1. NAME OF PROPERTY

Historic Name: **SCHOONMAKER REEF**

Other Name/Site Number: WAUWATOSA REEF, SCHOONMAKER QUARRY, RAPHU STATION, FRANCEY REEF, FRANCEY QUARRY, FULLER QUARRY, WAUWATOSA QUARRY

2. LOCATION

Street & Number: North of West State Street between North 66th Street extended and North 64th Street extended

Not For Publication:__

Vicinity:__

City/Town: Wauwatosa

State: Wisconsin County: Milwaukee Code: WI079 Zip Code: 53213

3. CLASSIFICATION

Ownership of Property		Category of Property	
Private:	X	Building(s):	__
Public-Local:	__	District:	__
Public-State:	__	Site:	X
Public-Federal:	__	Structure:	__
		Object:	__

Number of Resources within Property

Contributing	Noncontributing
__	__ buildings
1	__ sites
__	__ structures
__	__ objects
1	__ Total

Number of Contributing Resources Previously Listed in the National Register:__

Name of Related Multiple Property Listing: N/A

4. STATE/FEDERAL AGENCY CERTIFICATION

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this ____ nomination ____ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property ____ meets ____ does not meet the National Register Criteria.

Signature of Certifying Official Date

State or Federal Agency and Bureau

In my opinion, the property ____ meets ____ does not meet the National Register criteria.

Signature of Commenting or Other Official Date

State or Federal Agency and Bureau

5. NATIONAL PARK SERVICE CERTIFICATION

I hereby certify that this property is:

___ Entered in the National Register
___ Determined eligible for the National Register
___ Determined not eligible for the National Register
___ Removed from the National Register
___ Other (explain): _____

Signature of Keeper Date of Action

6. FUNCTION OR USE

Historic:	LANDSCAPE	Sub:	natural feature
	INDUSTRY/EXTRACTION		extractive facility (quarry)
Current:	LANDSCAPE	Sub:	natural feature

7. DESCRIPTION

ARCHITECTURAL CLASSIFICATION: N/A

MATERIALS: N/A
Foundation:
Walls:
Roof:
Other:

Describe Present and Historic Physical Appearance.

Schoonmaker Reef is a 425 million year-old fossil reef that grew during the Silurian Period (unit of geological time dating from 435,000,000 to 405,000,000 years ago) of Earth's history at a time when much of North America was covered by shallow tropical seas. It occurs stratigraphically within the Racine Dolomite (this is the proper name for a specific Silurian rock unit in Wisconsin and Illinois). The reef contains a large variety of marine fossil organisms, for which it is famous, including trilobites (a common type of extinct arthropod), cephalopods (shelled molluscs related to the chambered Nautilus and squids), brachiopods (sedentary invertebrate animals with a bivalved shell), bryozoans (colonial invertebrates with microscopic polyps, sometimes called moss animals), clams, snails and corals.[1] The reef rock is composed of dolomite, a limestone-like sedimentary rock containing magnesium and calcium carbonate. Unlike most sedimentary rocks, which are found in horizontal layers, most of the reef rock is massive, mound-like, and forms a large erosion-resistant rock hill.

This reef-controlled hill occurs in the north bluff of the Menomonee River valley in Wauwatosa. The bluff here is 70 feet high, with the reef exposed in the lower 20 feet. The upper bluff, which is composed of glacial sediments and soil deposited within the last million years, is in its natural state, is heavily wooded, and has never been developed. The reef is exposed in an almost continuous 600-foot-long outcrop, most of which is a quarry face that has remained undisturbed since the time of the late nineteenth century geologic studies.

In the early 1920s, Charles B. Whitnall, a national figure in urban park development who is considered the father of the renowned Milwaukee County park system, proposed that this site be included in a parkway which was to extend along the north bluff of the Menomonee River valley. The County Park Commission formally included this property in its parkway plans in 1924, but it never became part of the actual parkway.[2] The Schoonmaker Reef can be accessed by foot, but only with the landowner's permission.

[1] Mikulic, Donald G., The Paleoecology of Silurian Trilobites with a Section on the Silurian Stratigraphy of Southeastern Wisconsin, Ph.D. dissertation, Oregon State University, 864 pp., 1979.

[2] Milwaukee County Regional Planning Department First Annual Report, 1924.

8. STATEMENT OF SIGNIFICANCE

Certifying official has considered the significance of this property in relation to other properties:
Nationally: X Statewide:__ Locally:__

Applicable National Register Criteria: A__ B X C__ D X

Criteria Considerations (Exceptions): A__ B__ C__ D__ E__ F__ G__

NHL Criteria: 2,6

NHL Criteria Exclusions:

NHL Theme(s): VI. Expanding Science and Technology
3. scientific thought and theory

Areas of Significance: Science

Period(s) of Significance: 1844-1939

Significant Dates: 1862, 1877, 1903, 1939

Significant Person(s): Chamberlin, Thomas Crowder
Grabau, Amadeus William
Hall, James
Shrock, Robert Rakes

Cultural Affiliation: N/A

Architect/Builder: N/A

NHL Comparative Categories:
XIII. Science
B. Earth Science
2. Geology

State Significance of Property, and Justify Criteria, Criteria Considerations, and Areas and Periods of Significance Noted Above.

Summary

Schoonmaker Reef is nationally significant in the history of geology in the United States for its crucial role in the earliest recognition of fossil reefs in North America, a major geological advancement, and for its association with the careers of some eminent nineteenth and early twentieth century geologists, including James Hall, T. C. Chamberlin, A. W. Grabau, and R. R. Shrock. These geologists used data collected from the reef to formulate theories fundamental in the study of geology.

