

Glass Sands of Indiana--Industries.

BY EDWARD BARRETT.

It is not the purpose of the following article to discuss the question of the glass industries of Indiana, but rather to indicate the possibilities of the State in the matter of the raw materials that enter into the manufacture of ordinary glass products. The bulk of the glass manufacturies of the State is ordinary kinds for household purposes and ordinary construction. Indiana has abundance of good sands, both of glacial and sedimentary varieties, to furnish the bulk of materials for the manufacture of the kinds of glass mentioned above. It also has limestone of the purest variety to supply the necessary fluxing element. In the discussion of the essentials of a good glass sand or sandstone, we necessarily keep in mind the one great formation that furnishes the major part of the silica element in the manufacture of glass.

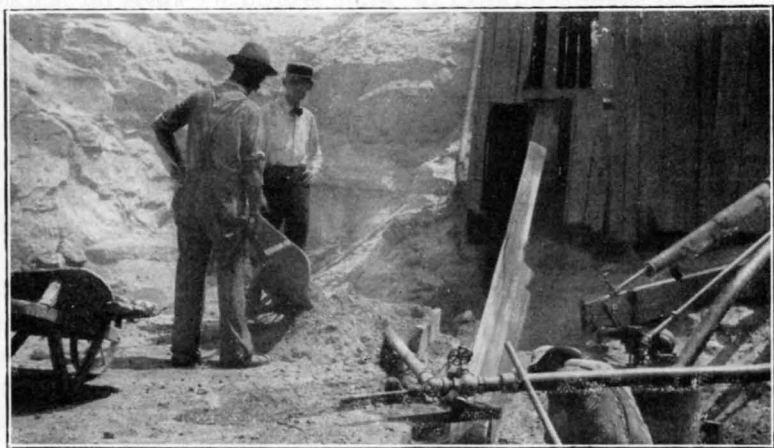
The most common impurities in any glass sand, particularly if it is sandstone, are oxide of iron and alumina. A short description of the methods of ridding the glass sand of these impurities is given under proper heads in another part of this paper. The questions of the per cent. of silica and the size of the particles also deserve and receive attention under proper heads.

GLASS SAND DEPOSITS.

It was stated above that the glass sand deposits or formations in Indiana are mainly of two kinds—sedimentary and glacial. The most important sedimentary deposit for glass purposes is the Mansfield sandstone, which is the basal member of the Pennsylvania system of rocks in Indiana. Down to very recent years this formation was known principally because it furnished the key to a study of the Carboniferous and Subcarboniferous systems.

The Mansfield sandstone outcrops in an area from the Ohio River in Perry County in a direction west of north to Benton County, influencing profoundly the topography of all of the counties between the ones mentioned above. The outcrops appear in bold cliffs along the stream courses. The massive and castellated form of the stone is due to the fact that after exposure and cemen-

tation by oxide of iron the sandstone resists weathering agencies. The exposures of the Mansfield where streams have cut part way through it are the most massive of any formation in Indiana. Examples of this may be seen at Williamsport, Warren County, where Fall Creek has cut its way through the sandstone to a depth of 75 to 100 feet on its way to the Wabash River. The head of the ravine formed by this creek ends abruptly in a massive outcrop of Mansfield sandstone over which the stream falls in a beautiful cataract a distance of 50 feet. A quarter of a mile to the east of the falls Mansfield sandstone was quarried for building purposes for many years, but owing to the many uses of cement



Base of facing of Mansfield Sandstone of Loogootee Glass Sand Company, one mile east of Loogootee, Indiana.

as foundation and structural material the quarries ceased operation a few years ago.

Three miles south of Attica, in Fountain County, the Attica Glass Sand Company has been operating a mining and washing plant for a number of years, drawing their supply of glass sand from an outcrop of a sandstone on Big Shawnee Creek.

In Parke County, prominent outcrops of the Mansfield occur on Sugar Creek and Raccoon Creek.

In Putnam County, prominent outcrops are found on the bluff of Big Walnut Creek, in the southwestern portion of the county.

In Clay County, bold exposures occur on the west bank of Croys Creek, about three and a half miles southeast of Brazil, and on Eel River in the eastern part of the county.

Many exposures occur in Owen County on the bluffs on either side of White River and some of its smaller tributaries within the county.

In Greene County there is a perfect network of exposures in stream valleys, large and small.

Probably the most massive and striking exposures of the Mansfield sandstone occur along the bluffs of the White River in Martin County. Just north of the city of Shoals, on the west bank of White River, the Mansfield exposes in the castlelike rock known as the "Pinnacle."

All of the northeast part of Dubois County has numerous exposures, particularly in the vicinity of Dubois and Jasper.

Continuing on down through western Crawford and Perry counties this formation is exposed in all of the upper portions of the bluffs in stream valleys.

