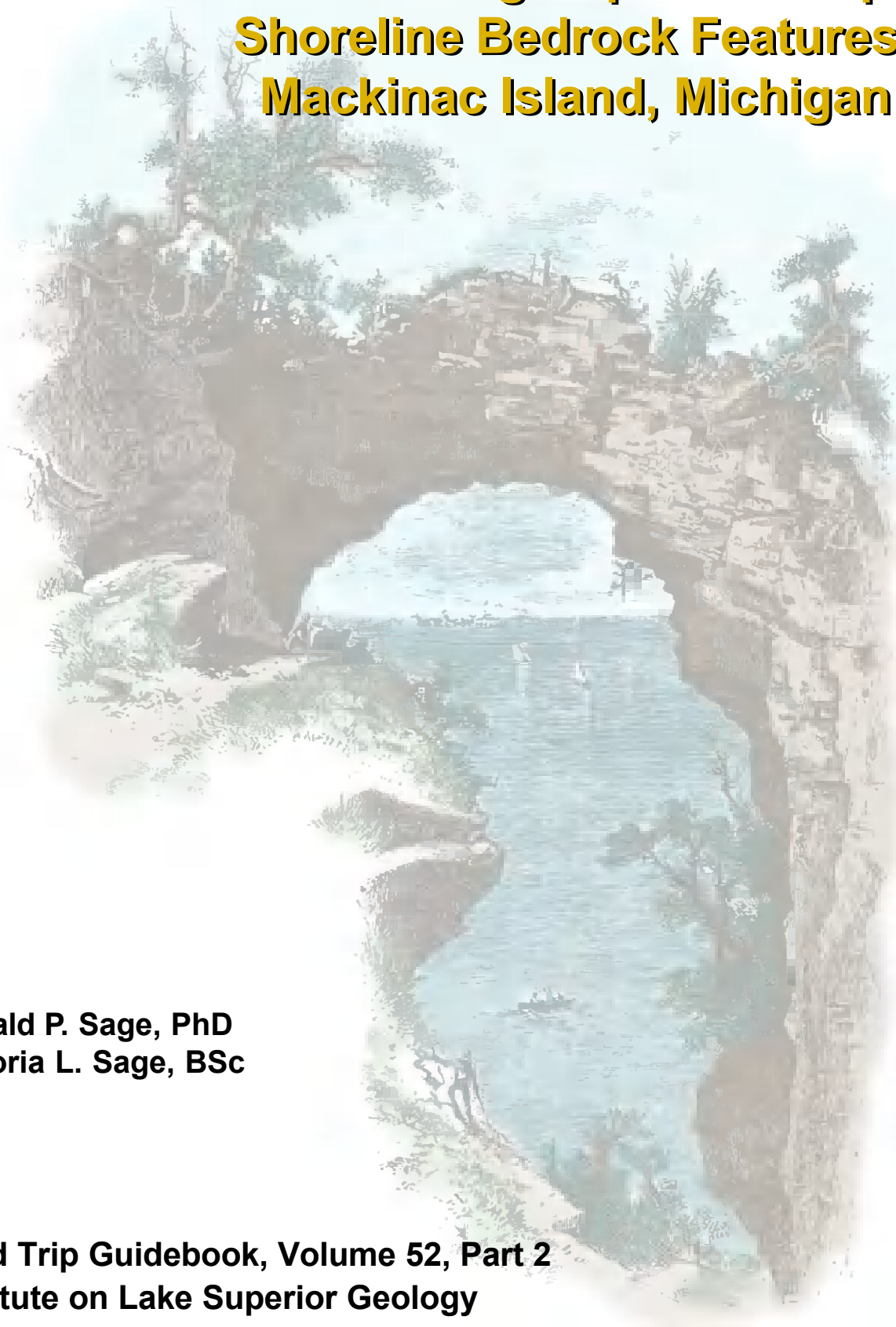


Glacial Lakes Algonquin and Nipissing Shoreline Bedrock Features: Mackinac Island, Michigan



By:

Ronald P. Sage, PhD

Victoria L. Sage, BSc

2006

Field Trip Guidebook, Volume 52, Part 2

Institute on Lake Superior Geology

Sault Ste. Marie, Ontario

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On the cover: Lithograph of Arch Rock on east shore of Mackinac Island. See page 16-17. Colorization: V.Sage.

Acknowledgements

This one-day trip is designed to visit all the prominent rock exposures carved by glacial Lakes Algonquin and Nipissing into the limestones exposed on Mackinac Island. The senior author has more than 30 years of geological field experience working in the Canadian Shield. The bedrock exposures on Mackinac Island are of interest to the author as they relate to the island economy.

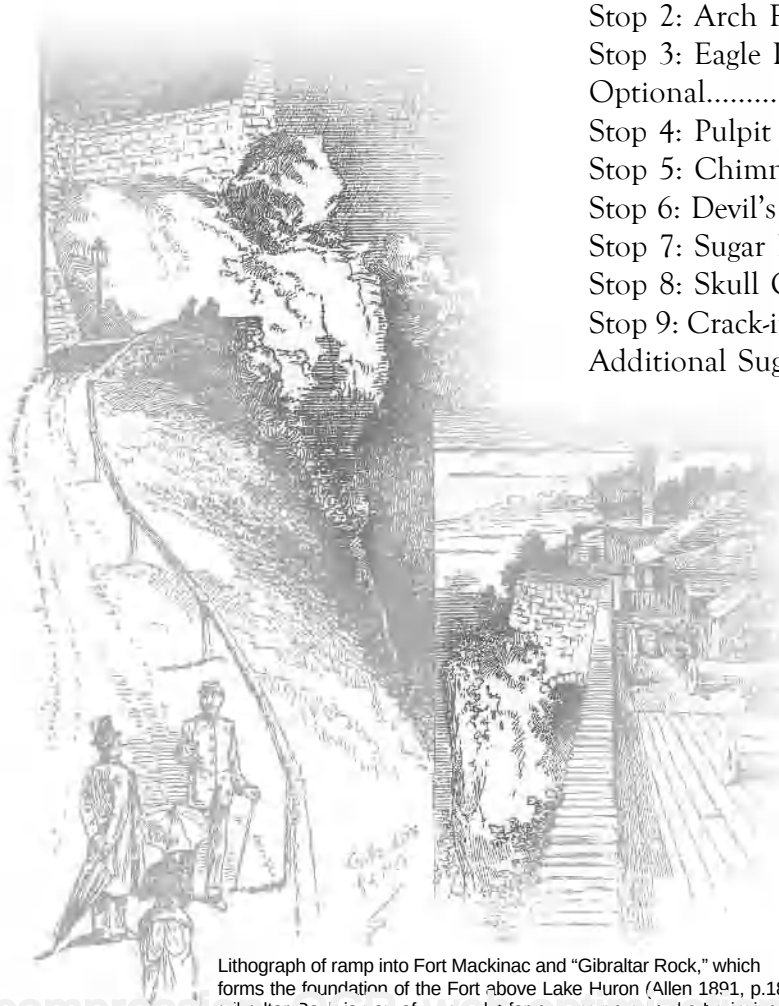
Victoria L. Sage, BSc, has worked in scientific and technical communication for the medical field. She has provided the computer programming skills required to put this guidebook together and has provided editorial assistance with text and guide format.

Both authors have worked on Mackinac Island as Guest Service Representatives for Mackinac State Historic Parks. During this period of employment Mr. Greg Hokans, Marketing; Mr. Phil Porter, Museum Programs and Dr. David Armour, Deputy Director offered encouragement and support to the staff working on the island and assisted in locating various published articles describing the features of Mackinac Island. Mr. Steve Brisson, Curator of Collections, provided copies of most of the historical lithographs of rock formations used in this guide that have made the Island famous.

Carol R. Sage, MS, has provided editorial assistance in preparing the Guidebook.

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Lithograph of ramp into Fort Mackinac and "Gibraltar Rock," which forms the foundation of the Fort above Lake Huron (Allen 1891, p.18). Gibraltar Rock is part of a complex of formations along Lake Huron's shore.