Large fossil collections were amassed at this locality by such prominent nineteenth-century amateur naturalists as Fisk Holbrook Day and Thomas A. Greene, and fossils from this site can be found in most major and many minor museums throughout the country, including the Museum of Comparative Zoology at Harvard University, the National Museum of Natural History at the Smithsonian Institution, the American Museum of Natural History, the Field Museum of Natural History, the University of Iowa, the University of Illinois, the University of Cincinnati, the University of Michigan, the Milwaukee Public Museum, the Thomas A. Greene Geological Museum, the University of Wisconsin, the Los Angeles County Museum, San Diego Museum of Natural History, and the University of California-Berkeley.

Increase A. Lapham, Wisconsin's first scientist, was the first to collect fossils and describe the geology of the rock outcrops here in 1844. It was James Hall, however, who, in 1862, first recognized and interpreted this as a fossil reef, making Schoonmaker Reef the first ancient reef described in North America and among the first described anywhere in the world.

Thomas C. Chamberlin used the Schoonmaker Reef extensively in devising his paleoecological (study of the relationship between ancient organisms and their environment) and sedimentological (the study of sedimentary rocks and the processes by which they are formed) model of reef development, which he published in his definitive 1877 work *The Geology of Eastern Wisconsin*. Amadeus W. Grabau highlighted the Schoonmaker Reef in the first compendium of fossil reefs worldwide, which he published in 1903. In 1939, Robert R. Shrock published Wisconsin Silurian Bioherms, a seminal paper which relied heavily on information derived from the Schoonmaker Reef. As a result of its prominence in these classic and important works, the Schoonmaker Reef was used as the text-book example of a fossil reef throughout the first half of the twentieth century, and Wisconsin gained world renown for its ancient reefs.

Because of its notoriety, Schoonmaker Reef was visited by many university classes and professional geological field trips. On one of these (1937 Tri-State Geological Field Trip) Schoonmaker Reef became the birthplace of the National Association of Geology Teachers, the premier organization of geology teachers in the world. This site still provides good exposures of the sedimentology and paleontology of the first-described fossil reef in North America and, therefore, it will continue to be important for geological research and studies in the history of science. The period of significance for Schoonmaker Reef was chosen to begin with Lapham's unpublished description of the exposure in 1844 and to end with the publication of Robert Shrock's reef study in 1939.

History

The Schoonmaker Reef possesses national significance in the history of science because it played a key role in the recognition and interpretation of ancient reefs in North America. It is one of two reefs in Milwaukee County considered national significant. The first, Soldier's Home Reef, was designated a National Historic Landmark in 1993.

Although Schoonmaker and Soldiers Home reefs have some features in common, they differ in many respects pertaining to their role in the history of geology. The Soldiers Home Reef is important primarily because its physical form preserves the natural topographical features of a rock hill that the early geologists observed and used to identify ancient reefs. In contrast, the Schoonmaker Reef was not important as a rock hill, but rather because it produced the largest number of fossils from a single ancient reef in the nineteenth century. It was possible to collect these fossils only because this reef had been quarried; evidence of this early quarrying still exists. These fossil collections from the Schoonmaker Reef, which can be found in museums and universities throughout the U.S., were essential in developing the ancient reef concept and identifying these features as ancient reefs.

Geologists around the world were long puzzled by unusual unbedded rock masses, or mounds, that interrupted normally flat-lying limestone strata. The solution to this enigma was finally provided by the eminent geologist James Hall, who, in 1862, was the first to accurately interpret such features in North America as ancient reefs. The Schoonmaker Reef was at the center of Hall's ground-breaking new interpretation, which represented an important advancement in geological knowledge. The Schoonmaker Reef continued to serve as the fundamental model for ancient reef development well into the twentieth century. As such, Schoonmaker Reef was the prime example of ancient reefs in geological research, and it has been featured in numerous geology text books and scholarly works.

The prominent rock-controlled hill formed by this ancient reef was quickly recognized as a valuable source of lime by early settlers in the area. Joseph Higgins is known to have burned lime at the Schoonmaker Reef in 1838; however, lime burning may have begun here as early as 1833. Silas Brown operated the lime kilns in the 1840s, and from 1850-1857, Daniel McCormick, Mason S. Daniels, Laura Hale, James Cannon, Zebulon Hall, William Watkins and Anthony Green ran the lime operation at various times. In 1857, John Schoonmaker and Isaac Van Shaick purchased the property. Van Shaick, who later sold his interest in the quarry, was active in politics, elected first as a Milwaukee alderman, then to the state legislature, and twice to the U. S. Congress.

This site is named for John Schoonmaker and his family because they operated the quarry here the longest (more than 50 years) and were its owners during the period that much of the early geological research took place. During the latter half of the nineteenth century the site was a major source of lime in the Midwest, serving the Milwaukee and Chicago markets primarily. By 1909, the lime business had ended, and George Francey of G. D. Francey Coal, Stone & Supply Company bought the site primarily to produce crushed stone for aggregate. George's nephew, Tom Francey, installed an innovative plant for crushing stone and producing concrete in 1930, which was featured in many trade journals at the time. Following Tom's death in the late 1930s, the quarry was leased by Sidney Fuller. In 1948, the Bliffert Concrete Company purchased the quarry and concrete plant from the Francey Company, but the quarry would continue to be operated through lease by the Fuller Company.

Abandoned in 1950, much of the site was filled in and built over, but the eastern portion of the site, containing both natural exposures and some of the earliest-quarried face, still remains. Without the extensive quarrying that took place at this site, the important geological relationships between reef and nonreef strata would never have been exposed, it is unlikely that Hall would have made his reef interpretation, and the large, important fossil collections could not have been assembled.

