

## GLASS SANDS OF OHIO

J. A. BOWNOCKER  
*Ohio State University*

### AGE OF GLASS SAND ROCKS.

The sands of Ohio that have been used for glass making or are now so used range in age from the Devonian to the Pennsylvanian. The following section shows more definitely the principal horizons:

Pennsylvanian system.....		{ Allegheny formation { Pottsville formation
Mississippian system.....		{ Logan formation { Black Hand formation
Devonian system.....		Sylvania sandstone

### SPECIFICATIONS FOR GLASS SANDS.

The American Ceramic Society has tentatively set specifications for glass sand, and while these include a number of items the most important by far is the chemical composition. The specifications on this point follow:\*

PERCENTAGE COMPOSITION OF SANDS OF VARIOUS QUALITIES  
(BASED ON IGNITED SAMPLES).

QUALITIES	SiO <sub>2</sub> Min.	Al <sub>2</sub> O <sub>3</sub> Max.	Fe <sub>2</sub> O <sub>3</sub> Max.	CaO MgO Max.
First quality optical glass.....	99.8	0.1	.02	0.1
Second quality flint glass containers tableware.....	98.5	0.5	.035	0.2
Third quality flint glass.....	95.0	4.0	.035	0.5
Fourth quality sheet glass rolled and polished plate.....	98.5	0.5	.06	0.5
Fifth quality sheet glass rolled and polished plate.....	95.0	4.0	.06	0.5
Sixth quality green glass containers and window glass.....	98.0	0.5	0.3	0.5
Seventh quality green glass.....	95.0	4.0	0.3	0.5
Eighth quality amber glass containers.....	98.0	0.5	1.0	0.5
Ninth quality amber.....	95.0	4.0	1.0	0.5

\*Am. Cer. Soc., Vol. 6, No. 6, p. 182.

## PRODUCTION OF GLASS SAND IN OHIO FOR CERTAIN YEARS.

	Short Tons	Value
1902.....	42,311	\$ 50,426
1905.....	76,460	79,999
1910.....	139,122	104,295
1915.....	55,844	139,229
1923.....	46,184	101,362

In 1923 there were 2,034,958 short tons of glass sands produced in the United States with a value of \$3,751,788. Ohio's contribution to the output for that year was therefore only a little more than 2 per cent in weight and less than that in value.

## LOCATION AND QUALITY OF OHIO GLASS SANDS.

Ohio has enormous quantities of sandstone, but as is shown on later pages its composition is not suitable for glass, except for common products where color is not objectionable. Iron is the chief trouble maker. Alumina is always present, but this in itself is not objectionable. In fact some glass makers add alumina, which is said to increase the toughness of glass. Calcium and magnesium oxide also are almost always present, but they do little or no harm if their proportion is fairly constant. However, in one locality in Ohio they range from 6 to 18 per cent of the rock, with of course a corresponding variation in the silica. Titanium oxide also is present, but its proportion is commonly less than one-fourth of one per cent. It, too, gives color and therefore is objectionable except in the most common varieties of glass.

These impurities can be reduced by washing. Thus in 42 samples the content of iron oxide averaged 0.35 per cent and after washing 0.18 per cent, a decrease of 49 per cent. In like manner the titanium oxide was reduced 57 per cent and the alumina 67 per cent. It should be stated that the chemical analyses which form so important a part of this paper were made in the laboratory of Professor D. J. Demorest.

In the following pages the principal deposits of sandstone in the State are reviewed. Those lowest in the geological time scale are first considered, then the next lowest, and so on.

## SANDS OF DEVONIAN AGE.

The Monroe limestone forms the surface of several thousand square miles in western Ohio. In Lucas County it consists of three principal divisions:

Detroit River dolomite.....	} Devonian	{ 120 feet
Sylvania sandstone.....		
Bass Island dolomite.....	} Silurian	

Only the Sylvania sandstone concerns us in this paper. It can be traced as a narrow band from the Ohio-Michigan State line south to Otsego Falls of the Maumee. Beyond that its position is below drainage and data concerning it are therefore lacking. While the sandstone has been quarried at several places in Lucas County, the best known deposit is that at Silica, two and one-half miles south of the State line.

*Silica.*—In 1914 the Owens Bottle Machine Company purchased the plant of the Toledo Silica Sand Co., at Silica, Lucas County. When this quarry was first opened is unknown, but sand was gotten here as early as 1863 and shipped to Pittsburgh, where it was used for making flint glass.\* Since that time the rock has been quarried at irregular periods.

When visited in 1917, from 16 to 24 feet of sandstone was being quarried, but the core drill is reported to have shown a maximum thickness of 60 feet.† The beds dip sharply to the west so that the outcrop is narrow. In general the sandstone is poorly cemented with calcite or dolomite and has a light-gray color. The beds range from a few inches to several feet in thickness and are irregular. Bottles and window glass have been the principal products in the glass line.

