

ABRASIVE MATERIALS.

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INTRODUCTION.

The abrasive materials are an interesting and important group of mineral products on account of their close relation to so many manufacturing industries. But few people understand and appreciate to how great an extent the arts are dependent upon these abrasive materials, and know their value, uses, and occurrence. It is not always the hardest abrasive that gives the best satisfaction for a given piece of work, and it is necessary to select not only the kind of abrasive but also the grade of that particular kind suitable to the nature of the abrasion that it is desired to make. An abrasive that will give satisfaction in one instance will not necessarily do so in another instance.

There are many kinds of abrasive materials on the market, some being natural products and others artificial, and they readily arrange themselves into three general groups, as follows:

1. Those which occur as a rock formation and are cut and manufactured directly into the form desired while retaining their original rock structure and appearance, as grindstones, scythestones, etc.
2. Those which occur as a constituent of either a rock or a vein and have to be mechanically separated from the associated gangue and cleaned, as corundum, garnet, etc.
3. Artificial abrasives, as carborundum, crushed steel, etc.

The abrasive materials included under these three heads and treated in this report are as follows: Oilstones and scythestones, grindstones and pulpstones, buhrstones and millstones, pumice, infusorial earth and tripoli, crystalline quartz, garnet, corundum and emery, feldspar, carborundum, crushed steel, artificial corundum, and adamite.

All of the above products are not used exclusively for abrasive purposes, and in some cases only a small part of the production is actually used as an abrasive material. With the exception, however, of infusorial earth and tripoli, only that portion of the production of the various abrasive materials that is used for abrasive purposes is included in this report. In the case of infusorial earth and tripoli, the total production is not large, and it is therefore all included under the one head.

From year to year there is a noticeable variation in the quantity of the different kinds of abrasives produced, which is due partly to the replacement of a certain abrasive by another natural product or by an artificial abrasive; and partly also to the closing down of certain of the mines, owing to their being exhausted or to the excessive expense of carrying on the mining operations. In the latter case the loss in the domestic production is often made up by the importation of that particular abrasive. In the aggregate, however, there is an increase in the amount of abrasive materials produced each year. This is the natural outcome of the continuous growth of our manufacturing industries.

The aggregate value of the production of abrasive materials in 1903 is the largest on record since these statistics have been collected, and amounted to \$1,493,303. As compared with the value of the 1902 production of \$1,326,755, this is an increase of \$166,548. The values of the different abrasives produced in the United States for the years 1900 to 1903, inclusive, are given in the following table:

Value of abrasives produced in the United States during 1900, 1901, 1902, and 1903.

Kind of abrasive.	1900.	1901.	1902.	1903.
Oilstones and scythestones	\$174,087	\$158,300	\$221,762	\$366,857
Grindstones	710,026	580,703	667,431	721,446
Buhrstones and millstones	32,858	57,179	59,808	52,552
Pumice			2,750	2,665
Infusorial earth and tripoli	24,207	52,950	53,244	76,273
Crystalline quartz	40,705	41,500	84,335	76,908
Garnet	123,475	158,100	132,820	132,500
Corundum and emery	102,715	146,040	104,605	64,102
Total	1,208,073	1,194,772	1,326,755	1,493,303

As is seen from this table, there was a large increase in 1903 in the value of the production of oilstones and scythestones, and of grindstones and pulpstones, and a considerable gain in infusorial earth, and it is to be noted also that the value of the 1903 production of each of these three abrasive materials is the highest since these statistics began to be collected in 1880. The other abrasives showed a decrease in 1903 in the value of their production, and in the case of corundum and emery the value is the lowest on record for any year. The consumption of this abrasive in the United States in 1903 was about the same as the year before, and the deficiency in production was supplied by the imports.

In addition to the value of the natural abrasives, the estimated value of the artificial abrasives amounted to \$493,815, an increase of \$103,570 as compared with the estimated value of \$390,245 of the 1902 production. The quantity of the two artificial abrasives, carborundum and

crushed steel, produced in the United States since 1900 is given in the following table:

Artificial abrasives produced in the United States during 1900, 1901, 1902, and 1903.