Mackinac Island occurs between Lakes Huron and Michigan and just south of Lake Superior. It lies on the northeast rim of the Michigan Basin, a basin structure that underlies the state of Michigan and portions of the states of Wisconsin, Illinois, Indiana, Ohio and the province of Ontario, Canada (Figures 1 and 2). It is a continental scale basin that is generally poorly exposed except in scattered locations along its rim where the older rocks forming the basin are sometimes exposed. Within central Michigan and in the center of the basin, the rocks exposed along the rim are buried beneath many thousands of feet of younger rocks.

Mackinac Island represents one of the best exposures of rocks of Silurian (440-395 million years) and Devonian (395-345 million years) age along the basin perimeter, and these Silurian and Devonian rocks project above the highest water level of the older glacial Lake Algonquin. The effects of coastline erosion are well

recorded in the wave cut cliffs and abandoned beaches found on the island. The island offers an excellent opportunity to examine shoreline features related to the glacial Lakes Algonquin and Nipissing formed at the edge of the receding continental ice sheets of 10,000 to 12,000 years ago. Since shoreline features are commonly in unconsolidated material only the latest events are recorded in these materials, the earlier features being obliterated by later events. It is anticipated that the actual events are much more complex than presented here. The present island contains a surface area of 2,221 acres (Russell, 1905, p. 56).

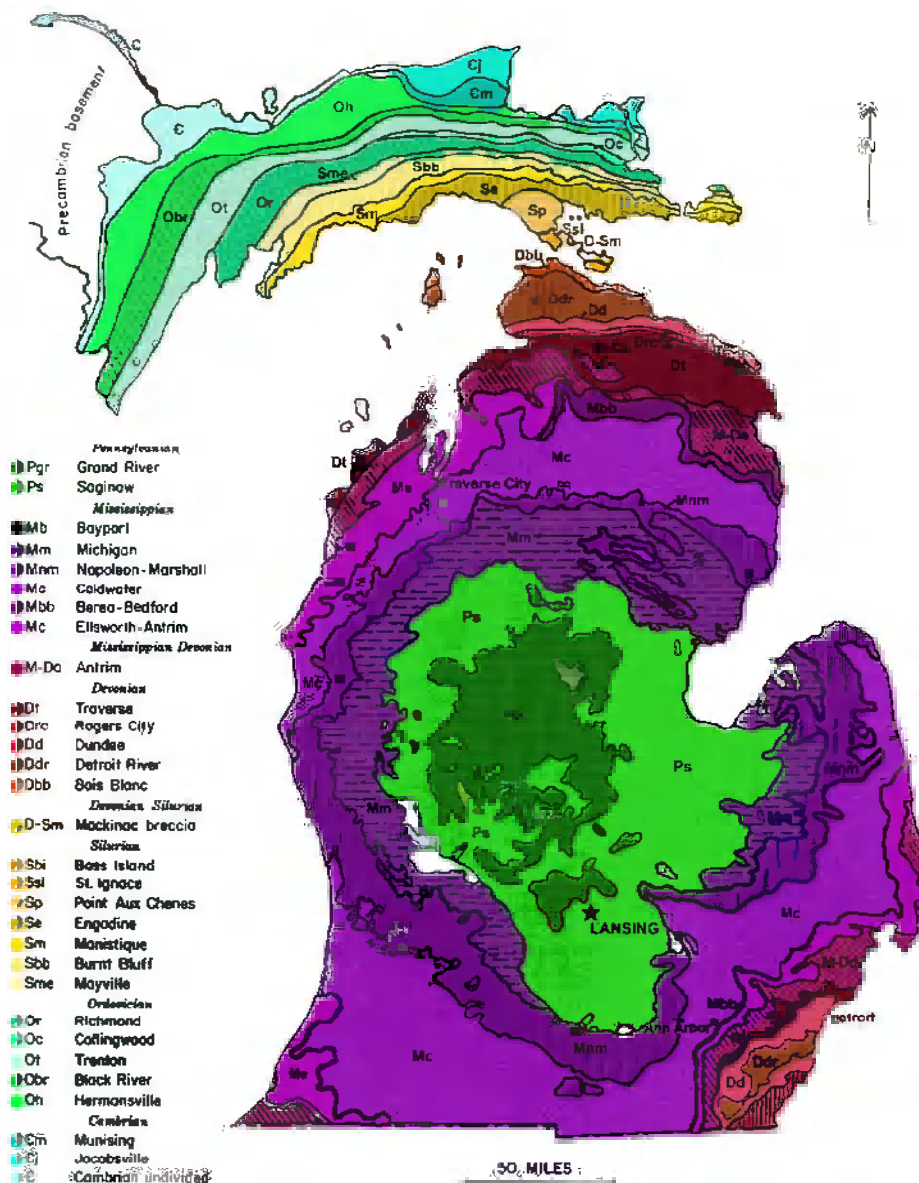


Figure 1: Bedrock geology of the state of Michigan (Dorr and Eschman, 1970).

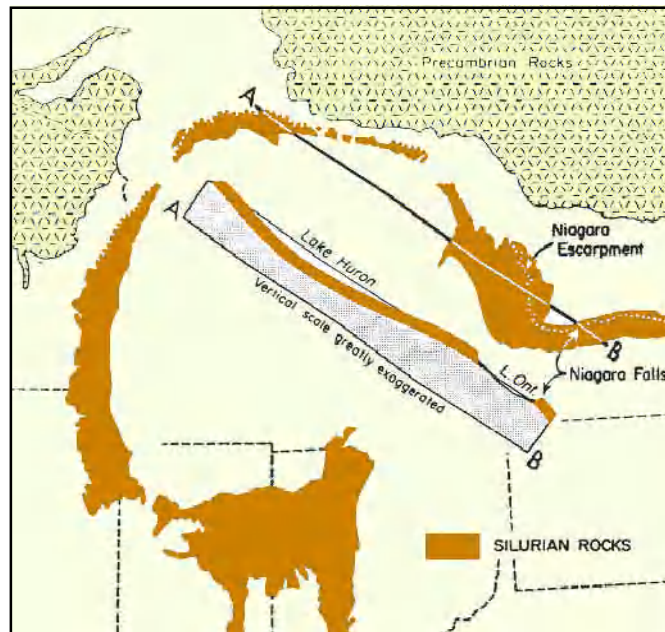


Figure 2: Outline map of the distribution of Silurian age rocks around the Michigan basin (Dorr and Eschman, 1970, p. 104). The line of section passes very close to Mackinac Island near point A.

Silurian – Devonian

Mackinac Island is composed of rocks of Silurian and Devonian age. The lower Silurian stratigraphy consists of the Point aux Chenes or Salina formation and the upper Devonian consists of the Bois Blanc and Detroit River formations (Figures 3, 4 and 5).

Point aux Chenes formation

The Silurian Point aux Chenes formation consists of upper beds of variegated shale and thin brown dolomites, which overlie a lowersalt series that can contain 1600 feet of salt in a number of beds (Landes et al., 1945, p. 159). The salt beds are thin along the northeast and northwest flanks of the Michigan Basin and the upper salt beds have been leached from the formation in upper Michigan (Landes et al., 1945, p. 159-160). Landes et al., (1945, p. 161) report that shale beds commonly separate salt beds in the upper half of the formation and dolomite in the lower half. A basal dolomite occurs everywhere below the lowest salt and, where unleached, the Point aux Chenes formation in northeastern Michigan has a thickness of 1175 to 2886 feet (Landes et al, 1945, p.161).

Bois Blanc formation

Landes et al., (1945, p. 163) report that the Bois Blanc formation contains Onondaga fossils of lower middle Devonian age. The formation consists of limestone and dolomite and ranges from 165 to 1000 feet in thickness in upper Michigan (Landes et al., 1945, p. 165-166).