#### *Chemical Analysis.*

	Rock Chips from Quarry Face	Glass Sand Washed
Silica, SiO <sub>2</sub> .....	90.73	95.11
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	.76	.13
Ferric oxide.....	.06	.02
Calcium carbonate, CaCO <sub>3</sub> ...	5.00	3.05
Magnesium carbonate, MgCO <sub>3</sub>	3.18	1.42
Titanium oxide, TiO <sub>2</sub> .....	.00	.00
Loss on ignition.....	.30	.25

The company reports the silica to range from 88 to 96 per cent and the calcium and magnesium carbonates from 6 to 18 per cent. The iron is low, but the varying proportion of silica and the rapidly changing calcium and magnesium make the sand unsatisfactory. No sand has been used from this quarry for glass making since 1920 and the large and well equipped plant has been dismantled.

\*Geol. Survey Ohio, Vol. I, p. 582.

†Prof. J. E. Carman, who has made a detailed study of this region, gives the thickness of the sandstone as 40 feet.

## SANDS OF MISSISSIPPIAN AGE.

The Mississippian rocks of Ohio consist of shales, sandstones, conglomerates, and limestone. They outcrop as a broad belt from Ashtabula and Trumbull counties west to the middle of the State and thence due south to the Ohio River, where the rocks cross into Kentucky. The only Mississippian rocks that have been used for glass making lie near the top and include the Black Hand and the Logan formations.

*Millwood.*—On the south side of the Kokosing River, near the village of Millwood, in the eastern part of Knox County, a sandstone of Mississippian age (probably the Black Hand) has been worked since 1906 for glass and molding sand. The rock which is worked to a depth of 22 feet lies in thin, uneven layers except near the base, where a bed of 3 or 4 feet thick was noted. As a whole, the rock is poorly cemented and hence easily crushed. On the east side of the quarry and part of the south the rock has a light buff color, but on the west side and part of the south it is light gray. The latter is or has been used at Mt. Vernon, Columbus, and Coshocton for glass making, and is now used by the Pittsburgh Plate Glass Co., at Mt. Vernon, for window glass. The buff sand finds a market for steel castings. The sand is also employed in making water glass, and for water filters. Columbus, Lima, Delaware, Struthers, Toronto, and Flint, Michigan, were supplied for the latter purpose. It is claimed that on the north side of the river there is 30 feet of light-colored sand. The operating company is the Knox White Sand Co.

Chips were taken of the gray sandstone from the west end of the quarry and from ledges exposed along the Kokosing, and on analysis gave the following results:

	Chips from West End of Quarry Percent	Chips from Bluffs of Kokosing Percent
Silica, SiO <sub>2</sub> .....	98.60	97.63
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	.18	.59
Ferric oxide.....	.09	.22
Calcium oxide, CaO.....	.02	.00
Magnesium oxide, MgO.....	.06	.01
Titanium oxide, TiO <sub>2</sub> .....	.03	.04
Loss on ignition.....	.21	.70
	<hr/> 99.19	<hr/> 99.19

After laboratory washing the first sample had its ferric oxide reduced to .07 per cent and the second to .14 per cent.

Microscopical examination of the first sample showed the following minerals which are listed in order of their abundance: quartz, kaolin, muscovite, limonite, zircon, sericite, hematite, rutile, and chlorite. In the second sample feldspars are listed in abundance after silica, due probably to less weathering than in the first sample.

*Plant of the E. H. Everett Co.* This plant is located at Black Hand rock on the Licking River in the eastern part of Licking County. It has been operated since about 1890 and the product goes to the plant of the American Bottle Co., at Newark, where it is used for making bottles for beverage purposes. A section in the quarry is given below:

Mantle rock.....	4 ft.
Logan formation. Thin-bedded, coarse-grained sandstones. Rejected.....	21
Black Hand formation. Thick-bedded, coarse-grained sandstone, pebbly in places. Buff colored.....	60

The sand is crushed, screened, and washed, and then thrown on the stock pile. The iron content varies. In places it is barely sufficient to impart a buff color, but occasionally it forms crusts of siliceous ore. In places thin shale or clay layers are found. No carbonaceous matter was observed. The composition of the sand is shown by the following analyses:

	Unwashed Sand	Washed Sand	Washings
Silica, SiO <sub>2</sub> .....	97.05	98.80	65.80
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	1.50	.12	16.60
Ferric oxide.....	.79	.52	5.71
Calcium oxide, CaO.....	.00	.00	.42
Magnesium oxide, MgO.....	.00	.00	.25
Titanium oxide, TiO <sub>2</sub> .....	.18	.10	1.10
Loss on ignition.....	.40	.22	6.30

The washed sand was examined with a microscope and the following minerals identified. They are listed in order of their abundance: Quartz, orthoclase, plagioclase, microcline, tourmaline, limonite, sericite, kaolinite, magnetite, chlorite, rutile, zircon, and monazite.

