PRELIMINARY REPORT ON HIGH-SILICA SAND IN INDIANA

Indiana Department of Conservation
GEOLOGICAL SURVEY
Report of Progress No. 5

1953

STATE OF INDIANA
George N. Craig, Governor

DEPARTMENT OF CONSERVATION
Doxie Moore, Director

GEOLOGICAL SURVEY
Charles F. Deiss, State Geologist
Bloomington

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PRELIMINARY REPORT ON HIGH-SILICA SAND IN INDIANA

by

Haydn H. Murray and John B. Patton

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PRELIMINARY REPORT ON HIGH-SILICA SAND IN INDIANA

By Haydn H. Murray and John B. Patton

INTRODUCTION

Purpose of this investigation

In the past few years, largely because of increased freight rates, a keen interest in finding sources of high-silica sand has developed. The Geological Survey has received many inquiries about possible sources of high-silica sand in the state. Although published information on the geology of the formations that may contain high-silica sand has been available, economic information, such as quality, distribution, extent, and accessibility, has not been available.

Field work

In the summer of 1951, the Geological Survey began a study of the sandstones in the state. This study was greatly expanded in the summer of 1952. Members of the Geological Survey have sampled and studied all sandstones and sands of Indiana that appear to have high-silica possibilities (pl. 1).

In 1951, one field party, led by Haydn H. Murray, with Samuel L. Riely as assistant, studied and sampled the Mansfield sandstone in Parke, Putnam, and Clay Counties. In 1952, six field parties examined and sampled sandstone and sand exposures in the state. These field parties were led by Charles L. Bieber, Charles E. Wier, Thomas G. Perry, William J. Wayne, Ned M. Smith, and Haydn H. Murray. Field assistants in 1952 were Donald C. Devening, David V. Lewis, George T. Moore, William R. Bastin, John M. Smith, and Samuel L. Riely. A total of 191 samples were taken. For each exposure studied, a memorandum report explaining the geology and evaluating the economic possibilities was written. These reports are kept on open file in the Industrial Minerals Section of the Geological Survey.

Samples and field data from one formation (the Ohio River formation) were gathered by Arthur P. Pinsak in preparation for a graduate thesis at Indiana University. Mr. Pinsak has kindly made this material available for inclusion in this report.

Scope of this report

The purpose of this report is to make available the salient features learned to date from the sand investigations that have been carried on in the field and in the laboratory during the past 1 1/2 years.

Information on those areas and samples which at this time appear to be most promising is included. The data presented herein are for the best sample or samples analyzed from the respective formations. Analyses and measured sections are presented for all formations whose iron content (expressed as Fe_2O_3) is less than 0.3 percent in any locality sampled. Except for the Sample sandstone formation, all analyses used in this report contain less than 0.3 percent Fe_2O_3.

This information cannot prove or condemn the high-silica sand potentialities of any area. Natural outcrops and weathered road cuts are not ideal sampling localities for raw materials in which tolerances are extremely low. Core drilling by any individual or firm who wishes to ascertain the commercial possibilities of any locality surely will be necessary.

Many additional samples have been collected, and most of them have been analyzed. The results will be reported in a later and more complete publication. This later publication also will contain information on the nature of cementation and accessory minerals, both of which are vital considerations in the development of commercial production of high-silica sand. As petrographic analysis is time-consuming, the results of this study could not have been published for nearly another year if all information had been withheld until the petrography had been completed.

USES FOR HIGH-SILICA SAND

High-silica sand is an important mineral in many industries. It is a major constituent of glass and silicon carbide and is used extensively as an abrasive in scouring powders, soaps, sandpaper, sand-blasting, and saws for cutting stone. A minor amount also is used as whetstones. In addition, high-silica sand is important to foundries because it is bonded with clay or some other binder to form molds for casting metals. In 1949, nearly 15,000,000 tons of silica sand, valued at $25,000,000, were produced in the United States (U. S. Bur. Mines, 1949, p. 1069).

In Indiana, the principal users of high-silica sand are the glass industries and the foundries. The Trenton gas boom at the turn of the century attracted many glass industries to the northeastern part of the state. Even though the gas has been depleted, glass making still is a major industry in that area. At the present time all high-silica sand used by the glass industries is imported from other states.

SAND REQUIREMENTS OF THE GLASS INDUSTRY

Sands that are used by the glass industry must meet rigid chemical and physical specifications. These specifications have been established to maintain close control over the raw materials in order that a uniform end product can be obtained. In general, all sands used in the glass industry must have a silicon dioxide content of 95 to 99.5 percent. The percentage of silicon dioxide required is dependent upon the type of glass that is being made. The high-silica sands must be relatively uniform in composition in order to produce a uniform glass. The most harmful impurities are iron compounds, which color the glass.

In addition to the chemical specifications, the glass sands must have a definite size range. The time and temperature required to melt coarse sand are too long and too high respectively to be economical; on the other hand, excessively fine sand will be carried away as dust by the forced drafts in the melting furnace. Most specifications therefore require that the silica sand particles be between 0.41 mm and 0.14 mm in diameter.

HIGH-SILICA SAND USED IN INDIANA

From 1850 to 1910, high-silica sands were produced in Indiana from the dunes along the shore of Lake Michigan; the Pendleton sandstone of Devonian age, quarried at Pendleton in Madison County; the Mansfield formation of Pennsylvanian age, quarried near Loogootee in Martin County; the Linton (formerly Staunton) formation of Pennsylvanian age, quarried near Coxville in Parke County; and the Ohio River formation of Tertiary age, quarried in eastern Harrison County and in southeastern Washington County.

STRATIGRAPHIC UNITS SAMPLED

General statement

A geologic map (fig. 1) and a stratigraphic column (fig. 2) are shown in order that each sandstone or sand that was sampled can be located both geologically and geographically.

St. Peter sandstone

The lowest stratigraphic unit sampled was the St. Peter sandstone of Ordovician age. Rocks as old as the St. Peter normally are not exposed in Indiana, but in one locality extreme structural deformation has forced Middle and Lower Ordovician rocks through the cover of younger strata. The St. Peter exposure lies 2 1/2 miles

