 per ton. These high prices were undoubtedly due to the fact that certain manufacturers required only a few tons of asbestos, and in order to obtain these small quantities they were obliged to pay this increase in price. The total quantity of asbestos produced in the United States since 1880 amounts to only 10,917 tons, which would make an average production of 474 tons per year. The greatest quantity produced in one year was 1,200 tons in 1882, and the next greatest, 1,054 tons, in 1900. The average value varied from $64.23 in 1890 to $11.12 in 1897. In 1894 there was a decided drop in the value of amphibole asbestos, from $50 to $13.73, and since that time the average has not exceeded $18.07. In 1902 the values varied from $16 to $40 per ton, the latter price having been received for 5 tons of chrysotile asbestos which were obtained as a by-product in talc mining.

The detailed statistics of the asbestos industry for 1902 are shown in Table 6.

The quantity of the amphibole asbestos produced in the United States during 1902, and considered as used, was 2,500 tons, valued at $46,000, while the amount of chrysotile asbestos was valued at $762,632, of which only a quantity valued at $200 was produced in this country, the balance having been practically all imported from Canada. The imports, as published by the United States Geological Survey, are given in Table 4 for the years 1889 to 1902, inclusive.

TABLE 4.—*Value of asbestos imported: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR ENDING DECEMBER 31—	Unmanufactured.	Manufactured.	Total.
1889	$251,239	$9,154	$263,393
1890	252,557	5,342	257,899
1891	353,589	4,872	358,461
1892	262,433	7,209	269,642
1893	175,602	9,403	185,005
1894	240,029	15,989	256,018
1895	225,147	19,731	244,878
1896	229,084	5,773	234,857
1897	263,640	4,624	268,264
1898	287,636	12,897	300,533
1899	303,119	8,949	312,068
1900	331,796	24,155	355,951
1901	667,087	24,741	691,828
1902	729,421	33,011	762,432

Table 5 shows the production of asbestos from 1889 to 1902 in Canada, from which nearly all of the mineral used in the United States is obtained.

TABLE 5.—*Annual production of asbestos in Canada: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (short tons).	Value.
1889	6,113	$426,554
1890	9,860	1,260,240
1891	9,279	999,978
1892	6,042	388,462
1893	6,473	313,806
1894	7,630	420,825
1895	8,756	868,175
1896	12,250	429,856
1897	[1] 30,442	445,368
1898	[1] 23,785	486,227
1899	[1] 25,536	485,849
1900	[1] 30,641	763,431
1901	[1] 38,079	1,186,434
1902	[2] 40,416	1,148,319

[1] Including asbestic. [2] Including 10,197 tons of asbestic.

DESCRIPTIVE.

As is seen from the preceding tables and text, the asbestos mining industry in the United States is very small, and there is but little chance of its increasing, unless large deposits of the chrysotile asbestos are discovered and developed. There are very large deposits of amphibole asbestos, but, as already stated, there is not sufficient demand for this variety to create a large industry.

Although in many respects the two varieties are similar in physical properties, there is a wide variation in strength of fiber, the chrysotile variety being superior in both strength and elasticity to any amphibole asbestos, and for this reason capable of being used for many purposes for which the latter can not be adapted. With respect to their heat-resisting properties, they are about equal, so that when asbestos is to be used as an ingredient in fireproof paint, wall plaster, as boiler coverings, as packing, in the manufacture of fireproof safes, and for nearly all purposes in which nonconductivity of heat and not strength of fiber is the important factor, the amphibole variety can be used to as good advantage as the chrysotile. For these purposes there is probably but little chrysotile asbestos used, except what is known as asbestic or the waste portions. There are, however, a number of other minerals, such as infusorial earth, tripoli, talc, and mica, that are strong competitors of the amphibole asbestos.

On the other hand, where strength of fiber is essential as well as nonconductivity of heat, as in the manufacture of cloth, rope, felt boards, tubes, washers, and blocks of various shapes, it is only the chrysotile variety that can be used. The fibers of chrysotile are seldom over 2½ inches long, and are usually from one-half to 1½ inches in length. The fibers of the amphibole variety, however, occur up to 3 feet in length, and when this asbestos is fairly free from grit, it appears like a very attractive proposition. In a number of cases deposits of amphibole asbestos have been developed in attempts to compete with chrysotile, but in each case the effort has resulted in failure.

It is interesting to note the variation in the value of these two varieties of asbestos; for the amphibole variety there is usually simply the one flat rate, which has varied, since 1894, from $11.12 to $18.07 per ton. On the other hand, the chrysotile asbestos varies in price according to the different grades as follows:

	Per ton.
No. 1 asbestos	$150 to $250
No. 2 (white) asbestos	75 to 125
No. 3 (red) asbestos	50 to 75
Mill fiber, or paper stock	20 to 40
Asbestic	1 to 3

The mill fiber, or paper stock, is the minute fibers of asbestos which have become broken and are not capable of being used for weaving, and the asbestic is the final waste material, which contains a small amount of minute fibers and a considerable amount of the crushed serpentine rock.

Occurrence.—Since 1880 asbestos properties have been prospected and developed in the United States in Arizona, California, Georgia, Maryland, Massachusetts, Michigan, New Jersey, New York, Pennsylvania, South Carolina, Vermont, Virginia, and Wisconsin. Although a considerable search has been made for asbestos deposits in this country, it has resulted thus far only in the discovery of producing deposits of the amphibole variety.

At the present time the deposits of amphibole asbestos that are being worked or developed to any extent are as follows:

About 3 miles from the railroad station at New Hartford, Conn., a deposit of this asbestos occurs in a ledge that outcrops strongly for a distance of about 750 feet in length, with a width of 20 feet. It has been opened in a number of places to a depth of 45 feet. A plant for crushing and preparing this material for the market was being erected in 1902.

At Sal mountain, 12 miles northwest of Clarksville, Ga., are located the largest developed asbestos deposits in the United States.

In the northeast corner of Rabun county, Ga., and about 1½ miles from Russell, S. C., deposits of amphibole asbestos occur.

In Virginia, about 14 miles south of Bedford City, a deposit of amphibole asbestos occurs in seams and veins varying from 8 to 50 inches in thickness.

In Wisconsin, near Stevens Point, Wood county, a deposit of this asbestos has been developed, although no asbestos was produced during 1902.

Many other deposits of amphibole asbestos are known to exist in the United States, but unless they are very favorably located for mining, and have good transportation facilities, it is practically impossible to work them on a profitable basis.

Chrysotile asbestos has been found sparingly associated with many of the outcrops of basic magnesian rocks that extend northeasterly from Alabama across Georgia, South Carolina, North Carolina, Virginia, Maryland, Pennsylvania, the New England states, and into Canada. These rocks are more or less altered to secondary serpentine, and in the more northern sections different areas are often completely converted to this secondary rock, as those of Pennsylvania, Maryland, Vermont, and Quebec province in Canada, while in North Carolina, Georgia, and Alabama there are but very few areas that have been altered to this extent. As would be expected, it is only in those areas in which the rocks have been completely changed to serpentine that the chrysotile asbestos occurs in commercial quantity. Although only the very small amount of this variety of asbestos obtained from Massachusetts was produced from a mine already in operation, yet a great deal of work was done on deposits of this variety in Vermont and Wyoming, with a smaller amount of work on deposits in California, Michigan, and North Carolina.

The Vermont deposits are located in the north central part of the state, in the town of Eden, Lamoille county, and in the adjacent town of Lowell, Orleans county.

The Wyoming deposits, which are located in the vicinity of Casper, Natrona county, have been pretty thoroughly developed, but thus far operations have not been sufficiently advanced for the marketing of the product.

The deposits of California thus far developed are in Riverside county. The other deposits in this state and those in North Carolina, have been developed little more than to prove that the chrysotile asbestos is to be found.

The basic magnesian rocks of the Pacific slope, in California, Oregon, and Washington, have in many instances been entirely converted to secondary serpentine, and are promising fields for investigation. It is possible that when they are thoroughly prospected they will be found to contain deposits of the chrysotile asbestos capable of profitable operation.

TABLE 6.—*Detailed summary: 1902.*

Number of mines or quarries	4
Number of operators	[1]4
Character of ownership:	
Firm	1
Incorporated company	3
Salaried officials, clerks, etc.:	
Total number	7
Total salaries	$2,628
General officers—	
Number	2
Salaries	$900
Superintendents, managers, foremen, surveyors, etc.—	
Number	4
Salaries	$1,665
Clerks—	
Number	1
Salaries	$63
Wage-earners:	
Aggregate average number	23
Aggregate wages	$8,250
Above ground—	
Total average number	22
Total wages	$7,875
Engineers, firemen, and other mechanics—	
Average number	5
Wages	$2,079
Miners or quarrymen—	
Average number	16
Wages	$5,328
All other wage-earners—	
Average number	1
Wages	$468
Below ground—	
Total average number	1
Total wages	$375
Miners—	
Average number	1
Wages	$375
Average number of wage-earners at specified daily rates of pay:	
Engineers—	
$1.25 to $1.49	1
Firemen—	
$1.00 to $1.24	2
Machinists, blacksmiths, etc.—	
$1.00 to $1.24	1
$2.50 to $2.74	1
Miners or quarrymen—	
$1.00 to $1.24	13
$1.25 to $1.49	1
$1.50 to $1.74	3
All other wage-earners—	
$1.50 to $1.74	1
Average number of wage-earners employed during each month:	
Men 16 years and over—	
January	15
February	10
March	14
April	14
May	9
June	7
July	8
August	27
September	32
October	61
November	53
December	26
Miscellaneous expenses, total	$1,758
Rent of offices, taxes, insurance, interest, and other sundries	$1,758
Cost of supplies and materials	$8,233
Product:	
Quantity, short tons	2,505
Value	$46,200
Power owned:	
Total horsepower	105
Engines—	
Steam—	
Number	2
Horsepower	105

[1] Includes operators distributed as follows: Connecticut, 1; Georgia, 1; Massachusetts, 1; Virginia, 1.

ASPHALTUM AND BITUMINOUS ROCK

ASPHALTUM AND BITUMINOUS ROCK.

By Joseph Struthers, Ph. D.

Asphaltum became known to Census statistics in 1860, when it was reported from California among manufacturing statistics as "asphaltum work." At the census of 1870 no report was published from California, but an establishment in West Virginia was recorded in the statistics of mining as having produced asphaltum valued at $450,000. At the census of 1880 West Virginia dropped out and California returned statistics for two mines, being shown among mining industries. At the Eleventh Census, the inquiries for which, as to mining, covered the year 1889, asphaltum was shown among mineral industries in California, Kentucky, and Utah.

At the census of 1902 Arkansas, Indian Territory, and Texas were added to these, making 5 states and 1 territory reporting asphaltum. The asphaltum by-product of petroleum refineries, being the result of manufacturing processes, was included among manufactures at the census of 1900, with a number of other by-products, under the caption of "Residuum" in the Report on Petroleum Refining. This product is not, therefore, included in the statistics for 1902 herewith presented, which concern the mining of the various kinds of hydrocarbon rocks having an asphaltic base, namely, bituminous limestone and sandstone, and some of the purer forms of bitumen, as elaterite, gilsonite, and uintaite.

The comparative statistics from 1860 to 1902 are presented in the following table:

Table 1.—*Comparative summary: 1860 to 1902.*

	1902	1889	1880	1870	1860
Number of mines or quarries	24	(1)	(1)	(1)	(1)
Number of operators	24	(1)	2	1	1
Salaried officials, clerks, etc.:					
Number	52	2	(2)	(2)	(2)
Salaries	$18,233	$3,000	(2)	(2)	(2)
Wage-earners:					
Average number	156	184	12	23	4
Wages	$79,570	$63,503	$2,220	$20,000	$3,600
Contract work	$10,060	$8,340	(1)	(1)	(1)
Miscellaneous expenses	$19,753	$9,610	(1)	(1)	(1)
Cost of supplies and materials	$21,928	$13,884	(1)	$26,773	$4,090
Product:[3]					
Quantity, short tons	66,238	51,735	444	30,000	(1)
Value	$236,728	$171,537	$4,440	$450,000	$10,000

[1] Not reported. [2] Not reported separately.

[3] The United States Geological Survey reports 105,458 short tons, valued at $765,048, which includes the residual asphaltum product of petroleum refineries. This residuum being the product of manufacturing processes is not reported by the Census.

From 1860 to 1889 the production was quite irregular. The large increase in value of product from $10,000 in 1860 to $450,000 in 1870 was due to the discovery in West Virginia of a vein of grahamite, which was soon exhausted. A revival of the industry took place between 1880 and 1889. The increase in wages from 1889 to 1902 was $16,067, or 25.3 per cent, and the increase in value of product was $65,191, or 38 per cent. The 24 mines reported for the industry in 1902 were controlled by 19 incorporated companies, 3 individual proprietors, and 2 firms.

The state showing the largest production was California, with 35,377 tons, or 53.4 per cent of the total, and a value of $101,353, or 42.8 per cent of the whole.

Kentucky was second with 22,498 tons, or 34 per cent, and $68,704, or 29 per cent of the value. Indian Territory was third with 2,566 tons, or 3.9 per cent, and $11,754, or 5 per cent of the value. The remainder, 5,797 tons, or 8.7 per cent, and $54,917, or 23.2 per cent of the value, was for all other states, of which Utah was the largest producer, both in quantity and value.

Thirteen mines were idle—3 in California, 2 in Indian Territory, 2 each in Missouri, Texas, and Utah, and 1 each in Kentucky and Tennessee. There were 6 mines for which development work was reported but no production—3 in California, and 1 each in Arkansas, Colorado, and Indian Territory. The statistics for these are shown in the following statement:

Development work: 1902.

Number of mines or quarries	6
Number of operators	6
Salaried officials, clerks, etc.:	
Number	5
Salaries	$3,160
Wage-earners:	
Average number	2
Wages	$1,030
Miscellaneous expenses	$1,602
Cost of supplies and materials	$72

Capital stock of incorporated companies.—The capitalization of 17 of the 19 incorporated companies, 2 failing to report in this particular, is shown in the following table:

TABLE 2.—CAPITALIZATION OF INCORPORATED COMPANIES: 1902.

	United States.	California.	Indian Territory.	Kentucky.	All other states.[1]
Number of incorporated companies	19	6	6	5	2
Number reporting capital stock	17	4	6	5	2
Capital stock issued	$9,760,700	$699,700	$725,000	$5,336,000	$3,000,000
Capital stock (all common):					
Authorized—					
Number of shares	130,000	16,000	23,500	60,500	30,000
Par value	$10,575,000	$700,000	$1,075,000	$5,800,000	$3,000,000
Issued—					
Number of shares	115,857	15,997	14,000	55,860	30,000
Par value	$9,760,700	$699,700	$725,000	$5,336,000	$3,000,000
Dividends paid	$13,000	$7,000	....	$6,000	....
Bonds:					
Authorized—					
Number	128	....	....	128	....
Par value	$110,000	....	....	$110,000	....

[1] Includes 1 company in Texas, and 1 in Utah.

The capital stock of the 5 Kentucky companies constituted 54.7 per cent of the total. The par value of the capital stock issued by the 17 companies reporting was 92.3 per cent of the total amount authorized. No bonds were issued and the par value of those authorized amounted to only $110,000, all in Kentucky.

The production of the active mines operated by the 19 incorporated companies, including the 2 companies not reporting their capital, was 59,448 tons, or 89.7 per cent of the total, and $201,346, or 85 per cent of the total value.

Employees and wages.—The wage-earners constituted 75 per cent of the salaried employees and wage-earners, and their wages were 62.3 per cent of the total salaries and wages. Kentucky led, with 41.7 per cent of the wage-earners and 28.4 per cent of the wages, California being second, with 20.5 per cent and 25.2 per cent, respectively. In addition to the amount paid in wages, $10,060 was paid to 60 employees for contract work.

As shown in Table 5, November was the month during which the largest number of wage-earners was employed in the industry, although employment was not very variable during the year. In Indian Territory the largest number is shown for December. The smallest number of wage earners for all the states appears for June. Of the total number of wage-earners, 58, or 37.2 per cent, received from $1 to $1.24 per day, and 27, or 17.3 per cent, from $2.50 to $2.74 per day. Machinists, blacksmiths, carpenters, and other mechanics received the highest rate—from $4 to $4.24. Of the total wage-earners, 116, or 74.3 per cent, were miners or quarrymen. Fifty, or 43.1 per cent of these, received from $1 to $1.24 per day; 25, or 21.6 per cent, from $2.50 to $2.74; and 14, or 12.1 per cent, from $2.75 to $2.99. The 21 "all other wage-earners" were engaged in miscellaneous work about the mines and quarries.

Supplies, materials, and miscellaneous expenses.—The cost of supplies and materials, reported as $21,928, is the largest item of expense other than wages and salaries. Of the $19,753 expended for miscellaneous expenses, $16,897, or 85.5 per cent, was paid for rent of offices, taxes, insurance, interest, and other sundries, and $2,856, or 14.5 per cent, for royalties, and rent of mine and mining plant.

Mechanical power.—Of the 24 operators from whom reports were received, 8 reported the use of power, the total of the primary power being 720 horsepower. Of this, 660 horsepower, or 91.7 per cent, was steam, and 60, or 8.3 per cent, gas or gasoline. There was, in addition, 1 electric motor having 25 horsepower. Kentucky reported 53.8 per cent of the steam power, and

Indian Territory 46.2 per cent of the steam and all of the electric power. The total gas or gasoline power was reported from California.

Production.—The United States Geological Survey has published annual statistics of the production of asphaltum since 1882, but these are not comparable with Census statistics, for the reason that after the year 1891 they include maltha, or brea, and the asphaltum by-products of petroleum refineries. During 1902 the quantity of by-product asphaltum produced by oil refineries in California and Texas, and sold and used in the trade as asphaltum, amounted to 20,826 short tons, valued at $303,249.[1]

According to the reports received for 1902, the average price of asphaltum was $3.57 per ton. The range was from $1.50 to $50, the former for less than 100 tons mined in Indian Territory, and shipped in the crude state, and the latter for less than 1,000 tons of elaterite mastic mined in Utah, f. o. b. at the mines.

Most of the imported asphaltum comes from the Island of Trinidad, British West Indies. The following table, compiled from tables published by the United States Geological Survey, shows the total imports into the United States from all countries since 1889. The values are at point of shipment:

[1] United States Geological Survey, "Mineral Resources of the United States," 1902.

TABLE 3.—*Crude asphaltum imported for immediate consumption: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR ENDING DECEMBER 31—	QUANTITIES. From Trinidad. Total (long tons).	Land (long tons).	Lake (long tons).	From all countries (long tons).	Total value.
1889	58,978	13,568	45,410	61,952	$138,163
1890	57,324	17,417	39,907	73,861	223,368
1891	73,027	20,517	52,510	102,433	299,850
1892	88,212	17,406	70,806	120,255	336,868
1893	68,886	3,450	65,436	74,774	196,314
1894	75,713	3,853	71,860	102,505	313,680
1895	69,720	4,744	64,976	79,557	[1] 210,556
1896	72,686	12,049	60,637	96,192	[1] 304,596
1897	93,650	19,243	74,407	115,528	[1] 392,770
1898	66,583	18,160	48,423	69,857	[2] 203,385
1899	95,941	25,164	70,777	106,474	[3] 425,263
1900	105,734	34,796	70,938	118,771	[4] 454,732
1901	112,216	31,767	80,449	138,833	[5] 553,473
1902	130,109	25,153	104,956	146,883	[6] 492,658

[1] In addition to the crude asphaltum imported in 1895, there was some manufactured or refined gum asphaltum, valued at $36,664. In 1896 the value of the manufactured asphaltum imported was $77,449, and in 1897, $25,095. The quantity was not reported.
[2] Includes 3,069 long tons, "dried or advanced," valued at $17,005.
[3] Includes 4,264 long tons, "dried or advanced," valued at $35,395.
[4] Includes 5,141 long tons, "dried or advanced," valued at $49,242.
[5] Includes 6,754 long tons, "dried or advanced," valued at $36,958.
[6] Includes 7,239 long tons, "dried or advanced," valued at $62,561.

Exports of crude asphaltum during 1902 amounted to 2,930 long tons, valued at $23,564.

The production of asphaltum and asphaltic rock in the principal producing countries of the world, from 1890 to 1901, inclusive, is given in Table 4.

TABLE 4.—PRODUCTION OF ASPHALTUM IN PRINCIPAL PRODUCING COUNTRIES: 1890 TO 1901.

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	UNITED STATES. Quantity (short tons).	UNITED STATES. Value.	TRINIDAD. Quantity (short tons).	TRINIDAD. Value.	GERMANY. Quantity (short tons).	GERMANY. Value.	FRANCE. Quantity (short tons).	FRANCE. Value.	ITALY. Quantity (short tons).	ITALY. Value.	SPAIN. Quantity (short tons).	SPAIN. Value.	AUSTRIA-HUNGARY. Quantity (short tons).	AUSTRIA-HUNGARY. Value.	RUSSIA. Quantity (short tons).	RUSSIA. Value.	VENEZUELA. Quantity (short tons).
1890	40,841	$190,416	94,834	$254,019	59,361	$89,961	198,934	$335,092	49,728	$232,351	47	$94	....	....	....	....	....
1891	45,054	242,264	110,929	297,132	54,163	89,419	278,316	402,631	31,054	131,028	274	505	43	$258	15,471	$108,000	....
1892	87,680	445,375	129,438	347,310	58,713	99,686	246,848	323,854	38,107	162,308	554	1,014	48	288	20,838	118,760	....
1893	47,779	372,232	106,515	285,309	52,056	84,962	244,644	311,116	28,630	109,200	904	1,235	97	624	18,337	120,000	1,771
1894	60,570	353,400	121,186	324,606	61,691	107,350	254,562	339,294	66,663	270,854	1,085	1,939	2,740	75,696	17,706	176,400	7,751
1895	68,163	348,281	102,368	274,200	65,638	108,153	294,234	355,700	51,478	197,584	870	1,525	2,963	59,001	20,699	144,893	3,073
1896	80,503	577,563	110,667	296,457	67,830	107,908	249,052	336,013	50,092	171,507	1,231	2,156	3,449	72,429	20,043	133,141	6,197
1897	75,945	664,632	146,172	292,344	67,933	91,984	257,127	328,002	60,984	183,017	1,825	3,196	3,699	81,104	24,488	171,416	11,528
1898	76,337	675,649	112,220	553,890	75,550	99,088	252,358	322,117	103,312	256,347	2,604	4,605	4,152	86,018	13,244	128,176	Nil.
1899	75,085	553,904	163,870	745,242	82,397	123,984	285,208	356,719	90,350	222,519	2,801	4,964	6,276	79,634	25,435	170,300	12,014
1900	54,389	415,958	177,751	855,744	98,833	160,000	293,654	383,429	112,115	292,287	4,621	8,632	3,787	70,603	([1])	....	17,981
1901	63,134	555,335	191,488	799,010	99,420	168,750	275,216	372,989	114,761	261,761	4,361	8,137	3,770	68,150	([1])	....	24,378

[1] Statistics not yet available.

The detailed statistics of the industry in the United States for 1902 are shown in Table 5.

DESCRIPTIVE.

Asphaltum is the name applied to different forms of bitumen. Its composition varies, and it is known by many other names, bestowed on account of some special characteristic resulting from its composition or the locality from whence it has been obtained. The most common of these names are: Natural mineral pitch, Jews' pitch, Trinidad asphalt, Cuban asphalt, Dead sea bitumen, manjak, maltha, brea, chapapote, elaterite, wurtzilite, nigrite, gilsonite, grahamite, and uintaite.

Asphaltum has been an article of commerce from remote antiquity, the supply having been obtained from the deposits near the Dead Sea, where the material floated on the surface or was washed ashore by the waves, the product being known to the Arabs by the name of Hajar Mousa, or Moses's stone.

In Germany asphaltum was known as early as 1626 under the name of "harzerde" (pitch earth), which was described in 1692 by Doctor Amiest as asphaltum.

Bituminous limestone is mentioned by Doctor Erynis in several publications prior to 1721. The deposits at Seyssel, France, were discovered in 1802, and the asphaltum interests of France and Switzerland were united in 1832 by Count de Sassenay.

Physical and chemical characteristics.—Asphaltum ranges in form from the liquid maltha to the hard, solid glance pitch, which gradually merges into asphaltic coal. The specific gravity of pure asphaltum ranges from 1 to 1.3, and the hardness from 2 to 3. The solid varieties have a black or dark-brown color and a peculiar characteristic pitchy odor when rubbed.

Asphaltum breaks with a more or less splintery fracture and does not soil the fingers. It is very brittle at low temperatures, but upon being warmed, although it remains sufficiently hard to be broken by a sharp blow, at the same time it yields to a steady pressure or tread. Asphaltums differ much in their properties, and all do not possess the binding power so necessary for a lasting pavement; they shade by insensible gradations into brittle asphaltic coals. The melting point of asphaltum is usually low. It is very inflammable, burns with a yellow, smoky flame, and when pure leaves very little if any residue. It is insoluble in water, slightly soluble in alcohol and fixed and essential oils, and readily soluble for the greater part in ether, oil of turpentine, naphtha, and carbon bisulphide. With benzole it forms a solution of an intense black color, used as a varnish. When subjected to destructive distillation, asphaltum is decomposed into a distillate of oils and a tarry residue which becomes solid when cold.

The chemical composition of asphaltum is so complex that elementary analyses throw little light on the subject. It still remains an open question whether important groups of definite and characteristic hydrocarbons can be separated and recognized.

Many chemical analyses of asphaltum from various localities have been published from time to time which, however, are of scientific value only. Of these analyses the following are characteristic:

Analyses of pure asphaltum, exclusive of earthy matter and other mechanical impurities.

CHEMIST.	Place.	Total per cent.	PER CENT OF— Carbon.	Oxygen.	Hydrogen.	Nitrogen.	Sulphur.
Bowen	Trinidad	100.00	85.89	0.56	11.06	....	2.49
Regault	Mexico	100.00	80.34	10.09	9.57	....	......
Bossingault	Peru	100.00	88.67	1.65	9.68	....	......
Bossingault	Cuba	100.00	81.50	6.90	9.60	....	......
Bossingault	Colombia	100.00	88.31	1.68	9.64	0.37	......
Kayser	Palestine	100.00	80.00	0.40	9.00	10.00	0.60

Means other than chemical analysis are generally used to ascertain the commercial value of asphaltum. The first of these is a solubility test of the sample dried at 212° F. in various solvents, as carbon bisulphide, alcohol, turpentine, ether, petroleum, naphtha, etc. Distillation is often used and the losses at various temperatures are recorded. The quantity and quality of mechanical impurities (water, clay, earthy matter) contained in the sample are also determined; finally, the best test of its applicability for pavement purposes is its viscosity at various temperatures. In some cases the value of an asphaltum for use in pavement construction is determined by an actual trial.

The substances classed as bitumens are hydrocarbon compounds, the more important of which, arranged in the order of their specific gravities at 70° F., are divided into six groups:

1. Natural gas.
2. Natural naphtha.
3. Petroleum, or natural oil.
4. Maltha, or soft, sticky bitumen.
5. Asphaltum, or stiff, sticky bitumen.
6. Glance pitch, or dry, brittle bitumen (often called gilsonite).

In addition to the substances comprising the above list, there are other bitumens of chemical interest only, which possess no commercial value.

In commerce there are four chief classes into which asphaltum is divided: (1) The natural liquid form, called liquid asphaltum or maltha; (2) asphaltum mixed with more or less vegetable and earthy matter, which yields, by the removal of the mechanically contained impurities, the product called hard, refined, or gum asphaltum; (3) asphaltum contained in sand or sandstone, called bituminous sandstone; (4) asphaltum contained in limestone, called bituminous limestone.

In addition to the natural products given in the above list mention should be made of "by-product asphaltum," which is obtained in the refining of crude petroleum having an asphaltic base to yield commercial illuminating and lubricating oils. There is no strict line of demarcation between oils classed as petroleum oils and those considered as asphaltum oils.

The term bituminous rock is applied to both sandstones and limestones impregnated with asphaltum. Bituminous rock is sold and shipped without previous refining, and is consumed chiefly for street pavements; being generally mixed with other ingredients at the place of use. An inconsiderable proportion, however, is treated for its asphaltic content, the product being sold as refined or gum asphaltum.

Asphaltic or bituminous limestone is a natural compound of asphaltum and limestone, at times containing, in addition, other bituminous substances, sand, and sulphur-bearing compounds. The quantity of asphaltum present varies in different deposits, and even in different portions of the same deposit, up to 20 per cent. The grain of asphaltic limestone is extremely fine, and under the microscope each grain appears completely coated with asphaltum. It is this property which renders the natural product of greater value than an artificial mixture of asphaltum, fine sand, and pulverized limestone.

Analyses of representative asphaltic limestones, showing their general composition, are given below.

Analyses of representative asphaltic limestones, showing their general composition.

CHEMIST.	Place.	Total per cent.	PER CENT OF— Asphaltum.	Calcium carbonate.	Clay and iron oxide.	Sand.	Magnesium carbonate.	Insoluble matter.	Loss.
Ponts et Chaus.	Val de Travers	100.00	10.15	88.40	0.25	......	0.30	0.45	0.45
Ponts et Chaus.	Seyssel ..	100.00	8.15	91.30	0.15	......	0.10	0.10	0.20
Ponts et Chaus.	Ragusa ..	100.00	8.92	88.21	0.91	0.60	0.96	......	0.40
Vor. Lab	Limmer .	100.00	14.30	67.00	......	[1]17.52	......	......	1.18

[1] Includes clay and iron oxide and magnesium carbonate.

The formation of natural asphaltum is attributed by some geologists to the slow decay and decomposition of vegetable matter whereby the contained hydrocarbons have been distilled and subsequently condensed in the adjoining rocks, the product thus collected forming asphaltum deposits. The formation of artificial asphaltum in the manufacture of gas by the distillation of coal in a retort is quoted as a proof of this theory. In this process a considerable portion of tarry matter passes over and is collected during the distillation which yields, by a second distillation, naphtha and other volatile products, leaving as a residue in the retort a tarry substance possessing the properties of asphalt.

Other geologists claim that asphaltum is the result of the decomposition of certain petroleums under the influence of heat, accompanied by polymeric changes not fully understood, whereby the more volatile constituents of the oil are expelled, leaving the residue in the form of solid asphaltum.

Occurrence.—Asphaltum is seldom found native or pure, the principal known deposits containing it in admixture with other materials, chiefly earthy matter, sand, or sandstone and limestone. It occurs disseminated throughout many crystalline rocks, and is not restricted to any one geologic formation. It is not known, however, in the Archæan age. In many cases it has been deprived of volatile matter, which has caused it to resemble anthracite. It occurs also in veins that have been evidently injected into fissures, while in a plastic condition, exemplified by the minerals albertite and grahamite. It exists as a liquid in bituminous limestones and sandstones, from which it oozes, constituting the so-called "tar springs."

The most important of the liquid asphalt deposits are found in southern California, of which the Las Conchas mine on the ocean near Carpentaria has been operated successfully. The maltha impregnates a clean Quaternary beach sand of from 20 to 30 feet in thickness, overlying a bituminous shale, from which the liquid asphalt exudes. The crude sand containing about 20 per cent of bitumen is refined to a product of 95 per cent bitumen content. The refined liquid is used to soften solid asphaltum and to coat wood and masonry for protection against the penetration of moisture.

Asphaltum is found also in beds resulting from the oxidation either of mineral tar or, primarily, petroleum. This class includes the immense deposits at Tamaulipas and Moloacan, Mexico. There are many and diversified occurrences of asphaltum in Europe, the chief deposits being the bituminous limestones at Seyssel, France; at Val de Travers, in Neuchatel, Switzerland; in the Dinaric Alps, bordering the eastern coast of the Adriatic sea, and at Ragusa, Italy. In Asia it occurs at many localities in Syria, around the Dead sea, the source of the early supply of asphaltum.

The largest producing asphaltum deposit of the world is at Pitch Lake, on the island of Trinidad, where the asphaltum occurs in the form of a basin-shaped deposit 18 feet thick at the edges and 80 feet thick at the middle, with an estimated content of 6,000,000 tons of asphaltum. The deposit is supposed to be supported by water, and while solid enough to admit of the passage of wagon and horse, it has a slow movement which tends to draw in the tramway used to convey the excavated material to the shore of the lake, unless properly supported by branches of trees. In fact excavations of a depth of 20 feet have become filled in six months. The asphaltum is broken from the mass by means of picks, before daylight while the material is brittle; it is then loaded on cars and conveyed by the tramway to the shore, from whence it is carried to the pier, 3,500 feet distant, by an aerial wire-rope conveyor and dumped directly into the holds of the vessels. On the voyage it becomes agglomerated into a solid mass, which must be again broken up by pick in order to remove it from the vessel. The product is roughly refined by heating in tanks and straining the liquefied material through a screen for the separation of roots and other vegetable matter with which it is contaminated. There is a similar lake deposit near San Timolis, Venezuela, the product being known commercially as Bermudez asphaltum.

The principal deposits of natural asphaltum occur as shown in the following statement:

ASPHALTUM MIXED WITH EARTHY MATTER.	ASPHALTIC LIMESTONE.	ASPHALTIC SANDSTONE.
United States:	United States:	United States:
California.	California.	California.
Colorado.	Indian Territory.	Colorado.
Indian Territory.	Michigan.	Indian Territory.
Montana.	New Mexico.	Kentucky.
Texas.	Texas.	New Mexico.
Utah.	Utah.	Texas.
Colombia.	Washington.	Utah.
Mexico.	Austria.	Cuba.
Palestine.	France.	France.
Peru.	Germany.	Germany.
Trinidad.	Hungary.	Russia.
Turkey in Asia.	Italy.	Spain.
Venezuela.	Russia.	
	Spain.	
	Switzerland.	

At the present time the chief producing localities are Trinidad, Dalmatia, Syria, Cuba, and the Seyssel, and Val de Travers deposits of bituminous limestones; local supplies of more or less value are obtained from other localities.

The following is a review by states of the asphalt industry in the United States during 1902:

Arkansas.—An asphaltum property near Pike City, Pike county, consists of a stratum of sand from 6 to 12 feet thick, containing various proportions of semifluid asphaltum. The product is obtained by sinking shallow pits, into which the material oozes from the bed. Borings have proved that the asphaltum beds extend over an area of several acres. A pit 100 feet in diameter has been dug, and a spur has been built to the railroad a half mile distant. A special feature of some portions of the bed is the occurrence of limestone with the sandstone, which yields a product available for paving purposes without the addition of other material.

The utilization of the asphaltum deposits in this state is solely a matter of cost of transportation. The average grade product should easily control the markets of Little Rock, Texarkana, and Fort Smith, and the higher grade material should compete advantageously with other asphaltum in cities as far distant as Memphis and St. Louis. It is also probable that pure asphaltum could be extracted from the asphaltic sandstone at a profit greater than that obtained by the sale of the crude product.

Analyses of samples of asphaltic rock from this district have been reported by Mr. C. W. Hayes,[1] as follows:

COMPONENTS.	Gray banded rock (per cent).	Brown cap sand (per cent).	Black sand rock (per cent).	Black gummy rock (per cent).	Calcareous sandstone (per cent).
Petrolene	6.68	1.73	14.13	6.61	3.46
Asphaltene	....	3.33	2.40	2.25	1.12
Silica	69.15	92.40	81.20	79.50	49.42
Calcium carbonate	20.35	....	....	6.14	46.00

[1] Engineering and Mining Journal, December 13, 1902.

California.—On the Sisquoc ranch, Santa Barbara county, the principal asphaltum property is the mesa deposit, 1,300 by 5,000 feet in area and of a reported minimum depth of 125 feet, which is estimated to contain 25,000,000 tons of bituminous rock, equivalent to 5,000,000 tons of asphaltum. The rock is mined, elevated by an electric crane, and shipped in steel cars to the refinery works on the mountain side, where gravity is utilized to move the materials. The crude rock is crushed by steel rolls and heated in revolving steel-jacketed drums, and as it becomes softened by heat it is treated with gasoline until thoroughly saturated. It is then passed into a series of agitating drums, which separate the solution containing the asphaltum from the tailings; the solution flows by gravity to the stills, and the gasoline is removed and recovered for repeated use. The residue in the still, consisting of asphaltum of 99 per cent purity, is cooled and barreled for shipment.

The product of the companies operating these mines is chiefly a bituminous sandstone, largely utilized for paving purposes on the Pacific coast, where, owing to the simple method of its preparation and the cheap water freight rates, it competes successfully with other asphaltum paving mixtures. There is no production of asphaltic limestone in California worthy of mention. In addition to the producers of asphaltum from natural rock in this state, a large number of crude petroleum refineries have been established, which furnish a considerable quantity of by-product asphaltum obtained from the crude petroleum oils of California. By-product asphaltum possesses similar properties to that obtained from the rock deposits, and replaces it to a considerable extent in paving and other uses.

Indian Territory.—The known asphaltum deposits in this territory are almost entirely within the reservation of the Chickasaw nation. Development work has been started at Ravia, Dougherty, and Tar Springs, and at the two former localities soft asphaltic sands and a bituminous limestone have been mined, and at the last-named place asphaltic sandstone is produced. Grahamite is mined near Tar Springs, the product being hauled to Comanche, 18 miles distant, and then shipped by the Chicago, Rock Island and Pacific Railroad. Considerable prospecting by drills has been accomplished in the vicinity of Tar Springs, and other deposits of asphaltic sands have been found below the surface deposit, separated therefrom by beds of red and blue clay and shale. The thickness of the asphaltic sand beds varies from 3 to 20 feet, while the clay and the shale strata range from 5 to 40 feet in thickness. The lower limit of the asphaltic sand has been found at a depth of 600 feet from the surface. The present supply of asphaltum is obtained by open-cut working. The sandstone capping is removed by drilling and blasting, and the soft asphaltic sands are broken up by blasting and removed by plows and scrapers to the refinery, where the sterile sand is segregated by mechanical concentration with hot water. The asphaltic material rises to the surface and passes to the reducers, where it is brought to the proper consistency by the application of heat and subsequently strained and barreled for shipment. The products vary with the demands of the market, and range from a semiliquid on the one hand to a hard and brittle form on the other. Very little of the latter is made, however, on account of the large amount of time and fuel required to produce it.

Kentucky.—The principal bituminous sandstone deposits in Kentucky are in Logan, Warren, Edmonson, Butler, Grayson, and Breckinridge counties, occupying an area of 20 by 50 miles in the central part of the state. The deposits are in fine-grained sandstone of the Subcarboniferous formation, and from geological evidence the asphaltum represents the residual matter from preexisting beds of petroleum. The numerous deposits in Grayson and Edmonson counties vary both in richness and magnitude, the range in the thickness of the beds being from 2 to 20 feet. But few of these deposits, however, are of commercial value. The richer deposits lie between strata of "black rock" from 1 to 2 feet thick, and the intervening asphaltum ledge varies in thickness from 3 to 15 feet and contains from 5 to 15 per cent of bituminous matter; below 4 per cent asphaltum content the material merges into "black rock."

Up to the present time only those deposits lying conveniently near railroad or river have been developed, and of such only those have been worked which offer the least difficulty in the way of uncovering. No tunneling or drifting has yet been attempted. At Bowling Green there is a 200-ton refining plant, equipped with corrugated rolls. The moisture in the material as it comes from the crushers is expelled by means of steam jets.

A property 4 miles northeast of Russellville, Logan county, has been developed quite extensively, the quarry face showing a 17-foot asphaltum ledge. The plant of this company includes a 250-ton gyratory crusher and plain 14 by 18 inch rolls. Quarries, mill, and tipple are connected by 1½ miles of narrow gauge track, and at the end of the year the rolling stock equipment consisted of 45 cars. At Louisville, the operating company has installed a plant for mixing and preparing asphaltum for street paving work, which has a daily capacity of preparing material to cover an area of 18,000 square feet.

An asphaltum company near Garfield, Breckinridge county, has a 100-ton plant. The asphaltic rock is broken in two sets of beaters revolving about horizontal shafts, the first making 600 and the second 1,200 revolutions per minute. The coarsely broken material from the first beater is passed to a 2-inch screen, the oversize being returned for a second treatment. The material passing through is treated in the second beater, which delivers to a screen. Material exceeding one-sixteenth of an inch in size is returned to the second beater for another treatment.

Texas.—There has been comparatively no appreciable production of asphaltum in this state in recent years. That reported in 1902 was liquid asphaltum.

Utah.—In recent years a small quantity of asphaltic limestone has been produced from deposits in the eastern part of the state, nearly the entire output being consumed in the local markets. The chief asphaltum product, however, is gilsonite (also called grahamite), which is mined about 60 miles from Vernal, Uinta county. Gilsonite is a very high grade material, of especial value for manufacture into varnishes, lacquers, paints, and similar products. On account of the high price it commands, the product can stand a long distance freight rate to chemical works.

Uses.—The principal use for asphaltum is in the construction of pavements. In addition, a considerable quantity is consumed for the manufacture of special varnishes; for waterproofing buildings and other objects as a protection against dampness; for coating vessels, as a protection against the teredo, or ship-boring worm; as an enamel for iron objects; for roofing purposes in the form of asphaltum or tar paper; for electric current insulation; and as an ingredient of cement.

Asphaltum sidewalks were first used in Paris in 1838, and to-day they extend to a distance exceeding in the aggregate 1,200 miles. The introduction of asphaltum pavements in the principal cities of the world is given by J. W. Howard[1] in the following chronological order: Paris, 1854; London, 1869; Budapest, 1871; Dresden, 1872; Hamburg, 1872; Berlin, 1873; followed shortly afterwards by Brussels, Geneva, Leipzig, Frankfort, and others. In the United States a so-called "tar-poultice pavement," composed of coal or gas tar, sand, etc., was laid in several cities during the period from 1870 to 1873, and in 1871 to 1873 successful experiments were carried out with an artificial asphaltic sandstone pavement in New York, N. Y., and in Newark, N. J. In 1878 a pavement composed of Trinidad asphaltum, sand, and powdered limestone was successfully introduced in Washington, D. C., and has since been the standard pavement of that city. At the present time more than a hundred of the principal cities of the United States have adopted some form of asphaltum pavement.

In making asphaltum pavement the general procedure is to grade the street to be paved, roll it with a steam

[1] The Mineral Industry, Vol. II, page 51, et seq.

roller, and then cover it with a layer of cement concrete 5 or 6 inches thick; or in case the street is macadamized or paved with stone blocks, the concrete is unnecessary. In the latter cases a thin layer of asphaltum concrete from 1 to 1.5 inches thick is laid directly upon the old surface. The foundation having been thus prepared, the asphaltum paving mixture, called the "wearing surface," is then spread over it with heated rakes to the desired thickness, which varies from 1.5 to 2.5 inches, depending upon the traffic to pass over it.

The ordinary Trinidad asphaltum paving mixture is made by adding and thoroughly mixing with hot refined asphalt about 15 per cent of its weight of residuum oil, the mixture serving to cement together the sand and powdered limestone which enter into the paving mixture. The proportions of the ingredients vary according to their physical and chemical quality, as well as to the climate in which the pavement is to be used, hot climates requiring less cement than cold. A typical pavement is composed of from 15 to 18 per cent of asphaltic cement, from 70 to 83 per cent of sand, and from 5 to 15 per cent of limestone.

For use in making pavements, the mined asphaltic limestone is crushed into pieces not exceeding 2 inches in diameter, and then reduced to about 10-mesh size in a ball or centrifugal pulverizer. The fine material is heated to 275° F. in heaters, spread over the prepared roadbed, and compressed by heated rammers, or otherwise, until it is of a thickness of from 2 to 2.5 inches. This form of pavement is not popular in places subject to fogs, rains, and low temperatures, for the reason that it becomes polished and slippery when wet, or dry in cold weather. In Paris and Berlin large supplies of sand are kept near the streets paved with asphaltic limestone for use during fog, slight rain, or snow.

Pavements made with Trinidad or other asphaltum in which sand, in proportions up to 80 per cent, is the chief ingredient, do not become slippery except when covered with ice; the sand makes them gritty and not susceptible to polish.

For the manufacture of black varnish, used chiefly for coating ironwork, pure asphaltum is dissolved in benzole or liquids containing benzole. The asphaltum from Syria is used for this purpose. By covering hot iron with asphaltum varnish the volatile ingredients of the latter are driven off, leaving a residual coating in the form of a smooth and polished enamel.

For insulating and cementing purposes asphaltum forms a very important ingredient on account of its wonderfully adhesive quality.

For waterproofing foundations of brick or stone, asphaltum is dissolved in petroleum and laid in the form of a cement or mortar, forming a very durable waterproof coating.

For making cement, petroleum residue is added to asphaltum in order to render it plastic, and from 5 to 10 per cent of sharp sand is mixed with it, according to the purpose for which it is to be used.

For roofing purposes asphaltum is used to a very large extent in admixture with coal tar, pitch, or petroleum residue; the material being used to saturate two or three thicknesses of felt, which are finally compressed into one compact sheet. The tar or roofing felt is held in place by nails driven through tin disks, and the whole completely covered with cement similar in composition to that used in making the felt; while this is still soft a covering of sharp sand, or screened gravel, is spread over the surface, forming a tight roof of great durability.

Asphaltum refining.—There are various methods used for the refining of asphaltum, depending on the nature of the crude material and the use to which it is to be applied. In general, with high grade material, the treatment has for its object the removal of water, volatile hydrocarbons, and mechanically suspended mineral and vegetable matter, but with asphaltums to be used in pavement construction it is essential to allow the mineral matter to remain in the product, for the reason that the asphaltum in this case is to serve solely as a binding and waterproofing material. In fact, asphaltic rock of the proper composition is not refined before use, but merely crushed, heated, and laid in place. The simplest method of extracting asphaltum from its compounds is by boiling in water, which causes the lighter asphaltum to rise to the surface, from whence it can be easily removed. Common salt or calcium chloride may be substituted for water in the treatment of material requiring a higher temperature or a heavier supporting liquid. In other cases asphaltum is extracted by means of a solvent, such as carbon bisulphide or naphtha, and obtained from the solution by heating in stills, which causes the volatile solvent to be distilled for repeated use and leaves the liquid asphaltum residue in a practically pure condition.

TABLE 5.—DETAILED SUMMARY: 1902.