When working in full the quarry produces approximately 250 tons per day, but the average is only one-half of that.

*Rockbridge.*—About 2 miles south from Rockbridge, Hocking County, the Black Hand formation was formerly worked for

glass and molding sand. When visited the quarry face had a maximum height of 60 feet and a length of 250 feet. The rock is coarse grained and has two layers of pebbles, each about 2 feet thick, and lying from 12 to 16 feet apart. At the north end of the quarry one of these thickens to 9 feet. Occasional quartz pebbles were found scattered through the mass of rock. At the top and bottom of the quarry the rock has a buff color, but below the pebbly layers it is light gray. Throughout the mass are spots or patches of darker color, due to concentration of iron.

This rock was crushed in a gyratory crusher and further reduced in a wet pan. It was then run through a revolving wheel screen and an auger washer, and transported to the stock pile for draining. Later it was passed through a drier and screened again.

Three grades of sand were produced. The best was a pure white that was obtained from beneath the pebbles. It was used in making window glass. The second grade was also a glass sand, but less pure than the first. However, much of the second grade was disposed of to steel mills and to brick plants. The third grade had its source in the colored rock and was used for sanding steel rails in coal mines and on traction lines. The pebbles, which are highly objectionable in glass sand, were carefully screened and sold to clean steel and iron castings. Two samples gave the following analyses:

	Pure Glass Sand Washed	Glass Sand Washed
Silica, SiO <sub>2</sub> .....	98.63	98.73
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	.44	.45
Ferric oxide.....	.13	.46
Calcium oxide, CaO.....	.00	.00
Magnesium oxide, MgO.....	.03	.00
Titanium oxide, TiO <sub>2</sub> .....	.25	.13
Loss on ignition.....	.20	.22
	99.68	99.99

Microscopic examination of the first sample showed the presence of the following minerals, which are listed in order of their abundance: Quartz, kaolinite, tourmaline, zircon, limonite, magnetite, apatite, and rutile. In the second sample limonite and hematite rank third and fourth in abundance.

A fire destroyed the plant in 1915 and it was then abandoned.

## SANDS OF PENNSYLVANIAN AGE.

Rocks of Pennsylvanian age extend from the Ohio-Pennsylvania line southwest to the Ohio River and cover a large part of the eastern third of the State. They include coal, clay, shale, sandstone, conglomerate, and limestone.

Only the two lower formations, Pottsville and Allegheny, have been sources of glass sand and of these the Pottsville is the more important. The basal member is the Sharon conglomerate, which in places is pebbly and elsewhere a coarse sandstone or even a shale. The rock is massive and poorly cemented.

The pebbles are of quartz and vary in size from a small fraction of an inch to 3 inches or more. The color is of light shades. Near the top, buff is the common color of the rock, but below, where weathering has been less, gray is the usual shade.

The Sharon varies greatly in thickness. Lamb places the maximum in northern Ohio at 90 feet and Stout\* that for the southern part of the State at 200 feet. Thicknesses of 50 feet are common. At present this sand is used in a small way for window glass and bottles.

The Allegheny formation has deposits of sandstone, but they are much thinner than the Sharon conglomerate. Nearly everywhere they are high in iron and therefore unsuited for glass except perhaps the most common wares. In Tuscarawas County rock of this age is quarried for steel molding sand.

*Hartford.*—The plant of the Standard Silica Co. is located one and one-half miles west of Hartford, Trumbull County, on the western margin of a ridge of the Sharon conglomerate. A maximum of 30 feet of the rock was quarried. The upper 6 to 8 feet is decidedly pebbly; below this the rock is a coarse sandstone. The color ranges from buff to gray. Small grains of coal are scattered through the rock.

The rock was loaded on cars with a steam shovel, was crushed, screened, washed, and dried. For several years this sand had a market for the manufacture of glass fruit jars. Other uses were for molding sand and for concrete.

This plant began shipping sand in December, 1910; it was closed in March, 1921. High freight rates are reported to have been the principal reason for closing the works.

---

\*This Journal, Vol. 21, p. 252.