Increase Allen Lapham, Wisconsin's first scientist, conducted the earliest geological study of the site and collected the first fossils from Schoonmaker Reef in 1844.[1] Around this time, Lapham sent fossils from here and other Milwaukee area localities to the prominent geologist James Hall of New York. Hall had established a North American Paleozoic reference section based on rock exposures in New York, and had been one of the first geologists to make detailed correlations between the Paleozoic rocks of eastern North America and Europe. Now, Lapham's Wisconsin fossils helped to interest him in determining how far west he could recognize his reference section. For this reason, Hall made several visits to the Milwaukee area in the 1850s to examine Lapham's fossil collections and localities, including the Schoonmaker Reef. Based on this study, in 1862, Hall became the first to recognize that the Schoonmaker Reef was a fossil "coral" reef, making it the first ancient reef recognized in all of North America. As part of his Report on the Geological Survey of the State of Wisconsin, Hall, who was then Wisconsin State Geologist, stated:

> At Wauwatosa, near Milwaukee, and at other points, there are isolated hills or ridges of Coralline limestone; while the surrounding low flat ground in underlaid by the thin and heavy-bedded Waukesha limestone. At one point in this low ground there is an open quarry, and at a little distance and on the opposite side of the road there is a similar quarry, both exhibiting the thinbedded and the thickbedded portions of the rock. In direct continuation we have the face of a hill of Coralline or Geodiferous limestone [Schoonmaker], which has been quarried along an extent of several rods. This has been burned into lime, while the other beds are unfit for that purpose...
>
> The entire mass appears like a coral reef, where the broken corals and shells are packed in a calcareous sand, the whole consolidated as a compact and nearly homogeneous mass; while as we recede from it, the more finely comminuted materials are spread over the adjacent sea-bottom, and, mingling with a little argillaceous matter, they form the thinbedded argillaceous dolomite of this region. This, at least in the present state of facts, seems to be the only satisfactory explanation which can be offered. That these isolated hills are not outliers of a former continuous mass, would seem to be proved by the sloping strata upon their flanks; and there is no reason to suppose that they have been abruptly elevated in this quiet and undisturbed region; they seem to have been small coral reefs or islands, and are known to exist only over a limited portion of the area occupied by this limestone formation.[2]

James Hall, perhaps the most eminent geologist and paleontologist in North America during the mid to late nineteenth century, was a man of many scientific accomplishments, among which his

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[1]Unpublished field notes by I. A. Lapham.

[2]Hall, James. Physical geography and general geology. In: James Hall & J. D. Whitney, *Report on the Geological Survey of the State of Wisconsin*, vol. I, p. 1-72. State Legislature of Wisconsin, Madison, 1862, p.63.

correct interpretation of ancient reefs was the most important. Hall was born in Hingham, Massachusetts, on September 12, 1811, and was introduced to the study of natural history at an early age by his local schoolteacher. Following his public school education, Hall enrolled in the newly founded Rensselaer Institute in Troy, New York, in 1830, where he was fortunate to have two of the country's earliest and most prominent geologists, Amos Eaton and Ebeneezer Emmons, as his mentors. At the age of 21, Hall became the youngest geologist at the New York Geological Survey, only four years after his graduation from Rensselaer in 1832. Within just a few years, Hall earned a reputation as one of the country's leading geologists and paleontologists. His experience and expertise were in great demand, and while conducting an exhaustive paleontological survey of New York, Hall also served as the state geologist of both Iowa and Wisconsin in the mid-1800s.

By 1866, Hall was appointed director of the New York State Museum, and, in 1893, the position of State Geologist of New York was created especially for him. Throughout much of his life, Hall was a leader in many of the most prominent scientific societies in nineteenth century America, serving as a founder of the Association of American Geologists and the American Association for the Advancement of Science, and as a charter member of the National Academy of Sciences, still the most prestigious scientific society in the nation. He was the first president of the Geological Society of America, president of the American Association for the Advancement of Science, and a three-time vice-president of the International Congress of Geologists. A prolific researcher and publisher, Hall had formulated the concepts of geosynclines and fossil reefs, and had produced 15 quarto volumes containing more than 4000 pages of text and more than 1000 paleontological plates by the time of his death on August 7, 1898. He also trained a number of assistants who would become some of the most prominent geologists and paleontologists in North America.[3]

Although they were first recognized and correctly interpreted by Hall, the significance of the Wisconsin reefs was underscored by the work of Thomas Crowder Chamberlin. Chamberlin ensured the fame of the Schoonmaker Reef when he focussed considerable attention on it, using it as the best example of an ancient reef, in his Geology of Eastern Wisconsin, published in 1877 while he was Wisconsin State Geologist. This classic work marked the beginning of integrated Paleozoic (the era of geological time ranging from 250 million to 560 million years ago) reef studies as Chamberlin related rock type and fossils to sedimentary processes and paleoecology. In particular, he recognized that the reefs contained fossils and rock types different from surrounding contemporaneous bedded rocks and that individual reefs differed among themselves.[4] He chose the Schoonmaker Reef as his prime example, noting that this site furnished "the best exposures, are the most fossiliferous, and have been the subject of most discussion." In this volume, Chamberlin used the Schoonmaker Reef and nearby exposures to describe the transition from reef mound to normally bedded strata, which he illustrated in an accompanying lithograph:

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[3]Fenton, Carroll Land, and Mildred Adams Fenton. *Giants of Geology*. New York: Doubleday & Company, 1952. Clarke, John M. *James Hall of Albany, Geologist and Paleontologist 1811-1898*, Albany, New York: Arno Press Reprint, 1978.

[4] Mikulic, Donald G. Ancient reefs: T. C. Chamberlin's work on the Silurian geology of eastern Wisconsin. *Geological Society of America Abstracts with Programs*, vol. 21, p. A124, 1989.

If we place ourselves at the extreme western exposure, known as Busack's quarry, we shall find a section showing heavy, well defined, nearly horizontal, slightly argillaceous beds, of a rather fine, uniform, compact grain, medium hardness, smooth conchoidal fracture, and bluish gray color. Interstratified with these, are layers having the lumpy nature...The layers dip eastward to about the middle of the quarry from which they rise, but not uniformly, for at this point an east and west axis occurs, having the general trend of the ridge farther east, and with which it probably has a definite connection. An east and west section in this part of the quarry would show a dip to westward and a north and south section would exhibit the layers curved gently over the axis. But as we trace the rock eastward, it changes in nature. Near the eastern extremity, the upper layer becomes slightly irregular in bedding, and rather soft, and granular in texture.