	United States.	California.	Indian Territory.	Kentucky.	All other states.[1]
Number of mines or quarries	24	9	6	5	4
Number of operators	24	9	6	5	4
Character of ownership:					
Individual	3	2	....	....	1
Firm	2	1	....	....	1
Incorporated company	19	6	6	5	2
Salaried officials, clerks, etc.:					
Total number	52	3	5	32	12
Total salaries	$48,233	$8,280	$4,410	$17,420	$18,123
General officers—					
Number	23	1	2	14	6
Salaries	$27,700	$4,800	$2,400	$8,300	$12,200
Superintendents, managers, foremen, surveyors, etc.—					
Number	17	1	3	10	3
Salaries	$15,013	$2,400	$2,010	$6,370	$4,233
Foremen, below ground—					
Number	1	....	....	....	1
Salaries	$1,240	....	....	....	$1,240
Clerks—					
Number	11	1	....	8	2
Salaries	$4,280	$1,080	....	$2,750	$450
Wage-earners:					
Aggregate average number	156	32	28	65	31
Aggregate wages	$79,570	$20,031	$13,185	$22,574	$23,780
Above ground—					
Total average number	140	32	26	65	17
Total wages	$66,709	$20,031	$11,922	$22,574	$12,182
Engineers, firemen, and other mechanics—					
Average number	17	....	6	9	2
Wages	$10,784	....	$3,334	$4,900	$2,550
Miners or quarrymen—					
Average number	101	27	11	48	15
Wages	$47,860	$18,156	$4,654	$15,418	$9,632
All other wage-earners—[2]					
Average number	22	5	9	8	....
Wages	$8,065	$1,875	$3,934	$2,256	....
Below ground—					
Total average number	16	....	2	....	14
Total wages	$12,861	....	$1,263	....	$11,598
Miners—					
Average number	15	....	1	....	14
Wages	$12,070	....	$472	....	$11,598
Miners' helpers—					
Average number	1	....	1	....	....
Wages	$791	....	$791	....	....
Average number of wage-earners at specified daily rates of pay:					
Engineers—					
$1.25 to $1.49	2	....	....	2	....
$2.00 to $2.24	2	....	2	....	....
$2.50 to $2.74	2	....	....	2	....
Firemen—					
$1.25 to $1.49	2	....	....	2	....
$1.75 to $1.99	1	....	1	....	....
$2.00 to $2.24	1	....	1	....	....
Machinists, blacksmiths, carpenters, and other mechanics—					
$1.75 to $1.99	1	....	....	1	....
$2.00 to $2.24	4	....	2	2	....
$4.00 to $4.24	2	....	....	....	2
Average number of wage-earners at specified daily rates of pay—Con.					
Miners or quarrymen—					
$1.00 to $1.24	50	....	5	45	....
$1.25 to $1.49	11	8	....	3	....
$1.50 to $1.74	11	2	4	....	5
$1.75 to $1.99	2	1	1	....	....
$2.00 to $2.24	3	2	1	....	....
$2.50 to $2.74	25	14	1	....	10
$2.75 to $2.99	14	....	....	....	14
Miners' helpers—					
$1.75 to $1.99	1	....	1	....	....
Timbermen and track layers—					
$2.00 to $2.24	1	....	1	....	....
All other wage-earners—					
$0.75 to $0.99	2	....	2	....	....
$1.00 to $1.24	8	....	....	8	....
$1.25 to $1.49	6	5	1	....	....
$1.50 to $1.74	4	....	4	....	....
$1.75 to $1.99	1	....	1	....	....
Average number of wage-earners employed during each month:					
Men 16 years and over—					
January	140	28	25	61	26
February	139	28	24	61	26
March	146	28	27	65	26
April	140	28	29	57	26
May	132	28	23	55	26
June	129	28	23	52	26
July	144	32	24	62	26
August	157	44	25	62	26
September	164	44	30	64	26
October	199	32	27	94	46
November	202	32	29	95	46
December	180	32	50	52	46
Contract work:					
Amount paid	$10,060	....	$1,029	....	$9,031
Number of employees	60	....	6	....	54
Miscellaneous expenses:					
Total	$19,753	$1,185	$2,213	$11,948	$4,407
Royalties and rent of mine and mining plant	$2,856	$800	$796	....	$1,260
Rent of offices, taxes, insurance, interest, and other sundries	$16,897	$385	$1,417	$11,948	$3,147
Cost of supplies and materials	$21,928	$1,350	$6,299	$7,353	$6,926
Product:					
Quantity, short tons	66,238	35,377	2,566	22,498	5,797
Value	$236,728	$101,353	$11,754	$68,704	$54,917
Power owned:					
Total horsepower	720	60	305	355	....
Engines—					
Steam—					
Number	11	....	7	4	....
Horsepower	660	....	305	355	....
Gas or gasoline—					
Number	1	1	....	....	....
Horsepower	60	60	....	....	....
Electric motors—					
Number	1	....	1	....	....
Horsepower	25	....	25	....	....

[1] Includes operators distributed as follows: Arkansas, 1; Texas, 1; Utah, 2.

[2] Includes timbermen and track layers.

BAUXITE

BAUXITE.

By Joseph Struthers, Ph. D.

While the production of bauxite in the United States on a commercial scale dates from the opening of the deposits in the state of Georgia during 1889, the mineral does not appear to have been produced in sufficient quantities to be included in the reports of the Eleventh Census. This report, therefore, contains the results of the first census of the mining of bauxite in the United States. Table 1 is a summary of the statistics for 1902.

Table 1.—*Summary: 1902.*

Number of mines or quarries	38
Number of operators	7
Salaried officials, clerks, etc.:	
Number	42
Salaries	$33,230
Wage-earners:	
Average number	150
Wages	$59,768
Contract work	$500
Miscellaneous expenses	$14,939
Cost of supplies and materials	$40,019
Product:	
Quantity, long tons	29,222
Value	$128,206

Of the 38 mines or quarries for which production was reported, 3 were in Alabama, 19 in Arkansas, and 16 in Georgia. The entire number was controlled by 7 operators, of whom 5 were incorporated companies and 2 individual owners. There were 34 mines operated by 3 incorporated companies, 1 company controlling 19, another 10, and another 5 mines. There were 2 companies and 2 individual owners operating 1 mine each. This centralization of the industry makes it impossible to publish the statistics for the different states without disclosing the operations of individual companies; therefore, only the totals for the United States are presented. One mine in Arkansas was reported idle in 1902.

Capital stock of incorporated companies.—A considerable portion of the total production of bauxite was mined by establishments that were engaged in mining operations as incidental to the manufacture of aluminum, paint, and chemical products. The capitalization of these companies represents both their mining and manufacturing industries and, therefore, is not included in this report. Of the 5 incorporated companies, 3 reported that they were engaged primarily in mining. Their authorized capitalization consisted of 2,500 shares of common stock with a par value of $225,000. Of this amount, 1,730 shares, valued at $148,000, had been issued at the close of the year covered by this investigation. No dividends appear to have been paid on this stock during the year.

Employees and wages.—The variation in the number of wage-earners employed during the different seasons of the year and the specified daily rates of pay are shown in Table 4. The height of activity in the industry appears to have been reached during the month of May, when an average of 168 wage-earners was reported. The smallest number, 132, was given for the month of December. The slight variation in the number employed during the entire year indicates a uniform production.

The mining of bauxite requires no particular skill on the part of the miner, and the rates of pay should not be compared with those reported for miners of other minerals where skill and experience are necessary. Of the total number of wage-earners, 77, or 51.3 per cent, were classed as miners. Of this number the wages for 64 ranged from $1 to $1.24 per day. The rates for "all other wage-earners," which includes those engaged in assorting, grading, handling, loading, and hauling the ore and in miscellaneous work in connection with the mining or quarrying of bauxite, were considerably higher than the rates reported for miners. Of the 53 reported for this class, 40 received from $1.50 to $1.74 per day. The rate of pay at which the greatest number of wage-earners was employed is from $1 to $1.24 per day, 69 having been paid at this rate. One hundred and thirty-four, or 89.3 per cent of all wage-earners, received from $1 to $1.74 per day. This uniformity in the rates of pay is due largely to the fact that 69 wage-earners, or 46 per cent of the total number, were reported by 2 operators working on a large scale.

The extraction of bauxite is from open cuts, no tunneling being required, and all of the employees, therefore, were reported as engaged above ground. The 150 wage-earners give an average of 3.95 to each mine, but it is probable that all of the mines were not operated during the entire year. In addition to these wage-earners, 10 others were reported as employed by contractors to whom the sum of $500 was paid.

Supplies, materials, and miscellaneous expenses.—The cost of supplies and materials constitutes an important item of expense in connection with the operation of bauxite mines. The total amount, $40,019, reported for supplies and materials probably includes a considerable proportion of the expenses incident to development work and the installation of new plants and machinery; it includes also the amount spent for supplies used in connection with the calcination of the crude bauxite. The total amount, $14,939, reported as miscellaneous expenses, includes amounts paid for legal services and other miscellaneous items, some of which are not strictly applicable to the operation of the mines.

Mechanical power.—Of the 7 operators from whom returns were received, 6 reported power, all of it owned, for the operation of their mines. The total primary power amounted to 624 horsepower, of which 575 horsepower was supplied by 19 steam engines and 49 horsepower by 2 gas or gasoline engines. There were also 4 electric motors with 64 horsepower.

Production.—The total production for the calendar year 1902, as shown by Table 1, was 29,222 long tons, valued at $128,206. The United States Geological Survey has published annual statistics concerning the quantity and value of bauxite. Table 2 shows the totals for each year since 1889. Since the economic importance of bauxite is due almost exclusively to its use in the manufacture of the metal aluminum, aluminum sulphate, common alum, and artificial emery, this table has been prepared so as to show the available figures for the manufacture of these substances. Statistics for the production of sodium aluminate and other salts that contain aluminum can not be secured.

For all practical purposes the yearly supply of bauxite in the United States, including both domestic production and imports less exports, may be taken as the equivalent of yearly consumption. The aggregate value of the aluminum and alum aluminum sulphate made from bauxite during 1902 amounted to $4,522,761.

TABLE 2.—PRODUCTION, IMPORTS, EXPORTS, AND CONSUMPTION OF BAUXITE AND THE PRODUCTION AND VALUE OF ALUMINUM, 1889 TO 1902, AND OF ALUM AND ALUMINUM SULPHATE, 1889 TO 1902.

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	TOTAL DOMESTIC PRODUCTION.		BAUXITE, IMPORTS.		EXPORTS.		CONSUMPTION.		ALUMINUM, PRODUCTION.		ALUMINUM SULPHATE, PRODUCTION.		ALUM, PRODUCTION.	
	Quantity (long tons).	Value	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (pounds).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1889	728	$2,366	12,922	$60,292	....	....	13,650	$62,658	47,468	$97,335	....	....	....	....
1890	1,844	6,012	12,278	46,137	....	....	14,122	52,149	61,281	61,281	....	....	....	....
1891	3,593	11,675	8,021	46,252	....	....	11,614	57,927	150,000	100,000	....	....	....	....
1892	10,518	34,183	5,716	57,948	....	....	16,234	92,131	259,885	172,824	....	....	....	....
1893	9,179	29,507	5,103	28,217	....	....	14,282	57,724	333,629	266,903	....	....	....	....
1894	11,066	35,818	1,028	6,661	....	....	12,094	42,479	550,000	316,250	....	....	....	....
1895	17,069	44,000	5,797	34,782	....	....	22,866	78,782	920,000	464,600	....	....	....	....
1896	18,364	47,338	2,119	10,477	....	....	20,483	57,815	1,300,000	520,000	....	....	....	....
1897	20,590	57,652	2,645	10,515	2,537	$5,074	20,698	63,093	4,000,000	1,500,000	....	....	....	....
1898	25,149	75,437	1,201	4,288	1,000	2,000	25,350	77,675	5,200,000	1,716,000	56,663	$1,416,675	18,791	$563,730
1899	35,280	125,598	6,666	28,768	2,030	4,567	39,916	144,799	6,500,000	2,112,500	81,805	2,106,479	27,276	845,556
1900	23,184	89,676	8,656	32,967	1,000	3,000	30,840	119,643	7,150,000	1,920,000	61,678	1,480,272	20,531	615,930
1901	18,905	79,914	18,313	67,107	1,000	3,000	36,218	144,021	7,150,000	2,238,000	74,721	1,793,304	7,775	233,250
1902	29,222	128,206	15,790	54,410	Nil.	....	45,012	182,616	7,300,000	2,284,590	80,075	1,938,671	8,539	299,500

At the present time most of the bauxite in this country is used as a source of alumina from which the metal aluminum is made. The quantity used in the manufacture of chemical salts is relatively small. Thus the development of the bauxite industry depends to a great extent on the manufacture of aluminum and on the increased use of this metal for purposes of construction requiring lightness and no especial strength. Aluminum is also used as a substitute for copper as a conductor of electricity.

The largest production of bauxite is in France. Next to France ranks the United States, and third comes the United Kingdom, of which Ireland furnishes the output. Table 3 shows the production of the three nations mentioned, for 1900 and 1901, as reported by the United States Geological Survey.

TABLE 3.—*World's production of bauxite: 1900 and 1901.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

COUNTRY.	1900		1901	
	Quantity (metric tons).	Value.	Quantity (metric tons).	Value.
Total	87,959	$189,022	106,184	$218,597
United States	23,556	89,676	19,207	79,914
France	58,530	92,596	76,620	124,168
United Kingdom	5,873	6,750	10,357	14,515

The total quantity of bauxite produced in the United States since the beginning of operations in 1889 amounts to 224,691 tons, or an average production of 16,049 tons per year. The greatest quantity produced during one year, 35,280 tons, was reported for 1899. There has been considerable variation in the average price per ton of bauxite, the range having been from $2.58 to $4.38. According to the reports received for 1902, the price varied from $2.50 to $6.50 per ton.

A detailed summary showing the statistics for the production of bauxite during 1902 is given in Table 4.

DESCRIPTIVE.

Occurrence.—The mineral bauxite was first discovered in the year 1821 near Baux, France, by the well-known French chemist, Berthier. He attempted to utilize it in the manufacture of alum, but, because of the large proportion of iron oxide it contained, he was unsuccessful. Later a deposit of the white variety, of greater purity than that of Baux, was discovered at Herault, also in France. The mineral did not, however, become of commercial importance until 1868 or 1869, when Sainte-Claire Deville, a French scientist, in the course of his experiments in the manufacture of aluminum, discovered the value of bauxite as an ore of this metal.

In 1881 occurred the first recorded discovery of bauxite in the United States. The find was made by Edward Nichols, at Hermitage, Floyd county, Ga. Afterwards deposits were found in Polk, Bartow, Gordon, and Chattooga counties. In 1891 R. S. Perry reported the discovery of the mineral in Calhoun county, Ala., although it had previously been found in that state in Cherokee county, where it had been known as iron-ore blossom and as Clinton fossiliferous iron ore. Other deposits were afterwards found in Cleburne county. In 1891, too, the mineral was reported by the Arkansas geological survey as having been found in Saline and Pulaski counties of that state. Other deposits have been found, notably in North Carolina, South Carolina, and New Mexico, but they are too limited in extent, and are too far from transportation facilities, or else contain too many impurities to be of value commercially. Arranged in the order of their outputs, Georgia, Alabama, and Arkansas furnish the total production of the United States.

The mining of the ore in this country is of comparatively recent inception, and, quite naturally, it has not reached a high state of efficiency. The mines are irregular holes dug in the hillsides, with deep, open drainage ditches leading from them. Below the surface the ore is sufficiently soft to be removed with pick and gad, which renders the extraction easy and lessens the cost of production. For a high grade product, however, the uneven quality of the ore makes necessary a sorting by hand or by screens. Screen sorting is generally preferred to hand sorting when the character of the ore will admit of the use of the screen. During the sorting process, when clay is mixed with the bauxite, a common log washer is occasionally used to separate it. The sorted product is then dried in the air or in kilns or furnaces prior to its shipment to market. In this process very satisfactory results have recently been secured from the use of furnaces of the revolving cylindrical type.

Refining was formerly done almost exclusively in Pennsylvania and New York, but recently new refining plants have been erected at Bauxite, in Saline county, Ark., and near East St. Louis, in St. Clair county, Ill. These plants are equipped with modern machinery, and hand labor has been superseded wherever practicable.

France produces three varieties of bauxite: The white of Herault; the pale of Baux and other localities of southern France; and the red, which contains a large proportion of iron oxide, and which is also found in several places in southern France. Of these, the white variety is the purest, containing from 65 to 74 per cent of alumina, from 0.25 to 3 per cent of ferric oxide, and from 12 to 18 per cent of silica. Thus it is comparatively free from iron oxide but contains a relatively large amount of silica. The most impure is the red variety, which contains from 50 to 62 per cent of alumina, from 24 to 28 per cent of ferric oxide, which imparts the red color, and from 1 to 7 per cent of silica. French bauxite is used chiefly in the manufacture of alum and alumina—the white variety, containing but little iron oxide, for alum; and the red variety containing but little silica, after purification, for alumina. Because of the low cost of mining and the low ocean freights of recent years, large quantities of this mineral have been brought to the United States and consumed, mainly for the manufacture of alumina from which metallic aluminum has been made. At the present time there is little, if any, French bauxite used for the manufacture of aluminum sulphate.

In the United Kingdom there are important deposits at Strain, near Ballyclare, and at Glenravel, both in county Antrim, Ireland. Of the European deposits, these are next in importance to those of France. An extensive use of this mineral of county Antrim for the manufacture of aluminum has been retarded, because the high percentage of silica it contains renders it inferior for this purpose to the bauxite of France. It is, however, of excellent quality and contains but little iron oxide or titanic oxide. Much of the product of the Irish mines is consumed in England, where it is made into alum.

In Germany there are several deposits of bauxite of considerable extent, but the quality is inferior to that of the French mineral. In one locality, however, the mineral is quite pure, but the deposit is too small in extent to be commercially valuable.

Austria, Italy, Asia Minor, French Guiana, and New South Wales also possess deposits of the mineral, but as yet none has been developed to the productive stage.

The following statement shows the analyses of specimens from various localities. This statement has been compiled from a large number of analyses which have produced results so varied that the extreme limits of each constituent have been presented. The average quantity of alumina (Al_2O_3) contained in marketed bauxite is practically 58 per cent.

Analyses of specimens of Bauxite from various countries.[1]

LOCALITY.	Alumina, Al_2O_3 (per cent).	Ferric oxide, Fe_2O_3 (per cent).	Silica, SiO_2 (per cent).	Calcium carbonate, $CaCO_3$ (per cent).	Titanium oxide, TiO_2 (per cent).	Water, H_2O (per cent).
France	30.3 to 75	0.1 to 48.8	0.3 to 2.2	0 to 12.7	1.6 to 4	12 to 22.1
Ireland	43.4 to 73	1.96 to 4.26	2.15 to 15.05	....	....	18.66 to 40.33
Germany	44.4 to 76.3	2 to 42.9	1 to 44.76	....	....	9.7 to 32.33
Austria	58 to 67.6	0.7 to 30	5.9 to 14.4	....	....	12.2 to 23.1
Italy	47.4 to 58.9	18.62 to 36.98	2.48 to 4.06	....	1.27 to 2.86	10.17 to 22.4
Georgia, United States	39.75 to 82.38	0.21 to 13.5	1.34 to 35.88	....	0.87 to 4.18	16.14 to 32

[1] Compiled from "The Mineral Industry," Vols. I to XI, inclusive.

Chemical properties.—The mineral bauxite is a hydrated aluminum oxide containing also various quantities of iron oxide (Fe_2O_3) and silica (SiO_2). Three varieties are distinguished, the monohydrate (Al_2O_3, H_2O), the dihydrate (Al_2O_3,$2H_2O$), and the trihydrate (Al_2O_3,$3H_2O$). Apart from impurities the composition of these minerals varies from the monohydrate (diaspore), which contains 85.12 per cent of Al_2O_3 and 14.88 per cent of H_2O, to the trihydrate (gibbsite), which contains 65.61 per cent of Al_2O_3 and 34.39 per cent of H_2O. More or less of the alumina in bauxite is replaced by iron or manganese oxides. Silica occurs in the mineral either free or in combination in clay. Minor impurities are compounds of phosphoric acid, sulphur, carbon dioxide, lime, and magnesia. In composition the French mineral appears to correspond to the monohydrate while that of the United States approximates the trihydrate. The composition of bauxite can be determined only by chemical analysis since it is not indicated by the physical properties of the mineral. According to Francis Laur,[1] the average composition is from 66 to 69 per cent of Al_2O_3; 27 per cent of H_2O, SiO_2, and F_2O_3; with from 3 to 4 per cent of TiO_2 and other impurities. In general the value of the ore is in direct proportion to the richness and purity of the alumina content. In ore of good quality the percentage of alumina is high, while that of iron oxide and silica is low. Bauxite has a strong affinity for water, which makes it necessary that the ore be dried before shipment. For the manufacture of aluminum the presence of iron oxide and titanic oxide in the ore is not objectionable, but for making alum these insoluble materials should not exceed 7 per cent, and the iron oxide should be less than 2.75 per cent. The trihydrate, on account of its greater solubility, is best suited for the manufacture of alum, and for this purpose the bauxite of the United States is preferable to that of France.

Physical properties.—Bauxite occurs in the earth's crust in the form of veins, beds, or amorphous masses, not crystallized, and without any constant organoleptic characteristics. The hardness, color, texture, and density often change in the same deposit. Usually the ore occurs in concretionary or pisolitic masses, although it is sometimes a hard, compact, homogeneous fine-grained rock. In some cases the structure is oolitic, and in others it is earthy, resembling clay. It may be hard or soft and compact or porous. The color varies from almost pure white to a deep red or black, passing through shades of cream, gray, yellow, and pink. The mineral is sometimes speckled or mottled, and is more or less stained by iron oxide, manganese minerals, or organic matter. The colors shade into one another gradually or abruptly, and seldom, if ever, does a deposit possess a uniform color. The hardness of average good ore varies from 1 to 3 and the specific gravity from 2.4 to 2.55.

When exposed to extreme heat bauxite becomes so hard that it is almost impossible to make any impression upon it with steel tools. This property in connection with its infusibility makes it an excellent material for crucibles and for furnace linings, since it resists chemical and calorific actions. The chief reason why bauxite is not used more extensively as a basic furnace lining is due to the impurities that are usually present in the mineral.

[1] Transactions of the American Institute of Mining Engineers, Vol. XXIV (1894), page 237.

IMPORTANT PRODUCTS DERIVED FROM BAUXITE.

Four principal substances are prepared from bauxite, viz, aluminum sulphate, alum, artificial emery, and aluminum hydroxide. From the last-named substance the metal aluminum is manufactured.

Aluminum sulphate—$Al_2(SO_4)_3$,$18H_2O$.—This is a chemical salt technically known as "concentrated alum." It is prepared by decomposing bauxite with sulphuric acid. If the mineral is dissolved directly in the acid, the product will contain a large quantity of iron, forming the so-called "alumino-ferric cake," which is used for many purposes where iron and free acid are not objectionable, as in the precipitation of sewage and of waste liquors from dyeworks. Pure aluminum sulphate is now generally prepared by the Bayer process, which consists in adding powdered alumina to the solution of sodium aluminate, containing 1 part of Al_2O_3 to 1.8 parts of Na_2O. The reaction causes a crystalline precipitate of aluminum hydroxide. The silica and the iron present remain dissolved in the solution. The precipitated aluminum hydroxide is separated from the solution and is thoroughly washed and later dissolved in pure, hot, concentrated sulphuric acid until the frothing ceases. The solution is then transferred to shallow leaden pans and allowed to cool; thus the pure aluminum sulphate is separated out in the form of a solid crystalline mass. Owing to its greater purity and greater strength, aluminum sulphate has largely replaced alum in the arts. Aluminum sulphate is extensively used as a mordant in dyeing; in preparing size for paper; for making alum and aluminum salts (red liquor, etc.); in tawing skins; for precipitating sewage or coloring matter in water; and, in general, for all purposes in which alum was formerly used.

Potassium alum — $K_2SO_4,Al_2(SO_4)_3,24H_2O$. — This product is known also as "potash alum" and "common alum." The manufacture of alum from bauxite involves the preparation of a pure solution of aluminum sulphate to which is added the proper proportion of an alkali sulphate in order to form the special alum desired. Thus potassium sulphate is used to form potassium alum and sodium sulphate for sodium alum. All alums crystallize from solutions perfectly, forming very pure crystals even from impure solutions, and it is because of this property that the alums are so extensively used in the arts. The chief uses of common alum are as a mordant in dyeing; in preparing size in paper making; in tawing skins; in making pigment lakes; for clarifying turbid liquors; for precipitating sewage waters; and for hardening plaster of Paris casts and other forms. For these uses, however, as mentioned above, aluminum sulphate is generally preferred because of its greater strength and solubility.

Aluminum hydroxide—$Al_2(OH)_6$.—The manufacture of aluminum hydroxide from bauxite is of great importance, because by a simple calcination it yields aluminum oxide (alumina), which is the chief crude material used for the manufacture of the metal aluminum. In making aluminum hydroxide, bauxite is roasted, pulverized, and mixed with calcined soda ash in the proportion of 1 part of Al_2O_3 to 1.1 parts of Na_2O, or greater if silica be present in the ore. The mixture is calcined at a white heat for three or four hours until all traces of carbon dioxide and water have been expelled. The calcined product is then ground and lixiviated with hot water; this process yields a solution of sodium aluminate from which the aluminum hydroxide is precipitated by passing carbon dioxide gas through it. The impurities, silica and iron oxide, remain dissolved in the mother liquor.

In order to avoid the costly and tedious chemical process of obtaining pure aluminum hydroxide, an electric furnace method has been recently patented by Mr. Charles M. Hall,[1] whereby the impurities in the bauxite, mainly iron oxide and silica, are removed, and the bauxite is thus purified for the aluminum reduction process. The process of purifying the bauxite consists in submitting it to a preliminary heating for some hours in the presence of carbon and metallic aluminum in an electric furnace, during which time the iron oxide and the silica become reduced to metallic iron and silicon and combine with the aluminum to form a heavy alloy, which can be detached easily from the mass of purified bauxite after it has cooled.

Artificial emery.—Within the past year or so a company at Niagara Falls, N. Y., has consumed a considerable quantity of bauxite for the manufacture of abrasive wheels.

[1] United States patents Nos. 677,207, 677,208 (July, 1901), and No. 706,553 (August, 1902).

TABLE 4.—*Detailed summary: 1902.*

Number of mines or quarries	38
Number of operators	[1]7
Character of ownership:	
Individual	2
Incorporated company	5
Salaried officials, clerks, etc.:	
Total number	42
Total salaries	$33,230
General officers—	
Number	5
Salaries	$10,000
Superintendents, managers, foremen, surveyors, etc.—	
Number	32
Salaries	$19,630
Clerks—	
Number	5
Salaries	$3,600
Wage-earners:	
Total average number above ground	150
Total wages	$59,763
Engineers, firemen, and other mechanics—	
Average number	17
Wages	$10,050
Miners or quarrymen—	
Average number	77
Wages	$21,269
Boys under 16 years—	
Average number	3
Wages	$450
All other wage-earners—	
Average number	53
Wages	$24,994
Average number of wage-earners at specified daily rates of pay:	
Engineers—	
$1.00 to $1.24	1
$1.25 to $1.49	5
$1.50 to $1.74	1
$2.00 to $2.24	1
$2.50 to $2.74	1
Firemen—	
$1.00 to $1.24	1
$1.50 to $1.74	1
$2.50 to $2.74	1
Machinists, blacksmiths, carpenters, and other mechanics—	
$2.50 to $2.74	3
$2.75 to $2.99	2
Miners or quarrymen—	
$0.75 to $0.99	5
$1.00 to $1.24	64
$1.25 to $1.49	8
Boys under 16 years—	
Less than $0.50	1
$0.50 to $0.74	2
All other wage-earners—	
$1.00 to $1.24	3
$1.25 to $1.49	10
$1.50 to $1.74	40
Average number of wage-earners employed during each month:	
Men 16 years and over—	
January	145
February	147
March	147
April	147
May	164
June	147
July	143
August	143
September	145
October	160
November	146
December	130
Boys under 16 years—	
January	2
February	2
March	3
April	3
May	4
June	4
July	4
August	4
September	3
October	3
November	2
December	2
Contract work:	
Amount paid	$500
Number of employees	10
Miscellaneous expenses:	
Total	$14,939
Royalties and rent of mine and mining plant	$2,090
Rent of offices, taxes, insurance, interest, and other sundries	$12,849
Cost of supplies and materials	$40,019
Product:	
Quantity, long tons	29,222
Value	$128,206
Power owned:	
Total horsepower	624
Engines—	
Steam—	
Number	19
Horsepower	575
Gas or gasoline—	
Number	2
Horsepower	49
Electric motors—	
Number	4
Horsepower	64

[1] Includes operators distributed as follows: Alabama, 1 (3 mines); Arkansas, 3 (19 mines); Georgia, 3 (16 mines).

FLINT AND FELDSPAR

(995)

FLINT AND FELDSPAR.

By Story B. Ladd.

The chief consumption of both flint (or quartz) and feldspar is in the pottery industry, and as the mining of these minerals is in some cases associated, the general statistics of the two industries are presented together, as well as separately.

Table 1 is a combined summary of the statistics for the flint and feldspar industries for 1902.

Table 1.—*Summary: 1902.*

Number of mines or quarries	46
Number of operators	43
Salaried officials, clerks, etc.:	
Number	45
Salaries	$34,425
Wage-earners:	
Average number	371
Wages	$154,898
Miscellaneous expenses	$33,698
Cost of supplies and materials	$68,920
Product:	
Quantity, short tons	81,652
Value	$394,633
Flint—	
Quantity, short tons	36,365
Value	$144,209
Feldspar—	
Quantity, short tons	45,287
Value	$250,424

Of the 46 mines, 18 produced flint, 23 feldspar, and 5 both flint and feldspar. Of these 5 mines, 4 were in Maine and 1 in Massachusetts. Feldspar was the chief product of the 4 mines in Maine, which also produced 1,254 short tons of flint, valued at $2,593, as a by-product; and flint was the chief product of the 1 mine in Massachusetts, with 112 short tons of feldspar, valued at $1,000, as a by-product. One corporation operated a feldspar and flint mine in Maine and a flint mine in Pennsylvania; 1 corporation operated a feldspar and flint mine in Maine and a flint mine in Maryland; and 1 corporation operated feldspar mines in Pennsylvania and Maryland.

The details of the capital stock of 9 of the 11 incorporated companies are shown in the following table:

Table 2.—*Capitalization of incorporated companies: 1902.*

Number of incorporated companies	[1] 11
Number reporting capitalization	[2] 9
Capital stock:	
Total authorized—	
Number of shares	106,910
Par value	$634,000
Total issued—	
Number of shares	46,103
Par value	$493,400
Dividends paid	$8,800
Common—	
Authorized—	
Number of shares	106,710
Par value	$624,000
Issued—	
Number of shares	45,903
Par value	$483,400
Dividends paid	$8,800
Preferred—	
Authorized—	
Number of shares	200
Par value	$10,000
Issued—	
Number of shares	200
Par value	$10,000
Assessments levied	$418

[1] Includes companies distributed as follows: Connecticut, 2; Maine, 3; Maryland, 2; Massachusetts, 1; Pennsylvania, 3.
[2] Includes companies distributed as follows: Connecticut, 2; Maine, 2; Maryland, 2; Massachusetts, 1; Pennsylvania, 2.

One of these 11 companies, mining feldspar in Pennsylvania, was not engaged chiefly in mining or quarrying, and its capitalization was not reported. Also 1 of the companies mining feldspar and flint in Maine was a large clay producer in Delaware, and its capitalization appears under the clay statistics. Both flint and feldspar were produced by 2 of the companies in Maine and 1 in Massachusetts; 6 of the companies mined feldspar only, and 2 mined flint only.

FLINT.

The statistics for flint or quartz presented herewith do not include those for crystalline quartz, which is used principally as an abrasive, or as a wood finisher, and which is separately considered in the class of abrasive materials.

The flint or quartz production of the United States in 1902, that is, the flint mined or quarried as such, with the exception above noted, amounted to 36,365 short tons, valued at $144,209. In 1889 the production of flint was 11,113 long tons, or 12,448 short tons, valued at $49,137. At the census of 1880 the production of "quartz and feldspar" was reported as 21,571 long tons, valued at $103,878.

The crystalline quartz production for the year 1902 was 15,104 short tons, valued at $43,085, which, added to the flint production, makes a total of 51,469 tons, valued at $187,294, for the combined production of flint and crystalline quartz for 1902. The production of quartz as a whole has therefore increased from 12,448 short tons in 1889, to 51,469 short tons in 1902, or over 300 per cent; and the value from $49,137 to $187,294, or over 280 per cent. The average price in 1889 was $3.95 per short ton; and in 1902, the average price for the entire quartz production, flint and crystalline quartz combined, was $3.64 per short ton.

There were 19 active flint mines or quarries located—4 in Connecticut, 6 in Maryland, 4 in Pennsylvania, 2 in New York, and 1 each in Massachusetts, Montana, and Virginia. These were controlled by 17 operators—10 individuals, 4 firms, and 3 incorporated companies.

There were 6 operators who reported no flint mined during the year—3 individual operators in Connecticut, 1 individual operator in Maryland, 1 individual operator in New York, and 1 incorporated company in Wisconsin, which was engaged chiefly in the production of clay, but in former years had produced a small amount of flint as a by-product.

Employees and wages.—The wage-earners constituted 86.9 per cent of the salaried employees and wage-earners, and their wages were 76.8 per cent of the total salaries and wages.

The average number of wage-earners employed during each month is shown in Table 5. The least number was employed during the winter months and the largest number during the summer months, though the range was not large, the minimum being 91 in December and the maximum 138 in July.

The average number of wage-earners employed at specified daily rates of pay is also shown in Table 5. The mines that produced flint or quartz as such, with the exception of the mine in Montana, were located in the Atlantic coast states and the product is chiefly used by the pottery industry, which is chiefly confined to the states east of the Mississippi. Of the wage-earners 71 per cent received less than $1.50 per day, 22 per cent $1.50 to $1.99 per day, and but 8 per cent $2 and over. Of the 65 miners or quarrymen 58 received from $1 to $1.74 per day, and only 7 received $1.75 and over. Of the latter, 4, at $3 to $3.24, were in Montana.

Supplies, materials, and miscellaneous expenses.—The cost of supplies and materials was reported as $18,642, and the miscellaneous expenses as $14,291. Of the latter, the sum of $5,813 was paid by 11 mines for royalties and rent of mine and mining plant, these mines being located, 2 in Connecticut, 3 in Maryland, 4 in Pennsylvania, and 1 each in New York and Virginia; and the sum of $8,478 by 17 mines for rent of offices, taxes, insurance, interest, and other sundries.

Mechanical power.—Of the 23 mines or quarries, 8 employed power aggregating 740 horsepower, of which 155 horsepower was furnished by 4 steam engines, and 585 horsepower by 10 water wheels. The waterpower was reported for 5 mines in Maryland and 1 mine in Massachusetts.

Production.—The total production for the year 1902 was 36,365 short tons, valued at $144,209. This consisted of 20,295 tons of crude flint, valued at $35,046, an average of $1.73 per ton, and 16,070 tons of ground flint, valued at $109,163, an average of $6.79 per ton. Montana was the largest producer in quantity, with 10,640 short tons of crude flint, valued at $14,250. The production of Maryland and Pennsylvania was approximately the same, each 26.9 per cent of the total, but Maryland produced 49.2 per cent of the ground flint, and Pennsylvania 34.5 per cent. The United States Geological Survey has published annual statistics showing the quantity and value of flint produced since 1892, and in the following table there is shown the total production and value for each year:

TABLE 3.—*Production of flint: 1892 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (short tons).	Value.
1892	22,400	$80,000
1893	33,231	63,792
1894	42,560	319,200
1895	13,747	21,038
1896	12,458	24,226
1897	13,466	26,227
1898	21,425	42,670
1899	29,852	180,345
1900	32,495	86,351
1901	34,420	149,297
1902	36,365	144,209

The average price of flint per ton is so variable, ranging from a minimum of $1.53 in 1895 to a maximum of $7.50 in 1894, that no comparison can be made as to values. The largest production was in 1894, when it reached 42,560 short tons, and the smallest was 12,458 short tons in 1896. Since 1896, the production shows a steady increase year by year. The average price of crude flint in 1900, 1901, and 1902 was practically stationary, varying only from $1.73 to $1.86 per ton, while the average price of ground flint increased from $3.73 per ton in 1900 to $6.72 per ton in 1901, and $6.79 per ton in 1902.

The value of the imports for consumption of flint and flint stones, unground, for the fiscal years ending June 30, 1900, 1901, and 1902, respectively, were $40,475, $64,697, and $85,092. The imports were chiefly from France, Denmark, and Belgium, in the order named, with more than half the values coming from France, and a small amount from Germany.

A detailed summary of the statistics for flint is given in Table 5.

Occurrence and use.—Although silica or quartz is widely distributed in igneous and metamorphic rocks, and constitutes the gangue of many metalliferous veins, yet it is only the pure non-ore bearing quartz veins that are chiefly drawn upon for the quartz production of the United States. Many quartzites or sandstones are of sufficient purity to be ground for potters' use.

The term flint, as properly used, refers to the cryptocrystalline variety of silica occurring in nodular masses in calcareous strata, particularly in chalk. This is found in the United States in Texas and Arkansas and Florida, but is not at present utilized. The mineral worked throughout the entire Appalachian region, either for pottery or under the name of "flint," and included in this report, is quartz. The imported flint, on the other hand, is in part, if not wholly, the true flint from the chalk cliffs.

Flints when calcined and ground to powder enter into the composition of many kinds of fine pottery and were formerly employed in the manufacture of the finer varieties of glass, hence termed "flint glass."

The manufacture of gunflints was formerly an important industry, and the use of flints in the "stone age" and the later periods for the manufacture of axes, knives, spearheads, arrowheads, and the like, forms one of the most interesting fields of research for the antiquary and archaeologist.

The flint product, like feldspar, is used chiefly in the pottery and porcelain industry, though some is consumed in the manufacture of scouring soaps and wood fillers.

FELDSPAR.

The feldspar product of the United States for the year 1902 amounted to 45,287 short tons, of a value of $250,424. In 1880 the production was included in "quartz and feldspar," cited under "Flint" in this report. The only statistics pertaining to the feldspar production reported at the Eleventh Census, for the year 1889, with which comparison can be made are the quantity produced and its value. The production was 6,970 long tons, or 7,806 short tons, valued at $39,370. The average prices for all material, crude and ground, for the census years 1889 and 1902, were $5.04 and $5.53 per short ton, respectively. There has been a very considerable increase in the production during the last decade, with slight increase in average value.

As shown by Table 6, Pennsylvania had the largest number of feldspar mines or quarries, 12 in number, and produced one-third of the entire feldspar product and approximately one-half of the ground feldspar.

There were 9 idle mines in 1902. Of the operators, 7 were individuals, 4 in Pennsylvania and 1 each in Alabama, Connecticut, and New York; 1 was an incorporated company in New York, and 1 a firm (limited partnership) in Connecticut. The capital stock of the incorporated company was 200,000 shares, all common stock, of a par value of $200,000, authorized; of which 150,000 shares, of a par value of $150,000, had been issued. The power of the idle establishments aggregated 42 horsepower, reported by 1 operator in Connecticut and 1 in New York.

Employees and wages.—The wage-earners constituted 90.3 per cent of the salaried employees and wage-earners, and their wages were 84.2 per cent of the total salaries and wages. The average number of wage-earners employed by months is shown in Table 6. The maximum number, 279, appears in July, and the minimum, 227, in February, with an average of 252. Boys under 16 years of age were employed in two cases; 1 mine in Pennsylvania employed an average of 2 for the year, and 1 mine in Maryland an average of 1.

The average number of wage-earners employed at specified daily rates of pay is also shown in Table 6. The mines producing feldspar were all located in the Atlantic coast states, and, moreover, were all surface mines, no underground working being reported; hence the wages paid were comparatively low. Of the wage-earners, 61 per cent received less than $1.50 per day; 32 per cent from $1.50 to $1.74, and but 7 per cent $1.75 and over. Of the 183 miners or quarrymen, who constituted 73 per cent of all wage-earners, 69 per cent received not to exceed $1.49 per day and 30 per cent from $1.50 to $1.74; only 3 miners received $1.75 or more.

Supplies, materials, and miscellaneous expenses.—The cost of supplies and materials was $50,278, and the miscellaneous expenses, $19,407. Of the latter the sum of $10,584 was paid by 14 mines for royalties and rent of mine and mining plant, these mines being located—4 in Connecticut, 2 in Maine, 2 in Maryland, and 6 in Pennsylvania; and $8,823 by 19 mines for rent of offices, taxes, insurance, interest, and other sundries.

Mechanical power.—Of the 27 mines or quarries, 13 employed power aggregating 1,204 horsepower, of which 854 horsepower was furnished by 15 steam engines and 350 horsepower by 7 water wheels. The waterpower was reported for 2 mines in Connecticut, 1 in Maine, and 1 in Pennsylvania.

Production.—The total production for 1902 was 45,287 short tons, valued at $250,424. This consisted of 21,870 short tons of crude feldspar, valued at $55,501, an average of $2.54 per ton, and 23,417 short tons of ground or prepared feldspar, valued at $194,923, an average of $8.32 per ton.

Of the several producing states Pennsylvania reported the largest amount, constituting 33 per cent of the total quantity, 29 per cent of the total crude product, and 37 per cent of the total ground product. Connecticut was the next in rank, producing 31 per cent of the total quantity, 24 per cent of the total crude product, and 37 per cent of the total ground product. Maine produced 19 per cent of the total product, 21 per cent of the total crude product, and 16 per cent of the total ground product.

The United States Geological Survey has published annual statistics of the quantity and value of feldspar produced since 1892, and they are shown in Table 4.

TABLE 4.—*Production of feldspar: 1892 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (short tons).	Value.
1892	16,800	$75,000
1893	20,578	68,307
1894	19,264	167,000
1895	8,523	30,000
1896	10,203	35,200
1897	12,516	43,100
1898	13,440	32,395
1899	24,202	211,545
1900	24,821	180,971
1901	34,741	220,422
1902	45,287	250,424

For the years 1892 to 1899, inclusive, the production of the combined product of crude and ground feldspar and the average price per ton was so variable, ranging from a minimum of $2.41 per short ton for 1898 to a maximum of $8.74 per short ton in 1899, that no comparisons can be made as to values. In 1893 the production aggregated 20,578 short tons, succeeded by a drop to 8,523 short tons in 1895. Since 1895 there has been an increase, year by year, of the total quantities. The average price of crude feldspar per ton was $4.06 in 1900, $2.18 in 1901, and $2.54 in 1902. The price of ground feldspar per ton shows a slight increase, advancing from $7.54 in 1900 to $8.01 in 1901 and $8.32 in 1902.

There was some importation of feldspar from Canada, but not being separately returned to the Treasury Department the statistics can not be given.

A detailed summary of the statistics for feldspar is given in Table 6.

Occurrence and use.—The members of the group of feldspar, or feldspars, are anhydrous double silicates, consisting of a silicate of alumina combined with a silicate of potash, soda, or lime, or with two or all of these. In all the members of the group there exists the simple relation of one atom of the sesquioxide, alumina, to one of the protoxide base or bases, but the proportion of silica varies considerably in the different species. The highly silicated species, as orthoclase, albite, and oligoclase, occur in granite, trachytes, and other so-called acid rocks, while the less silicated feldspars, as labradorite, are confined to basalts and other basic rocks.

Orthoclase is the most ordinary species, and is the one most commonly used in this country. It is a potash feldspar, of which a typical analysis from Bedford, N. Y., is: Silica, 64.97; alumina, 20.85; alkalies, 13.72; and water, 0.46=100.

Labradorite is a soda-lime feldspar, consisting of silica, 55.75; alumina, 26.50; lime, 11; soda, 4; peroxide of iron, 1.25; water, 0.50=99.

The feldspars fuse, when exposed to a high temperature, to a vitreous enamel possessing considerable hardness, a property which has led to their use in glazing pottery. The chief consumption of feldspar is in the manufacture of pottery and tiles, although it is also used in the manufacture of wood fillers, scouring soaps, and in glass manufacture.

TABLE 5.—*Flint, detailed summary: 1902.*

	United States.	Connecticut.	Maryland.	Pennsylvania.	All other states.[1]
Number of mines or quarries	19	4	[2]6	[2]4	5
Number of operators	17	4	5	3	5
Character of ownership:					
Individual	10	3	1	3	3
Firm	4	1	2	....	1
Incorporated company	3	....	2	....	1
Salaried officials, clerks, etc.:					
Total number	18	2	14	1	1
Total salaries	$14,330	$1,200	$11,080	$1,500	$550
General officers—					
Number	3	....	3	....	....
Salaries	$3,875	....	$3,875	....	....
Superintendents, managers, foremen, surveyors, etc.—					
Number	10	1	7	1	1
Salaries	$9,105	$900	$6,155	$1,500	$550
Clerks—					
Number	5	1	4	....	....
Salaries	$1,350	$300	$1,050	....	....
Wage-earners:					
Above ground—					
Total average number	119	10	65	27	17
Total wages	$47,454	$4,835	$21,383	$11,713	$9,523
Engineers, firemen, and other mechanics—					
Average number	11	1	7	2	1
Wages	$5,187	$737	$3,037	$1,248	$165
Miners or quarrymen—					
Average number	65	8	26	16	15
Wages	$27,648	$3,923	$8,332	$6,875	$8,518
All other wage-earners—					
Average number	43	1	32	9	1
Wages	$14,619	$175	$10,014	$3,590	$840
Average number of wage-earners at specified daily rates of pay:					
Engineers—					
$1.50 to $1.74	2	....	2	....	....
$2.00 to $2.24	2	....	....	2	....
$2.50 to $2.74	1	1	....	....	....
Firemen—					
$1.50 to $1.74	2	....	2	....	....
Machinists, blacksmiths, carpenters, and other mechanics—					
$1.50 to $1.74	3	....	3	....	....
$2.00 to $2.24	1	....	....	....	1
Miners or quarrymen—					
$1.00 to $1.24	23	....	23	....	....
$1.25 to $1.49	20	....	2	16	2
$1.50 to $1.74	15	8	....	....	7
$1.75 to $1.99	2	....	....	....	2
$2.00 to $2.24	1	....	1	....	....
$3.00 to $3.24	4	....	....	....	4
All other wage-earners—					
$0.50 to $0.74	1	....	1	....	....
$1.00 to $1.24	31	....	31	....	....
$1.25 to $1.49	9	....	....	9	....
$1.50 to $1.74	2	1	....	....	1
Average number of wage-earners employed during each month:					
Men 16 years and over—					
January	99	4	61	23	11
February	95	5	61	23	6
March	103	5	63	28	7
April	119	9	67	28	15
May	131	13	67	30	21
June	137	17	67	30	23
July	138	15	69	32	22
August	134	16	69	28	21
September	134	11	69	28	26
October	127	9	68	28	22
November	120	8	69	23	20
December	91	8	50	23	10
Miscellaneous expenses:					
Total	$14,291	$675	$9,572	$3,137	$907
Royalties and rent of mine and mining plant	$5,813	$520	$3,087	$2,074	$132
Rent of offices, taxes, insurance, interest, and other sundries	$8,478	$155	$6,485	$1,063	$775
Cost of supplies and materials	$18,642	$1,965	$8,627	$4,425	$3,625
Product:					
Quantity, short tons	36,365	1,812	9,798	9,785	14,970
Value	$144,209	$11,575	$56,551	$42,721	$33,362
Crude—					
Quantity, short tons	20,295	852	1,895	4,238	13,310
Value	$35,046	$1,775	$5,300	$7,721	$20,250
Ground—					
Quantity, short tons	16,070	960	7,903	5,547	1,660
Value	$109,163	$9,800	$51,251	$35,000	$13,112
Power owned:					
Total horsepower	740	15	525	40	160
Engines—					
Steam—					
Number	4	1	1	2	....
Horsepower	155	15	100	40	....
Water wheels—					
Number	10	....	8	....	2
Horsepower	585	....	425	....	160

[1] Includes operators distributed as follows: Massachusetts, 1; Montana, 1; New York, 2; Virginia, 1.