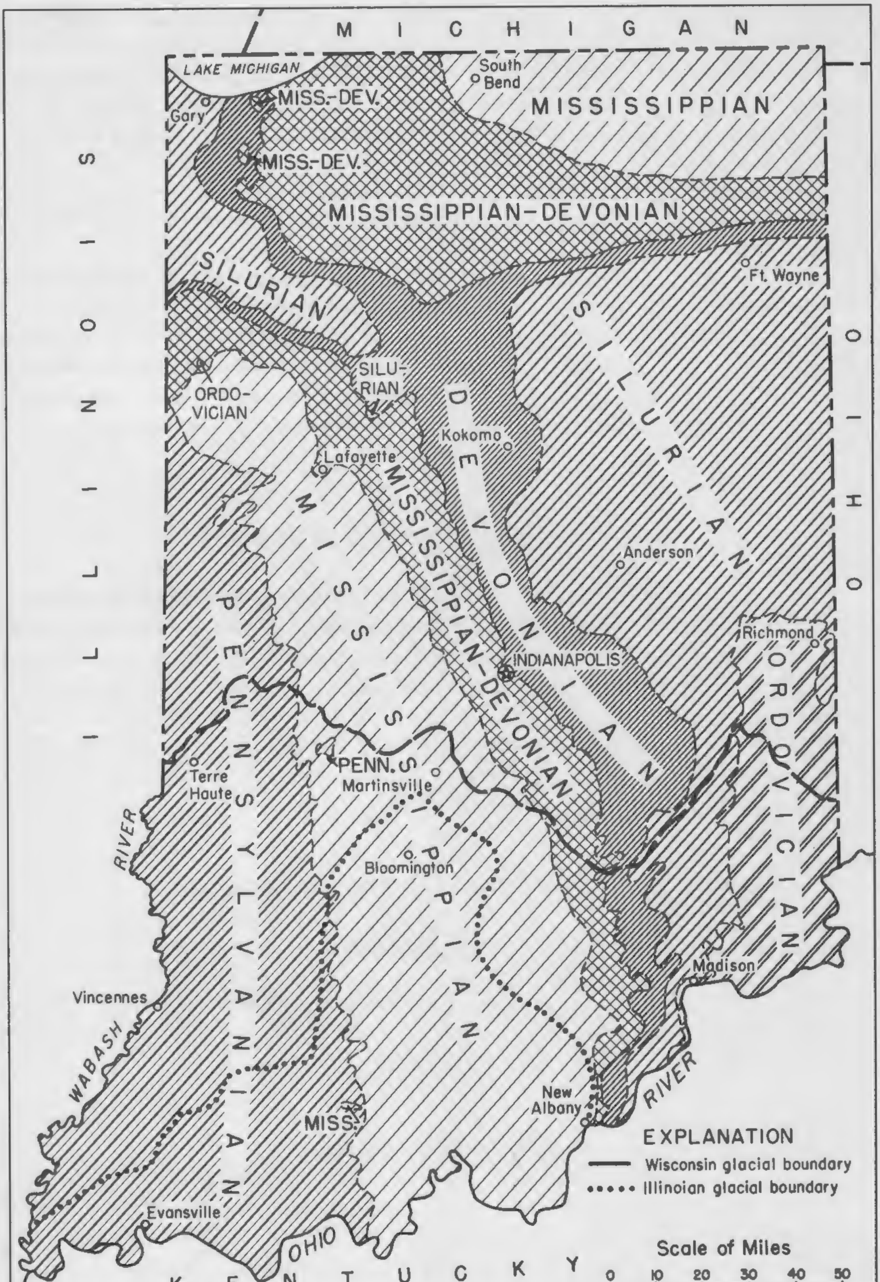

Figure I. *Generalized bedrock map of Indiana.* Compiled by J. B. Patton 1952

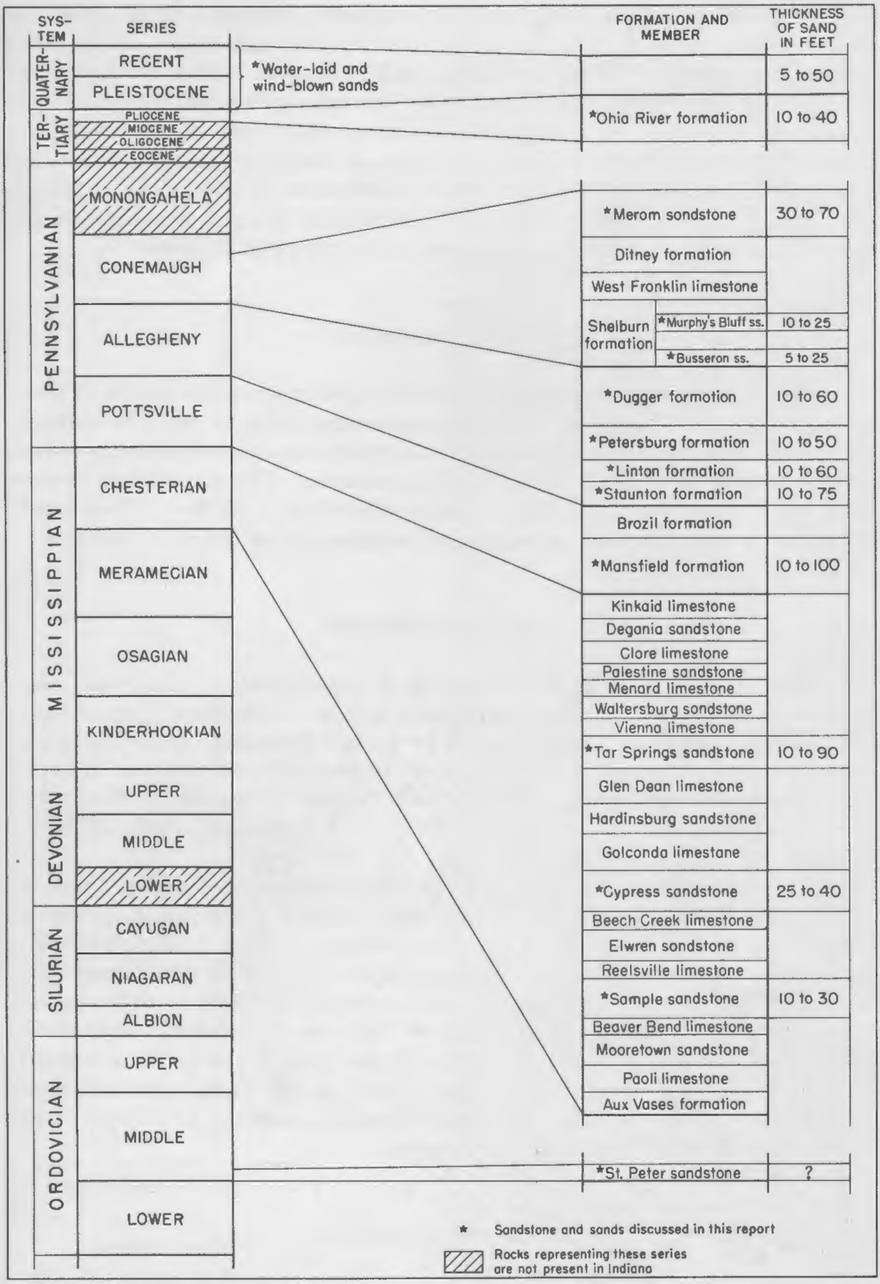

Figure 2. *Geologic column of Indiana, showing stratigraphic position and geologic age of sands and sandstones*

east of Kentland, Newton County, at a quarry operated by the Newton County Stone Company. The exposure is 100 feet wide and 80 feet thick. The other lateral dimension is not known. This sandstone is about 1,300 feet out of place in the stratigraphic column and was forced to the surface by a fault or some other type of earth movement. The volume of sandstone present may be insufficient to be worked economically. The St. Peter sandstone is light gray to white, medium-grained, and friable. It commonly ranges from 40 to 80 feet in thickness where it crops out to the west in Illinois.

Sample sandstone

The Sample sandstone is part of the Lower Chester rocks of Mississippian age. The type locality of this sandstone is Sample Station, Breckenridge County, Kentucky. The formation generally contains a large amount of shale and shaly sandstone. The sandstone lenses locally are massive and attain a thickness of 10 to 30 feet. This sandstone crops out only in the extreme south-central part of Indiana.

Cypress sandstone

In southern Indiana the Cypress is a persistent, massive, medium-grained, buff to gray sandstone which is Chester (Upper Mississippian) in age. The Cypress is a cliff-forming, relatively resistant sandstone that ranges from 25 to 40 feet in thickness. It crops out in south-central Indiana from Owen County to the Ohio River. The type locality of the Cypress sandstone is in Cypress Creek, in Union County, Illinois (Englemann, 1868, pp. 189-190).

All workers in Mississippian stratigraphy do not agree upon the correlation of the beds that have been called Cypress in southern Indiana with the Cypress of the type section. The disagreement is based upon the age and correlation of the Beech Creek limestone, which underlies the sandstone beds termed Cypress in this report. These sandstone beds can be traced into the Big Clifty sandstone, named by Norwood (1876, p. 369). If the Beech Creek limestone is proved to be equivalent to the lower part of the Golconda limestone of southern Illinois, the sandstone formation above it should carry the name Big Clifty instead of Cypress.

Tar Springs sandstone

The Tar Springs sandstone is massive, cross-bedded, and fine- to medium-grained. The formation lies at the base of the Upper

Chester group of Mississippian age. The type locality is at Tar Springs, Breckenridge County, Kentucky. In southern Indiana the sandstone beds are missing locally, but are generally about 45 feet thick and in places reach a thickness of 90 feet. The formation crops out from Martin County south to the Ohio River.

Mansfield formation

Bodies of sandstone form a large proportion of the Mansfield formation (Pottsville series, Pennsylvanian), which also contains shales, coals, clays, limestones, and conglomerates. The type locality for this formation is at Mansfield, Parke County. The sandstones in the Mansfield formation are coarse- to medium-grained, cross-bedded, massive, friable, and variable. At some localities the sand bodies are light-gray, clean sand, and at others they contain mica and numerous ironstone concretions. The Mansfield varies in color but generally is reddish buff. The individual sandstones in this formation range from 10 to 100 feet in thickness. The Mansfield formation crops out from Warren County southeast to Perry County on the Ohio River.

Staunton formation

Sandstones in the Staunton formation (Allegheny series, Pennsylvanian) are limited in areal extent because they generally grade laterally into shales and sandy shales. Some of the sand bodies are channel fillings, and others are distinct lithofacies of the formation. Locally these sandstones attain a thickness of 50 to 75 feet. The type locality of the Staunton formation is near the town of Staunton, Clay County. As originally defined by Cumings (1922, p. 525), the Staunton formation included Coal IIIa, but Wier (1952, p. 11) restricted the formation to include only those rocks between the top of Coal II and the top of Coal III. The Staunton sandstones are fine- to medium-grained, micaceous, and friable. The sandstone bodies in the Staunton formation are best developed at the surface in Parke, Greene, Daviess, Pike, and Spencer Counties.

Linton formation

The type locality of the Linton formation (Allegheny series, Pennsylvanian) is 4 miles north of Linton, Greene County. This formation, named by Wier (1952, p. 12), includes the rock interval from the top of Coal III to the top of Coal IV. Sandstones in the Linton formation are local in extent because they are lithofacies which change to shales and siltstones. The sandstone lenses attain a thickness of 60 feet in some places but generally are 30 to 40 feet thick. The sandstones in the Linton formation are best developed in Vermillion, Parke, Clay, Greene, Daviess, Pike, and Spencer Counties. The Linton sandstone is medium-grained, micaceous, and friable.

Petersburg formation

The type locality of the Petersburg formation (Allegheny series, Pennsylvanian) is near Petersburg, Pike County. The formation, restricted by Wier, 1952, p. 14), includes the rocks in the interval between the top of Coal IV and the top of the Alum Cave limestone, which occurs above Coal V. Sandstones of local extent occur in this formation above Coal IV and above Coal IVa. These sandstones are similar to the Pennsylvanian sandstone previously described in that they are fine- to medium-grained, micaceous, and friable. The sandstones attain a thickness of 40 to 50 feet in some areas. The sandstones in the Petersburg formation are best developed in Pike and Greene Counties.

