HIGH-PURITY SILICA SAND OF MIDDLE ORDOVICIAN AGE IN THE MIDWESTERN STATES

By Keith B. Ketner

Certain quartz sands of Middle Ordovician age in the Midwestern States are well known for their purity and are exploited for a wide variety of industrial uses. The principal Middle Ordovician formations containing high-purity sands are the St. Peter Sandstone which crops out extensively from Minnesota to Arkansas; the Everton Formation principally of Arkansas; and the Oil Creek, McLish, and Tulip Creek Formations (all of the Simpson Group) of Oklahoma. The St. Peter and sandy beds in the other formations are commonly called "sandstones," but a more appropriate term is "sands" for in most fresh exposures they are completely uncemented or very weakly cemented. On exposure to air, uncemented sands usually become "case hardened" where evaporating ground water precipitates mineral matter at the surface; but this is a surficial effect. This report summarizes the available information on the extent of exposures, range of grain size, and chemical composition of the Middle Ordovician sands.

EXTENT OF EXPOSURES AND THICKNESS

Maps A, B, and C show where the principal Middle Ordovician sand-bearing formations are exposed at the surface or are thinly overlain by unconsolidated material. Map A was compiled from the State geologic maps of Minnesota (Sloan and Austin, 1966; Schwartz, 1936); Iowa (Tester, 1937); Wisconsin (Bean, 1949); and Illinois (Willman and others, 1967). The St. Péter Sandstone shown on Map A, seems nearly horizontal, but it actually dips very gently away from the Wisconsin uplift to the west, south, and east. The very irregular, dendritic patterns in southern Minnesota, much of Wisconsin, and northermost Illinois are produced where the St. Peter Sandstone crops out on hillsides along sharply incised stream valleys. The more rounded, broad patterns in Minnesota, eastern Wisconsin, and part of Illinois are in glaciated areas where the Ordovician rocks underlie a veneer of unconsolidated deposits, and have not been intricately dissected by present-day streams.

Map B was compiled from the State geologic maps of Missouri (McCracken, 1961) and Arkansas (Haley and others, 1976). Ordovician sands in this region crop out on the east and southern margins of the Ozark uplift. From the center of the uplift in southern Missouri, the sandstones dip very gently to the east and south. Additional small exposures (not shown on Map B) are scattered through central Missouri where they form erosional remnants preserved in small depressions.

Map C was compiled from the Geologic Map of Oklahoma (Miser, 1954). In this region the formations are folded, and the attitudes of the sandstone units range from horizontal to nearly vertical. The map pattern shows the extent of the Simpson Group, a group of six formations. In the outcrop area, only three of the six formations contain beds of nearly pure silica sand--the Oil Creek, McLish, and Tulip Creek Formations.

In most of the areas of exposure shown on Maps A, B, and C, the sands range in thickness from 20 to 60 m.

MINERAL COMPOSITION

The high-purity sandstones described here are composed almost entirely of well-rounded sand-size quartz grains. Minor components are finer particles composed principally of quartz, clay, and iron oxide. These fines are easily separated from the sand, either by agitation in water and drainage of suspended particles, or by wet screening. Sand-size material purified in either of these ways still includes a very small amount of impurities in the form of: (1) non-quartz sand-size grains, principally zircon and tourmaline; (2) coatings on quartz grains, principally iron oxide and calcium carbonate and, (3) minute mineral inclusions within the grains of quartz sand, principally feldspar, mica, and amphibole. Detrital impurities in the Ordovician sands were described in detail by Thiel (1935), Tyler (1936), Lamar (1928), and Dake (1921). The mineral inclusions in quartz sand grains of the St. Peter were described in detail by Tyler (1936). Detrital non-quartz sand grains can be removed from the quartz sand by various mineral dessing methods and coatings can be removed by acid treatment, but the mineral inclusions cannot be removed and their presence, therefore, sets an absolute upper limit on the silica content of quartz sand.