There is scarcely an exposure mentioned above in any one of the counties but what the Mansfield would be suitable for glass sand purposes, particularly in making glass of the utility kind. There is a feature of the Mansfield exposures in Indiana which is particularly important. There is scarcely an important exposure of this formation but what the base of such exposure lies above drainage, thus enhancing the convenience and easiness in quarrying.

The area of exposure mentioned above is also crossed by at least seventeen important railroad lines, as follows, beginning at the north:

1. Cleveland, Cincinnati, Chicago and St. Louis.
2. Lake Erie and Western.
3. Wabash (main line).
4. Wabash (branch line).
5. Toledo, St. Louis and Western.
6. Cleveland, Cincinnati, Chicago and St. Louis (Peoria div).
7. Cincinnati, Hamilton and Dayton.
8. Vandalia (Logansport Division).
9. Cleveland, Cincinnati, Chicago & St. Louis (St. Louis div).
10. Vandalia (St. Louis Division).
11. Evansville and Indianapolis.
12. Monon (Wallace Branch).
13. Vandalia (Vincennes Division).
14. Illinois Central (Indianapolis Southern).
15. Chicago and Southeastern (Southern Indiana).

16. Baltimore and Ohio Southwestern.

17. Southern.

Many of the outcroppings are also in close proximity to a number of short branch lines of several of the above railroads. To make transportation doubly complete, the Monon Railroad from Chicago to Louisville follows the outcrop of this important formation almost its entire distance from Lafayette to the Ohio River.

No formation in Indiana is in closer proximity to the streams of the State. All of the important streams of the State have cut their way through its outcrops, and scores of tributary streams furnish abundant water supply for mining and washing purposes, and many of the streams furnish abundant water power for the operation of machinery. A number of firms have taken advantage of these transportation and water facilities and have established plants for mining and preparing this sandstone for market. These plants and work they are doing are mentioned in another part of this paper.

The Mansfield sandstone, lying as it does at the base of the coal measures, is convenient to a fuel supply from the coal fields which lie along its entire margin on the west. In many places seams of coal of workable thickness extend in tongues well into the Mansfield area.

QUALITIES OF MANSFIELD SANDSTONE.

Texture.—Samples gathered from most of the above points show that this sandstone varies greatly in texture, possessing every variation from a coarse conglomerate to a fine-grained sandstone. In many places the Mansfield consists of a pebbly strata, made up of a multitude of quartz pebbles; again it consists of a coarse conglomerate; and again a coarse sandstone, and the cementing element in all of these varieties is usually ferric oxide.

Color.—The natural color of the Mansfield when first laid down was white, very much like coarse granulated sugar; but oxidation has changed the color to shades of yellow, brown and red, and variations of these colors.

Thickness.—The Mansfield is probably the most massive formation in Indiana in its structure, often showing faces from 25 to 75 feet.

Workability.—The formation on first opening or quarrying is rather friable, and in many places could be torn down by hydraulic force. In other places quarrying could be done with a common

hand pick while still others require powder blasting. At present the stone is quarried in Indiana principally by the blasting process.

With an inexhaustible supply of the Mansfield formation in Indiana, comparing well in chemical analysis with the glass sands of Illinois, Missouri and Kansas, and having in close proximity those facilities, viz., fuel, water and transportation, the writer knows of no good reason why there should not some day in the near future be a line of glass industries either for shipping or manufacturing, or both, extending all the way from the Wabash River at Attica to the Ohio River at Cannellton.

In this preliminary investigation of the glass sands and glass sand facilities of Indiana, the State Geologist visited many of the Mansfield exposures.

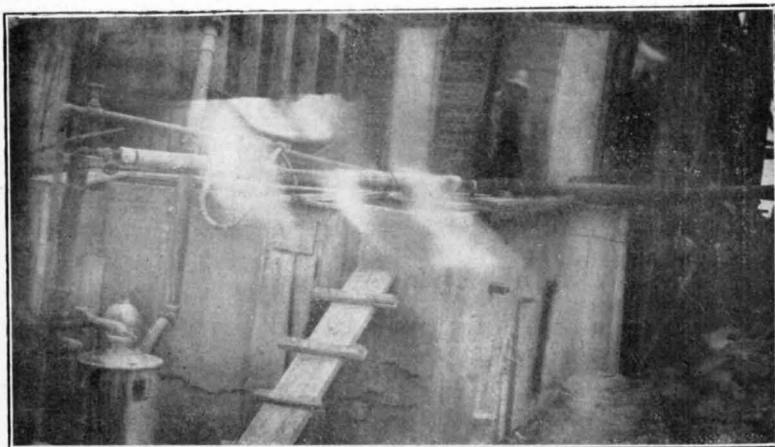
COXVILLE.