Dugger formation

The type locality of the Dugger formation (Allegheny series, Pennsylvanian) is 2 miles northeast of Dugger, Sullivan County. This formation, named by Wier (1952, p. 17), includes the rocks in the interval between the top of the Alum Cave limestone and the top of Coal VII. Generally, argillaceous sandstone which locally grades into massive sandstone occurs above the Alum Cave limestone and above Coal VI. The sandstone above the Alum Cave limestone attains a thickness of 60 feet locally, and the one above Coal VI reaches a thickness of 30 feet in some places. The sandstones in the Dugger formation are best developed in Pike County. The sandstones are fine- to medium-grained, micaceous, friable, and iron-stained.

Busseron sandstone

The Busseron sandstone is the basal member of the Shelburn formation (Conemaugh series, Pennsylvanian). The name Busseron, although not a name which has been formally given to this sandstone member, has been used in the literature for sandstone outcrops along Busseron Creek, in Vigo and Sullivan Counties. This sandstone occurs above Coal VII and is persistent, medium-bedded to massive, micaceous, and fine-grained. The thickness of this sandstone member ranges from 5 to 25 feet. The Busseron sandstone is best developed in Vigo and Sullivan Counties, but sandstone bodies of local extent appear at the same stratigraphic position in Pike and Warrick Counties.

Murphy's Bluff sandstone

The Murphy's Bluff sandstone is a member of the Shelburn formation. It lies just above the Vigo limestone, approximately in the middle of the formation. The sandstone is argillaceous and fine-grained and at most places is thin-bedded, but locally it grades into massive bodies or lenses. This sandstone attains a thickness of 25 feet and is best developed in Vigo and Gibson Counties.

Merom sandstone

The type locality of the Merom sandstone (Conemaugh series, Pennsylvanian) is at the town of Merom, Sullivan County. This formation consists of sandstone that is cross-bedded, massive, and friable, with coarse and angular grains. Argillaceous sandstone lenses and small lenticular coal streaks commonly are present in this formation. The Merom sandstone ranges from 30 to 70 feet in thickness and is best developed in Sullivan and Knox Counties.

Ohio River formation

The Ohio River formation (Pliocene, Quaternary) of Ashley and Kindle (1903, p. 68) consists of cross-bedded, firm sand. Locally it contains pockets and lenses of clay. Malott (1922, p. 134) reported a thickness of 80 feet in some localities but, in general, only 20 to 30 feet is exposed. The sand generally is red to white, and the grains generally are subangular. The formation crops out in Clark, Harrison, Floyd, and Washington Counties.

Pleistocene and Recent sands

The Pleistocene sands are found mainly in dunes, outwash plains, and sluiceways. The sand is loose, subangular, and generally contains many sand-size rock fragments and other impurities. Most of the Pleistocene and Recent sands sampled for this project were from the Kankakee lacustrine section (Malott, 1922, pp. 114-116), which contains large sandy lake plains. The sand bodies generally are lenticular and not more than 10 to 15 feet thick. Some of the larger dunes attain a thickness of 40 to 50 feet. These sands are best developed in Jasper, Porter, Pulaski, and Starke Counties. Other Pleistocene and Recent sands were sampled from the White River Valley in Daviess, Knox, and Pike Counties.

DESCRIPTIONS OF SELECTED EXPOSURES

General statement

This report contains analyses and measured sections for all sampled exposures that contained less than 0.3 percent Fe_2O_3. A total of 13 localities are described in the following paragraphs which give lithologic and economic descriptions.

St. Peter sandstone

The description of the Newton County Stone Company quarry section is from the memorandum report by Haydn H. Murray. This exposure is located in the NE1/4NE1/4 sec. 25, T. 27 N., R. 9 W., in the south wall of the Newton County Stone Company quarry, 3 miles east of Kentland.

The St. Peter sandstone of Ordovician age is exposed in the quarry. The exposure is approximately 100 feet wide and 80 feet thick. It is highly fractured, as are the steeply dipping dolomite beds on either side. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
2	Sandstone: White, medium-grained, friable, very massive; grains are rounded and frosted; fracture planes are numerous and have red iron oxide coatings.	40.0	M52-120
1	Sandstone: Same description as above.	30.0	M52-119
	Total thickness	70.0	

This deposit is apparently too small to warrant any commercial quarrying of the sandstone at this locality. If drilling were to prove a sizable sandstone body, economic development would be feasible, as the quality of the sand is excellent.

Cypress sandstone

Upper Sulphur Creek section. --From the memorandum report by Thomas G. Perry. This exposure is located in the SW1/4SW1/4 sec. 5, T. 1 N., R. 1 W., approximately 3.7 miles east of French Lick, Orange County, and about 2,300 feet northeast of Upper Sulphur Creek.

The Cypress sandstone forms a prominent cliff and crops out for a distance of half a mile. The exposure overlies 15.4 feet of Beech Creek limestone. The exposure is lithologically homogeneous, but for convenience in sampling the section was divided into two units.

Unit	Description	Thickness in feet	Sample number
2	Sandstone: White-cream, with a faint brown tint, fine-grained, well-sorted; grains subround to subangular. Upper 5 feet has rare, elliptical, iron-stained sandstone concretions, 2 inches in greatest dimensions, that project from cliff face.	15.6	Py52-9
1	Sandstone: White-cream, with a faint brown tint, fine-grained, well-sorted; grains subround to subangular.	15.2	Py52-8
	Total thickness	30.8	

The exposure is readily accessible by road and is less than 4 miles from French Lick, the nearest rail center. Upper Sulphur Creek is the nearest source of available surface water. The overburden is relatively thin directly over the sampled exposure, but it gradually increases and reaches 50 feet in thickness 700 feet northeast of the exposure.

Painter Creek section. --From the memorandum report by Thomas G. Perry. The exposure is located in the NE1/4NE1/4 sec. 15, T. 1 S., R. 2 W., approximately 7 1/2 miles south of French Lick on the east side of Highway 145 immediately south of Painter Creek, in Orange County.

Only the lower half of the Cypress formation is exposed at this locality. The top of the exposure is soil-covered. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
2	Sandstone: White or light-tan, fine-grained, well-sorted; grains subangular;		

Unit	Description	Thickness in feet	Sample number
	bed thickness 0.3 foot to 3.2 feet. Iron oxide present as small rust spots which are irregularly distributed or occur along lamination. An interval 1 1/2 feet in thickness and 3.2 feet above the base of the unit is deeply weathered and was included in the measured thickness but was not sampled.	11.5	Py52-24
1	Sandstone: White or cream-white, fine-grained, soft, well-sorted; weathers drab gray; bed thickness 1.0 foot to 1.8 feet. Iron oxide present as small rust-brown spots that do not appear to be laminated; iron staining particularly prevalent in the lower 1 1/2 feet of the unit.	7.3	Py52-23
	Total thickness	18.8	

The overburden probably does not exceed 30 feet in thickness within a distance of 500 feet east of the exposure, and probably is less if the bedrock surface rises beneath the overburden. Because of the small amount of overburden, the presence of an adequate water supply, and the accessibility of the exposure, this site appears to be particularly favorable for commercial development. The nearest rail facilities are at French Lick and Eckerty, both about 7 1/2 miles distant.

English section.--From the memorandum report by Thomas G. Perry. This exposure is located in the SE1/4SW1/4 sec. 19, T. 2 S., R. 1 E., approximately 1.1 miles southeast of English and occurs in a gully that is 500 feet northeast of Highway 37, in Crawford County.

This exposure of the Cypress sandstone directly overlies 7 1/2 feet of Beech Creek limestone; the contact between the two formations is clearly shown. The top of the Cypress formation is soil-covered. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
4	Sandstone: Mainly light-tan, fine-grained, well-sorted; weathers drab gray;		

Unit	Description	Thickness in feet	Sample number
	bed thickness is 0.1 foot to 1.2 feet and averages 0.6 foot; commonly iron-spotted; iron staining also laminated in appearance, particularly in the thinner beds. A thin film of iron oxide in some places separates stratigraphically adjacent beds. Top of unit is soil-covered.	14.6	Py52-16
3	Sandstone: White to light-tan, very fine-grained, well-sorted; weathers tan gray and drab gray; bed thickness 0.1 to 0.9 foot. Iron staining is inconspicuous and irregular in its occurrence.	5.3	Py52-15
2	Sandstone: Light-gray, light-tan, and uncommonly rust-brown, fine-grained, well-sorted; grains subangular; bed thickness 0.1 to 0.7 foot; slight iron staining commonly results in a banded appearance. The thinner beds and the lower iron content distinguish this unit from Unit 1.	15.4	Py52-14
1	Sandstone: Light-tan to commonly rust-brown, fine-grained; well-sorted; grains subround to subangular; weathers to various shades of gray; thin- and thick-bedded. Iron content, which varies laterally, commonly imparts a banded appearance to the sandstone. This is the most highly iron-stained unit in this section.	4.9	Py52-13
	Total thickness	40.2	

A prohibitive amount of overburden would prevent surface quarrying operations south, southwest, and southeast of the exposure. An area approximately 2,000 feet in length and 500 feet in width, immediately northwest of the exposure, shows a marked decrease in the amount of overburden, and the top of the Cypress formation probably is covered by not more than 15 feet of soil in this area. English, 1 mile distant, offers the nearest rail transportation. Adequate surface water supplies do not occur within 1 mile of the exposure.