Below this is a layer from 22 to 24 inches thick, divided into sublayers, somewhat irregularly, and occasionally showing lines of deposition. To casual observation, it appears to be a compact, fine-grained, even-textured dolomite, but closer inspection shows it to contain many small cavities that are angular and sharply defined, and are the result of the removal of minute fossils, in which the rock abounds at this point. Aside from these, the rock is as previously described, with occasional seams of argillaceous material. Below this, the rock is similar to that in the western part of the quarry. In the extreme southeastern portion exposed in connection with this quarry, the rock becomes quite irregular in structure.

There ensues at this point, unfortunately, an interruption of several rods in the exposure, so that this incipient change in structure cannot be traced to its consummation.

Passing this interval, we find at the western extremity of Mr. Schoonmaker's quarry, at the surface, a cellular, even textured, regularly bedded rock similar to that last described, but of lighter color, and more distinctly granular nature. This dips southward at an angle of about 15°. As the face of the quarry curves round to the south, the whole section is composed of similar rock down to and beneath the water that occupies the bottom of the quarry at this point. But these lower layers dip less and less, until they become horizontal, and even slightly incline toward the irregular mass. If we trace these lower layers toward the ridge, their inclination increases as well as their thickness-this latter sometimes markedly—until they are lost in the obscure structure of the reef, or disappear at the surface.

As we pass eastward along the face of this ridge, now well exposed by quarrying, the dip of the ill-defined layers increases gradually to 54° when the stratification can no longer be clearly distinguished. This obscurity continues for 80 paces. There are some indications of horizontal bedding in this space, and also some that the dip is to the south, and that the exposure is along the strike of the strata, but neither observation is altogether trustworthy.

East of this, blue and lighter colored bands indicate a dip of about 30° eastward. This continues for about 35 paces, the observation at the eastern extremity showing a dip of 31° in a direction E10° to 15° S, this being the dip as exposed, not necessarily the full amount of true dip. The same qualification is true of the other observations made on the dip along the face of this exposure.

Ten paces of unexposed face succeeds, followed by 90 paces uncovered, which shows an obscure dip of about 30°E of S. Again 30 paces are concealed, beyond which a face 40 yards in length succeeds, whose dip is 33° E of S. After another interruption of 60 paces, we find the last exposure of about 10 paces length, whose very obscure stratification

> indicates a dip to the SW. The ridge reaches a height of about 45 feet above the sole of the quarry.
>
> Near the summit of the ridge, at its western extremity, is a slight outcrop apparently in place, and seeming to dip to the northwestward (20°, N30°W). If this be reliable, we should infer that the ridge was comparatively narrow, as the exposure lies only 17 paces back from the face of the quarry.
>
> The trend of the ridge, as estimated from the exposures, is a little to the north of east.
>
> The rock at Story's and Schwickhart's quarries...is closely similar to that in the western part of Busack's quarry, and the same remark may be made of the fossils, which consist mainly of Orthoceratites. But in Busack's quarry, where the strata approach the reef, the fauna is much amplified...
>
> From all the foregoing facts, it may be regarded as fairly demonstrated that these horizontal beds were laid down simultaneously with the formation of the mounds. The cellular nature of the rock of the latter, and the uncompressed condition of fragile fossils, are fatal to any theory of upheaval, or other violent action.[5]

Chamberlin's innovative interpretation of these different rock types was the first to compare the features of ancient and modern reefs, which James Dwight Dana and Charles Darwin had only recently described.

> It appears...there are three well marked classes of limestones, with intermediate gradations, one class, consisting of very irregular, often brecciated or conglomeritic dolomite, forming masses that usually appear as mounds, or ridges of rock, of obscure stratification, a second class, formed of pure, soft, granular dolomites, a part of them calcareous sandrock, and a third class, consisting of compact, fine grained, regular, even beds. We have demonstrated that the three forms change into each other when traced horizontally. They were therefore formed simultaneously. The view that best explains these facts is, (1) that the mounds and ridges were ancient reefs, and (2) that the granular sand rock was formed from calcareous sands, derived by wave action from the reef, and (3) that the compact strata originated from the deposit of the finer calcareous mud that settled in deeper and more quiet waters, the whole process being analogous to, if not identical with, the coral formation of the present seas.[6]

Chamberlin considered the abundance of fossil organisms, which numbered about 200 species, found in Schoonmaker Reef as especially important evidence for the modern reef analogy.

> ...some of [the reefs] are remarkable for the richness and variety of their fauna. The reef near Wauwatosa (Schoonmaker's quarry), is a striking instance of this. There have been collected from it, chiefly by Dr. Day, probably not less than two hundred species...And an exhaustive examination of the collections would doubtless much increase the number.[7]

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[5]Chamberlin, T. C. Geology of Eastern Wisconsin. *Geology of Wisconsin*, Vol. II, Part II, pp.365-367.

[6]Chamberlin, T. C. Geology of Eastern Wisconsin. *Geology of Wisconsin*, Vol. II, Part II, pp.368-369.

[7]Chamberlin, T. C. Geology of Eastern Wisconsin. *Geology of Wisconsin*, Vol. II, Part II, p.369.