Kind of abrasive.	1900.	1901.	1902.	1903.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Carborundum	2,634,900	3,838,175	3,741,500	4,759,890
Crushed steel.....	700,000	690,000	735,000	755,000

The importation of certain abrasive materials still further swells the total value of the abrasives used in the United States. In 1903 the total value of the abrasives imported was \$621,585, as compared with \$426,736 in 1902, an increase of \$194,849. This brings the total value of the abrasive materials consumed in the United States in 1903 to \$2,608,603, which is \$464,867 more than the value, \$2,143,736, of the 1902 consumption. In the following table is given the total estimated value of all the abrasive materials consumed in the United States for the years 1900 to 1903, inclusive:

Total value of all abrasive materials consumed in the United States, 1900-1903.

Year.	Natural abrasives.	Artificial abrasives.	Imports.	Total value.
1900.....	\$1,208,073	\$275,641	\$400,307	\$1,884,021
1901.....	1,194,772	383,386	490,712	2,068,870
1902.....	1,326,755	390,245	426,736	2,143,736
1903.....	1,493,203	493,815	621,585	2,608,603

These totals should be reduced probably by \$100,000 to represent the value of the abrasive materials exported from the United States.

Twenty-one different States contributed to the production of 1903, and they are given below in the order of the value of their respective productions, together with the kind of abrasive mined.

List of States producing abrasives in 1903.

1. OHIO: Grindstones, pulpstones, oilstones, and scythestones.
2. NEW YORK: Millstones, infusorial earth, garnet, and emery.
3. NEW HAMPSHIRE: Oilstones, scythestones, and infusorial earth.
4. ARKANSAS: Oilstones.
5. MICHIGAN: Grindstones and scythestones.
6. CONNECTICUT: Quartz and garnet.
7. MISSOURI: Grindstones and infusorial earth.
8. VERMONT: Scythestones and millstones.
9. INDIANA: Oilstones.
10. VIRGINIA: Millstones and infusorial earth.
11. NORTH CAROLINA: Millstones, garnet, and corundum.
12. MASSACHUSETTS: Infusorial earth and emery.
13. PENNSYLVANIA: Millstones, quartz, and garnet.

14. MONTANA: Grindstones and corundum.
15. CALIFORNIA: Infusorial earth and quartz.
16. NEBRASKA: Pumice.
17. KENTUCKY: Oilstones.
18. MARYLAND: Infusorial earth.
19. KANSAS: Emery.
20. GEORGIA: Infusorial earth.
21. FLORIDA: Infusorial earth.

OILSTONES AND SCYTHESTONES.

There were no new localities producing oilstones and scythestones in 1903, the production being obtained from the old localities in Arkansas, Indiana, Kentucky, Michigan, Ohio, New Hampshire, and Vermont. In the two latter States the material mined is a quartz-schist; in the others it is a sandstone. There is included under this head all kinds of oilstones, whetstones, water hones, knife sharpeners of all varieties, razor hones, dental points, etc. The novaculite (sandstone) of Arkansas is the most valuable of all the abrasives of this class on the market.

PRODUCTION.

Notwithstanding the decided increase in the production of oilstones and scythestones in the United States in 1902 as compared with 1901, there was a still larger increase in the production of 1903, which was valued at \$366,857. This is an increase of \$145,095 as compared with the value of the 1902 production, \$221,762, which in turn was an increase of \$63,462 over the value of the 1901 production, \$158,300. This is also the highest recorded value for these abrasives. The increase is due partly to the large demand for the Arkansas and Wichita oilstones, made from the Arkansas novaculite, which bring the highest price of any oilstone or scythestone made, and to the increase in the exportation of scythestones and oilstones. In nearly every instance the producers of the materials used in the manufacture of oilstones and scythestones are also the manufacturers of the finished or marketable product, and for this reason it is the value of the finished stone instead of the raw material that is given in these statistics.

The 1903 production was obtained from the following States, given in the order of the value of their production: New Hampshire, Arkansas, Vermont, Indiana, Ohio, Michigan, and Kentucky. There were eighteen producers of the oilstones and scythestones in these States.

In the following table is given the value of the oilstones and scythestones produced in the United States from 1891 to 1903, inclusive:

Value of oilstones and whetstones produced in the United States, 1891-1903.