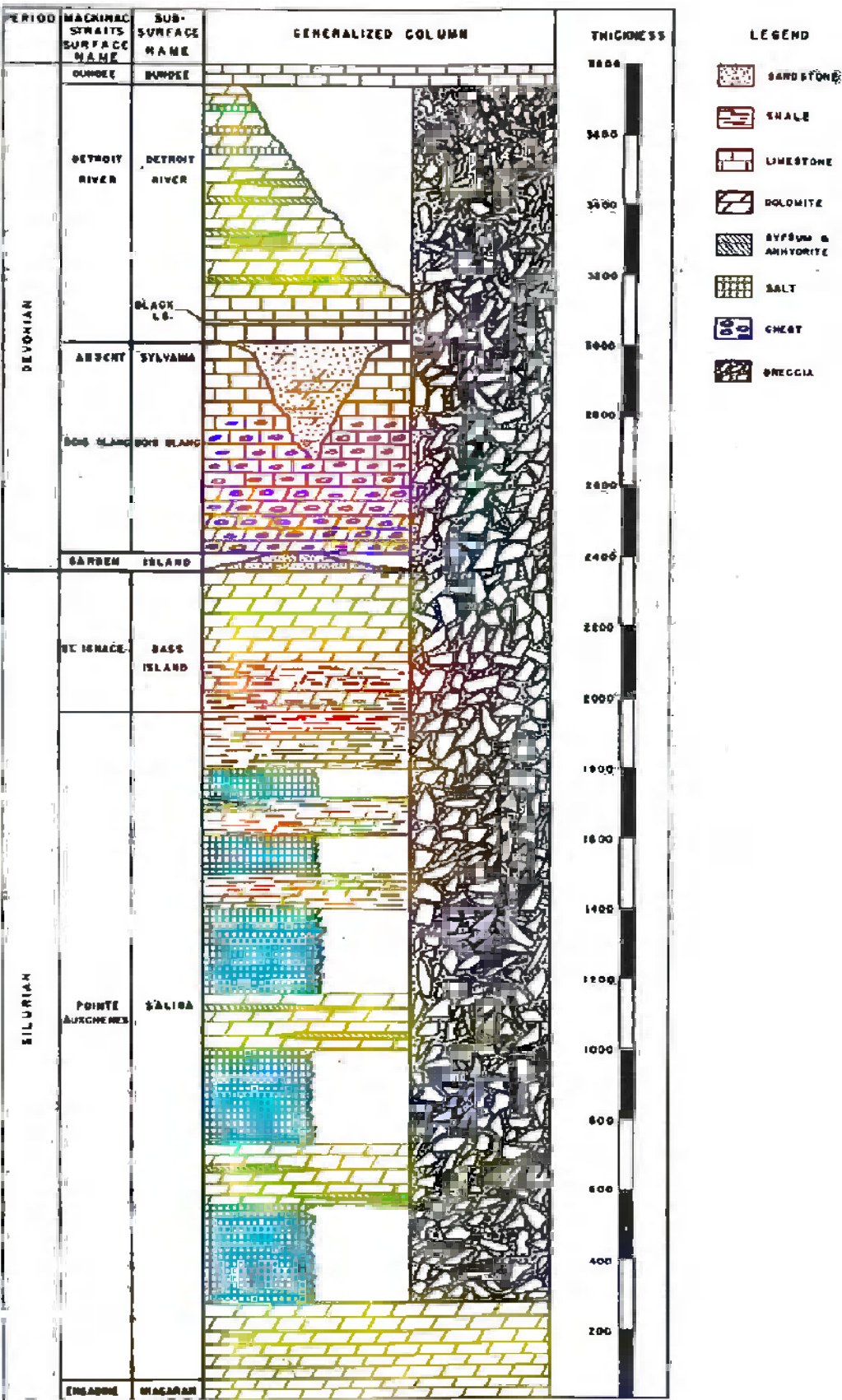


Figure 3: Generalized columnar section of the region around the Mackinac Straits (Landes et al., 1945, p. 154).

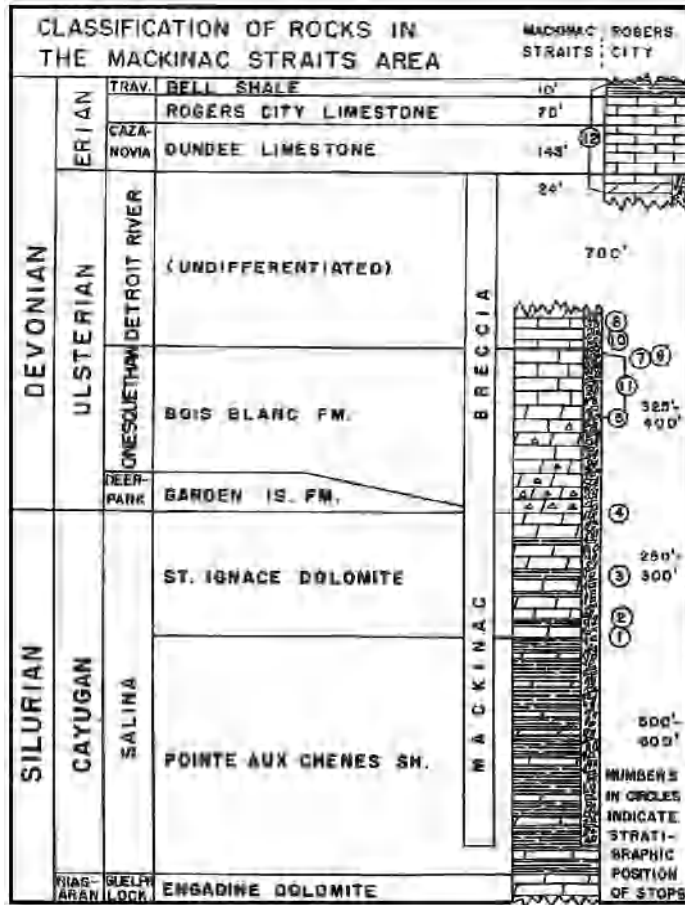


Figure 4: Generalized stratigraphic column at the Straits of Mackinac showing the distribution of Mackinac breccia across the Silurian and Devonian time periods (Sheldon, 1959, p. 12).

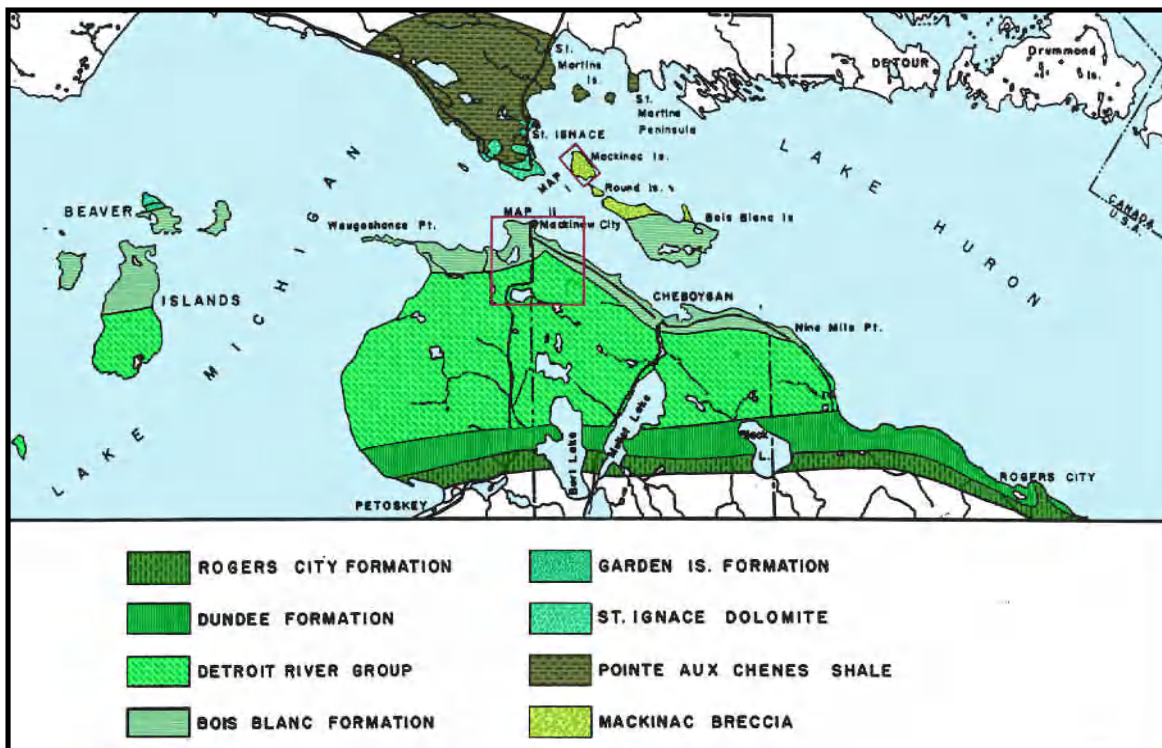


Figure 5: Generalized surface geologic map of the Mackinac Straits area that displays the distribution of the Mackinac breccia (Sheldon, 1959, p. 3).