Prominent among these is the deposit at Coxville, Parke County, where the Aeme Glass Sand Company is mining a sandstone which for many years past was known as Mansfield but later geological research has placed at a later age than the Mansfield. This deposit is located at the village of Coxville, about eighteen miles northeast of the city of Terre Haute, on a bluff of Raccoon Creek, where the sandstone shows a face of about 40 feet. Of this deposit the U. S. Geological Survey speaks as follows:

"The beds are massive, lie nearly horizontal, and are covered by a few inches to nearly 10 feet of drift clay containing boulders and gravel. This sand is rather soft, of medium-sized, angular grains, and the mass ranges from white to light brown in color. Close inspection shows that certain beds are speckled with iron-oxide spots the size of a pin head, so closely spaced that thirty or more spots appear in a square inch of surface. The sand is slightly micaceous and the bed contains occasional clay streaks. When crushed and dried the average sand has a light yellowish-brown color, due to impurities, a large proportion of which might be removed if the product were washed. The process of treatment is simple. After the customary drilling and shooting down, the broken rock and loose sand is loaded into the mill by a steel bucket a cable conveyer and dumped directly into a Blake jaw crusher. The material then passes through one set each of corrugated rolls and smooth rolls and is thus separated into its individual grains. A belt conveyer, elevator and chute, in the order given, carry the sand to a rotary drier burning coke. From the drier the sand may

be delivered directly to cars or stored in bins. The capacity of this mill is about 250 tons a day. The quarry is fairly well situated with respect to transportation facilities, having direct connections with the Chicago and Eastern Illinois Railroad, and switching connections at Rosedale with the Vandalia line. The market for this sand consists chiefly of glass works in the State that make beer bottles. Some of these works are at Terre Haute. Without washing the sand is not satisfactory for flint and window glass. It is, however, in great demand for furnace use."

Analysis of the Coxville glass sand may be seen in table of analyses in this paper.



Sand storage and drying bins of Loogootee Glass Sand Company one mile east of Loogootee, Indiana.

GREENCASTLE.

About five miles southwest of Greencastle, Putnam County, at Fern, the Mansfield exposes along a small stream leading to Big Walnut Creek. The exposure is really in a bluff of that stream. Here the Root Glass Company of Terre Haute has installed a quarrying and crushing plant for utilizing this sandstone. The sandstone here is of a typical, massive variety and shows a face of at least 40 feet. The crushing plant is built within a few feet of the quarry and a spur from the St. Louis Division of the Big Four Railroad supplies transportation. The major portion of the output of the plant is used in the company's glass plant at Terre Haute, though a number of cars are shipped each month to other

glass factories in Indiana and Illinois. The quality of the sandstone has proved to be very satisfactory to the companies using it. The plant has a capacity of at least one hundred tons a day.

BRAZIL.

On the west bank of Croys Creek, a branch of Eel River, about three miles and a half southeast of Brazil, there occurs a number of massive exposures of the Mansfield sandstone, the principal ones of which are on the farm of Dr. J. D. Sourwine of Brazil. The writer visited these exposures in his investigations and took samples therefrom, the chemical analyses of which are given in another part of this paper.

The State Geologist has no hesitancy in saying that the Mansfield sandstone at the above point on Croys Creek is of a quality for the successful manufacture of utility glassware.

ATTICA.

In all of the valleys of the small streams about Attica, as well as the Wabash River itself, there are exposures of Mansfield sandstone suitable for glass making purposes. The deposits of Mansfield sandstone on Big Shawnee Creek, three and a half miles south of Attica, and on Fall Creek, at Williamsport, and several points on the Wabash River bluffs near Fountain, are all suitable for the making of plain glass products. Analyses of samples from these places show from 95 to 97 per cent. silica, and a small per cent. of oxide of iron and alumina, the latter two being the most prominent discoloring elements in the Mansfield.

WOLCOTT.

The Mansfield deposit near the town of Wolcott seems to be rather isolated, most of the surrounding country being heavily glaciated. But at this point, however, there is only a stripping of some six or eight feet. The quarry lies just south of the Logansport and Effner Division of the Vandalia Railroad and is reached by a short spur from this road. The quarry was operated for a number of years by the American Window Glass Company. The sandstone here is of very loose structure and could easily be reduced by a hydraulic jet.

Analyses made by the American Window Glass Company of

samples from this deposit show the following percents of silica, alumina and oxide of iron:

	No. 1	No. 2	No. 3	No. 4
Silica (SiO_2)	99.990	99.714	99.659	99.579
Alumina (Al_2O_3) .....	.008	.280	.310	.350
Iron oxide (Fe_2O_3)	trace	.066	.011	.021

According to E. F. Burchard, of the U. S. Geological Survey, this sand is suitable for the following purposes:

"No. 1 is suitable for the very highest grades of glassware and flint glass. Nos. 2 and 3 are suitable for tableware, plate glass, chimneys, prescription ware, etc., and No. 4 is used for window glass."

LOOGOOTEE.