*National Sand and Stone Company.*—The plant of this company is located in Mahoning County about 2 miles south of Mineral Ridge. The rock is a coarse sandstone, the lower 3 feet in places conglomeratic, and lies at or near the base of the Pennsylvanian. Specks and even small pockets of coal are occasionally found; one was noted which measured 5 inches in thickness. As much as 43 feet of sandstone has been quarried. The top 10 feet is in beds usually less than 12 inches thick, but the rest of the quarry is more massive and beds measuring 10 feet were found. The rock is friable and therefore easily crushed. The upper two-thirds of the stone has a buff or yellow color, and that below gray, the difference being due to weathering. The buff stone is crushed and washed and disposed of for foundry purposes, for brick making, and on traction rails to prevent slipping.

The gray stone is crushed in a jaw crusher, ground in a wet pan, washed, screened, and dried. In washing, 6 tons of water is said to be used for each ton of sand. Glass is the chief use of this product and the market is said to extend from Cleveland to Washington, Pa. The proprietor stated that the General Electric Co. finds this sand satisfactory for making electric light bulbs. It has also been used in making various grades of bottles and window glass. Other uses are for water glass and the white coat for plastering.

Following are analyses of two samples of washed glass sand from this plant:

Silica, SiO <sub>2</sub> .....	99.33	98.31
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	.10	.39
Ferric oxide.....	.009	.31
Calcium oxide, CaO.....	.07	.09
Magnesium oxide, MgO.....	.05	.04
Titanium oxide, TiO <sub>2</sub> .....	.09	.08
Loss on ignition.....	.15	.26
	<hr/>	<hr/>
	99.799	99.48

*Massillon.*—At Massillon, Stark County, is the Everhard quarry, which was opened in 1884. Its main products have been steel molding sand, furnace sand, core sand, building stone, and to a much smaller extent glass sand.

The beds worked are coarse grained, and have a maximum thickness of 60 feet. The rock is friable and shelly near the top, but thicker below. In fact, beds 10 feet thick and without a horizontal break were noted. The color is buff, but in a



quarry a little farther west it is light brown, called pink by the workmen.

Selected chips from the quarry face had the following composition:

	Percent
Silica, SiO <sub>2</sub> .....	96.51
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	1.90
Ferric oxide.....	.58
Calcium oxide, CaO.....	.07
Magnesium oxide, MgO.....	.01
Titanium oxide, TiO <sub>2</sub> .....	.12
Loss on ignition.....	.56
	99.75

A sample collected in the same manner was examined with a microscope and the following minerals noted. They are listed in the order of their abundance: Quartz, limonite, kaolinite, feldspars, muscovite, hematite, sericite, zircon, and magnetite.

#### DUNDEE SANDSTONE.

The Dundee sandstone lies near the base of the Allegheny formation. It is well exposed along the valley of Sugar Creek in the northwest corner of Tuscarawas County, where it is worked in a large way at Barrs Mills, Dundee, and Beach City for steel molding purposes and furnace bottoms, and to a much smaller extent for glass sand. The rock is coarse grained, but is without pebbles, and has a color which ranges from gray to buff, the latter predominating. Fifty feet or more of the rock is quarried.

The composition of the sand along Sugar Creek Valley is shown below:

	Massillon Sand & Stone Co. Unwashed Barrs Mills	National Malleable Castings Co. Unwashed Dundee	Beach City Silica Sand Co. Unwashed
Silica, SiO <sub>2</sub> .....	98.28	96.63	97.76
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	.32	2.00	.69
Ferric oxide.....	.24	.42	.34
Calcium oxide, CaO.....	.00	.00	.00
Magnesium oxide, MgO.....	.13	.04	.11
Titanium oxide, TiO <sub>2</sub> .....	.07	.20	.05
Loss on ignition.....	.32	.60	.40

A sample of the stone from Barrs Mills was examined with the microscope, and the following minerals noted. In order of their abundance they are, quartz, microcline, feldspars, limonite, kaolinite, tourmaline, chlorite, zircon, titanite, and serpentine.

*Barberton.*—The plant of the Summit Silica Co. is located near the southern border of Barberton, Summit County, where a ledge of the Sharon conglomerate, 45 feet high, is the basis of the industry. In places the pebbles are confined to part of the ledge, while elsewhere they occur through the mass. The company estimates that 60 per cent of the rock is pebbly. Most of the pebbles are less than one inch in diameter and the largest observed measured about 3 inches. They are of quartz and have various shades of light colors.

The rock is crushed and washed, and that used for glass making is dried and screened. However, only the sandy part of the rock is marketed for glass making. In other words, the crushed pebbles are not used for that purpose. The sand is suitable for window glass, bottles, and in fact any kind of glass except the higher grades.