[2] The additional mine was operated by one of the operators mining feldspar and flint in Maine.

TABLE 6.—FELDSPAR, DETAILED SUMMARY: 1902.

	United States.	Connecticut.	Maine.	Pennsylvania.	All other states.[1]
Number of mines or quarries	27	6	5	12	4
Number of operators	26	6	5	12	3
Character of ownership:					
Individual	15	4	2	9	....
Firm	3	....	....	....	3
Incorporated company	8	2	3	[2]3	....
Salaried officials, clerks, etc.:					
Total number	27	8	6	9	4
Total salaries	$20,095	$5,345	$4,713	$8,712	$1,325
General officers—					
Number	4	....	2	2	....
Salaries	$4,275	....	$775	$3,500	....
Superintendents, managers, foremen, surveyors, etc.—					
Number	20	7	4	6	3
Salaries	$14,800	$4,745	$3,938	$5,092	$1,025
Clerks—					
Number	3	1	....	1	1
Salaries	$1,020	$600	....	$120	$300
Wage-earners:					
Above ground—					
Total average number	252	71	40	125	16
Total wages	$107,444	$33,672	$16,414	$50,876	$6,482
Engineers, firemen, and other mechanics—					
Average number	18	7	4	6	1
Wages	$8,954	$3,505	$1,871	$3,128	$450
Miners or quarrymen—					
Average number	183	38	27	104	14
Wages	$77,541	$17,869	$10,871	$42,881	$5,920
Boys under 16 years—					
Average number	3	....	....	2	1
Wages	$532	....	....	$420	$112
All other wage-earners—					
Average number	48	26	9	13	....
Wages	$20,417	$12,298	$3,672	$4,447	....
Average number of wage-earners at specified daily rates of pay:					
Engineers—					
$1.25 to $1.49	1	....	....	1	....
$1.50 to $1.74	5	2	2	....	1
$1.75 to $1.99	2	2	....	....	....
$2.00 to $2.24	2	1	....	1	....
$2.50 to $2.74	1	....	....	1	....
Firemen—					
$2.00 to $2.24	1	....	1	....	....
Machinists, blacksmiths, carpenters, and other mechanics—					
$1.50 to $1.74	1	1	....	....	....
$1.75 to $1.99	3	1	....	2	....
$2.00 to $2.24	2	....	1	1	....
Miners or quarrymen—					
$1.00 to $1.24	1	....	....	....	1
$1.25 to $1.49	125	....	16	102	7
$1.50 to $1.74	54	37	10	1	6
$1.75 to $1.99	1	....	1	....	....
$2.50 to $2.74	2	1	....	1	....
Boys under 16 years—					
$0.75 to $0.99	3	....	....	2	1
All other wage-earners—					
$1.00 to $1.24	1	....	....	1	....
$1.25 to $1.49	23	4	8	11	....
$1.50 to $1.74	21	21	....	....	....
$1.75 to $1.99	2	1	....	1	....
$2.00 to $2.24	1	....	1	....	....
Average number of wage-earners employed during each month:					
Men 16 years and over—					
January	226	71	25	123	7
February	225	70	26	122	7
March	229	72	25	118	14
April	248	68	41	119	20
May	249	68	36	125	20
June	256	70	49	117	20
July	276	71	61	125	19
August	259	70	57	116	16
September	272	77	48	132	15
October	252	71	42	124	15
November	254	72	39	129	14
December	242	72	31	126	13
Boys under 16 years—					
January	2	....	....	2	....
February	2	....	....	2	....
March	2	....	....	2	....
April	3	....	....	2	1
May	3	....	....	2	1
June	3	....	....	2	1
July	3	....	....	2	1
August	3	....	....	2	1
September	3	....	....	2	1
October	4	....	....	2	2
November	4	....	....	2	2
December	4	....	....	2	2
Miscellaneous expenses:					
Total	$19,407	$4,564	$3,983	$9,074	$1,786
Royalties and rent of mine and mining plant	$10,584	$3,854	$812	$4,818	$1,100
Rent of offices, taxes, insurance, interest, and other sundries	$8,823	$710	$3,171	$4,256	$686
Cost of supplies and materials	$50,278	$10,677	$5,388	$32,423	$1,790
Product:					
Quantity, short tons	45,287	13,949	8,495	15,121	7,722
Value	$250,424	$73,764	$38,711	$115,699	$22,250
Crude—					
Quantity, short tons	21,870	5,207	4,665	6,388	5,610
Value	$55,501	$14,122	$12,206	$19,923	$9,250
Ground—					
Quantity, short tons	23,417	8,742	3,830	8,733	2,112
Value	$194,923	$59,642	$26,505	$95,776	$13,000
Power owned:					
Total horsepower	1,204	577	150	427	50
Engines—					
Steam—					
Number	15	6	3	5	1
Horsepower	854	407	70	327	50
Water wheels—					
Number	7	3	2	2	....
Horsepower	350	170	80	100	....

[1] Includes operators distributed as follows: Maryland, 2; New York, 1.

[2] One company operated 2 mines, 1 each in Pennsylvania and Maryland.

FULLER'S EARTH

FULLER'S EARTH.

By Story B. Ladd.

Fuller's earth was first discovered in the United States at Quincy, Fla., in 1893, and the production is now for the first time reported at a United States census. Table 1 is a summary of the statistics for the year 1902.

TABLE 1.—*Summary: 1902.*

Number of mines	4
Number of operators	4
Salaried officials, clerks, etc.:	
Number	14
Salaries	$10,040
Wage-earners:	
Average number	114
Wages	$33,775
Contract work	$4,021
Miscellaneous expenses	$2,057
Cost of supplies and materials	$28,966
Product:	
Quantity, short tons	11,492
Value	$98,144

There were only 4 mines in operation, 2 each in Arkansas and Florida, the latter state producing 90.4 per cent of the total quantity. The production for 1902 was 11,492 short tons, valued at $98,144, or an average of $8.54 per ton, the minimum being $8 and the maximum $13.33. The 4 mines were controlled by 1 individual operator and 3 incorporated companies. There were 2 idle mines in 1902—1 in Georgia and 1 in New York.

Capital stock of incorporated companies.—The following table presents the details of the capitalization of the incorporated companies:

TABLE 2.—*Capitalization of incorporated companies: 1902.*

Number of incorporated companies	[1]3
Number reporting capitalization	[2]2
Capital stock:	
Total authorized—	
Number of shares	3,200
Par value	$230,000
Total issued—	
Number of shares	3,200
Par value	$230,000
Common—	
Authorized—	
Number of shares	2,200
Par value	$130,000
Issued—	
Number of shares	2,200
Par value	$130,000
Preferred—	
Authorized—	
Number of shares	1,000
Par value	$100,000
Issued—	
Number of shares	1,000
Par value	$100,000

[1] Includes 1 company in Arkansas and 2 in Florida.
[2] Includes 1 company in Arkansas and 1 in Florida.

All of the stock authorized—3,200 shares, having a par value of $230,000—has been issued. No dividends were reported.

Employees and wages.—The average number of wage-earners employed during each month, and their specified daily rates of pay according to occupations, are shown in Table 4. The large increase in the number of men employed for the last four months of the year was due to the beginning of operations by a new producer. Eliminating the men employed by this new operator, it appears that the busiest month was January, while the industry was at its lowest ebb in July.

As the excavation of fuller's earth requires no skill, the rates of pay should not be compared with those in mining industries requiring skill and experience. The rates for miners are only those ordinarily received by unskilled day laborers. Of the 54 miners employed, 81.5 per cent received less than $1.25 per day, and the remaining 18.5 per cent from $1.25 to $1.99 per day. Eight employees were engaged in contract work, for which $4,021 was expended.

Supplies, materials, and miscellaneous expenses.—The cost of supplies and materials was $28,966; the miscellaneous expenses amounted to $2,057, all for rent of offices, taxes, insurance, interest, and other sundries.

Mechanical power.—For the 4 mines 460 horsepower was reported, supplied by 7 steam engines with a capacity of 430 horsepower, and 2 gas or gasoline engines with a capacity of 30 horsepower. All of the gas or gasoline power and 80 per cent of the steam power were reported from Florida.

Production.—The production for the year 1902 was 11,492 short tons, valued at $98,144. The United States Geological Survey has published annual statistics showing the quantity and value of fuller's earth produced. In the following table these, together with the statistics of imports of both the crude and manufactured article, with the average value per ton, are shown from 1898 to 1902. Quantities are shown in short tons for purposes of comparison.

Table 3.—PRODUCTION AND IMPORTS OF FULLER'S EARTH: 1898 TO 1902.

YEAR.	PRODUCTION.			IMPORTS.[1]								
				Total.			Crude.			Wrought or manufactured.		
	Quantity (short tons).	Value.	Average value per ton.	Quantity (short tons).	Value.	Average value per ton.	Quantity (short tons).	Value.	Average value per ton.	Quantity (short tons).	Value.	Average value per ton.
1898	14,860	$106,500	$7.17	9,356	$71,044	$7.59	2,283	$15,921	$6.97	7,073	$55,123	$7.79
1899	12,381	79,644	6.43	11,558	69,640	6.03	4,192	23,194	5.53	7,366	46,446	6.31
1900	9,698	67,535	6.96	9,154	64,797	7.08	2,723	14,750	5.42	6,431	50,047	7.78
1901	14,112	96,835	6.86	12,061	80,697	6.69	3,268	17,230	5.27	8,793	63,467	7.22
1902	11,492	98,144	8.54	15,134	102,580	6.78	4,239	26,635	6.28	10,895	75,945	6.97

[1] Quantities have been converted into short tons for purposes of comparison.

For each year except 1902 the domestic production slightly exceeded the imports, the percentage of the total consumption—production and imports—which was produced in the United States being 61 in 1898, 52 in 1899, 51 in 1900, 54 in 1901, and 43 in 1902.

During the period from 1897 to 1902 the average value of imports per short ton ranged from a minimum of $6.03 in 1899 to a maximum of $7.59 in 1898; the average value of fuller's earth imported in a crude state—unwrought or unmanufactured—ranged from a minimum of $5.27 in 1901 to a maximum of $6.97 in 1898, while the average value of the wrought or manufactured earth imported ranged from a minimum of $6.31 in 1899 to a maximum of $8.37 in 1897. During the period from 1867 to 1883 the average value per short ton of imports of fuller's earth, based upon the custom house returns to the Treasury Department, ranged from a minimum of $9.77 in 1870 to a maximum of $11.25 in 1882, with an average of $10.59 for the entire period.

Table 4 is a detailed summary for the industry in 1902.

DESCRIPTIVE.

Fuller's earth derives its name from having been used in fulling cloth and wool and cleansing them of grease; it was also used by furriers for cleansing furs. It is a variety of clay resembling other clays in appearance, but commonly lacking plasticity. It is fine grained, of variable color, of a specific gravity of from 1.8 to 2.2, and has strong absorbent properties.

The composition of fuller's earth varies considerably, but this variation may be due in part to impurities. As a rule there is a high percentage of combined water; this is most marked in the case of the foreign product. The following analyses show the composition of samples, both domestic and foreign:

Analyses of fuller's earth.[1]

CONSTITUENT.	Gadsden county, Fla.	Decatur county, Ga.	Reigate, England.	Enid, Okla.	Fairburn, S. Dak.	Sumter, S. C.
Silica	62.83	67.40	53.00	50.86	58.72	74.20
Alumina	10.35	10.08	10.00	33.88	16.90	10.10
Ferric oxide	2.45	2.49	9.75	3.31	4.00	1.80
Lime	2.43	3.14	0.50	....	4.06	1.90
Magnesia	3.12	4.09	1.25	....	2.56	2.10
Soda	0.20	....	....	....	2.11	1.60
Potash	0.74	....	....	....		
Water	7.72	5.61	24.00	15.00	8.10	5.70
Moisture	6.41	6.41	....	....	2.30	2.50

[1] United States Geological Survey, "Mineral Resources of the United States," 1901, pages 933 and 934.

A variety of fuller's earth occurring in the island of Argentiera, Greece, has been mined since ancient times. In England there is an argillaceous deposit 150 feet thick, extending from Dorsetshire to Bath and Cheltenham. Fuller's earth is mined especially near Reigate, in Surrey, and at one time was considered of such importance that its exportation was prohibited under severe penalties.

The discovery of fuller's earth in Florida in 1893 caused much excitement, and a search was made for other deposits. The deposit at Quincy, Gadsden county, in that state, extending through Leon county and into Decatur county, Ga., still ranks first in commercial importance. But beds, varying widely in character, have been found in Hillsboro, Manatee, and Marion counties, Fla.; Columbia county, Ga.; Sumter county, S. C.; Oneida county, N. Y.; Saline county, Ark.; Garfield county, Okla.; Custer county, S. Dak.; Cherry county, Nebr.; Fremont county, Colo.; Kern county, Cal.; and in Utah. The Florida and Georgia deposits, which are very similar, do not resemble the English product. The fuller's earth of South Dakota, however, is almost identical with the English earth, and mines in that state will probably in time become important producers.

The methods of mining fuller's earth and preparing it for the market are very simple. The overburden of sand and worthless plastic clay is removed, and the wet fuller's earth is chopped out in thin slices with mattocks and dried in the sun. The wet, greenish clay loses perhaps half of its weight, changes to a creamy white color, and becomes very brittle, easily splitting into thin layers. Artificial driers and an arrangement for grinding the earth to the requisite degree of fineness have been recently introduced.

The Florida earth, ground to 60 mesh or finer, is used almost entirely as a substitute for boneblack in filtering mineral lubricating oils. The common practice is to run the earth into long cylinders, through which the crude black mineral oils are allowed to percolate very slowly. The oil which comes out first is water white in color and much thinner than that which follows.

While the Florida earth is superior to the English variety for the refining of mineral oils, the English product is much more desirable for the treatment of animal and vegetable oils. The process is radically different. The oil is heated in large tanks to a temperature above the boiling point of water, and from 5 to 10 per cent of its weight of fuller's earth, ground to 120 mesh, is added; the mixture is stirred vigorously for twenty minutes and then filtered off through bag filters.

Perhaps the most remarkable feature of filtration by the use of fuller's earth is the fact that—even in the mixture of oils present in crude petroleum—the oil which first percolates through the earth is the lowest in specific gravity. Indeed, the separation which can be secured by this process is comparable with the results of fractional distillation.

TABLE 4.—*Detailed summary: 1902.*

Number of mines	4
Number of operators	[1]4
Character of ownership:	
Individual	1
Incorporated company	3
Salaried officials, clerks, etc.:	
Total number	14
Total salaries	$10,000
General officers—	
Number	2
Salaries	$3,500
Superintendents, managers, foremen, surveyors, etc.—	
Number	9
Salaries	$5,000
Clerks—	
Number	3
Salaries	$1,500
Wage-earners:	
Total average number (above ground)	114
Total wages	$33,775
Engineers, firemen, and other mechanics—	
Average number	12
Wages	$6,335
Miners—	
Average number	54
Wages	$17,140
Boys under 16 years—	
Average number	24
Wages	$3,725
All other wage-earners—	
Average number	24
Wages	$6,575
Average number of wage-earners at specified daily rates of pay:	
Engineers—	
$1.50 to $1.74	1
$2.00 to $2.24	2
$3.00 to $3.24	1
Firemen—	
$1.00 to $1.24	3
$1.50 to $1.74	2
Machinists, blacksmiths, carpenters, and other mechanics—	
$1.50 to $1.74	3
Miners—	
$0.75 to $0.99	15
$1.00 to $1.24	29
$1.25 to $1.49	2
$1.50 to $1.74	5
$1.75 to $1.99	3
Boys under 16 years—	
$0.75 to $0.99	24
All other wage-earners—	
$0.75 to $0.99	15
$1.00 to $1.24	5
$1.25 to $1.49	4
Average number of wage-earners employed during each month:	
Men 16 years and over—	
January	88
February	63
March	60
April	66
May	66
June	55
July	48
August	60
September	130
October	158
November	148
December	138
Boys under 16 years—	
January	24
February	24
March	24
April	24
May	24
June	24
July	24
August	24
September	24
October	24
November	24
December	24
Contract work:	
Amount paid	$4,021
Number of employees	8
Miscellaneous expenses (rent of offices, taxes, insurance, interest, and other sundries)	$2,057
Cost of supplies and materials	$28,966
Product:	
Quantity, short tons	11,492
Value	$98,144
Power owned:	
Total horsepower	460
Engines—	
Steam—	
Number	7
Horsepower	430
Gas or gasoline—	
Number	2
Horsepower	30

[1] Includes operators as follows: Arkansas, 2; Florida, 2.

GRAPHITE

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GRAPHITE.

By Joseph Struthers, Ph. D.

Statistics for the mining of graphite were first reported separately at the census of 1880. Table 1 shows the comparative statistics of the mining operations for 1880, 1889, and 1902.

Table 1.—*Comparative summary: 1880 to 1902.*

	1902	1889	1880
Number of mines	28	(1)	3
Number of operators	19	(1)	(1)
Salaried officials, clerks, etc.:			
Number	27	(2)	(2)
Salaries	$18,924	(2)	(2)
Wage-earners:			
Average number	164	101	93
Wages	$76,729	$38,329	$29,600
Miscellaneous expenses	$6,039	$6,398	(1)
Cost of supplies and materials	$51,840	$7,734	$2,900
Product: [3]			
Quantity, short tons	27,438	7,003	[4] 940
Value	$227,508	$72,662	$49,800

[1] Not reported.
[2] Not reported separately.
[3] The United States Geological Survey reports 3,936,824 pounds of crystalline, valued at $126,144, and 4,739 short tons of amorphous, valued at $55,964, these representing the product marketed, while the Census figures represent the product mined.
[4] Does not include the return for one large producer in New York, received too late for tabulation.

The states reporting production in 1880 were New York, North Carolina, and Pennsylvania. In 1889 there is no record of production in North Carolina, but operations in Michigan, New York, Pennsylvania, Rhode Island, and Wyoming were reported. In 1902 mining operations were carried on in 13 states—Alabama, Georgia, Massachusetts, Michigan, Montana, New Mexico, New York, North Carolina, Pennsylvania, Rhode Island, South Dakota, Wisconsin, and Wyoming. The period between 1880 and 1889 does not show so great a development of the industry as that between 1889 and 1902, the increase in the value of production being 213.1 per cent in the later period, as compared with 45.9 per cent in the earlier one; this advance was due largely to the increased demand for graphite in the arts.

There were 12 mines—5 in New York, 3 each in North Carolina and Pennsylvania, and 1 in Alabama—reported as idle during 1902, and 3—1 each in New Hampshire, New York, and Pennsylvania—at which development work was done.

Capital of incorporated companies.—Fifteen of the 19 active operators were organized as incorporated companies. The details of the capitalization of these companies are shown in the following table:

Table 2.—*Capitalization of incorporated companies: 1902.*

Number of incorporated companies	[1] 15
Capital stock and bonds issued	$2,632,800
Capital stock:	
Total authorized—	
Number of shares	1,571,640
Par value	$2,914,000
Total issued—	
Number of shares	1,299,688
Par value	$2,614,800
Dividends paid	$8,750
Common—	
Authorized—	
Number of shares	1,470,140
Par value	$2,664,000
Issued—	
Number of shares	1,218,188
Par value	$2,384,800
Dividends paid	$8,750
Preferred—	
Authorized—	
Number of shares	101,500
Par value	$250,000
Issued—	
Number of shares	81,500
Par value	$230,000
Bonds:	
Authorized—	
Number	40
Par value	$20,000
Issued—	
Number	36
Par value	$18,000
Interest paid	$1,080
Assessments levied	$1,000

[1] Includes companies distributed as follows: Alabama, 1; Georgia, 1; Massachusetts, 1; Michigan, 2; Montana, 1; New Mexico, 1; New York, 3; Pennsylvania, 2; Rhode Island, 1; South Dakota, 1; Wisconsin, 1.

The total par value of stock and bonds issued was $2,632,800; of this amount 90.5 per cent represents the value of common stock, 8.7 per cent the value of preferred stock, and the remaining eight-tenths of 1 per cent the value of the bonds. The dividends paid during 1902 represent three-tenths of 1 per cent of the par value of stock issued, and the $1,080 paid as interest on bonds constitutes 6 per cent of the par value of all bonds issued.

Employees and wages.—The average number of wage-earners employed during each month of 1902, and their daily rates of pay by occupations, are shown in Table 5. The minimum number of wage-earners shown for any month during the year was in January, 137 men and 1 boy; the maximum number in October, 185 men and 1 boy. Judging by the slight variation in the number of employees, the production, although below the average during the winter and spring months, must have been fairly steady.

Of the total number of wage-earners, 34.8 per cent were paid at rates less than $1.50 per diem, and 65.2 per cent at higher rates. Of the total number, engineers formed 4.8 per cent; machinists, blacksmiths, carpenters, and other mechanics 11 per cent; and miners, the largest class, 53 per cent.

Mechanical power.—A total of 769 horsepower was reported for this industry; 749 horsepower was furnished by 18 steam engines and 10 horsepower by 1 water wheel, while 10 electric horsepower was rented.

Production.—Although the production of graphite has had a very important bearing upon the development of several of the metallic industries in the United States, it was not until 1880 that authentic statistics of production were collected. Since the quantities of graphite which have been exported from the United States are so small as to be negligible in this connection, for all practical purposes the total consumption of graphite within the United States may be assumed as equivalent to the production plus the importation. Table 3, compiled from the reports of the United States Geological Survey, gives the marketed production of natural graphite in the United States, together with the imports, for the period 1880 to 1902, with the production of artificial graphite since 1897. The statistics of production here shown differ from Census figures in that they represent only the marketed output and not the actual quantity mined.

TABLE 3.—PRODUCTION AND IMPORTS OF GRAPHITE: 1880 TO 1902.

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	PRODUCTION.[1]							IMPORTS.[2]			
	Total value.	Crystalline.		Amorphous.		Artificial.		Total value.	Unmanufactured.		Manufactured, value.
		Quantity (pounds).	Value.	Quantity (short tons).	Value.	Quantity (pounds).	Value.		Quantity (long tons).	Value.	
1880	$49,800	622,500	$49,800					$300,963	5,495	$278,022	$22,941
1881	30,000	400,000	30,000					413,640	7,546	381,966	31,674
1882	34,000	425,000	34,000					389,371	7,521	363,835	25,536
1883	46,000	575,000	46,000					383,670	7,745	361,949	21,721
1884	35,000	500,000	35,000					288,256	7,204	286,393	1,863
1885	26,231	327,883	26,231					207,228	5,523	207,228	
1886	33,242	415,525	33,242					164,111	4,108	164,111	
1887	34,000	416,000	34,000					331,621	8,442	331,621	
1888	33,000	400,000	33,000					353,990	9,200	353,990	
1889	72,662	(3)	72,662					378,057	8,869	378,057	
1890	77,500	(3)	77,500					594,746	12,798	594,746	
1891	110,000	1,559,674	110,000					555,080	10,118	555,080	
1892	87,902	1,898,365	87,902					667,775	11,677	667,775	
1893	63,232	843,103	63,232					865,379	14,437	865,379	
1894	64,010	918,000	64,010					225,720	5,814	225,720	
1895	52,582	644,700	[4]52,582	2,793				260,090	8,814	260,090	
1896	48,460	535,858	[4]48,460	700				437,159	15,280	437,159	
1897	75,879	1,361,706	[4]65,730	1,070		162,382	$10,149	270,952	8,533	270,952	
1898	86,803	2,360,000	[4]75,200	890		185,647	11,603	743,820	13,482	743,820	
1899	199,581	2,900,732	[4]167,106	2,324		405,870	32,475	1,990,649	20,793	1,990,649	
1900	266,439	5,507,855	[4]197,579	611		860,750	68,860	1,390,141	14,417	1,390,141	
1901	286,714	3,967,612	135,914	809	$31,800	2,500,000	119,000	895,010	14,325	895,010	
1902	292,808	3,936,824	126,144	4,739	55,964	2,358,828	110,700	1,168,554	18,201	1,168,554	

[1] For calendar years.
[2] Through 1887, for fiscal years; beginning with 1888, for calendar years.
[3] Quantity not reported.
[4] Includes value of amorphous.

There were 10 long tons of graphite valued at $834, exported from the United States during 1900 as compared with 5 tons valued at $365, exported during 1901. There were no exports during 1902.

The following table shows the world's production of graphite by years, from 1896 to 1901:

TABLE 4.—WORLD'S PRODUCTION OF GRAPHITE: 1896 TO 1901.

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

[Quantity in metric tons.]

COUNTRY.	1896		1897		1898		1899		1900		1901	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Total	56,739	$977,405	70,546	$1,787,185	126,752	$9,898,790	85,282	$3,704,942	[1]81,194	[1]$1,761,113	[1]72,427	$5,575,166
United States	933	48,460	1,589	65,730	1,878	75,200	3,774	167,106	3,054	197,579	2,533	167,714
Austria	35,972	410,081	38,504	439,610	33,062	421,058	31,819	395,280	33,663	418,126	29,992	1,918,509
Canada	126	9,455	396	16,240		13,698	1,025	24,179	1,744	30,940	2,005	38,780
Ceylon	10,463	414,405	19,275	1,159,885	78,509	9,243,263	29,087	2,904,970	19,168	[2]875,190	22,707	[2]3,203,215
Germany	5,248	72,108	3,861	66,126	4,593	97,916	5,196	120,250	9,248	136,500	1,435	160,000
India			61	316	22	110	1,548	7,572	1,858	9,104	2,530	(2)
Italy	3,148	10,193	5,650	11,300	6,435	17,423	9,990	55,944	9,720	55,720	10,313	59,211
Japan	215	6,925	204	16,075	346	10,265	53	5,120	94	9,118	(3)	(3)
Mexico	620	5,287	907	8,663	1,857	18,237	2,305	22,847	2,561	25,650	762	7,615
Sweden	14	491	99	3,240	50	1,620	[4]535	1,674	84	3,186	56	1,900

[1] Latest available figures used in making up total.
[2] These values are taken from the official yearbooks of the United Kingdom.
[3] Statistics not available.
[4] Includes crude.

The detailed statistics of the industry for 1902 are shown in Table 5.

DESCRIPTIVE.

The name graphite is derived from the Greek γράφειν, "to write," and refers to the use of the mineral for that purpose. Graphite is sometimes called "plumbago" or "black lead," because of its lead-like appearance, although it contains no lead. Graphite was known to the ancients. Up to the latter part of the eighteenth century, however, the names plumbago and molybdena seem to have been applied indiscriminately to graphite and to molybdenite (molybdenum sulphide, MoS_2), both of which leave a black mark when rubbed on paper. Graphite appears to have been first distinguished as early as 1565, by Conrad Geissner, but the popular misconception as to the two substances prevailed until 1779, when the famous chemist Scheele showed them to be entirely distinct.

Physical and chemical characteristics.—Graphite occurs as a form of carbon, and constitutes the last stage in the mineralization of vegetable matter. In the first stage of this process the woody tissue is converted into peat; the peat to a lignite; the substance then passes through the range of bituminous coals to semianthracite, anthracite, graphitic anthracite, and finally it is converted into graphite, which is practically pure carbon. There is no strict line of demarcation between these various forms of carbon, which merge gradually into one another. In structure and purity, specimens from different deposits show a wide divergence.

The mineral occurs in two forms, the crystalline and the amorphous. Crystalline graphite is usually found in a compact foliated or granular mass. At times the crystals are in the form of distinct hexagonal plates. The amorphous variety is, as its name implies, without crystalline structure. The term has been used to include a wide range of natural carbonaceous products—such as the graphitic anthracite of Rhode Island, which is of a structure between scaly and granular, and selected samples of which contain as much as 52 per cent of carbon; and the so-called Baraga graphite of Michigan, which in reality is a carbonaceous schist. The crystalline variety consists of finer grades, and hence is used where softness and a smooth uniformity of structure are desirable, as for lubricants or in the better grades of pencils.

Graphite is iron-black or steel-gray in color and has a metallic luster; to the touch it is smooth and soap-like. Its specific gravity varies from 2.015 to 2.583, the variation being due to the impurities—such as iron oxide, alumina, magnesia, lime, and silica—which are present in all natural graphite. Usually, there is also from five-tenths of 1 per cent to 1.3 per cent of hydrogen—a fact which seems to point to an organic origin. Graphite is infusible, and resists the corrosive action of many chemicals and molten metals. These properties render the crystalline variety, with its flake-like form, of great value in the manufacture of graphite crucibles for special purposes—for instance, to resist intense heat in the manufacture of crucible steel; to possess great density at a high heat, as in the refining of gold and silver; and to resist the corrosive action of easily oxidized metals and alloys in a molten condition, as in melting brass, bronze, etc. Although crystalline graphite will burn in oxygen at and above a temperature of 575° C., it is a good conductor of heat and electricity; this property renders it of special value for the manufacture of the commutator brushes used in electrical machines, for use in electroplating, and for electrodes in many electrolytic chemical processes.

In its chemical relations, graphite occupies a position distinct from that of any other form of carbon. The most striking difference is the effect of treatment with fuming nitric acid and potassium chlorate; diamond is unaltered, and amorphous carbon (charcoal) is completely dissolved, but graphite is converted into a compound known as graphitic acid or graphitic oxide ($C_{11}H_4O_5$).

As a fact of mineralogical interest, but one which has no industrial importance, it may be mentioned that meteoric masses have been found containing graphite which in its properties resembles the graphite formed during the cooling of high carbon and pig iron.

Occurrence and mining of crystalline graphite in the United States.—Crystalline graphite is widely distributed throughout the United States, but the known deposits of sufficient extent and purity to warrant working on a commercial scale are few in number. During the past decade the domestic output of high-grade crystalline graphite has been obtained chiefly from the mines near Ticonderoga, Essex county, N. Y. The mines in Chester county, Pa., were reopened in 1897, after a long period of inactivity, and have been in continuous operation since that time. In 1899 the mines in Clay county, Ala., produced a small amount. There has been considerable activity in the exploitation of graphite properties in Bartow county, Ga.; near Dillon, Beaverhead county, Mont.; in Merrimack county, N. H.; in McDowell county, N. C.; at Bloomington, in northern New Jersey; and in many localities in California; but up to the present time the work has been confined chiefly to determining the character and extent of the deposits, and to ascertaining by experiment the best method of concentrating the ore so as to convert it into a salable product. The limited number of graphite mines now producing the crystalline variety of the mineral bears witness to the difficulties encountered in the development of a prospect into a paying property.

The principal mines in New York are at Ticonderoga, Essex county. The graphite is of the foliated variety, occurring in minute scales in the cleavage planes of a seam of gray quartzite. The ore contains an average of 10 per cent of graphite, of which but little more than one-half is extracted by the prevailing method of working. The graphite-bearing bed lies between strata of massive micaceous gneiss, garnetiferous gneiss, and light-colored quartzite entirely free from graphite. The gneiss dips about 20° south. The graphite beds do not conform to this dip, but have a low pitch to the east. There are two mines in the same bed, on different sides of a fault. The graphite-bearing quartzite is from 1 to 5 feet thick in one mine, and from 2 to 15 feet thick in the other. This vein (known as the Hague vein) seems to have been in a line of weakness during the geologic upheavals, for the ore and wall rocks near the surface are very much pulverized, so that, while the ore carries a good percentage of graphite, the yield is small. It is probable that the deepening of the workings will result in finding the graphite in coarse flakes in the unaltered rocks, unless the faulting has occurred along the vein throughout its course. The mines are opened by adit levels, and the mined ore is treated for the separation of the graphite by crushing and washing in a mill near the mines, followed by a further refining at the works of the company at Ticonderoga.

There are numerous limestone deposits in Essex and neighboring counties of New York which contain graphite disseminated throughout the mass, or in small lenses of very rich ore. While a number of these deposits are being promoted and developed, the only ones of apparent promise are on Lead Hill, back of Ticonderoga, and on Warner Hill, between Ticonderoga and Crown Point. It is probable that if any more valuable mines are opened in this section they will be in the graphitic quartzite, as the lenticular bodies in the limestone have proved uncertain.

In Pennsylvania the principal graphite mine is 1 mile east of Chester Springs, Chester county. The mineral occurs in two layers of disintegrated mica schist, one 4 feet and the other 6 feet in thickness. Adit levels have been run in on the hillside, following the layers, and the rock is so disintegrated that most of the ore can be removed by pick and shovel without recourse to blasting. At the mill the ore is crushed in rolls and cleaned in a log washer of the type commonly used at clay works. After being washed it is again ground, refined by pneumatic concentration, and screened into different grades. There are other graphite properties in the state, notably at Byers, several miles below Chester Springs, and at Pikeland, both in Chester county, and also at Mertztown and Boyertown, Berks county. These properties have been productive at various times, but for the most part are now inoperative. The existence of graphite throughout a large part of the ridge extending from Phoenixville to the Brandywine river seems very probable. Occasionally pockets are found which yield nuggets and masses of nearly pure graphite, such as formed the basis of the producing mines in this region, but more often the mineral is associated with iron oxides, quartz, and feldspar, so that the extraction of the graphite involves considerable difficulty.

Concentrating crystalline graphite.—The increased demand for crystalline graphite has led to a careful study of the concentration of low-grade graphite disseminated in flakes. Operative plants have changed and improved their methods, and new concentrating processes are being tested.

There are two common methods of concentrating crystalline graphite from its ore—the wet and the dry. The wet or water method has been developed to a marked degree of efficiency, and is the one now generally used. The mode of procedure is to crush the ore wet, and separate coarsely by stationary buddles, the concentrates being dried and further treated with buhrstones and screens. No mill, however, has adopted either method in its entirety, because the specific gravities of the constituents of the ore vary so little. Several pneumatic processes have lately proved a partial success, but they have been of limited application, on account of the impossibility of removing the small scales of mica which occur in some of the deposits.

Two new features in concentration practice, in both of which the older method of complete submersion beneath the surface is replaced by flotation, are worthy of note—first, the use of petroleum vapor, which, being readily absorbed by graphite, permits the flakes to be more readily separated from the gangue material by flotation; and, second, the heating of the ground product before separation, which makes the flakes of graphite so light that they float on the surface of the water, whence they are removed.

Occurrence and mining of amorphous graphite in the United States.—Under this head are included also the graphitic anthracite of Rhode Island and the so-called Baraga graphite of Michigan. The incentive to develop properties containing amorphous graphite is much less than in the case of the crystalline variety. On account of the limited use of the former, the value of the crude product is only from one-eighth to one-tenth of that of the latter. For the manufacture of graphite crucibles and for many electrical purposes no satisfactory substitute for crystalline graphite has been discovered, while in the case of amorphous graphite there are many other materials of equal suitability for its various uses.

The mining of amorphous graphite in the United States has been of comparatively recent development. During 1902 the product was obtained chiefly from Wisconsin, followed by Michigan, Rhode Island, South Dakota, Wyoming, and New Mexico, in the order named. There are numerous deposits in other states, but none in sufficient quantity or purity to be of commercial value at the present time.

In Wisconsin, the mines near Stevens Point, Portage county, produce graphite which is reported to contain, at times, as much as 74 per cent of carbon. It is utilized in the manufacture of paint, lubricants, and greases.

In Michigan, there are several thousand acres in Baraga county, composed of a carbonaceous schist without a sign of a vein of graphite. This material is ground for paint and is improperly called graphite.

In Rhode Island, the mines near Cranston have been operated for many years. The graphite shows a structure between scaly and granular, and the grade of the product has not until recently exceeded 55 per cent of carbon, the remainder of the ore being silica and iron oxide, with a trace of sulphur. The property was originally a quarry, and in making the open cut the vein has been exposed for a distance of 70 feet or more. A shaft has been sunk, and most of the ore is now obtained from pockets, although it is found also in a few fissure veins.

In South Dakota, there are several graphite properties in the vicinity of Custer containing promising veins of graphite, one of which is reported to be 4 feet in width and of high-grade mineral. At Castle Creek, in Pennington county, 25 miles northwest of Custer, there is a vein which is reported to contain 40 per cent of carbon and to be in contact with a 10-foot layer of graphitized slate.

In New Mexico, considerable exploratory work has been done at the graphite properties 8 miles southwest of Raton, Colfax county.

Occurrence and mining of graphite in foreign countries.—In Ceylon, which is the chief producer of high-grade crystalline graphite, the main deposits are in the western and northwestern provinces. The graphite, which is scaly or fibrous in structure, is found in veins of irregular occurrence and extent, which break through crystalline rocks of the character of granulite. The minerals associated with graphite in the material which forms the vein are feldspar, rutile, pyrite, biotite, and calcite. The country rock is often highly decomposed, and then consists mainly of kaolin and similar decomposition products. The formation of graphite in these deposits has been attributed by Dr. Ernst Weinschenk to the decomposition of vapors carrying carbonic oxide and cyanogen compounds.

In one of the Ceylon mines near Caltura the graphite occurs in a series of veins in gneiss which has become converted, to a depth of 36 feet, into a mass resembling laterite. The indications point to the deposition of the carbon by the decomposition of hydrocarbon vapors, forming a true vein.

The Ceylon mining industry, which is entirely in the hands of the natives, has been profitable for many years, chiefly on account of the purity and consequent high value of the product. The method of mining is extremely primitive. A shaft is sunk to the level of the ground water (from 40 to 200 feet), and drifts are cut from the bottom of the shaft until the air is so bad that the lamps of the miners will no longer burn; the ground is then stoped upward, the waste being dropped behind until the shaft is filled. In some cases the veins are followed by open cuts and galleries. The underground workings are roughly timbered, and powder is used to break the rock. The ore is hoisted by windlass and bucket, or passed out by hand. A peculiar feature of the industry is the opposition to the installation of modern mining machinery and methods, on the ground that the new conditions might be less satisfactory than the older and fairly profitable ones. The mined product is famous for its purity, the analysis of several samples showing a carbon content of from 99.283 to 99.792 per cent.

In Austria, graphite occurs in the provinces of Bohemia, Styria, Moravia, Carinthia, and lower Austria. The chief producing mines are at Schwarzbach, in Bohemia. The deposits, which are lenticular, occur in gneiss, in parallel beds, extending over an area 14 miles long by 10 miles wide.

At Schwarzbach six beds have been exploited for a length of 1,800 feet and to a depth of 300 feet. The mines produce both hard and soft ore, the latter being graded into three classes. The first and second are hand picked, dried, and packed in barrels for the market; the third class and the hard mineral are crushed in water and dressed in tanks, the heavier impurities sinking to the bottom, while the slime, containing the graphite in a state of fine division, is collected in a filter press, and the resultant cakes, containing about 50 per cent of carbon, are dried and shipped to the market.

In Styria, which ranks second in importance, there is found a highly metamorphosed system of carboniferous shales, clay-slates, limestones, and conglomerates with coal seams, the coal of which has passed into graphite. It is very compact, very pure, and often extremely hard, in some cases retaining exactly the appearance of the coal from which it has been derived. The graphite region extends from Leoben to St. Lorenzen, a distance of 25 miles. The most important deposits are at St. Michael, where five parallel beds, varying in thickness from a few inches to several feet, and occurring in grayish-black schist, have been exploited for a length of over 600 feet. The preparation for market consists in simple screening. The product, which contains nearly 80 per cent of carbon, is used in making graphite crucibles.

Other graphite deposits are found in lower Austria, Moravia, and Carinthia; but the mineral, which is associated with granular limestone in gneiss, and is usually amorphous and friable, is too impure to warrant working commercially.

The graphite deposits of Germany are confined to the easternmost corner of Bavaria. In a region bounded on the south by the Danube and on the east by the Austrian frontier are gneisses and gneissose rocks impregnated with scaly graphite. In some places—chiefly in the immediate neighborhood of intercalations of granular limestone, altered by contact metamorphism—the mineral occurs in lenticular masses, rich in carbon. Both the graphite-bearing rock and its near neighbors are highly decomposed, so that kaolin and other decomposition products are found in intimate association with the graphite deposits. The lenticular form of the deposits, their geological relationship with limestone intercalations, and their frequent association with kaolin and other decomposition products, connect them closely with the Bohemian type, from which they are differentiated by the less compact and more crystalline character of the graphite. The genetic connection between the Passau and Ceylon types is very close.

At Borrowdale, England, fine-scale graphite was at one time found in veins in "greenstone porphyry." The gangue material was chiefly calc-spar, brownspar, and quartz, containing nests and lumps of very fine graphite, especially suitable for the manufacture of pencils. These mines, however, have been exhausted.

The mines at Batugol, province of Irkutsk, Siberia, also are practically exhausted. The graphite was finely fibrous and purer than that at Borrowdale. The veins run through a granitic or dioritic rock, while in the closely adjoining limestone (altered by contact metamorphism) are great lumps of pure graphite, suitable only for pencils.

Artificial graphite.—Graphite can be made artificially in several ways, among which are the following:

(1) In the production of cast iron from ore containing a large proportion of carbon, by allowing the molten mass to cool slowly. As cast iron can retain in combination a much larger proportion of carbon when molten than when solid, the cooling of the mass causes the carbon to separate out, forming scales of graphite disseminated throughout the iron. It is to the presence of the scales of graphite that gray pig iron owes its peculiar properties and its gray color. When this form of pig iron is dissolved in acid, the scales of graphite remain as an insoluble residue. When cast iron is kept in a molten condition for a long time, as in the manufacture of converter steel, scales of graphite collect on the surface of the molten metal, forming so-called "kish." This source of artificial graphite is of no commercial importance.

(2) By the reaction or decomposition of various chemical compounds containing carbon, notably the cyanide class of salts. Graphite can not be produced commercially from chemicals on account of the excessively high cost.

(3) By the treatment of certain carbonaceous materials in the electric-arc furnace, which is the process now used on a very large scale.

Pure graphite has many valuable properties, such as high electrical conductivity, great resistance to chemical action, and absence of the property of absorbing gases, which is possessed more or less by all forms of amorphous carbon. Natural graphites of the high degree of purity required for delicate chemical and electrical processes are so expensive that in most cases the cost is prohibitive. The inception of the artificial graphite industry is due to the efforts and experiments of Mr. Edward G. Acheson,[1] who during 1897 manufactured more than 160,000 pounds of this product. In 1901 the output in the United States reached 2,500,000 pounds. At first the operations were confined to the graphitization of carbon electrodes, but since 1899 very large quantities of artificial graphite have been made, to be utilized for purposes for which natural graphite was formerly used. In graphitizing electrodes the ordinary electrode, which is composed of a mixture of petroleum, coke, pitch, and a carbide-forming material (silica or iron oxide), is subjected to the intense heat of an electric-arc furnace. The so-called "artificial graphite" is produced by subjecting anthracite coal, coke, or charcoal, together with a small proportion of some oxide or sulphate, to the intense heat of an electric-arc furnace; the impurities are eliminated, the ash being reduced in some cases to as low as five-tenths of 1 per cent.

The so-called artificial graphite, which is in the form of grains or powders, is used chiefly in the manufacture of paint, dry batteries, and commutator brushes, although a considerable quantity is used in the manufacture of lubricants for high-grade work, in electroplating, and in certain chemical processes which require a carbon of exceptional purity. Experiments have been made with this material as a coating for the grains of high explosives, to prevent the generation of the

[1] United States patents Nos. 645284, 645285, 701758, and 711031.

static charge of electricity, the spark from which is supposed to cause the spontaneous ignition of the powder.

Graphitized electrodes possess special qualities which render them valuable in electrolytic processes for the production of caustic soda and of chlorine and metals in chloride solution, and in electro-metallurgical processes, such as the production of calcium chloride, the electric smelting of copper and iron ores, and the manufacture of various iron alloys.

In spite of the development of artificial graphite, however, in recent years there has been a large increase in the demand for natural graphite, due to the growth of the iron and steel industries; the largely increased use of copper and its alloys; the development of electrical machinery, which calls for graphitized products; and the increased need for special lubricants to be used at comparatively high temperatures.

Uses of graphite.—Graphite is used for making refractory crucibles, stove polish, foundry facings, paint, and lead pencils; as a lubricant; and in powder glazing, electrotyping steam packing, etc.

For the making of crucibles crystalline graphite is required; the fibrous or laminated variety is used, because its superior binding qualities add to the strength of the crucible. The ordinary mixture consists of 50 per cent of graphite, from 35 to 45 per cent of air-dried clay, and from 5 to 15 per cent of sand. The graphite is ground to a fineness of from 40-mesh to 100-mesh size, according to the special use to which the crucible is to be put; if coarse it will give a porous crucible, while if too fine it will be apt to crack when heated, because of its great density. The clay is selected, not on account of its refractoriness, but because of its plasticity. The sand is free from fluxing impurities, such as iron oxide, lime, magnesia, etc., and is sifted through a 40-mesh screen.

In combining the constituents, the clay is made into a thin paste with water, and the graphite and sand are thoroughly mixed in by repeated treatments in an ordinary pug mill. The mass is kept moist for several weeks, in order to insure the expulsion of any air bubbles which may have been formed in the mixing. This stage of the work is called "tempering." A portion of the tempered mixture of the proper weight for a crucible of the desired size is molded into shape on an ordinary potter's wheel. This method is superior to machine molding, because the rotary motion and external pressure cause the flakes of graphite to become arranged nearly parallel to the sides of the molded shape, thus binding the mass together more strongly. The freshly-molded crucibles are inclosed for several hours in a close-fitting sectional mold of plaster, which absorbs a portion of the moisture; they are then dried for a week or ten days at a temperature of from 70° to 80° F., and finally are fired for several days in a common pottery kiln. The use for graphite crucibles of a fusible clay of great plasticity instead of one of high refractoriness is based upon the fact that for the combination of two substances by fusion mechanical contact is absolutely essential, so that, whether the clay be refractory or not, the presence of an inert material between the particles of clay and sand prevents fusion. Furthermore, as soon as the crucible is placed in the kiln the graphite on the outer surface is burned away by the oxidizing gases, permitting contact between the particles of clay and sand; these, reacting upon each other, fuse and form on the outside of the crucible a glaze which protects from oxidation the graphite flakes beneath the surface.