The most important sand plant in southern Indiana at present is that of the Loogootee Glass Sand Company. This company operates a quarry of Mansfield sandstone about a mile and a half east of Loogootee on the Baltimore and Ohio Southwestern Railroad. The capacity of the plant for crushing, washing and drying the sand is about twenty cars of thirty tons each a month. A part of the output is used by Graham Brothers, who operate a glass factory in the town of Loogootee. Some of the prepared sand is sent to Evansville, but the larger portion of the output goes to Louisville, Kentucky. The quarry at present shows a face of 40 feet. The writer was informed by O. H. Gernest, superintendent of the plant, that test bores show that the Mansfield sandstone at this quarry is at least 100 feet thick. The exposed parts of the deposit are strongly colored by oxide of iron, colors varying from yellow into dark brown and dark cherry red. The sandstone is broken down by the use of dynamite. The Jeffrey crusher into which the sandstone is fed is located in the bottom of the quarry. After crushing, the sand is elevated by means of a belt conveyer into the washing bins, where the larger part of the impurities are washed from it by means of a hydraulic jet. The clean sand is re-elevated to the drying bins, and after being dried by means of steam pipes and coils is loaded into the cars. A considerable per cent. of the Mansfield from this quarry is a coarse quartz conglomerate. Much of this is separated from the raw material before being put through the crusher.

SHOALS.

In the vicinity of Shoals, there are many massive exposures of the Mansfield sandstone, which in appearance and quality do not vary much from the same formation farther north, the principal difference being the amount of ferric oxide with which the sandstone is impregnated. This is particularly true of the face of the exposures. After a few feet of the face of the deposit is broken away the iron stain grows less and a sand is produced which, by proper washing, would grade alongside of the Loogootee sand, five miles to the west.

JASPER.

In the vicinity of Jasper, Dubois County, and on the line of the French Lick Branch of the Southern Railroad, many exposures of Mansfield sandstone occur, which in appearance and texture is similar to the Shoals and Loogootee sands, and doubtless could be used in several varieties of common glass.

MICHIGAN CITY.

Probably the best known and largest deposit of loose or drifted sand is the well-known ridge of sand on the lake front at Michigan City. This accumulation of sand is probably the result of the combined action of the lake and winds. The huge ridge of glistening sand is known locally as the "Devil's Slide." There is an inexhaustible amount of sand in this ridge because the ridge is continually renewed by sand washing up from the lake and then moved by the wind and forming this huge dune.

Several of the glass sand industries of the State use this sand in the manufacture of glass products. Notable among these is the well-known firm of Ball Bros. of Muncie, Indiana, manufacturers of jars. This company has been using the sand from Lake Michigan for about twenty-five years and it has proved very satisfactory. This sand has the advantage of freedom from the usual impurities which accompany indurated deposits, for the reason that it comes ready washed from the lake. Ball Bros. use about 150 tons of this sand per day. Their products are shipped to all parts of the world. The Michigan City sand is also used in foundry work in making cores, particularly by the Chandler-Taylor Company of Indianapolis.

DEPAUW.

Near the town of DePauw, twenty-three miles west of New Albany, occur a number of deposits of loose sand, which in former years was used in glass making. For many years, sands from deposits near New Albany were used in the DePauw Glass Works in the manufacture of glass products. These sands probably belong to what is known geologically as the Ohio River sands.

The Root Glass Company of Terre Haute, which operates the American Glass Sand plant at Fern, west of Greencastle, operates its Terre Haute plant exclusively on plain bottles and carbonated water bottles. The output of the plant is between 300,000 and 350,000 gross of bottles, which is very close to its capacity.

The Root Glass Company was started in the fall of 1901 and has gradually increased its capacity up to the present time. Shipments of its products are made over the entire United States, also to Canada, Old Mexico, Cuba and South America.

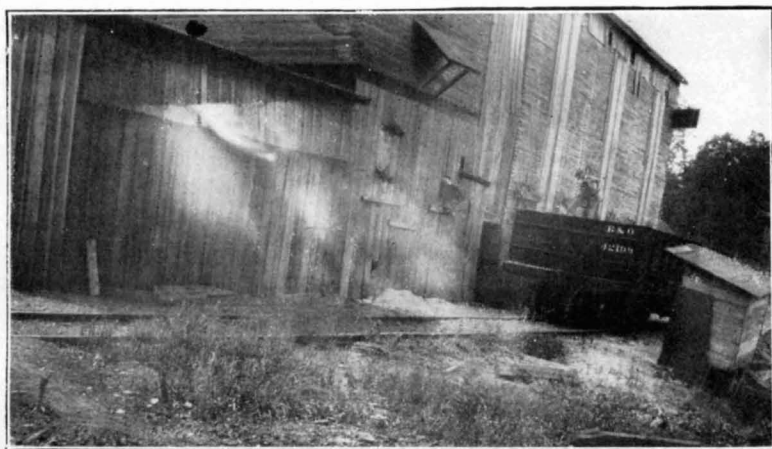
PROPORTION BY WEIGHT OF COMPONENTS OF GLASS.