Dog Creek section.--From the memorandum report by Thomas G. Perry. This exposure is located in the NE1/4NE1/4 sec. 6, T. 2 S., R. 1 E., approximately 3.1 miles northeast of English, and near the top of a ridge 370 feet northwest of a gravel road in the valley of Dog Creek, in Crawford County.

This exposure of Cypress sandstone overlies 14.2 feet of Beech Creek limestone. The top of the Cypress formation is soil-covered and the exposure forms a small cliff. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
1	Sandstone: Cream-white and light-tan, fine-grained, well-sorted; weathers drab gray; grains subangular; bed thickness 0.6 foot to 2.2 feet. Iron oxide present as rust spots that are irregularly distributed or occur along laminae.	15.6	Py52-22

Exploitation of this exposure does not appear favorable because of unsuitable topography in the area and lack of an adequate surface water supply in the immediate vicinity.

Mansfield formation

Croy's Creek section.--From the memorandum report by Haydn H. Murray. This exposure is located in the E1/2NW1/4 sec. 35, T. 13 N., R. 6 W., in Clay County. The sandstone crops out in gullies along the west side of Croy's Creek, 4 1/2 miles east of Brazil and 1 mile south of U. S. Highway 40.

The sandstone overlies a shale which crops out just north of the sandstone exposure along the bank of Croy's Creek. The top of the formation is covered by glacial till. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
1	Sandstone: Buff, friable, medium-grained, massive; grains subangular. Some iron streaks parallel to bedding planes.	40.0	M51-22

This sandstone exposure is located half a mile from the nearest railroad. The overburden is thin directly above the exposure but may thicken to 20 or 30 feet directly west of the exposure. The topography west of the exposure is relatively flat. Croy's Creek would furnish enough water to maintain a washing plant at the quarry.

Lena section. --From the memorandum report by Haydn H. Murray. This sandstone exposure is located in a railroad cut in the SE 1/4SE1/4 sec. 36, T. 14 N., R. 6 W., in Parke County. It is 6 miles east of the town of Carbon, Clay County, and 1 mile east of the unincorporated village of Lena.

The sandstone is exposed continually fo r approximately 300 yards along the New York Central Railroad. It is overlain by glacial till The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
1	Sandstone: White to buff, medium-grained, friable. Grains subangular. The beds are massive at the base of the exposure but at the top are flaggy and thin, ranging from 0.2 to 0.6 foot in thickness. The bedding planes are coated with iron oxide.	12.0	M51-5

The availability of rail transportation, an adequate water supply, and the thin overburden of 10 feet or le ss make this a good prospect. An extensive drilling program would be necessary to determine the thickness and extent of the sandstone before any estimates of reserves could be made.

Pine Creek section. --From the memorandum report by Haydn H. Murray. This exposure is located in the NW1/4NW1/4 sec. 15, T. 2 N., R. 8 W., on Pine Creek, 300 yards south of a bridge. This bridge is 5 miles north of Williamsport and 1 mile east of U. S. Highway 41, in Warren County.

This sandstone unit is stratigraphically in the middle of the Mansfield formation. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
1	Sandstone: Light-gray to white, medium-grained, massive, friable, micaceous. A 2-foot by 8-foot lens of hard, dense, calcareous sandstone is present in the middle of this unit.	35.0	M52-118

The overburden on this sandstone is approximately 20 feet thick. Drainage might present a problem because the sandstone crops out along Pine Creek and because the sandstone probably extends below creek level. The nearest rail line is at Williamsport, 5 miles distant.

Harrison Steel Company quarry section. --From the memorandum report by Haydn H. Murray. This exposure is in a quarry in the NW1/4SE1/4 sec. 13, T. 21 N., R. 8 W., 1 1/8 miles southwest of Attica, in Fountain County. The quarry is being actively worked for foundry sand by the Harrison Steel Company of Attica.

This sandstone quarry is stratigraphically in the upper part of the Mansfield formation. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
2	Sandstone: White, medium-grained, thin-bedded, friable. Grains subangular. A few iron streaks and small blebs of clay occur in the sandstone.	16.0	M52-109
1	Sandstone: Same lithologic description as above. Medium-bedded to massive in appearance.	12.0	M52-108
	Total thickness	28.0	

The overburden ranges from 3 to 10 feet in thickness. The nearest rail line is three quarters of a mile east of the quarry. This is a very clean sand, and reserves appear to be plentiful in the vicinity of the quarry.

Farlen section. --From the memorandum report by Charles L. Bieber. This exposure is located in the NE1/4NE1/4 sec. 23, T. 5 N., R. 5 W., 3 1/2 miles east and northeast of Odon, along Highway 45, in Daviess County, and is half a mile north of the crossroads community formerly called Farlen.

The sandstone is part of the Mansfield formation and probably is underlain by siltstone, shale, and thin-bedded sandstone which are exposed along the highway 2 miles north of this locality. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
2	Sandstone: Brown, massive, iron-stained.	2.0	B52-15
1	Sandstone: White to buff, medium-grained, massive, friable; contains subangular grains.	18.5	B52-14
	Total thickness	20.5	

The overburden on the sandstone is 15 feet thick. The nearest rail line crosses the highway 2 miles south of the sampling site. Water supply might present a problem because there is no adequate source of surface water in the immediate vicinity.

Taswell section.--From the memorandum report by Charles L. Bieber. This exposure is located in the SE1/4SE1/4 sec. 18, T. 2 S., R. 1 W., half a mile northeast of Taswell, in Crawford County.

The sandstone generally lies unconformably on Chester limestones and is one of the massive lower Mansfield units. The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
5	Covered interval: Probably thin-bedded sandstone and sandy shale.	20.8	
4	Sandstone: Massive, iron-stained.	2.5	
3	Covered interval: Probably consists of thin-bedded sandstone and sandy shale.	36.5	
2	Sandstone and siltstone: Massive in upper part; thin-bedded, silty, and contains plant fossils in lower part.	15.6	B52-33
1	Sandstone: White with buff iron streaks and specks, fine-grained, massive; contains cross bedding; weathers with honeycomb structures on surface.	52.2	B52-32
	Total thickness sampled . . .	67.8	

The overburden at this locality is apparently thick, but drilling would be required to reveal the exact nature of the covered interval. The nearest rail line goes through the town of Taswell, a quarter of a mile south of the sampling site. Many other excellent exposures of sandstone occur in the vicinity, and reserves would be adequate for large-scaled operations to continue for many years.

Uniontown section.--From the memorandum report by Charles L. Bieber. This exposure is located in the NW1/4SE1/4 sec. 6, T. 4 S., R. 2 W., 2 miles south of Uniontown, in Perry County.

The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
3	Covered: Soil.	0 - 5	
2	Sandstone: Buff, medium-grained, massive; cross bedding and joint planes		

Unit	Description	Thickness in feet	Sample number
	numerous. Surface is honeycombed by weathering effects.	68.1	B52-36
1	Covered to valley bottom.	30.0	

The overburden is thin, and the sandstone unit probably extends laterally under 160 acres of land. The nearest rail line runs through Birdseye, 10 miles north of the exposure.

Ohio River formation

Miller sand pit section.--From the memorandum report by Arthur P. Pinsak. This exposure is located in the NE1/4 sec. 18, T. 1 S., R. 5 E., 2 miles southeast of Martinsburg and 4 miles south of Pekin, in Washington County, in an old sand pit known as the Miller pit.

The following section was measured and sampled:

Unit	Description	Thickness in feet	Sample number
1	Sand: Variegated, reddish-brown, tan, and white; medium-grained, thin-bedded, cross-bedded. The sand is lighter in color at the base of the section than at the top.	14.4	AP52-1

The overburden is 8 feet thick at this exposure. The closest rail line is at Pekin, 4 miles north of the pit. The sand terminates at the south end of the pit, where it is eroded. The sand probably persists to the north and east, but drilling would have to be done to substantiate this belief.

Jorris sand pit section.--From the memorandum report by Arthur P. Pinsak. This exposure is located in the SE1/4NW1/4 sec. 20, T. 1 S., R. 5 E., 2 1/2 miles north of Greenville, in an old sand pit known as the Jorris pit, in Clark County.

The sand appears to rest on the Salem limestone, which crops out in a gully 250 yards southeast of the pit. The following section of the Ohio River formation was measured and sampled:

Unit	Description	Thickness in feet	Sample number
1	Sand: Variegated, red-brown, tan, and white; medium-grained, thin-bedded. Sand is lighter		

Unit	Description	Thickness in feet	Sample number
	in color and cleaner at base of measured section than at the top.	16.8	AP52-3

The overburden is 4.6 feet thick. East of the pit the Ohio River formation is dissected by deep gullies. The topography is gently rolling north, west, and south of the pit. Large streams are not present in the area, and an adequate water supply may be lacking. The nearest rail line passes through Borden, which is 5.2 miles northeast of this exposure.

Buena Vista section.--From the memorandum report by Arthur P. Pinsak. This exposure is located at the intersection of secs. 21, 22, 27, and 28, T. 5 S., R. 5 E., 1 1/4 miles southeast of Buena Vista, in Harrison County.

