

ABRASIVE MATERIALS.

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INTRODUCTION.

The abrasive materials included in this report are millstones and buhrstones, grindstones and pulpstones, oilstones and scythestones, corundum and emery, abrasive quartz and abrasive feldspar, garnet, infusorial earth and tripoli, pumice, and the artificial abrasives carborundum, alundum, and crushed steel. Of some of these materials only a small part of the entire product is actually used for abrasive purposes. In this report, so far as it has been possible, there is included, with the exception of tripoli and possibly infusorial earth, only that part of the product that is actually used for abrasive purposes. Thus under grindstones and pulpstones, which are obtained from sandstone, only a small percentage of the stone that is quarried is used in the manufacture of abrasives, the remainder being used chiefly in the building industry; also, as stated on another page, only a small proportion of the crystalline quartz and feldspar produced is used in the abrasive industry. A large part of the tripoli mined in Missouri is used in the filter-stone industry. Practically all the raw material mined or quarried for millstones, pumice, corundum, emery, and garnet (except the gem garnet) is used for abrasive purposes.

Fairly detailed descriptions of the occurrence and mode of preparation of the different abrasive materials have appeared in preceding reports of the United States Geological Survey. Thus, in the report for 1907, a detailed description was given of the method of preparing millstones from the Esopus conglomerate in Ulster County, N. Y., the center of the millstone industry in that State, and also of the mode of preparing Missouri tripoli for use in filter stones. In the present report the garnet deposits in New York are treated at some length, as well as the occurrence of pumice in the central Western States, and a detailed description is given of the methods employed in the manufacture of scythestones at Pike, N. H. A detailed description of the manufacture and technology of alundum, among the artificial abrasives, is also given.

The following table gives the value of all the natural abrasive material produced in the United States during the years 1904 to 1908, inclusive. The value of the production for 1908 showed a decline of \$606,698 as compared with that of 1907. There was an

increase in the value of pumice, but a decrease in the value of all other abrasives. The general decline in the abrasive industry was in keeping with the general industrial depression of the year.

Value of natural abrasives produced in the United States, 1904-1908.

Kind of abrasive.	1904.	1905.	1906.	1907.	1908.
Oilstones and scythestones.....	\$188,985	\$244,546	\$268,070	\$264,188	\$217,284
Grindstones and pulpstones.....	881,527	777,606	744,894	896,022	536,095
Buhrstones and millstones.....	37,338	37,974	48,590	31,741	31,420
Pumice.....	5,421	5,540	16,750	33,818	39,287
Infusorial earth and tripoli.....	44,164	64,637	72,108	104,406	97,442
Abrasive quartz and feldspar.....	74,850	88,118	121,671	126,582	79,146
Garnet.....	117,681	148,095	157,000	211,686	64,620
Corundum and emery.....	57,235	61,464	44,310	12,294	8,745
	1,407,101	1,427,980	1,473,393	1,680,737	1,074,039

Natural abrasives were produced in 23 States in 1908, the same number as in 1907. The list of States follows, together with the material produced by each:

List of States producing abrasives in 1908.^a

ARKANSAS: Oilstones.
 CALIFORNIA: Infusorial earth.
 CONNECTICUT: Infusorial earth, quartz, and feldspar.
 GEORGIA: Infusorial earth.
 ILLINOIS: Tripoli.
 INDIANA: Oilstones.
 KANSAS: Pumice.
 MARYLAND: Infusorial earth and quartz.
 MASSACHUSETTS: Emery, infusorial earth, and quartz.
 MICHIGAN: Scythestones and grindstones.
 MINNESOTA: Feldspar.
 MISSOURI: Tripoli and grindstones.
 MONTANA: Grindstones.
 NEBRASKA: Pumice.
 NEW HAMPSHIRE: Scythestones.
 NEW YORK: Emery, garnet, infusorial earth, and millstones.
 NORTH CAROLINA: Millstones.
 OHIO: Grindstones, pulpstones, oilstones, and scythestones.
 PENNSYLVANIA: Millstones and quartz.
 VERMONT: Scythestones.
 VIRGINIA: Millstones.
 WEST VIRGINIA: Grindstones.
 WISCONSIN: Quartz.

Under the head of artificial abrasives are included alundum, carborundum, and crushed steel. The production of these substances from 1905 to 1908, inclusive, is given in the following table:

Production and value of artificial abrasives in the United States, 1905-1908.

Year.	Quantity in pounds.	Value.	Year.	Quantity in pounds.	Value.
1905.....	9,820,000	\$701,400	1907.....	14,632,000	\$1,027,246
1906.....	11,774,300	777,081	1908.....	8,098,000	626,340

^a The writer wishes to acknowledge the cooperation of the state geologists of Illinois, Maryland, New York, North Carolina, and Virginia in the collection of statistics of abrasives.