CHEMICAL COMPOSITION

Table 1 gives the chemical composition of impurities in representative samples of sandstone that have been agitated in water and wet screened to remove material finer than sand size (grains less than .06 mm in diameter). As previously stated, the reported impurities represent a combination of detrital grains, coatings, and inclusions. The data clearly indicate that washed sand of the midwestern Middle Ordovician formations is more than 99 percent silica. Some of the alumina reported by the analyst may be contamination from the ceramic plates used in grinding the samples. Microscopic inspection of sample no. 5, indicates the unusually high content of CaO is due to coatings and grains of calcium carbonate.

SIZE DISTRIBUTION

Middle Ordovician sands in the area of exposure are composed principally of fine- to medium-size quartz grains (0.1-0.5 mm diameter). Exceptions are the sand at Ottawa, Illinois, which is distinctly coarser, and sand in Oklahoma which is finer. Sand of the other areas is so uniform that regional trends in grain size are difficult to determine. Table 2 summarizes comparative size data from 29 localities. This table shows the size of the 5th, 50th, and 95th percentiles of sand-size material. For example, 5 percent by weight of the sand-size material from Cannon Falls consist of grains larger than .30 mm, 50 percent are larger than .19 mm, and 95 percent are larger than .10 mm. The data on which Table 2 is based were published elsewhere (Ketner, 1979). These data consist of 276 complete size analyses.

PRINCIPAL DESCRIPTIVE REPORTS

Published reports on the general, regional, and genetic aspects of the St. Peter Sandstone equivalent rocks are those by Dake (1921), Thiel (1935), Dapples (1955), Potter and Pryor (1961), and Amaral and Pryor (1977).

Thiel (1935) described the grain-size variations of the St. Peter Sandstone in Minnesota, Wisconsin, and Iowa, and included considerable data on chemical and mineral composition.

In a recent report, Ostrom (1971) presented chemical and size analyses of Wisconsin sandstones including the St. Peter Sandstone. Stratigraphic information and an extensive list of references is given in another publication (Ostrom, and others, 1970). Tyler (1936) presented data on the heavy minerals, including those enclosed within the quartz sand grains, of the St. Peter Sandstone in Wisconsin.

Lamar (1928) described the St. Peter Sandstone of Illinois, including a structure contour map, grain-size analyses, and data on impurities and heavy minerals.

Dake (1918, 1921) presented data on the stratigraphy, chemical composition, and grain-size distribution for the St. Peter Sandstone of Missouri. More recent data on grain size is available from the Missouri Geological Survey in Rolla.

Giles (1930) described the St. Peter Sandstone and older Ordovician sandstones of northern Arkansas. His report includes chemical data, grain-size analyses, and a review of the stratigraphic relations of various Ordovician sandstones. In another paper, Giles (1932) discussed the texture of these rocks in detail. Frezon and Glick (1959) give more recent stratigraphic data.

Ham (1945) discussed sands of the Middle Ordovician Simpson Group of Oklahoma and presented data on chemical composition, size distribution, and heavy minerals. Decker and Merritt (1931) presented additional stratigraphic data and detailed descriptions.