The U. S. Geological Survey presents the following table on the general proportions by weight of the various components of glass:

<i>Component.</i>	<i>Plate Glass.</i>	<i>Window Glass.</i>	<i>Green Bottle.</i>	<i>Lead Flint.</i>	<i>Lime Flint.</i>
Sand (SiO_2)	100	100	100	100	100
Salt cake (Na_2SO_4) .....	.....	42	38	.....	.....
Soda ash (Na_2CO_3)	36	...	...	.....	36
Limestone (CaCO_3)	24	40	34	.....	.....
Carbon (C) .....	.75	6	5	.....	.....
Arsenic (As_2O_3)	1	2	...	.15	.02
Slaked lime ($\text{Ca}(\text{OH})_2$) .....	.....	...	...	.....	12
Potash (K_2CO_3) .....	.....	...	...	34	.....
Red lead ($2\text{PbO}+\text{PbO}_2$) .....	.....	...	...	48	.....
Niter (NaNO_3) .....	.....	...	...	6	1
Manganese (MnO_2) .....	.....	...	...	.06	6.66
Antimony (Sb) .....	.....	...	...	.02	.23

“Sand is therefore the major constituent of glass, constituting from 52 to 65 per cent. of the mass of the original mixture, or from 60 to 75 per cent. of the finished product after melting has driven off carbon dioxide, sulphur dioxide, and other volatile materials. To the sand is due the absence of color (according to its purity), the transparency, brilliancy and hardness of glass. In other words, the quality of the glass depends largely on the quality of the sand.

For the finest flint ware, such as optical and cut glass, 'water whiteness,' absolute transparency, great brilliance and uniform density are required, and only the purest sand can be employed, since slight impurities, especially small quantities of iron, tend to destroy these effects. For plate and window glass, which are commonly pale green, absolute purity is not so essential, but generally the sand should not carry more than two-tenths per cent. of ferric oxide. Green and amber glass for bottles, jars and rough structural work can be made from sand relatively high in impurities. An excess of the chief impurity, iron, is usually avoided in the quarries by a careful selection of the whitest sand, although the



Storage and loading bins of Loogootee Glass Sand Company, one mile east of Loogootee, Indiana.

whitest sand is not invariably the purest. Repeated washing tends to remove the iron. Magnetic separators also have been resorted to, especially when the iron is present in the form of magnetite. Clay materials are objectionable because they cloud the glass. Washing helps to remove them, since they occur usually in a very finely divided state. Magnesia, which is more apt to be introduced into glass materials through limestone than through sand, is troublesome because it renders the batch less fusible. If the sand is derived from indurated sandstone the latter should be friable or easily crushed. In examining sand, in order to ascertain its value for glass-making purposes, inspection with a magnifying glass is the best preliminary test. The following points should be observed: The sand should be nearly white in color; it should be of

medium fineness (passing a 20 to 50 mesh horizontal sieve); the grains should be uniform in size, even, and angular, or, less preferably, they may be rounded. A simple chemical test may be employed by heating the sand in a dilute acid. Effervescence indicates the presence of lime; loss of color shows the presence of clay impurities. Iron in the most minute quantity may be detected by dissolving sand in hydrofluoric acid and adding potassium ferrocyanide, which produces a blue precipitate if iron is present. Complete quantitative analyses as well as a furnace test should be made as a final determination of the character of a prospective glass sand. The impression has long prevailed, especially among writers on the subject of glass making, that round-grained sands are at a decided disadvantage in comparison with the sharp, angular variety. Practice seems to disagree with this idea, at least in the case of the Mississippi Valley plants, where smooth, rounded sand is successfully used for all ordinary varieties of glass and for some fine flint ware. As a rule, no very close check is kept on materials by manufacturers of the ordinary commercial grades of glass. Results are watched with care, however, and experience with certain materials usually determines their use or rejection. Sand uniformly finer than one-sixtieth inch is said to 'burn out' in the batch and not to produce as much glass per unit of weight as does coarser sand. In a mixture of coarse and fine sand the finer sand is liable to settle to the bottom of the batch, thus preventing an even mixture of the materials and producing in consequence a glass uneven in texture."

ANALYSES OF GLASS SANDS OF INDIANA.

(53)