The total estimated value of all abrasive materials consumed in the United States for the years 1904 to 1908, inclusive, is given in the following table.

Total value of all abrasive materials consumed in the United States, 1904-1908.

Year.	Natural abrasives.	Artificial abrasives.	Imports.	Total value.
1904.....	\$1,407,101	\$830,926	\$547,804	\$2,785,831
1905.....	1,427,980	701,400	654,821	2,784,001
1906.....	1,473,393	777,081	909,964	3,160,438
1907.....	1,680,737	1,027,246	754,140	3,462,123
1908.....	1,074,039	626,340	476,073	2,176,452

BUHRSTONES AND MILLSTONES.

The production of buhrstones and millstones in the United States in 1908 was valued at \$31,420, substantially the same production as in 1907.

The market for millstones has been greatly curtailed of late years. The table given on a subsequent page shows that recently the industry has dwindled very much and that the value of the production for 1908, as well as for 1907, closely approximates what it was at the beginning of the present decade. The explanation of this falling off in the millstone industry is due to the introduction of superior forms of grinding machinery, chiefly rolls, ball mills, etc. The roller-mill process is now used almost exclusively in grinding wheat. Some corn and mustard mills in the Southern States still use handmade millstones. A part of the product is sold to the cement and talc manufacturers and to grinders of quartz and mineral paints.

The production of millstones, as usual, came from but four States, namely, New York, North Carolina, Pennsylvania, and Virginia. Though stone suitable for buhrstones and millstones is found in other States, there was no production from them reported to this office.

Millstone industry in New York.—New York has led for many years in the production of millstones and chasers, the latter term being applied to stones which run on edge. The raw material is obtained in Ulster County, southeastern New York, and is known as Esopus stone, Esopus being an early name for Kingston, which was formerly the main point of shipment. The material suitable for millstones is quarried from the Shawangunk conglomerate, which is found near the western base of Shawangunk Mountain in the Valley of Rondout River. The material suitable for millstones is exceedingly scanty, being confined in linear extent to a strip extending from High Falls on the north to Kerhonkson on the south, a distance of approximately 10 miles. Beyond these limits the texture and other properties of the rock have been found unsuitable for the highest grade of stones.

The methods employed in quarrying the rock are simple. The rock is pried or split out, advantage being taken of the joint planes, especially the concentric surface joints. The tools used are the ordinary hand drill, together with plugs and feathers. Blasting is often resorted to, but the charges of powder are usually light. The rough stones thus obtained are quarry dressed and finished, these

operations being performed entirely by hand, the chief tools employed being the bull point and hammer. The operation of drilling the "eye" is performed by centering the stone and then drilling from the center of both faces inward. In many stones the eye is square. To fashion a square eye, a round eye is first drilled out and then squared up. A few of the men engaged in the industry make a modification of the regular millstone for use in the grinding of paint. In this modification the ordinary millstone is cut in halves and an iron casting is placed between the halves, which are then joined together by an iron band.

Chasers are larger than the regular millstones. They are used for heavier work as in grinding quartz, feldspar, barytes, etc., and as already mentioned, they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 50 to 84 inches, and as much as 22 inches in thickness. These chasers are run on pans paved with blocks of Esopus conglomerate, which are usually roughly cubical with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks, the material placed in the pan is ground to powder.

In the following table is given the value, by States, of the millstones, buhrstones, and chasers produced in the United States from 1904 to 1908, inclusive:

Value of buhrstones produced in the United States, 1904-1908, by States.

State.	1904.	1905.	1906.	1907.	1908.
New York.....	\$24,585	\$25,915	\$28,848	\$23,072	\$18,341
Virginia.....	4,759	8,186	15,611	4,684	7,954
North Carolina.....	6,500	2,522	1,507	1,969	4,052
Pennsylvania.....	1,494	1,351	2,624	2,016	1,073
	37,338	37,974	48,590	31,741	31,420

The following table gives the value of millstones and buhrstones produced in the United States since 1880:

Value of buhrstones and millstones produced in the United States, 1880-1908.

1880.....	\$200,000
1881.....	150,000
1882.....	200,000
1883.....	150,000
1884.....	150,000
1885.....	100,000
1886.....	140,000
1887.....	100,000
1888.....	81,000
1889.....	35,155
1890.....	23,720
1891.....	16,587
1892.....	23,417
1893.....	16,639
1894.....	13,887
1895.....	22,542

1896.....	\$22,567
1897.....	25,932
1898.....	25,934
1899.....	28,115
1900.....	32,858
1901.....	57,179
1902.....	59,808
1903.....	52,552
1904.....	37,338
1905.....	37,974
1906.....	48,590
1907.....	31,741
1908.....	31,420

IMPORTS.