Chamberlin noted that the different rock types contained different kinds of fossils, that were related to the ancient environment and analogous to modern coral reefs:

> The fauna of the compact strata is distinguished for the conspicuous presence of straight and curved Cephalopods with comparatively few associates. The cephalopods are abundant, as already noted, in the reefs and crinoid beds, but are overshadowed by the number and variety of other forms, while in the compact rock, they generally predominate.
>
> It appears then, (1) that upon the reefs there swarmed a vast variety of life; (2) that upon certain banks of shoal areas there was also great abundance and variety, among which the crinoid family attained unusual prominence; (3) that over areas of submarine sand-flats there either was little life present, or, from the porous nature of the rock, it has been illy preserved, and (4) that over the deeper areas, that deposited fine calcareous mud, the gigantic Cephalopods held sway. Vivid descriptions, almost specifically applicable to the formations in question, save in the modern aspect of the life, may be found in the writings of Prof. Dana and Mr. Darwin on recent coral formations...
>
> In [Dana's] work, there are frequent descriptions or references to sandrock, solid limestone, and various conglomeritic forms, that might almost have embodied as a portion of the lithological description of this exposure of the Racine limestone. It does not appear, however, that Corals played so conspicuous a part, relatively, in the formation of these ancient reefs as they do in modern ones...[8]

Chamberlin was one of the most famous geologists and educators of the late nineteenth and early twentieth centuries. Born near Mattoon, Illinois, on September 25, 1843, Chamberlin was only two years old when his family moved to a farm near Beloit, Wisconsin. He received his early education at the district grammar school, and went on to attend Beloit College. Here, Professor Henry Nason, a chemist and mineralogist, sparked Chamberlin's lifelong interest in science. After his graduation from Beloit in 1866, Chamberlin taught high school in Delavan, Wisconsin, for two years. Following a stint of graduate study at the University of Michigan, studying under the geologist Alexander Winchell, Chamberlin taught natural science at the State Normal School in Whitewater, Wisconsin, from 1869 to 1873. He then returned to his alma mater, Beloit College, as a faculty member, where he became its first Professor of Geology in 1880.

While at Beloit, Chamberlin also worked for the Wisconsin Geological Survey, and was appointed to the post of State Geologist in 1876. While working for the Survey, he made an exhaustive study of the bedrock and glacial geology of eastern Wisconsin. As a result, Chamberlin became a leading American authority on glacial geology, and, in 1881, he was appointed to head the newly formed Glacial Division of the United States Geological Survey.

Continuing his work for the USGS, in 1887, Chamberlin became president of the University of Wisconsin, and is credited with transforming that institution from a college into a university. In 1892, he left Wisconsin to establish the Department of Geology at the newly-founded University of Chicago, where he remained until his retirement in 1919. In addition, to his important and influential reef and glacial work, Chamberlin is noted for his method of multiple working hypotheses, which he formulated while at the University of Wisconsin in 1889, and for the

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[8]Chamberlin, T. C. Geology of Eastern Wisconsin. *Geology of Wisconsin*, Vol. II, Part II, p.370.

planetisimal hypothesis he devised with Forest Moulton at the University of Chicago, which was considered a leading theory for the origin of the solar system at the time of Chamberlin's death in 1928.[9]

Chamberlin's comprehensive study of Schoonmaker Reef and other Silurian reefs in Wisconsin enabled later geologists to correctly identify similar features in Silurian strata throughout the Great Lakes region. As a result of Chamberlin's work, Wisconsin Silurian reefs in general, and Schoonmaker Reef in particular, became the classic example of North American fossil reefs well into the twentieth century. In 1899, William C. Alden, one of Chamberlin's former students and a geologist with the United States Geological Survey, published the first photograph of the Schoonmaker Reef, which went on to be extensively reproduced in geology textbooks.[10]

Amadeus William Grabau, considered one of the founders of sedimentology, published an important paper on Paleozoic coral reefs in the Geological Society of America Bulletin in 1903. In this article, which was one of the first to describe fossil reefs from around the world, Grabau used the Schoonmaker Reef as a prime example. He also based a classification of reef limestones on these reefs that is still in use today. Concerning the Schoonmaker Reef, Grabau stated:

> Reef structure is of common occurrence in the Siluric (Niagaran) limestones of southeastern Wisconsin. One of the best known examples is the old Schoonmaker [sic] quarry, near Wauwatosa. This has been fully described by Chamberlin, who recognized the reef character of the main rock mass of the quarry. The quarry was opened in a mound or hillock which undoubtedly owed its preservation to the hard character of the reef mass. At the time of my visit, however, it had been abandoned for a long time, and the walls had become more or less weathered and overgrown, while the deeper portion was filled with water. The same reef is exposed in the eastern part of the quarry, but there are smaller reef-like mounds which may have been subsidiary reefs, or may be merely parts of the larger one. No bedding is visible in the reef portions, which appear to consist mainly of stromatoporoids. These, however, are recognizable, as a rule, only on the weathered surfaces, the general aspect of the fresh face being that of extreme massiveness of the rock, with a total absence of stratification. Around the reef, however, the rock is bedded and granular, and it may be seen in many places dipping away from the central reef portion. The highest dips which I observed were 28 degrees, decreasing rapidly to 18 degrees; but Chamberlin mentions a dip of 54 degrees close to the reef, observed while the face was well exposed by quarrying. Other dips mentioned by Chamberlin are 30, 31, and 34 degrees, besides those of lower angle. Chamberlin also mentions the increase in thickness of the sedimentary layers toward the reef, with which they finally merge.[11]

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[9]Schultz, S. F. Thomas C. Chamberlin: the Kettle Moraine and multiple glaciation. *Wisconsin Academy of Sciences, Arts and Letters Transactions*, vol. 67, p. 135-148, 1979, and Chamberlin, R. T. *Thomas Crowder Chamberlin, 1843-1928.* National Academy of Science Biographical Memoir, vol. 15, Memoir. 11, p. 305-307, 1934.

[10] Pirsson, Louis V., and Charles Schuchert. *A Text-Book of Geology*. John Wiley & Sons, New York, fig. 88, 1924. Longwell, Chester R., Adolph Knopf, Richard F. Flint, Charles Schuchert, and Carl O. Dunbar. *Outline of Geology*. John Wiley & Sons, New York, fig. 42, 1937.