Following is an analysis of a sand from this plant:

	Unwashed and Unscreened Sand. Percent.
Silica, SiO <sub>2</sub> .....	97.41
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	.58
Ferric oxide.....	.31
Calcium oxide, CaO.....	.11
Magnesium oxide, MgO.....	.00
Titanium oxide, TiO <sub>2</sub> .....	.09
Sodium oxide, Na <sub>2</sub> O.....	.04
Potassium oxide, K <sub>2</sub> O.....	.08
Loss on ignition.....	.44
	99.06

Microscopical examination of the first sample showed the following minerals which are listed in order of their abundance: Quartz, magnetite, zircon, kaolinite, feldspar, muscovite, and apatite.

*Chalfants.*—The Chalfants plant of the Central Silica Co. is situated in the northern part of Perry County, and has been in existence for more than 40 years. The rock worked is the Pottsville conglomerate, and is covered with from 4 to 6 feet of stripping, which is removed with a drag line system. Beneath the stripping the stone is worked to a depth of 35 feet. It is coarse-grained sandstone and in places contains quartz pebbles. Near the top the rock is shelly; farther down the layers are thicker; while near the base of the quarry the rock is massive. The material is poorly cemented and its color varies from buff to light brown. The rock is loaded onto cars with a steam shovel, and is hauled to the mill by a dinky engine.

The rock is broken in a gyratory crusher and is further reduced in a dry pan. It is then run through a 6-mesh rotary screen and the material which passes through it is washed and dried. Again this sand is screened, first through a 20-mesh and then through a 16-mesh. What passes through the latter is disposed of in large part for green and amber bottles and for window glass. When the plant is working to capacity this amounts to 80 tons per day or about 48 per cent of the output.

*Jackson County.*—Sandstone was formerly quarried on the J. S. McKitterick farm, one mile north of Jackson, for bottle glass, but when the plant at Jackson was closed the one market for this glass sand was at an end.

The sandstone, of which a ledge of 60 feet is exposed, lies on or near the horizon of the No. 1 coal. It is coarse grained and poorly cemented. The color varies from gray to brown. No mill was erected, the rock being crushed with hammers by hand labor.

*The Ohio Flint and Glass Sand Co.*—The quarry of this company is located on the Jasper Middaugh farm in the southwest corner of Section 25, Reading Township, Perry County. The rock lies at an elevation of about 1,080 feet and while its position in the rock column has not been accurately determined, it appears to lie in the Allegheny formation, or lower coal measures.

The sandstone which is covered with about 2 feet of mantle rock has been quarried to a depth of 18 feet, and it is reported that the drill showed 14 feet of sandstone below this. Near the top the rock is thin-bedded, but the layers increase in thickness below. The sandstone is coarse grained and poorly cemented. White mica or muscovite is common. The color varies from light gray to buff. Other knobs in this locality carry the sandstone.

#### *Analyses.*

	Washed Sand	Chips from Quarry Face
Silica, SiO <sub>2</sub> .....	98.01	94.23
Iron oxide, Fe <sub>2</sub> O <sub>3</sub> .....	.29	.34
Alumina, Al <sub>2</sub> O <sub>3</sub> .....	.35	2.98
Titanium oxide, TiO <sub>2</sub> .....	.20	.28
Phosphorus pentoxide, P <sub>2</sub> O <sub>5</sub> .....	.02	.02
Calcium oxide, CaO.....	.14	.20
Magnesium oxide, MgO.....	.34	.22
Sodium oxide, Na <sub>2</sub> O.....	.16	.11
Potassium oxide, K <sub>2</sub> O.....	.24	.86
Ignition loss.....	.45	1.00

The rock is trucked to Rushville Station, where it is crushed, screened, washed, and dried. It is claimed that in washing the sand loses much of its color. For some months the plant is idle because the roads are such that trucking can not be done. At present (1924) the company is considering the erection of an aerial tramway from quarry to mill. The sand has been used by the Hazel Atlas Glass Co., at Zanesville.

## COMPOSITION OF OHIO SANDS.

	Silica, SiO <sub>2</sub>	Alumina, Al <sub>2</sub> O <sub>3</sub>	Ferric Oxide	Calcium Oxide, CaO	Magnesium Oxide, MgO	Titanium Oxide, TiO <sub>2</sub>	Loss on Ignition
<i>Athens County</i>							
Palos (Mahoning sandstone, Conemaugh formation) Chips from fresh surface.....	89.88	6.01	.82	.00	.12	.12	1.12
<i>Carroll County</i>							
Craig Stone Co. (Conemaugh formation) Chips from fresh surface.....	94.91	2.80	.54	.00	.04	.15	.90
Prosperity Quarry (Conemaugh formation) Chips from fresh surface.....	95.92	2.31	.36	.00	.05	.12	.90
<i>Columbiana County</i>							
Jessup Quarry, Salem (Allegheny formation) Rock crushed but unwashed.....	85.14	6.08	3.66	.10	.13	.25	2.65
O'Mara Quarry, Lisbon. (Allegheny formation) Chips from rock face.....	94.30	2.97	.58	.00	.15	.15	1.10
<i>Coshocton County</i>							
Chips from ledge near Chili (Allegheny formation).....	96.24	.....	.45	.00	.04	.....	.58
Layland Sand & Stone Co. (Pottsville formation) Chips from quarry face.....	95.20	2.30	.45	.00	.10	.10	.69
Moore Quarry, Warsaw (Pottsville formation) Chips from quarry face.....	92.66	3.92	.50	.00	.01	.15	.70
<i>Cuyahoga County</i>							
Berea sandstone at Berea Chips of rock and sand from grindstone plant.....	91.78	4.12	.84	.11	.04	.24	1.19
Berea sandstone, Berea.....	93.13	3.86	.65	.19	.25	.....	1.43