Year.	Value.	Year.	Value.
1891	\$150,000	1898	\$180,486
1892	146,730	1899	208,283
1893	135,173	1900	174,077
1894	136,873	1901	158,300
1895	155,881	1902	221,762
1896	127,098	1903	366,857
1897	149,970		

From 1880 to 1890, inclusive, the production and value of the rough stone have been published in these reports, except in the case of the output of 1890, when the value for the unfinished product was given for the novaculite of Arkansas, while in all other cases the value of the finished stones was given. The annual production from 1880 to 1890 was as follows:

Production of oilstones and whetstones, 1880-1890.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	<i>Pounds.</i>			<i>Pounds.</i>	
1880	420,000	\$8,600	1886	1,160,000	\$15,000
1881	500,000	8,580	1887	1,200,000	16,000
1882	600,000	10,000	1888	1,500,000	18,000
1883	600,000	10,000	1889	5,982,000	32,980
1884	800,000	12,000	1890		69,909
1885	1,000,000	15,000			

IMPORTS.

Notwithstanding the very large increase in the production of oilstones, scythestones, etc., in the United States, there is imported each year a considerable quantity of razor hones from Germany and Belgium, and a variety of oilstones known as the "Turkey" oilstone, from France and Italy. In 1903 the value of these imported stones amounted to \$65,763. This is about one-fifth the value of the domestic production. There has been considerable variation in the imports of oilstones and whetstones from year to year, and since 1891 they have ranged in value from one-fifth to one-third of the value of the domestic production. The year of greatest comparative importation was 1901, when the value of the oilstones and razor hones imported amounted to \$64,655, and the value of the domestic production was only \$158,300.

In the following table there is given the total value of all kinds of hones and oilstones imported into the United States since 1880:

Imports of hones and whetstones, 1880-1903.

Year ending—	Value.	Year ending—	Value.
June 30—		December 31—	
1880	\$14,185	1892	\$33,420
1881	16,631	1893	25,301
1882	27,882	1894	26,671
1883	30,178	1895	32,439
1884	26,513	1896	50,588
1885	21,434	1897	34,485
December 31—		1898	30,856
1886	21,141	1899	34,510
1887	24,093	1900	39,316
1888	30,676	1901	64,655
1889	27,400	1902	56,456
1890	37,454	1903	65,763
1891	35,344		

EXPORTS.

The exportation of American oilstones and scythestones is steadily increasing, but as no separate record is kept of the exports of these stones no definite valuation can be given. It is, however, very probable that the value of the exports now exceeds the value of the imports. There is a considerable demand abroad for New Hampshire scythestones, which make up a large portion of the material exported. There is also a growing demand for the Arkansas oilstones. Besides these there are smaller amounts of Indiana oilstones exported.

GRINDSTONES AND PULPSTONES.

Although sandstone suitable for manufacturing into grindstones is known to occur in many of the States, there are only a few that have these deposits so situated that they make commercial propositions. During 1903 grindstones were produced in Michigan, Missouri, Montana, Ohio, and West Virginia with, however, over one-half of the production from the one State, Ohio. The grindstones that are manufactured in Montana are used locally, but the Montana Sandstone Company, of Butte, Mont., which is producing this stone, expects to be able to manufacture a grindstone that will give good satisfaction in the optical industry. The stone has been tested by Riehle Brothers Testing Machine Company of Philadelphia, who reported the following tests made on 3-inch cube samples:^a

Subjected to the frost test, the specimen was frozen twelve hours at 6° F. above zero, then placed in water at 70°, raised to 212°, and maintained for five hours. The specimen showed no evil effects from the test.

^a Eighth Biennial Report, Bureau of Agriculture, Labor, and Industry of Montana, 1901-2.

Subjected to compression, the specimen spawled at 57,000 pounds pressure, and broke at 76,000 pounds.

Subjected to the absorption test, the weight of the specimen, after drying five hours at 212° F., was 1,194.5 grams. Weight of specimen after boiling five hours at 212° F. was 1,243 grams. Increased weight due to absorption, 48.5 grams, equal to 3.9 per cent absorption.