[11]Grabau, A. W. Paleozoic coral reefs. *Geological Society of America Bulletin*, vol. 14, p. 337-352, 1903.

Amadeus William Grabau was the third of ten children of German immigrants William Grabau, a Lutheran pastor, and Maria van Rohr, who died when Amadeus was only six. Grabau was born January 9, 1870, at Cedarburg, Wisconsin, where he received his early education and developed a strong interest in natural history. In 1885, he moved to Buffalo, New York, with his father and stepmother, where he attended high school and collected fossils from the Devonian rocks nearby.

Grabau became interested in geology through a correspondence course with W. O. Crosby, a professor at the Massachusetts Institute of Technology. Recognizing Grabau's scientific promise, Crosby brought him to MIT, where he received a bachelors degree in 1896. The next year he went to Harvard University where he received a masters degree in 1898 and a doctor of science degree in 1900. From 1899 to 1901, Grabau taught geology at the Rensselaer Polytechnic Institute and lectured on the subject at Tufts College. In 1901, Grabau went to teach at Columbia University, where he was a professor from 1905-1919.

As a result of anti-German sympathies that swept the U.S. during World War I, Grabau accepted a position as China Foundation Research Professor at the National University in Peking and Chief Paleontologist at the Chinese Geological Survey in 1920. His productive years in China were cut short by the Japanese invasion, however, and he died on March 20, 1946.

Grabau's research interests were in paleontology, stratigraphy and sedimentology, and his study of ancient reefs was only one of his many accomplishments. He published the definitive book on the geology of the Niagara Escarpment in New York, which is still used as a guide to this famous natural feature. He also published other important reference works, including a two volume *Text-book of Geology*, *North American Index Fossils*, and the 1200-page *Principles of Stratigraphy*. Grabau formulated the pulsation theory, which is summarized in his book *Rhythm of the Ages*. This theory proposed that changes in the earth's crustal features were the result of rhythmic fluctuations in sea level, which is still a basic tenet in the modern theory of sequence stratigraphy.

Grabau was a fellow in the Geological Society of America, the Paleontological Society, the American Association for the Advancement of Science, the Paleontological Society of China, and he held office in the Peiking Society of Natural History, the Deutsche Akademie der Naturforscher, and the Geological Society of China. He also served as research associate for the Central Asiatic Expedition of the American Museum of Natural History, which was led by Roy Chapman Andrews and made famous by the discovery of dinosaur eggs in Mongolia. He was awarded the Mary Clark Thompson Medal by the National Academy of Science and, in 1925, he received the first Grabau Medal, which was named in his honor and was to be awarded biennially for outstanding contributions to Chinese science.[12]

Robert Rakes Shrock conducted a detailed study of Wisconsin Silurian reefs in the 1930s, which he published in 1939 in the *Geological Society of America Bulletin*. Because of the prominence of this scientific journal, the Schoonmaker Reef became very well known internationally. By the time of his research, quarrying at the Schoonmaker site had uncovered more of the reef and, for

[12]Shimer, Hervey W. Memorial to Amadeus William Grabau, *Proceedings Volume of the Geological Society of America Annual Report for 1946*, p. 155-166, 1947.

the first time, Shrock was able to diagram the cross-section of a reef with associated strata in its entirety. Shrock noted:

> The Schoonmaker reef is one of the most widely known on the North American continent. It is well exposed in a large and deep quarry along the north side of the Menomonee River, in Wauwatosa, just northeast of the intersection of State Street and Eighth Avenue [68th Street]. Here the core rock and associated strata have been quarried for over 75 years, and paleontologists have collected from the richly fossiliferous dolomites over a longer period of time, for there are natural exposures in a low bluff extending eastward for some distance from the quarry.
>
> The present quarry faces excellently reveal core rock, peripheral flanking strata, and the thin-bedded dolomites which form the foundation on which the bioherm [another geologic term for a reef] started. The bioherm appears to be a high and relatively narrow east-west ridge starting at the west edge of the present quarry and extending eastward for several hundred yards before disappearing under glacial drift.
>
> Along the west wall of the quarry well-bedded strata dip off the biohermal ridge in northerly, westerly and southerly directions, with dips ranging from 20 to 36 degrees...Westward from the bioherm the core rock changes into thin-bedded dolomites...
>
> ...The fossiliferous core rock probably furnished most of the fossils gathered by the early collectors, and it may be assumed that species reported from Wauwatosa came in large part from the core rock of the Schoonmaker bioherm...
>
> Laterally the massive core rock first becomes crudely bedded and granular and then grades into the well-defined flanking strata which dip gently off the biohermal mound, thinning out wedge-like as they give way to the thin-bedded, horizontal strata of the interbiohermal lagoons. Some of these wedges of flank rock are 20-25 feet thick at the junction with the core and thin to less than 5 feet before losing their identity in the interbiohermal beds. In some parts of the bioherm, core and flank rock interfinger and give to it a serrated margin, but in other parts they change from one to the other abruptly, and in these instances the interbiohermal strata end abruptly against the core remaining horizontal rather than rising gently toward it.
>
> These relations indicate that the growing bioherm which stood a few tens of feet above the surrounding bottoms had an irregular margin. In one place there appears to have been a cliff, at the base of which granular, calcareous sand worn off the growing bioherm gradually built up into thick wedges of what is now flank rock. In other parts of the bioherm extensions of the core were built out over the adjacent bottom; these were later buried beneath calcareous sand so that now core and flank rock interfinger.
>
> The rock of the biohermal flanks is thick-bedded, even-textured, porous and granular, relatively unfossiliferous dolomite which appears to have been formed in large part of the calcareous sands produced from erosion of the growing bioherm.[13]

Robert Rakes Shrock was born on August 27, 1904, in the village of Wawpecong, near Kokomo, Indiana, the son of Andrew Shrock, a carpenter and mechanic, and Stella Glassburn.9 He