## COMPOSITION OF OHIO SANDS—CONTINUED.

	Silica, SiO <sub>2</sub>	Alumina, Al <sub>2</sub> O <sub>3</sub>	Ferric Oxide	Calcium Oxide, CaO	Magnesium Oxide, MgO	Titanium Oxide, TiO <sub>2</sub>	Loss on Ignition
<i>Fairfield County</i>							
Allegheny Quarry, 4 miles east of Lancaster (Black Hand and Logan formations)							
Chips from fresh surface of quarry.....	96.03	1.34	.92	.00	.13	.25	.55
Sharp Quarry, Sugar Grove (Black Hand formation)							
Clean chips from spalls.....	97.43	.51	.58	.00	.10	.09	.41
<i>Gallia County</i>							
Fitzpatrick farm, near Alice (Conemaugh formation)							
Chips from face of ledge, unwashed....	93.07	3.71	.42	.02	.03	.12	.80
Same, but washed.....	95.43	1.85	.37	.00	.03	.12	.40
<i>Harrison County</i>							
Ozark Quarry (Conemaugh formation)							
Chips from quarry face.....	93.56	4.04	.60	.00	.03	.13	1.15
<i>Hocking County</i>							
Rockbridge Quarry of Central Silica Co. (Black Hand formation)							
Glass sand, washed.....	98.63	.44	.13	.00	.03	.25	.20
Glass sand, washed.....	98.73	.45	.46	.00	.00	.13	.22
<i>Holmes County</i>							
Uhl Quarry, near Killbuck (Pottsville formation)							
Purest rock.....	97.41	.65	.12	.12	.00	.07	.27
White rock.....	97.06	1.30	.15	.01	.06	.15	.25
Less pure rock.....	96.48	1.44	.20	.00	.04	.13	.30
Glenmont Quarry (Pottsville formation)							
Chips from quarry face.....	95.24	2.55	.38	.07	.00	.28	.43
Columbus Co. Quarry (Pottsville formation)							
Chips from quarry face.....	96.30	1.88	.42	.00	.03	.12	.60
Gray Quarry near Hardy's Switch. (Pottsville formation)							
Chips from quarry face.....	94.25	3.17	.63	.01	.06	.15	.61
<i>Jefferson County</i>							
Quarry on Champion and Duffy farms (Conemaugh formation)							
Chips from quarry face.....	84.42	8.08	2.50	.04	.01	.51	2.10
<i>Knox County</i>							
Millwood White Sand Co. (Logan (?) sandstone)							
Glass sand, unwashed.....	98.60	.18	.09	.02	.06	.03	.21
Molding sand, washed.....	98.29	.15	.28	.03	.06	.03	.23
Chips from ledges along the Kokosing	97.63	.59	.22	.00	.01	.04	.70