Subjected to specific gravity test, the weight of the specimen in air, after drying five hours at 212° F., was 1,217.5 grams. Weight of specimen in water, 701.9 grams. Specific gravity, 2.34.

Specimen subjected to abrasion test was dried five hours at 212° F., after which it weighed 1,217.5 grams. The weight of this specimen after abrasion at 30 pounds mean pressure was 1,022.6 grams, equal to 16 per cent loss.

Near Buckhannon, W. Va., a sandstone deposit has been developed and experimented with by the Buckhannon Marble and Granite Company, which is now manufacturing a grindstone for the glass-cutters' trade. The company has two grits, a coarse and a fine one, which are of very even texture, and if large blocks can be obtained, like the samples examined, they should make grindstones of superior quality. A considerable quantity of the grindstones imported are used by glass cutters and in optical works, and if the Montana and especially the West Virginia deposits can furnish a good stone, adapted for the glass-workers' industry, they should be able to enter into successful competition with the foreign stones.

At Griesel, Mo., a small number of grindstones were manufactured by Mr. Charles A. White, and thus another State is added to those that are producers of this class of abrasives.

PRODUCTION.

The production of grindstones and pulpstones in 1903 was confined to Michigan, Missouri, Montana, Ohio, and West Virginia, with by far the largest amount from Ohio, which was the only State that produced any pulpstones. The total value of all kinds of grindstones produced in 1903 was \$721,446, which is \$54,015 greater than the value of the 1902 production, \$667,431. This value is the greatest recorded for the production of grindstones during any year since these statistics were first collected in 1880, being \$11,420 greater than the value of the 1900 production, \$710,026, which was the previous greatest value. In comparing the values of the productions of the earlier years with those of the last few years, it must be borne in mind that the average value per ton has decreased from \$15 to \$18 per ton to from \$8 to \$11 per ton, these values being exclusive of pulpstones. Consequently the actual tonnage of grindstones produced in the last five years is greater than for previous years. Of the total value of the 1903 production, the sum of \$33,970 is due to pulpstones, an increase of \$10,882 as compared with the value (\$23,088) of the 1902 production, and this in turn was an increase of \$4,288 over the 1901 value of

\$18,800. The sum of \$687,476 due to grindstones is an increase of \$43,133 as compared with \$644,343, the value of the 1902 production, which was an increase of \$82,440 over the value of the 1901 production of \$561,903. In the following table is given the value of the production of grindstones and pulpstones for the years 1901 to 1903:

Value of the production of grindstones and pulpstones, 1901-1903.

	1901.	1902.	1903.
Grindstones	\$561,903	\$644,343	\$687,476
Pulpstones	18,800	23,088	33,970
Total	580,703	667,431	721,446

Since 1898 there has been a decided increase in the production of grindstones, which is due very largely to the marked increase during this same period of all kinds of manufacturing industries, nearly all of which use some variety of grindstone. There has also been an increase in the production of pulpstones, which, although not large in itself, causes a large gain in percentage.

Some of the producers in making their reports to the Survey use the ton as the unit of measurement, while others give the actual number of grindstones made. In 1903 the number of grindstones reported, exclusive of pulpstones, aggregated 52,383 pieces, valued at \$501,500, as compared with 29,543 pieces, valued at \$100,875, in 1902. The product reported by weight amounted to 16,891 tons, valued at \$185,976, as compared with 44,268 tons, valued at \$538,713, in 1902. The average value of that portion of the 1903 product reported by weight was \$11 per ton. The price per ton reported varied from \$6 to \$26, the latter figure being for the Montana production, which was sold locally. The weight of the pulpstones produced in 1903 was 414 tons, valued at \$33,970, or an average of \$82.05 per ton, the value varying from \$30 to \$100 per ton.

There is given in the following tables the value of the grindstones and pulpstones produced in the United States during 1903 and 1902, by States:

Value of grindstones and pulpstones produced in the United States during 1903, by States.

State.	1903.
Ohio.....	\$646,776
Michigan.....	70,550
West Virginia, Missouri, and Montana	4,120
Total	721,446

Value of grindstones and pulpstones produced in the United States during 1902, by States.

