The White Cliffs of Ottawa

The St. Peter Sandstone and North America's Largest Silica Production Facility

Hosted by

Illinois State Geological Survey and U.S. Silica Company American Association of State Geologists

June 13, 2005

Karan S. Keith and Tim J. Kemmis



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Rod R. Blagojevich, Governor

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State-of-the-art mining at the Ottawa Silica Company Quarry, July 1940. Workers used scrapers to remove thin overburden down to the sandstone, shoveled out (by hand) the loose overburden remaining in depressions, and then loaded it onto this brand-new dump truck. The final cleaning was done with stiff brushes and compressed air or steam. The men (left center) are drilling a blast hole on the cleaned sandstone surface. The processing plant is in the background.

Acknowledgments

This guidebook is a collaborative effort between the U.S. Silica Company and the Illinois State Geological Survey. Robert Krepps and Greg Maslowski from U.S. Silica contributed information about the company, its history, mine processing, and the silica industry. They also provided recent photographs of the U.S. Silica site and historic photographs from the company's predecessor, the Ottawa Silica Company.

At the Illinois State Geological Survey, Karan Keith and Tim Kemmis wrote and prepared the guidebook. Pam Carrillo finalized the guidebook layout and graphics and prepared the figures. ISGS photography and photographic scanning were completed by Joel Dexter, Karan Keith, Tim Kemmis, and Daniel Byers. Cheryl Nimz provided editorial guidance throughout guidebook preparation, and Jon Goodwin, Rob Finley, and Zak Lasemi provided editorial review.

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The field trip route crosses an area glaciated during the Wisconsin Episode. During this glacial episode, the Lake Michigan Lobe advanced into Illinois several times, depositing a succession of glacial tills and related deposits, each having unique characteristics. The glacial succession has been subdivided and mapped as various formations and members (Hansel and Johnson 1996, Willman and Frye 1970).

The field trip route from St. Charles to Ottawa crosses successively older end moraines within the Wisconsin Episode sequence: the Minooka, St. Charles, Marseilles, and Farm Ridge morainic systems. Each glacial advance related to these particular moraines in the field trip area deposited Lemont Formation glacial diamicton sequences, primarily the clayey Yorkville Member, forming a succession of very fine-grained glacial tills over bedrock.

For the following road log, entries made in bold indicate turns onto different streets or highways and the features that occur there. Other entries indicate features of interest along the route.

Cumulative

mileage

- 0.0 Leave Pheasant Run Resort and Convention Center in St. Charles; turn right (north) onto Kautz Road.
- 0.1 Take immediate left (west) onto Illinois Route 64.
- 0.5 Crest of Minooka Moraine. View ahead is toward the Fox River valley. The Fox River valley flows north-south along the reach from Elgin to Oswego. This stretch of the river began as a glacial meltwater stream flowing along the front of the Minooka Moraine.
- 0.6 Left (south) onto Kirk Road. Kirk Road runs generally along the crest of the Minooka Moraine. For the next 15 miles, the field trip will go south through the Fox River cities of St. Charles, Geneva, Batavia, and Aurora. St. Charles, founded in 1834 and boasting international employers, innovative schools, beautiful parks, a responsive government, and significant architecture, calls itself the "Pride of the Fox!" Geneva, the county seat for Kane County, was first settled in 1833. On the main rail line east into Chicago, Geneva grew rapidly in the 1850s and prospered as a resort town to Chicagoans. Its early history included several companies that manufactured agriculture-related products. Batavia is Kane County's oldest town and at one time was called the "Windmill City" because more windmills were produced here than anywhere else in the country. Celebrities who have called Batavia their hometown include professional basketball great Dan Issel, Super Bowl guarterback Ken Anderson, professional golfer Sharon Moran, and singing star Jackie de Shannon. Aurora is Illinois' second largest city and is referred to as the "City of Lights" because it was one of the very first communities to adopt all electrical street lighting
- 2.0 On left, ground moraine behind Minooka Moraine.
- 3.6 On right, Settler's Hill Landfill. This landfill is developed in clay-rich glacial tills of the Lemont Formation. Of interest to birders, Settler's Hill is considered to be a good spot to see a variety of rare gulls, including Thayers, Iceland, and Lesser and Greater Black-backed gulls.



Field trip route.

6.2 On left, main entrance to Fermilab. Fermilab (originally the National Accelerator Laboratory) was established in 1967. Fermilab's 6,800-acre site was originally home to farmland and the village of Weston. Some of the original barns are still in use by the laboratory for purposes ranging from storage to social events. A small burial ground, with headstones dating back to 1839, has been maintained in the northwest corner of the site. The lab's first director and pioneering particle physicist, Robert Wilson, was buried in the Pioneer Cemetery following his death on January 16, 2000, at the age of 85. Among Wilson's early imprints on the lab was the establishment of a herd of American bison, symbolizing Fermilab's presence on the frontiers of high-energy physics and the connection to its prairie origins. The herd remains on the grounds today, and new calves are born every spring.

Two major components of the Standard Model of Fundamental Particles and Forces have been discovered at Fermilab: the bottom quark (May–June 1977 at the original Main Ring accelerator) and the top quark (February 1995 at the Tevatron). The Tevatron is the world's highest-energy particle accelerator. Its 1,024 superconducting magnets are cooled by liquid helium to -268° C (-450° F), and its low-temperature cooling system was the largest ever built when it was placed in operation in 1983. The American Society of Mechanical Engineers designated the Tevatron cryogenic system an International Historic Mechanical Engineering Landmark.