The value of the imports of buhrstones and millstones into the United States has decreased materially in the last two years. In 1908 the value was approximately two-thirds that of 1907 and a little more than half that of 1906. This marked decrease in 1908 was in the value of the rough material, as the value of the material made up into millstones was nearly three times that of 1907. The table showing the value of imports from 1904 to 1908 follows:

Value of buhrstones and millstones imported into the United States, 1904-1908.

Year.	Rough.	Made into mill- stones.	Total.	Year.	Rough.	Made into mill- stones.	Total.
1904.....	\$30,117	\$2,269	\$32,386	1907.....	\$26,431	\$877	\$27,308
1905.....	30,478	938	31,416	1908.....	16,075	2,567	18,642
1906.....	32,921	277	33,198				

GRINDSTONES AND PULPSTONES.

PRODUCTION.

The value of the production of grindstones and pulpstones during 1908 amounted to \$536,095, a decrease of \$359,927 as compared with the production of 1907. This is the lowest value of these commodities reported to the Survey in recent years. The production came as usual from the following States: Ohio, Michigan, West Virginia, Montana, and Missouri. Wyoming has not produced any grindstones since 1906. In the following table is given the value of the production of grindstones and pulpstones during the last five years:

Value of the production of grindstones and pulpstones, 1904-1908.

	1904.	1905.	1906.	1907.	1908.
Grindstones.....	\$820,207	\$726,536	\$694,894	\$846,522	\$495,495
Pulpstones.....	61,320	51,070	50,000	49,500	40,600
	881,527	777,606	744,894	896,022	536,095

In the following table are given the values of the grindstones and pulpstones produced in the United States from 1904 to 1908, by States:

Value of grindstones and pulpstones produced in the United States, 1904-1908, by States.

State.	1904.	1905.	1906.	1907.	1908.
Ohio.....	\$767,552	\$644,315	\$644,720	\$764,276	\$482,128
Michigan.....	112,500	111,500	78,500	(a)	(a)
West Virginia, Missouri, and Montana.....	b 1,475	b 21,791	b 21,674	131,746	53,967
	881,527	777,606	744,894	896,022	536,095

a Included with West Virginia, etc.

b Including a small production from Wyoming in 1904, 1905, and 1906.

The value of the production of pulpstones and grindstones in the United States from 1880 to 1908, inclusive, is shown in the following table:

Value of grindstones and pulpstones produced in the United States, 1880-1908.

1880.....	\$500,000	1895.....	\$205,768
1881.....	500,000	1896.....	326,826
1882.....	700,000	1897.....	368,058
1883.....	600,000	1898.....	489,769
1884.....	570,000	1899.....	675,586
1885.....	500,000	1900.....	710,026
1886.....	250,000	1901.....	580,703
1887.....	224,400	1902.....	667,431
1888.....	281,800	1903.....	721,446
1889.....	439,587	1904.....	881,527
1890.....	450,000	1905.....	777,606
1891.....	476,113	1906.....	744,894
1892.....	272,244	1907.....	896,022
1893.....	338,787	1908.....	536,095
1894.....	223,214		

IMPORTS.

The value of the imports of pulpstones and grindstones has shown a steady increase up to 1907, when there was a decided falling off. The decrease in 1908 from 1907 closely approximated that of 1907 from 1906. The figures of imports for the last five years are given in the following table:

Value of pulpstones and grindstones imported and entered for consumption in the United States, 1904-1908.

1904.....	\$93,152	1907.....	\$111,495
1905.....	113,752	1908.....	80,382
1906.....	134,136		

CANADIAN PRODUCTION.

The value of the production of grindstones in Canada during 1908 amounted to \$45,128, as compared with \$60,376 in 1907. In the table following is given the value of the Canadian production of grindstones during the last five years:

Value of production of grindstones in Canada, 1904-1908.

1904.....	\$42,782	1907.....	\$60,376
1905.....	57,200	1908.....	45,128
1906.....	61,624		

OILSTONES AND SCYTHESTONES.

PRODUCTION.

The production of oilstones and scythestones in the United States during 1908 amounted to \$217,284, as compared with \$264,188 in 1907, a decrease of \$46,904, or nearly 18 per cent. The production of oilstones and whetstones is from Arkansas, Indiana, and Ohio, and the first State mentioned produces the largest part of the output. Scythestones are manufactured from material found in New Hampshire, Vermont, Ohio, and Michigan.