The quantity of the mineral used for making lead pencils is comparatively small, but the quality must be of the best. For use as a lubricant a high grade of the crystalline product is essential. But material of an inferior grade is employed in the manufacture of stove polish, of foundry facings, and of graphite paint, which is used to protect ironwork (as in smokestacks, iron roofs, elevated steel structures, etc.). While crystalline graphite is used to some extent, its special properties are not absolutely required, and hence the amorphous variety, both natural and artificial, is largely employed for these purposes.

TABLE 5.—DETAILED SUMMARY: 1902.

	United States.	New York.	All other states and territories.[1]
Number of mines	28	3	25
Number of operators	19	3	16
Character of ownership:			
Individual	3	....	3
Firm	1	....	1
Incorporated company	15	3	12
Salaried officials, clerks, etc.:			
Total number	27	7	20
Total salaries	$18,924	$6,627	$12,297
General officers—			
Number	4	....	4
Salaries	$2,600	....	$2,600
Superintendents, managers, foremen, surveyors, etc.—			
Number	14	3	11
Salaries	$10,112	$3,560	$6,552
Foremen, below ground—			
Number	5	2	3
Salaries	$4,435	$1,815	$2,620
Clerks—			
Number	4	2	2
Salaries	$1,777	$1,252	$525
Wage-earners:			
Aggregate average number	164	71	93
Aggregate wages	$76,729	$35,583	$41,146
Above ground—			
Total average number	101	36	65
Total wages	$45,288	$19,053	$26,235
Engineers, firemen, and other mechanics—			
Average number	27	12	15
Wages	$16,038	$7,558	$8,480
Miners—			
Average number	33	....	33
Wages	$12,089	....	$12,089
Boys under 16 years—			
Average number	1	....	1
Wages	$150	....	$150
All other wage-earners—			
Average number	40	24	16
Wages	$17,011	$11,495	$5,516
Below ground—			
Total average number	63	35	28
Total wages	$31,441	$16,530	$14,911
Miners—			
Average number	54	33	21
Wages	$27,672	$15,780	$11,892
Miners' helpers—			
Average number	6	2	4
Wages	$2,350	$750	$1,600
All other wage-earners—			
Average number	3	....	3
Wages	$1,419	....	$1,419
Average number of wage-earners at specified daily rates of pay:			
Engineers—			
$1.50 to $1.74	4	....	4
$2.00 to $2.24	1	1	....
$2.75 to $2.99	2	....	2
$3.00 to $3.24	1	....	1
Firemen—			
$1.50 to $1.74	1	1	....
Machinists, blacksmiths, carpenters, and other mechanics—			
$1.25 to $1.49	3	....	3
$1.50 to $1.74	4	2	2
$2.00 to $2.24	2	1	1
$2.50 to $2.74	5	5	....
$2.75 to $2.99	4	2	2
Miners—			
$0.75 to $0.99	2	....	2
$1.00 to $1.24	24	....	24
$1.25 to $1.49	6	1	5
$1.50 to $1.74	37	30	7
$1.75 to $1.99	3	....	3
$2.00 to $2.24	5	2	3
$2.25 to $2.49	9	....	9
$2.50 to $2.74	1	....	1
Average number of wage-earners at specified daily rates of pay—Continued.			
Miners' helpers—			
$1.00 to $1.24	2	2	....
$1.25 to $1.49	4	....	4
Timbermen and track layers—			
$1.50 to $1.74	3	....	3
Boys under 16 years—			
$0.50 to $0.74	1	....	1
All other wage-earners—			
$0.75 to $0.99	6	....	6
$1.00 to $1.24	1	....	1
$1.25 to $1.49	8	....	8
$1.50 to $1.74	24	24	....
$2.25 to $2.49	1	....	1
Average number of wage-earners employed during each month:			
Men 16 years and over—			
January	137	60	77
February	138	61	77
March	152	63	89
April	149	68	81
May	167	70	97
June	171	78	93
July	163	76	87
August	169	76	93
September	174	80	94
October	185	74	111
November	176	72	104
December	175	74	101
Boys under 16 years—			
January	1	....	1
February	1	....	1
March	1	....	1
April	1	....	1
May	1	....	1
June	1	....	1
July	1	....	1
August	1	....	1
September	1	....	1
October	1	....	1
November	1	....	1
December	1	....	1
Contract work:			
Amount paid	$900	....	$900
Number of employees	2	....	2
Miscellaneous expenses:			
Total	$6,039	$1,124	$4,915
Royalties and rent of mine and mining plant.	$520	$60	$460
Rent of offices, taxes, insurance, interest, and other sundries	$5,519	$1,064	$4,455
Cost of supplies and materials	$51,840	$19,543	$32,297
Product:			
Total quantity, short tons	27,438	1,375	26,063
Total value	$227,508	$77,437	$150,071
Crude—			
Quantity	24,276	50	24,226
Value	$79,900	$200	$79,700
Refined—			
Quantity	3,162	1,325	1,837
Value	$147,608	$77,237	$70,871
Power:			
Total horsepower	769	240	529
Owned—			
Engines—			
Steam—			
Number	18	4	14
Horsepower	749	230	519
Water wheels—			
Number	1	1	....
Horsepower	10	10	....
Rented—			
Electric, horsepower	10	....	10

[1] Includes operators distributed as follows: Alabama, 1; Georgia, 2; Massachusetts, 1; Michigan, 2; Montana, 1 (8 mines); New Mexico, 1; North Carolina, 2; Pennsylvania, 2; Rhode Island, 1; South Dakota, 2; Wisconsin, 1 (2 mines); Wyoming (1 mine; operator reported in South Dakota).

LITHIUM ORE

LITHIUM ORE.

By Joseph Hyde Pratt.

The production of lithium ore has not been reported at any prior census, and there are, therefore, no comparative statistics available. The mining of lithium minerals for their lithia contents has been erratic in the United States, and it is only within the past few years that these minerals have been mined in any quantity. This is due to the small demand for lithium carbonate, which is the principal compound of lithium that is sold. The production for 1901 is stated by the United States Geological Survey to have been 1,750 tons, valued at $43,200. According to the same authority, 440 tons were mined in 1900 in San Diego county, Cal., and probably between 75 and 100 tons were obtained elsewhere for experimental purposes.

The following table is a summary of the industry for 1902:

Table 1.—*Summary: 1902.*

Number of mines or quarries	3
Number of operators	3
Salaried officials, clerks, etc.:	
Number	1
Salaries	$600
Wage-earners:	
Average number	6
Wages	$3,744
Miscellaneous expenses	$200
Cost of supplies and materials	$1,265
Product:	
Quantity, short tons	1,245
Value	$25,750

Detailed statistics by states can not be published without disclosing the business of individual establishments, 2 of which were located in California and 1 in South Dakota. One mine, in South Dakota, was idle. Of the 3 operators 2 were individuals and 1 was a firm.

Employees and wages.—Of the total amount, $4,344, paid in salaries and wages, $3,744, or 86.2 per cent, was paid to the wage-earners. There were 2 wage-earners on the average to a mine. The yearly average number of wage-earners employed was 6, the greatest average number, as shown by Table 2, being 23 for July and August, and the least, 5 for September. Four of the 6 miners, or 66.7 per cent of the total, received from $1.75 to $1.99 per day.

Production.—The production of lithium minerals in the United States during 1902 was 1,245 short tons, valued at $25,750. The world's annual production of lithium carbonate, which is the principal salt used, has been variously estimated at from 50,000 to 150,000 pounds. Most of this is manufactured in Germany, and a large proportion of the lithium minerals mined in the United States have been shipped to Germany, being returned in the form of lithium carbonate, quoted in New York at $1.35 per pound; the minerals are worth about $20 per ton f. o. b. at point of shipment. A small amount of ore has been treated at some of the chemical manufacturing plants in New Jersey, but thus far they have been unable to make it a profitable proposition. A company in New York, which controls the larger proportion of the deposits of lithium minerals in San Diego county, Cal., expects to erect a plant on the Pacific coast for the manufacture of lithium salts from their own ores.

If the estimate of 55,000 pounds of lithium salts, reported as the annual consumption in the United States, is correct, over one-third of this amount is imported. To produce this amount of lithium salts would require 371 tons of mineral containing at least 3 per cent of lithia (Li_2O); this indicates the relatively small amount of lithium minerals required to supply the home consumption of lithium salts.

Occurrence and uses.—The minerals which have been sources of lithium salts are lepidolite and spodumene, which contain from 4 to 7.6 per cent of lithia (Li_2O). There is another mineral, amblygonite, which has recently been found in quantity and will very probably be mined as a source of lithium salts. The first two minerals are silicates of aluminum and lithium, while the amblygonite is a phosphate of aluminum and lithium with varying percentages of the other alkalies.

Lepidolite has been the chief source of lithia, although theoretically spodumene contains a considerably higher percentage of lithia. Two of the mines in 1902 produced lepidolite and 1 spodumene, the value of the lepidolite constituting over 70 per cent of the total value of the product shown.

The principal occurrences of lepidolite in the United States are in the vicinity of Pala, San Diego county, Cal. Although it has been known for some years that lepidolite deposits occurred there, it was not until about 1899 that any special work began, and regular shipments were not made until the following year. Lepidolite has also been found in some quantity at Hebron, Auburn, Rumford, and Paris, Me., but thus far no work has been done especially for this mineral at any of these places. The mining has been confined to tourmaline, which is found associated with it. In some cases the lepidolite has been separated and a few barrels shipped.

Spodumene has been found in quantity at Branchville, Conn., where it occurs in a pegmatitic dike in crystals, often of very large size, and in the Black Hills of South Dakota. The latter locality is the most noted one commercially and is probably the only one from which spodumene has been shipped as a source of lithium salts. In South Dakota the mineral occurs in pegmatitic dikes, which were formerly worked for tin.

The only locality where amblygonite has been reported to occur in sufficient quantity to make it a possible commercial source of lithium salts is near Pala, Cal., where it has been found associated with lepidolite.

Although only a few large deposits of these lithium minerals are known in the United States, it is not at all improbable that if the demand for them should increase to any considerable extent other deposits in quantity would be found; but, on account of the present comparatively small demand for the minerals, there is now practically no incentive for investigation.

The demand for lithium minerals is not large, for the reason that the uses of the salts of lithium are very limited; it is these salts that are used in the arts, and not the metal itself. The principal use of the salts is in the preparation of mineral waters and effervescing lithia tablets used for medicinal purposes. Another use that might be made of lithium carbonate and of lithium nitrate, if the price could be reduced sufficiently, is in pyrotechnics for red fire, for which purposes strontium salts are now used.

The following table is a detailed summary of the lithium industry for 1902:

TABLE 2.—*Detailed summary: 1902.*

Number of mines or quarries	3
Number of operators	[1]3
Character of ownership:	
Individual	2
Firm	1
Salaried officials, clerks, etc. (superintendents):	
Number	1
Salaries	$600
Wage-earners (miners or quarrymen):	
Average number	6
Wages	$3,744
Average number of wage-earners at specified daily rates of pay (miners or quarrymen):	
$1 to $1.24	1
$1.75 to $1.99	4
$3.25 to $3.49	1
Average number of wage-earners employed during each month:	
Men 16 years and over—	
June	21
July	23
August	23
September	5
Miscellaneous expenses:	
Total (rent of offices, taxes, insurance, interest, etc.)	$200
Cost of supplies and materials	$1,265
Product:	
Quantity, short tons	1,245
Value	$25,750

[1] Includes 2 operators in California and 1 in South Dakota.

MARL

MARL.

By Story B. Ladd.

The statistics of marl presented herewith relate to the marl product mined and used as a fertilizer, and are confined to the greensand deposits found in New Jersey, Delaware, Maryland, and Virginia. At the Tenth Census no statistics in regard to marl were published. At the Eleventh Census the total production of marl in the United States for the year 1889, was 139,522 short tons, valued at $63,956. The production was limited to five states, viz, New Jersey, Virginia, North Carolina, Alabama, and Arkansas. In four of the states the production was very small, New Jersey alone producing 99 per cent of the total.

During the period 1889 to 1902 there was a very extensive development in the manufacture of Portland cement from the marls of Michigan, Indiana, Ohio, and New York, in the lake region, resulting in a consumption of over a million cubic yards of the material, but as this was all manufactured into cement it is considered in connection with the statistics for cement.

Table 1 is a summary of the statistics for the marl industry as reported for the year 1902:

Table 1.—*Summary: 1902.*

Number of mines or quarries	11
Number of operators	11
Salaried officials, clerks, etc.:	
Number	2
Salaries	$2,100
Wage-earners:	
Average number	13
Wages	$4,769
Miscellaneous expenses	$1,407
Cost of supplies and materials	$2,755
Product:	
Quantity, short tons	12,439
Value	$12,741

Of the 11 mines or quarries for which production was reported, 10 were in New Jersey and 1 was in Virginia. The Virginia mine was in Prince George county and the New Jersey mines were distributed as follows: 1 in Burlington county, 1 in Gloucester county, and 8 in Monmouth county. One hundred and four properties reported to the United States Geological Survey as in operation in 1901 were idle during 1902. All of these were in the state of New Jersey, and were distributed as follows: Burlington county, 52; Camden county, 1; Gloucester county, 2; Monmouth county, 48; and Salem county, 1. As but 1 producer outside the state of New Jersey reported in 1902, the statistics are presented for the United States as a whole.

Capital stock of incorporated companies.—Of the 11 producers, 2 were incorporated companies—1 in New Jersey and 1 in Virginia—but neither was engaged exclusively in mining. Their authorized capitalization consisted of 5,380 shares of common stock, of a par value of $67,300. All of the stock was issued but no dividends were paid on it.

Employees and wages.—But 1 producer reported salaried employees; these were 1 superintendent and 1 clerk. The small number of wage-earners employed—13 by the 11 producers—shows that the work was done largely by the owners themselves. The work is all above ground, being mere excavation. Only one establishment reported the employment of power, with 2 employees classed under "engineers, firemen, and other mechanics." Of the total amount, $6,869, paid for salaries and wages by the 11 producers, the sum of $4,769, or 69.4 per cent, was paid to the 13 wage-earners, and $2,100, or 30.6 per cent, to the 2 salaried employees.

The variation in the number of wage-earners employed at different seasons of the year is shown by Table 3, which gives the average number of men and boys, respectively, employed during each month. The small number of wage-earners reported for each month will not warrant any deductions. It may be said, however, that more laborers find employment late in the autumn and early in the spring, when the farming operations of the proprietors are practically suspended. Thus the range in 1902 was from 10 wage-earners during January and February and during the summer to 17 in November.

In addition to asking the average number of employees and the total amount paid as wages, the schedule called for the number of wage-earners employed at the specified daily rates of pay, and these statistics are also shown in Table 3. The excavation of marl requires no skill and the rates of pay should not be compared with those paid in other mining industries requiring skill and experience. Thirty-eight and four-tenths per cent received less than $1 per day; 30.8 per cent, from $1 to $1.24; and 30.8 per cent, from $1.50 to $1.74.

Supplies, materials, and miscellaneous expenses.—The total amount expended for supplies and materials was $2,755. Most of this is chargeable against 4,267 tons of marl dried and ground. The amounts chargeable against the 8,172 tons of crude marl reported is less than 3 cents per ton. The total amount reported for miscellaneous expenses, $1,407, is also for the most part expense chargeable to the treated product. It was paid for "rent of offices, taxes, insurance, interest, and other sundries," and no expense was reported for "royalties and rent of mine and mining plant." Of the 11 producers, 7 reported no expense for supplies and materials, and 8, no miscellaneous expenses.

Production.—The United States Geological Survey publishes statistics concerning the quantity and value of the marl product of the country produced each year, and Table 2 shows the totals for each year since 1880 and the average price per ton.

TABLE 2.—*Production of marl: 1880 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (short tons).	Value.	Average value per ton.
1880	1,000,000	$500,000	$0.50
1881	1,000,000	500,000	0.50
1882	1,080,000	540,000	0.50
1883	972,000	486,000	0.50
1884	875,000	437,500	0.50
1885	875,000	437,500	0.50
1886	800,000	400,000	0.50
1887	600,000	300,000	0.50
1888	300,000	150,000	0.50
1889	139,522	63,956	0.46
1890	153,620	69,880	0.45
1891	135,000	67,500	0.50
1892	125,000	65,000	0.52
1893	75,000	40,000	0.53
1894	75,000	40,000	0.53
1895	60,000	30,000	0.50
1896	60,000	30,000	0.50
1897	60,000	30,000	0.50
1898	60,000	30,000	0.50
1899	60,000	30,000	0.50
1900	60,000	30,000	0.50
1901	[1] 99,880	124,880	1.25
1902	[1] 12,439	12,741	1.02

[1] Includes crude and manufactured products.

The production for 1902 was 12,439 tons, valued at $12,741. Crude marl contributed 8,172 short tons, and the remaining 4,267 tons were treated by drying and grinding. The former was valued at $4,865 and the latter at $7,876. This shows an average value of $1.02 per ton for both crude and treated marl. The average value per ton for crude marl used as a fertilizer without previous treatment was $0.595; the average for the treated product was $1.845.

The detailed statistics of the marl industry for 1902 are given in Table 3.

DESCRIPTIVE.

Marl in a general sense is a mixture of calcium carbonate and clay, occurring naturally with more or less siliceous sand. It is sometimes compact and sometimes pulverulent, and there is a wide range in the character of the material to which the term is applied in different localities. The term "greensand" is given to marl having a green color, because of the presence of grains of green silicate of iron. Most of the varieties of marl found in the United States conform to the general definition, and have calcium carbonate as their principal constituent. The cretaceous marls of New Jersey, as a rule, contain lime in small and variable amounts, and also considerable potash and phosphoric acid. The fertilizing value is due chiefly to these last two constituents. Potash constitutes from 3.5 per cent to 7 per cent, and phosphoric acid from 1.25 per cent to 9 per cent of the whole. The marls of New Jersey have long been used; in some years very extensively.

Marl improves both the chemical and physical conditions of the soil, neutralizing acidity, making available plant food otherwise insoluble, and promoting nitrification. It is very lasting in its effects, and has been used from ancient times for restoring worn-out and improving barren lands. On account of its bulkiness and the large amounts required to secure beneficial results, marl can be used profitably only in close proximity to the deposits. Mr. James C. Booth, in a report of the geological survey of Delaware for 1841, recommends the use of from 60 to 100 bushels per acre on light soils and from 100 to 200 bushels on clay soils, and states that from 200 to 500 bushels may be used on soils of good quality abundantly supplied with humus. The addition of 10 per cent of quicklime to the marl quickens its action.

TABLE 3.—*Detailed summary: 1902.*

Number of mines or quarries	11
Number of operators	11
Character of ownership:	
Individual	9
Incorporated company	2
Salaried officials, clerks, etc.:	
Total number	2
Total salaries	$2,100
Superintendents, managers, foremen, surveyors, etc.—	
Number	1
Salaries	$1,800
Clerks—	
Number	1
Salaries	$300
Wage-earners:	
Total average number, above ground	13
Total wages	$4,769
Engineers, firemen, and other mechanics—	
Average number	2
Wages	$750
Miners or quarrymen—	
Average number	10
Wages	$3,919
Boys under 16 years—	
Average number	1
Wages	$100
Average number of wage-earners at specified daily rates of pay:	
Engineers, $1.50 to $1.74	1
Firemen, $1 to $1.24	1
Miners or quarrymen—	
$0.75 to $0.99	4
$1 to $1.24	3
$1.50 to $1.74	3
Boys under 16 years—	
Less than $0.50	1
Average number of wage-earners employed during each month:	
Men 16 years and over—	
January	10
February	10
March	16
April	10
May	10
June	10
July	11
August	11
September	11
October	15
November	17
December	13
Boys under 16 years—	
January	1
February	1
March	1
April	1
May	1
June	1
July	1
August	1
September	1
October	1
November	1
December	1
Miscellaneous expenses:	
Rent of offices, taxes, insurance, interest, and other sundries	$1,407
Cost of supplies and materials	$2,755
Product:	
Total quantity, short tons	12,439
Total value	$12,741
Crude—	
Quantity	8,172
Value	$4,865
Dried and ground—	
Quantity	4,267
Value	$7,876
Power owned:	
Total horsepower	50
Engines, steam—	
Number	1
Horsepower	50

MICA

MICA.

By Joseph Hyde Pratt.

The mica industry has probably seen as much variation in value and quantity of product as any other of the nonmetallic mineral industries.

In Table 1 is given a comparative summary of the statistics from 1870 to 1902.

Table 1.—*Comparative summary: 1870 to 1902.*

	1902	1889	1880	1870
Number of mines	49	4	22	(1)
Number of operators	38	(1)	(1)	[2] 1
Salaried officials, clerks, etc.:				
Number	21	(3)	(3)	(3)
Salaries	$13,444	(3)	(3)	(3)
Wage-earners:				
Average number	98	185	272	24
Wages	$44,043	$42,174	$65,600	$5,000
Miscellaneous expenses	$12,914	$8,753	(1)	(1)
Cost of supplies and materials	$11,961	$7,408	$6,110	$85
Value of product	$118,849	$52,450	$127,825	$7,000

[1] Not reported. [2] Establishment. [3] Not reported separately.

The 49 mines reported in operation during 1902 were located in the following states: North Carolina, 28; California, 10; South Dakota, 3; Maine, 2; New Hampshire, 2; Virginia, 2; Georgia, 1; and New Mexico, 1. Of the 38 operators, 26 were in North Carolina, 3 in South Dakota, 2 each in Maine, New Hampshire, and Virginia, and 1 each in California, Georgia, and New Mexico. Of these operators, 18 were individuals, 11 were firms, and 9 were incorporated companies. North Carolina was the main producer of mica in the United States; in 1902 the value of its production was 59.8 per cent of the total.

The total amount of salaries and wages paid in 1902 was $15,313 more than the amount reported for 1889 and $8,113 less than at the census of 1880. The production reported in 1902 was 373,266 pounds of cut or sheet, 1,028 short tons of scrap or waste, and 372 short tons rough as mined. This production of sheet mica is about five times that reported in 1880 and nearly eight times that for 1889; but the total value, $118,849, of all the mica produced in 1902, although much more than that shown for 1870, is $8,976 less than the value of the production reported at the census of 1880. This is due in part to the somewhat higher prices received in 1880, and also to the very large quantity of small disks and sheets cut in 1902 for electrical purposes.

The decrease of $75,375 in value between 1880 and 1889 reflects the decrease in production and fall in price caused by the large amount of mica imported from India. The reporting of 196 tons of scrap or waste in 1889 indicates the beginning of the use of mica in the manufacture of wall papers, lubricants, etc.

The principal changes in the mica industry, since the census of 1890, have resulted from the utilization of the scrap mica, which was formerly thrown away as valueless, and the cutting of large quantities of small disks, 1 inch in diameter, and small sheets 1 by $1\frac{1}{2}$ inches and 1 by 2 inches, for electrical purposes. This waste having become of value it is possible to work properties which would otherwise be unprofitable. Many new uses for both sheet and scrap mica have been devised during the past few years, so that although there has been a very large falling off in the amount of sheet used in stoves (which was formerly the principal use of mica) the quantity of all mica used has greatly increased.

The mines that were idle in 1902 number 36, of which 14 were in North Carolina, 5 each in New Hampshire and Idaho, 3 in New Mexico, 2 each in Alabama and South Dakota, and 1 each in Georgia, Nevada, Ohio, Pennsylvania, and Vermont. They were owned by 34 operators, of whom 21 were individuals, 7 were firms, 5 were incorporated companies, and 1 was a cooperative association. The authorized capital stock of the 5 incorporated companies was $1,100,000, of which shares to the value of $229,500 were issued. The assessment levied amounted to $1,600.

Capital stock of incorporated companies.—Table 2 gives the details of the capitalization of the 9 incorporated companies operating productive mines.

Table 2.—*Capitalization of incorporated companies: 1902.*

	United States.	North Carolina.	South Dakota.	All other states.[1]
Number of incorporated companies	9	3	2	4
Number reporting capitalization	8	2	2	4
Capital stock (all common):				
Total authorized—				
Number of shares	5,302,000	501,000	3,500,000	1,301,000
Par value	$5,450,000	$550,000	$3,500,000	$1,400,000
Total issued—				
Number of shares	3,150,348	50,100	1,908,248	1,192,000
Par value	$3,254,248	$55,000	$1,908,248	$1,291,000

[1] Includes companies distributed as follows: California, 1; Georgia, 1; Maine, 1; New Hampshire, 1.

Of the authorized capital stock, all of which was common, 59.7 per cent had been issued. South Dakota reported 64.2 per cent of the whole amount authorized and 58.6 per cent of the amount issued.

Employees and wages.—The total number of employees reported for the mica industry in 1902 was 119, comprising 21 salaried employees and an average during the year of 98 wage-earners. They received in salaries and wages $57,487, of which amount $13,444, or 23.4 per cent, was paid out in salaries and $44,043, or 76.6 per cent, was paid out in wages.

The month in which the greatest number of wage-earners was engaged, as shown in Table 6, was August, when the number amounted to 112; the lowest was in January, with 75. The falling off during the winter months of January, February, and March was in "all other states." It is interesting to note that there were no wage-earners under 16 years of age employed.

The average number of wage-earners at specified daily rates of pay is also given in Table 6. The wages received varied from 75 cents to $3.74 per day, the most usual rate, however, being from $1 to $1.24. There were 62 wage-earners whose wages were less than $1.25 per day, and of these 49 were classified as miners. These low wages are accounted for by the fact that most of the mining was carried on in North Carolina, where there is a low scale of wages. The miners in the Western states command higher wages as indicated by the fact that the 12 miners who were reported to have received from $2.50 to $2.74 per day were employed in western mines.

Of the 98 wage-earners, 81 worked above ground and only 17 below ground, indicating that most of the mica mining was done in shallow pits and cuts. It was not extensive enough to require much underground work. The number of wage-earners classified as miners was 70. Of these 58 worked above ground and 12 below ground. One foreman was reported employed below ground; therefore, the total number of underground miners was 13, and of underground employees 18.

Supplies, materials, and miscellaneous expenses.—The total cost of supplies and materials and miscellaneous expenses, reported at the census of 1902 for the mica mining industry was $24,875, of which $11,961 was paid for supplies and materials required in mining the mica; $3,142 for roy lties and rent of mines and mining plants; and $9,772 for rent of offices, taxes, insurance, and other sundries.

Mechanical power.—The total horsepower utilized in the mica industry was 201, generated by 8 steam engines with 160 horsepower; 1 gasoline engine with 25 horsepower; and 1 electric motor of 16 horsepower. Of this amount, only 10 horsepower, generated by 1 steam engine, was used in North Carolina.

Production.—The production of mica in 1902 consisted of 373,266 pounds of cut, sheet, or plate, valued at $83,843; of 1,028 short tons of scrap or waste, valued at $13,081; and 372 tons rough as mined, valued at $21,925, making the value of the total production $118,849. The 372 tons of mica rough as mined would yield approximately 150,000 pounds of cut, leaving 297 tons of scrap.

The large increase in the production of sheet mica during the past few years has been accompanied by a large decrease in the production of scrap mica. This decrease is accounted for by the fact that most of the scrap mica now produced is that obtained as waste in the present mining or cutting of the sheet mica, where formerly a very large percentage put on the market was obtained from old dumps from former mining. In the following table is shown the annual production of mica in the United States since 1889, these figures having been published by the United States Geological Survey:

TABLE 3.—*Production of mica: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Total value.	CUT OR SHEET.		SCRAP OR WASTE.		ROUGH AS MINED.	
		Quantity (pounds).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1889	$50,000	49,500	$50,000	(1)	(1)	(1)	(1)
1890	75,000	60,000	75,000	(1)	(1)	(1)	(1)
1891	100,000	75,000	100,000	(1)	(1)	(1)	(1)
1892	100,000	75,000	100,000	(1)	(1)	(1)	(1)
1893	88,929	51,111	[2] 88,929	156	(3)	(1)	(1)
1894	52,388	35,943	[2] 52,388	191	(3)	(1)	(1)
1895	55,881	44,325	[2] 55,881	148	(3)	(1)	(1)
1896	67,191	49,156	65,441	222	$1,750	(1)	(1)
1897	95,226	82,676	80,774	740	14,452	(1)	(1)
1898	131,098	129,520	103,534	3,999	27,564	(1)	(1)
1899	121,465	108,570	70,587	1,505	50,878	(1)	(1)
1900	147,960	456,283	92,758	5,497	55,202	(1)	(1)
1901	118,578	360,060	98,859	2,171	19,719	(1)	(1)
1902	118,849	373,266	83,843	1,028	13,081	372	$21,925

[1] Not given.
[2] Includes value of scrap.
[3] Included with value of cut or sheet.

For comparison, Tables 4 and 5, taken from the published reports of the United States Geological Survey, are given to show the value of imports of mica since 1880; Table 4 gives the value of imports from 1880 to 1896, and Table 5, the quantity and value from 1897 to 1902.

TABLE 4.—*Value of unmanufactured mica imported and entered for consumption in the United States: 1880 to 1896.*

YEAR ENDING—	Value.	YEAR ENDING—	Value.
June 30—		December 31—	
1880	$12,562	1888	[1] $57,541
1881	5,889	1889	[1] 97,351
1882	5,175	1890	[1] 207,375
1883	9,884	1891	95,242
1884	28,284	1892	218,938
1885	28,685	1893	147,927
December 31—		1894	126,184
1886	[1] 56,254	1895	174,886
1887	[1] 49,085	1896	169,085

[1] Including mica waste.

On July 24, 1897, a new classification of imports of mica was adopted, showing "unmanufactured" and "cut or trimmed." The imports are given in Table 5.

TABLE 5.—*Mica imported and entered for consumption: 1897 to 1902.*

YEAR.	Quantity (pounds).	Value.	YEAR.	Quantity (pounds).	Value.
1897.			1900.		
Prior to July 24....	656,118	$140,353	Unmanufactured.	1,892,000	$290,872
After July 24:			Cut or trimmed...	64,391	28,688
Unmanufactured	66,821	10,981			
Cut or trimmed..	226,771	41,068	Total	1,956,391	319,560
Total	949,710	192,402	1901.		
1898.			Unmanufactured.	1,598,722	299,065
			Cut or trimmed...	78,843	85,989
Unmanufactured..	877,930	115,930			
Cut or trimmed....	78,567	34,152	Total	1,677,565	385,054
Total	956,497	150,082	1902.		
1899.			Unmanufactured.	2,149,557	419,362
			Cut or trimmed...	102,299	46,970
Unmanufactured..	1,709,839	233,446			
Cut or trimmed....	67,293	42,538	Total	2,251,856	466,332
Total	1,777,132	275,984			

As is shown in the above table, the imports for mica for 1902 amounted to 2,251,856 pounds, valued at $466,332, which is an increase over the importation of 1901 of 574,291 pounds, valued at $131,278. The main point to be noticed, however, is that this increase is greater than the total value of the production of mica in the United States during 1902, showing that the increasing demand for mica in this country is being supplied largely by foreign countries.

The relatively small production of mica in the United States as compared with the importation can be accounted for partially by the low prices maintained for plate mica, by the uncertainty of the occurrence of mica in the veins, and by the large number of small producers each depending upon one small mine. When the mica in the mines of these small producers begins to give out or becomes poor, they do not have the means to carry the necessary amount of "dead" work. The importation of mica from Canada and India at a low valuation tends also to curtail the production of mica in the United States because of the influence it has on the prices of the mica produced at home. This is especially true of the mica imported from India, which can be mined and landed in this country at a price lower than the cost of production at some of the mines in the United States.

The detailed statistics of the industry for 1902 are given in Table 6.

DESCRIPTIVE.

Occurrence and use.—Mica, in some form or other, is probably familiar to everybody because it is so very widely distributed in nature, being a component part of many of the crystalline and sedimentary rocks. Its commercial value is dependent upon its occurrence in blocks or masses that are capable of being split into sheets a square inch or more in size. Deposits of commercial mica occur for the most part in pegmatitic dikes or veins which are found in granite and hornblende and mica gneisses or schists. These dikes or veins vary in thickness from a few inches to several hundred feet and are often very irregular, having arms or veinlets branching off in many directions. In character, these dikes are similar to granite, and sometimes they are called "coarse granite," and if we could conceive of the constituents of granite being magnified a hundred times or more we would have an appearance similar to a pegmatitic dike.

The mica in these pegmatitic dikes will seldom average over 10 per cent of the contents of the dike and sometimes will be as low as 1 per cent. Often a dike will have the appearance of containing a very high percentage of mica on account of a number of blocks being clustered together in bunches almost touching each other, while in another portion of this same dike the mica will be almost entirely absent for a distance of from 5 to 20 feet; thus the general average of mica in the dike will be from 1 to 10 per cent only. Of the mica obtained from these dikes, usually only from 5 to 25 per cent can be cut into sheet or plate mica. The average is probably about 10 per cent. Occasionally large quantities of mica are mined in which there is not over 1 per cent that can be made into sheet mica. These commercial occurrences of mica are not very abundantly distributed throughout the United States, although rocks in which mica is one of the chief constituents are very common. At the present time deposits of commercial value are known to occur in Alabama, Arizona, California, Colorado, Connecticut, Georgia, Idaho, Maine, Missouri, Nevada, New Hampshire, New Mexico, New York, North Carolina, Rhode Island, South Carolina, South Dakota, Vermont, Virginia, and Wyoming; and in Arkansas there are also deposits which may become of commercial importance. In most of these states the deposits were not worked in 1902. In some of them the deposits were not available on account of their distance from railroads, this being especially true of those in Arizona, Colorado, Nevada, New Mexico, and Wyoming. In others little has been done owing to the uncertainty of the price and the demand. Many of the deposits of Maine have only recently been opened, and therefore have not been extensively developed.

Mica was first produced in the Eastern states along the Appalachian mountains, and twenty years ago mining was carried on vigorously in Connecticut, New Hampshire, North Carolina, and Virginia. In the eastern field the principal mining is in North Carolina, which, since the beginning of the mica industry in the United States, has been the chief producer of the mineral. At just what time the first work was done on the mica deposits of North Carolina is uncertain, and since there is no record of the old mining and none of the inhabitants of this section have any information whatever regarding these old workings, they have been attributed to the Indians. Trees 2 feet and over in diameter have been observed growing from these cuts. Stone implements have been found in some of the old tunnels, indicating the antiquity of these workings. Most of these old mines are located in Mitchell and Yancey counties.

Of the North Central states, South Dakota has been and still is the state in which the largest quantity of mica is produced; while of the Western states and territories, New Mexico has for a number of years been the largest producer, but is now likely to have to give way to California. These California deposits have only been opened up within the past few years, but the mining is now being carried on quite extensively. At the present time the Nevada deposits are too isolated to warrant mining on an extensive scale. The completion, however, of the railroad, which is being constructed from California across Nevada and Arizona to Utah, will make these deposits more available for commercial purposes.

The uses of mica are somewhat varied; there are two forms in which it is used, (1) sheet or plate mica and (2) scrap mica.

Sheet or plate mica.—Mica is cut into sheets of various sizes which are used for stoves, lamp chimneys, incandescent lights, and in electrical apparatus for insulation purposes. While the use of this sheet mica for stoves has decreased very rapidly during the past ten years, there has been a corresponding increase in its use for electrical apparatus. It is also used in place of glass in the manufacture of a great many novelties and in many respects increases the usefulness of the articles made. There was formerly a considerable demand for the larger sheets of mica, but these have been replaced to some extent at the present time by a manufactured product known as micanite, which is made from very small, perfect pieces of mica rearranged and cemented together into larger sheets. For some purposes these manufactured sheets are as satisfactory as the natural ones and are, of course, much cheaper.

The value of sheet or plate mica varies with the size of the sheet and is from 2 cents to $8 per pound. The values of from 2 to 5 cents per pound are for the small disks and rectangular sheets that are cut by machinery and are used extensively in electrical apparatus. The larger sheets are cut by hand and considerable skill is required to cut the largest pattern possible from the crude block of mica.

Scrap mica.—The waste or scrap mica not suitable for cutting into sheets of even the smallest size has a value when ground to a flour, which is used in the manufacture of wall papers, lubricants, fireproofing material, artificial snow, novelties, etc. Coverings for boiler tubes and steam pipes are also manufactured from particles of scrap mica which are not ground but are broken into pieces of approximately the same general dimensions, one-half by one-fourth of an inch. These are then arranged with their longer dimension and face parallel to the length of a wire net coil, pressed into the shape of a pipe or tube, against which the layer of scrap mica is kept tightly in place by means of heavy canvas. A number of the states, especially North Carolina, offer very favorable locations for the erection of plants to manufacture products from scrap mica, as there is usually a supply of available water-power near the deposits.

The commercial value of scrap mica before it is ground is from $8 to $10 per ton, delivered at the railroad, and it is this value that has made it possible to work some of the mines that otherwise would have been shut down, for in some cases this waste mica represents from 75 to 95 per cent of the mica mined. After being ground, the mica is worth from $40 to $60 per ton, according to its mesh.

There are a number of minerals, especially quartz and feldspar, associated with the mica, which in some instances should prove of considerable commercial value as by-products in mining the mica, provided water-power for grinding these minerals can be secured near the source of supply. Occasionally some of the gem minerals, as beryl and tourmaline, are found associated with the mica, and furnish some very handsome cut stones. Some of the pegmatitic mica-bearing dikes are rich in the variety of minerals that they contain, while others have very few besides those typical of a pegmatitic dike. Between forty-five and fifty different minerals have been found associated with mica at the different mines throughout the country.

The small production of mica in the United States as compared with the importation is not due to a deficiency in the supply of the mineral in this country. It is undoubtedly true that in the Appalachian region, especially in the southern area, there are many good deposits of mica yet to be discovered which will yield as rich returns as many of those that have already been mined. It is also true that many of the mines that were worked so extensively twenty years ago, especially those in North Carolina, still contain good deposits of mica which the former owners were prevented from taking out on account of the presence of water, which they were unable to control with the means that they had at hand. Any increase in the duty on mica or any considerable decrease in the importation of mica from India and Canada would cause an increase in the price of mica, and would result undoubtedly in a large and immediate increase in its production in the United States.

TABLE 6.—DETAILED SUMMARY: 1902.

	United States.	North Carolina.	South Dakota.	All other states and territories.[1]
Number of mines	49	28	3	18
Number of operators	38	26	3	9
Character of ownership:				
Individual	18	15	1	2
Firm	11	8		3
Incorporated company	9	3	2	4
Salaried officials, clerks, etc.:				
Total number	21	4	9	8
Total salaries	$13,444	$1,411	$9,580	$2,453
General officers—				
Number	6		5	1
Salaries	$4,300		$4,000	$300
Superintendents, managers, foremen, surveyors, etc.—				
Number	12	3	2	7
Salaries	$7,314	$961	$4,200	$2,153
Foremen below ground—				
Number	1	1		
Salaries	$450	$450		
Clerks—				
Number	2		2	
Salaries	$1,380		$1,380	
Wage-earners:				
Aggregate average number	98	50	22	26
Aggregate wages	$44,043	$15,160	$18,288	$10,595
Above ground—				
Total average number	81	38	19	24
Total wages	$37,523	$11,728	$15,900	$9,895
Engineers, firemen, and other mechanics—				
Average number	12	5	3	4
Wages	$6,673	$1,524	$3,540	$1,609
Miners or quarrymen—				
Average number	58	28	12	18
Wages	$25,312	$8,692	$9,000	$7,620
All other wage-earners—				
Average number	11	5	4	2
Wages	$5,538	$1,512	$3,360	$666
Below ground—				
Total average number	17	12	3	2
Total wages	$6,520	$3,432	$2,388	$700
Miners—				
Average number	12	9	1	2
Wages	$4,600	$2,592	$1,308	$700
Miners' helpers—				
Average number	3	2	1	
Wages	$1,280	$560	$720	
All other wage-earners—				
Average number	2	1	1	
Wages	$640	$280	$360	
Average number of wage-earners at specified daily rates of pay:				
Engineers—				
$1.00 to $1.24	2	2		
$1.25 to $1.49	1			1
$1.50 to $1.74	1			1
$3.00 to $3.24	1		1	
Firemen—				
$0.75 to $0.99	1	1		
Machinists, blacksmiths, carpenters, and other mechanics—				
$0.75 to $0.99	1	1		
$1.25 to $1.49	1	1		
$1.50 to $1.74	1			1
$2.00 to $2.24	1			1
$3.50 to $3.74	2		2	
Average number of wage-earners at specified daily rates of pay—Continued.				
Miners or quarrymen—				
$0.75 to $0.99	8	7		1
$1.00 to $1.24	41	29		12
$1.25 to $1.49	2			2
$1.50 to $1.74	3	1		2
$2.00 to $2.24	3			3
$2.50 to $2.74	12		12	
$3.00 to $3.24	1		1	
Miners' helpers—				
$0.75 to $0.99	2	2		
$3.00 to $3.24	1		1	
All other wage-earners—				
$0.75 to $0.99	4	4		
$1.00 to $1.24	3	2		1
$1.25 to $1.49	1			1
$2.50 to $2.74	4		4	
$3.00 to $3.24	1		1	
Average number of wage-earners employed during each month:				
Men 16 years and over—				
January	75	43	28	4
February	76	44	28	4
March	78	44	28	6
April	101	45	28	28
May	98	50	19	29
June	106	53	20	33
July	108	57	20	31
August	112	54	20	38
September	108	55	18	35
October	105	48	19	38
November	104	53	18	33
December	105	54	18	33
Miscellaneous expenses:				
Total	$12,914	$2,952	$7,406	$2,556
Royalties and rent of mine and mining plant	$3,142	$2,592		$550
Rent of offices, taxes, insurance, interest, and other sundries	$9,772	$360	$7,406	$2,006
Cost of supplies and materials	$11,961	$3,121	$4,579	$4,261
Product:				
Total value	$118,849	$71,148	$18,450	$29,251
Cut or sheet mica—				
Quantity, pounds	373,266	303,816	6,000	63,450
Value	$83,843	$65,419	$1,200	$17,224
Scrap or waste mica—				
Quantity, short tons	1,028	545		483
Value	$13,081	$4,729		$8,352
Rough, as mined—				
Quantity, short tons	372	10	205	157
Value	$21,925	$1,000	$17,250	$3,675
Power owned:				
Total horsepower	185	10	115	60
Engines—				
Steam—				
Number	8	1	3	4
Horsepower	160	10	115	35
Gas or gasoline—				
Number	1			1
Horsepower	25			25
Electric motors—				
Number	1		1	
Horsepower	16		16	

[1] Includes operators distributed as follows: California, 1 (10 mines); Georgia, 1; Maine, 2; New Hampshire, 2; New Mexico, 1; and Virginia, 2.

MONAZITE

MONAZITE.

By Joseph Hyde Pratt.

There is no mention of the monazite industry in any previous census report, for the reason that the production of this mineral for commercial purposes did not really begin until 1893. As early as 1879 the existence of monazite in commercial quantities in North Carolina was proved by W. E. Hidden, but it was not until 1887 that the first shipment was made. During that year 12 tons of monazite sand from the Brindletown district, in Burke county, N. C., were shipped for experimental purposes, and in the following two years, 1888 and 1889, a few tons were shipped to a northern company. The statistics for 1902 are summarized in the following table:

Table 1.—*Summary: 1902.*

Number of mines	23
Number of operators	22
Salaried officials, clerks, etc.:	
Number	3
Salaries	$2,100
Wage-earners:	
Average number	88
Wages	$25,318
Miscellaneous expenses	$2,083
Cost of supplies and materials	$256
Product:	
Quantity, pounds	802,000
Value	$64,160

One mine in North Carolina was reported idle during 1902. The industry is one of placer mining and is irregularly carried on in many instances, the expenses of some of the producers being advanced by the operators of a concentrating plant. It was deemed inadvisable to obtain separate statistics for these three or four hundred small and irregular miners. Over half the quantity of monazite produced during 1902 is credited to them. This is accounted for in the report of the concentrating plant which purchased the mineral, the miners selling monazite to such plant being included in its return as employees engaged in mining by the pound, and the total amount paid for the mineral being given as their wages. The number of these irregular contract miners was reduced to 65—the number computed to have been working 300 days during the year—and is included in the statistics here presented.

The number of placer deposits or mines for which statistics were received at the census of 1902 was 23. Of the 22 operators working these mines, 20 were individuals, 1 was a firm, and 1 an incorporated company. The incorporated company had a total authorized capital stock of $500,000, divided into 10,000 shares, of which 20 shares, with a total par value of $1,000, had been issued.

Employees and wages.—Of the total amount, $27,418, reported as paid for salaries and wages, $25,318, or 92.3 per cent, was paid to the wage-earners and $2,100, or 7.7 per cent, to the salaried employees. On an average, there were 3.8 wage-earners to a mine. The average number of wage-earners by months and their daily rates of pay by occupations are given in Table 3. The maximum, 130, was reached in August and the minimum, 20, in November and December. Of the 88 wage-earners, 86 were classed as miners. Of these, 73 received from $1 to $1.24 per day, and 13 from 75 to 99 cents.

Supplies, materials, and miscellaneous expenses.—Only $256 were reported to have been expended for supplies and materials. Next to the amount paid for wages that for miscellaneous expenses, $2,083, is the largest. Of this $1,739, or 83.5 per cent, was paid for royalties and rent of mine and mining plant.

Mechanical power.—Of the 22 operators only 1 reported power. This was a firm in North Carolina, which owned 2 steam engines with a total of 30 horsepower.

Production.—The United States Geological Survey has published annual statistics of the production of monazite, beginning with 1893. These statistics, together with the average value per pound, are shown for each year in the following table:

Table 2.—*Production of monazite: 1893 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (pounds).	Value.	Average value per pound.
1893	130,000	$7,600	$0.058
1894	546,855	36,193	0.066
1895	1,573,000	137,150	0.087
1896	30,000	1,500	0.05
1897	44,000	1,980	0.045
1898	250,776	13,542	0.054
1899	350,000	20,000	0.057
1900	908,000	48,805	0.054
1901	748,736	59,262	0.079
1902	802,000	64,160	0.08

The total quantity produced during the ten years was 5,383,367 pounds, an average of 538,337 pounds per year. By far the largest quantity was produced in 1895, the next largest in 1900, and the third largest in 1902. The average price during the ten years was 7¼ cents per pound.

The value of monazite has varied from 25 cents per pound, the price received for the production of 1887, to 3 cents per pound received for the less pure sand sold by the small producers who were able to eliminate only a small percentage of the heavy minerals. At the present time the sand mined by the small producer is sold to the concentrators and is paid for on the basis of its value after it has been concentrated as thoroughly as possible, so that during the past year or two the price reported by these small producers has increased from 4 cents per pound for crude sand to 8 or 9 cents per pound for the refined product.

The entire production reported at the census of 1902 is credited to North Carolina. Since the beginning of the industry monazite has been produced chiefly in North Carolina, although at first a considerable quantity was obtained from Spartanburg county, South Carolina.