The Ohio River formation apparently lies on the St. Louis limestone, as a St. Louis outcrop was observed in a gully 1,000 feet north of the exposed Ohio River formation. The following section of the Ohio River formation was measured and sampled:

Unit	Description	Thickness in feet	Sample number
1	Sand: Variegated, reddish-brown, tan, and white; medium-grained, thin-bedded, cross-bedded. The formation changes color from reddish-tan to white from top to bottom of the measured section.	13.0	AP52-5

Overburden is 7 feet thick on the Ohio River formation at the place where this sample was taken. The terrain is dissected by a series of gullies so that extensive continuous deposits probably are not available. As large streams are not present in the area, a supply of surface water would be lacking. The nearest rail line is in New Albany, 17 miles north of the exposure. As the Ohio River is 2.2 miles east of the exposure, barge transportation might be used for sand shipments.

LABORATORY PROCEDURE

General statement

In order to obtain a sample which would be representative of the rock units, chip samples were used for the analyses. Chip sampling was accomplished by removing small chips of sandstone from the exposed face in such a way as to give nearly continuous samples from the bottom to the top of the rock unit. A rock unit is defined herein as a vertical interval which has similar lithological characteristics. Some formations contain many units, whereas others may be essentially homogeneous and consist of one continuous unit. A change in texture, color, grain size, bedding, or cementing material constitutes a break between units. Chips of nearly equal size were taken from individual rock units, although the size of the chips was dependent on the thickness of the unit. A 10-pound sample was required for the analysis. If the sandstone unit was thin, large chips were taken to make up the 10 pounds; but, if the sandstone unit was thick, much smaller chips were taken.

Preparation

Each sample collected during this investigation was processed in the same manner (fig. 3). All samples were crushed in a small laboratory jaw crusher. The jaws on the crusher were covered with wooden blocks in order that the sand would not be contaminated by iron. All the splits were made by using a sample splitter of the Jones type. The sieve analyses were performed on an End Shak Sieve test machine or a Ro-Tap Sieve testing machine.

Studies on beneficiation now are being carried on in the Industrial Minerals Section of the Geological Survey. These studies probably will be completed by June 1953. Petrologic studies in progress include heavy mineral separations, identification of all minerals, types of cementation, and textural relationship of mineral grains. All these studies will be included in a comprehensive bulletin on the high-silica sand project.

Chemical and spectrographic analyses

All determinations except those of silica were made in the Spectrographic Laboratory of the Geological Survey by Richard K. Leininger and Robert F. Blakely. The silica determinations were made chemically by Maynard E. Coller.

In the table on pages 28-29 analyses are given for each unit sampled, as shown in the descriptions of the exposures, and also a composite average of the total sample from each formation or member is given.

The sands covered in the table of chemical analyses can hardly be evaluated except by a comparison with analyses of glass sands that are being produced currently. The wide divergence in purity of glass sands is illustrated on page 30 by the analyses of raw St. Peter sand-

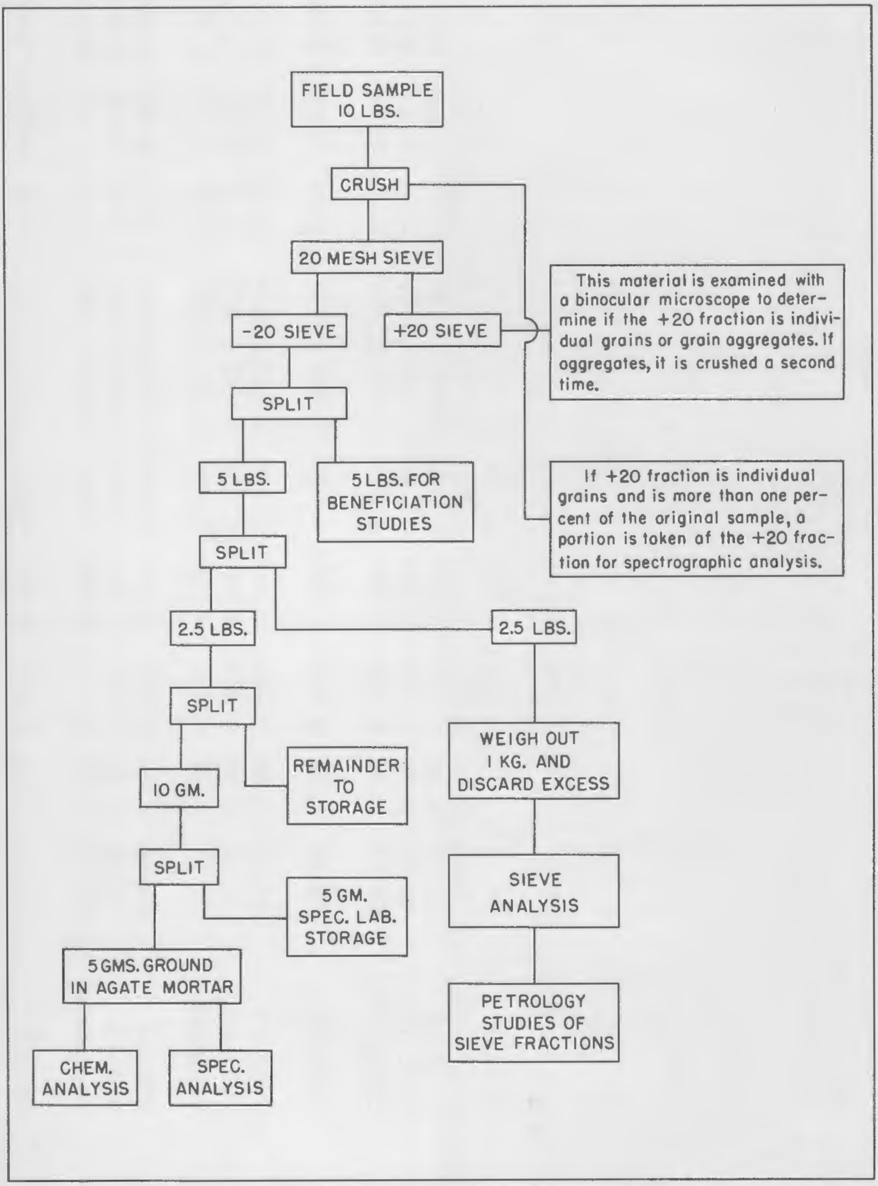

Figure 3. *Flow sheet of the procedure used to prepare samples of sands and sandstones for analysis.*

Chemical analyses of unwashed Indiana sands

Formation	Sample No.	SiO_2 (pct.)	Al_2O_3 (pct.)	Fe_2O_3 (pct.)	CaO (pct.)	MgO (pct.)	TiO_2 (pct.)	Na_2O (pct.)	K_2O (pct.)	ZrO_2 (pct.)	MnO (pct.)
St. Peter	M52-119	99.62	0.24	0.016	0.05*	0.012	0.018	0.10*	----	0.01	0.0003*
	M52-120	99.07	0.27	0.016	0.15	0.097	0.028	0.10*	----	0.03	0.0003
	Composite	99.26	0.25	0.016	0.11*	0.060	0.024	0.10*	----	0.02	0.0003*
Cypress	Py52-8	95.54	3.00	0.220	0.10	0.039	0.290	0.01*	0.62	0.04	0.0020
	Py52-9	95.68	3.10	0.240	0.10*	0.044	0.500	0.10*	----	0.12	0.0010
	Composite	95.61	3.00	0.230	0.10*	0.042	0.400	0.06*	----	0.08	0.0020
	Py52-13	97.14	1.70	0.380	0.10*	0.038	0.380	0.10*	----	0.07	0.0040
	Py52-14	97.19	2.10	0.170	0.10*	0.028	0.330	0.10*	----	0.05	0.0030
	Py52-15	96.30	3.20	0.130	0.10*	0.038	0.250	0.10*	----	0.02	0.0010
	Py52-16	96.98	2.40	0.200	0.10*	0.032	0.270	0.10*	----	0.03	0.0020
	Composite	96.99	2.40	0.200	0.10*	0.032	0.300	0.10*	----	0.04	0.0020
	Py52-22	96.24	2.30	0.250	0.10*	0.030	0.400	0.01*	0.33	0.09	0.0020
	Py52-23	96.26	2.30	0.250	0.10*	0.039	0.480	0.01*	0.35	0.12	0.0030
	Py52-24	96.44	2.10	0.220	0.10*	0.030	0.500	0.01*	0.37	0.11	0.0005
	Composite	96.37	2.20	0.230	0.10*	0.033	0.490	0.01*	0.36	0.11	0.0010
Mansfield	B52-14	98.08	1.40	0.110	0.05*	0.022	0.330	0.10*	----	0.07	0.0004
	B52-15	97.58	1.40	0.220	0.05*	0.024	0.430	0.10*	----	0.08	0.0005
	Composite	97.98	1.40	0.110	0.05*	0.022	0.340	0.10*	----	0.07	0.0004
	B52-32	97.30	1.40	0.300	0.05*	0.028	0.280	0.05*	0.20	0.06	0.0030

Chemical analyses of unwashed Indiana sands (Continued)