## COMPOSITION OF OHIO SANDS—CONTINUED.

	Silica, SiO <sub>2</sub>	Alumina, Al <sub>2</sub> O <sub>3</sub>	Ferric Oxide	Calcium Oxide, CaO	Magnesium Oxide, MgO	Titanium Oxide, TiO <sub>2</sub>	Loss on Ignition
<i>Jackson County</i>							
Jackson Sand Mining Co., 2 miles north of Coalton. (Pottsville formation)							
Bin sample, top sand, unwashed.....	96.79	2.00	.20	.00	.08	.17	.55
Bin sample, bottom sand, unwashed...	96.19	2.22	.20	.00	.03	.18	.65
Chips from near-by ledges.....	98.50	.70	.22	.10	.00	.10	.35
Buzzard Rocks cliff							
Chips from quarry face.....	98.60	.45	.37	.10	.00	.05	.30
<i>Lawrence County</i>							
Wallenfelsz and Williams farm, north of Ironton, (Pottsville formation)							
Chips from quarry face.....	91.09	4.80	1.10	.00	.10	.15	.92
Petersburg Fire Brick & Tile Co., Coal Grove. (Allegheny formation)							
Chips of fire stone.....	85.57	9.06	.42	.02	.03	.34	2.10
Chips of ganister.....	92.35	4.51	.63	.00	.07	.45	1.13
<i>Licking County</i>							
Everett Quarry, Toboso (Black Hand formation)							
Glass sand, unwashed.....	97.05	1.50	.79	.00	.00	.18	.40
Glass sand, unwashed.....	97.11	1.47	.72	.00	.02	.18	.40
Glass sand, washed.....	98.80	.12	.52	.00	.00	.10	.22
Washings.....	65.80	16.60	5.71	.42	.25	1.10	6.30
<i>Lorain County</i>							
Cleveland Stone Co. Quarry. South Amherst (Berea sandstone).....	92.15	3.85	1.40	.50	.20	.40	1.70
<i>Lucas County</i>							
Toledo Silica Sand Co. (Monroe formation)							
Rock chips from north end of quarry..	90.73	.76	.06	5.00	3.18	.00	.30
Car sample of sand. Washed and screened.....	95.11	.13	.02	3.05	1.42	.00	.25
<i>Mahoning County</i>							
Spencer Quarry, 2 miles south of Ellsworth (Pottsville or Allegheny formation)							
Chips from quarry face.....	98.14	.45	.13	.04	.02	.09	.35
National Sand & Stone Co., 2 miles south of Mineral Ridge. (Pottsville formation)							
Best glass sand, washed.....	99.33	.10	.009	.07	.05	.09	.15
Glass sand.....	98.31	.39	.31	.09	.04	.08	.26

## COMPOSITION OF OHIO SANDS—CONTINUED.

	Silica, SiO <sub>2</sub>	Alumina, Al <sub>2</sub> O <sub>3</sub>	Ferric Oxide	Calcium Oxide, CaO	Magnesium Oxide, MgO	Titanium Oxide, TiO <sub>2</sub>	Loss on Ignition
<i>Perry County</i>							
Chalfant Quarry of Central Silica Co. (Pottsville formation)							
Glass sand, washed.....	99.43	.18	.13	.00	.05	.04	.22
Steel sand, washed.....	95.66	1.84	.19	.00	.16	.22	.87
Ganister, unwashed.....	98.61	.39	.20	.00	.06	.20	.27
Blast sand, washed.....	97.99	1.08	.22	.00	.07	.08	.53
Washed sand from pit of Ohio Flint & Glass Sand Co., Reading Township. (Allegheny (?) formation).....	98.01	.35	.29	.14	.34	.20	.45
Chips of sandstone from face of same quarry.....	94.23	2.98	.34	.20	.22	.28	1.00
<i>Pike County</i>							
Berea sandstone, near Waverly.....	91.00	5.20	1.47	tr.	.28	.....	1.80
<i>Portage County</i>							
Kent Quarry (Pottsville formation)							
Chips from old quarry face.....	98.56	.28	.10	.08	.02	.07	.40
Portage Silica Co. (Pottsville formation)							
Steel molding sand, washed.....	98.14	.16	.35	.38	.05	.08	.31
Fine blast sand, washed.....	98.46	.17	.23	.17	.00	.03	.28
Coarse blast sand, washed.....	98.04	.24	.28	.21	.01	.03	.30
Very fine washings.....	92.15	3.19	.72	.76	.06	.65	.40
<i>Stark County</i>							
Coxey Silica Sand Co., Pauls. (Pottsville formation)							
White steel molding sand, unwashed..	96.87	1.58	.13	.00	.03	.17	.57
Buff steel molding sand, unwashed...	95.67	1.95	.53	.12	.00	.15	.64
Sonnhalter Sand & Stone Co., Massillon. (Pottsville formation)							
Glass sand, washed.....	96.77	.84	.61	.02	.17	.20	.52
Rolling mill sand, unwashed.....	93.63	3.50	.80	.04	.00	.23	1.25
Massillon Silica Sand Co. (Pottsville formation)							
Finer steel molding sand, unwashed..	97.40	1.44	.49	.11	.02	.13	.52
Coarser steel molding sand, unwashed.....	97.48	.56	.32	.05	.04	.07	.50
Everhard Co., Massillon. (Pottsville formation)							
Bottle glass or steel molding sand....	95.75	1.60	.81	.00	.02	.15	.68
Furnace bottom sand.....	96.29	1.63	.33	.03	.00	.20	.43
<i>Scioto County</i>							
Damarin Hill Quarry, Portsmouth. (Pottsville formation)							
Chips from face of quarry.....	97.49	1.59	.28	.00	.07	.15	.51
McDermott Quarry, (Cuyahoga formation)							
Blue-gray stone.....	85.60	7.25	2.60	tr.	tr.	.75	1.70
Yellow stone.....	84.50	6.35	3.00	tr.	tr.	.75	2.15