Detroit River Formation

This formation is not exposed in the area of Mackinac Island. The lower part of the formation consists of limestone and dolomite that is difficult to separate from the Bois Blanc formation (Landes et al., 1945, p. 174). Above the basal limestone of the Detroit River formation, there is an evaporate series consisting of dolomite, anhydrite and salt that in the center of the Michigan Basin may be 1145 feet in thickness (Landes et al., 1945, p. 174). The evaporate thickness ranges up to 600 feet along the periphery of the basin, but the evaporate series is absent along the rim in the vicinity of Mackinac Island (Landes et al., 1945, p. 174-175).

Mackinac Breccia

Mackinac breccia is the most prominent rock type found on Mackinac Island when one examines the rock formations created by the interaction of glacial Lakes Algonquin and Nipissing. All the rock formations that have received special attention on Mackinac Island are composed of this rock unit. The term "Mackinac breccia" was originally applied by Douglas Houghton, first state geologist for the state of Michigan (Shelden, 1959, p. 19).

The Mackinac breccia is an indurated breccia although, in the region of Mackinac Island, non-indurated breccia is the dominate lithology (Landes et al.; 1945, p. 135). Mackinac Island and the St. Ignace peninsula are composed of a non-indurated megabreccia and a small amount of transformational breccia (Landes et al., 1945, p. 134-135). Landes et al. (1945, p. 133) report that the cement to the indurated breccias is carbonate.

The indurated Mackinac breccia is easy to recognize in an outcrop by its pock-marked surface that is caused by differential weathering of the breccia fragments. The more soluble fragments are removed leaving large cavities in the breccia units giving rise to the well-developed pock-marked surface. The fragments are angular and up to 10 feet or more in maximum length and consist of a mixture of rock fragments from units higher in the stratigraphy. The resistance to weathering of the indurated breccia suggests that some silica also serves as a cementing agent for the breccia fragments. If all the cement was carbonate, it would be dissolved upon exposure to weathering or solution and the Mackinac breccia would collapse and become indistinguishable from the regional brecciation.

Erosion of the regional limestones of Silurian and Devonian age by the glacial Lakes Algonquin and Nipissing has removed the softer, less indurated material enclosing the indurated breccia masses. This has resulted in the prominent rock formations now preserved along the former coastlines of the glacial lakes.

Mackinac Island occurs in a broad zone of brecciation found at the northeast corner of the Michigan Basin (Figure 6). Salt decreases in thickness from 1200 feet to 0 feet northwest of Alpena County and north of Cheboygan County, Michigan, and the zone of brecciation corresponds with the disappearance of salt in the stratigraphy. This salt has a blunt edge suggesting this boundary may be a leached rather than a natural, depositional edge (Figure 7) (Landes et al., 1945, p. 146).

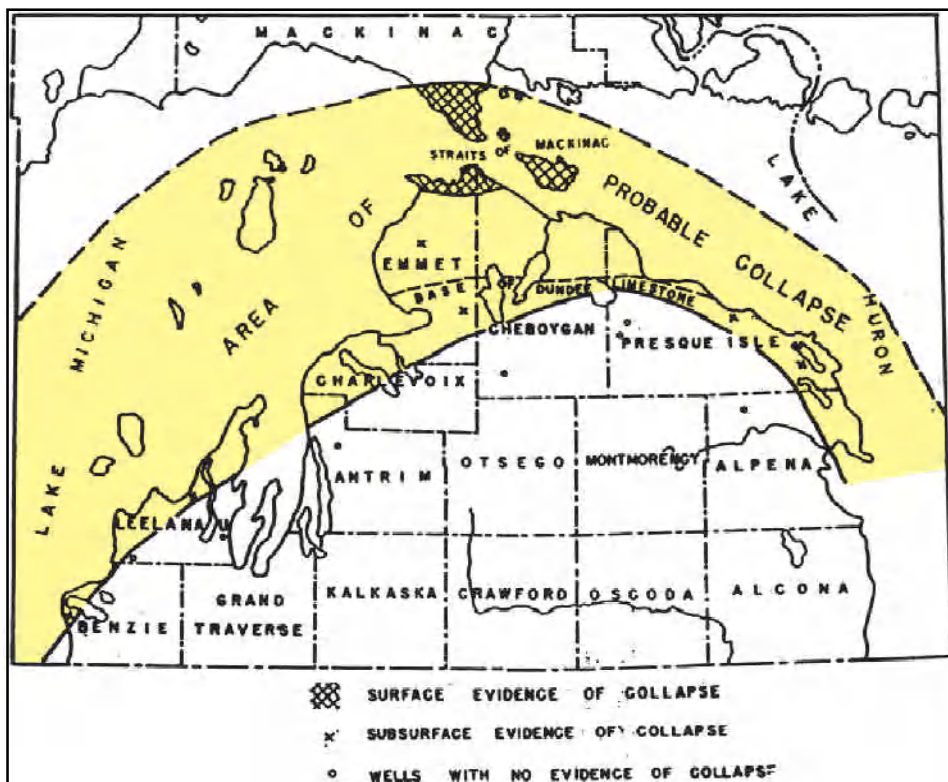


Figure 6: Map of the Mackinac Straits area showing the region of solution collapse and Mackinac breccia distribution (Landes et al., 1945, p. 175).

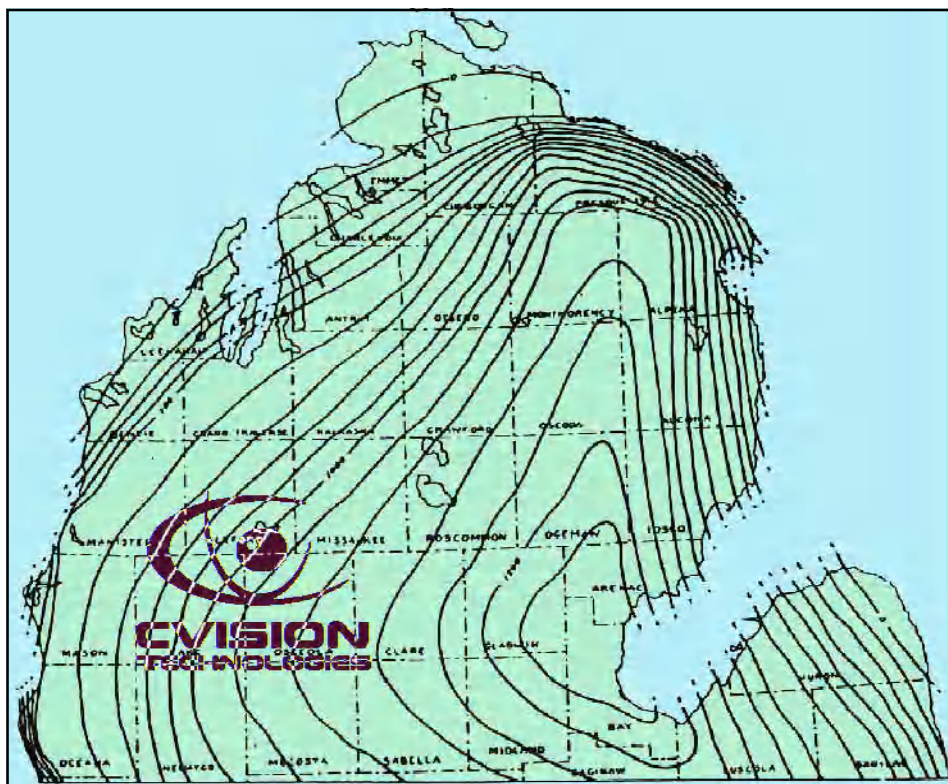


Figure 7: Isopach map showing combined thickness of Salina salt (Landes et al., 1945, p. 146). The salt disappears abruptly just southeast of Mackinac Island and outcroppings of Mackinac breccia.