Formation	Sample No.	SiO_2 (pct.)	Al_2O_3 (pct.)	Fe_2O_3 (pct.)	CaO (pct.)	MgO (pct.)	TiO_2 (pct.)	Na_2O (pct.)	K_2O (pct.)	ZrO_2 (pct.)	MnO (pct.)
	B52-33	97.32	1.50	0.320	0.05*	0.040	0.340	0.05*	0.20*	0.08	0.0006
	Composite	97.30	1.40	0.300	0.05*	0.031	0.290	0.05*	0.20*	0.06	0.0020
	B52-36	97.56	1.20	0.290	0.05*	0.048	0.340	0.05*	0.20*	0.08	0.0020
	M51-5	96.10	2.80	0.300	0.02	0.040	0.320	----	0.30	----	------
	M51-22	96.80	2.50	0.230	0.02	0.040	0.200	0.20	0.1-1.0	----	------
	M52-108	97.51	1.90	0.078	0.01*	0.034	0.250	0.01	0.32	0.06	0.0004
	M52-109	97.30	1.80	0.130	0.05*	0.037	0.150	0.017	0.44	0.02	0.0008
	Composite	97.40	1.80	0.110	0.03*	0.036	0.190	0.01	0.39	0.04	0.0006
	M52-118	96.66	1.90	0.240	0.094	0.092	0.200	0.03	0.53	0.03	0.0009
Ohio River	AP52-1	98.43	1.00	0.250	0.05*	0.034	0.069	0.05*	----	0.01	0.0003
	AP52-3	98.13	1.20	0.190	0.05*	0.039	0.080	0.05*	0.20*	0.01	0.0003
	AP52-5	99.22	0.54	0.087	0.05*	0.031	0.033	0.05*	----	0.006	0.0002

*Less than

stone from the Ottawa, Illinois district, as given by Willman and Payne (1942, pp. 368-369).

Analyses of raw sand from Ottawa district

Sample	SiO_2 (pct.)	Al_2O_3 (pct.)	Fe_2O_3 (pct.)	MgO (pct.)	CaO (pct.)	TiO_2 (pct.)	Na_2O (pct.)	K_2O (pct.)	CO_2 (pct.)
1. St. Peter sandstone	94.31	2.98	0.33	0.36	0.19	0.08	0.11	0.18	1.49
2. St. Peter sandstone	98.47	0.75	0.08	0.08	0.21	0.05	0.00	0.06	0.47

Before it is washed, most of the St. Peter sandstone has an SiO_2 percentage of 97 to 98, and after it is washed the percentage is above 99.

Chemical composition may vary widely in acceptable glass sands, depending upon the type of glass to be manufactured, as shown in the following table given by Ries (1949, p. 973):

Specifications for chemical composition of glass sands

Qualities	SiO_2 minimum (pct.)	Al_2O_3 maximum (pct.)	Fe_2O_3 maximum (pct.)	CaO/MgO maximum (pct.)
First quality, optical glass	99.8	0.1	0.020	0.1
Second quality, flint-glass containers and tableware	98.5	0.5	0.035	0.2
Third quality, flint glass	95.0	4.0	0.035	0.5
Fourth quality, sheet glass, rolled and polished plate	98.5	0.5	0.060	0.5
Fifth quality, sheet glass, rolled and polished plate	95.0	4.0	0.060	0.5
Sixth quality, green glass containers and window glass	98.0	0.5	0.300	0.5
Seventh quality, green glass	95.0	4.0	0.300	0.5
Eighth quality, amber glass	98.0	0.5	1.000	0.5
Ninth quality, amber glass	95.0	4.0	1.000	0.5

Sieve analyses

Sieve analyses were performed on all sand samples collected during this study. These analyses were performed according to standard procedures (American Society for Testing Materials, 1949, pp. 763-765). Each sample was sieved for 15 minutes. Comparative test runs on the End Shak and Ro-Tap mechanical shakers showed insignificant differences at the end of the 15-minute period. The sieve analyses were done by Arthur P. Pinsak, Robert E. Boyer, W. Kelley Summers, and John M. Smith.

The table on pages 32-33 gives the sieve analysis for each unit sampled, in addition to a composite analysis for each formation or member.

The grading shown by these sieve tests may be partially evaluated by comparing them with the following sieve specifications given by Ries (1949, p. 972).

Grading of glass sands

Passing sieve	Retained on sieve	Percentage
No. 20		100
No. 20	No. 40	40 - 60
No. 40	No. 60	30 - 40
No. 60	No. 100	10 - 20
No. 100	-------	0 - 5

CONCLUSIONS

With regard to size grading and chemical composition, some of the raw sand samples covered in this report fall within the general specification ranges of some grades of glass sands. Virtually all sands currently used for glass manufacture in the United States are washed and sized. Some manufacturers also subject the sand to chemical treatment, flotation, and other types of beneficiation. Such processing is, of course, ultimately paid for by the consumer.

To evaluate sand deposits entirely on the basis of their properties in the raw state is unrealistic. Impure sands which are amenable to processing and beneficiation may have better commercial prospects than cleaner sands which are not amenable to improvement. This amenability is based upon factors, such as nature and degree of cementation, kind and amount of accessory minerals, and the relationship of the iron content to quartz grains, other mineral grains, and cementation. The determination of all these factors is labora-

Sieve analyses of unwashed Indiana sands

Formation	Sample No.	U. S. standard sieve size 20 (pct.)	30 (pct.)	40 (pct.)	60 (pct.)	80 (pct.)	100 (pct.)	140 (pct.)	200 (pct.)	270 (pct.)	325 (pct.)	-325 (pct.)
St. Peter	M52-119	---	3.4	13.6	41.5	9.7	6.7	6.3	3.8	7.1	3.4	4.2
	M52-120	---	3.1	18.4	40.4	12.9	7.2	6.4	2.5	1.9	1.7	5.5
	Composite	---	3.2	16.3	40.8	11.5	6.9	6.3	3.0	4.1	2.4	4.9
Cypress	Py52-8	---	1.9	2.4	5.6	9.9	11.7	37.2	20.4	4.9	3.1	2.8
	Py52-9	---	2.4	3.0	5.9	13.5	10.7	28.6	21.6	6.9	3.5	3.9
	Composite	---	2.1	2.7	5.7	11.7	11.2	32.8	21.0	5.9	3.3	3.3
	Py52-13	---	1.7	3.5	10.1	47.2	9.7	18.9	5.6	1.3	0.9	1.3
	Py52-14	---	2.7	4.0	11.5	29.1	10.3	25.0	11.5	2.8	1.7	1.7
	Py52-15	---	2.4	2.9	6.0	17.6	7.2	34.0	20.7	4.0	2.6	2.2
	Py52-16	---	2.3	2.7	6.3	29.4	8.4	25.1	15.6	5.0	2.8	2.7
	Composite	---	2.4	3.3	8.7	29.8	9.1	25.4	13.5	3.5	2.1	2.1
	Py52-22	---	1.5	2.5	5.8	15.45	12.4	13.6	38.0	6.2	1.2	2.9
	Py52-23	---	2.2	3.7	8.1	12.4	13.1	19.6	32.2	4.5	1.6	2.4
	Py52-24	---	1.8	3.6	8.4	12.1	11.9	38.7	12.3	6.3	1.9	2.7
	Composite	---	1.9	3.6	8.2	12.2	12.3	31.3	20.0	5.6	1.8	2.6
Mansfield	B52-14	---	2.3	4.3	19.5	45.2	8.6	11.7	4.2	1.5	0.7	1.8
	B52-15	---	1.9	3.0	7.0	16.1	20.8	35.9	9.4	2.7	1.7	1.6
	Composite	---	2.2	4.1	18.3	42.3	9.8	14.0	4.7	1.6	0.8	1.7

Sieve analyses of unwashed Indiana sands (Continued)

Formation	Sample No.	U. S. standard sieve size 20 (pct.)	30 (pct.)	40 (pct.)	60 (pct.)	80 (pct.)	100 (pct.)	140 (pct.)	200 (pct.)	270 (pct.)	325 (pct.)	-325 (pct.)
	B52-32	---	1.1	2.3	11.4	20.2	25.7	26.3	8.4	2.3	1.0	1.4
	B52-33	---	3.0	4.4	15.5	20.7	17.1	21.8	7.9	3.8	2.4	3.5
	Composite	---	1.5	2.8	12.3	20.3	23.8	25.2	8.2	2.6	1.3	1.9
	B52-36	---	2.6	4.6	26.1	29.9	12.2	17.0	4.3	1.25	0.7	1.5
	M51-5	---	0.1	0.1	8.6	20.2	41.5	19.7	4.5	1.7	1.6	1.3
	M51-22	---	---	0.1	38.0	34.5	15.6	6.6	1.5	0.7	0.7	1.0
	M52-108	---	2.3	6.3	48.2	22.0	7.4	7.0	2.8	1.3	0.7	2.1
	M52-109	0.3	5.2	24.9	32.7	14.5	8.6	7.3	2.6	0.9	0.6	1.4
	Composite	---	3.9	16.9	39.3	17.7	8.0	7.1	2.6	1.0	0.6	1.7
	M52-118	---	3.6	6.9	38.8	23.3	8.3	11.1	4.0	1.4	0.7	2.0
Ohio River	AP52-1	---	0.2	5.3	54.8	30.6	5.2	2.2	0.5	0.2	0.2	0.6
	AP52-3	---	0.1	0.8	43.6	40.5	7.0	4.6	1.2	0.4	0.3	1.4
	AP52-5	---	0.1	5.0	73.6	15.9	2.4	1.4	0.4	0.2	0.2	0.6

tory work which goes beyond the results offered in this report.