The production of monazite in commercial quantities became a well established industry in 1893, the output for that year being 130,000 pounds, valued at $7,600; during the next two years the production increased very rapidly, until, in 1895, it amounted to 1,573,000 pounds, valued at $137,150, or about 9 cents per pound. It was at this time that the Brazilian deposits of monazite, which occur in large quantity as beach sands along the seashore in the extreme southern part of the province of Bahia, began to be worked on a considerable scale; the production in the United States was affected thereby to such an extent that by the end of 1896 it had decreased to 30,000 pounds. In 1898 there was again a considerable demand for North Carolina monazite, and the production amounted in that year to 250,776 pounds, valued at $13,542. Since that time the production of this mineral has increased, and at the census of 1902 it was 802,000 pounds, valued at $64,160. It sometimes happens that while the quantity of monazite sand produced in a particular year is more than that for the year following, the value of the production of the latter year is considerably more than that of the former, because of the higher percentage of monazite obtained by a more thorough cleaning of the sand.

The monazite industry is steadily increasing, and there is now a considerable demand for this mineral, not only in this country but also abroad. During 1902 a German company was organized and bought up monazite lands in North Carolina. This company has erected the most complete concentrating plant in the district. Its production is to be shipped abroad.

DESCRIPTIVE.

Occurrence.—The commercial deposits of monazite do not occur in the original rocks, which are granitic mica gneisses and hornblende gneisses, and contain only a fraction of a per cent of this mineral; they are found in the placers of the present streams and rivers, and in the old sand and gravel deposits of former streams. As these gneisses are constantly being decomposed and disintegrated, the monazite is continually being washed down and deposited so that in many cases the top soils form workable deposits for monazite sand. The area in which these deposits are located is in Burke, Cleveland, McDowell, Polk, and Rutherford counties, N. C., and in the northern part of Spartanburg and York counties, S. C. They are found along the following streams: Silver, South Muddy, and North Muddy creeks, and Henry and Jacob forks of the Catawba river, in Burke and McDowell counties; the Second Broad river and its tributaries in McDowell and Rutherford counties; and the Broad river and its tributaries in Cleveland and Rutherford counties, N. C., and Spartanburg and York counties, S. C. All these streams have their sources in the South mountains of North Carolina.

Process of cleaning.—The value of monazite sand is dependent principally upon the oxide of thorium, and to a less extent on the oxides of cerium, lanthanum, and didymium. As the thorium oxide or thoria contents are due to the presence of the mineral monazite, the nearer to a pure monazite that the sand can be cleaned, the higher the percentage of thoria. Formerly a sand containing from 65 to 70 per cent of monazite was considered of very good quality; now, with improved machinery and new methods a sand can be obtained that is over 95 per cent monazite. In washing the sands, the lighter material is readily floated off, but magnetite, menaccanite (or ilmenite), rutile, brookite, garnet, zircon, etc., remain with the monazite. The magnetic minerals, such as magnetite and menaccanite are then removed. Formerly the other minerals could be only partially eliminated, but now, with the improved electro-magnetic separator, the other iron minerals are readily picked out; the final operation is the picking up of the monazite grains, leaving the zircon, corundum, etc. In this way an almost pure monazite concentrate is obtained.

Uses.—The principal use of the oxides of thorium, lanthanum, and didymium is in the manufacture of the cylindrical hoods of the Welsbach and other incandescent gas lights. Small quantities of the cerium oxalate obtained during the process of separating the other oxides are used in pharmacy.

Table 3 is a detailed summary of the monazite industry for 1902.

TABLE 3.—DETAILED SUMMARY: 1902.

Number of mines	23
Number of operators	[1]22
Character of ownership:	
Individual	20
Firm	1
Incorporated company	1
Salaried officials, clerks, etc.:	
Total number (superintendents, managers, foremen, surveyors, etc.)	3
Total salaries	$2,100
Wage-earners:	
Total average number	88
Total wages	$25,318
Miners—	
Average number	86
Wages	$24,728
All other wage-earners—	
Average number	2
Wages	$590
Average number of wage-earners at specified daily rates of pay:	
Miners—	
$0.75 to $0.99	13
$1.00 to $1.24	73
All other wage-earners—	
$0.75 to $0.99	1
$1.00 to $1.24	1
Average number of wage-earners employed during each month:	
Men 16 years and over—	
January	27
February	29
March	108
April	118
May	126
June	119
July	127
August	130
September	119
October	113
November	20
December	20
Miscellaneous expenses:	
Total	$2,083
Royalties and rent of mine and mining plant	$1,739
Rent of offices, taxes, insurance, interest, and other sundries	$344
Cost of supplies and materials	$256
Product:	
Quantity, pounds	802,000
Value	$64,160
Power owned:	
Total horsepower	30
Engines—	
Steam—	
Number	2
Horsepower	30

[1] Operators all in North Carolina.

PRECIOUS STONES

30223—04——66

PRECIOUS STONES.

By George F. Kunz.

In the United States precious stones have been generally found by accident; in prospecting for, operating, or developing mines of other minerals; or in the working of gravels containing gold, monazite, etc. With the exception of the figures relating to the number of operators and the value of production, the statistics herewith presented are for properties operated by companies which carry on the search for stones with some approach to regularity. These companies produce sapphire, tourmaline, beryl, chrysoprase, opal, and turquoise. In addition to these, certain quantities of emerald, peridot, several varieties of quartz, such as rock crystal, smoky, rose, gold, and rutilated quartz, amethyst, agate and moss agate, and silicified wood; also garnet (pyrope and rhodonite), amazon stone, chlorastrolite, mesolite, pyrite, anthracite, and catlinite, were produced in this country during 1902, but not on a large scale, nor under conditions suitable to serve as a basis for statistical treatment.

In discussing this subject, consideration of the peculiar condition under which production is carried on, and of the noncommercial uses of the product, is of importance. No comparison of the returns in 1902 with those of the Eleventh Census is practicable, owing to the different methods by which these reports were made up. Moreover, it is difficult to present any careful analysis of the figures, and the results necessarily are uncertain. The data in Table 1 are based upon trustworthy information derived from the operators.

The value of the turquoise produced amounted to $130,000, or 39.6 per cent of the whole, and of sapphire, $115,000, or 35 per cent. Much of the production of precious stones was more or less accidental, picked up by prospectors for other minerals, or by excursionists along the beaches. This fact will explain the apparent inconsistency between the small number of mines and the large number of operators reported. It will be readily understood that in such cases no items of expense are properly chargeable. The statistics following, with the exception noted above, are for those companies actively engaged in the systematic exploitation of precious stone deposits. The peculiar condition existing, however, should not be lost sight of.

There were 3 mines, 1 each in California, New Mexico, and North Carolina, reported idle during 1902.

Table 1.—*Summary: 1902.*

Number of mines or quarries	46
Number of operators	460
Salaried officials, clerks, etc.:	
Number	22
Salaries	$28,687
Wage-earners:	
Average number	108
Wages	$88,017
Miscellaneous expenses	$7,481
Cost of supplies and materials	$17,781
Value of product	$328,450

Capital stock of incorporated companies.—Of the 460 operators reported, 449 are classified as individuals, 1 as a firm, and 10 as incorporated companies. Three of the individuals only, however, are miners of precious stones in the strict sense of the word. Of the 10 incorporated companies 1 is located in Arizona, 3 in California, 2 in Montana, 3 in New Mexico, and 1 in North Carolina. The following table shows the details of their capitalization:

Table 2.—CAPITALIZATION OF INCORPORATED COMPANIES: 1902.

	United States.	Arizona.	California.	Montana.	New Mexico.	North Carolina.
Number of incorporated companies	10	1	3	2	3	1
Capital stock issued (all common)	$1,562,078	$85,000	$600,078	$400,000	$452,000	$25,000
Total authorized:						
Number of shares	1,461,400	100,000	508,500	400,000	450,400	2,500
Par value	$2,129,000	$100,000	$1,152,000	$400,000	$452,000	$25,000
Total issued:						
Number of shares	1,042,978	85,000	105,078	400,000	450,400	2,500
Par value	$1,562,078	$85,000	$600,078	$400,000	$452,000	$25,000
Dividends paid	$20,000			$20,000		

No bonds or preferred stock appear to have been issued by these companies. Of the 1,461,400 shares of common stock authorized, there were 1,042,978 shares issued.

Employees and wages.—Of the $116,704 reported as paid for salaries and wages, $28,687, or 24.6 per cent, was paid to salaried employees, and $88,017, or 75.4 per cent, to wage-earners. In Table 4 is given the average number of wage-earners employed each month during the year. One hundred and forty-one men were given employment during June, while in March only 87 were reported. The average number for the year was 108. Table 4 shows also the average number of wage-earners at specified daily rates of pay. There were 79 wage-earners, or 73.1 per cent of the whole number, classed as miners. Of these, 61, or 77.2 per cent, received $2 or more per day, and only 18, or 22.8 per cent, less than that amount. Of the total number of employees, 82, or 75.9 per cent, received $2 or more per day, and 26, or 24.1 per cent, less than $2. Four machinists, or other mechanics, were employed, as were also 5 miners' helpers, and 20 employees doing miscellaneous work. All the miners' helpers earned from $3 to $3.24 per day.

Supplies, materials, and miscellaneous expenses.—Next to wages, the principal item of expense was for supplies and materials, for which $17,781 was expended. Of the $7,481 reported as miscellaneous expenses, $437 was for rents and royalties of mining plants, and $7,044 for office rent, taxes, insurance, and other sundries.

The yearly production of precious stones by kinds and value, as reported by the United States Geological Survey, is given in Table 3.

TABLE 3.—PRODUCTION OF PRECIOUS STONES IN THE UNITED STATES: 1896 TO 1902.

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

STONE.	1896	1897	1898	1899	1900	1901	1902
Total	$97,850	$130,675	$160,920	$185,770	$233,170	$289,050	$328,450
Diamond	None.	None.	None.	300	150	100	None.
Sapphire	10,000	25,000	55,000	68,000	75,000	90,000	115,000
Ruby	1,000	None.	2,000	3,000	3,000	500	None.
Topaz	200	None.	100	None.	None.	None.	None.
Beryl (aquamarine, etc.)	700	1,500	2,200	4,000	11,000	5,000	4,000
Emerald	None.	25	50	50	4,000	1,000	1,000
Tourmaline	3,000	9,125	4,000	2,000	2,500	15,000	30,000
Peridot	500	500	500	500	500	500	500
Quartz, crystal	7,000	12,000	17,000	12,000	10,000	10,000	12,000
Smoky quartz	2,500	1,000	1,000	None.	1,000	1,000	2,000
Rose quartz	500	None.	100	100	100	150	200
Amethyst	500	200	250	250	500	500	2,000
Prase	100	None.	None.	None.	None.	None.	None.
Gold quartz	10,000	5,000	5,000	500	2,000	2,000	3,000
Rutilated quartz	500	None.	100	50	50	50	100
Dumortierite in quartz	50	None.	None.	None.	None.	None.	None.
Tourmalinated quartz	None.	None.	None.	None.	None.	1,000	None.
Agate	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Moss agate	1,000	1,000	1,000	1,000	1,000	500	500
Chrysoprase	600	None.	100	100	100	1,500	5,000
Silicified wood (silicified and opalized)	4,000	2,000	2,000	3,000	6,000	7,000	7,000
Opal	200	200	200	None.	None.	None.	150
Garnet (almandite)	500	7,000	5,000	5,000	500	100	None.
Garnet (rhodonite)	None.	None.	None.	None.	20,000	21,000	1,500
Garnet (pyrope)	2,000	2,000	2,000	2,000	1,000	1,000	1,000
Garnet (topazolite)	100	None.	None.	None.	None.	None.	None.
Amazon stone	1,000	500	500	250	250	200	500
Oligoclase	500	25	10	20	20	None.	None.
Moonstone	250	None.	None.	None.	None.	None.	None.
Turquoise	40,000	55,000	50,000	72,000	82,000	118,000	130,000
Utahite (compact variscite)	500	100	100	100	100	250	None.
Chlorastrolite	500	500	5,000	3,000	3,000	3,000	4,000
Mesolite (thomsonite, so called)	500	500	1,000	1,000	1,000	1,000	1,000
Prehnite	100	100	100	50	50	None.	None.
Diopside	200	100	None.	None.	None.	None.	None.
Epidote	250	None.	None.	None.	None.	None.	None.
Pyrite	1,000	1,000	1,000	1,000	2,000	3,000	3,000
Malachite	None.	None.	None.	250	200	100	None.
Rutile	100	800	110	200	100	None.	None.
Anthracite (ornaments)	2,000	1,000	1,000	2,000	2,000	2,000	2,000
Catlinite (pipestone)	3,000	2,000	2,000	2,000	2,000	2,000	2,000
Fossil coral	1,000	500	500	50	50	100	None.
Arrow points	1,000	1,000	1,000	1,000	1,000	500	None.

A detailed summary of the statistics for the mining of precious stones in the United States during 1902, where the operations were followed on a commercial basis and warranted statistical treatment, is given in Table 4.

DESCRIPTIVE.

Precious stones derive their value chiefly from their rarity. Other qualities that influence their value are beauty of color, hardness, and the caprice of fashion. Under this classification a distinction could be made between precious and semiprecious stones, but it is not observed in this discussion. Precious stones include the diamond, the sapphire, the ruby, and the emerald; semiprecious stones include a wide variety of other gem minerals. The opal and the pearl are sometimes classed as precious stones, although the latter is not strictly a mineral product. In ordinary speech the precious or semiprecious stone signifies a gem cut or polished for ornamental purposes. In mineralogy the term is used to designate a class of minerals of sufficient hardness to scratch quartz, which are without metallic luster, although generally brilliant and beautiful. In archaeology the term is restricted to engraved stones, such as intaglios and cameos. A jewel is a gem that has been mounted.

In the report of the Eleventh Census upon "Mineral Industries," page 669ff, an account is given of the occurrence and production of precious stones in this country during the year 1889. The present discussion treats only of the discovery and production of precious stones in the United States since that time.

Diamond.—The diamond, the hardest of known substances, is pure carbon, which crystallizes in the isometric system, generally in an octahedral form. Its specific gravity is 3.525. It occurs in a great variety of colors, ranging through all the shades of the spectrum, occurring most frequently as white, yellow, or brown, and rarely as red, rose-red, blue, or green. By far the greatest number of diamonds come from South Africa, but they are found also in Brazil, India, Borneo, and occasionally in North America.

In the United States diamonds have been found at various points, but they have been few in number, and mostly of small size. Their occasional occurrence in California and east of the southern Alleghanies has been known for fifty years. Since 1890 a few others have been found in these regions, and some in the Northwestern states, varying from one-third of a carat to 21 carats in weight.

The northwestern diamonds are very interesting as being contained in the deposits of the glacial drift, scattered along an irregular line of some 600 miles, from Wisconsin to the vicinity of Cincinnati, Ohio. All the material distributed by this ancient glacial action has been brought down from the north, and therefore the source of these diamonds is somewhere in the unexplored regions of Canada and not in the United States. Geologists recognize two distinct drift deposits in the Western states, called the older or Illinoian drift, and the later or Wisconsin drift. Some of the diamonds found in Indiana and in Wisconsin are referred to one of these drifts and some to the other, though most of them belong to the later. The whole number of diamonds actually known from these glacial deposits amounts to about 25, over half of which are from Wisconsin and one-third from Indiana.

The localities of discovery during the period since 1890 are as follows:

Alabama.—Shelby county, one of $4\frac{1}{2}$ carats. Lee county, one of 3 carats.

California.—A number of localities, chiefly in the central portion of the state, in connection with the hydraulic gold washings of Amador, Butte, Eldorado, and Nevada counties. A single diamond is reported from Tulare county, and a number of very small ones in the gold sands of streams in Del Norte and Trinity counties. No large stones have been found in California, and nowhere are they abundant enough to lead to any mining for them. Nevertheless some handsome ones have been casually obtained in the central counties above named, chiefly in the ancient gold-bearing gravels overlaid by lava flows, and fragments of diamonds crushed by the stamp mills are not uncommon in the flumes and sluices. Most of the stones found within recent years have come from the vicinity of Placerville, Eldorado county.

Indiana.—Brown county, five—one of 2 carats, others very small. Morgan county, three—one of $3\frac{3}{4}$ carats, others very small.

Kentucky.—Cabin Fork creek, Russell county, one.

Michigan.—Dowagiac, Cass county, one of $10\frac{7}{8}$ carats.

Ohio.—Milford, Clermont county, one of 6 carats.

Tennessee.—Koko creek, Tellico river, Monroe county, several reported. Union Crossroads, Roane county, one of 3 carats. Luttrell, Union county, one of $1\frac{13}{16}$ carats.

Wisconsin.—Plum creek, Rock Elm township, Pierce county, several very small stones. Oregon, Dane county, one of $3\frac{13}{16}$ carats. Kohlsville, Washington county, one of 21 carats. Saukville, Ozaukee county, one of $6\frac{3}{8}$ carats. Eagle, Waukesha county, one of $15\frac{13}{32}$ carats. Burlington, Racine county, one of $2\frac{1}{16}$ carats.

The whole subject of the Indiana occurrence is fully described by the state geologist, Prof. W. S. Blatchley,[1] in his annual report for 1902. The geological features of the region are first treated with special reference to the distribution of the drift deposits in central Indiana. These have been known since 1850 to contain gold, and a large amount of local prospecting and panning has been carried on along the streams for years. The gold is found associated with magnetic iron sand, menaccanite, and other heavy minerals. It is in these auriferous sands that diamonds have been found at intervals for some twenty-five years, but especially of late. Some of the diamonds belong certainly in the second, or later, drift, like most of those in Wisconsin; others found south of that line but within the margin of the older drift belong, perhaps, to the older deposits instead of having been washed out from the later beds and carried south by streams, as formerly supposed. The terms "earlier" and "later" are now frequently replaced by "Illinoian" and "Wisconsin," and designate the two glacial drifts, but these terms may be misconceived as to their geographical signification and hence require explanation. The center of ice movement in the glacial era was determined some years ago by Canadian geologists as having traveled or shifted toward the east from the west. Of the two ice invasions that spread over the northern United States, the earlier is called by some geologists the "Illinoian," as having covered a large part of that state not reached by the later one; while the name "Wisconsin" is applied to the later by Prof. T. C. Chamberlin, because it extended westward to a portion of that state not covered by the earlier, and formed there what he terms the Wisconsin boundary, although its source was far east of the earlier drift, and it forms the main deposit of the Eastern states.

Professor Blatchley's list comprises eight diamonds that he himself has seen, and seven more of which he has credible information. The earliest published mention of the occurrence of diamonds in Indiana was made by the late Prof. E. T. Cox, state geologist, in his annual report for 1878, page 116, although the well-known artist, Mr. Daniel Beard, of New York, owns a

[1] Gold and Diamonds in Indiana, by W. S. Blatchley. Twenty-seventh Annual Report of the Department of Geology and Natural Resources of Indiana, Indianapolis, 1902.

fine diamond of about 2 carats found in Indiana before that year.[1] Professor Cox mentions several diamonds, of which this may be one, as found in the drift of Brown and Morgan counties, and refers to them with interest because of their evident transportation from a far northern source. Of the eight stones seen by Professor Blatchley, four are from the newer and four from the older drift, or at least from the area covered by it south of the margin of the newer. The list in detail is as follows:

1. The Stanley diamond, found in 1900, by Calvin Stanley, while panning for gold in Morgan county, on a branch of Gold creek, 3 miles northwest of Centerton, and 3 miles west of Brooklyn. It was found in the bed of the stream at the base of a cliff of shale. The stone was an octahedron weighing $4\frac{7}{8}$ carats, with a yellow tinge and a small black spot. It was purchased first by Mr. R. L. Royse, of Martinsville, Ind., and by him sold to C. E. Nordyke, of Indianapolis, who had it cut into two stones in Cincinnati. These have a peculiar greenish yellow tint, and weigh respectively $1\frac{1}{8}$ and $1\frac{1}{16}$ carats.

2. The Young diamond, found by a local gold hunter, Mr. W. W. Young, in 1898, on Lick creek in Brown county, $4\frac{1}{2}$ miles south of Morgantown. It is an oblong dodecahedron of $1\frac{21}{32}$ carats, white with a yellow cast, and very clear and flawless. It is retained by the finder.

3. An elongated hexoctahedron, of pink color, but only one-eighth of a carat in weight. It was found, like the last, on Lick creek, by Mr. John Merriman, and now belongs to Mr. Nordyke, of Indianapolis.

4. A yellow hexoctahedron of three-sixteenths of a carat, found by Mr. Merriman on Lick creek. It is now owned by Mr. Royse.

5. A light brownish yellow hexoctahedron of five thirty-seconds of a carat, found and owned by Mr. Royse.

6. A bluish rhombic dodecahedron, weighing eleven-sixteenths of a carat, found by Mr. Merriman on Gold creek, Morgan county, now also belonging to Mr. Royse.

7 and 8. These are pinkish crystals, neither of which exceeds one-eighth of a carat, found in May, 1903, by Mr. Royse. They were taken from the tailings of sluice boxes on the farm of Doctor Cook, near Brey, in Morgan county.

The first, and the last three, from Morgan county, are from the newer or Wisconsin drift, the others, from Brown county, are from the older or Illinoian area.

Sapphires and rubies.—The sapphire, ruby, oriental topaz, oriental amethyst, and oriental emerald are names given respectively to the transparent blue, red, yellow, purple, and green varieties of corundum, which is nearly pure alumina, Al_2O_3. The colors of these minerals are ascribed to the presence of minute quantities of metallic oxides. Their specific gravity ranges from 3.97 to 4.05, and their hardness is 9. Rubies are found in Burma, Ceylon, and Siam. Sapphire also occurs in those countries, as well as at the Simla pass in the Himalayas, and in Australia.

The great hardness of corundum gives it a special value for polishing purposes, and the amount produced for such uses during 1902 has been treated under "Abrasive materials." Although corundum is found in the crystalline rocks along the Appalachian mountains from Massachusetts to northern Georgia, few gems of any special value have been found, except in the Cowee valley in North Carolina, where true rubies are obtained to some extent, although mining has ceased for a few years past.

Other deposits in which these gems are found exist in Montana. Sapphires of the finest quality are now mined in Yogo gulch, and others of much beauty are found at other points in the same state.

Until within a few years, these gems had been found only occasionally in the United States—nearly all of them in North Carolina—and were principally cut from small transparent portions of the colored corundums that were otherwise more or less opaque. Corundum is mined in that state extensively as an abrasive material, and ruby and sapphire are simply transparent varieties of it. The Montana gems began to attract notice about 1869, and for some years they were collected abundantly from the bars of the upper Missouri east of Helena; these were of varied and often beautiful tints of pink, blue, green, and intervening shades, but rarely of the deep colors in favor for jewelry. The latter, the rich blue sapphires equal to those of India, have since been found at Yogo gulch, in Fergus county, and active work in mining them from the rock has been carried on for several years by the New Mine Sapphire Syndicate and the Burke and Sweeney Company. Two other important localities in Montana are at Rock creek, in Granite county, and Dry Cottonwood creek, in Deerlodge county, worked by the American Gem Syndicate Company. The former of these yields a wonderful variety of colors, often very beautiful, but few that have the deep shades most valued in the gem market. No locality in the world has shown such variety of tints in sapphires—pink, reddish brown, brown, yellow, green, etc., with occasionally a ruby of the paler type of Ceylon. Gems of considerable value have been annually mined at Yogo gulch for several years past. Fine sapphires of the "cornflower" and "velvet" blue of the best oriental stones have been obtained, weighing as much as 3 carats, and a few as high as 5 and even 7 carats, after cutting. Besides those used for setting, large quantities of small ones from both these localities have found ready sale for watch jewels and bearings; indeed, more have been sold for this purpose than for gems.

[1] This diamond, from facts that Mr. Beard has given the writer, must have been found as early as 1826.

True rubies have been found, and to some extent mined, in the Cowee valley, Macon county, N. C. Some of them have the rich and peculiar "pigeon's-blood" color of the finest rubies from Burma, but the crystals are small or imperfect, and the yield thus far has been quite limited. The operations were conducted by the American Prospecting and Mining Company.

Emerald.—True emeralds, suitable for cutting and setting, can hardly be said to be found in the United States. It is true that large and very fine crystals of emerald were obtained at Stonypoint, Alexander county, N. C., in 1877; but these, although valuable and beautiful as specimens, were not clear enough to cut into gems. More recently a locality has been opened at Crabtree, Haywood county, in the same state, where small and handsome emerald crystals, both translucent and opaque, occur thickly in the white feldspar and quartz of a vein of pegmatite (coarse feldspathic granite). This green and white mixture is very pleasing, and as the three minerals have nearly the same degree of hardness, the whole can be cut and polished together, making a novel and beautiful ornamental stone. Pieces are cut *en cabochon*, i. e., rounded, not faceted, showing sections of the emerald crystals in different directions in the white mass. This material has been introduced into ornamental and minor jewel work under the name of "emerald matrix," by the American Gem Company.

Beryl.—Beryl is essentially the same mineral as emerald, though of paler shades and much less esteemed. Fine transparent beryls, however, are choice gem stones, and several varieties of them are found in the United States. Among these are emerald beryls, of rich light-green shades; aquamarines, faintly tinged with green; golden beryls, of a rich yellow; blue beryls, sometimes almost as beautiful as pale sapphires; and rose beryls, of light-pink color. Some very fine gems have been cut from crystals of these kinds, especially from Topsham, Me., in the quarries of the Trenton Flint and Spar Company. Other fine gems come from Connecticut, North Carolina, and Colorado. In North Carolina, near Sprucepine post office, many fine beryls—some of the richest blue color ever found—have been mined by the American Gem Company. The finest and largest aquamarine known is from Stoneham, Me. Golden beryls of much beauty have been cut from material mined at Merryall, in Litchfield county, Conn. Green and blue beryls have been found in North Carolina, and aquamarines at Mt. Antero, Colo. The discoveries of fine gem material are, however, not frequent nor in large amount, so that there is no systematic mining or regular production.

Topaz.—Topaz is a fluosilicate of alumina and crystallizes in rhombic prisms with a hardness of 8. The true topaz occurs but sparingly in the United States, although here and there it has been found fine enough to yield choice cut gems. Still, as with many other gem minerals, there is no locality that furnishes any steady supply. Within recent years a few white topazes have been obtained at the Stoneham, Me., and Chatham, N. H., localities; also at Cheyenne mountain, Pikes Peak, and at Nathrop, Colo. They are generally sherry-colored at the former localities, in crystals weighing up to 3 ounces each; at Nathrop in smaller brilliant crystals.

Very recently a number of topaz crystals have been obtained near Ramona, San Diego county, Cal. The crystals vary from quite small ones of great brilliancy up to 1 or 2 inches long and half that diameter. Most of them are perfectly colorless, but some have the pale blue or greenish blue of the topazes from Sarapulka, in the Urals. The larger crystals are somewhat dull externally, but almost all are clear within and would cut into handsome gems.

Garnet.—The name garnet is used for a well-defined group of minerals very closely related in both chemical and physical properties. They are complex silicates of alumina, with varying amounts of lime, magnesia, iron, manganese, and other metallic oxides, which, by their presence in different proportions and combinations, impart various colors to the compound. All the garnets crystallize in the isometric system. Several of the varieties are richly colored, and when transparent are favorite gem stones, though not of the highest value.

The kinds chiefly used in jewelry are those known as precious garnet, or almandine, Bohemian garnet, or pyrope, and manganese garnet, or spessartite. The two former present deep crimson shades, and the latter is of an orange-red or light red-brown color. These are all found in the United States, but there is no regular production, save to some extent of pyrope, in Arizona and New Mexico, and of a beautiful light purple-red garnet known as rhodonite, an intermediate variety between pyrope and almandine, in Macon county, N. C. This latter is among the discoveries of the last decade, having attracted attention and been more or less mined since 1897, and the stones produced have been cut and sold as rather novel American gems. The locality is in the Cowee valley, where the ruby corundums before alluded to have been found. The garnets occur chiefly in the valley of Mason's branch, a small stream flowing from Lisle Knob, a spur of the Cowee mountains. All are found in rather small pieces, but their color is a beautiful light red, and their luster when cut is remarkably brilliant. They were at first taken for almandine, and so reported, but analysis shows that their composition lies between that variety and pyrope, and hence they were given the separate name of rhodonite (from the Greek *rhodon*, a rose). In the years 1900 and 1901 the output of these garnets amounted to $20,000 and $21,000, respectively. It has since fallen off somewhat, but work is actively carried on, and large pieces have been obtained, up to 43 and even 59 carats.

Pyrope garnets of fine quality are found in several localities in New Mexico and Arizona, and are frequently miscalled Arizona rubies. The principal locality in New Mexico is on the Navajo Indian reservation, and the finest large specimen from there is the property of Mr. W. T. Kaufman, of Marquette, Mich. It is more than half an inch in diameter, weighs 11⅛ carats, and has a magnificent red color, equal to any garnet that the writer has seen from any locality. They are also found at some places in northern Arizona, and one of the finest, from near Fort Defiance, was figured by the writer several years ago.[1] They occur loose in the soil, on or near the surface, and are gathered by Indians, soldiers, and cowboys, principally from around ant hills and scorpion holes, where they are brought up and thrown out by the insects. Their source is doubtless in peridotite rocks, from which they are weathered out in the decomposition of the outcrops. In the years since 1896 the annual sales have been estimated at from $1,000 to $2,000.

Spessartite (manganese garnet) was found in magnificent specimens twenty years ago in the albite mine at Amelia Court House, Va., and splendid gems were cut from these. But unfortunately the mine has been closed and abandoned for years past, and one of the finest localities for American gems has thus ceased yielding. Very recently beautiful crystals have been found at Ramona, in San Diego county, Cal. Some are 15 millimeters in diameter or more, of a rich orange-brown color, and the smaller crystals exceedingly clear and brilliant. This may prove to be a source of choice gem material, although as yet the amount of it present has not been ascertained.

Many other varieties of garnet are known to exist in various parts of the country, and some gems have been cut from them at times, but there is no regular production. Several kinds are reported in Tulare county, Cal., and one of great rarity and beauty at Carrville, Trinity county, in the same state. This is the emerald-green chrome garnet, known as uvarovite, which furnishes beautiful gems when in crystals of any size. This was reported in 1900 as found in small crystals, lining cavities in chrome iron, very richly colored and brilliant, but none of the crystals was more than 3 millimeters in diameter, and no further exploration seems to have been made since.

Tourmaline.—Tourmaline belongs to the rhombohedral system of crystallization, occurring in prisms, the sides of which are generally striated and channeled. The transparent variety is of a hardness of 7.5, its specific gravity ranges from 3 to 3.25, and in composition it is a very complex silicate of alumina. Many different colors are found, ranging all the way from a colorless variety through red, green, blue, and brown, to black. These differences in color are chiefly due to the varying amounts of manganese and iron present. The gem is dichroitic; thus when viewed through the side it may be a transparent green, but either opaque or yellow-green when viewed endwise of the prism.

Tourmaline was but little known in jewelry ten years ago, although some very beautiful gems had been cut from the transparent red, green, and blue crystals obtained at Paris Hill, Me., and Haddam Neck, Conn. Some mining had been done at these places, and many splendid specimens obtained. But within a few years past, wonderful discoveries of gem tourmaline have been made in southern California, at Pala and Mesa Grande, in San Diego county, and in the San Jacinto mountains in Riverside county. The crystals found at these localities are of great size and beauty, and gems have been cut from them in abundance. A single collection of these crystals has been valued at $10,000. The prevailing colors are pink, salmon, and red, all in very rich shades, also fine green and blue, though less frequently in these colors than those found at Mt. Mica and other localities near Paris, Me. Tourmaline is peculiar in that it often presents two or three different and even contrasting colors in the same crystal, which sometimes shade into each other, but often present a sharp line of contact. Advantage has been taken of this feature, which is marked in the California crystals, to produce in jewelry the novelty of parti-colored gems. Beautiful cut stones may now be seen that are half red and half green, or showing other similar contrasts. Many of the larger stones are somewhat flawed; these are often cut *en cabochon* (rounded), and many also as oriental beads. Some present a fibrous texture, and on cutting yield a cat's-eye effect. Many of the larger and less pure pieces have been cut into regular forms for ecclesiastical and other art work. Remarkable crystals possessing the cat's-eye properties have been found at the mine of the Himalaya Mining Company, at Mesa Grande, California.

There are two mines at Pala, Cal., owned by the Pala Lithia Company, one of which yields beautiful specimens of rather small and opaque pink tourmaline crystals, in radiated groups, in lilac lepidolite (lithia mica), none of which, however, is suitable for gem material. The mine is worked for the lepidolite, as a source of lithia compounds, and specimens find a ready sale to collectors and museums. The other mine, which has only recently been discovered, carries large and splendid crystals of tourmaline of mingled colors, and also a new gem named Kunzite, a transparent lilac spodumene.

[1] Gems and Precious Stones of North America, 1892, Plate III, fig. A.

The localities of Mesa Grande and San Jacinto, which have been furnishing beautiful tourmaline adapted for use as gems, have been steadily worked for several years. Meanwhile, tourmaline is coming to be generally known and esteemed in jewelry as it never has been before.

The entire output of tourmaline in the country is estimated in the reports of the United States Geological Survey as amounting to $15,000 in 1901 and to $30,000 in 1902.

Kunzite (*lilac spodumene*).—Reference has been made above, under tourmaline, to the discovery of this new and interesting gem stone at Pala, Cal. This locality is remarkable for its lithia compounds, among which are the colored tourmalines and the spodumene, both of which contain lithia in small amounts, combined with silica, alumina, and other oxides.

The mineral spodumene is usually obtained in large, opaque, whitish crystals, but from time to time small specimens, often richly colored and transparent, are found. The three characteristic varieties of the latter are a clear yellow gem spodumene from Brazil,[1] the green "hiddenite" or "lithia emerald" of North Carolina,[2] and small lilac specimens sometimes found in Connecticut.[3] These last are without doubt remnants of large crystals, which must have been very beautiful. Spodumene is particularly subject to alteration, and when found has usually lost all its transparency and beauty of tint.

Large and magnificent crystals of unaltered spodumene, of rich lilac color, have now been discovered near Pala, San Diego county, Cal., in connection with other lithia minerals.[4] This locality has yielded crystals measuring 10 by 20 by 4 centimeters, perfectly clear, of a rose-lilac tint, varying with the spodumene dichroism from a very pale color when looked at across the prism to a rich amethystine hue observed longitudinally. No such spodumene has ever been seen before, and the discovery is of great mineralogical interest. The crystals have been etched by weathering like the hiddenite variety. When cut and mounted parallel to the base, they furnish gems of great beauty, entirely new in jewelry, and make a notable addition to American gem stones.

An extended investigation into certain optical properties of the gem minerals in the Tiffany-Morgan and Bement collections in the American Museum of Natural History, New York, was conducted jointly by the writer and Prof. Charles Baskerville, of the University of North Carolina, during the autumn of 1903. These experiments developed marked and interesting peculiarities of the new mineral.[5] Doctor Baskerville says of it in the American Journal of Science, July, 1904:

> I have submitted large crystals to the action of ultraviolet light with very positive continued phosphorescence. When submitted to bombardment of the Roentgen rays of high penetration for several minutes, a fluorescence is observed, and on removal to a dark chamber it exhibits a persistent, white luminosity not observed with this class of minerals, as learned by experiments with altered and unaltered spodumene from the localities mentioned, including cut stones and such handsome crystals of hiddenite as afforded by the collections mentioned. I have been able to excite a crystal (2 by 4 by 10 centimeters) by the action of the X rays for five minutes sufficiently to cause it to photograph itself when subsequently placed directly upon a sensitive plate (thin white paper being interposed) and allowed to remain in an especially constructed padded black box in a dark room for a period of ten minutes. The material is penetrated by the rays, as shown by a cathodegraph. The excitation is not superficial, but persists throughout the mass.

Doctor Baskerville submitted crystals to the action of emanations of radium bromide, 300,000 activity, especially imported from the Société Centrale des Produits Chimiques at Paris. After a few minutes' exposure the mineral began to glow, and its phosphorescence was most pronounced after the removal of the radio-active body. A five-minute exposure to 125 milligrams of radium bromide caused 600 grams of the gem material to become luminescent in the dark after removal of the radium preparations. This remarkable property was not exhibited by hiddenite or any other specimens of spodumene examined. Doctor Baskerville proposed for it the name of "Kunzite."

Californite.—Californite (vesuvianite)[6] a mineral which promises to be a notable addition to the increasing list of semiprecious or ornamental stones found in the United States, has recently been discovered in California. This is not a new mineral species, properly, but a compact massive variety of vesuvianite (idocrase). It was first announced in the report of the United States Geological Survey for 1901,[7] by the writer, as having been found by Dr. A. E. Heighway, on the South Fork of Indian creek, 12 miles from Happy Camp and 90 miles

[1] Pisani, Comptes Rendus, 1877, Vol. 84, page 1509.

[2] J. L. Smith, American Journal of Science, 1881, Vol. 21, page 128.

[3] Penfield, American Journal of Science, 1880, Vol. 20, page 259.

[4] American Journal of Science, September, 1903.

[5] The following articles treat of the new mineral:
Science, Vol. XVI, August 28, 1903. On a New Lilac-Colored Spodumene from Pala, Cal. By George Frederick Kunz.
The American Journal of Science, Vol. XVI, pages 264 to 267, September, 1903. A New Lilac-Colored Spodumene from Pala, Cal. By George Frederick Kunz.
Science, N. S., Vol. 18, pages 303, 304, September 4, 1903. Kunzite; a New Gem. By Charles Baskerville.
Ed. note American Journal of Science, Vol. XVI, page 335, October, 1903. The Lilac-Colored Spodumene (Kunzite) from California.
Private reprint on Kunzite, October, 1903. Remarks on Action of Radium on Kunzite. By Sir William Crookes.
Separate reprint from Report, "Mineral Resources of the United States," United States Geological Survey, 1903, pages 53, 54. Spodumene var Kunzite. By George Frederick Kunz.

[6] New York Academy of Sciences, October 19, 1903; New York Min. Club, October 20, 1903.

[7] United States Geological Survey, "Mineral Resources of the United States," 1901, page 747.

from Yreka, in Siskiyou county, Cal. Here a hard and handsome stone, varying in color from olive to almost grass-green, and taking a fine polish, outcrops for some 200 feet along a hillside about 100 feet above the creek, and large masses have fallen into the bed of the creek. At first it was supposed to be jade (nephrite), but upon analysis proved to be vesuvianite. The fallen pieces were in some cases as much as 5 feet square and 2 feet thick, of excellent quality for polishing, and of varying shades of light to dark green. The associated rock is precious serpentine.

A very similar mineral was discovered some years ago at one or two places in the Alps, and, like this, was at first described as jade, but on analysis proved to be massive vesuvianite. The likeness to green jade is very marked in both these and the California mineral, and the mistake is not surprising.

The following analysis was made through Prof. F. W. Clarke, chief chemist of the United States Geological Survey, by Mr. George Steiger, in the spring of 1903:

Analysis of vesuvianite from Siskiyou county, California.

SiO_2	35.85	TiO_2	0.10
Al_2O_3	18.35	P_2O_5	0.02
CaO	33.51	H_2O- (below 100° C.)	0.29
Fe_2O_3	1.67	H_2O+ (above 100° C.)	4.18
FeO	0.39		
MgO	5.43	Total	99.84
MnO	0.05		

The analysis is essentially that of a normal vesuvianite, though the percentage of water is unusually high. The lime and the iron are below the average, and the titanium and phosphorus are exceptional occurrences.

The mineral is compact, extremely tough, and readily takes a high polish, quite as beautiful as that of nephrite (jade), with which it was at first confounded. The hardness is 6.5 and the specific gravity (from two determinations) is 3.286. The luster is vitreous, often inclining to resinous, and the streak is white. The color is a yellow leek-green, with inclusions of a darker green, which are generally more translucent than the surrounding mass.

This interesting mineral exists in large quantity, and could be cut into a variety of ornaments, in the same way as jade, nephrite, and chrysoprase. It is a form of vesuvianite distinctive enough to receive a special variety name, which, if appropriate and euphonious, would undoubtedly aid the sale of the stone in the arts. The name of "Californite" has been proposed for it.

The discovery of what appears to be the same mineral has recently been announced from two other localities in California quite remote from the first. One of these was reported by that indefatigable prospector, Mr. M. Braverman, of Visalia, as existing in Burrough, in Fresno county, a mile and a half from Hawkins schoolhouse and 32 miles east of Fresno city. The material is pale olive green, translucent, with darker spots in a paler mass. It breaks with an uneven fracture, slightly splintery and partly crystalline, and hence much resembles the material from Siskiyou county. The other locality is apparently not very far from the last mentioned. It is said to be in Tulare county, near the town of Selma, which, though in Fresno county, is near the Tulare line. Here the mineral is of richer color, at times resembling the tint of apple-green chrysoprase, for which it was at first mistaken.

An analysis was made of the green mineral (No. 1) below, through the courtesy of Prof. F. W. Clarke, chief chemist United States Geological Survey, by Mr. George Steiger. In comparison is shown also the analysis of a remarkable associated mineral (No. 2), which proved to be a peculiar variety of garnet.

Analysis of two minerals from California.

	No. 1, Californite, green.	No. 2, Garnet, white.
SiO_2	36.55	38.59
AL_2O_3	18.89	22.24
Fe_2O_3	0.74	0.45
FeO	0.74	0.36
MgO	2.33	0.64
CaO	35.97	35.97
Na_2O	None.	None.
K_2O	None.	None.
H_2O- (below 100° C.)	0.58	0.31
H_2O+ (above 100° C.)	3.42	0.80
TiO_2	None.	None.
CO_2	0.91	0.39
F	0.13	0.17
MnO	None.	0.10
BaO	None.	None.
SrO	None.	None.
B_2O_3	None.	None.
	100.26	100.02
	0.05	0.07
	100.21	99.95

Chlorastrolite and mesolite.—In the region about Lake Superior occur two or three peculiar little minerals that have attained some value as "local" gem stones. These, in the order of their importance, are chlorastrolite, thomsonite (properly mesolite), and lintonite; besides one or two other varieties, rarer and of less account. These are all nearly related in composition, being silicates of alumina with varying amounts of lime and oxide of iron. They are all found as rounded nodules, not from wear, however, but natural, as being the filling of small ovate cavities (originally bubble holes) in the trap rocks of the region. As the rocks decompose these harder nodules fall out, and are rolled on the lake beaches or by streams, and are often supposed to be pebbles, but they are not such in reality. They seldom exceed half an inch in diameter, but when polished they make quite pretty stones, and are in considerable demand for local jewelry, as rings, studs, and the like.

Chlorastrolite is found only at Isle Royale, Lake Superior, where it abounds in the trap and on the beaches. It has a characteristic color, from bluish to olive green, and a peculiar radiated mosaic-like structure or pattern. Prof. N. H. Winchell, of the University of Minnesota, has studied these minerals carefully, and shown that the chlorastrolite passes into a substance identical with the so-called thomsonite, the two forming the extremities of a series of closely-related minerals that fill such cavities in igneous rocks of this character. As the proportion of iron diminishes the chlorastrolite loses its color and its pretty little stellate structure, becomes pale and even whitish, and graduates into a white or pinkish body like the mesolite. The best mesolite comes from Grand Marais, Minn., and is in similar nodules, ranging from white to reddish and brown, in concentric zones or bands. This mineral Professor Winchell shows to be not thomsonite, as supposed, but the related species, mesolite, and this latter name should be substituted in these cases for the other, which is erroneously applied. Lintonite is a green mineral with something of the radiated pattern of chlorastrolite, but belongs really to thomsonite proper.

The demand for these little semigems is pretty steady, and the value of the output is considerable. They are not mined, but simply gathered along the beaches, etc., and the production for several years past is estimated to amount to $1,000 annually for thomsonite (i. e., mesolite) and from $3,000 to $5,000 for chlorastrolite.[1]

Opal.—Prior to 1889 no precious opal had been found in the United States. At about that time, however, and during the subsequent decade, several occurrences of it were discovered, and mining operations were undertaken at some points with apparent promise of successful yield. But for various reasons no important or continuous production has been developed as yet, although the igneous rocks of Washington, Idaho, Oregon, California, Nevada, and Utah, undoubtedly contain much handsome opal.

The first important opening was in 1890, near Moscow, Latah county, Idaho, close to the Washington line. Buildings were erected and a post office called Gem City was established. Fine opal was present in the trachyte rock, and for a year or two there was considerable production. In 1891 the value of the output was estimated at $5,000. For some time past, however, little has been heard of this formerly promising locality.

Other occurrences were noted at about the same time. One of these was in Morrow county, Oreg., where several thousand dollars' worth of specimens were said to have been obtained in 1892, and many were exhibited at the Spokane fair. Another was at Opaline, in Owyhee county, Idaho, and exhibits of these were made in the Idaho section of the Mining Building at the Columbian Exposition of 1893. Another occurrence was reported in 1895, near Salmon city, Lemhi county, Idaho, where beautiful opal was found in bowlders of trachyte, and finally traced to the ledge whence it had come. Many very handsome pieces were obtained, and the mineral was present in great variety of color and quality, but no definite work seems to have been undertaken.

In the same year Mr. Don Maguire, of Ogden, Utah, described an occurrence in Lemhi county, Idaho, on Panther creek. This has been recently opened, and will be referred to again.

In 1894 banded opal in large sheets, with hyalite, was reported from Beaver valley, Utah, near Granite Peak, apparently in connection with an ancient geyser, but no work seems to have been attempted there.

In 1897 other localities of precious opal were described at Durkee, Oreg., and at Dunsmuir, Siskiyou county, Cal. Work was undertaken at the former place, but practically nothing has been heard of it since.

Recently, in 1902, one or more promising occurrences have been announced in southern California, in the region of the Mojave desert. One of these is in San Bernardino county, about 25 miles north of Barstow, the junction of the Santa Fe and California Southern railroads. Here opal occurs in veins and pockets in a porphyritic dike about 2 miles in length. Much of it is semiopal, of various colors, some a beautiful amber-yellow, and with these occur precious and fire opal. The locality is promising, but needs to be explored and developed. In Tulare county, also, are found some beautiful semiopals that might be valuable in ornamental art work. One of these, from near Yokohl, is transparent yellow and amber-like; another is from the chrysoprase mine near Visalia. It is translucent green, and has been called chrysoprase opal, or chrysopal, by the discoverer, Mr. M. Braverman. The Idaho locality at Panther creek, Lemhi county, before alluded to, has been rediscovered and described during 1902. Opal of many varieties and colors is abundant here, in a porphyritic dike, traced for a mile and a half, parallel to the creek, and at times as much as 150 feet wide. Much of it is very beautiful, but it is also very brittle, and goes to pieces in extracting it, so that stones of any size are difficult to procure. This locality, however, when more fully examined, may yet prove to be valuable.

There are many minor occurrences that have been noted and many varieties of semiopal that may hereafter yield material of some value in the arts. Gem opals, however, are not yet produced to any extent or with any regularity in the United States, although there is considerable promise at several points.