Breccia Origin

The origin of the Mackinac breccia has been discussed by Stanley (1945), Landes et al. (1945), and Shelden (1959). The most complete discussion of the origin is that of Landes et al. (1945), who completed a detailed summary of all previous work in determining breccia development. Landes et al., (1945, p.142) attribute the development of a modern model for the formation of the Mackinac breccias to Mr. Henry H. Hindshaw, former assistant to the state geologist for New York.

A brief summary of the model for the formation of the Mackinac breccia is as follows (Landes et al., 1945, p. 143-145) and has been previously summarized by Shelden (1959).

The land surface is floored with rocks of Niagara age (Silurian) and was submerged beneath the Pointe aux Chenes Sea. During this time, several hundred feet of shale, dolomite, salt and gypsum were deposited. Post-deposition, emergence followed along the rim of the Michigan Basin and percolating ground waters leached salt from the rim of the salt-bearing rocks. Caves were produced when the salt in the Pointe aux Chenes was removed from rocks lying above the ground water table. The solution of the salt created caverns that became unstable and collapsed.

There were two types of collapse: regional and local. The collapse was probably sudden and the overlying rocks broke into angular fragments of all sizes. This probably created localized sink holes above the collapse, and the larger areas of regionalized collapse created tilted stratigraphy in the region. The period of collapse took place during emergence following Detroit River deposition and preceding Dundee deposition. This collapse took place over a time interval rather than at a specific time. Shelden (1959, p. 23) reports slickensides and normal faults within larger blocks of collapsed rock. The Mackinac breccias occur in columns, and some clasts may represent down drop of 600 to 750 feet (Landes et al., 1945, p. 129). After collapse, erosion of the surface developed a peneplane and surface irregularities (such as sinkholes) were filled. The limestones of the Dundee formation were deposited on this peneplane surface.

Percolating ground waters gradually cemented the collapse breccias. Recent emergence has brought the rocks to surface where differential erosion has completed sculpting the breccias into the forms observed on the Island.

Age of brecciation

Landes et al., (1945, p.137) interpret the age brecciation as likely post-Detroit and pre-Dundee. The brecciation likely took place over an extended period of time.

Recent

Mackinac Island has been affected by recent glaciation of the Wisconsin period and glacial Lakes Algonquin and Nipissing following retreat of the glaciers. Glacial Lake Algonquin represents an age of 11,000 to 12,000 years ago, and glacial Lake Nipissing represents an age of approximately 4,000 years ago. Viewing of the island from St. Ignace and Mackinaw City presents a profile of an island with a hump in the middle with two relatively flat planes separated by a steep slope (Figures 19 and 20). The present mean level of Lake Huron is 580.37 feet above sea level and the highest point on the island is at Fort Holmes, 900.5 to 904.1 feet above sea level (Stanley, 1945, p. 65, 72-73). The highest level reached by glacial Lake Algonquin is 809 feet above sea level (Taylor, 1915, p. 69), which is the highest peneplane observed in the profile of the island. This former high water level is approximately 229 feet above the present lake level (Taylor, 1915, p. 69). That portion of Mackinac Island lying above this high water mark is referred to as the "Ancient Island". The "Ancient Island" part of Mackinac Island was glaciated during the Wisconsin period and a few glaciated boulders, cobbles and pebbles displaying glacial striations can be found in the area (Stanley, 1945, p. 13). The ice moved in a southwest direction and left a thin covering of glacial till on the "Ancient Island" (Stanley, 1945, p. 12-13). Glacial ice retreated northeastward in a series of retreats and advances with the retreats exceeding the advances (Landes et al., 1945, p. 10). The process of retreat-and-advance by glacial ice will destroy evidence left in unconsolidated materials from earlier (older) retreats and advances and only the last event is preserved in the geological record.

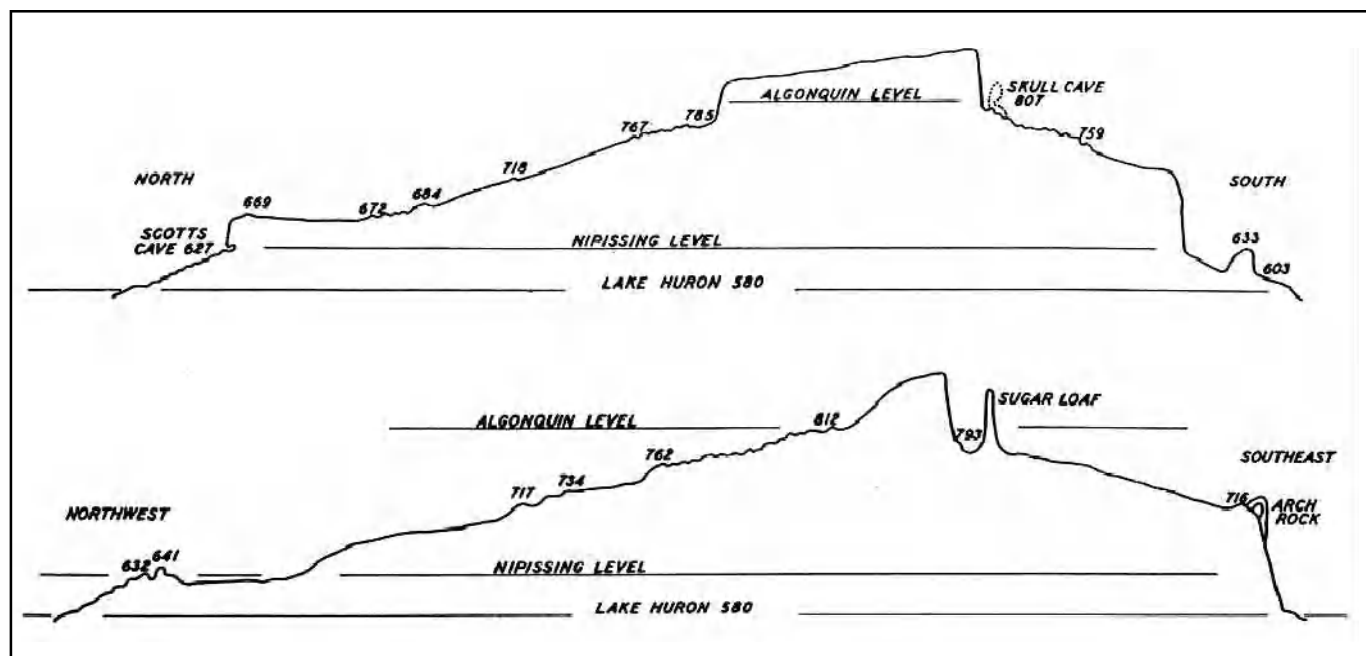


Figure 8: Profile across Mackinac Island showing former shore levels looking east from St. Ignace (Stanley, 1945, p. 22).