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[13]Shrock, R. R. Wisconsin Silurian bioherms. *Geological Society of America Bulletin*, vol. 50, no. 4, p.529-562, 1939.

attended the two-room elementary school in Wawpecong and high school in Kokomo. Graduating with honors, he won a scholarship to Indiana University, from which he received his A.B. degree in 1925. In 1928, after receiving master and doctorate degrees in geology from Indiana University, he went to teach at the University of Wisconsin. It was during this period that he worked summers for the Wisconsin Geological Survey and did his research on Silurian reefs. In 1937, he left Wisconsin to accept a faculty position at the Massachusetts Institute of Technology, where he remained until his retirement in 1975. There, Shrock served as Chairman of the Department of Geology and Geophysics for 16 years. During his long career, Shrock published several significant volumes in paleontology and sedimentology, including Index Fossils of North America, Sequence in Layered Rocks, and Principles of Invertebrate Paleontology, all of which became important reference works. A well-respected member of his profession, Shrock was given fellowship in the American Academy of Arts and Sciences, held offices in the Society of Economic Paleontologists and Mineralogists, the National Association of Geology Teachers, the Wisconsin Academy of Sciences, Arts and Letters, the Paleontological Society, American Association for the Advancement of Science, received an honorary doctor of science degree from Indiana University, and was awarded the Twenhofel Medal in recognition of his important contributions to the field of sedimentology. Having initiated a cooperative oceanographic program between MIT and the Woods Hole Oceanographic Institute, Shrock had an oceanographic research vessel named in his honor. Remaining productive until his death in 1993, Shrock turned his attention to the history of science following his retirement, writing two books: *The Geologists Crosby of Boston* and the massive two-volume *Geology at MIT*: 1865-1965.[14]

Beginning in the 1840s, Schoonmaker Reef became a very important source of Silurian fossils from the midwestern U. S. Significantly, fossils that Increase Lapham collected and sent to New York for identification were the impetus for Hall's Wisconsin visits and subsequent recognition of ancient reefs. Most of the fossil specimens, however, were collected by gentleman naturalists such as Fisk Holbrook Day and Thomas Arnold Greene. Through their efforts, professional paleontologists, which were few in number at the time, received a large variety and number of fossil specimens to study and describe. Chamberlin noted:

> Dr. F. H. Day, of Wauwatosa, through years of industrious accumulation, has gathered, from the several localities of this formation in the southeastern part of the state, a very extensive collection, that is exceedingly rich in new, interesting, and typical forms.[15]

Approximately 90% of species listed from the Racine Limestone in Chamberlin's Geology of Eastern Wisconsin were based on Dr. Day's collection. Day had collected approximately two hundred species of fossils from the Schoonmaker Reef alone, a locality, which Chamberlin remarked, was especially notable for its trilobites. Among the thousands of specimens that Day collected from this reef were 16 trilobite, 28 coral, 8 bryozoan, 4 crinoid, 19 brachiopod, 11 snail, 9 bivalve, and 24 cephalopod species.

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[14]Shrock, Robert Rakes. *Geology at M.I.T. 1865-1965*. Cambridge: The MIT Press, p.723-762, 1977. Shrock, Wendolyn, and Robert E. Shrock. Robert R. Shrock, 1904-1993. *Journal of Paleontology*, vol. 68, p. 686, 1994.

[15]Chamberlin, T. C. Geology of Eastern Wisconsin. *Geology of Wisconsin*, Vol. II, Part II, p. 93-405. David Atwood, Madison, 1877, p.371.

Fisk Holbrook Day was born at Richmond, New York, on March 11, 1826, to Lydia Lovell Holbrook and the Reverend Warren Day.10 Day graduated from Jefferson Medical College in Philadelphia, and, in 1854, moved to Wauwatosa, Wisconsin. He would remain in Wauwatosa for nearly 40 years, and at one time was considered its most prominent citizen.

Day had a thriving private medical practice, and, by 1864, he had been appointed Physician for Milwaukee County and, later, Superintendent of the County Hospital. In these offices, Day was responsible for many health care reforms, including the establishment of a statewide system of county insane asylums. In his spare time, Day was a gentleman naturalist with many and varied interests, including archaeology, botany, architecture, and astronomy. But, above all, Day was most especially devoted to geology and paleontology. Day specialized in collecting Silurian fossils, especially from the Schoonmaker Reef near his Wauwatosa home.

Among the spectacular fossils he collected there are a 7-foot-long cephalopod and a fine specimen of the trilobite Bumastus dayi, which Harvard paleontologist Percy Raymond named in his honor in 1916. Day was once offered the then-extravagant sum of $100 for this particular specimen. By 1880, Day had amassed the finest collection of Silurian-age fossils ever made in southeastern Wisconsin. His interest in paleontology may have originated with his father, who had collected fossils back in New York. By the 1860s, the younger Day had begun to attain national recognition as a dedicated amateur paleontologist, and James Hall, whom his father had met in New York, traveled to Wauwatosa to study his fossil collection. Hall illustrated some of Day's fossils, which are now in the American Museum of Natural History collection, making them some of the earliest-described fossils from Wisconsin. Many of the specimens that Hall described were from the Schoonmaker Quarry, where he recognized the first fossil reef in North America.

Day supplied specimens and information to other professional geologists, including Fielding B. Meek (Smithsonian Institution), Charles Doolittle Walcott (future Director of the U. S. Geological Survey and Secretary of the Smithsonian Institution), E. O. Ulrich (later of the U. S. Geological Survey), Samuel Calvin (University of Iowa), Edward Drinker Cope (world-renown vertebrate paleontologist and biologist from Philadelphia), A. W. Vogdes (San Diego Natural History Society), Nathan Shaler (Harvard University), and Thomas C. Chamberlin. In 1881, Alexander Agassiz, a Harvard professor and son of the famous naturalist Louis Agassiz, purchased the bulk of Day's fossil collection, which comprised chiefly specimens from the Schoonmaker Reef, for the Museum of Comparative Zoology at Harvard University.