Turquoise.—Turquoise is a hydrated phosphate of alumina, containing small quantities of copper, iron, or manganese. The mineral varies in color from a fine sky blue to many shades of bluish green, and to apple green and dark green, which show no blue whatever. The hardness of the mineral is 6, and its specific gravity is 2.75.

[1] United States Geological Survey, "Mineral Resources of the United States," 1898 to 1902; table of production of precious stones.

Turquoise was almost unknown in the United States when the census of 1890 was taken. A few specimens in collections of minerals attested its existence at some points in Arizona and Nevada, and objects worked by the Indians of the Southwest were known to be abundant, but there was no production of it, and all the turquoise used in jewelry came, as it had for centuries past, from the mines in Khorassan, in eastern Persia. Since then a remarkable change has taken place, and the Southwestern states and territories are now furnishing the main supply for the world. Turquoise has been discovered at a number of points in large quantities and of fine quality. It is known to exist in Arizona, New Mexico, Nevada, and southern California, while some localities are reported in Texas and southern Colorado. The main production is in New Mexico, in Santa Fe and Grant counties, and at Turquoise mountain in Arizona. The California localities operated by the Himalaya and the Toltec companies are northeast of Manvel, in San Bernardino county. At almost every point where the mineral is found there are interesting and conspicuous evidences of ancient workings in pre-Columbian times; in many cases these were plainly both extensive and long continued; stone tools and similar objects are abundant, and at some points remarkable rock carvings are to be seen, especially about the California localities. The Toltec Turquoise Company has also operated other mines near Manvel, Cal., over the line in Lincoln county, Nevada.

Turquoise is now being regularly mined in New Mexico, at perhaps a dozen places, by the Azure Turquoise Company, the American Turquoise Company, the Gem Turquoise Company, and by Mr. A. C. Young; and in Arizona by six companies, among them the Aztec Turquoise Company. In 1902 turquoise was discovered in Alabama, on property of the Otero Company, near Idaho, Clay county, about 95 miles east of Birmingham, in the region of the Talladega mountains. This mineral sometimes loses or changes its color, and for this reason several of the above-named companies engrave a trade-mark upon the back of every stone that they sell as a guarantee that the company will replace it with another stone in case of any failure of quality appearing within six months after its sale to the retail purchaser. Thus, all stones from the American Turquoise Company are marked with an "A," from the Azure Company with a circle, from the Toltec Company with a "T," etc. This assurance to the buyer is a marked improvement on the methods of the Persian dealers, who were wont to decamp for parts unknown during the night after a sale. Some of the companies claim, indeed, that their stones never change color, but they furnish a guarantee, notwithstanding.

In 1900, according to official reports, the output from the oldest and largest mine, at Los Cerrillos, N. Mex. (now called Turquesa), had amounted to a total of over $2,000,000 since 1890. The production from all the American mines was estimated at $118,000 in 1901, and at $166,500 in 1902. A single stone has been sold for as much as $3,000.

Utahite and prosopite.—Several handsome and interesting minerals, related to or resembling turquoise, have been identified in Utah during the last decade. Some of these have been largely sold as specimens, though as yet they have not been found in sufficient quantity to be mined for use in the arts. They would, however, be beautiful ornamental or semiprecious stones. Two of these minerals are utahite and prosopite. The former resembles turquoise in composition, being a hydrous phosphate of alumina; the latter is a fluoride of alumina and lime. Both occur in choice shades of green, due usually to a small amount of copper compounds, and both are hard enough to take a handsome polish.

Utahite, so named by the writer in 1895, was discovered in Cedar valley, in a spur of the Oquirrh mountains, near Camp Floyd, Utah, in the previous year, by Mr. Don Maguire. It belongs to the mineral species variscite, but presents a new and peculiar form. Variscite usually occurs in crystals or incrustations; utahite forms compact nodular masses, ranging from the size of a walnut to that of a cocoanut. These occur in slaty layers in a crystalline limestone, and are generally surrounded with a brown ferruginous crust. In color, the interior mass is of various shades of bright green, generally a very vivid golden green or light emerald; and the nodules, cut across and polished, have been much admired and sought by collectors. The mineral is not very abundant at the locality, and can only be removed from the rock with care by the hands. Pieces could be easily cut for small objects, and would be extremely handsome for such uses, owing to the brilliant and delicate coloring. It has been used to some extent for ring stones, cuff buttons, seal rings, and other purposes as jewelry with considerable success.

Prosopite at first was supposed to be identical with utahite, but an analysis made by Mr. W. J. Hillebrand proved it to be a fluoride of alumina, known already as a rare species of mineral from Saxony, Germany, and from Pikes Peak, Colo., where it occurs, but without the rich blue-green color of that found in Utah. Here it was obtained by Mr. Josiah Beck in 1895 in the Dugway mining district, in Tooele county, in a region of low and desert hills. The mineral was not fully identified until 1899, when the analysis was made and the result published.[1] The prosopite is a beautiful stone, but whether it exists in sufficient amount to be of practical use has not yet been determined.

Anthracite.—There is a small but fairly constant sale in the coal region of eastern Pennsylvania of articles of ornament carved from anthracite coal, such as

[1] American Journal of Science, January, 1899, pages 53, 54.

inkstands, paper weights, etc. These are usually made partly polished and partly rough, so as to show a contrast between the two different kinds of black surfaces. They are sold almost entirely as local souvenirs to persons visiting that part of the country. The sale of such articles has been estimated for some years past at a total varying from $1,000 to $2,000.

Catlinite (*pipestone*).—This material, celebrated in Indian history and immortalized by Longfellow in "Hiawatha," is used to some extent for making ornaments and souvenirs that are sold to visitors in the region of its occurrence—Pipestone county, in southwestern Minnesota. It is not really a definite mineral species, but essentially an indurated red clay. Among the Indians it has long been held almost sacred as the material for making "pipes of peace." The principal locality where it is found was, and still is, visited by Indians from all parts of the country to obtain it for that purpose, and is still regarded by them as a kind of inviolable spot, where all have the right to come. The United States Government has very properly set apart the land on which the quarry exists as a small reservation, to secure this free right of access to all Indians forever. It is jealously guarded by the native tribes, and it is seldom that large pieces can be secured by white men; hence the supply is rather limited and is likely to remain so. The only large object ever made from this material was a mantelpiece, carved by an Indian artist, with designs from Hiawatha, which was exhibited in the Minnesota building at the Pan-American Exposition of 1901. It had been shown previously at the Columbian Exposition in 1893, and is now in the courthouse at Pipestone, Minn., in the room occupied by the Women's Historical Society, to which organization it belongs. The sale of ornaments and souvenirs made of catlinite is estimated at about $2,000 annually, for some years past.

Fluorspar (*Illinois*).—The old and celebrated "Shawneetown" region in southern Illinois has lately been yielding fluorite of remarkable beauty. In a lot of specimens recently sent to the writer for examination were cleavage pieces of much beauty from several of these localities, notably the Empire mines and Cave-in-Rock. From the former were large cleavages of rich reddish purple, and of the peculiar sea-blue of that region; in one case the general color was of the latter kind, clouded at points with the former—like the tint of a blue Alabashka topaz with included clouds of Uralian amethyst. Both the purple and the sea-blue varieties at times pass into almost colorless fluor. That received from Cave-in-Rock presents an octahedral cleavage, perfectly transparent and of amber yellow. A cubical crystal received from Rosiclare was pale bluish, becoming nearly colorless.

QUARTZ MINERALS.

Rock crystal.—Rock crystal is a variety of transparent colorless quartz, composed of nearly pure silica. While it is not rare as a mineral, yet it is seldom found in masses of large size. When so found, however, it is valuable for use in the ornamental arts. One or two localities in the Alps, that have been known and worked from Roman times, though very difficult and perilous of access, have furnished material for all the objects in European palaces and museums which have been carved from this substance. In Japan, too, large crystals were formerly obtained, from which were made the polished balls, so much prized by the natives, and afterwards by foreigners, who have now almost drained the country of them by purchase. The main supply in recent years has been derived from Madagascar and Brazil.

Within the last decade very fine rock-crystal masses have been obtained in the United States, especially in California. An important discovery was made in 1891–92 by Mr. James Blackiston, near Placerville, Eldorado county. Here, in a partly decomposed quartz vein, were found crystals ranging from small sizes up to masses of 80 or 90 pounds in weight. Some are clear and flawless, while others have the peculiar and beautiful marking known as "included phantoms." This feature has been caused by successive deposits, and is shown by the appearance of several crystals of identical form, one within another, each being outlined by a thin coating of some other mineral, which delicately colors the otherwise transparent quartz. These coatings in the California crystals are of rich green chlorite. Similar chlorite phantoms in clear quartz have since been found also in San Bernardino county, in the mountains of that name.

The most remarkable discovery of quartz in California, however, was made in 1897, in Calaveras county, at the old Green Mountain mine, in Chile gulch, near Mokelumne Hill. Here, in one of the ancient river channels filled with auriferous gravel and covered by an overflow of lava—a formation characteristic of that region of the state—was found a quantity of enormous quartz crystals, embedded in the old gravel. It is claimed that 12 tons were taken out in the years 1897 and 1898. One giant crystal, surrounded by an attached cluster of smaller ones, weighed over a ton. A number of the finest specimens were sent to New York, and splendid balls were cut from them by machinery especially constructed for the purpose. Two of these balls were a little over 7 inches across, but they are not absolutely flawless. A third, 5½ inches in diameter, without a blemish, was valued at $3,000. The latter, and one of the other two, are in the Tiffany-Morgan collection at the American Museum of Natural History in New York; the other is in the Museum of the Jardin des Plantes at Paris, with the collection of American gem minerals that was prepared for the Pan-American Exposition of 1901.

So far as the gravel deposit was explored, the crystals appeared to be strewn through it, and it would seem to contain a large amount of valuable material, although no work has been done there since 1898. Other localities in California where crystals weighing several pounds have been found are Drum valley, Three-rivers, and Yokohl, in the neighborhood of Visalia, in Tulare county.

In Oregon, large transparent masses have been found near Bay City, but no particulars of their occurrence are given.

Some fine rock crystal occurs in North Carolina, in Chestnut Hill township, Ashe county, on a spur of Phoenix mountain, near Long Shoal creek. Here, at two or three spots not far apart, were found pieces up to 50 pounds in weight, and two very large crystals, of 188 and 285 pounds, respectively. A crystal ball, 5 inches in diameter, and a number of art objects, all of American workmanship, made from this material, were shown at the Columbian Exposition at Chicago in 1893. Another find in North Carolina was reported in 1896, from Elkin, in Surry county, by Mr. R. M. Chatham, who described crystals up to 40 pounds in weight. Some large crystals are also known to have been found in South Carolina, and it is probable that much rock crystal adapted for use in the arts, exists in the mountain regions of the South.

Colorado has furnished some fine material, especially that from Mt. Antero, Chaffee county. A polished ball, 6 inches in diameter, from the summit of this mountain was exhibited at the Columbian Exposition.

A find of considerable quantity was reported in 1896, at Cheyenne pass, Wyoming, about 18 miles west of Cheyenne city, but no development at that point appears to have been undertaken.

The quartz crystals of Hot Springs, Ark., have been known for many years and furnish a constant source of business to the farmers of the surrounding country, who collect them and bring them in by the wagon load to sell to local dealers and to tourists. These crystals are not large enough to yield art material, but they are beautiful as specimens, either as single crystals or more frequently in groups. It is estimated that in the year 1896 no less than 15,000 pounds were gathered in Montgomery, Saline, and Garland counties and sold in the city of Hot Springs for $5,000.

Colored varieties.—Among the colored varieties, besides amethyst, of crystalline quartz suitable for use as precious or semiprecious stones, two are important—smoky quartz and rose quartz. Both are found at various points in the United States and have been mined more or less during the past ten years, although there is no large or continuous supply.

Smoky quartz.—The most noted place in which smoky quartz occurs is at and near Pikes Peak, Colo., where it is abundant in fine crystals, in a coarse granite, associated with the beautiful crystals of green feldspar (amazon stone), for which that locality is famous. It is found also at Mt. Antero, in Colorado, where the smoky quartz obtained in 1891 yielded one of the finest faceted stones in the world, measuring 3½ inches in length. It was cut and exhibited at the Columbian Exposition. Much of the material from Pikes Peak is sent abroad for cutting, and returned to be sold at Denver and Colorado Springs, Colo., at Hot Springs, Ark., and other interior resorts, as jewelry to tourists. The annual sales amount to about $10,000, three-fourths of which is for cut stones and one-fourth for specimens.

Large crystals, up to 4 and 5 inches in diameter, have been collected at Brandy creek, in Lemhi county, Idaho. They have been found, too, at Three Mile Gulch, near Helena, Mont., and a gigantic crystal, nearly 2 feet long and weighing 93½ pounds, was found in 1900, on Clear creek, Jefferson county, Mont., by Mr. E. P. Chisolm. Crystals have also been reported at points in South Dakota. A considerable quantity occurs in connection with the colored tourmalines in southern California, both at the San Jacinto mine in Riverside county and those at Mesa Grande in San Diego county.

In the East very fine smoky quartz has been found in Maine and in North Carolina, as well as at some other points. The specimens from Maine are particularly beautiful. Crystals of 40 pounds in weight were reported in 1896, by Mr. R. M. Chatham, from a locality near Elkin, in Surry county, N. C., and it was already well known in the neighboring counties of Alexander, Burke, and Iredell. In Connecticut, at New Milford, some 200 pounds of smoky quartz, worth over $100, was taken out in 1898. But the most valuable yield has been in Oxford county, Me., where as much as 3 tons of crystals were reported by Mr. T. F. Lamb, of Portland, as mined in 1897, on Mt. Apatite. Much has been taken out since, including one perfect crystal 12 pounds in weight, and a polished ball 3 inches in diameter has been cut from material obtained here.

Rose quartz.—The delicate pink variety of quartz known as rose quartz has long been obtained at several points in New England, especially at Albany, Stow, and Paris, in Maine; at Southbury, in Connecticut; also at Bedford, in Westchester county, N. Y. Though a beautiful material, it had been little used in the arts or as a gem until quite recently, when it was tried with some success. In general, and particularly in the case of the specimens from the localities in Maine, the tint varies greatly from an almost colorless variety, sometimes opalescent, to pale pink, salmon, and deep rose. When cut into double *cabochons*, or balls, it sometimes shows the asteria effect, like a star sapphire. Very fine, rich-colored pieces, partly opalescent and in size up to

4 or 5 inches in diameter, have been obtained at Round mountain, near Albany, Me., and a ball of 2½ inches across, with other cut objects from this locality, were shown at the Columbian Exposition.

Rose quartz occurs also at Acworth, N. H., in the celebrated beryl locality, and a large block of this material, some five feet square by half that thickness, has been set up as a monument in Franklin, N. H., to the late Walter Aiken, of that place. The mass is somewhat fissured, however, and rose quartz is liable to fade in the sunlight, so that neither in texture nor in color is it adapted for monuments or other use out of doors.

In 1894 the occurrence of rose quartz in Iredell and Cabarrus counties, N. C., was announced by Prof. T. K. Brunner. In 1895, 50 tons of it were mined at Theresa, in Jefferson county, N. Y., and its presence was noted in Colorado by Mr. E. H. Saltiel, at the headwaters of Currant creek, in Park county. In the same year Messrs. M. Braverman and W. H. Smith described several places where it occurred in the neighborhood of Visalia, in Tulare county, Cal., especially on the Yokohl river, where about $150 worth was then taken out. It exists in some quantity, and of excellent color, at Yokohl and Threerivers, in the same county, and probably at other points in that section.

By far the most extensive occurrence, however, is in the Black Hills of South Dakota. Specimens were first brought in by Prof. W. P. Jenney on his exploring expedition in 1876, and a fine display of it was made in the South Dakota building at the Columbian Exposition of 1893. The exact locality is near French creek, 6 miles east of Custer, in the county of that name. Here it exists in great quantity and of fine quality, outcropping along a ledge for 500 feet in a vein varying in thickness from a few feet up to 60. The color, as usual, ranges through many shades, from faint pink or even white, to the tint of a ripe watermelon, and in places alters completely within a few inches. Contrary to the general opinion, there is no evidence of its fading by exposure to light, for outside portions, and even rolled bowlders, show in some cases a fine deep coloring. Thus far the mining has been carried on mainly by hand, much in the nature of quarrying. About three-fourths of the stone removed is rejected as lacking color; the rest is sorted and sold according to size and color, chiefly to dealers and collectors, at prices ranging from 5 to 25 cents a pound. One mass weighing over a ton was recently sold to be cut into table tops, 30 by 36 inches in size, which were sent to Paris to fill an order. The production reported to the United States Geological Survey amounted to 4 tons in 1902.

Amethyst.—Amethyst is a variety of quartz of a deep purple or bluish violet color, shading almost to pink. Like ordinary quartz, it is composed of silica, and the coloring is due to the presence of oxides of manganese and iron. Its hardness is about 7, and its specific gravity is slightly above 2.65.

Fine gem material has been found in the United States, though nowhere is it mined with any regularity. The localities from which the finest specimens come are in Maine, Pennsylvania, North Carolina, southern Virginia, and northeastern Georgia, and several discoveries have been made recently in the West. The main developments within the last ten years are the following:

Deer Hill and Stow, in Maine, were noted localities some time ago, but have not yielded much lately. At Denmark, however, in the same state, Mr. G. R. Howe obtained many fine crystals in 1894, and had a number of gems cut that were very richly colored—equal to any from the Ural mountains.

Another old locality was Upper Providence township, in Delaware county, Pa. Here, in 1894, a large amount of amethyst was obtained that yielded gems of the finest quality, one of which was of 33 carats; and another, still larger, is in the Lea collection in the National Museum at Washington.

Virginia has only recently come into notice as a possible source of amethyst production. In 1896 its occurrence, in beautiful crystals, was announced at two points in Goochland county, by Mr. G. L. Chase, and also near Lovingston, Nelson county, by Mr. Benjamin Dillon. In 1902 a promising locality was discovered and opened in Amherst county, near Lowesville.

North Carolina has for years yielded more or less amethyst at various points in Burke, Catawba, Iredell, Lincoln, Wake, and other counties. In 1901 mining was begun in Macon county, on Tesanty creek, where a large vein traversing a decomposed granite had been exposed by a landslide. Several thousand dollars' worth of material was taken out, as rich and fine in quality as any ever found in the United States.

Amethyst of excellent quality has been occasionally found in Anderson county, S. C., in Hall and Rabun counties, Ga., and at Amethyst mountain, in Gillespie county, Texas.

The western sources of production are chiefly in Montana. In 1895 a crystal weighing 12 pounds was found at Granite, and in 1900 remarkable discoveries were made in Jefferson county, some 22 miles southeast of Butte, by Mr. A. P. Pohndorf. Here amethyst occurs in fine crystals, curiously mingled with quartz both colorless and smoky. Crystals of black tourmaline so penetrate the quartz as to render it opaque. The amethyst itself is free from these inclusions, though sometimes it forms parts even of the same crystals.

In Colorado, amethyst is reported from Cripple Creek and from localities in Park and Mineral counties, but no special data have been given as to these occurrences.

Good material has been brought from two or three points in Alaska, but there has been no development as yet.

Quartz pebbles.—Natural rolled pebbles of quartz, of various colors, are often beautiful, sufficiently so at times to be applied to some uses in the arts or for cheap jewelry. At many points along the Atlantic coast, visitors to the seaside resorts gather pebbles of attractive aspect, especially those of colorless transparent quartz, and sometimes have them cut as souvenirs. These are the so-called Cape May diamonds, and there is quite an industry at many resorts in gathering pebbles to cut for gems, seals, etc. A good deal of fraud is also practiced upon visitors, all manner of ornaments being sold as material found in the vicinity. At Narragansett Pier, R. I., some local dealers and lapidaries have been known to sell foreign-cut quartz, cairngorm stone, topaz, crocidolite, Ceylonese moonstone, and even glass as stones from the beach. In some cases pebbles found by visitors and entrusted to lapidaries for cutting have been replaced by cut stones imported from Bohemia, Oldenburg, and the Jura, where cutting is done on such a large scale and at such low wages that the stones can be brought here at one-tenth of the cost of cutting, the material itself, in the case of quartz, having but small value. The annual proceeds from the sale of cut stones, and the money expended in cutting them at these and other resorts throughout the country, may amount to $20,000 or more a year, and the sale of specimens to a like sum.

Another ingenious fraud has been practiced at Hot Springs, Ark., where clear, rolled pebbles of colorless quartz, found on the banks of the Ouachita river, are in special demand, being more valued for cutting than the crystals of the vicinity, because of a mistaken idea that they will cut into clearer gems. Fine pebbles of this kind are scarce, and so they have been artificially imitated by putting a number of crystals into a box, which is kept revolving by waterpower. In a few days mutual attrition has rolled and roughened the crystals into beautiful pebbles—so beautiful, indeed, that an expert can distinguish them from the real ones by their more perfect whiteness of surface.

Along the coast of California and Oregon there are various localities where many very attractive pebbles of chalcedony, agate, etc., are found. The principal beaches are at Crescent City, at the northern extremity of California; Pescadero, some 28 miles west of San José; and Redondo, a few miles south of Los Angeles. These pebbles are very abundant and in great variety, and are much sought by visitors. Many are put up and sold in bottles of water, to preserve their bright colors and markings and their translucency; and many are drilled and strung to make chains and similar fancy ornaments. Some of those at Pescadero are little hollow geodes of chalcedony, occasionally an inch long, inclosing a liquid with a moving bubble. These little natural-sealed flasks are found also on the beach at Tampa, Florida.

There are likewise many inland localities—several in California, especially on the shore of Lake Tahoe; also in Colorado, and the beaches of Lake Superior—long famous for their agate pebbles, chlorastrolites, etc.

One special use of quartz pebbles in ornamental art work should be here alluded to. On Plum Island, in Long Island sound, there are quantities of pebbles of colored quartz—amethystine, smoky, yellow, etc.—brought down by glacial action from the crystalline rocks of Connecticut and rolled and rounded on the island beach. These have been used in a very effective manner, in the same way as rounded pieces of colored glass, by leading them for screens, shades, etc., to show their tints by transmitted light. This application was introduced about 1897, by Mr. Louis C. Tiffany, of New York.[1]

Agate and chalcedony.—These minerals are forms of quartz (silica), but differ from those previously noted in being noncrystalline, or at least the crystalline structure, if present at all, is only discernible by the microscope. They are also never transparent, but vary from translucent to nearly opaque. With the exception of colorless chalcedony or white carnelian, they are variously and often richly colored by metallic oxides, principally those of iron and manganese, and furnish a number of semiprecious stones that have long been favorites in jewelry and art work.

There are many localities in the United States where handsome agates and chalcedonies occur, and some of these may hereafter be commercially developed. But with the exception of the little local trade in agate and chalcedony pebbles, already mentioned as carried on at certain of the beach resorts on the Pacific coast (see quartz pebbles, above), and likewise to some extent with the agate pebbles of Lake Superior, there is hardly any continuous production or sale. At one point, however, a deposit of agate occurs that is unequaled in the world, and deserves special mention. This is the agatized forest, or Chalcedony Park, of Arizona, where an area of many square miles is strewn with logs and trunks of an ancient growth of trees, now completely altered to silica, and stained with the richest and most varied hues by the oxides above named. Silicified wood is by no means uncommon, but it rarely presents such beauty of coloring as here, where fallen and broken trunks many feet in length and ranging up to as much as 4 feet in diameter, with the woody structure perfectly visible, are converted into agate and chalcedony of every mingled shade of red, brown, and purple. When polished this makes one of the most beautiful and interesting ornamental stones in the world, and has attracted great admiration abroad as well as in this country. Splendid exhibits of it in the form of table tops, clock bases, pedestals for statuary, and many kinds of minor articles, have been made at the Columbian and Pan-American Expositions and at the Paris Exposition of

[1] United States Geological Survey, "Mineral Resources of the United States," 1887, page 14.

1900. These have been shown by the Drake Company, of Sioux Falls, S. Dak., who obtained a large amount of the material, and erected machinery and polishing works at that place, operated by waterpower, and succeeded in producing beautiful results. Previously there had been no polishing works in this country that could deal with large pieces of a material as hard as quartz.

The locality is in Apache county, Ariz., a few miles south of the Southern Pacific Railroad from Adamana station, not far from the town of Holbrook. It consists of three open valleys or eroded areas among a wilderness of mesas and buttes. The logs, more or less shattered into pieces and fragments or cylindrical cross sections, lie along these valleys by thousands, having been washed out of the rather soft sandstone that formerly covered the whole region, and which still remains in the intervening hills and buttes. At some points the logs may be seen in place in the sandstone, especially at the celebrated "chalcedony bridge," where a large trunk spans a gully worn in the side of a small hill. Geologically these beds belong to the Triassic formation, equivalent to the brown and red sandstones of New Jersey and the Connecticut valley. But the trees grew at a somewhat earlier time, and were overthrown and buried in the sandstone when that was laid down by an invasion of the Triassic sea. These points have been fully determined by Prof. Lester F. Ward, of the United States Geological Survey, in two visits to the region in 1899 and 1901.

This beautiful material exists in very large quantities, but since access has been made more easy from the railroad, tourists, vandals, and speculators have been coming in and there has been danger of seriously despoiling one of the most remarkable natural curiosities in the country. Some years ago the legislature of Arizona petitioned Congress to set apart the Chalcedony Park as a reservation, and this course was strongly recommended by Prof. Lester F. Ward, after his recent visits. Of course, under Government control, a judicious and reasonable removal of material for use in the arts is now permitted; and under such supervision a permanent supply for legitimate purposes will be assured, but spoliation and speculation will be properly prevented.

The yield reported in the last five years has risen steadily; it was $2,000 in 1898, $3,000 in 1899, $6,000 in 1900, and $7,000 in 1901 and also in 1902.

Chrysoprase.—Another semiprecious stone which has been developed in the United States within the past decade is chrysoprase, a chalcedony of a light green color, caused by the presence of oxide of nickel. This stone has been highly valued for centuries, but is of rare occurrence, and most of that used in jewelry and in the arts has been obtained from Silesia. Its existence in North America had been recognized at some points before, but the only promising locality was at Riddles, Douglas county, Oreg. Mr. George W. Smith, a surveyor, obtained specimens in Tulare county, Cal., as far back as 1878. These he submitted to experts, who pronounced them to be true chrysoprase. The first who positively identified them as such, by actual determination of the nickel oxide, was Mr. M. Braverman, of Visalia, Tulare county, who is well known for his enthusiasm in locating and collecting California minerals. From that time specimens were gathered and sent quite widely to museums and cabinets; but not for some years was its commercial value appreciated. When that became known, systematic development was attempted, the neighborhood was prospected, and other occurrences discovered, so that now there are not fewer than five localities in Tulare county where chrysoprase is known to occur. The first of these to be discovered was the one at Venice Hill, 12 miles northeast of Visalia; the others are on Stokes mountain, on the Tule river, on Deer creek, and at Lindsay, 16 miles south of Visalia. Mr. Braverman has been active in the search for these localities, and has presented to the California State Mining Bureau a very fine specimen from the last-named place. The veins which it forms are of no great thickness, and much of the material is flawed and cracked, or too pale to be valuable. Still a large quantity of fine chrysoprase has been obtained and cut, from these several localities, especially the last two and the first. The total production for several years did not much exceed $100 annually, but since a new company took up systematic work two years ago the yield rose to $1,500 in 1901, and $15,000 in 1902. Most of the material is cut into squares, ovals, etc., for rings and studs, and into small pieces of various shapes for inlaying as mosaic.

Within the past year a promising locality has been discovered in North Carolina, at Morganhill, in Buncombe county, some 16 miles from Asheville. Here it occurs in several parallel seams or veins quite near to each other; the color is pale at the surface, but becomes deeper below. No extensive work has yet been done here, although some very rich green material has been cut and placed on the market, and the outlook is favorable.

Moss agate.—The name "moss agate" is applied to a variety of translucent chalcedony, usually nearly colorless, that is penetrated by minute branching or "dendritic" (tree-like) crystallizations of oxide of manganese or of iron, the former black, the latter brown or reddish. It has long been a favorite semiprecious stone in Europe and the East, but large pieces are rare. Small rounded nodules of it are abundant at various places in the West, particularly in Wyoming. In 1893 large masses were found near Hartville, Wyo., occurring in a vein 8 or 10 inches thick in limestone. Slabs of 2 or 3 feet in length could be taken out, according to Mr. H. A. Crane, of Hartville, who described its occurrence, and table tops made of it were shown in the Wyoming section of the World's Columbian Exposition at Chicago. The translucent white slabs, with moss-like markings in black, are very beautiful.

Two other localities in which fine moss agate has been found are reported in Wyoming, one 47 miles and the other 75 miles northwest of Cheyenne. No important developments, however, appear to have been made at these points.

TABLE 4.—DETAILED SUMMARY: 1902.

	United States.	California.	Montana.	New Mexico.	All other states and territories.[1]
Number of mines or quarries	46	31	3	8	4
Number of operators	460	47	3	60	350
Character of ownership:					
Individual	449	44	....	57	348
Firm	1	....	1	....	....
Incorporated company	10	3	2	3	2
Salaried officials, clerks, etc.:					
Total number	22	7	2	3	10
Total salaries	$28,687	$9,087	$1,780	$5,160	$12,710
General officers—					
Number	3	....	....	....	3
Salaries	$2,500	....	....	....	$2,500
Superintendents, managers, foremen, surveyors, etc.—					
Number	13	5	1	2	5
Salaries	$21,247	$6,787	$1,250	$4,200	$9,010
Foremen below ground—					
Number	2	1	....	1	....
Salaries	$2,760	$1,800	....	$960	....
Clerks—					
Number	4	1	1	....	2
Salaries	$2,180	$500	$480	....	$1,200
Wage-earners:					
Aggregate average number	108	19	39	36	14
Aggregate wages	$88,017	$12,591	$43,664	$22,087	$9,675
Above ground—					
Total average number	72	12	24	22	14
Total wages	$56,058	$6,937	$25,514	$13,932	$9,675
Engineers, firemen, and other mechanics—					
Average number	4	....	3	1	....
Wages	$3,867	....	$3,267	$600	....
Miners or quarrymen—					
Average number	50	12	14	14	10
Wages	$39,088	$6,937	$14,760	$10,056	$7,335
All other wage-earners—					
Average number	18	....	7	7	4
Wages	$13,103	....	$7,487	$3,276	$2,340
Below ground—					
Total average number	36	7	15	14	....
Total wages	$31,959	$5,654	$18,150	$8,155	....
Miners—					
Average number	29	5	10	14	....
Wages	$25,295	$4,435	$12,705	$8,155	....
Miners' helpers—					
Average number	5	....	5	....	....
Wages	$5,445	....	$5,445	....	....
All other wage-earners—					
Average number	2	2	....	....	....
Wages	$1,219	$1,219	....	....	....

	United States.	California.	Montana.	New Mexico.	All other states and territories.[1]
Average number of wage-earners at specified daily rates of pay:					
Machinists, blacksmiths, carpenters, and other mechanics—					
$2.00 to $2.24	1	....	....	1	....
$3.00 to $3.24	3	....	3	....	....
Miners or quarrymen—					
$1.00 to $1.24	5	....	....	....	5
$1.50 to $1.74	5	5	....	....	....
$1.75 to $1.99	8	1	....	7	....
$2.00 to $2.24	15	4	....	11	....
$2.25 to $2.49	5	....	....	5	....
$2.50 to $2.74	8	6	....	2	....
$2.75 to $2.99	4	....	4	....	....
$3.00 to $3.24	11	....	8	3	....
$3.50 to $3.74	8	1	2	....	5
$3.75 to $3.99	10	....	10	....	....
Miners' helpers—					
$3.00 to $3.24	5	....	5	....	....
All other wage-earners—					
$1.50 to $1.74	8	1	....	7	....
$2.00 to $2.24	3	....	....	....	3
$2.25 to $2.49	1	....	....	....	1
$2.50 to $2.74	1	1	....	....	....
$2.75 to $2.99	3	....	3	....	....
$3.00 to $3.24	4	....	4	....	....
Average number of wage-earners employed during each month:					
Men 16 years and over—					
January	92	30	11	40	11
February	90	27	12	40	11
March	87	23	13	40	11
April	112	18	41	42	11
May	109	16	51	31	11
June	141	17	82	31	11
July	140	17	81	31	11
August	120	8	69	32	11
September	118	15	61	31	11
October	94	17	26	34	17
November	99	25	12	36	26
December	94	15	9	44	26
Miscellaneous expenses:					
Total	$7,481	$1,568	$830	$1,900	$3,183
Royalties and rent of mine and mining plant	$437	....	....	....	$437
Rent of offices, taxes, insurance, interest, and other sundries	$7,044	$1,568	$830	$1,900	$2,746
Cost of supplies and materials	$17,781	$7,113	$5,920	$2,480	$2,268
Value of product	$328,450	$65,000	$115,000	$51,600	$96,850
Power owned:					
Total horsepower	150	25	75	....	50
Engines, steam—					
Number	4	1	1	....	2
Horsepower	150	25	75	....	50

[1] Includes operators distributed as follows: Arkansas, 50; Arizona, 46 (1 mine); Colorado, 25; Idaho, 1; Maine, 13; Minnesota, 110; Nevada, 8 (1 mine); New Hampshire, 10; North Carolina, 18 (1 mine); Pennsylvania, 55; South Carolina, 5; South Dakota, 3; Virginia, 3; Wyoming, 3.

TALC AND SOAPSTONE

TALC AND SOAPSTONE.

By Joseph Hyde Pratt.

Talc and soapstone have assumed a very important place among the minor minerals, and in respect to the value of the production are near the head. This is due not so much to the variety of uses to which they are put as to the very remarkable growth in the utilization of talc in the manufacture of paper, for nearly two-thirds of the value of the production in 1902 was used for this purpose. Statistics for talc and soapstone include a small production of serpentine and the production of pyrophyllite, both of which are mined and used for the same purposes as those for which talc is employed.

In treating the statistics of the talc and soapstone mining industry it is necessary to include also the statistics of the manufacturing processes which are conducted at the mines under the same management, as the financial and other details are inseparable. This method has been customary since the census of 1860, which was the first census to give statistics for this industry.

Table 1.—*Comparative summary: 1860 to 1902.*

	1902	1889	1880	1870[1]	1860
Number of mines or quarries	20	(2)	14	(2)	(2)
Number of operators	20	(2)	(2)	[3] 9	[3] 6
Salaried officials, clerks, etc.:					
Number	75	(4)	(4)	(4)	(4)
Salaries	$63,713	(5)	(4)	(4)	(4)
Wage-earners:					
Average number	771	[6] 280	178	74	27
Wages	$279,083	[5] $115,621	$57,545	$38,444	$10,824
Miscellaneous expenses	$80,136	(2)	(2)	(2)	(2)
Cost of supplies and materials	$125,932	$35,454	$18,201	$98,325	$10,425
Product:[7]					
Quantity, short tons	97,563	36,461	12,651	(2)	(2)
Value	$1,138,167	$475,878	$121,395	$189,115	$27,600

[1] Classification was "soapstone stoves, fireplaces, sinks, and cisterns."
[2] Not reported.
[3] Establishments.
[4] Not reported separately.
[5] Salaries included in wages.
[6] Foremen included in wage-earners.
[7] The United States Geological Survey reports 97,954 short tons, valued at $1,140,507, which includes 391 short tons of soapstone, valued at $2,340, used as a mineral pigment and so reported by the Census.

The industry, as will be seen by the table, increased from a product in 1860 valued at $27,600 to one in 1902 valued at $1,138,167. From 1870 to 1880 there was a falling off in value of $67,720, although there were 5 more mines or establishments in operation and 104 more employees engaged in the work. This probably can be accounted for by the fact that a number of new properties were being opened and developed, and this development required a large increase in the number of employees without resulting in production for the current year.

Only the statistics for New York and North Carolina can be given separately, as there were not more than 2 producers in any of the other states. There were 20 mines in operation in the United States during 1902, of which 6 were in North Carolina; 4 in New York; 2 each in Maryland, Pennsylvania, and Virginia; and 1 each in California, Georgia, Massachusetts, and New Jersey. Thirteen mines were reported idle—1 each in California, Maryland, Massachusetts, North Carolina, and Ohio; 2 each in New Hampshire and Virginia; and 4 in Georgia.

Capital stock of incorporated companies.—Of the 20 mines reported, 13 were operated by incorporated companies, 4 by individuals, and 3 by firms. The details of the capital stock and funded debt authorized and issued by the 13 incorporated companies are shown in the following table:

Table 2.—*Capitalization of incorporated companies: 1902.*

	United States.	New York.	North Carolina.	All other states.[1]
Number of incorporated companies	13	4	5	4
Capital stock and bonds issued	$7,697,925	$6,119,500	$768,425	$810,000
Capital stock:				
Total authorized—				
Number of shares	98,877	61,300	13,377	24,200
Par value	$7,758,425	$6,130,000	$918,425	$710,000
Total issued—				
Number of shares	91,802	55,725	11,877	24,200
Par value	$7,050,925	$5,572,500	$768,425	$710,000
Dividends paid	$91,300	$67,300	....	$24,000
Common—				
Authorized—				
Number of shares	78,577	41,000	13,377	24,200
Par value	$5,728,425	$4,100,000	$918,425	$710,000
Issued—				
Number of shares	76,977	40,900	11,877	24,200
Par value	$5,568,425	$4,090,000	$768,425	$710,000
Dividends paid	$32,000	$8,000	....	$24,000
Preferred—				
Authorized—				
Number of shares	20,300	20,300	....	....
Par value	$2,030,000	$2,030,000	....	....
Issued—				
Number of shares	14,825	14,825	....	....
Par value	$1,482,500	$1,482,500	....	....
Dividends paid	$59,300	$59,300	....	....
Bonds:				
Authorized—				
Number	1,900	900	....	1,000
Par value	$730,000	$630,000	....	$100,000
Issued—				
Number	1,817	817	....	1,000
Par value	$647,000	$547,000	....	$100,000
Interest paid	$12,660	$6,660	....	$6,000

[1] Includes operators distributed as follows: California, 1; Pennsylvania, 1; Virginia, 2.

Five of the incorporated companies were in North Carolina, 4 in New York, 2 in Virginia, and 1 each in California and Pennsylvania. The capital stock and funded debt of the 4 New York companies constituted 79.5 per cent of the total. The par value of the capital stock issued was 90.9 per cent of the total par value authorized. The bonded indebtedness was 8.4 per cent of the capital stock and funded debt. The dividends paid amounted to 1.3 per cent of the total stock issued and 5.1 per cent of the total stock on which they were declared. Sixty-five per cent of the total amount paid in dividends was declared on preferred stock and 35 per cent on common. Of the total dividends 73.7 per cent was paid on the stock of the New York mines and 26.3 per cent on that of the mines in Virginia.

Employees and wages.—In considering the question of employees and wages, it is to be observed that the talc and soapstone industry is a composite one of mining and manufacturing. There are two principal kinds of manufacture: (1) The grinding of talc into flour, after which it is packed in bags preparatory to shipment, and (2) the sawing and finishing of soapstone into slabs, mantelpieces, laundry tubs, etc. Thus it can readily be seen that more employees are required, in proportion to the tonnage of the mineral mined, in an establishment where the higher grades of manufactured articles are made than in a plant where the mined talc is merely ground. This will explain the large number of employees in proportion to the tonnage in "all other states," because in these the soapstone mined is largely converted into manufactured articles, this being especially true of Virginia.

The number of salaried employees was 75, or 8.9 per cent of the aggregate average number of all employees, which was 846, and they received in salaries $63,713, or 18.6 per cent of the total salaries and wages, which amounted to $342,796. The number of wage-earners was 771, who received $279,083 in wages, which were 91.1 and 81.4 per cent, respectively, of the total number of employees and total wages. There were on an average 38.5 wage-earners to a mine. Of the states, the statistics of which are shown in detail, New York had 21.1 per cent of the wage-earners, and they received 30 per cent of the wages paid. North Carolina had 8 per cent, and they received 7.7 per cent of the wages.

Of the 771 wage-earners, only 98, or 12.7 per cent, worked below ground, the remaining 673, or 87.3 per cent, being employed above ground. Some of these, however, were employed in cleaning and preparing the talc and soapstone for market, while all the underground wage-earners were directly employed in mining the talc. Besides the number of wage-earners mentioned above, there were 9 foremen included among the salaried employees, who worked below ground.

Of the 771 wage-earners, 411, or 53.3 per cent, are classified as "miners or quarrymen and stonecutters;" of these 73, or 17.7 per cent, were employed in New York; 57, or 13.9 per cent, in North Carolina; and 281, or 68.4 per cent, in "all other states." In New York, 69 miners were employed underground and only 4 were reported as working above ground. In North Carolina, 8 miners were reported as working underground, and in "all other states" only 3 were so reported.

The daily rates of pay of the wage-earners, as given in Table 5, varied from 50 cents to $3.49 per day. Nearly one-half of the total number of all classes of wage-earners, or 46.8 per cent, received from $1 to $1.24 per day; 132, or 17.1 per cent, were paid from $1.25 to $1.49 per day. The highest rate of pay was received by those classified as "all other wage-earners," 16 of whom were paid from $3.25 to $3.49 per day, these being employed in the manufacture of the more intricate articles made from soapstone.

Of the 411 miners or quarrymen, 249, or 60.6 per cent, received only from $1 to $1.24 per day, this being due largely to the fact that most of these workmen were employed in the southern mines, where the rate of wages was much lower than it was for the same class of labor either in the North or East.

The average number of wage-earners employed during each month is also shown in Table 5. The busiest months for the industry were August, when an average of 826 employees were at work, and September, when the average reached 841. The month with the smallest average was November, with 705. In New York the greatest average number employed was 168, that number working in January and December. In North Carolina the greatest average was 85, employed in July, August, and September.

Supplies, materials, and miscellaneous expenses.—The amount, $125,932, reported as paid for supplies and materials was the principal item of expense, next to wages. Of the amount, $80,136, reported for miscellaneous expenses, $31,364, or 39.1 per cent, was expended for royalties and rent of mine and mining plant, and $48,772, or 60.9 per cent, for rent of offices, taxes, insurance, interest, and other sundries.

Mechanical power.—Of the 20 operators, 16 reported primary power aggregating 3,945 horsepower. Of this, 2,700 horsepower, or 68.4 per cent, was supplied by water wheels; 1,235, or 31.3 per cent, by steam engines; and 10, or three-tenths of 1 per cent, by gas or gasoline engines. There were reported in addition 3 electric motors having a capacity of 225 horsepower. Of the 2,700 horsepower furnished by water wheels, 1,650, or 61.1 per cent, was used in New York; 630, or 23.3 per cent, in North Carolina; and 420, or 15.6 per cent, in "all other states." Of the 1,235 horsepower generated by steam, 530, or 42.9 per cent, was employed in New York; 70, or 5.7 per cent, in North Carolina; and 635, or 51.4 per cent, in "all other states." The 10 horsepower generated by gas or gasoline engines was used in California. The electric motors were reported from Virginia.

Production.—The total production of talc and soapstone in 1902 was 97,563 short tons, valued at $1,138,167, of which the state of New York, with 4 establishments, produced 71,100 tons, or 72.9 per cent, and North Carolina 5,238 tons, or 5.4 per cent, leaving 21,225 tons, or 21.7 per cent, for the 7 other states. In the value of the production New York is credited with 54.1 per cent of the total value, North Carolina with 7.8 per cent, and the 7 other states, collectively, with 38.1 per cent. In order to show the growth of the talc and soapstone industry in the United States since 1880, there is given in Table 3 the production of these minerals as reported by the United States Geological Survey since that year:

TABLE 3.—*Production of talc and soapstone: 1880 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States."]

YEAR.	Quantity (short tons).	Value.	Average value per ton.
1880	12,651	$121,395	$9.60
1881	12,000	135,000	11.25
1882	12,000	165,000	13.75
1883	14,000	225,000	16.07
1884	20,000	310,000	15.50
1885	20,000	310,000	15.50
1886	24,000	350,000	14.58
1887	27,000	385,000	14.26
1888	35,000	460,000	13.14
1889	36,461	475,878	13.05
1890	55,024	641,505	11.66
1891	69,568	737,049	10.59
1892	65,833	909,934	13.82
1893	56,932	658,503	11.57
1894	63,050	836,385	13.27
1895	60,735	637,392	10.49
1896	68,272	753,508	11.04
1897	78,932	762,565	9.66
1898	76,587	698,542	9.12
1899	79,420	768,955	9.68
1900	91,443	883,041	9.66
1901	97,843	908,488	9.29
1902	97,954	1,140,507	11.64

Since 1880 the average price per ton has ranged from $9.12 in 1898 to $16.07 in 1883. In 1902 the prices reported as received for the talc and soapstone products varied from $2.25 for material sold in the rough as quarried, to $31,025 received for manufactured articles. This wide variation in price is readily explained by the various uses to which talc and soapstone are put, and to the amount of work that is required in preparing the manufactured articles for market.

The imports of talc, 1880 to 1902, inclusive, principally from France and Italy, as published by the United States Geological Survey, are shown in the following table:

TABLE 4.—*Talc imported into the United States: 1880 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States."]

YEAR.	Quantity (short tons).	Value.	YEAR.	Quantity (short tons).	Value.
1880	(1)	$22,807	1892	531	$5,546
1881	(1)	7,331	1893	1,360	12,825
1882	(1)	25,641	1894	622	6,815
1883	(1)	14,607	1895	3,165	26,843
1884	(1)	41,165	1896	1,966	18,693
1885	(1)	24,356	1897	796	8,423
1886	(1)	24,514	1898	761	9,338
1887	(1)	49,250	1899	254	3,544
1888	24,165	22,446	1900	79	1,070
1889	19,229	30,993	1901	2,386	27,015
1890	1,044	1,560	1902	2,859	35,366
1891	81	1,121			

1 Not reported.

The detailed statistics of the industry for 1902 are given in Table 5.

DESCRIPTIVE.

The name talc has been used very commonly, and yet erroneously, for a number of minerals which are similar to it in physical properties, but distinct mineralogically. Commercially, the name talc is usually applied to the fibrous and foliated varieties, which are the purer forms, and the name soapstone confined to the massive varieties. Mineralogically, the name talc refers not only to the foliated and fibrous varieties, but also to those which are compact, and soapstone or steatite is simply a variety of this mineral. Talc may be considered as occurring in the varieties, foliated and massive, with a third division known as fibrous talc, which is usually called pseudomorphous, as it has generally resulted from the alteration of the mineral enstatite. The foliated talc is the most valuable, being pure and very free from grit, so that it is suitable for use in the manufacture of talcum powders, etc. Occasionally this variety is so compact that it can be used in the manufacture of tailors' pencils, when it commands the highest price paid for any talc. Certain varieties of the massive talc are also pure enough to be ground into a flour talc, but the greater portion is used in the manufacture of soapstone articles.