To increase the number of proton-antiproton collisions in the Tevatron, Fermilab has added the two-mile main injector accelerator, greatly enhancing the chances for important discoveries. The two mammoth collider detectors, CDF and DZero, have undergone extensive upgrades, anticipating what many scientists describe as a "revolution" in new knowledge and discoveries in particle physics.

Fermilab is also home to a world-leading neutrino program, with the MiniBooNE and MINOS experiments. The MINOS experiment propels neutrinos through the earth to a detector 450 miles away in a former iron mine a half-mile underground in Soudan, Minnesota.

8.9 **Right (west) onto Interstate 88 (west to Aurora).**

- 9.8 Cross crest of Minooka Moraine. Descend moraine to toll booth and the Fox River valley.
- 10.6 On right, former quarry in Silurian dolomite.
- 10.9 Cross the Fox River valley.
- 12.0 This stretch of Interstate 88 crosses moderate-relief, knob-and-kettle, hummocky glacial topography related to the St. Charles Moraine.
- 14.3 Exit right onto IL 56 (west) to US 30/IL 47 at Sugar Grove.
- 15.5 The route continues to cross moderate-relief, knob-and-kettle, hummocky glacial topography related to the St. Charles Moraine.

18.5 Exit right (south) onto US 30/IL 47 at Sugar Grove.

- 19.0 City of Sugar Grove.
- 20.3 Descend from moderate-relief, hummocky, glacial topography down to low-relief ground moraine also related to the St. Charles Moraine advance.



- 25.0 Enter the outskirts of Yorkville. The town of Yorkville was laid out in 1836. It is the county seat for Kendall County and the home of the Speaker of the U.S. House of Representatives, Dennis Hastert.
- 27.2 Cross the Fox River. From Oswego to Ottawa, the Fox River flows southwest along the front of the Marseilles Morainic System.
- 28.0 Trees ahead mark the front of the Marseilles Morainic System.
- 28.9 **Turn right onto IL 71 (Stagecoach Trail Road).** To Ottawa, IL 71 runs either along the crest or front of the Marseilles Morainic System or the flat outwash plain in front of the Marseilles Morainic System.
- 32.0 View to the right from here on the Marseilles Morainic System is the Fox River valley and the (slightly) older Wisconsin glacial episode landscapes beyond. Other views of these landscapes occur over the next few miles.
- 37.1 Enter Newark, Illinois. Newark was one of the first settlements in Kendall, County, beginning in 1832, and a stage coach stop on the main road from Chicago to Ottawa. During the early 1900s, Newark was well-known for the Fowler Institute, a private high school established in 1855.
- 38.0 As the Lake Michigan glacial lobe retreated northward, one of Illinois' largest moraine-dammed lakes formed behind the Marseilles Morainic System. Lake waters spilled over the moraine at three locations, one right here just west of Newark, one to the northeast at Oswego, and the ultimate breach of the moraine system at Marseilles, which resulted in a major flood event that established the present Illinois River valley.
- 44.0 Enter Norway, Illinois, established in 1834 as the first permanent Norwegian settlement in the United States. Led by Cleng Peerson, the original community was a group of Quakers who had left their Norwegian homeland because of religious persecution.
- 53.0 Cross Interstate 80.
- 54.2 Descend into Illinois River valley onto gravel terrace along the valley wall.
- 54.6 Descend from the terrace to Illinois River valley floodplain. Enter Ottawa. This part of the valley has been scoured by the Illinois River down to Pennsylvanian age Carbondale Formation, leaving only a thin veneer of sand and gravel and fine-grained alluvium. Locally in this part of Ottawa, coal was strip-mined from the Pennsylvanian deposits.

The city of Ottawa, at the confluence of the Fox and Illinois Rivers, has always been located along important lines of transportation, including the Illinois and Michigan (I & M) Canal (1848), several major railways connecting Chicago to the West, and Interstate 80.

Ottawa has always been distinguished as one of Illinois' important industrial centers, including mining (silica and coal), glassworks (several different companies have produced an extremely wide range of products through the years), chemicals, and formerly farm equipment and other manufacturing companies.

- 55.1 Continue straight ahead; IL 71 is joined by US 6 from the left.
- 56.5 Cross Fox River. St. Peter Sandstone is exposed along the river banks.



East of the Fox River in Ottawa, the Illinois River valley is underlain by scoured Pennsylvanian age Carbondale Formation. West of the Fox River, the Illinois River valley is underlain by scoured Ordovician age St. Peter Sandstone. On both sides of the river, bedrock is overlain by a thin veneer of sand, gravel, and fine-grained alluvium.

57.2 Junction with IL 23 and IL 71. Continue straight ahead on US 6.

58.5 **Turn left (south) onto Boyce Memorial Drive**.

- 58.7 Cross I & M Canal. Although not widely acknowledged today, the I & M Canal was key to the success and development of Chicago. Opened in 1848, the canal connected Lake Michigan to the Illinois River, completing the interstate waterway network linking American cities from New York to New Orleans. Today many of these canals, including the I & M Canal system, are being renovated for recreational use and enjoyment.
- 59.0 **Turn right (west) into U.S. Silica, Ottawa.** The entrance is marked by brick wall and split rail fence. U.S. Silica has been operating this site for over 100 years. The Ottawa facility is the largest silica producer in North America and possibly the world and Illinois ranks as the #1 silica producing state in the country.