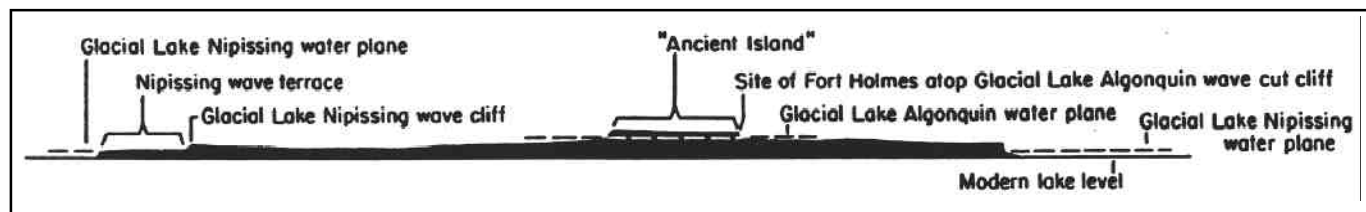


Figure 9: Profile of Mackinac Island looking eastward from St. Ignace with the various glacial lake levels noted (Dorr and Eschman, 1970, p. 177).

Upper Algonquin

The Lake Algonquin shoreline is a well-developed major feature in the region of the Straits of Mackinac (Landes et al., 1945, p. 11) (Figures 10 and 11). Landes et al. (1945, p. 11-12) indicate that drainage from this glacial lake was eastward towards North Bay and Mattawa, Ontario. But, as the ice sheet withdrew, isostatic rebound caused uplift to the northeast until the waters overflowed to the south at Port Huron and Chicago. This is a three-stage outlet for Lake Algonquin. As isostatic uplift continued in response to the retreating ice sheets, the lake level was stabilized by the outflow through Port Huron and Chicago and the eastward drainage abandoned (two stage outlet) (Landes et al., 1945, p. 12). As uplift continued, the lake level continued to recede and gradually erosion along the Port Huron drainage caused the abandonment of the Chicago outlet (Landes et al., 1945, p. 12). Beach lines associated with the Upper Algonquin of glacial Lake Algonquin lie between 799 and 759 feet above sea level and the type section is the Short Rifle Range lying between Fort Mackinac and Fort Holmes (Stanley, 1945, p. 31-32). Taylor (1915, p. 69) reports that the highest beach level is 809 feet above sea level or approximately 229 feet above the present level of Lake Huron. Glacial strata have not been observed on glacial boulders below the level of 205 feet above lake level (Taylor, 1892, p. 212-213).

Lower Algonquin

Below the Upper Algonquin is a zone relatively free of beach development, which is thought to represent a period of relatively rapid falling of the lake level (Stanley, 1945, p.32). This zone lies between approximately 762 and 635 feet above sea level (Stanley, 1945, p. 32-36). The best-described beach line in the Lower Algonquin is the "Battlefield Beach" at an elevation of 718 feet above present sea level located in the north central part of the island (Stanley, 1945, p. 33-34; Landes et al., 1945, p. 13). Stanley (1945, p. 35-36) and Landes et al. (1945, p. 13-14) describe other locations as examples of beaches within the Lower Algonquin. The Lower Algonquin beaches are characteristically less well developed than the Upper Algonquin. The quick lowering of the lake level is in response to the opening of discharge channels to the east as the ice sheet retreats (Landes et al., 1945, p. 13). The lowering probably extended to much lower levels than present lake levels, and a buried river valley between

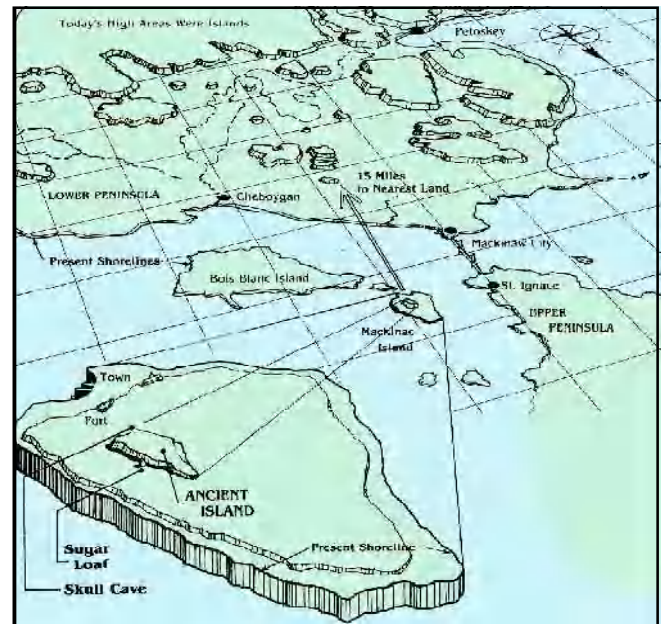


Figure 10: High water level for glacial Lake Algonquin approximately 11,000 years ago. This illustration indicates most of the region was under water. This view is oriented north looking south (Porter and Nelhiebel, 1984, p. 11).

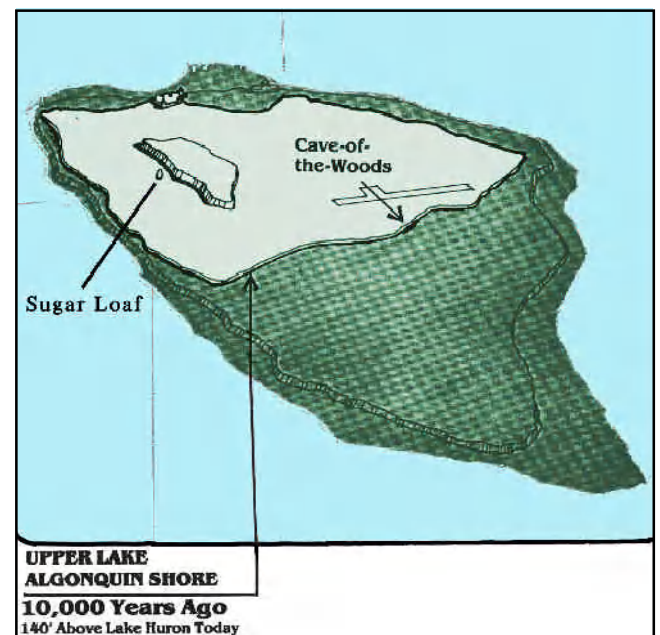


Figure 11: Upper glacial Lake Algonquin shoreline approximately 10,000 years ago (Porter and Nelhiebel, 1984, p. 47).

Lake Huron and Lake Michigan was probably reactivated (Landes et al., 1945, p. 14). At this low water stage the present islands within the Straits did not exist but were part of what is now the mainland.

Landes et al. (1945, p. 14) indicate that the lake levels ceased falling when the lowest outlet from the Huron Basin, the Mattawa Valley (east of North Bay), was freed of ice and unobstructed flow eastward was established. The removal of glacial obstruction left only isostatic rebound as a mechanism of changing lake water flow. The Mattawa Valley is located to the east and northeast of Mackinac Island where this continental uplift would be most effective (Landes et al., 1945, p. 14). Continental uplift to the east generated continually rising lake levels until southern flow was reestablished, and then eastward flow through the Mattawa Valley was terminated (Landes et al., 1945, p. 14). As the lake waters rose, topographic features created in the unconsolidated glacial deposits as the lake level dropped were obliterated or buried beneath the rising waters.

Submerged (buried) stream valley of the Straits of Mackinac

The presence of a submerged valley in the Straits of Mackinac was disclosed by soundings between 1918 and 1924 (Stanley, 1938, p. 966) (Figure 12). This valley loops around Mackinac Island to the north and is likely the result of Pleistocene or earlier erosion (Stanley, 1938, p. 966, 974). This valley was likely filled with glacial drift during the Wisconsin ice advance and cleaned out during the low water level between the glacial Lakes Algonquin and Nipissing (Stanley, 1938, p. 974). Stanley (1938, p. 966) and Sheldon (1959 p. 59) suggest flow along this valley was towards to the east. This valley lies 150 to 250 feet below the present level of Lake Huron with the greatest depths being recorded through the Straits near Mackinaw City (Stanley, 1938, p. 968). Stanley (1938, p. 968) reports the greatest depth to be 289 feet below present lake level. This valley exceeds 70 miles in length (Stanley, 1938, p. 966).