The properties of talc (exclusive of soapstone) that make it suitable for the purposes for which it is used are its extreme softness, its purity or freedom from grit, its stability, and its smooth, slippery surface. Since the minerals serpentine and pyrophyllite closely approximate many of these properties, they are used to some extent for the same purposes. This is true especially of the latter, which can be used for many of the purposes for which flour talc is employed.

Occurrence.—Talc is found very commonly throughout many of the states, and in small quantities it is very widely distributed. The steatite variety occurs more frequently in commercial quantities, but it can be worked profitably only when it is located most favorably with regard to transportation facilities and in proximity to a market for the manufactured articles. In a number of states this variety is quarried and used for chimneys and fireplaces by the inhabitants of the district in which it occurs, but it is impossible to tell exactly how much is used in this way. It has been roughly estimated that in the mountains of North Carolina from 25 to 50 short tons per year are so used.

Large deposits of foliated talc have thus far been found only in North Carolina and New York, and in both cases they are associated with limestone. Small amounts of this variety of talc are found associated with the basic magnesian rocks extending from Alabama to Canada, but in no case has it been found in commercial quantity. Where, however, the pyroxenite variety of these basic magnesian rocks has been converted into the secondary rock composed almost entirely of the steatite variety of talc, it makes a deposit of commercial value if favorably located, as mentioned above.

Talc has been mined in California, Georgia, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Vermont, and Virginia. In 1902 it was mined in all these states except New Hampshire and Vermont. The California "talc product" that was put on the market in 1902 was not talc, but a variety of serpentine obtained from Santa Catalina Island, Los Angeles county. Recently, however, a deposit of talc was discovered in Tulare county, near Lindsay, about 2½ miles east of the railroad, where it occurs in lenses of from 6 to 8 feet in width and 100 or more feet in length. Since no good talc deposits are being worked on the Pacific coast, this deposit is worthy of investigation as to its commercial possibilities.

The deposits of Georgia and North Carolina are somewhat similar in their occurrence, and are probably parts of the same belt, although the Georgia talc is more compact and not so fine in quality. In Georgia the principal mining has been done in Murray county. At least one-half of the talc mined in this state is put on the market in the form of ground talc.

The deposits of North Carolina are found in Swain and Cherokee counties, and that portion of the belt in Swain county furnishes the most valuable talc that is produced in the United States, and in many respects is a unique occurrence of this mineral. The quality of this talc is such as is used in the manufacture of tailors' pencils, etc., and for which there is a larger demand than can be met. All the rest of the North Carolina talc is ground to flour, and most of it is used in the manufacture of toilet powders. In Moore county occur the pyrophyllite (soapstone) deposits, which have been mined quite extensively, the product being used for various purposes. None of it is as good quality as the genuine talc, nor does it command as high a price. For foundry purposes, however, as far as can be judged, it ought to be as satisfactory as the other.

The Massachusetts talc deposits are not very numerous, and the only one worked in 1902 was near Dalton, Berkshire county. The talc is of the foliated variety, and all that was mined was ground to flour talc.

The deposits of talc in Maryland and Virginia are of the steatite variety, and nearly all mined in these states is used for manufactured articles. A very small amount has been ground to a flour talc. A fibrous talc has been obtained in some quantity in the vicinity of Wiehle, Fairfax county, Virginia.

Soapstone deposits occur on both sides of the Delaware river, being found in Warren county, N. J., and in Northampton county, Pa., in the vicinity of Easton. The general width of this soapstone belt is from 500 to 600 feet, and the mineral is obtained usually by quarrying. Practically all of the Pennsylvania and New Jersey talc or soapstone is put on the market in the form of a ground product, most of which is used in the manufacture of paper.

St. Lawrence county, N. Y., is the scene of the largest talc industries in this country. The talc is of the fibrous variety, and is used almost entirely in the manufacture of paper. There are about twelve mines in this talc region, and they are located near Talcville, St. Lawrence county, and Littleyork, Cortland county. Since the consolidation of a number of the smaller properties the mining and manufacture of ground talc has been carried on more systematically and on a larger scale, thus increasing the production of talc in this state and decreasing the cost.

About 3 miles southeast of the village of Rochester, Vt., are old talc mines which were worked rather extensively during 1865–66. These are now being reopened and developed, and the material will be put on the market as ground talc.

There were no new deposits that produced talc during 1902, although some work was done in investigating deposits, most of the deposits investigated, however, proved to be of little or no commercial value, being for the most part of the steatite variety.

Methods of mining, manufacturing, and cleaning.—The mining of talc is either (1) by means of open cuts and pits, (2) by a system of shafts or tunnels and drifts, or (3) occasionally by a combination of both cuts and shafts. The mining of the soapstone (steatite) is largely by the first method. Mining by shafts, tunnels, and drifts is confined to the foliated and fibrous varieties of talc. In New York the method of mining is practically the same at all of the mines. Inclined shafts are sunk, following the dip of the country rock, which is first gneiss, and then massive white dolomite, as the beds of talc are approached. These rocks stand very well, so that timbering is required only occasionally. When the shafts reach the beds of talc, drifts are run along the strike of the deposit. On account of the compactness of this talc, blasting is usually necessary in removing it. As the talc comes from the mine it varies in size from particles no larger than dust to masses two feet or more in length, and it is conveyed in hand cars to the mills, where it is pulverized. The larger masses are broken with sledges and then passed through Blake crushers and conveyed by a belt to a pair of slightly corrugated steel rolls, which reduce the talc to small pieces, one-fourth inch or less in length. From the rolls the crushed talc is carried by an endless belt conveyor to bins on the top floors of the mills, and then it is conveyed automatically into Griffin mills on the floor below. A draft of air is forced through the mill, and as the talc becomes fairly fine it is blown through an opening and falls to the floor below. It is returned to the second floor and conveyed into large hopper shaped bin cars, from which it is dropped into Alsing cylinders, in which is a quantity of waterworn quartz pebbles, 2½ inches or less in diameter. As the cylinder revolves the constant pounding and rubbing of these quartz pebbles on the talc completely pulverize it. From this cylinder the talc passes through a grating, thus becoming separated from the quartz pebbles, and is conveyed automatically into a bag filling machine, where it is bagged and weighed, ready for shipment.

Talc mining in North Carolina does not present any serious difficulties, as the deposits do not extend to any great depth. The presence of water in the mines in the lowlands occasionally causes considerable expense and loss of time. Most of the mines thus located have been worked by means of open pits, which during a period of heavy rain have to be abandoned on account of being flooded. Although some of the deposits, especially those on the hillsides, can be worked advantageously by means of open pits, the majority of them are worked to the best advantage when shafts or tunnels and drifts are used. Little blasting is necessary at any of the mines, as the talc can usually be removed readily by pick and gad. As the rough blocks of talc are taken from the mine they are hand cobbed if necessary and sorted into three grades. The larger pieces are cleaned by rubbing them with steel brushes, and the smaller ones by a founder's scouring machine. They are then dried by being spread over a floor of steam pipes, which are kept at a temperature of 212° F. When these pieces are dry they are crushed and ground by means of crushers, rolls, and pulverizers, and the foreign material removed by screening. It is then further ground in buhrstone mills, similar to those used in grinding wheat, and passed through bolting cloth, which makes the final product nearly uniform in grain. This ground product is handled very much like flour, and in filling the bags with the flour talc, an ordinary flour packer is often used.

In Maryland, New Jersey, Pennsylvania, and Virginia, where it is principally the steatite variety of talc that is produced, the mining operations are carried on almost entirely in very large open cuts and pits. The preparation of the ground talc from the New Jersey and Pennsylvania mines or quarries is a process similar to that described above. In Virginia, where the soapstone is used almost exclusively for manufactured articles, the tonnage mined is of course very much larger than the weight of the articles manufactured and put on the market.

Uses.—Talc is employed in the arts in two distinct forms, as powder, or flour talc, and as pieces sawed into various sizes and shapes. The flour talc is now used as a base for fireproof paints, lubricants, and many of the cheaper soaps, for electric insulators, for boiler and steam pipe coverings, for foundry facings, for the dressing of skins and in the manufacture of dynamite, of the various toilet powders and of paper. Formerly certain varieties of clay were used as a filling in the manufacture of paper, but with the discovery of large deposits of talc, especially of the fibrous variety, in New York, talc has largely replaced them, its fibrous and pliable character giving additional strength as well as weight. The introduction of talc in the manufacture of toilet powders put on the market under the name of talcum powders gave a new use for the more valuable talc.

The soapstone, or steatite varieties of talc, are used for the most part in the manufacture of hearthstones, linings of furnaces, for cupola and converter linings in many steel works, for laboratory tables and ovens, for laundry tubs and slate pencils, and, to a limited extent, in building. It is also used quite extensively in the manufacture of soapstone griddles, foot warmers, boot driers, and for many other articles of everyday use.

TABLE 5.—DETAILED SUMMARY: 1902.

	United States.	New York.	North Carolina.	All other states.[1]
Number of mines or quarries	20	4	6	10
Number of operators	20	4	6	10
Character of ownership:				
Individual	4		1	3
Firm	3			3
Incorporated company	13	4	5	4
Salaried officials, clerks, etc.:				
Total number	75	29	12	34
Total salaries	$63,713	$19,654	$7,710	$36,349
General officers—				
Number	12	3	3	6
Salaries	$23,270	$2,250	$2,520	$18,500
Superintendents, managers, foremen, surveyors, etc.—				
Number	38	17	7	14
Salaries	$28,039	$12,160	$3,990	$11,889
Foremen below ground—				
Number	9	7		2
Salaries	$4,404	$4,144		$260
Clerks—				
Number	16	2	2	12
Salaries	$8,000	$1,100	$1,200	$5,700
Wage-earners:				
Aggregate average number	771	163	62	546
Aggregate wages	$279,083	$83,680	$21,416	$173,987
Above ground—				
Total average number	673	77	54	542
Total wages	$238,046	$46,278	$18,716	$173,052
Engineers, firemen, and other mechanics—				
Average number	282	13	5	264
Wages	$95,047	$7,800	$2,527	$84,720
Miners or quarrymen and stonecutters—				
Average number	331	4	49	278
Wages	$106,281	$1,760	$16,189	$88,332
All other wage-earners—				
Average number	60	60		
Wages	$36,718	$36,718		
Below ground—				
Total average number	98	86	8	4
Total wages	$41,037	$37,402	$2,700	$935
Miners—				
Average number	80	69	8	3
Wages	$32,402	$28,902	$2,700	$800
Miners' helpers—				
Average number	17	17		
Wages	$8,500	$8,500		
All other wage-earners—				
Average number	1			1
Wages	$135			$135
Average number of wage-earners at specified daily rates of pay:				
Engineers—				
$1.00 to $1.24	2		2	
$1.25 to $1.49	9			9
$1.50 to $1.74	4			4
$1.75 to $1.99	1	1		
$2.00 to $2.24	4	3		1
$2.25 to $2.49	1	1		
Firemen—				
$1.00 to $1.24	5			5
$1.25 to $1.49	2			2
$1.50 to $1.74	3	2	1	
Average number of wage-earners at specified daily rates of pay—Cont'd.				
Machinists, blacksmiths, carpenters, and other mechanics—				
$0.75 to $0.99	110			110
$1.00 to $1.24	105			105
$1.25 to $1.49	3			3
$1.50 to $1.74	9	2		7
$1.75 to $1.99	5	2		3
$2.00 to $2.24	9	2	2	5
$2.50 to $2.74	4			4
$2.75 to $2.99	2			2
$3.00 to $3.24	4			4
Miners or quarrymen and stonecutters—				
$0.50 to $0.74	3		3	
$0.75 to $0.99	15		11	4
$1.00 to $1.24	249		15	234
$1.25 to $1.49	104	48	27	29
$1.50 to $1.74	33	22		11
$1.75 to $1.99	3	1	1	1
$2.00 to $2.24	4	2		2
Miners' helpers—				
$1.50 to $1.74	17	17		
All other wage-earners—				
$1.25 to $1.49	14	14		
$1.50 to $1.74	24	23		1
$1.75 to $1.99	2	2		
$2.00 to $2.24	3	3		
$2.75 to $2.99	2	2		
$3.25 to $3.49	16	16		
Average number of wage-earners employed during each month:				
January	766	168	48	550
February	717	163	48	506
March	769	161	48	560
April	783	162	54	567
May	813	164	63	586
June	764	163	65	536
July	791	156	85	550
August	826	164	85	577
September	841	166	85	590
October	766	164	65	537
November	705	157	50	498
December	711	168	48	495
Miscellaneous expenses:				
Total	$80,136	$38,786	$27,981	$13,369
Royalties and rent of mine and mining plant	$31,364	$28,226	$720	$2,418
Rent of offices, taxes, insurance, interest, and other sundries	$48,772	$10,560	$27,261	$10,951
Cost of supplies and materials	$125,932	$15,253	$12,447	$98,232
Product:				
Quantity, short tons	97,563	71,100	5,238	21,225
Value	$1,138,167	$615,350	$88,962	$433,855
Power owned:				
Total horsepower	3,945	2,180	700	1,065
Engines—				
Steam—				
Number	12	3	2	7
Horsepower	1,235	530	70	635
Gas or gasoline—				
Number	1			1
Horsepower	10			10
Water wheels—				
Number	33	21	6	6
Horsepower	2,700	1,650	630	420
Electric motors—				
Number	3			3
Horsepower	225			225

[1] Includes operators distributed as follows: California, 1; Georgia, 1; Maryland, 2; Massachusetts, 1; New Jersey, 1; Pennsylvania, 2; and Virginia, 2.

MAGNESITE

MAGNESITE.

By Joseph Struthers, Ph. D.

The output of magnesite in the United States is obtained solely from California. The mineral occurs in other states, but the deposits are not of sufficient extent or purity to render their exploitation a commercial possibility. The deposits of this mineral occur in several localities in California, but a mine located in Tulare county was the only one in active operation during 1902. It is impossible, therefore, without disclosing individual operations, to publish the complete statistics for this branch of the mining industry, and they are included in the group of "all other minerals" in the general tables. Of the magnesite mines which were idle during 1902, 2 are located in Alameda county, 2 in Napa county, and 1 each in Santa Clara, Sonoma, and Stanislaus counties, a total of 7. The mineral has also been found in San Bernardino county.

Production.—During 1902 the production of magnesite in California amounted to 3,086 short tons of crude ore. Of this product 2,236 short tons were calcined, the result being 1,050 short tons of the calcined product, valued at $15,780. The remaining 850 short tons of crude ore were valued at $3,859. The value of the entire product was therefore $19,639.

The quantity and value of crude magnesite marketed in the United States during the years 1891 to 1902, inclusive, including the value of the calcined product, is given in the following table from the report of the United States Geological Survey:

Table 1.—*Production of magnesite: 1891 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (short tons).	Value.
1891	439	$4,390
1892	1,004	10,040
1893	704	7,040
1894	1,440	10,240
1895	2,220	17,000
1896	1,500	11,000
1897	1,143	13,671
1898	1,263	19,075
1899	1,280	18,480
1900	2,252	19,333
1901	13,172	43,057
1902	3,466	21,362

The census figures for 1902, as given in the text, are for the quantity mined that year, while those of the Survey include 380 tons, valued at $1,723, mined previously but sold in 1902.

The production of crude magnesite is practically under the control of one firm in California, which ships much of the output to two manufacturers of carbon dioxide gas for use in the production of the gas by calcination. The calcined product, essentially magnesium oxide, or magnesia, is returned to the shipper and is subsequently utilized by paper mills in California and Oregon. The demand for calcined magnesite for this purpose in the West is limited, and only a small portion of the available supply is utilized—a trade condition which is reflected by the different unit value of the calcined product from year to year when considered in connection with the quantities produced. Thus in 1900 the supply of calcined magnesite amounted to 1,013 short tons, and the average value per ton was $15.70; in 1901 the output, 4,726 short tons, far exceeded the demand, and the average value decreased to $5.57 per ton; in 1902 the quantity produced, 1,050 short tons, was again just sufficient to satisfy the normal consumption, and the average value per ton rose to $15.03.

Consumption.—It is impracticable to furnish accurate statistics of the consumption of magnesite and of magnesite products in the United States, owing to the fact that in the official reports no distinction is made between the imports of crude and of calcined magnesite; furthermore, the statistics of the quantity and value of imported magnesite bricks are not separately reported. During 1902 the imports of crude and calcined magnesite (which were chiefly from Greece and Austria) amounted to 49,786 short tons, valued at $373,928, as compared with 33,461 short tons in 1901. There was also a very large importation of magnesite bricks, but no statistics of their quantity or value are available. By adding the figures for imports to the figures for the marketed production, as given by the Geological Survey, an estimate may, however, be made of the consumption exclusive of the quantity contained in brick form; on this basis the quantity of crude and calcined magnesite consumed in the United States during 1902 was 53,252 short tons, as compared with 46,633 short tons in 1901 and 31,076 short tons in 1900. These statistics show the increasing importance of magnesite in the industrial arts in the United States; they also show that only a very small fraction of the supply is of domestic origin.

The industry in the United States.—Magnesite is found in many localities in the United States—in California and in Massachusetts; at Bare Hill, near Baltimore, Md.; near Rye and at Stonypoint, N. Y.; near Hoboken, N. J.; in Yancey and Cabarrus counties, N. C.; in Chester and Lancaster counties, Pa.; in Arizona and in Texas. But the deposits have been worked with commercial success only in the first-named state. The deposits in California are quite widespread, occurring in the following counties: Alameda, Colusa, Fresno, Kern, Mariposa, Monterey, Napa, Placer, San Luis Obispo, Santa Clara, Stanislaus, Tulare, and Tuolumne. The only producing property during the year was in Tulare county, near Portersville, where the mineral occurs in a series of vertical and flat veins, in some cases 10 feet in width, and has wall rocks of serpentine and granite. Some of these veins outcrop boldly, and a few of them have been traced on the surface for several thousand feet. A large quantity of mineral has been disclosed by open cuts and a tunnel. A 10-ton kiln, using crude petroleum as fuel, serves to calcine the product, which is then shipped to paper mills, and a second kiln will be erected as soon as the demand warrants it. The calcining treatment, which is carried on at a temperature of 2,500° F., occupies from three to three and one-half hours; the carbon dioxide gas expelled is allowed to escape into the air. In the calcination of magnesite, 48 to 52 per cent of its weight is lost by the expulsion of the carbon dioxide. The cost of the calcined product at the kiln is from $12 to $14 per ton. The demand for magnesite has increased rapidly east of the Rocky mountains, but owing to the high cost of transportation from the Pacific coast, most of the mineral used is imported, mainly from Greece. An important problem of the industry in California is to reduce the cost of calcination to a point which will admit of the shipment of the calcined product to Pittsburg, where it might be used for the manufacture of magnesite brick and other refractory products, an industry in which at present magnesite imported from the island of Euboea, in Greece, and from Styria, in Austria, is used. Another important feature is the development of the iron and steel industry on the Pacific coast, which will give a strong impetus to the mining of magnesite and its manufacture into bricks and concrete for use as a basic lining of furnaces or converters, for treating phosphoric pig iron to make basic open-hearth or basic Bessemer steel.

The industry in foreign countries.—The greater portion of the world's production of magnesite at the present time comes from the deposits in Austria and Greece. During 1901 the exports of calcined magnesite from Austria amounted to 40,236 metric tons, valued at $321,800. The deposits in Austria have attained their greatest development near Vietsch. The formation is of the Silurian age and consists of argillaceous shales, quartzite, dolomite, and gneiss. The magnesite occurs in beds conformable with the strata and is usually seamed with calcite, dolomite, and quartz, with occasionally segregations of dolomite crystals; it is necessary, therefore, to cob and pick the mineral. The sorted ore, which usually contains from 90 to 96 per cent of magnesium carbonate, is calcined at a white heat in kilns lined with magnesite bricks at those sections where the temperature is the highest, in order to prevent the introduction of impurities into the material. The small amounts of silica and ferric oxide contained in the ore are sufficient only to sinter it. The kilns are continuous in action and yield 80 tons of calcined ore daily. This product is sorted mechanically for the removal of the fine dust, as well as quartz and other impurities, that may not have been separated in the preliminary cobbing process. The sorted calcined material is then crushed, formed into bricks in steel molds by hydraulic pressure of about 4,500 pounds per square inch, and finally burned in kilns at a high temperature, thus producing the solid and compact magnesite brick as it appears in the trade.

In Greece the magnesite mines are near Mantudi and Limni in the northern part of the island of Euboea. The mineral is in crypto-crystalline form and occurs in large veins in serpentine; picked samples contain as high as 98 per cent of magnesium carbonate, but the average composition approximates 95 per cent Formerly the sorted ore was calcined in kilns fired by wood, but this process has been cheapened by the introduction of modern shaft calciners using a local lignite for fuel. Ordinarily the completely calcined ore falls to powder when moved and causes the lower and cooler portion of the ordinary kiln to become choked with fine material, thereby preventing the access of air which is necessary for the combustion of the fuel. The modern furnace is constructed especially to overcome this defect. The magnesite from Euboea is exceptionally pure and on account of the absence of impurities, it sinters only at a very high temperature. As this magnesite is so highly refractory, it is necessary in the manufacture of bricks to add a suitable binding material. At the brickworks at Mantudi, a small proportion of serpentine is added to the mixture which is molded and burned at a temperature of 1,400° C. in a regenerative furnace of the Siemens type, yielding a very hard and dense brick.

Deposits of magnesite have been found at Sutton and Bolton, Ontario, Canada; near Frankenstein, Germany; in the Department of Ufa, southern Urals, Russia; in India; and at several localities in Hungary. A few of these deposits have been worked, but the output from them at the present time is very small, when compared with the total production of the world.

Occurrence and characteristics.—Magnesite, magnesium carbonate ($MgCO_3$), corresponds chemically to calcite, calcium carbonate ($CaCO_3$). In the pure state, it contains 47.6 per cent of magnesium oxide, and 52.4 per cent of carbon dioxide. When impure, magnesium silicate is present and at times iron oxide. Pure magnesite occurs in transparent, rhombohedral crystals; in the massive form it is compact and granular, resembling unglazed porcelain in appearance. In color it is generally white, but often of a yellowish, grayish, or even brownish tinge. The brownish color is imparted to the mineral by the impurity, iron oxide, which if present to the extent of several per cent forms the variety "breunnerite," or "brown spar," as it is sometimes called. In hardness magnesite varies from 3.5 to 4.5, and though brittle, it is exceedingly difficult to drill. Its specific gravity varies from 3 to 3.12.

The formation of magnesite, which is usually associated with serpentine, is attributed to the action of carbonated waters upon eruptive magnesium rocks, such as olivine (chrysolite); when this action has been carried nearer to completion, the serpentine also is decomposed, yielding as final products magnesite and quartz. While magnesite generally occurs associated with serpentine, it is found also with other magnesian minerals, as talc, brucite, dolomite, etc. It is sometimes found in gypsum, and when the veins are irregularly mixed with the gypsum the mass forms the variety of marble known as "verd antique."

Uses.—In the crude condition magnesite is used largely for making carbon dioxide gas, either by the application of heat alone or by treatment with sulphuric acid. The carbon dioxide so produced is utilized largely either in the gaseous or liquefied state to "charge" or carbonate mineral waters and other beverages, and its use in mechanical refrigeration in warm countries and on shipboard is increasing. When crude magnesite is decomposed by sulphuric acid, magnesium sulphate is obtained as a by-product, which, being dissolved in water, filtered, and crystallized, yields Epsom salts ($MgSO_4$, $7H_2O$). During 1902 it is estimated that at least 17,500,000 pounds of this salt were produced in the United States. At least 90 per cent of the domestic output of Epsom salts produced during 1902 was consumed in the manufacture of dyes, laundry soaps, and paints, and in tanning leather; the remaining 10 per cent was used in the preparation of medicinal salts. Early in 1903 a combination was effected of the various concerns engaged in making Epsom salts in the United States. Crude magnesite is used to a minor extent in the manufacture of the magnesia alba of pharmacy. This preparation is a mixture of magnesium carbonate and hydrate.

The consumption of magnesite in its calcined state (which corresponds to magnesia, MgO) has increased very largely since 1899, owing to its uses in the form of bricks or concrete as a refractory lining for open-hearth furnaces and Bessemer converters in the steel industry, and for special parts of furnaces used in the smelting of copper and lead ores; as a lining for rotary kilns used in the manufacture of Portland cement; as a nonconducting covering for boilers, steam pipes, etc., to prevent loss of heat; and more recently in electric furnace construction as a refractory material. It is used also in the manufacture of paper stock by the sulphite process, the wood pulp being digested under pressure in calcium-magnesium acid sulphite, whereby the lignin which forms the coloring matter of the wood, as well as other incrusting material of the fiber, is converted into soluble products, which are subsequently removed by washing. The general adoption of the basic process of making steel has also largely increased the use of magnesite for furnace linings, especially in the form of bricks.

MINERAL INDUSTRIES OF PORTO RICO

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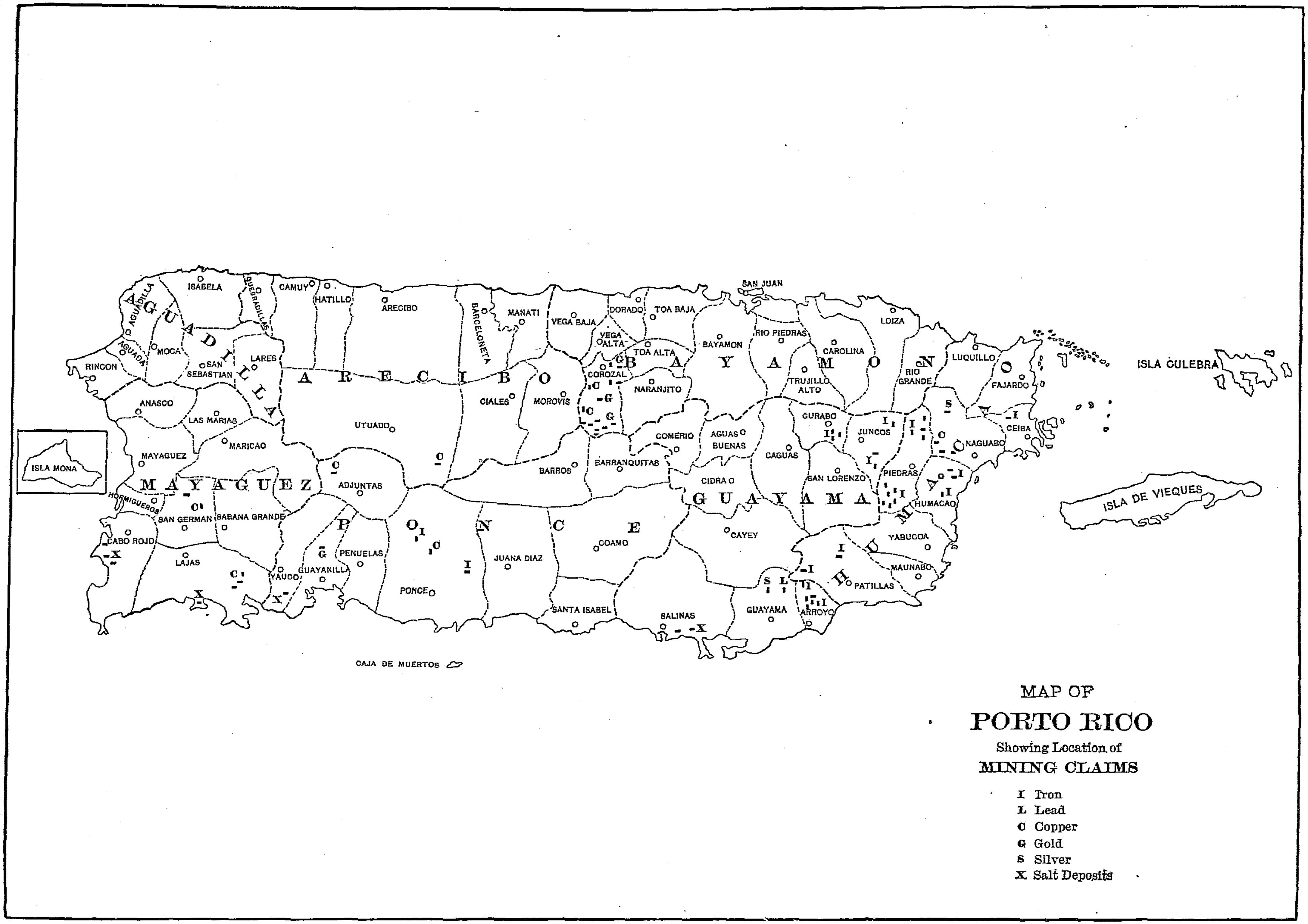

MAP OF
PORTO RICO
Showing Location of
MINING CLAIMS
I Iron
L Lead
C Copper
G Gold
S Silver
X Salt Deposits
AGUADILLA
ARECIBO
BAYAMON
MAYAGUEZ
GUAYAMA
PONCE
HUMACAO
ISLA MONA
ISLA CULEBRA
ISLA DE VIEQUES
CAJA DE MUERTOS
SAN JUAN
ISABELA
QUEBRADILLAS
CAMUY
HATILLO
ARECIBO
BARCELONETA
MANATI
VEGA BAJA
DORADO
TOA BAJA
VEGA ALTA
TOA ALTA
RIO PIEDRAS
CAROLINA
LOIZA
LUQUILLO
FAJARDO
RIO GRANDE
RINCON
AGUADA
MOCA
SAN SEBASTIAN
LARES
COROZAL
NARANJITO
TRUJILLO ALTO
ANASCO
LAS MARIAS
MARICAO
UTUADO
CIALES
MOROVIS
GURABO
JUNCOS
CEIBA
NAGUABO
MAYAGUEZ
COMERIO
AGUAS BUENAS
CAGUAS
BARROS
BARRANQUITAS
ADJUNTAS
CIDRA
SAN LORENZO
PIEDRAS
HUMACAO
HORMIGUEROS
SAN GERMAN
SABANA GRANDE
CAYEY
YABUCOA
CABO ROJO
PENUELAS
JUANA DIAZ
COAMO
LAJAS
YAUCO
GUAYANILLA
PONCE
MAUNABO
PATILLAS
SANTA ISABEL
SALINAS
GUAYAMA
ARROYO

MINERAL INDUSTRIES OF PORTO RICO.

By William F. Willoughby.

The investigation of the mineral industries of Porto Rico for the year ending December 31, 1902, report of which is given in the pages that follow, representing, as it did, the first attempt to present a comprehensive exhibit of the character and importance of the mineral resources of the island and of their exploitation, had to contend with the difficulties usually attendant upon initial statistical or census work in any field. These difficulties consisted not so much in securing data concerning mineral deposits and their working, after their existence was known, as in securing information concerning such existence and working itself. In the present case this difficulty was especially acute owing to the lack of official data and the fact that in no case were mining operations being conducted as a regular industrial enterprise. Such work as was done during the year was almost wholly of a prospecting and experimental character. Even brickmaking and stone quarrying were carried on in an intermittent manner, bricks being made as demand arose for them and quarries being worked here and there by contractors in need of material for roadmaking.

In view of these conditions it was deemed that the most important work that could be done by the investigation would consist of presenting (1) such historical data as could be obtained regarding the search for, and discovery of, minerals in the past, and efforts that had been made for their utilization; (2) a statement of the laws in force regarding the location and exploitation of mining claims; (3) a list of all mineral deposits of which information could be secured by making the most thorough investigation possible; and (4) an account, with such statistical data as could be obtained, of work actually done during the year in the utilization or manipulation of such mineral resources.

In these efforts it is believed that, thanks to the cooperation of the different insular and local officials, a large measure of success has been attained. The thoroughness of the canvass may be seen from the following statement of the means employed in securing information. In addition to the personal researches of the author and his assistants, information was sought and secured from each of the sixty collectors and deputy collectors of taxes attached to the Treasury Department of the island, whose duties are such as to make them personally acquainted with every important taxpayer or industrial enterprise in their respective districts, from the twenty-odd internal revenue agents whose duties take them to every part of the island, no matter how difficult of access, and finally from all the contractors and superintendents engaged in the construction or maintenance of the highways. The commissioner of the district of Porto Rico and the chief of the Bureau of Mines under his jurisdiction likewise rendered every possible assistance in the way of furnishing data taken from official records and in directing all of their employees to furnish any information in their power.

Mining, as generally understood in the United States, has not up to the present time been a stable industry in Porto Rico. Certain minerals were known to exist by Ponce de Leon and his followers in the early part of the sixteenth century, but no systematic or scientific methods were then, or have been since, employed in their extraction. The absence of any relics pertaining to the period antedating the discovery of the island by the Spaniards would tend to show that metals were not used in the manufacture of warlike implements or domestic utensils, neither has there been unearthed any metal adornments, such as anklets, arm rings, or similar decorations with which primitive tribes conversant with the use of metals were wont to adorn their women folk. The complete absence also of shafts, tunnels, and other evidences of ore mining, such as are being constantly uncovered in other Spanish-American countries, would further tend to confirm the opinion that neither the Borinqueños nor their Spanish conquerors practiced mining except in a desultory manner, and the lack of historical mention of such industry likewise strengthens this belief. Fray Iñigo Abad, in his "History of Porto Rico" (1788), makes reference to early remittances of gold to the Spanish peninsula, but all the gold extracted was undoubtedly obtained from river washings by enforced native labor. In his description of the effects of the great hurricane of 1530 the same historian says: "Se volvian los ojos á las minas, las veian todas sumergidas por las crecientes de los rios" (They turned their eyes to the mines, but found them all submerged by the overflow of the rivers).

Official or other reliable data relative to the geological formation of the island is also practically nonexistent. Some attempt to compile a report on the subject was made by Angel Vasconi, a Spanish engineer, and the result of his labors was laid before the directors of the Exposition of Mineralogy held at Madrid in 1883. The monograph comprising the report is not extant in Porto Rico, but a portion of the rough draft was found among the archives of the insular Bureau of Mines by its present chief and was largely drawn upon by the Governor of Porto Rico in his second annual report to the President of the United States. The information therein contained is considered worthy of reproduction as presenting in succinct and precise form what little is known of the mineral bearing formations which go to make up the soil and subsoil of this new possession of the United States.

[Extract from the second annual report of the Governor of Porto Rico to the President of the United States.]

Gold placers were worked for some years by the Spaniards in the first century of the conquest, and, according to official statistics, 2,700 pounds of gold were sent to Spain from the year 1509 to the year 1536. It is believed that that figure only represents the part belonging to the Crown of Spain—that is to say, the fifth of the total production during that period of time.

The Sierra de Luquillo, the more abrupt and the highest of all the mountains in Porto Rico, belongs to the main cordillera, or chain, which cuts the island from east to west, with a prolongation to the Windward Islands, by the east, and to the little island of Desecheo, situated opposite to Mayaguez and Añasco, by the west. That mountain, or sierra, is in the northeastern part of the island, and owing to its situation and the elevation of its hills—the highest being El Yunque, 1,200 meters [3,937 feet] above sea level—is the first vessels can distinguish in coming to Porto Rico. From El Yunque and the hills named Cuchilla Firme, Meseta, Peña Parada, and others, various rivers flow in which gold has been found. The Mameyes, one of the richer in gold, has as tributaries the rivulets known as Filipina, Cajones, Guaraguao, La Mina, La Máquina, Tabonuco, and Anon. In this last named, the Anon, some thirty-eight years ago, a rich concern did some work in the washing of sands or auriferous alluvia, obtaining from one to two pounds of fine gold per day. The rocks more abundantly found in the watershed of Mameyes River are eurite and porphyry, crossed with veins of quartz and iron pyrites. The alluvial lands occupy a good extension of the middle and lower parts of these watersheds, and are composed of clay, sand, and bowlders, forming deposits of analogous nature. Their depth is variable. In the valley of the Anon there are some cuts, from six to eight meters (20 to 26 feet) deep, made in such alluvial deposits with the view of exploiting the auriferous strata.

It is known that the watershed of the rivers Corozal, Negros, Congos, Cibuco, Mavilla, and Manatí contain auriferous sands. The idea which occurs to one examining the vicinity of Corozal is that that valley was emptied, through a process of erosion, by the diluvial waters, which produced in the calcareous soil cuts more than 130 meters [427 feet] deep, through which ran a stream. It is believed that the waters of that stream deposited the quaternary alluvia. The calcareous soil, said to be of the Tertiary formation, occupies the right shore of the river and extends itself by the north toward the sea. On the left shore, and in the bed of the river, the limestone has disappeared, giving place to potent strata of sandstone, on which the auriferous quaternary alluvia lay. The alluvial deposits are more potent the lower they are, and gold is found very near the surface in the higher and hilly parts, while, on the contrary, in the great deposits of the lower parts of the valley the auriferous strata are covered by sterile masses. Near the source of the Congos River, in the bed of it, and 25 centimeters (9.8 inches) deep, some pieces of quartz have been found containing from 8 to 10 grams [123 to 154 grains] of pure gold. In the jurisdiction of Corozal some washing machinery was established, and the result was from $2.17 to $4.30 for each ton of sand.

There are also, according to official information, some gold placers in Mayaguez, San German, Yauco, and Coamo. The gold is found in grains or nuggets of $2 or $3 value, and, rarely, nuggets of even higher value. In the Fajardo River a piece was found which weighed 4 ounces, and in the Congos another piece of 1 pound was also found; but the biggest piece of pure native gold was discovered in the lands belonging to Mr. Bou, in the jurisdiction of Corozal. That piece was sold to Mr. Bou by the finder for $200 in money and some other valuable things. In the bed of the Filipina rivulet there were obtained from 60 kilograms [132 pounds] of sand six-tenths of a gram [9 grains] of pure gold, which makes 10 grams [154 grains] for 1 ton of sand. The enterprises mentioned were abandoned, and the only work on the mines was done by the "lavadores," washmen. They use an instrument called "gaveta," made of wood, shaped like a plate, of 40 centimeters [16 inches] in diameter and 12 centimeters [5 inches] deep. In the watersheds of Mameyes River and in all the rivers crossing the jurisdiction of Corozal numbers of peasants can be seen engaged in the work of washing auriferous sand, from which they obtain gold in amount sufficient to pay for their support.

Since the American occupation, work on the mines has had renewed life, and the number of applications for mining concessions filed in the Bureau of Agriculture and Mines has increased. Up to July concessions have been granted for 107 hectares (264 acres) of land.

The minerals of copper obtained are: Ferriferous motley copper, native copper, green and blue carbonates, yellow copper sulphide, often accompanied with iron pyrites and iron oxides. Spanish explorers of the island paid little or no attention to copper. It is generally found along the main chain of mountains dividing the island from east to west, from the neighboring island of Vieques, and then following through Rio Blanco, Gurabo, Corozal, Ciales, Jayuya, Maricao, and some other places which belong to the southern chain of mountains, such as Las Piedras, Humacao, Ponce, Piñalejo, and also in the vicinity of the road from Caguas to San Juan, the richest place being the barrio of Rio Blanco, in the municipality of Naguabo. The first works for the exploitation of copper began in 1869. In the mine named "La Abundancia" some small excavations were made, and the superficial carbonate was gathered, and many tons of rich mineral were thus obtained. Like results were reached in the mines named Santa Amalia, La Castellana, and Santa Teresa, all located in the barrio of Rio Blanco. In the last-named mine copper indications were noted from the surface to a depth of 25 meters [82 feet], first as green carbonate with 23 per cent of copper, then as ferriferous motley copper, and, in some parts, yellow sulphide, very pure. In 1879, 10 tons of copper sulphide were obtained from the mine Santa Teresa, and 60 tons of carbonate of copper from the Santa Amalia. Owing to the difficulties and high prices of transportation, work ceased.

The existence of silver in the island has been officially recognized. On July 19, 1538, the "oficiales reales" wrote to the King of Spain that "veins of lead containing some silver have been found," and on March 29 of the following year they wrote, "With respect to the silver mines here discovered we arranged that that mineral be fused here, but there is no person who knows how to do it. In some places veins of that metal have been found, but nothing has been done, waiting the arrival of some one who knows how to fuse and work it." In the History of Porto Rico, by Fray Iñigo Abad, with notes by Don José Julian Acosta, the statement is made that in the Serrania de Añasco there was a mine containing silver; and, in a report prepared in 1879 by the chief engineer of the bureau of mines, reference is made to certain samples of silver found in the barrio Llamos, of the municipality of Isabela. In other official documents the existence of silver in the northwestern part of the island is affirmed. Concessions have been made of silver mines in Naguabo, Corozal, Rio Grande, Fajardo, Lajas, and Las Piedras.

In the subsoil of the eastern part of the island there is feldspathic rock. This section is confined on the north by the Sierra de Luquillo, and on the south by the Pandura, parallel ranges of hills, and distant one from the other from 25 to 30 kilometers (16 to 19 miles). It is stated that the surface lodes occupy a large area, the depth not having been determined as yet. Iron is found, according to tests made, at the rate of 61 per cent of the mineral. Iron of excellent quality has been found in the barrios Mameyes and Jayuya, municipality of Utuado, and in Luquillo, Piedras, Naguabo, Humacao, Gurabo, Patillas, San Lorenzo, and Arroyo. The concessions of iron mines are numerous. Some efforts are being made now with the view of organizing enterprises for the exploitation of iron in the eastern part of the island.

There are in the island, according to official information, some deposits of lead minerals. Good samples of galena have been found in Arroyo, Mayaguez, and Naranjito. There are two concessions granted in the municipality of Guayama, one being for the exploitation of lead and the other for argentiferous galena. Minerals containing some amount of peroxide of manganese have been gathered in the vicinity of Corozal. Native bismuth has been discovered in Ponce. Samples of platinum, tin, and mercury have been obtained in the jurisdiction of Corozal.

All other official reports touch but lightly on the mineral resources of the island and do not convey any information not embodied in the foregoing extract. Mr. Robert T. Hill, of the United States Geological Survey, in his accurate and interesting work entitled "Cuba and Porto Rico," devotes but ten lines to the subject, saying:

A little placer gold is found in the rivers of the Sierra Luquillo and Corozal, and mercury in the Rio Grande. Gold was formerly mined by the early Spanish settlers and is still taken out in small quantities by the natives. Molybdena, magnetic pyrite, manganite, limonite, chrysocolla, epidote, and garnet are the minor minerals found. Specular iron is reported in several places, notably in the river Cuyul. Magnetic iron is also reported from Gurabo and Ciales. Crystals of quartz are found in the Rio Prieto, agate of good quality at Caja de Muertos, and malachite at Rio Blanco.

MINING LAWS.

Notwithstanding the absence of anything approaching an organized mining industry in Porto Rico there is, nevertheless, a complete system of laws and regulations governing the right to exploit both precious and base metals in the island.

This is substantially contained in the law of July 6, 1859, and the ministerial order of December 29, 1868, enacted originally for application in the Spanish peninsula only, but subsequently extended to Porto Rico by the law of May 3, 1895. Many of the provisions of these statutes have by reason of the change of sovereignty become inapplicable, and it is understood that a new mining law is being drafted and will be presented at the next session of the insular legislature. In so far as possible, however, the principles and procedure of the existing laws are being observed, and deficiencies arising from changed political conditions treated by analogy.

Minerals subject to mining claims are divided by the law into three classes, as follows:

Class I: Minerals of an earthy nature, minerals of a siliceous nature, slates, minerals of a sandy nature, granites, basalts, limestones, gypsums, sands, marls, clayey earths, construction materials in quarry formation.

Class II: Placers, metallic sands or alluvia, bogs, emery, ochers and almagras, scoria and mineral tailings, peats, pyritic earths, aluminous earths, magnesium earths, salt deposits, lime phosphates, barytes, fluorspars, steatites, ravolins, clays.

Class III: Metallic veins, anthracites, pit coals, lignites, asphalts, bitumens, petroleum and mineral oils, graphites, saline substances, including alkaline and terraceous salts, either solid or in solution, copperas, sulphur, precious stones, iron ores.

In order to obtain legal title to a mining claim the claimant must submit a petition to the Commissioner of the Interior of Porto Rico setting forth the area of the desired claim, the class of mineral to be worked, and the name of the owner of the property wherein the claim is situated. He must also furnish a survey of the claim and, within ten days from date of filing his petition, must deposit the sum of $36 if the claim does not exceed in area 12 pertenencias (30 acres), and $1.20 for each additional pertenencia. No claim can be filed for less than 4 pertenencias, but there is no limit to the number of pertenencias that may be included in one claim. Each pertenencia must, however, be contiguous along the whole of one of its sides to some other pertenencia of the same claim, and must consist of a regular square, each side measuring 100 meters (328 feet). The aforesaid deposit is to cover the expense of an official survey made later by the Government. The first conditions being complied with, the petition is advertised for sixty days to enable protests to be filed, which protests are submitted to the claimant for reply within twenty days. The complete brief is then passed upon by the Commissioner of the Interior of Porto Rico, and his decision, if favorable to the claimant, is followed by the appointment of a surveyor to lay out the claim and the payment of a further fee by the claimant, amounting to 60 cents per pertenencia ($2\frac{1}{2}$ acres), to cover expenses of title. A title signed by the Governor is then issued, and is valid forever, subject to an annual rental (canon de minas) of $2.40 per pertenencia for precious metals, or 96 cents per pertenencia for base metals. This title does not carry any obligation to work the mine, and lapses only on failure to pay the annual rental.

Pending legislation relative to the disposition of public lands (terrenos baldios), no mining claims are being allowed on public property.

PRECIOUS METALS.

There are at present twenty mining claims registered on the books of the Bureau of Mines, none of which, however, is in operation.

Registered mining claims of precious metals.

NAME OF OWNER.	Name of mine.	LOCATION OF MINE.			AREA OF MINE—		Class of mineral said to exist.
		Department.	Municipal district.	Ward.	In hectares.	In acres.	
Henry D. Sayre	San Luis	Bayamon	Corozal	Negros	18	44	Gold.
Do	O'Reylly	do	do	Padilla	25	62	Gold and other.
Do	Sayre	do	do	Palos Blancos	14	35	Do.
Josef Zervas	Augusta	Ponce	Guayanilla	Pasto	24	59	Do.
Wm. B. Crawford	La Palma	Bayamon	Toa Alta	Palmarejo	12	30	Do.
Henry D. Sayre	Rachel	do	Corozal	Cuchillas	32	79	Do.
Do	Lena	do	do	Negros	12	30	Do.
Do	Henry	do	do	Cuchillas	35	86	Do.
Do	The World	do	do	Palos Blancos	148	366	Do.
Do	Huyler	do	do	Cuchillas	12	30	Do.
Do	Dunham	do	do	do	12	30	Do.
Do	Mate	do	do	Negros	12	30	Do.
M. Lancaster	Palmarejo	do	do	Palmarejo	24	59	Do.
D. McLean	Florine	do	do	Palos Blancos	25	62	Do.
Do	Edwin	do	do	Dos Bocas	12	30	Do.
Henry D. Sayre	Ethel	do	do	do	17	42	Do.
C. Bernstein	Catinesterlila	Humacao	Luquillo	Mameyes	12	30	Auriferous sand.
Argueso & Miner	Ernestita	do	Naguabo	Rio Blanco	100	247	Silver and nickel.
D. McLean	Vanderbilt	Bayamon	Corozal	Dos Bocas	12	30	Silver and other.
Hogan & Pierce	Reina del Cobre	do	do	do	12	30	Do.