Tour U.S. Silica operation at Ottawa.

- 59.0 **Turn left (north) onto Boyce Memorial Drive.**
- 59.5 **Turn right (east) onto US 6**.
- 60.7 Turn right (south) onto Columbus Street (IL 23 and IL 71).
- 61.6 Cross Illinois River.
- 61.8 **Turn right (west) at end of bridge onto Illinois Route 71.** Illinois Route 71 parallels the Illinois River valley and is founded on scoured St. Peter Sandstone that has a thin veneer of sand, gravel, and fine-grained alluvium. Along this stretch, the top of the St. Peter Sandstone forms multi-level bench terrace straths.
- 62.5 On left, abandoned quarry of St. Peter Sandstone.
- 64.7 Cross Covel Creek. St. Peter Sandstone outcrops along creek banks.
- 68.1 Ascend into uplands. St. Peter Sandstone outcrops in the valley walls.
- 71.0 Turn right (north) into Starved Rock State Park.
- 71.6 **Turn right (east) to Starved Rock State Park Lodge.**
- 71.9 Starved Rock State Park Lodge. Exit buses for banquet.

End of field trip. Following banquet, return to Pheasant Run Resort and Convention Center.

Opposite page: From the 1500s to the 1700s, Starved Rock was home to the Illinois Nation (Illiniwek), a confederacy of Algonquian Indian tribes from parts of Wisconsin, Illinois, Iowa, and Missouri. In 1673, French explorers Marquette and Jolliet passed Starved Rock on their way up the Illinois River. In 1675 Marquette returned and founded the Mission of the Immaculate Conception near the present day town of Utica. Several years later Frenchmen LaSalle and Tonti explored the Starved Rock region. In 1683 the French built Fort St. Louis atop Starved Rock at its strategic position above the last rapids on the Illinois River. In the 1760's the Ottawa Indian Chief Pontiac was slain by a member of the Illinois. To avenge his murder, the Potawatomi and Fox, related to the Ottawa tribe, attacked the Illinois village by Starved Rock. The Illinois, trapped atop the 125-foot sandstone butte, were starved by the Ottawa, giving rise to the name "Starved Rock."



Introduction

"Silica sand is the commercial designation for sand that consists almost or entirely of quartz or silica. It is used for the manufacture of high-grade glass, for which purpose very pure silica is required, as the slightest impurities affect the quality of the glass; also as steel molding sand, refractory sand, engine sand, abrasive sand. . . . Finely pulverized, this sand is used in the manufacturing of scouring soaps and pastes, grinding and polishing powders, mold facings, glazes, alloys, and as a mineral filler, etc. Carefully screened coarse sand from Ottawa, Illinois, known as Standard Ottawa Testing Sand, is employed in testing cement and mortar and for many experimental purposes." Ekblaw and Carroll (1931).

Did You Know?

Illinois is the nation's No. 1 industrial sand (silica) producer

U.S. Silica Company, Ottawa, Illinois,

- *is North America's largest silica producing plant.*
- has an annual production of 2.2 million tons, accounting for nearly one-half of Illinois' total production of 4.9 million tons.

Industrial needs make silica a valuable natural resource.

Silica sand mined at Ottawa is used for a diversity of applications, including

- glass production (container glass, flat glass, fiberglass, specialty glass, and chemical glass).
- foundry and refractory sand.
- abrasives, polishes, paint, and other fillers.
- water filtration.
- enhanced oil recovery by filling and propping open the fractures generated in bedrock by hydraulic fracturing.
- testing sand, filling the requirements of the ASTM standard sand used in testing cement and mortar, as well as for many other experimental purposes. The mine and laboratory at U.S. Silica have been providing the world with standard testing sand for well over 75 years.

Geology is what makes U.S. Silica Company's Ottawa, Illinois, plant the No. 1 producer in North America. Composition, site-specific grain-size characteristics, local geologic structure, and material quality come together to produce a unique and valuable deposit of silica sand.



At Ottawa, glacial floodwaters stripped away most of the overburden.



Standard testing sands first developed in Ottawa over 75 years ago. Mining in La Salle County, Illinois, began in the nineteenth century, and the first commodity mined was coal. Silica sand mining began by the 1860s, although the earliest quarry locations are unknown. Systematic commercial mining of silica sand began in 1896 when United States Silica Company (a now defunct company, unrelated to the present U.S. Silica Company) opened a plant 2 miles southwest of Ottawa on the south bank of the Illinois River. By 1913, there were 13 silica sand operations in and around Ottawa. Presently there are four industrial silica mining and processing operations in La Salle County (U.S. Silica in Ottawa, Unimin in Utica, Fairmount Minerals in Wedron, and Manley Brothers in Troy Grove), making La Salle County the most productive silica sand region in the country.