State.	1902.
Ohio.....	\$560,412
Michigan, Montana, and Wyoming.....	a 84,672
West Virginia	22,347
Total	667,431

^aThe greater part of the value of this production was from Michigan.

As is seen from these tables, there was an increase of \$86,364 in the value of the Ohio production in 1903 over that of 1902, while there was a large falling off in the value of the West Virginia production. The production for Michigan was about the same in both 1902 and 1903. Wyoming, which had a small production in 1902, did not report any in 1903, while Missouri was added to the list of producers in 1903, making the number of States producing grindstones in 1903 the same as in 1902. There was a total of 21 producers of grindstones in 1903, of whom 14 were in Ohio, 4 in Michigan, and 1 each in Missouri, Montana, and West Virginia.

The following table shows the value of the production of grindstones and pulpstones from 1880 to 1903, inclusive. This table illustrates very clearly the depression and revival of this industry, and therefore of the manufacturing industries of the country, during and since the financial depression of 1893 and the years immediately following.

Value of grindstones produced in the United States, 1880-1903.

Year.	Value.	Year.	Value.
1880	\$500,000	1892.....	\$272,244
1881	500,000	1893.....	338,787
1882	700,000	1894.....	223,214
1883	600,000	1895.....	205,768
1884	570,000	1896.....	326,826
1885	500,000	1897.....	368,058
1886	250,000	1898.....	489,769
1887	224,400	1899.....	675,586
1888	281,800	1900.....	710,026
1889	439,587	1901.....	580,703
1890	450,000	1902.....	667,431
1891	476,113	1903.....	721,446

IMPORTS.

The grindstones that are imported into the United States are principally pulpstones and grindstones for use in the glass and the optical trades. These are obtained from Newcastle-upon-Tyne, England, and from Wales, Scotland, and Bavaria; and in 1903 their value amounted to \$85,705, as compared with \$76,906, the value of those imported in

1902. With the increase in the production of pulpstones from Ohio and the introduction of the West Virginia stone on the market for use in the glass and the optical trades, it would seem that there should be a greater decrease in the imports than has taken place during the last three or four years. The Bureau of Statistics of the Department of Commerce and Labor, in reporting the imports of grindstones, has not made any separation of the quantity of the finished and of the unfinished products since 1883.

In the table below are given the quantity and the value of the grindstones imported into the United States from 1868 to 1885, inclusive, and of the value since 1886.

Grindstones imported and entered for consumption in the United States, 1868-1903.

Year ending—	Finished.		Unfinished or rough.		Total value.
	Quantity.	Value.	Quantity.	Value.	
June 30—	<i>Long tons.</i>		<i>Long tons.</i>		
1868.....		\$25,640		\$35,215	\$60,855
1869.....		15,878		99,715	115,593
1870.....		29,161		96,444	125,605
1871.....	385	43,781	3,957.15	60,035	104,716
1872.....	1,202	13,453	10,774.80	100,494	113,947
1873.....	1,437	17,033	8,376.84	94,900	111,933
1874.....	1,443	18,485	7,721.44	87,525	106,010
1875.....	1,373	17,642	7,656.17	90,172	107,814
1876.....	1,681	20,262	6,079.34	69,927	90,189
1877.....	1,245	18,546	4,979.75	58,575	77,121
1878.....	1,463	21,688	3,669.41	46,441	68,129
1879.....	1,603	24,904	4,584.16	52,343	77,247
1880.....	1,573	24,375	4,578.59	51,899	76,274
1881.....	2,064	30,288	5,044.71	56,840	87,128
1882.....	1,705	30,286	5,945.61	66,939	97,225
1883.....	1,755	28,055	6,945.63	77,797	105,852
1884.....					^a 86,286
1885.....					50,579
December 31—					
1886.....					39,149
1887.....					50,312
1888.....					51,755
1889.....					57,720
1890.....					45,115
1891.....					21,028
1892.....					61,052
1893.....					50,569
1894.....					52,688
1895.....					54,276
1896.....					66,195
1897.....					49,496
1898.....					62,973
1899.....					63,852
1900.....					92,581
1901.....					88,871
1902.....					76,906
1903.....					85,705

^a Since 1883 not separately classified.