All of these claims have been filed since the American occupation of the island, and some little exploration work has been done in the case of a few of the claims situated in the Corozal district. The owners of each of the above-enumerated claims have been interrogated by letter as to whether their respective claims were in operation, but except from the owners of two of these claims (Augusta and La Palma) no response has been elicited. The owners of the other mines are not to be found at present in the island. It may, therefore, truthfully be said that ore mining of precious metals is entirely prospective and confined to the filing and registration of the above-mentioned claims, none of which is being exploited.

PLACER GOLD MINING.

Such gold mining as is actually engaged in at present in Porto Rico is entirely of the placer type, unimportant in scope and confined to the Corozal district of the island. There are some twenty or more miners of the peon class engaged steadily in the work of extracting gold from the sands of the river by means of an oscillating movement of the hands applied to a wooden disk in which the sands are washed. From the best information obtainable, the value of the gold thus secured daily will aggregate, approximately, $25. It is understood that Mr. Henry D. Sayre, who is the *concessionaire* of eleven mining claims in the Corozal district, intends shortly to operate on an extensive scale. Mr. Sayre is an experienced miner, who has invested a considerable sum of money in exploration, surveys, and assays in Porto Rico, and is said to be very favorably impressed with the mineral wealth of the Corozal district. He has recently applied to the executive council of Porto Rico for a franchise authorizing him to divert the waters of the Mabille river from their natural course with a view to obtaining the deposits of gold in the river bed. Whether any attempt at ore mining will be made by Mr. Sayre is not at present known, but it is understood that he claims to have discovered the original veins from which the deposits in the river bed are derived. Although there is evidence of placer mining having been practiced in other parts of the island as well as in the Corozal district, particularly in the vicinity of San German, no mining for gold is at present carried on outside of the Corozal region. This failure to operate elsewhere in the island is doubtless due to the belief that the gold deposits in other sections have become so nearly exhausted as to preclude their extraction in quantities profitable even for the peon class.

BASE METALS.

The foregoing description of the situation relative to precious metals applies almost in its entirety to the baser metals. The following mining claims have been filed and are registered in the office of the Commissioner of the Interior of Porto Rico, but no single one of the mines appearing in the list is actually being operated.

Registered mining claims of base metals.

Name of owner.	Name of mine.	Location of mine.			Area of mine—		Class of mineral said to exist.
		Department.	Municipal district.	Ward.	In hectares.	In acres.	
Arturo H. Noble	Corcega	Ponce	Adjuntas	Guilarte	12	30	Copper.
John W. Conner	Freddie	Mayaguez	San German	Hoconuco Bajo	18	44	Do.
Pedro Santisteban	Soledad	Bayamon	Corozal	Padilla	6	15	Do.
Do	Elena and Eugenia	Mayaguez	Lajas	Lajas Arriba	15	37	Copper and other.
Do	Capron	do	do	do	15	37	Do.
Angel Mattey	Mercedes	Arecibo	Utuado	Jayuya	12	30	Copper and iron.
Henry D. Sayre	Anaconda No. 2	Mayaguez	San German	Cain Alto	40	99	Copper and other.
Miguel Porrata	Maria Josefina	Ponce	Ponce	Tibes	25	62	Do.
Alejandro Fernandez	Perseverancia	Humacao	Naguabo	Rio Blanco	12	30	Copper carbonate.
Manuel Ugalde	Esperanza	do	do	do	12	30	Do.
Argueso & Miner	Santa Amalia	do	do	do	100	247	Copper sulphate.
Pedro Santisteban	Santa Agueda	Mayaguez	Lajas	Lajas Arriba	15	37	Copper sulphate and carbonate.
Miguel Planellas	Estrella	Guayama	Guayama	Carmen	12	30	Lead.
Arturo Aponte	Rosita	do	do	do	12	30	Galena.
Pedro Santisteban	Esperanza	do	Juncos	La Ceiba	96	237	Iron.
Do	Eloisa	Humacao	Piedras	Colores	25	62	Do.
Do	Carranzana	Guayama	Juncos	do	20	49	Do.
Do	Palonia	Humacao	Piedras	Boqueron	40	99	Do.
Do	San Miguel	do	do	Colores	21	52	Do.
Do	San Anton	do	Humacao	Collores	12	30	Do.
Do	Begoña	do	Piedras	Colores	21	52	Do.
Do	Luisa	do	do	do	13	32	Do.
Do	Buen Suceso	Guayama	Gurabo	Mamey	71	175	Do.
Do	Providencia	Humacao	Patillas	Mariana	50	124	Do.
Jose Santisteban	San Pedro	do	Piedras	Boqueron	39	96	Do.
Do	San Ramon	do	do	do	47	116	Do.
Do	San Jose	do	do	do	28	69	Do.
Do	Asuncion	Guayama	Gurabo	Jagual	30	74	Do.
Do	Valentina	Humacao	Piedras	Colores	15	37	Do.
Do	Santo Tomas	do	do	do	12	30	Do.
Tomas R. Nido	Fortuna	Guayama	Arroyo	Ancones	24	59	Do.
Carlos McCormick	Idalia	do	do	Laurel	77	190	Do.
Guillermo McCormick	El Bronce	do	do	do	31	77	Do.
Cayetano Rangel	La Victoria	Ponce	Ponce	Portugues	6	15	Do.
Pedro Santisteban	Sabina	Humacao	Humacao	Collores	36	89	Iron and other.
M. Porrata Doria	Celina	do	Fajardo	Chupacallos	24	59	Do.
Argueso & Miner	Maria	do	Humacao	Mariana	8	20	Do.
J. Cobian Valdes	Casualidad	Guayama	Arroyo	Ancones	18	44	Oxide of iron.
Carlos McCormick	Seguridad	do	do	Laurel	54	133	Do.
Tomas R. Nido	Merceditas	do	do	do	93	230	Do.
Carlos McCormick	Palmira	do	do	do	62	153	Do.
Do	Margarita	do	do	do	53	131	Do.
Raimundo Uriarte	Aurora	Ponce	Ponce	Tibes	24	59	Do.
Pedro Gandia	Natividad	Humacao	Patillas	Real	54	133	Do.
Pedro Santisteban	Caridad	Guayama	Gurabo	Mamey	21	52	Do.
Do	La Fe	do	Juncos	Ceiba Norte	14	35	Sesquioxide of iron.
Ramon Latimer	Pilar	Bayamon	Corozal	Palmarejo	12	30	Pirolusita.

A letter of inquiry was sent to each of the owners of the above claims. The replies received may be classified as follows:

Not operated.—Pilar, Natividad, Aurora, Fortuna, Merceditas, Soledad, Eugenia, Capron, Santa Agueda, Eloisa, Esperanza, Carranzana, San Miguel, San Anton, Begoña, Luisa, Buen Suceso, Providencia, Sabina, Caridad, La Fe, San Ramon, San Jose, Asuncion, Valentina, San Pedro, Palonia, Santo Tomas, Mercedes.

Operations suspended.—Estrella, Rosita.

Operations confined to exploration and assay.—Maria Josefina, Celina.

Not reported.—Corcega, Freddie, Anaconda No. 2, Perseverancia, Santa Amalia, Idalia, El Bronce, La Victoria, Maria, Casualidad, Seguridad, Palmira, Margarita.

It is understood that some of the iron ore deposits are of an exceptionally rich character, fully equal in percentage of mineral to the famous Daiquiri mines near Santiago de Cuba. These deposits are situated inland some five or six miles from the eastern seacoast town of Naguabo, and can not be operated with profit until means of transportation is furnished to tide water.

SALT.

The production of salt in Porto Rico is confined exclusively to the southern coast. The process of solar evaporation is the only one employed, and that in its most primitive form. The consumption of this article, estimated from the best data obtainable, is about 300,000 quintals (15,000 tons) per year. All salt required for home consumption, as well as a large amount in excess for export purposes, could readily be produced in the island, but owing to insufficient capital (as alleged by persons engaged in the industry), want of skill in operating, or inclemency of the elements, and notwithstanding the fact that a protective duty of 12 cents per hundredweight has been imposed on foreign salt introduced into Porto Rico, thousands of tons of this commodity are annually imported from Curaçao. The Curaçao salt meets with ready sale here at prices ranging from 20 to 50 cents per quintal, whereas it is claimed that with proper management salt can be produced in Porto Rico at a maximum cost of 10 cents per quintal.

The production of salt in 1902 was almost nil. A canvass gave the following results:

Production of salt: 1902.

NAME OF OPERATOR.	Address of operator.	LOCATION OF WORKS.		Salt produced.	Package.	Value of package.	Net value of salt.	Process employed.
		Department.	Municipal district.					
Juan Padilla	Cabo Rojo	Ponce	Yauco	[1] 5,000	Sack	$0.03	$1,250	Solar.
Aneeto Caballero	Salinas	Guayama	Salinas	[1] 2,000	....do		800	Do.
Juan Miguel Toro	Cabo Rojo	Mayaguez	Cabo Rojo	[2] 650	....do		540	Do.
U. Lopez & Co.	San German	....do	Lajas		....do	.03		Do.

[1] Hundredweight. [2] Bushels.

In view of the abnormally small production of salt in Porto Rico in 1902, shown in the above statement, it is of interest to reproduce here the reasons advanced therefor by some of the operators:

The reason of the production of the extremely small quantity of 650 bushels is the heavy rains which fell during the year 1902. In other years six, eight, or ten times the amount was produced.

The insignificant duties paid by foreign salts give rise to the anomalous condition in Porto Rico of importations from Curaçao and other places of a larger amount of salt than is manufactured in the island.

During the year 1902 no salt was produced from the deposit (Fortuna), the hurricane of 1899 having completely destroyed its utility to its former owners, and the whole of said year (1902) being employed by its present lessees in getting it into shape again.

Said deposits (Carmen and Monserrate) have in former years produced 25,000 to 30,000 quintals. The small production in 1902 was owing to the early rains along this coast.

The salt industry of Porto Rico does not produce the fifth of what it should, owing to the lack of capital on the part of the operators. With an initial expenditure of $5,000 the deposit I own should produce 100,000 quintals of salt.

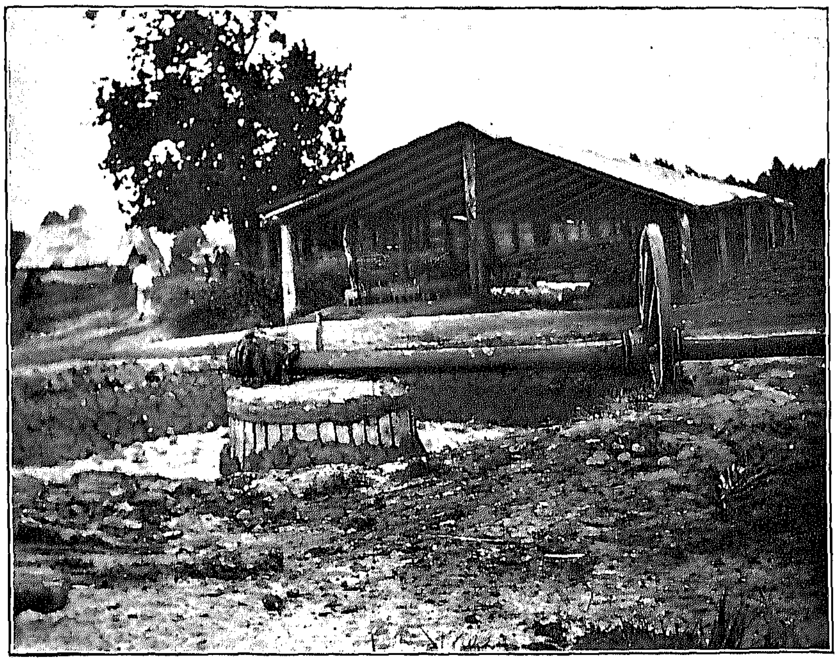
CLAY PRODUCTS.

No attempt has heretofore been made in Porto Rico to canvass this industry, consequently there were no initial data available to aid in the present study. It was known, in a general way, that bricks were made in the island, also that no modern machinery was utilized in their manufacture.

That the industry was not extensive or important was quite evident from the absence of brick edifices and the almost universal use of lumber in the construction of dwelling houses, except in the cities of San Juan, Ponce, and Mayaguez. This first inquiry, therefore, could not be other than crude and incomplete, by reason of the following facts: (1) No previous statistics existed showing establishments engaged in the industry; (2) brickmaking was not engaged in continuously by any one establishment, ovens being baked, from time to time, as the necessity demanded; (3) lack of precise information on the part of the operators themselves as to number of bricks made, their actual cost, average selling price, etc. For the foregoing reasons it is apparent that many persons who engage in the manufacture of brick as occasion therefor arises could not be reached at all. In the brief period at the disposal of the writer it was not possible to ascertain the location of more than 35 operators. Of these, 30 were successfully interrogated, with the results shown in the following table:

Clay products: 1902.

NAME OF OWNER.	LOCATION OF OFFICE AND FACTORY.		COMMON BRICK.			KILNS.	
	Department.	Municipal district.	Number.	Value.	Process used in making.	Kind used.	Number used.
Luis A. Bonnet	Vieques	Vieques	150,000	$1,500	Hand labor	Brick oven	1
Gavino Garces	Mayaguez	San German	60,000	360	....do	....do	2
Mariano Gonzalez	Bayamon	Carolina	120,000	250	....do	....do	1
Francisco Parra	Ponce	Santa Isabel	150,000	750	....do	....do	1
Federico Guzman	Mayaguez	San German	50,000	300	....do	....do	1
Santos Franceschi	Ponce	Coamo	20,700	144	....do	....do	1
Jesus Diaz	....do	Yauco	100,000	500	....do	....do	2
Hacienda Florida	....do	....do	150,000	750	....do	....do	3
Isidro Sanjurjo	Mayaguez	Mayaguez	240,000	1,680	....do	....do	2
Mariano Renovales	Ponce	Juana Diaz	100,000	720	....do	....do	2
Vilella Hermanos	Aguadilla	Lares	50,000	400	....do	....do	1
José Irizarri	Ponce	Ponce	200,000	1,200	....do	....do	1
N. Arabia	....do	....do	800,000	5,200	....do	....do	2
Teresa Bardeguez	Humacao	Yabucoa	36,000	324	....do	....do	1
Suen. C. Velasquez	Ponce	Juana Diaz	120,000	720	....do	....do	1
Severiano Ramirez	Mayaguez	Cabo Rojo	50,000	350	....do	....do	2
Gumersindo Lluch	....do	....do	17,000	136	....do	....do	1
Manuel G. Muñoz	Guayama	Cayey	80,000	640	....do	....do	1
M. Munitiz	....do	....do	80,000	480	....do	....do	1
Soc. Agricola "Tuna"	....do	Guayama	250,000	2,000	....do	....do	2
Alfredo Cristy	Mayaguez	Mayaguez	180,000	1,260	....do	....do	4
Balbino Rodriguez	Aguadilla	Aguada	20,000	140	....do	....do	1
Fco. Antongiorgi	Ponce	Yauco	150,000	750	....do	....do	3
Mariana Sierra	Aguadilla	Aguadilla	66,350	520	....do	....do	1
Viuda de Battle	Mayaguez	Mayaguez	46,700	340	....do	....do	1
F. A. Vendrell	Ponce	Santa Isabel	50,000	300	....do	....do	1
Federico Gatell	Mayaguez	Mayaguez	100,000	700	....do	....do	2
J. Caloca	Bayamon	Rio Piedras	150,000	1,250	....do	....do	1
Juan Perez	....do	....do	135,000	1,080	....do	....do	1
Ca. Azucarera del Este	Humacao	Yabucoa	115,505	1,155	....do	....do	1
Total			3,837,255	25,899			45



PORTO RICO—OX-POWER WHEEL FOR MIXING CLAY.

PORTO RICO—MOLDING BRICKS BY HAND.

The foregoing table shows that in 45 kilns 3,837,255 common bricks, valued at $25,899, were produced in 1902, or an average price of $6.75 per thousand. It is not believed, however, that this actually represents the total number of bricks manufactured in one year in Porto Rico; probably three times the above number would more nearly approach a correct estimate. The process employed is absolutely and literally the hand process, and consists in mixing the clay with water in a wooden trough until the requisite consistency is obtained. The mass is then molded into bricks by hand, the operator employing a wooden mold for that purpose. The crude bricks are afterwards placed in a brick oven and baked, when they are ready for market. Bricks made in this manner are not nearly so durable as those manufactured in the United States by means of approved modern machinery. Clay roofing tiles were extensively manufactured in Porto Rico at one time, but since the introduction of cheap iron roofing have entirely disappeared from use.

LIMESTONE.

With the exception of the fringe of flat lands lying between the coast line and the mountainous formations in the interior, the island of Porto Rico is practically one vast limestone deposit. Owing to its abundance and accessibility, and to the fact that its conversion into the proper form for use in building and kindred purposes requires no large outlay of capital, the industries having to do with lime rock, while quite numerous, are too scattered and unimportant to admit of the compilation of statistics on any elaborate scale. It is by reason of the foregoing considerations, also, that limestone and its products command no stable price in Porto Rico. Owing to the propinquity of certain quarries to points at which the material is needed, owners of such quarries can at times find a market for limited quantities of the stone at prices ranging from 3 to 10 cents per cubic meter. In such cases, however, the actual work of the extraction of the stone and its subsequent delivery to the place where required is generally attended to by the purchaser of the stone rather than by the owner of the quarry, and on account of the insignificant value of the material no attempt is made to keep an accurate record of the quantity used. By far the most important item of expense in connection with the use of the stone is that of transportation. The following table of quarries adjacent to the principal public highways already constructed or in course of construction in Porto Rico, many of which are themselves constructed of and upon limestone formations, will serve to illustrate the bountifulness of the supply of lime rock in the island. A list is given of the quarries that have been opened up and from which limestone has been actually extracted. These quarries are grouped according to the highway near which they are located, and their exact location is shown in the first column, which gives the number of kilometers and meters with the equivalent in miles and yards they are distant from the town first mentioned after name of the road at the head of the respective groupings:

Road from San Juan to Ponce.

Location.		Kind of stone.	Owner.
In kilometers and meters.	In miles and yards.		
7.700	4-1,381	White limestone	P. Ubarry.
20.300	12-1,080	Blue limestone	Public works.
25.200	15-1,159	Calcareous	Do.
25.200	15-1,159	....do	P. Larrosa.
54.900	34-199	....do	L. Rodriguez.
55.800	34-1,184	....do	N. Nunez.
61.100	37-1,700	....do	J. Fernandez.
61.400	38-268	....do	F. Fernandez.
67.000	41-1,112	Limestone	Heraclio Mendoza.
78.200	45-852	....do	Public works.
78.200	48-1,040	....do	Gavino Rodriguez.
84.000	52-343	....do	Public works.
85.100	52-1,546	....do	—. Taboada.
87.700	54-870	....do	Public works.
90.900	56-849	....do	Dona Paz.
94.200	58-938	....do	Domingo Emanuelli.
99.500	61-1,454	....do	Teodoro Santiago.
100.300	62-569	....do	Julio M. Larrauri.
104.100	64-1,205	....do	Jorge Velez.
105.300	65-757	....do	Pedro Quevedo.
106.600	66-419	....do	C. Caratini.
107.600	66-1,403	....do	Do.
108.200	67-409	....do	Remigio Mateo.
111.900	69-935	Blue limestone	José Esbri.
111.100	69-60	....do	Julian Plaza.
114.300	71-40	....do	Sucesores Gallart.
120.100	74-1,103	White and yellow limestone.	Manuel Cristian.
125.400	77-1,619	....do	Sucesores Serralles.
126.600	78-1,171	....do	Manuel Leon Parra.
126.100	78-624	Blue limestone	Joaquin Arce.
128.100	79-1,052	....do	José S. Valdes.
129.200	80-495	White and yellow limestone.	José Usera.

Road from Catano to Vega Alta.

6.900	4-506	White limestone	P. Lavandero.
7.900	4-1,600	....do	A. Santos.
11.600	7-366	....do	A. Acevedo.
11.900	7-694	....do	S. Olivo.
13.300	8-465	....do	
14.900	9-455	....do	I. Sanchez.
15.100	9-674	....do	J. Perez.
15.100	9-674	....do	N. Roman.
15.100	9-674	....do	L. La Cruz.
16.500	10-445	....do	S. Martinez.
17.200	10-1,210	....do	I. Sanchez.
20.200	12-971	....do	A. Echeveste.
23.300	14-841	....do	Mr. Miner.
23.700	14-1,279	....do	Mr. Lothrop.
24.200	15-65	....do	Mr. Stevens.

Road from Caguas to Humacao.

6.700	4-287	Blue limestone	M. Portela.
7.200	4-834	....do	F. Echevarria.
9.700	6-48	....do	T. Hernandez.
11.500	7-257	White limestone	R. Jimenez.
13.200	8-356	....do	M. Mendez.
14.500	9-17	....do	Sucesores Farnia.
14.700	9-236	....do	Sucesores Rodriguez.
16.000	9-1,658	....do	C. Serrano.
17.450	10-1,484	....do	Sucesores Rodriguez.
19.500	12-205	....do	Julio Gay.
22.800	14-294	Blue limestone	S. Rivera.
25.400	15-1,378	....do	F. Lopez.
25.500	15-1,487	....do	Do.
28.100	17-810	....do	Luis Celis.
28.100	17-810	....do	F. Arroyo.
32.400	20-233	Dark limestone	S. Rocafort.
34.500	21-770	....do	D. Carmona.

Road from Rio Piedras to Fajardo.

Location: In kilometers and meters.	Location: In miles and yards.	Kind of stone.	Owner.
2.200	1-646	Blue limestone	J. Gonzalez.
2.700	1-1,193	White limestone	Manuel Falu.
3.800	2-686	....do	E. Gómez.
5.000	3-188	....do	E. Van Rhyn.
5.500	3-735	....do	José Ubarry.
8.400	5-386	Blue limestone	M. Pérez.
11.100	6-1,579	....do	S. de Ezquiaga.
15.100	9-674	....do	Francisco Jimenez.
16.200	10-117	....do	Basilio Pineiro.
16.600	10-554	....do	R. H. Delgado.
18.300	11-653	Yellow limestone	Factoria Central.

Road from Reyes Catolicos Bridge to Corozal.

Location: In kilometers and meters.	Location: In miles and yards.	Kind of stone.	Owner.
2.300	1-755	White limestone	I. Sanchez.

Road from Manati to Ciales.

Location: In kilometers and meters.	Location: In miles and yards.	Kind of stone.	Owner.
1.400	0-1,531	White limestone	F. Calaf.
8.900	5-933	....do	V. Cortes.
10.110	6-496	....do	F. Caso.
11.500	7-257	....do	Fernández & Co.

Morovis Branch.

Location: In kilometers and meters.	Location: In miles and yards.	Kind of stone.	Owner.
3.700	2-526	White limestone	F. Fuxench.
5.006	3-195	....do	E. Cacho.
8.000	4-1,709	....do	J. Cordero.

Comerio Road.

Location: In kilometers and meters.	Location: In miles and yards.	Kind of stone.	Owner.
1.100	0-1,203	White limestone	J. R. Carmona.
2.800	1-1,302	....do	M. Ponton.

Road from Cayey to Arroyo.

Location: In kilometers and meters.	Location: In miles and yards.	Kind of stone.	Owner.
1.420	0-1,553	Limestone	Joaquin Fernández.
4.000	2-854	White limestone	Public works.
5.000	3-188	....do	Do.
8.000	4-1,709	....do	Do.
12.000	7-803	....do	Do.
14.800	9-345	Limestone	C. Cruet.
23.500	14-1,060	....do	F. Ortiz.
28.800	17-1,576	....do	Guayama municipality.

Road from Ponce to Adjuntas.

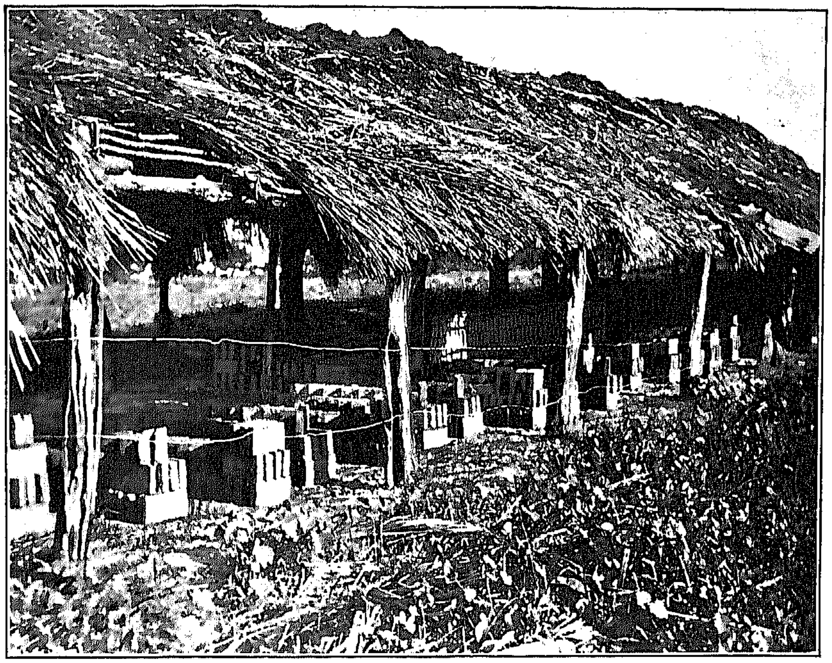
Location: In kilometers and meters.	Location: In miles and yards.	Kind of stone.	Owner.
1.500	0-1,640	Limestone	José Irizarry.
2.800	1-1,302	....do	Julio N. Chardon.
3.200	1-1,740	....do	Do.
3.200	1-1,740	....do	Tomás Armstrong.
3.300	2-89	....do	Sucesores Chardon.

The statements in regard to limestone preceding the above table apply with equal force to lime in its commercial forms. Practically every farmer in the interior of the island can, and does, produce lime in greater or less quantities, according to his needs, of which no account is kept. A canvass of such persons as could be ascertained to be engaged in the sale of lime in any of its forms gave the results appearing in the following table:

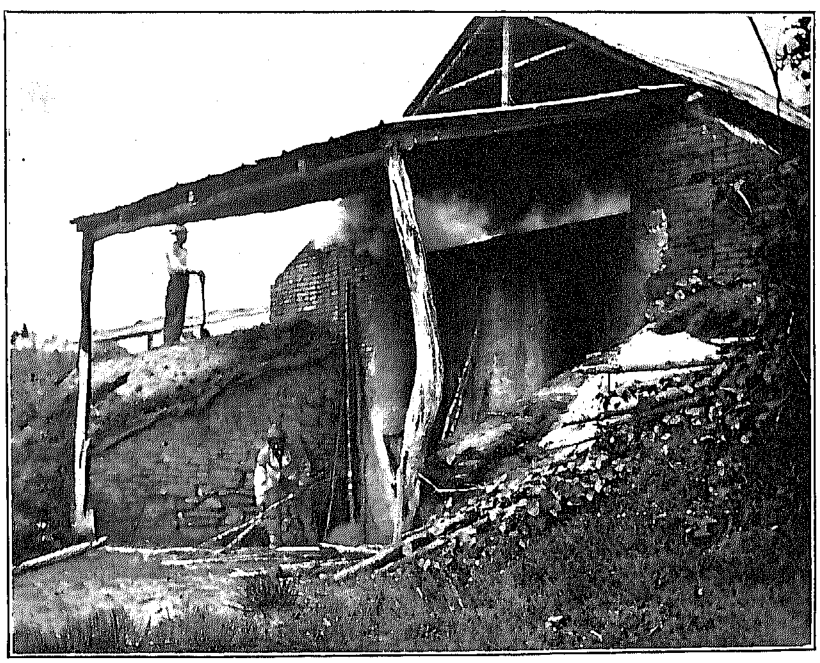
Production of limestone: 1902.

Name of owner.	Location of quarry: Department.	Location of quarry: Municipal district.	Limestone quarried: For building purposes: Quantity— In cubic meters.	Limestone quarried: For building purposes: Quantity— In cubic yards.	Limestone quarried: For building purposes: Value.	Limestone quarried: Stone burned into lime: Quantity— In cubic meters.	Limestone quarried: Stone burned into lime: Quantity— In cubic yards.	Limestone quarried: Stone burned into lime: Value.	Crushed stone for roadmaking: Quantity— In cubic meters.	Crushed stone for roadmaking: Quantity— In cubic yards.	Crushed stone for roadmaking: Value.	Total value.	Condition of trade in 1901 compared with 1902.
Tomás Armstrong	Ponce	Ponce							80	105	$60	$60	About the same.
Victor Martino	....do	....do	30	39	$90	115	151	$347				437	In 1901 better than in 1902.
Francisco Fiol	....do	....do							950	1,243	95	95	
Narciso Manescau	....do	....do	33	43	16							16	In 1901, flourishing; in 1902, dull.
José B. Ortiz	....do	....do	50	65	15							15	
Trujillo & M. Mercado	....do	....do				400	523	150				150	In 1901 better than in 1902.
Esteban de Leon	....do	....do				50	65	25				25	
José F. Valls	....do	....do				200	262	600				600	Much better in 1901.
Clavell Hermanos	....do	....do				70	92	210				210	1901 the same as 1902.
Ramón Ortiz Quintana	....do	....do				20	26	60				60	Much better in 1902.
Jaime Bas Garcia	....do	....do	50	65	25							25	
Esteban Ortiz	....do	....do							950	1,243	2,177	2,177	
Carlos Gilot	....do	....do							915	1,197	2,096	2,096	
Monserrate Ramos	Mayaguez	Cabo Rojo							90	118	248	248	Not operated.
José Villa	....do	....do							60	78	16	16	Not operated in 1901.
José Ortiz	....do	....do							40	52	4	4	
Sebastián Bausá	Bayamon	Bayamon							500	654	25	25	1901 the same as 1902.
Juan B. Cesareo	....do	....do				65	85	26				26	Better in 1902.
Vilella U. Hermanos	Aguadilla	Lares				100	131	50				50	Quarried only 65 cubic yards in 1901.
Emilio Torres	....do	....do	50	65	25				80	105	40	65	Not operated in 1901.
E. B. Pérez	Mayaguez	Las Marias				77	101	180				180	Do.
F. Philippi	....do	....do				25	33	100				100	1901 the same as 1902.
Marcos Ortiz	Ponce	Juana Diaz				60	78	240				240	Do.
Cristino Siuró	....do	....do	[1]15	20	45	60	78	180				225	
C. Dejardins	Mayaguez	Maricao				20	26	10				10	1901 the same as 1902.
Nicanor Santana	....do	....do				50	65						
José B. Dumont	Guayama	Cayey				15	20	75				75	1901 the same as 1902.
Vicente Vazquez Martinez.	....do	....do				14	18						Do.

[1] For flagging.



PORTO RICO—DRYING BRICKS PREVIOUS TO FIRING.



PORTO RICO—FIRING A BRICK-LOADED OVEN.

Production of limestone: 1902—Continued.

NAME OF OWNER.	LOCATION OF QUARRY.		LIMESTONE QUARRIED.						CRUSHED STONE FOR ROADMAKING.			Total value.	Condition of trade in 1901 compared with 1902.
			For building purposes.			Stone burned into lime.			Quantity—		Value.		
	Department.	Municipal district.	Quantity— In cubic meters.	Quantity— In cubic yards.	Value.	Quantity— In cubic meters.	Quantity— In cubic yards.	Value.	In cubic meters.	In cubic yards.			
Eugenio Gómez	Bayamon	Rio Piedras							100	131			
Juan Mollfulleda	do	Carolina				24	31	$58				$58	Better in 1901.
Eladio Marquez	do	do							250	327	$3	3	
Sobrinos de Ezquiaga	do	do				25	33	100				100	Not operated.
Juan Moreno Aviles	Mayaguez	Añasco				60	78						1901 the same as 1902.
J. Sabater Rivera	Guayama	Salinas				350	458	500				500	Do.
Rafael Diaz	Ponce	Yauco				60	78	30				30	
Segundo Castilló	Mayaguez	Mayaguez							239	313	358	358	1901 better than 1902.
Odon Somonte	Guayama	Caguas				80	105	20				20	1901 the same as 1902.
Jorge Bird Arias	Humacao	Fajardo	195	255	$119	25	33	400				519	Demand very small; trade in 1902 about the same as 1901.
José R. Fernández	Guayama	Caguas				80	105	16				16	1901 the same as 1902.
Pablo Ubarri	Bayamon	San Juan	100	131	150				1,200	1,570	1,500	1,650	
Francisco Jimenez	do	Carolina				72	94	90				90	
Santiago Colon	Ponce	Ponce				200	262	150				150	Better in 1902.
Bonifacio Oquendo	Bayamon	Bayamon				150	196	45				45	1901 the same as 1902.
Fernando Salgado	do	do				140	183	42				42	Do.
Ramón Millan	Arecibo	Camuy				300	392	70				70	Do.
Julio N. Chardon	Ponce	Ponce				10	13	25	100	131	10	35	Do.
Ulises Garcia Salgado	Bayamon	Rio Piedras	20	26	40	120	157	940				980	Do.
Eduardo Valdivieso	Ponce	Ponce				100	131	30				30	Dull in 1902.
Segundo T. Fradera	Mayaguez	Lajas				3	4						
F. A. Vendrell	Ponce	Santa Isabel				4	5	4				4	1901 better than 1902.
Juan Valls	do	do				40	52	80				80	Not operated in 1901.
Baldomero Vera	Arecibo	Utuado				20	26	40				40	1901 the same as 1902.
Federico Juarbe	do	Arecibo							61	80	103	103	Not operated in 1901.
José Ubarri	Bayamon	Rio Piedras				20	26	1	100	131	7	8	1901 the same as 1902.
José Castelló	Mayaguez	Cabo Rojo				20	26	20				20	
Guanica Centrale	Ponce	Yauco	5,500	7,194	5,500	500	654	500	[1]4,500	5,886	4,500	10,500	
Total			6,043	7,903	[2]6,025	3,744	4,896	5,414	10,215	13,364	[3]11,237	22,586	

[1] For railroad ballast.
[2] Includes 15 cubic meters (20 cubic yards), valued at $45, used for flagging.
[3] Includes 4,500 cubic meters (5,886 cubic yards), valued at $4,500, used for railroad ballast.

Whenever the demand is such as to make the production of an oven of lime sufficiently lucrative the farmer will prepare one and take it to the nearest market. The production of lime in Porto Rico, therefore, is important rather by reason of the large number of persons engaged therein on a small scale than on account of commercial importance. A certain amount of lime is used by the sugar factories to clarify sirup. In response to interrogatories as to quantity and cost of the lime thus used at the more important factories in the course of a year, the owners stated that where the lime was not to be had on their own premises it was usually obtained from some neighboring deposit gratis.

The limestone formations may be divided into two classes, white and yellow. There are also deposits, few in number, of a blue limestone, somewhat resembling granite formation, and of much harder composition than either the white or yellow varieties mentioned above.

PHOSPHATE ROCK.

There are four phosphate rock mining claims registered in the office of the Commissioner of the Interior of Porto Rico, none of which is being operated at present, viz:

Registered mining claims of phosphate rock.

NAME OF OWNER.	Name of mine.	LOCATION OF MINE.			AREA OF MINE—		Class of mineral.
		Department.	Municipal district.	Ward.	In hectares.	In acres.	
Alfredo Collado	Fortuna	Mayaguez	Cabo Rojo	Monte Grande	6	15	Phosphate rock.
Miguel Arzuaga	La Confianza	Arecibo	Manati	Las Boquillas	6	15	Do.
Joaquin de Alarcon	Trabajo	Aguadilla	Isabela	Arenales Bajos	12	30	Do.
J. Sanchez Valdes	Joachin and San Jose	Ponce	Ponce		12	30	Do.

There are other deposits of phosphate rock not registered, as shown in the following table, one of which it is claimed produced 50 tons during the year 1902:

Unregistered mining claims of phosphate rock.

NAME OF OWNER.	Address of owner.	LOCATION OF MINE.			TOTAL AMOUNT IN TONS.		Value of sales.
		Department.	Municipal district.	Ward.	Produced.	Sold.	
Domingo Emanuelli	Coamo	Ponce	Coamo	Palmarejo	50	35	$105
M. Porrata Doria	Ponce	do	Ponce	Caja de Muertos			
Fausta Aponte	Coamo	do	Coamo	San Ildefonso			
Miguel Arzuaga	Barceloneta	Arecibo	Manati	Las Boquillas			
José Sanchez Valdes	Ponce	Ponce	Ponce	Machuelo			
Felipe Alfaro	Isabela	Aguadilla	Isabela	Arenales Bajos			

The insular government is the owner of the largest known deposit of phosphate rock, which is situated in the island of Caja de Muertos. This deposit was formerly operated on an extensive scale and the product shipped to Germany. It is idle at the present time, however, pending action by the executive council of Porto Rico upon a franchise to work the deposit, for which application has been made. In statistics previously compiled on this subject, deposits of bat guano have been confused with phosphate rock in consequence of such guano being found upon rocks or in caves of a phosphatic character.

GRANITE.

It is not believed that any real granite is to be found in Porto Rico. Two residents of the central section of the island claiming to have discovered granite on their premises gave the information that only 18 cubic meters (24 cubic yards) had been sold in the rough for curbing purposes and 81 cubic meters (106 cubic yards) crushed for roadmaking purposes. It is probable, however, that the stone in question is of dioritic formation and not granite, as they allege.

MINERAL SPRINGS.

There are four widely known mineral springs in Porto Rico, the waters of which contain medicinal properties of no mean value. They are:

Mineral springs in Porto Rico.

NAME OF OWNER.	Residence of owner.	Date of report.	Name of spring.	LOCATION OF SPRING.			Remarks.
				Department.	Municipal district.	Ward.	
Sucesión Usera	Coamo	June 4, 1903	Coamo, Maria	Ponce	Coamo	San Ildefonso	Used only as baths.
Virella U. Hermanos	Arroyo	do	Carmen, Dolores	Guayama	Arroyo	Algarrobo	Do.
Guillermo Orrach	Caguas	do	Florencio	do	Caguas	Bairoa	Do.
Sucesión Ortiz	Ponce	May 22, 1903	Quintana	Ponce	Ponce	Portugues	Do.

The first-named spring is famous locally as a health resort, there being a well-appointed hotel furnishing accommodations for 110 guests. The waters are supplied to visitors in the form of hot and cold baths and for drinking purposes, but have never been bottled, nor has any attempt been made to put them on the market. The springs run from a soft red sandstone, at an altitude of 196.85 feet above sea level, with a temperature, at point of exit, of 43° C. An analysis by Quintanilla in 1891 gave:

Gases in solution, per liter of water at 0° C. temperature and 760 millimeters pressure:

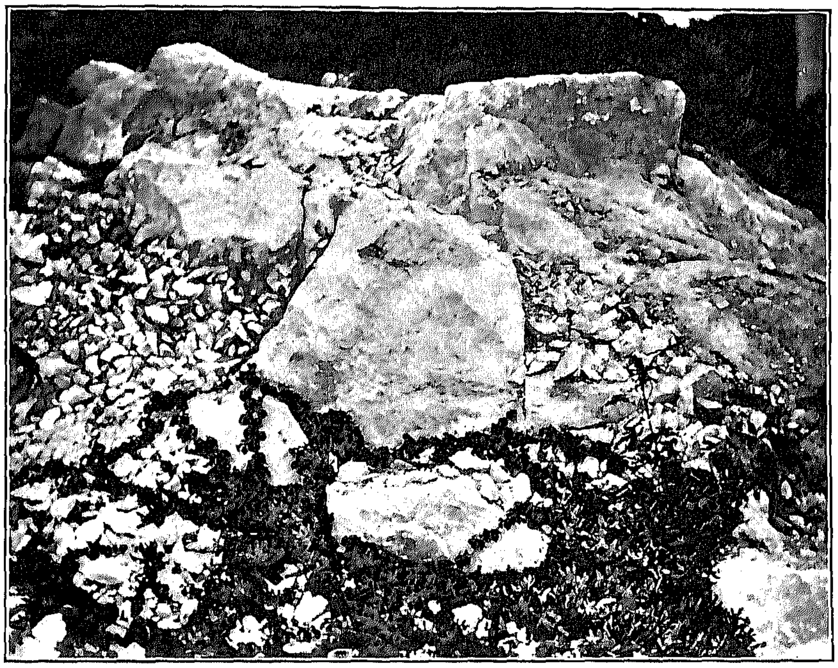
	Cubic centimeters.	Cubic inches.
Nitrogen	13.740	0.84
Oxygen	1.761	0.11
Hydrogen sulphide	1.967	0.12

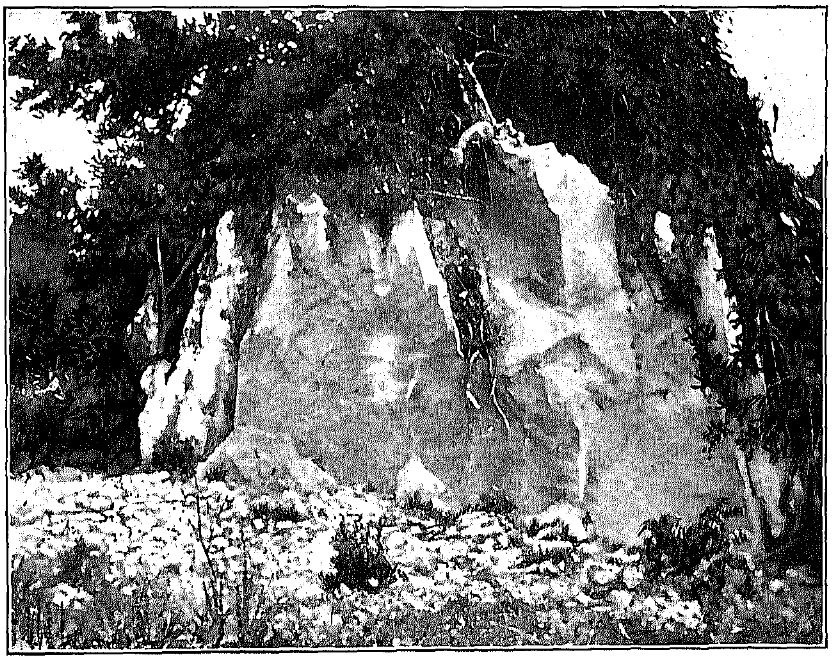
Fixed elements, per liter:

	Grams.	Grains.
Free carbonic acid	0.01296	0.20000
Sulphate of lime	0.79903	12.33063
Sulphate of soda	0.52531	8.10658
Chloride of potash	0.00031	0.00478
Chloride of sodium	0.22054	3.40337
Silicate of soda	0.08127	1.25416
Carbonate of soda	0.03503	0.54058
Ferrous carbonate	0.01114	0.17191

Traces of tannic, nitric, and boric acids and bromine and lithia.

The Florencio springs are not operated for the benefit of the public. There is a private bath house used by the family of the proprietor and by other persons by special permission. The waters have never been bottled nor put on the market. The proprietor states that local physicians prescribe the waters for skin diseases and stomach troubles, but that a scientific analysis has never been made.





PORTO RICO—LIMESTONE QUARRIES.

The Quintana springs, near the town of Ponce, are also quite extensively known locally as possessing excellent medicinal virtues. The waters are administered in the form of baths, but within recent months, owing to the bad state of the road leading to the baths and the abandoned condition of the establishment itself, the springs have ceased to be a public resort. An analysis made in San Juan in 1894 classifies the water as colorless, odorless, transparent, salty, and somewhat bitter in taste; no matter in suspension; density, 1.0057.

Gases in solution:	Cubic centimeters.	Cubic inches.
Ozone	0.0191	0.0012
Oxygen	0.0100	0.0006
Carbonic acid	0.0025	0.0002
Fixed elements, per liter:	Grams.	Grains.
Chloride of sodium	0.519	8.009
Chloride of magnesia	0.015	0.231
Sulphate of soda	0.123	1.898
Sulphate of potash	0.021	0.324
Sulphate of lime	0.081	1.250
Carbonate of lime	0.122	1.883
Ferrous carbonate	0.012	0.185
Silica	0.032	0.494
Organic matter	0.050	0.772

Traces of manganese and bromine.

The Arroyo springs are not operated by the proprietors, who state that no trustworthy analysis of the waters has as yet been made.

Accompanying this report is a map showing approximately the location of mining claims, salt deposits, and mineral springs in Porto Rico. Owing to the fact that no scientific triangulation or survey of the island has ever been made, it has been impossible to indicate on the map with exactness the geographical position of these claims. It is believed, however, that the general purpose of showing the approximate location of the mining deposits of Porto Rico is sufficiently well served. The reason given above with respect to the want of exactness in the location of mining claims applies to the boundaries separating municipalities as well.

Every effort was made to obtain data showing the number of persons employed during the year in the exploitation of the mineral resources of the island. For obvious reasons such an effort could not meet with any great degree of success. As has been stated, in no case were mines or quarries operated during the year as a continuous industrial enterprise. Even in respect to such work as brickmaking, lime burning, or quarrying, operations were of an intermittent character. As regards quarrying, the rock was usually taken out by the contractors engaged upon road construction or repair in connection with their other work. No amount of research, therefore, would have permitted a definite statement either of the total output or of the number of persons employed. The best that can be done is to make a rough estimate, based upon the general information secured, in obtaining the data for the report of the probable average number of persons that may be said to have gained a livelihood in some capacity in connection with the exploitation of the mineral resources of the island.

In respect to the extraction of precious metals, a fair estimate would put the average number of men constantly employed during the year in exploitation work for gold mines and the laying out of claims and similar work at twenty-five. Thirty additional men were probably employed in placer mining, chiefly in the Corozal district. Exploitation and field work in connection with copper mines probably did not engage more than ten men. About one hundred and fifty men may be said to have been constantly employed in the operation of salt mines. Brickmaking probably gave employment to an equivalent of two hundred men working all the year. Estimating from the amount of limestone extracted for the purpose of roadmaking and repairs and for burning, an exceedingly rough approximation would place the amount of labor expended in limestone quarrying operations at five hundred men. As only 50 tons of phosphate rock were mined during 1902, probably not more than two or three men had constant employment during the year.

That Porto Rico possesses mineral resources that will be of great value to the island in future years there can be no doubt. In their utilization the stage as yet has only been reached where efforts are being made to determine more exactly their character and extent. Authorization for water rights and concessions of various characters are being constantly sought of the insular government, and it is certain that when another investigation along the lines of the present one is made the phase of industrial exploitation in respect to a number of minerals will have been definitely entered upon.