In the Ottawa area, glass manufacturing was one of the most important industries that grew in conjunction with the silica sand business. With an abundance of high-quality silica sand, improved transportation, a supply of water, and close proximity to the coal fields, Ottawa seemed destined to become one of the most important glass-making centers in the country. The first glass-manufacturing operation established in Ottawa was the Ottawa (Window) Glass Company, which was built in 1867 on Chestnut Street along the north bank of the I & M Canal. The glass-making era was a prosperous one for Ottawa, with high employment and good pay; some of the more skilled workers could earn as much as \$100 per week. The development of gas fields in Indiana led to a cheap fuel source elsewhere; glass prices dropped, and, by 1898, most of the glass operations had been abandoned. Today only Peltier Glass Co. and Pilkington Glass plc continue to operate in Ottawa.

Company History

U.S. Silica began as the Ottawa Silica Company on a snowy day in March 1900. Edmund B. Thornton, who quarried the famous limestone building stone in Bedford, Indiana, purchased an option on 39 acres of land several miles west of the city of Ottawa, Illinois. The land he purchased was considered worthless for farming because the St. Peter Sandstone was at or near the surface, but this geology was ideal for Thornton, who was searching for an abrasive material for sawing Indiana limestone into large blocks for the construction industry. Indiana limestone, one of the nation's most important building stones, has been used for such buildings as the Empire State Building and the Pentagon. Sawing sand remains a product of U.S. Silica's Ottawa plant.

The output of the Ottawa Silica Company in its first year of business was 150 railcars of sand, but the company prospered through production of high-quality washed sand delivered to meet customers' demands. This service allowed the company to grow and eventually take over silica production in the Ottawa area. In 1929, the Ottawa Silica Company acquired the United States Silica Company; after World War II, the company took over the America Silica Company, which had formed through the merger of several smaller companies and operated guarries at Buffalo Rock, Highby Canvon, and Utica. Then, in 1953, the Ottawa Silica Company purchased the Standard Silica Company, the only other silica producer in Ottawa. The Thornton family owned and operated the Ottawa Silica Company until 1986, expanding the plant, improving product guality, and acquiring additional reserves. In 1986, the Thornton family sold Ottawa Silica Company to Rio Tinto Zinc (RTZ), which is based in London and is the largest mining company in the world. In January 1987, RTZ formed U.S. Silica Company, merging the Ottawa Silica Company with Pennsylvania Glass Sand Corporation, a competitor that RTZ had purchased a year and a half before. In 1997, D. George Harris and Associates of New York City acquired U.S. Silica Company from RTZ. U.S. Silica is headquartered in Berkeley Springs, West Virginia; the Ottawa plant is one of U.S. Silica's 16 operating locations and is the largest silica plant in North America.

History of Mining in the Ottawa Area



Early overburden removal used horses.



Later, more efficient power shovels were used.

The Ottawa plant was certified to ISO 9000 standards in 1994, and the employees are dedicated to providing exceptional quality in their products. The U.S. Silica team is committed to defining and meeting customer requirements and expectations, striving to continually improve processes, products, and services to promote product value and increase customer satisfaction. In particular, U.S. Silica does its utmost in processing and plant management to ensure next-day shipment and to provide quality-control testing for every shipment. U.S. Silica owns reserves projected to meet demand for the next 50 years, and plans are moving ahead to develop a new mining area because the present quarry has about 5 years of remaining reserves.

Geology is a principal reason U.S. Silica's Ottawa facility is the largest silica sand producer in North America. The St. Peter Sandstone is generally a fine-grained, well-sorted, well-rounded, friable to weakly cemented, non-fossiliferous, nearly pure quartz sandstone, essentially free of clay, carbonates, and heavy minerals. In addition, here in Ottawa, it includes a coarser, mediumgrained unit, the Starved Rock Member. The industrial value of the St. Peter Sandstone at Ottawa is directly related to its geologic history.

At Ottawa, the Ordovician age St. Peter Sandstone's most valuable attributes are

- composition of nearly pure (99.85% SiO₂), well-rounded quartz.
- fine- to medium-grain sizes that can be separated and blended to meet a wide variety of industrial requirements.
- friable to weakly cemented lithology, making it easy to mine and process, while retaining valuable sand grain size and shape in the final product.
- thickness of over 100 feet, providing an extensive resource.
- geologic structure that brings the sandstone close to the surface making it easy to mine.
- thin overburden resulting from erosion by past glacial floodwaters in the Illinois River valley.
- purity and whiteness, because glacial floodwaters stripped away overburden that had the potential to stain the underlying sandstone.

Composition, Grain Size, Grain Shape, and Cementation

The St. Peter Sandstone differs from many sands in that it is composed almost exclusively of grains of quartz, rather than a mixture of quartz and other minerals. Composition, grain-size distribution, grain shape, formation thickness, and weak cementation are distinctive characteristics of the St. Peter Sandstone and are the consequence of its depositional environment and geologic history.

Deposition of the St. Peter Sandstone began about 450 million years ago in the middle Ordovician as shallow seas began their second major transgression, the Tippecanoe Sequence (Sloss et al. 1949), across what was to become the North American midcontinent. As the sea transgressed, it began to deposit the St. Peter sands on a major regional unconformity that covered parts of Missouri, Illinois, Indiana, Nebraska, Iowa, Minnesota, Wisconsin, and Michigan. In southern Illinois, the St. Peter Sandstone unconformably overlies the Ordovician Everton Dolomite. In central and northern Illinois, where the Everton strata are missing, the St. Peter Sandstone overlies various different older units, ranging from the Ordovician Shakopee Dolomite (youngest below the unconformity) to the Cambrian Galesville Sandstone (oldest below the unconformity).