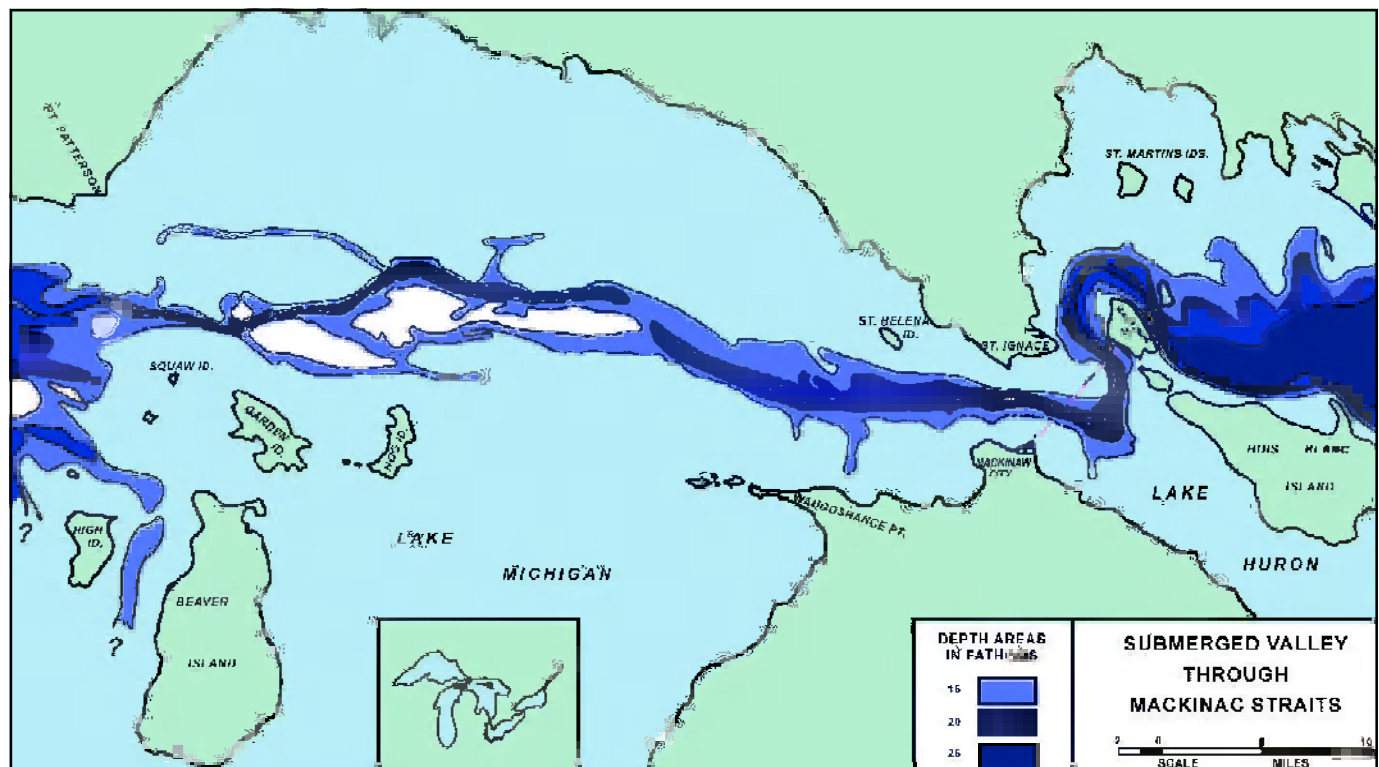


Figure 12: Submerged valley through the Straits of Mackinac (Stanley, 1938, p. 967). At this time, the water level of Lake Huron was approximately 120 feet lower than it is today.

Nipissing Shorelines

As isostatic rebound continued, the level of Lake Huron returned to a level 50 feet above its present level (Stanley, 1945, p. 39) (Figure 13). Stanley (1945, p. 39) suggests the process of uplift and higher water levels took place slowly over a period of several thousand years and the previous geological features in unconsolidated glacial material were destroyed. Nipissing beaches reached elevations of 629 to 635 feet above sea level (Stanley, 1945, p. 42). At the time of Nipissing beach development, 85% of the isostatic rebound had been completed (Shelden, 1959, p. 59; Landes et al., 1945, p. 14). Nipissing beaches do not completely enclose Mackinac Island but obliquely transect the lower Algonquin beaches (Stanley, 1945, p.39, 41). Nipissing beaches are preserved on the northwest and southeast portions of Mackinac Island; the City of Mackinac is built on Nipissing beaches (Landes et al., 1945, p. 15; Stanley, 1945, p. 44; Leverett and Taylor, 1915, p. 452).

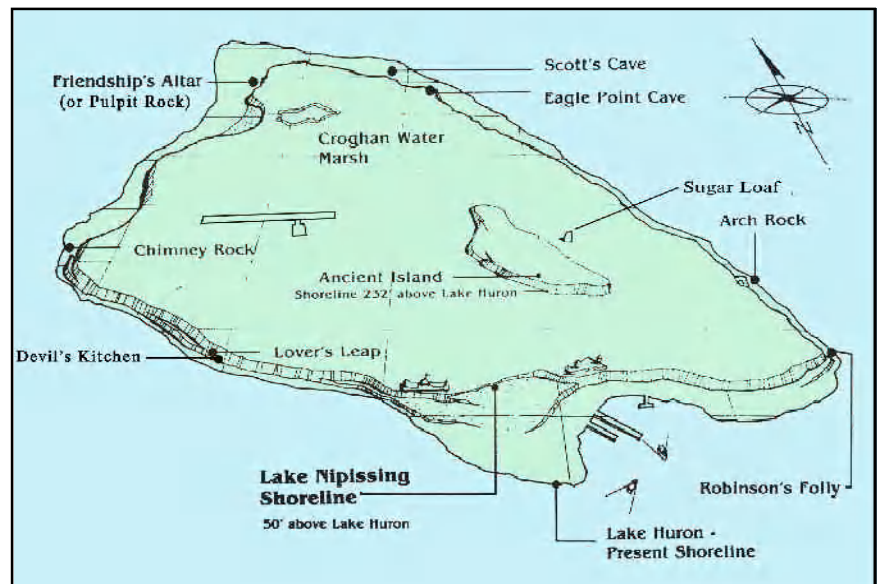


Figure 13: Modified oblique view of Mackinac Island showing the shoreline of glacial Lake Nipissing with scenic rock formations noted (Porter and Nelhiebel, 1984, p. 13). Friendship Altar and Pulpit Rock are the same feature. This shoreline is approximately 4,000 years old.

Post-Nipissing

During post-Nipissing time, Lake Huron drains south past Port Huron and is approximately 55 feet lower than the highest level of glacial Lake Nipissing (Sheldon, 1959, p. 63).

Stop Descriptions

The Mackinac Island field trip is a one-day trip that is designed to visit all the major bedrock outcrops that contribute to the scenery of the island. These outcrops have been described in previous technical and non-technical literature for more than 150 years. These scenic bedrock exposures have contributed much to the island economy over the years. Figure 14 is a simple sketch of Mackinac Island showing the location of the sites on this tour and those geographic features mentioned in this text. The island's major bedrock outcrops are the direct product of the interaction between glacial lakes and bedrock during the retreat of the Wisconsin ice sheets.

Upon arrival, one disembarks on the south side of Mackinac Island where the glacial Lake Nipissing beach deposits are best developed. Fort Mackinac is built on the Lake Nipissing sea cliffs. Below this cliff lie the deposits of glacial Lake Nipissing. These beach deposits are largely obscured in most areas by subsequent construction. The sea cliff below Fort Mackinac has a prominent rock formation called Gibraltar Rock that projects out from the cliff but is not detached. Continued erosion around this prominent rock could have caused its detachment from the sea cliff to create a sea stack (see the Table of Contents for a lithograph of Gibraltar Rock). The cliff face on which Fort Mackinac is built is fenced off from the public and, if time permits, a closer examination can be made after completion of the field trip.