CANADIAN PRODUCTION.

The production of grindstones in Canada has not yet become very large, and in 1903 there were produced only 5,538 tons in quantity, valued at \$48,302, or \$8.72 per ton. This value per ton is somewhat lower than the average price of \$11 per ton received for the United States production.

BUHRSTONES AND MILLSTONES.

PRODUCTION.

The value of the production of buhrstones in 1903 was \$52,552, a decrease of \$7,256 as compared with \$59,808, the value of the production in 1902. For the last three years the value of the production has been over \$50,000, and it is very probable that the production will continue for some time to come to increase gradually in value. From 1880 to 1887 the value of the production ranged between \$100,000 and \$200,000, but from 1887 to 1894 there was a large decrease, from \$100,000 to \$13,887, due to the introduction of the roller-mill process in grinding wheat, which superseded the use of buhrstones, except in a few local areas. Since 1894, however, there has been a gradual increase in the production on account of the use of these stones for grinding the coarser cereals, mineral paint ores, fertilizers, cement rock, barytes, quartz, and other minerals. For these uses the demand is increasing each year.

There were 5 States from which the production of 1903 was obtained, with a total of 26 producers, as follows: New York, 17; Pennsylvania and Virginia, 3 each; North Carolina, 2, and Vermont, 1. These were the same States from which the production of 1902 was obtained. The following table gives the value of the production in 1902 and 1903 by States:

Value of buhrstones produced in the United States in 1902 and 1903, by States.

State.	1902.	1903.
New York.....	\$39,570	\$35,441
Virginia.....	11,435	9,812
North Carolina and Vermont.....	6,825	5,902
Pennsylvania.....	1,978	1,397
Total.....	59,808	52,552

As is shown by this table, the decrease in the value of the production of buhrstones in 1903 as compared with 1902 is nearly uniformly divided among all the States.

The value of buhrstones produced in the United States since 1880 is given in the following table:

Value of buhrstones produced in the United States, 1880-1903.

Year.	Value.	Year.	Value.
1880	\$200,000	1892	\$23,417
1881	150,000	1893	16,639
1882	200,000	1894	13,887
1883	150,000	1895	22,542
1884	150,000	1896	22,567
1885	100,000	1897	25,932
1886	140,000	1898	25,934
1887	100,000	1899	28,115
1888	81,000	1900	32,858
1889	35,155	1901	57,179
1890	23,720	1902	59,808
1891	16,587	1903	52,552

IMPORTS.

There is considerable variation in the value of the imports of buhrstones into the United States, as is shown in the following table, which gives the value of the buhrstones imported since 1868.

Value of buhrstones and millstones imported into the United States, 1868-1903.

Year ending—	Rough.	Made into millstones.	Total.	Year ending—	Rough.	Made into millstones.	Total.
June 30—				December 31—			
1868	\$74,224		\$74,224	1886	\$29,273	\$662	\$29,935
1869	57,942	\$2,419	60,361	1887	23,816	191	24,007
1870	58,601	2,297	60,898	1888	36,523	705	37,228
1871	35,406	3,698	39,104	1889	40,432	452	40,884
1872	69,062	5,967	75,029	1890	32,892	1,103	33,995
1873	60,463	8,115	68,578	1891	23,997	42	24,039
1874	36,540	43,170	79,710	1892	33,657	529	34,186
1875	48,068	66,991	115,059	1893	29,532	729	30,261
1876	37,759	46,328	84,087	1894			^a 18,087
1877	60,857	23,068	83,925	1895			^a 20,316
1878	87,679	1,928	89,607	1896			^a 26,965
1879	101,484	5,088	106,572	1897			^a 22,956
1880	120,441	4,631	125,072	1898	22,974	1,025	23,999
1881	100,417	3,495	103,912	1899	18,368	513	18,881
1882	103,287	747	104,034	1900	27,960	944	28,904
1883	73,413	272	73,685	1901	40,885	1,302	42,187
1884	45,837	263	46,100	1902	15,243	915	16,158
1885	35,022	455	35,477	1903	21,160	8,481	29,641

^a Not separately classified.