The initial deposits, now locally preserved at the base of the St. Peter Sandstone in Illinois, are called the Kress Member. At some locations, the Kress Member is a residue from the solution of underlying cherty dolomites and sandstones, consisting of a coarse rubble or conglomerate of chert in a matrix of clay or sand; at other places, the Kress Member is mostly red sandy clay, red and green shale, and argillaceous sandstone resulting from the reworking of residual materials by the advancing sea (Willman and Buschbach 1975).

With continued transgression of the sea northward, waves and currents deposited clean, white, fine-grained sand with additional eolian reworking in parts of Wisconsin (Dott et al. 1986). This



thick, extensive, fine-grained sand, classified as the Tonti Sandstone Member of the St. Peter Sandstone in Illinois, and its correlatives, constitute the bulk of the St. Peter Sandstone in the midcontinent. The Tonti is commonly 100 to 200 feet thick, but ranges up to 500 feet in thickness.

During maximum transgression, an offshore bar formed in a broad band extending southwest from Chicago to Lee County, Iowa. This bar separated Glenwood Formation deposition in a lagoon to the north from carbonate deposition to the south (Fraser, 1976). Deposits making up this offshore bar are coarser grained than the Tonti Sandstone Member and constitute a medium-grained sandstone with a wider range of grain sizes. In Illinois, this geographically restricted, medium-grained sandstone is classified as the Starved Rock Sandstone Member. It ranges in thickness from 60 to 200 feet (Willman and Buschbach 1975).

The occurrence of the Starved Rock Sandstone Member at Ottawa is a key reason why Ottawa is a major silica source. Its wider range of grain sizes can be separated and blended to meet an extensive range of industrial applications not possible where only the finer-grained Tonti Sandstone Member of the St. Peter Sandstone is present. U.S. Silica quarries both the Starved Rock and underlying Tonti members. The Starved Rock Sandstone Member constitutes the upper 60 to 85 feet of the section. As Table 1 shows, the medium-grained Starved Rock Sandstone Member is coarser, frequently with 25% to 50% of the sand coarser than 40 mesh size, whereas the underlying Tonti Sandstone Member typically is fine grained and has less than 10% sand coarser than the 40 mesh size.

		Sieve size ¹							
	Depth	30	40	50	70	100	140	200	270
Member	(ft)	(Cumulative percent retained on sieve)							
Starved Rock	6–16	0.6	13.9	50.2	80	95.6	99.5	99.9	100
Starved Rock	16–26	1.5	25.7	63.1	86.4	96	99.5	99.9	100
Starved Rock	26–36	8.5	47.8	75.9	90.7	98	99.9	100	100
Starved Rock	36–46	9.1	46.8	71.2	87.8	96.4	98.7	99.5	100
Starved Rock	46–56	4.4	45.7	77.1	90.2	95.7	98.6	99.9	100
Starved Rock	56-66	7.5	50.2	76.4	89.3	95.7	98.2	99.6	99.9
Starved Rock	66–76	7.2	49.7	76.5	89.5	96.5	99.3	99.9	100
Starved Rock	76–86	6.3	43.8	72.8	85.4	92.4	97.1	99.7	100
Tonti	86–96	0.3	17	63.2	82.8	92.5	98.3	100	100
Tonti	96–106	0.6	17.2	51.2	76.5	94.5	99.1	100	100
Tonti	106–116	0.1	4.2	25.4	69.2	94.3	99.6	100	100
Tonti	116–126	0.6	6.4	38.6	77	96.1	99.4	99.8	100
Tonti	126–136	1.9	10.3	40.7	80.7	98.2	99.9	100	100
Tonti	136–146	2.3	18.1	41	72.2	90.5	98.9	99.9	100
Tonti	146–156	1.4	9.2	26.9	56.2	82.6	96.5	99.7	100
Tonti	156–162	1	8.1	29	59.6	85.6	97.1	99.9	100

Table 1 Gradation of the St. Peter Sandstone in Boring B at U.S. Silica in Ottawa.

¹Sieve size is mesh number, the number of openings per inch



(adapted from Willman and Bushbach 1975).

The St. Peter Sandstone at Ottawa consists of horizontally bedded (above) and cross-bedded (below) sandstones.



As stated earlier, the composition, grain size, and grain shape of the St. Peter Sandstone are related to its source and geologic history. The source of the St. Peter Sandstone ultimately is quartz grains derived from pre-Cambrian crystalline rocks of the Canadian Shield that were eroded to form Ordovician and Cambrian sandstones, such as the Cambrian Galesville Sandstone. These, in turn, were then eroded and reworked as the seas transgressed across the midcontinent. The repeated cycles of marine erosion and reworking concentrated and sorted the quartz-rich sands, giving the St. Peter Sandstone its distinctive composition, grain size, and grain shape. Cementation of nearly pure quartz sand, such as the St. Peter, is difficult in the absence of significant heat and pressure. Consequently, despite its long history, most of the St. Peter Sandstone has remained friable and weakly cemented.