LOCATION OF DEPOSIT.	OWNER.	AUTHORITY.	Silica (SiO ₂), Per Cent.	Alumina (Al ₂ O ₃), Per Cent.	Ferric Oxide (Fe ₂ O ₃), Per Cent.	Calcium Oxide (lime), (CaO), Per Cent.	Magnesium Oxide (MgO), Per Cent.	Loss by Ignition (mostly water and organic matter), Per Cent.	Other Minerals.	Total.	Remarks.
Clark County— Jeffersonville.....	Newport Sand Bank Co., New- port, Ky.	Laboratory, Cincinnati College of Pharmacy, Cincinnati, Ohio.	94.00	5.00	1.00	None.	None.	.....	.....	100.00	Fine-grained molding sand.
Floyd County— New Albany.....	Ditto.....	Ditto.....	92.00	1.50	5.00	Trace.	.....	.....	.....	98.50	Fine light-colored molding sand.
Fountain County— Attica.....	Western Silica Co., Danville, Ill.	State Geologist of Indiana.....	98.84	.38	.10	.....	.03	.32	Titanium oxide (TiO ₂), Trace.	99.67	.....
Hancock County— Maxwell.....	E. L. Dobbins, Greenfield.....	.....	85.00	.....	.....	.50	13.50	.....	Loam, 1 per cent.....	100.00	.....
Jackson County— Brownstown.....	Newport Sand Bank Co., New- port, Ky.	Cincinnati College of Pharmacy, Cincinnati, Ohio.	92.00	6.50	1.00	.....	.50	.....	.....	100.00	Coarse red molding sand
Laporte County— Michigan City.....	Pinkston Sand Co.....	.....	91.98	4.44	.56	2.20	Trace.	.72	Loss, 10 per cent.....	100.00	Molding sand, grinding sand.
Martin County— Loogootee.....	Loogootee Glass Sand Co.....	J. F. Elson, New Albany.....	97.78	1.13	.10	.06	.....	.....	.....	99.07	Glass sand, selected sample
Ditto.....	Ditto.....	Operator, report of State Geolo- gist.	96.26	2.50	.92	.....	.16	.....	Potassium and sodium oxides (K ₂ O) and (Na ₂ O) 0.13%.	99.97	Glass sand, crude.
Parke County— Coxville (near Rosedale)	Acme Glass Sand Co., Terre Haute.	W. A. Noyes, Rose Polytechnic Institute, Terre Haute.	98.61	.74	.22	.12	Trace.	.32	.....	100.01	Glass sand, unwashed.
Clay County— Brazil.....	Dr. Sourwine.....	W. M. Blanchard, Chemist, Labo- ratory De Pauw University, Greencastle, Indiana.	96.52	2.69	.18	.19	.06	.70	.....	100.34	.....
Ditto.....	Ditto.....	Ditto.....	95.41	2.79	.40	.19	.17	.80	.....	99.76	.....
Ditto.....	Ditto.....	Ditto.....	94.88	3.05	.66	.32	.07	.93	.....	99.91	.....
Ditto.....	Ditto.....	Ditto.....	98.00	.61	.32	.10	.08	.36	Sulphuric Anhydride (SO ₂) .13%.	99.60	.....
Ditto.....	Ditto.....	Ditto.....	93.69	2.68	1.05	.51	.08	1.05	Ditto, .14% Soda (Na ₂ O), 50%.	99.70	.....

We cannot do better than to include in this discussion the following from U. S. Geological Survey Bulletin No. 313:

PREPARATION OF GLASS SAND.

"The method of treatment of glass sand depends on the character of the deposit and on its position. The materials used for glass sand in central United States are mainly bedded sandstones, and a complete process of preparation includes quarrying, breaking, crushing, and grinding into component grains, screening, washing, draining, drying, and final screening to various sizes. Some beds of sandstone are so loose and friable that they can be reduced by a strong hydraulic jet; some producers dispense with the operation of washing their sand, others do not dry it. It has been shown that washing improves the quality of sand of the highest grade. It is mistaken economy to neglect this important phase of treatment on account of the expense of installing washers, for the price of sand, and often its use or rejection, is affected by the small percentage of impurity that may be washed away. Two methods of washing are followed. One method involves several sets of bins, into which sand and water are elevated or pumped so that the sand settles quickly while the finer impurities are washed away; the other employs a crude, open-top pug mill, in which rotating "augers" or screws move the sand up inclined troughs, rolling it over and over so that by attrition it is freed from a large portion of its impurities and stain, and the impurities are then readily removed by a stream of water playing down the troughs.

"Drying is effected by three general types of apparatus: (1) Rotary cylinders, through which the sand passes against a draft of flame and hot gas; (2) a stationary roaster, and (3) coils of steam pipes. The first method involves the greatest initial cost, but is by far the most rapid and efficient.

"Sand that passes a 60-mesh sieve or one of smaller mesh is regarded as fine grained that which passes 30- and 40-mesh sieves is regarded as medium grained, and that which is retained by 30- or 20-mesh sieves or sieves of coarser mesh is considered coarse grained. The divisions have been made the basis for classifying, according to their grain, the various sands mentioned in the following notes."