Although more than four tons of fossils were shipped to Harvard, where they are an important part of the paleontology collection, Day retained more than 5000 fossils in his home. In 1884, however, he sold much of his remaining collection to his friend and fellow amateur naturalist Thomas Greene of Milwaukee. These fossils are part of the Thomas A. Greene Collection, which is now housed University of Wisconsin in Milwaukee. Day's specimens probably make up the majority of the Greene Museum Wauwatosa collection. When Day died in 1899, he left behind a collection of another 10,000 fossils, which his heirs sold to the University of Michigan.[16]

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[16]Mikulic, Donald G. Milwaukee's Gentlemen Paleontologists, *Wisconsin Academy of Sciences, Arts & Letters Transactions*, vol 71, p. 5-20, 1983.

Thomas Arnold Greene was born in Providence, Rhode Island, on November 2, 1827. In 1848, having apprenticed with a druggist for 5 years in Rhode Island, Greene moved to Milwaukee to open his own drug store. He and Henry H. Button soon established a successful wholesale drug business, which made Greene a wealthy man but afforded little time for his hobbies of geology and botany. In 1878, however, his physician prescribed relaxation, and Greene turned his attention to collecting fossils in the local stone quarries. Greene pursued the ambitious goal of assembling the largest and most comprehensive fossil collection possible from the Milwaukee and Chicago area. Because of his personal dedication and wealth, Greene was able to accomplish this task, accumulating more than 75,000 fossils, before his death on September 7, 1894. His heirs built a museum building and donated the collection to Milwaukee Downer College, now part of the University of Wisconsin-Milwaukee. Like Day, Greene also loaned fossils to paleontologists, such as Hall, who borrowed 400 specimens. Greene collected primarily from the richly fossiliferous Silurian reefs, which were quarried extensively for lime in southeastern Wisconsin. His fossil collection, along with that of F. H. Day and a few other amateur naturalists, provide an irreplaceable record of the biotic composition of these reefs now that most of these sites have been largely destroyed or covered.[17]

The naturalists' collections inspired a lot of paleontological research on fossil taxa by many prominent paleontologists, including Stuart Weller, A. F. Foerste, P. E. Raymond, R. P. Whitfield, J. Clarke, and James Hall. These fossils were highly sought after by prominent museums of the day, and through donation, exchange and sale, individual specimens and entire collections found their way into those institutions. Some of the earliest large collections at such prominent institutions as Harvard's Museum of Comparative Zoology included many fossils from Schoonmaker Reef.

In addition to being a major source of fossils at many museums, the Schoonmaker Reef is also recognized as the birthplace of one of the most prominent geological organizations in the U.S. It was at this site, on the 1937 Tri-State Geological Field Trip, that several geology professors from various small colleges decided they needed a vehicle to communicate effectively with one another. The result was the National Association of Geology Teachers, whose publication, The Journal of Geological Education, disseminates information useful in teaching geology.

Schoonmaker Reef remains important to geology because it is the first fossil reef recognized in North America. The designated rock face remains much the same way as it appeared in the late nineteenth century. Therefore, the actual features used by the early geologists to formulate the important fossil reef concept can still be seen. As a result, being able to examine the Schoonmaker Reef exposure allows us to better understand earth history as well as the historical development of a significant geological idea. This understanding is important in the history of science and is essential to refining basic geologic concepts as they evolve. Because of this and the fact that the site contains some unique rock features, the Schoonmaker Reef site will continue to inspire new geological investigations and may yield important additional information during future study.

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[17]Mikulic, Donald G. Milwaukee's Gentlemen Paleontologists, *Wisconsin Academy of Sciences, Arts & Letters Transactions*, vol 71, p. 5-20, 1983. Kluessendorf, J. and Mikulic, D. G. Mr. Greene and his brachiopods, *Rocks & Minerals* 72:1 (1997), pp.50-55.

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Previous documentation on file (NPS):

__ Preliminary Determination of Individual Listing (36 CFR 67) has been requested.
__ Previously Listed in the National Register.
__ Previously Determined Eligible by the National Register.
__ Designated a National Historic Landmark.
__ Recorded by Historic American Buildings Survey: #
__ Recorded by Historic American Engineering Record: #

Primary Location of Additional Data:

__ State Historic Preservation Office
__ Other State Agency
__ Federal Agency
__ Local Government
__ University
__ Other (Specify Repository):

10. GEOGRAPHICAL DATA

Acreage of Property: approximately 1.4 acres

UTM References:	Zone	Easting	Northing
A	16	419060	4766310

Verbal Boundary Description:

Schoonmaker Reef is part of a rock bluff and old quarry face in the north bank of the Menomonee River valley in the SE1/4, SW1/4, SE1/4, and SW1/4, SE1/4, SE1/4, Section 22, T 7N, R 21E, Wauwatosa Township, Milwaukee 7.5' quadrangle, Wauwatosa, Milwaukee County, Wisconsin. The northern boundary of the designated portion of the reef is defined by the top of the rock bluff along the northern property boundary of Western Metal Specialty (a division of Western Industries Incorporated). The western boundary is defined by the western boundary of the Western Metal Specialty property from the north edge of the property south to the foot of the bluff. The southern boundary is defined by the foot of the bluff and old quarry face along the north edge of the Western Metal Specialty buildings and fence-line. The eastern boundary is chosen as a line extending from the north edge of Western Metal Specialty property south to the bottom of the bluff along a line projected south from the end of 64th street.

Boundary Justification:

The boundaries were chosen to include the largest contiguous portion of exposed reef, the remaining nineteenth century quarry face and adjacent, natural bluff. No additional buildings, sites, structures, or objects are included within the boundary.

11. FORM PREPARED BY

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