Formation Uniformity and Thickness

Other important geologic factors that make the St. Peter Sandstone in Ottawa such an important industrial sand source are its uniformity and thickness. Horizontally bedded and cross-bedded sandstones make up thicknesses of St. Peter Sandstone that vary from a few feet up to 700 feet, but commonly range from 100 to 200 feet thick in Illinois. The greatest thicknesses occur in northern Illinois where thickness is dependent in large part on the high relief of the sub-St. Peter erosion surface (unconformity).

Geologic Structure

The St. Peter Sandstone at Ottawa is exposed near the crest of one of the major structural features in the Illinois Basin, the La Salle Anticlinorium. In the Ottawa area, this bedrock structure is responsible for the St. Peter Sandstone occurring near the ground surface where it can be easily mined.

The La Salle Anticlinorium is a composite anticlinal fold structure in which several associated smaller, sub-parallel folds, domes, and monoclines are oriented mainly parallel to the north-northwest strike of the larger structure (Nelson 1995). The north-northwest–trending axis of the La Salle Anticlinorium is more than 200 miles long. The anticlinorium is highly asymmetrical with a steeply dipping western limb and a gently dipping eastern limb, and it has vertical relief of as much as 2,500 feet.

The principal uplift and folding of the La Salle Anticlinorium occurred late in the Paleozoic. About one-half of the deformation took place after Chesterian (Mississippian) time and before Pennsylvanian sedimentation in Illinois. Deformation continued gradually during the Pennsylvanian, and major folding resumed after the Pennsylvanian until the end of the Paleozoic (Nelson 1995). The La Salle Anticlinorium is interpreted to be the product of Late Paleozoic displacements on faults in the crystalline Precambrian basement (Nelson 1995) that die out upward through the thick Paleozoic sedimentary cover.

Geomorphology

Late Wisconsin Episode glacial meltwaters also played a part in making the Ottawa area the nation's prime industrial sand producer. Late glacial floodwaters carved the upper reaches of the Illinois River valley, removing nearly 100 feet of overburden and leaving the sandstone near the land surface as a bedrock bench that can be clearly seen in photos and on topographic maps. In many other areas, weathering of overburden materials has caused the sandstone to become stained with impurities, whereas, in the Ottawa area, staining is minimal because the thin alluvial overburden generally lacks minerals that cause significant staining.



Location of the La Salle Anticlinorium (Nelson 1995).





Geology of the St. Peter Sandstone



The well-rounded, nearly spherical sand of the St. Peter Sandstone, with purity of 99.85% SiO₂, is a mineral well suited to many industrial needs. At Ottawa, the St. Peter Sandstone comprises a larger range of grain sizes than at other locations because of the presence of the Starved Rock Sandstone Member. This fact not only allows for a wider range of products, but U.S. Silica's airsizing process allows the company to separate the sand into specific grain sizes and then blend the sand to meet the customer's exact requirements, giving U.S. Silica's Ottawa operation great flexibility in meeting very specific demands

The St. Peter Sandstone at Ottawa has several attributes that make it an easy resource to mine:

- 1. The La Salle Anticlinorium provides the geologic structure to bring the St. Peter near to the surface.
- 2. Late Quaternary downcutting by glacial meltwaters coursing down the Illinois River Valley eroded away much of the overburden resulting in only a few feet of overburden at most.
- 3. The sandstone is very weakly cemented, allowing it to be mined hydraulically without the need for crushing, which retains the well-rounded grain shape.

The thin overburden of the St. Peter Sandstone at Ottawa has always made mining relatively easy. The sandstone is prepared for mining by stripping off the overburden, which is a few inches to a few feet thick and is made up of thin sand, gravel, and fines that do not appreciably stain the underlying sandstone, leaving predominantly white, pure sandstone with depth (Lamar 1965).



Blasting the St. Peter outcrop face. In the early part of the twentieth century, horses played an important role in overburden removal. With the advent of the gasoline engine, more mechanized equipment was developed. Today, after the overburden has been stripped, a pattern of 6.5-inch-diameter blast holes drilled into the sandstone is blasted using ANFO (ammonium nitrate and fuel oil). This disaggregates the sandstone, which can then be mined using hydraulic mining techniques first developed during the California gold rush in 1849. Water under high pressure is sprayed into the disaggregated sandstone, creating a sand-water slurry that is pumped to the plant. Six thousand gallons of water per minute are used in the hydraulic mining operation. Although winter's cold provides challenges to the use of hydraulic mining methods, U.S. Silica is able to mine year-round, relying on emergency stockpiles during the most severe weather conditions.



Pump houses and piping used in hydraulic mining.



Water cannon used to hydraulically mine the St. Peter Sandstone.

Mining and Processing Methods

At the processing plant, the sand is washed using an additional 3,000 gallons of water per minute, dried, and air-separated into eleven different sizes, ranging from 20 mesh to 110 mesh. From these eleven bins, finished products, which number about 70, are blended using state-of-the-art equipment and computer control. In addition to these basic products, special blends can also be made to meet customer requirements.



Processing plant control room.



Vibrating feeder.

Filter belts.



Derrick screens.

The first step in processing the crude sand is wet processing by the hydrosizer. This process separates the sand into coarse (one third of the bulk sand here at Ottawa) and fine particle sizes (two thirds of the bulk sand). The sizeseparated sand slurry is then carried across a filter belt, which dewaters the slurry, decreasing the water content from 50% to 7% water. The dewatered sand is dropped into a vibrating feeder, which feeds the sand into a dryer. After drying, the coarse material is screened and separated into two bin sizes. The fine sand is sent to the air sizers and separated into nine different bin sizes.