These observations have borne heavily on glass sands because glass manufacture is the largest single use for high-silica sand and because fairly standardized requirements are recognized for the glass industry. The suitability of the sands reviewed herein for abrasives and other special uses must be considered in the light of the needs of each industry. The emphasis placed herein on low-iron content need not apply to many of the other fields in which high-silica sands are used. Nor should the sampling localities listed herein be regarded as recommended areas for development. The nature of this study has required that samples be obtained wherever the material was exposed, as test-drilling facilities have not been available. Within the thousands of square miles underlain by these sandstone formations, many additional favorable localities inevitably exist, some of them undoubtedly better than any exposed naturally. Any company or individual interested in developing high-silica sand production thus should regard this preliminary report as a point of departure for a private exploration program.

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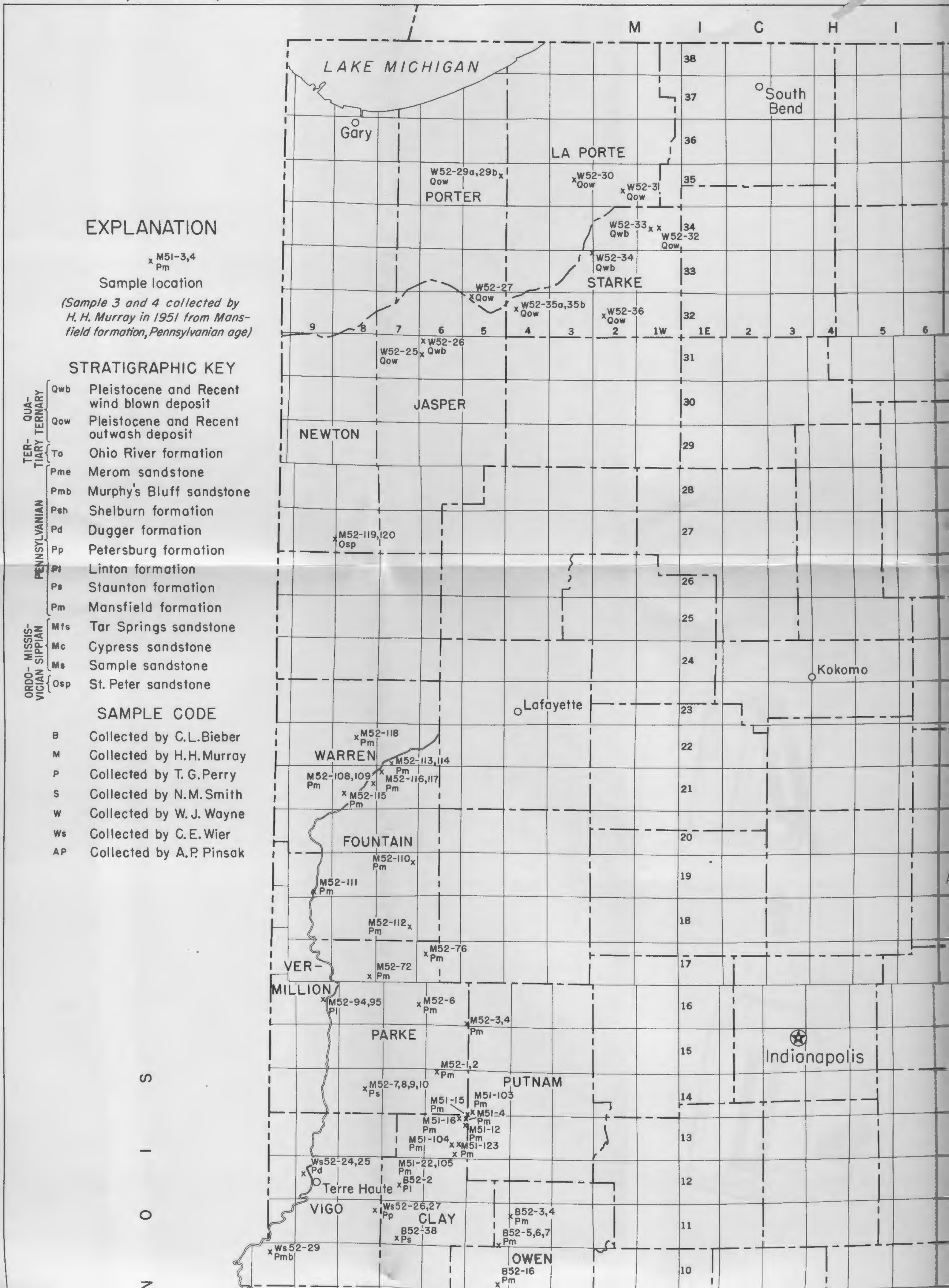
EXPLANATION
M51-3,4 Pm
Sample location
(Sample 3 and 4 collected by H. H. Murray in 1951 from Mansfield formation, Pennsylvanian age)
STRATIGRAPHIC KEY
QUATERNARY