## COMPOSITION OF OHIO SANDS—CONTINUED.

	Silica, SiO <sub>2</sub>	Alumina, Al <sub>2</sub> O <sub>3</sub>	Ferric Oxide	Calcium Oxide, CaO	Magnesium Oxide, MgO	Titanium Oxide, TiO <sub>2</sub>	Loss on Ignition
<i>Summit County</i>							
Summit Silica Co., Barberton, (Pottsville formation)							
Sand, unscreened and unwashed.....	97.41	.58	.31	.11	.00	.09	.44
Emery Sand Plant, Twinsburg. (Pottsville formation)							
Sand, unwashed.....	97.74	.46	.83	.00	.18	.09	.34
Akron White Sand Co., Akron. (Pottsville formation)							
Sand, unwashed.....	97.10	1.27	.19	.00	.05	.08	.55
Newell Quarry, Macedonia. (Pottsville formation)							
Chips from lower half of quarry.....	98.00	.36	.53	.01	.08	.....	.34
Chips from lower half of quarry.....	98.29	.69	.18	.00	.00	.04	.28
Bramley Quarry, Copley (Pottsville formation)							
Chips from quarry face.....	98.54	.28	.24	.01	.01	.07	.29
Boston ledges, Boston Township. (Pottsville formation).							
Chips from 50-foot face.....	97.91	.51	.44	.05	.06	.05	.32
Eric Railroad cut, 2½ miles west of Barberton. (Pottsville formation)							
Chips from face of ledge.....	96.07	2.91	.19	.14	.06	.18	.46
<i>Trumbull County</i>							
Trumbull Stone & Sand Co., 5 miles west of Warren. (Pottsville formation)							
Selected furnace sand, unwashed.....	97.13	1.52	.27	.01	.03	.23	.39
Furnace sand, unwashed.....	95.99	1.97	.35	.09	.00	.27	.62
<i>Tuscarawas County</i>							
American Sand Co., 1 mile north of Dundee (Pottsville formation)							
Selected steel molding sand, unwashed	97.99	.....	.45	.00	.05	.....	.43
Steel molding sand, unwashed.....	96.00	2.08	.31	.02	.03	.18	.61
National Malleable Castings Co., Dundee. (Pottsville formation)							
Core sand, unwashed.....	96.10	1.91	.33	.00	.02	.26	.67
Steel molding sand, unwashed.....	96.63	2.00	.42	.00	.04	.20	.60
Beach City Silica Sand Co., (Pottsville formation)							
Steel molding sand from bottom rock..	97.76	.69	.34	.00	.11	.05	.40
Steel molding sand from top rock.....	97.95	1.00	.37	.00	.06	.12	.35
Dundee Silica Sand Co., Dundee. (Pottsville formation)							
Furnace bottom sand, unwashed.....	94.30	2.85	.86	.00	.04	.33	.80
Coarse steel molding sand from bottom of quarry.....	98.76	.25	.19	.00	.04	.04	.40
Selected steel molding sand.....	97.40	1.13	.13	.00	.02	.17	.30



## COMPOSITION OF OHIO SANDS—CONTINUED.

	Silica, SiO <sub>2</sub>	Alumina, Al <sub>2</sub> O <sub>3</sub>	Ferric Oxide	Calcium Oxide, CaO	Magnesium Oxide, MgO	Titanium Oxide, TiO <sub>2</sub>	Loss on Ignition
<i>Tuscarawas County—(Continued)</i>							
White Rock Silica Sand Co. (Allegheny formation)							
Furnace bottom sand, unwashed.....	96.87	1.20	.45	.00	.06	.11	.43
Steel molding sand, unwashed.....	96.52	1.83	.31	.00	.03	.17	.39
Massillon Silica Sand Co., Barrs Mills. (Pottsville formation)							
Steel molding sand, unwashed.....	98.28	.32	.24	.00	.13	.07	.32
George J. Miller farm, 1½ miles southwest of Newcomerstown. (Allegheny formation)							
Fresh chips from outcrop.....	92.55	.....	.....	.03	.01	.....	1.15
<i>Vinton County</i>							
Beckley farm, 1½ miles south of McArthur							
Fresh chips from outcrop.....	94.03	3.24	.40	.00	.08	.13	.76
<i>Wayne County</i>							
Oliver Silica Sand Co., Warwick. (Pottsville formation)							
Steel molding sand, unwashed.....	98.30	.89	.27	.02	.05	.07	.32
Franklin Industrial Co., Warwick. (Pottsville formation)							
Steel molding sand, unwashed.....	97.47	.72	.38	.00	.06	.09	.60