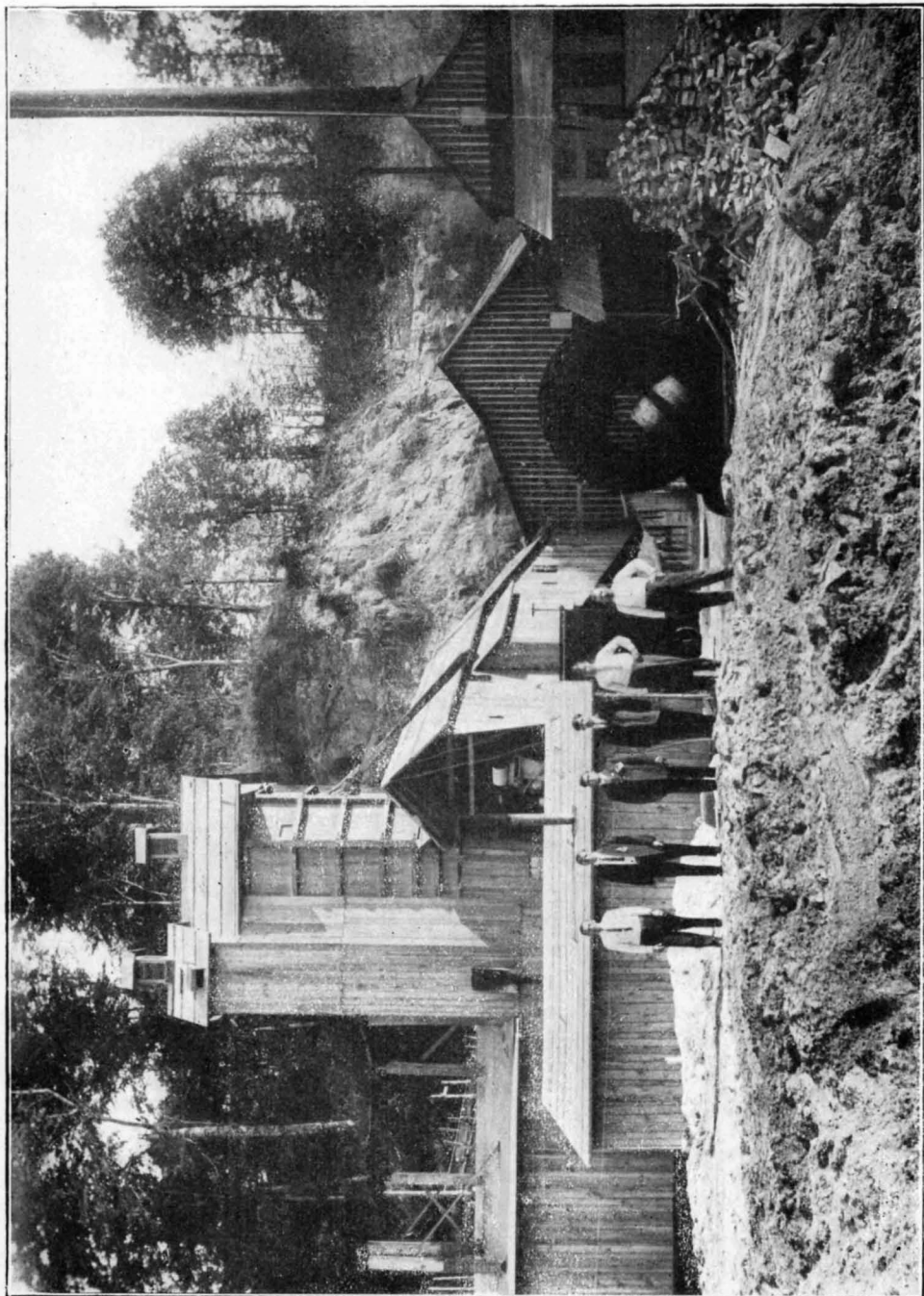
INDIANA LIMESTONE AS AN INGREDIENT FOR GLASS MAKING.

Lying to the east of the Mansfield sandstone area geographically and below it geologically are Indiana's purest and best limestones, viz., the Mitchell and the Bedford or Oolitic. The outcrops of these two limestone formations run almost parallel with the Mansfield throughout its entire length, and always within a fraction of a mile to a few miles distant. Their drainage systems are the same, and railroad facilities the same.

The Mitchell and Bedford limestones contain from 95 to 98 per cent pure calcium carbonate and a small per cent of silica and a mere trace of impurities harmful to glass products. The greatest number of plants in operation in Indiana for the crushing and grinding of these limestones is in the area mentioned above.

The superiority of these limestones as a glass ingredient is because of their freedom from iron oxide, the most common impurity encountered in the manufacture of glass. Clay and iron sulphide are two other impurities met with in the manufacture of glass, and the Mitchell and Bedford limestones are singularly free from these, as a rule containing a mere trace. The opinion prevails that impurities usually come to the batch from the sand or sandstone used in the manufacture of glass. Frequently, however, the impurities come from the limestone used in the batch. Therefore, careful and frequent analyses of the limestone ingredient should be made, so that limestone containing any considerable per cent of the above impurities should be rejected.

The preparation of limestone as a glass ingredient consists in reducing or grinding the limestone to an almost impalpable powder, in which condition it is easily mixed with the sand and other ingredients. Below are given four chemical analyses of Bedford Oolitic limestone. These analyses were made by Dr. Noyes for the Twenty-First Annual Report of this Department. Also we give below four chemical analyses of Mitchell limestone by Noyes and Smith, as given in the Thirtieth Annual Report of the Department of Geology.



American Glass Sand Company's plant for mining, crushing and washing Mansfield sandstone, four miles southwest of Green-

ANALYSES OF BEDFORD OOLITIC LIMESTONE FROM SOUTHERN INDIANA.