In the following table is given the value of the oilstones and scythestones from 1891 to 1908:

Value of oilstones and scythestones produced in the United States, 1891-1908.

1891.....	\$150,000	1900.....	\$174,087
1892.....	146,730	1901.....	158,300
1893.....	135,173	1902.....	221,762
1894.....	136,873	1903.....	366,857
1895.....	155,881	1904.....	188,985
1896.....	127,098	1905.....	244,546
1897.....	149,970	1906.....	268,070
1898.....	180,486	1907.....	264,188
1899.....	208,283	1908.....	217,284

The scythestone industry in New Hampshire.—Scythestones are manufactured by the Pike Manufacturing Company at Pike Station, in the northwestern part of New Hampshire, near Connecticut River.

The raw material from which the stones are made is a fine-grained, thinly laminated, micaceous sandstone, whose quartz grains occur in definite layers separated by thin layers of mica flakes. Associated with this material occurs rock in which the quartz particles occur in rather coarser grains and in lenses rather than in layers. The quartz particles in the rock may give place entirely to argillaceous material. When the quartz grains become coarse and irregularly disposed and when argillaceous material is present the rock is unfit for abrasive purposes and is discarded. Besides the planes of schistosity, there are developed at right angles to them splendid joint planes. Such a plane normal to the plane of schistosity is known as a "foot," and the stone between an upper and a lower "foot" is known as a "bent" of stone. After the stone is shattered by the blasting the "bent" is pried out. The quarries are not extensive in area and are bounded by stone known as "hard head," which apparently may be almost any foreign stone hard to work and unfit for scythestones.

The raw material is found generally in peculiar wedge-shaped lenses striking northeast-southwest. The broader end of the lenses is toward the southwest, and they pinch out and taper to the northeast. The methods of quarrying are briefly as follows: The covering of clay, which averages but a few feet in thickness, is plowed up, shoveled into cars, carried off a short distance, and dumped. After this surface stripping, holes are drilled with a steam drill to depths varying from 6 to 12 feet, and the rock is loosened by blasting, the charge of powder used varying with the depth of the hole from 4 pounds to 10 pounds. The rock loosened along the plane of schistosity is then pried out in big, irregularly shaped pieces. These slabs

vary in thickness, but are generally less than 1 foot thick. The largest slabs thus secured are broken up into smaller rectangular slabs, which are piled up and reserved for the winter, when quarrying is suspended and the workmen are compelled by reason of the excessive cold to work indoors. This material is known by the name of "timber." The smallest slabs are worked up at once in the warm season. They are first cut into the rough rectangular slabs known as "timber." The "timber" is split into thinner slabs, approximately the thickness of the finished stones, and then by the aid of knives and hammers these slabs are, in turn, broken into oblong rectangles, which is the raw material from which the finished scythestone is made directly.

This raw material is hauled in wagons from the quarry to the town of Pike, a mile distant, where it is ground into the finished stones. The operations involved in grinding are simple. Several rough stones have their rough edges ground smooth by pressing them together against a horizontally revolving wheel covered with coarse sand obtained near by. Pressure is exerted by hand or by heavy iron blocks. The individual stones are next taken and manipulated by hand until ground into the requisite shape. This is accomplished on the same wheel used in the preliminary grinding. The wheel or table on which the grinding is done is made of wood, and into it are driven steel wedges or "butts" obtained from nail factories. The grinding is thus accomplished on what amounts practically to a steel surface.

IMPORTS AND EXPORTS.

The value of the imports of hones, whetstones, and oilstones in 1908 amounted to \$44,304, as compared with \$89,939 in 1907. This importation, which was slightly less than half that of the preceding year, and but slightly more than half that of the year 1906, is the lowest recorded in several years. The importation is in part offset by the exportation of Arkansas oilstones and New Hampshire scythestones, the value of which, however, can not be given, since no separate record of them is kept. The following table shows the value of all kinds of hones, oilstones, and whetstones imported into the United States in the last five years:

Value of imports of hones, oilstones, and whetstones, 1904-1908.

1904.....	\$61,609	1907.....	\$89,939
1905.....	65,753	1908.....	44,304
1906.....	83,863		

CORUNDUM AND EMERY.

Practically all the corundum and nearly all the emery now used in the United States is imported, and the industries in which these two abrasives are factors are now mainly manufacturing industries. To escape the duty, emery is imported crude as ballast from Greece and Turkey; corundum comes mainly from Canada in pulverized form.

In 1908 the output of emery in the United States came from but two localities, Chester, Mass., and Peekskill, N. Y. The emery at Chester is considered of good quality, but operations at this locality are practically suspended. The Ashland Emery and Corundum Com-