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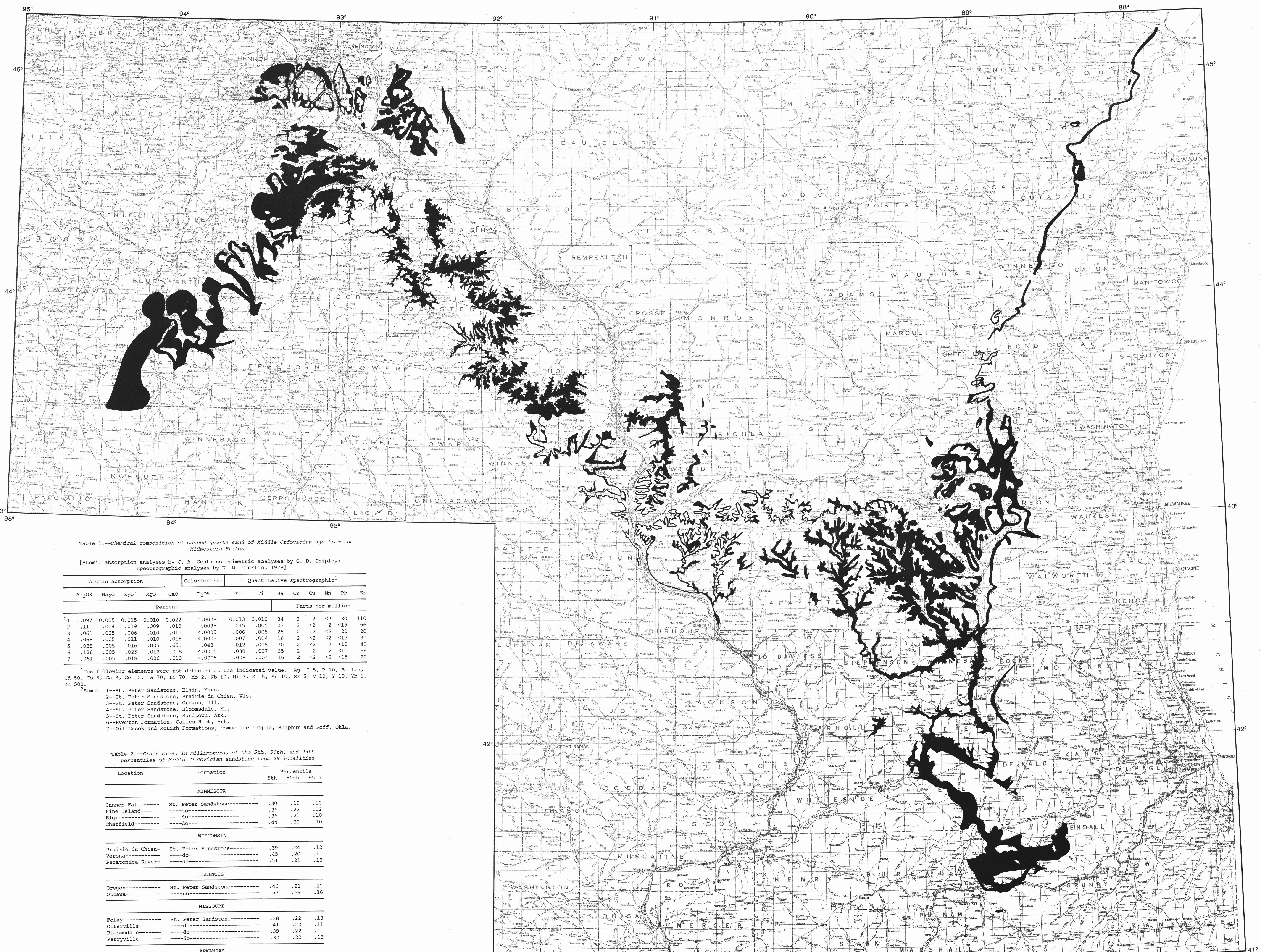


Map A.--Areas in Minnesota, Iowa, Wisconsin, and Illinois where the St. Peter Sandstone is exposed at, or near, the surface

Table 1.--*Chemical composition of washed quartz sand of Middle Ordovician age from the Midwestern States*

[Atomic absorption analyses by C. A. Gent; colorimetric analyses by G. D. Shipley; spectrographic analyses by N. M. Conklin, 1978]