Source of Sample.	Calcium Carbonate (CaCO ₃).	Magnesium Carbonate (MgCO ₃).	Ferric Oxide (Fe ₂ O ₃).	Insoluble Residue (Silica, etc.).	Total.
Bedford Stone Quarry, Lawrence County	98.27	.84	.15	.64	99.90
Hunter Bros. Quarry, Monroe County	98.11	.92	.16	.86	100.05
Romona Oolitic Stone Co., Owen County	97.90	.65	.18	1.26	99.99
Twin Creek Stone Co., Washington County	98.16	.97	.15	.76	100.04

ANALYSES OF MITCHELL LIMESTONE FROM SOUTHERN INDIANA.

Source of Sample.	Calcium Carbonate (CaCO ₃).	Magnesium Carbonate (MgCO ₃).	Ferric Oxide and Alumina (Fe ₂ O ₃ + Al ₂ O ₃).	Insoluble Residue (Silica, etc.).	Total.
Oolite from Eichel Quarry, Milltown, Ind.	98.91	.63	.15	.48	100.17
Gray stone from Mitchell Lime Quarry, Mitchell, Ind....	96.65	1.20	.27	1.57	99.69
Gray stone from south of Harrodsburg, Ind.	97.64	....	.32	.82	98.74
Gray stone from land of J. B. Lyne, Monroe County....	99.04	....	.09	.80	99.92

These analyses clearly sustain the reputation of the Bedford and Mitchell limestone as carriers of a high per cent of calcium carbonate and unusual freedom from impurities.

GENERAL ASPECTS OF GLASS-SAND INDUSTRY.

“The consumption of glass sand has been rapidly increasing for many years, and it is probable that it will continue to do so indefinitely. Vast resources of the material are in sight. The uses for glass are now so varied and extensive that it may well be classed with iron and cement in its importance under present conditions. Glass sand in situ possesses relatively little intrinsic value. The market value is due to the labor cost of extraction and preparation.

“The factors on which a deposit of sand depends for its possible value for glass making are (1) chemical composition, (2) physical character, (3) amount available, (4) location with respect to fuel supplies, (5) conditions of quarrying or mining, (6) location with respect to transportation routes, and (7) location with respect to markets.

"A deposit so thin as 20 feet should have an areal extent of at least 20 acres of good sand in sight to warrant the erection of a mill and trackage. Most deposits are thicker than 20 feet, but it would be safer to have a much higher ratio between areal extent and thickness than the minimum given. Where ledges of sand require stripping of overlying limestone, the limestone may in certain cases be of such purity that it also could be used for glass making; if this is not the case other uses should be sought for it as a by-product. In regard to fuel, every plant turning out glass sand in quantity sufficient to net a profit must be equipped with power for moving the sand and drying it, and in most cases with equipment for cleaning as well. The margin of profit is at present so low that the cost of preparation can not reasonably stand freight charges on coal for more than 50 miles. Natural gas would be a suitable fuel, especially in the operation of rotary driers. In respect to transportation routes, the general principle 'the more available the better' is applicable. Aside from the necessity of securing fair and uniform freight rates experience has shown, especially where the dependence is on only one railroad for transportation, that shortness of cars at certain seasons may seriously handicap a plant in its shipments and lead to cancellation of many orders. In respect to markets, it must be considered that sand is for its value one of the bulkiest products, and therefore one whose cost to the consumer is greatly influenced by distance. At the same time the question of permanence of these markets must be considered.

"Some of the large sand properties, together with their mills, represent an outlay of about \$75,000, a sum that requires good business judgment for its investment and subsequent careful management in order to keep it paying adequate interest. Strong competition in the Middle States has forced prices down very low at present, and competition in the form of the small producer who leases a sand bank and works out by hand and team all the choice sand within convenient distance and then abandons the quarry, having figured only daily wages to himself as profits, has resulted in some embarrassment to the larger companies."

According to statistics compiled by the U. S. Geological Survey, the quantity of glass sand produced in the United States and the value thereof for the ten years—1902 to 1911 inclusive—was as follows;

QUANTITY AND VALUE OF GLASS SAND PRODUCED IN THE UNITED STATES, 1902-1911, IN SHORT TONS.

<i>Years.</i>	<i>Quantity.</i>	<i>Value.</i>
1902	943,135	\$807,797
1903	823,044	855,828
1904	858,719	796,492
1905	1,060,334	1,107,730
1906	1,089,430	1,208,788
1907	1,187,296	1,250,067
1908	1,093,553	1,134,599
1909	1,104,000	1,163,375
1910	1,461,089	1,516,711
1911	1,538,666	1,543,733

It will be seen from these figures that the production of glass sand in 1911 was 77,577 tons more than in 1910, and the value in 1911 was \$27,022 in excess of 1910. The price per ton in 1911, however, was approximately \$1.00 per ton, as against \$1.04 per ton in 1910.