Air sizers.

The various sizes of silica sand are blended, bagged, or loaded and shipped. To prepare ground silica products, either coarse or fine fraction material can be processed in the grinding mills.





Bagging operations.

Grinding mills.

Products can be shipped in bulk via rail, truck, or barge, or packaged in 50-pound, 100-pound, or 2,500-pound bags. Approximately 65% to 70% of shipments from the U.S. Silica plant at Ottawa are by rail, 30% to 35% are by truck, and 1% are by barge.

Hydraulic mining and subsequent processing require substantial amounts of water, as previously noted. At U.S. Silica, this water is recycled using a "closed loop" system, which effectively recycles the same water in the mining and wet processing areas. The water used comes from groundwater seepage into the quarry. This water is recycled and stored in ponds on site. More water is available from seepage than is actually used; therefore, U.S. Silica has an NPDES (National Pollutant Discharge Elimination System) permit to discharge excess water to the Illinois River. No chemicals are used in mining or in processing, and there are essentially no impurities in the sandstone. Thus, pond water and groundwater at the Ottawa facility are excellent quality.

Mining and Processing Methods



Rail shipments account for 65% of U.S. Silica's shipments.



Hydraulic mining and plant processing use recycled water.

U.S. Silica ships more than 2 million tons of silica sand annually to several thousand customers worldwide and has more than 70 standard products that are produced for four major industries. The great range in grain size of the St. Peter Sandstone at Ottawa also means that thousands of products can be tailor-made to unique customer specifications. The four major markets that U.S. Silica serves are listed here:

- 1. Melting sand—for the glass industry
 - Standard melting sand, approximately 15% retained on a 40 mesh screen.
 - Fine melting sand, approximately 6% retained on a 40 mesh screen.
 - There are five submarkets for melting sand: (1) container glass, (2) flat glass, (3) fiberglass, (4) specialty glass, and (5) chemical glass.
- 2. **Foundry Sand**—More than 20 grades, ranging in AFS-GFN (American Foundry Society-Grain Fineness Index) sizes from 30 to 110.
- 3. **Oil and Gas Extraction**—U.S. Silica produces the highest quality 20/40, 30/50, and 40/70 sand in the business for hydraulic fracturing.
- 4. Matrix Minerals—Silica is used for a diverse array of products including
 - Construction sand for the building industry.
 - Fillers and extenders used in paint, drywall compound, and grout.
 - ASTM testing sands.
 - Damp sand, pool filter sand, and play sand.

U.S. Silica's products include natural grain sand as well as ground silica, which requires fine grain size. The natural grain sand is round, making it desirable for many industrial uses. The high purity of the St. Peter Sandstone, once washed, makes it suitable for making high-quality glass and for chemical and metallurgical uses such as the manufacture of sodium silicate and silicon carbide. The hardness of the sand makes it useful for grinding large sheets of plate glass to prepare them for polishing. The well-rounded grains withstand high temperatures without melting; thus, large tonnages of washed silica sand are used to make molds into which molten metal is poured to make various castings. Because it is clean and does not dissolve in water, silica sand is used to filter impurities from drinking water and swimming pool water. Its whiteness makes it a desirable constituent in plaster, mortar, and pre-cast building panels where it acts as filler and provides opacity and color.

The coarser grains of the washed silica sand are rounded, strong, and available in uniform sizes, making it ideal for hydraulic fracturing of oil-bearing strata in oil and gas extraction. Thousands of tons are used annually. The sand is mixed with oil, other petroleum products, or water and is forced by powerful pumps into sandstone or limestone formations that contain oil. The great force thus exerted opens fractures in the rock strata and pushes the liquid and sand into them. When the pressure is relieved, the sand grains serve as props to hold the fractures open. The oil can then flow more readily into the wells, increasing oil production.

Products and Uses of Silica Sand



Sure Play[®] and Pro White[®] Bunker Sand. These sands offer consistency in color and sizing year after year. Their high infiltration rate and low clay content reduce maintenance. Greens Construction Drainage Layers. Gravels are washed and graded to meet drainage criteria. This uniform gravel product complements root zone sand mixtures. Various sizes are available.

FilPro Filtration Sands are produced from hard ore quartz sands that are resistant to degradation during handling and backwashing. These dense and durable sands can effectively improve filter efficiency, reduce detention time and head pressures, and optimize flow rates.





U.S. Silica Company supplies over 80 grades of round, angular, and sub-angular sands to the foundry industry for molding and core-making applications. Because of the high silica content and the company's ability to meet a wide range of sand specifications, it helps foundry customers produce high-integrity castings, free of defects and with superior surface finishes. ASTM International worked with the Ottawa Silica Company to develop testing sands from the St. Peter Sandstone, and these continue to be worldwide standards. One of the earlier products made at U.S. Silica was standard silica sand. This sand was sieved and sold as Standard Ottawa Sand for uses such as cement testing. Ottawa ASTM testing sands are used in testing cement and mortar and for many experimental purposes. The testing sands conform to ASTM standard C778 (Standard Specification for Standard Sand), which is for silica sand composed almost entirely of naturally rounded grains of pure quartz and is used for preparing mortar in the testing of hydraulic cements. There are two types of testing sands: 20/30 sand, predominantly graded to pass the 850- μ m (No. 20) sieve and be retained on the 600- μ m (No. 30) sieve, and graded sand, which is predominantly graded between the 600- μ m (No. 30) sieve and the 150- μ m (No. 100) sieve. These standard sands are used to test the air content of hydraulic cement mortars (ASTM C185) and compressive strength (ASTM C109).