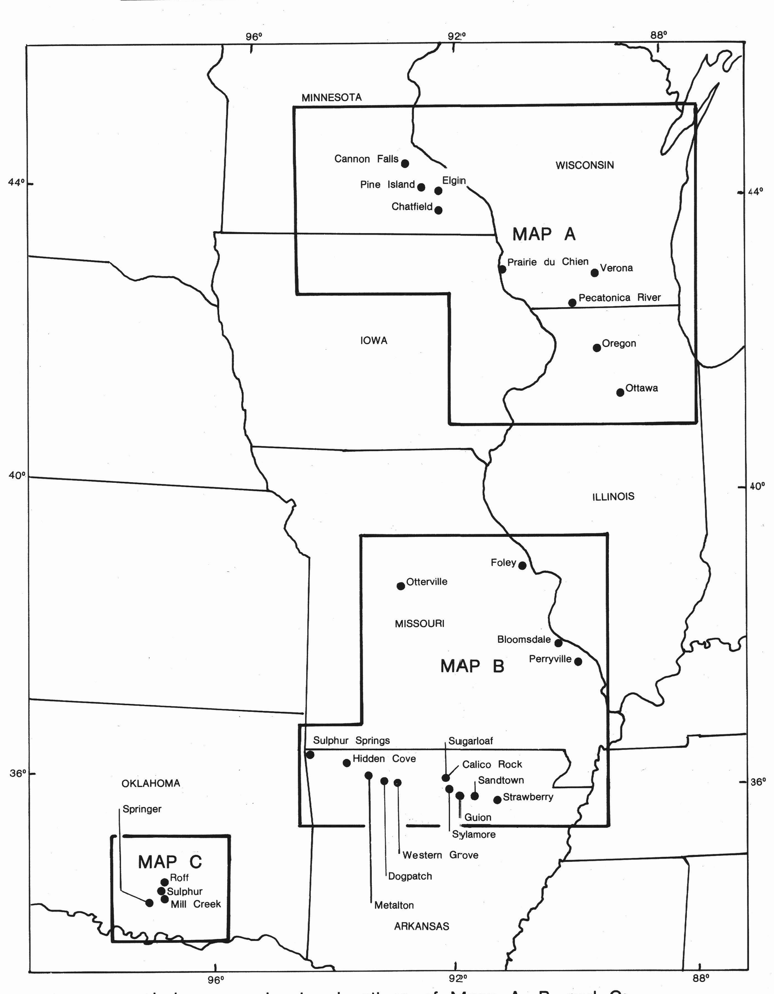
	Atomic absorption					Colorimetric	Quantitative spectrographic[1]							
	Al_2O_3	Na_2O	K_2O	MgO	CaO	P_2O_5	Fe	Ti	Ba	Cr	Cu	Mn	Pb	Zr
	Percent								Parts per million					
[2]1	0.097	0.005	0.015	0.010	0.022	0.0028	0.013	0.010	34	3	2	<2	30	110
2	.111	.004	.019	.009	.015	.0035	.015	.005	23	2	<2	2	<15	66
3	.061	.005	.006	.010	.015	<.0005	.006	.005	25	2	2	<2	20	20
4	.068	.005	.011	.010	.015	<.0005	.007	.004	16	2	<2	<2	<15	30
5	.088	.005	.016	.035	.653	.043	.012	.005	70	2	<2	7	<15	40
6	.126	.005	.025	.012	.018	<.0005	.038	.007	35	2	2	2	<15	88
7	.061	.005	.018	.006	.013	<.0005	.008	.004	16	2	<2	<2	<15	20

[1]The following elements were not detected at the indicated value: Ag 0.5, B 10, Be 1.5, Cd 50, Co 3, Ga 3, Ge 10, La 70, Li 70, Mo 2, Nb 10, Ni 3, Sc 5, Sn 10, Sr 5, V 10, Y 10, Yb 1, Zn 500.