Qwb Pleistocene and Recent wind blown deposit
Qow Pleistocene and Recent outwash deposit
TERTIARY
To Ohio River formation
PENNSYLVANIAN
Pme Merom sandstone
Pmb Murphy's Bluff sandstone
Psh Shelburn formation
Pd Dugger formation
Pp Petersburg formation
Pl Linton formation
Ps Staunton formation
Pm Mansfield formation
MISSISSIPPIAN
Mts Tar Springs sandstone
Mc Cypress sandstone
Ms Sample sandstone
ORDOVICIAN
Osp St. Peter sandstone
SAMPLE CODE
B Collected by C.L. Bieber
M Collected by H.H. Murray
P Collected by T. G. Perry
S Collected by N.M. Smith
W Collected by W. J. Wayne
Ws Collected by C.E. Wier
AP Collected by A.P. Pinsak
M I C H I
LAKE MICHIGAN
Gary
South Bend
LA PORTE
PORTER
STARKE
JASPER
NEWTON
WARREN
FOUNTAIN
VERMILLION
PARKE
PUTNAM
VIGO
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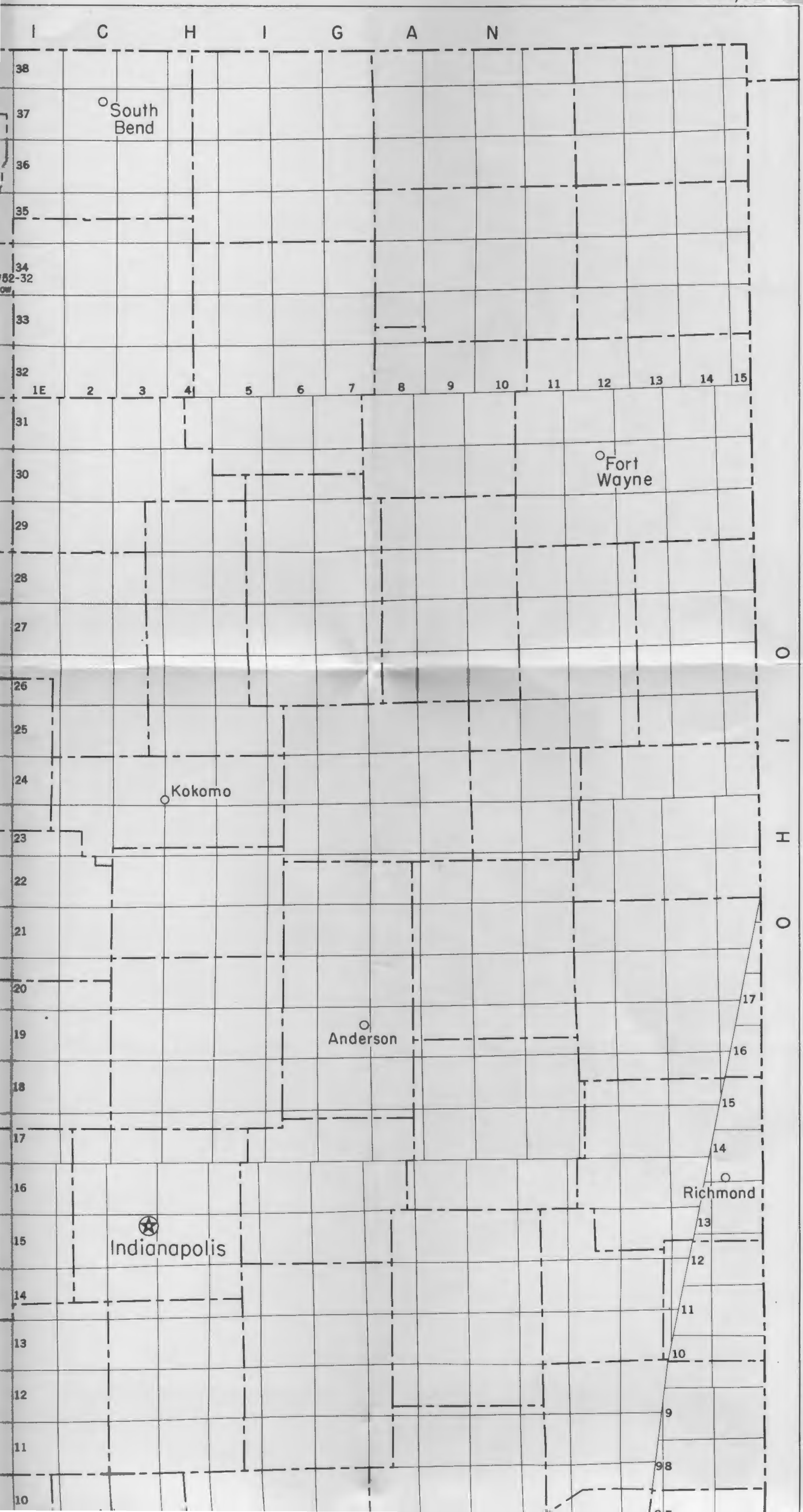
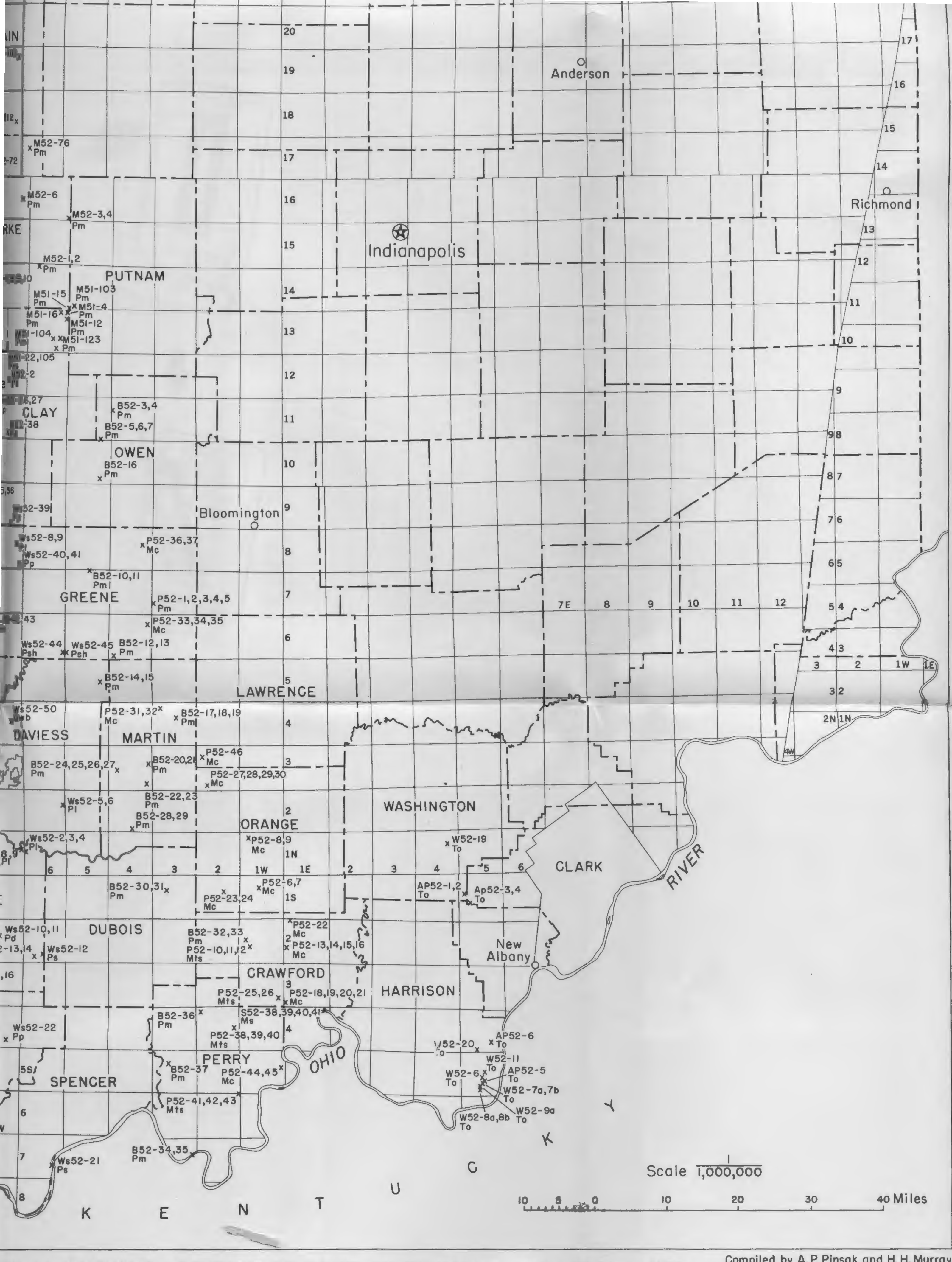
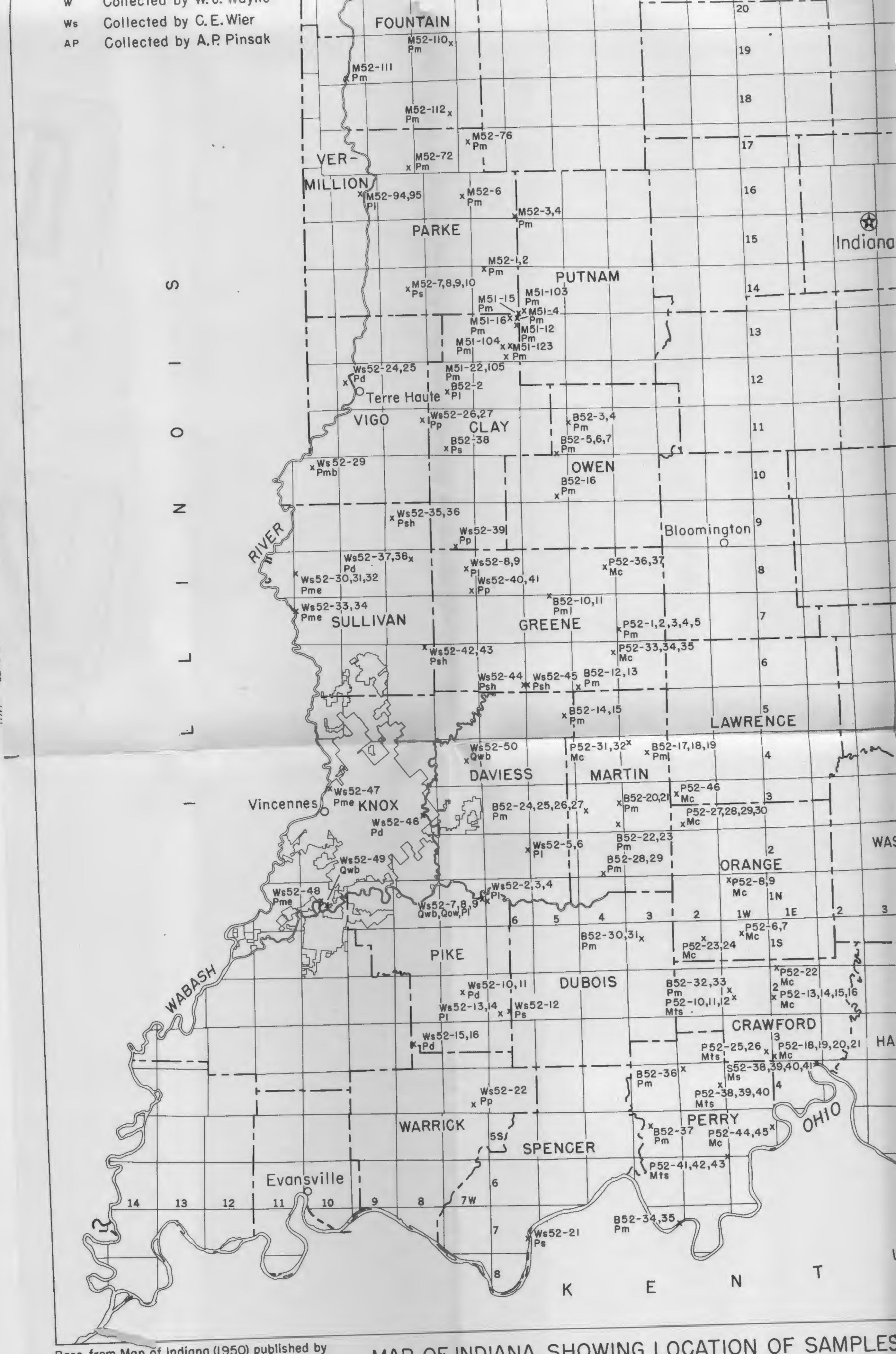
Terre Haute
I L L I N O I S


I C H I G A N
South Bend
Fort Wayne
Kokomo
Anderson
Richmond
Indianapolis
O H I O



DIANA SHOWING LOCATION OF SAMPLES OF SANDS AND SANDSTONES

Compiled by A.P. Pinsak and H.H. Murray
January 1953



Base from Map of Indiana (1950) published by U.S. Geological Survey. Minor revisions and additions made from Indiana Department of Conservation, Geological Survey county base maps.

MAP OF INDIANA SHOWING LOCATION OF SAMPLES