				Usage per test			
Material	Test method	Standard	Sand type	Grams	Pounds	Comments	
Standard sand	Specification	C-778-92a	Graded			Source: Ottawa, IL	
Standard sand	Specification	C-778-92a	20-30			Source: Ottawa, IL	
Hydraulic cement	Compressive strength	C-109M-95	Graded	1,375/ 2,035	3.0/4.5	6 or 9 2-inch cubes	
Hydraulic cement	Air content	C-185-95	20-30	1,400	3.1%	Water varies	
Masonry cement	Specification	C-91-97	(50%) Graded (50%) 20-30	735 735	1.6 1.6	Compressive strength, water retention, and air entrapment tests	

 Table 2
 ASTM cement testing standards requiring Ottawa sands.

Products and Uses of Silica Sand



U. S. Silica Company mines and produces whole grain and ground silica for the building products industry.

Ground and fine-ground (micronized) silicas are naturally bright white, low in moisture, and chemically inert. They contain at least 99.5% pure SiO_2 and are used in many different products requiring rigid control of physical and chemical properties.

Applications of silica include

- *Coatings* As a filler and extender in paint formulations,
- *Ceramics* In ceramics, U.S. Silica's high quality ground silica provides a bright, white silica base for glazes and bodies, and the consistent size distribution ensures reproducible viscosity in slips.
- *Plastic and rubber* Ground silica has found wide industrial application as an additive for plastics and rubber.



Silica is used as a high-quality component in many products, including paint, caulk, and cleanser.

Ground silica is irregular in shape due to milling, which causes the grains to fracture. Ground silica is used in the manufacture of counter tops, rubber, fused silica used in lost-wax castings, electrical insulators, coatings, buffing compounds, and many other applications.

The industrial silica industry in the United States is healthy. Major U.S. companies that mine silica are U.S. Silica, Unimin, Fairmont Minerals, Oglebay Norton, and Badger Mining. Unimin and Fairmont Minerals mine the St. Peter Sandstone in La Salle County near Ottawa, whereas Oglebay Norton and Badger Mining mine different silica sources elsewhere.

Current production at U.S. Silica, Ottawa, is 2.2 million tons per year, which is very near the plant's productive capacity. U.S. Silica's value-added products and exclusively produced products, such as standard Ottawa Testing Sand, are shipped worldwide. Lower priced products are restricted to regional distribution. Indications are that present demand will continue, and reserves have been identified that will provide St. Peter Sandstone to Ottawa's U.S. Silica plant for the next 50 years and beyond.

U.S. Silica's major customers include Owens-Brockway Glass Container, Inc., Anchor Hocking, Pilkington, Ball-Foster Glass Container Co. (now owned by Saint-Gobain Containers), PPG Industries, PQ Corporation, Johns Manville, GE Lighting, Guardian Fiberglass, DuPont, 3M, Osram Sylvania, Caterpillar, Wheland Foundry, American Steel, Griffin Wheel, United Gilsonite Laboratories (UGL), PQ Corporation, and many others.

Demand for silica is largely constant and stable throughout the year because of product and customer diversity, so economic swings and cycles have little impact on overall demand. The demand for some products, such as swimming pool filter sand, is obviously seasonal, but those products constitute only a small percentage of industry demand. To date, demand for silica products has been increasing, although markets change with time as new silica uses and products are developed and alternative materials replace certain silica uses, for example, synthetic field turf, in use by most professional and major college outdoor sports teams; fiber-cement building panels; and thin film transistor (laptop computer screens and small flat screen TVs. Similarly, new materials are developed to replace silica-based products. For example, in the packaging industry, glass bottles and containers have been replaced largely by plastic, aluminum, and paper. Soft scrubs have also been developed that use ground limestone instead of silica. Blasting sand has been replaced by mixtures of coal fragments and walnut shells, and other new materials have been developed to compete with silica-based products.

U.S. Silica employs over 110 people at the Ottawa facility. The hourly workforce is represented by the United Steel Workers of America and has an excellent working relationship with company management. Employment is career oriented, with low absenteeism and very little turnover; most employees leave the company because of retirement.

U.S. Silica is an integral part of the community of Ottawa. The company has been involved in the community since its beginning. Employees are active in schools, churches, and many other organizations and charities. U.S. Silica also contributes to local philanthropic needs, such as the statues that the town erected to pay tribute to William Dickson Boyce, founder of the Boy Scouts of America, and the statue of Abraham Lincoln and Stephen Douglas, honoring the site of the first Lincoln-Douglas debate.

U.S. Silica has developed reclamation plans that mesh with local government plans for promoting tourism. Once mined out, the quarries will be allowed to fill with groundwater, creating large lakes for recreational boating and fishing. Post-mining use is still not in the foreseeable future, but the community will reap recreational benefits from the mine sites after mining activities cease.



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