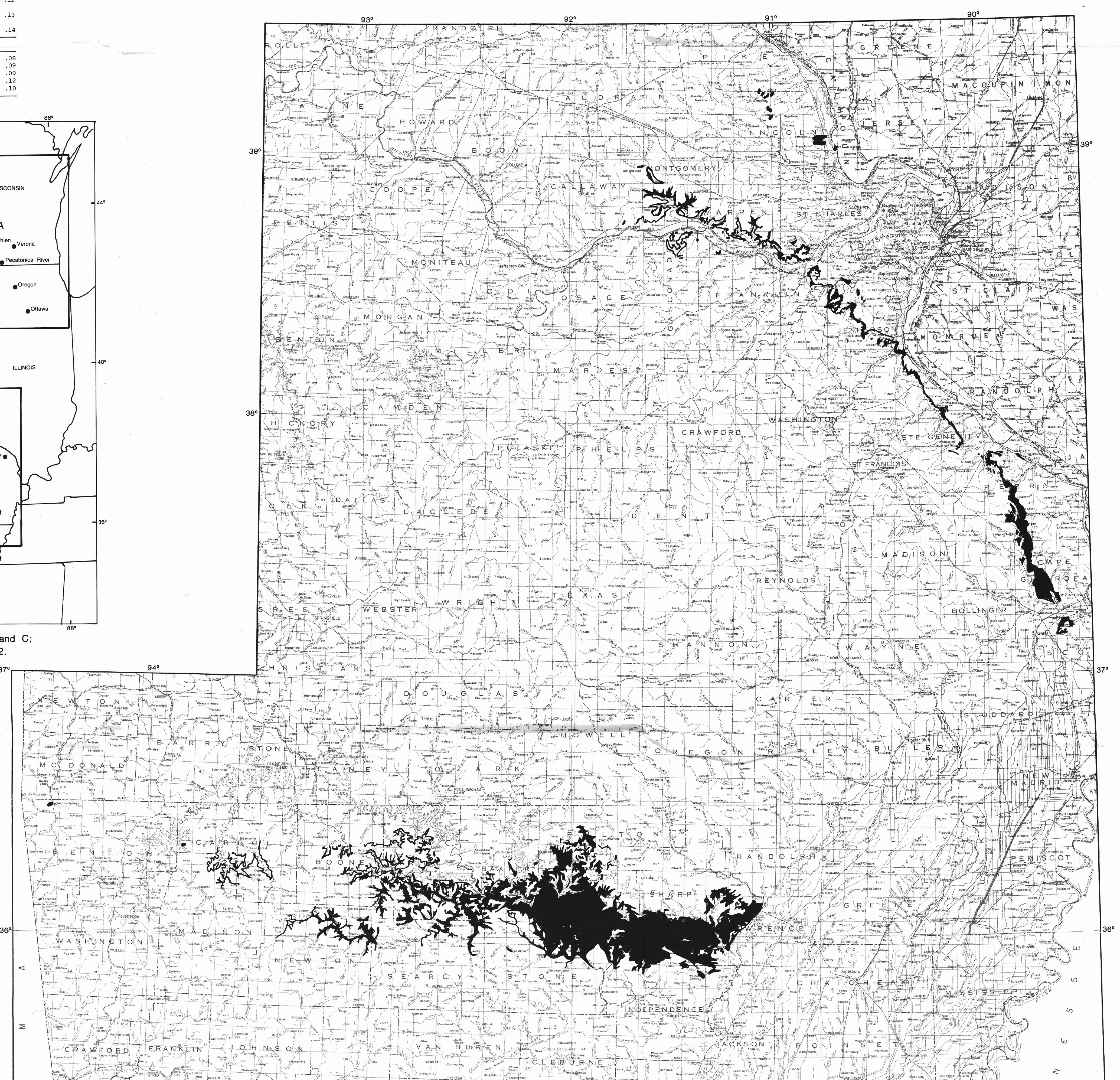
[2]Sample 1--St. Peter Sandstone, Elgin, Minn.
2--St. Peter Sandstone, Prairie du Chien, Wis.
3--St. Peter Sandstone, Oregon, Ill.
4--St. Peter Sandstone, Bloomsdale, Mo.
5--St. Peter Sandstone, Sandtown, Ark.
6--Everton Formation, Calico Rock, Ark.
7--Oil Creek and McLish Formations, composite sample, Sulphur and Roff, Okla.

Table 2.--*Grain size, in millimeters, of the 5th, 50th, and 95th percentiles of Middle Ordovician sandstone from 29 localities*

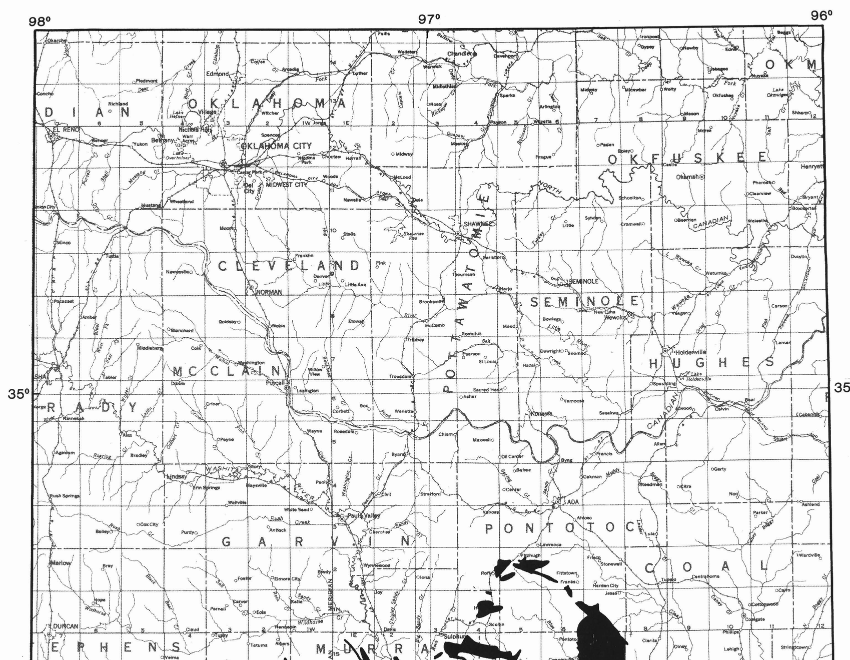
Location	Formation	Percentile 5th	50th	95th
	MINNESOTA			
Cannon Falls-----	St. Peter Sandstone---------	.30	.19	.10
Pine Island------	----do---------------------	.36	.22	.12
Elgin------------	----do---------------------	.36	.21	.10
Chatfield--------	----do---------------------	.44	.22	.10
	WISCONSIN			
Prairie du Chien-	St. Peter Sandstone---------	.39	.24	.12
Verona-----------	----do---------------------	.45	.20	.11
Pecatonica River-	----do---------------------	.51	.21	.12
	ILLINOIS			
Oregon-----------	St. Peter Sandstone---------	.46	.21	.12
Ottawa-----------	----do---------------------	.57	.39	.16
	MISSOURI			
Foley------------	St. Peter Sandstone---------	.38	.22	.13
Otterville-------	----do---------------------	.41	.22	.11
Bloomsdale-------	----do---------------------	.39	.22	.11
Perryville-------	----do---------------------	.32	.22	.13
	ARKANSAS			
Strawberry-------	St. Peter Sandstone---------	.41	.27	.13
Sandtown---------	----do---------------------	.36	.22	.12
Guion------------	----do---------------------	.39	.22	.09
Sylamore---------	----do---------------------	.39	.21	.10
Sugarloaf--------	----do---------------------	.40	.22	.10
Calico Rock------	Calico Rock Sandstone Member of Everton Formation.	.37	.22	.12
Western Grove----	St. Peter Sandstone---------	.42	.21	.11
Dogpatch---------	Newton Sandstone Member of Everton Formation.	.41	.22	.12
Metalton---------	Kings River Sandstone Member of Everton Formation.	.34	.19	.11
Hidden Cove------	Unnamed sandstone member of Everton Formation.	.37	.22	.13
Sulphur Spring---	----do---------------------	.39	.24	.14
	OKLAHOMA			
Roff-------------	McLish Formation-----------	.29	.14	.08
Sulphur----------	Oil Creek Formation---------	.20	.14	.09
Mill Creek-------	----do---------------------	.23	.15	.09
Springer---------	Tulip Creek Formation-------	.26	.17	.12
Springer---------	McLish Formation	.19	.14	.10



Index map showing locations of Maps A, B, and C; and sample localities shown on Table 2.



Map B.--Areas in Missouri and Arkansas where the St. Peter Sandstone and the Everton Formation are exposed at, or near, the surface.



Map C.--Areas in Oklahoma where the Simpson Group is exposed at, or near, the surface.

Bases from U.S. Geological Survey, State base maps of Arkansas, 1967, Illinois, 1970, Iowa, 1966, Minnesota, 1965, Missouri, 1969, Oklahoma, 1972, Wisconsin, 1968, 1:1,000,000

Data compiled in 1978

SCALE 1:1 000 000

25 0 25 50 75 100 MILES

25 0 25 50 75 100 KILOMETERS

MAP SHOWING HIGH-PURITY SILICA SAND OF MIDDLE ORDOVICIAN AGE IN THE MIDWESTERN STATES

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