The field trip consists of two parts. The first part is a trip around the island on Shoreline Road to examine the erosive activities of glacial Lake Nipissing. The second part is an interior tour of the island to examine the erosive activities of glacial Lake Algonquin.

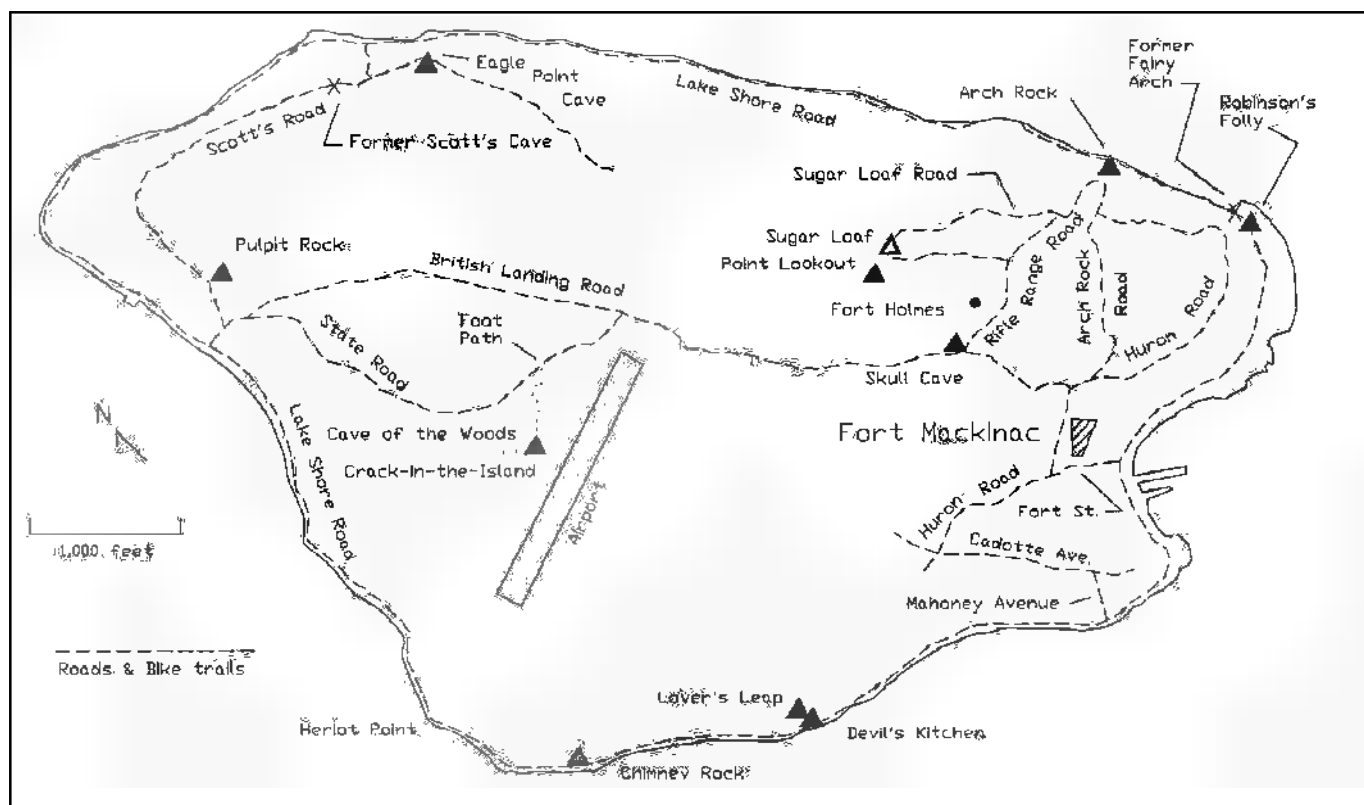


Figure 14: Sketch map indicating the sites of rock outcroppings to visit and those geographic features needed to locate them.

Stop1: Robinson's Folly

Moving eastward along Shoreline Road (through the settlement) approximately one mile from the landing on Mackinac Island, the first outcrop one encounters is a prominent cliff face of Mackinac breccia known as Robinson's Folly (Figure 15). This prominent headland is reportedly named after Captain Daniel Robertson of the British 84th Regiment who supposedly built a summer house on the promontory, which subsequently collapsed into Lake Huron (Wood, 1918, p. 584-585). The name "Robinson" is a corruption from the French addressing him as "Robinçon" (Wood, 1918, p. 584-585). Meade (1986 [1897], p. 165-170) presents five stories on the naming of Robinson's Folly. The reader should refer to Meade's lengthy discussion of the name if interested in the origin.

Robinson's Folly is 127 feet (Van Fleet, 1970, p. 147; 1882, p. 24) or 128 feet (Winchell, 1861, p. 210) above the present level of Lake Huron. It represents a prominent portion of the sea cliffs formed along the eastern side of Mackinac Island through the erosive action of glacial Lake Nipissing.

A short distance north of Robinson's Folly is a second outcropping of breccia that was the former site of a sea arch known as Fairy Arch (Figure 16). This arch was destroyed during road construction around the island, but a photograph was published by an anonymous source (1899, p. 5).

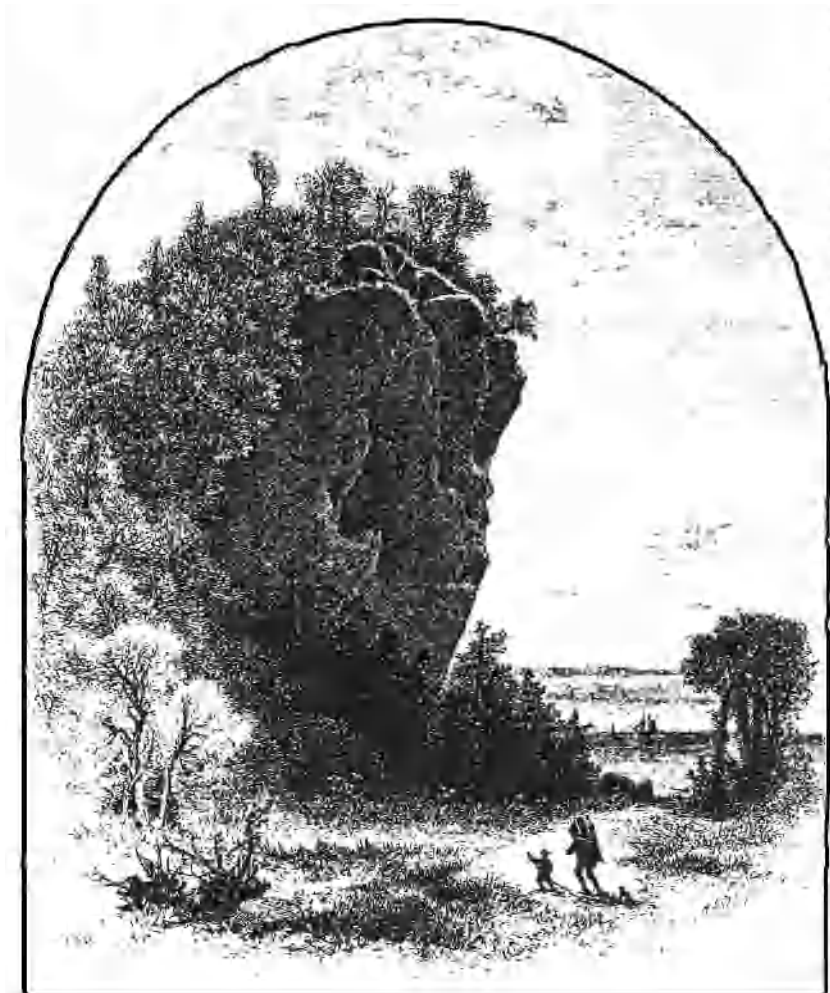


Figure 15: Lithograph of Robinson's Folly, a glacial Lake Nipissing sea cliff (Woolson, 1894, p. 289).

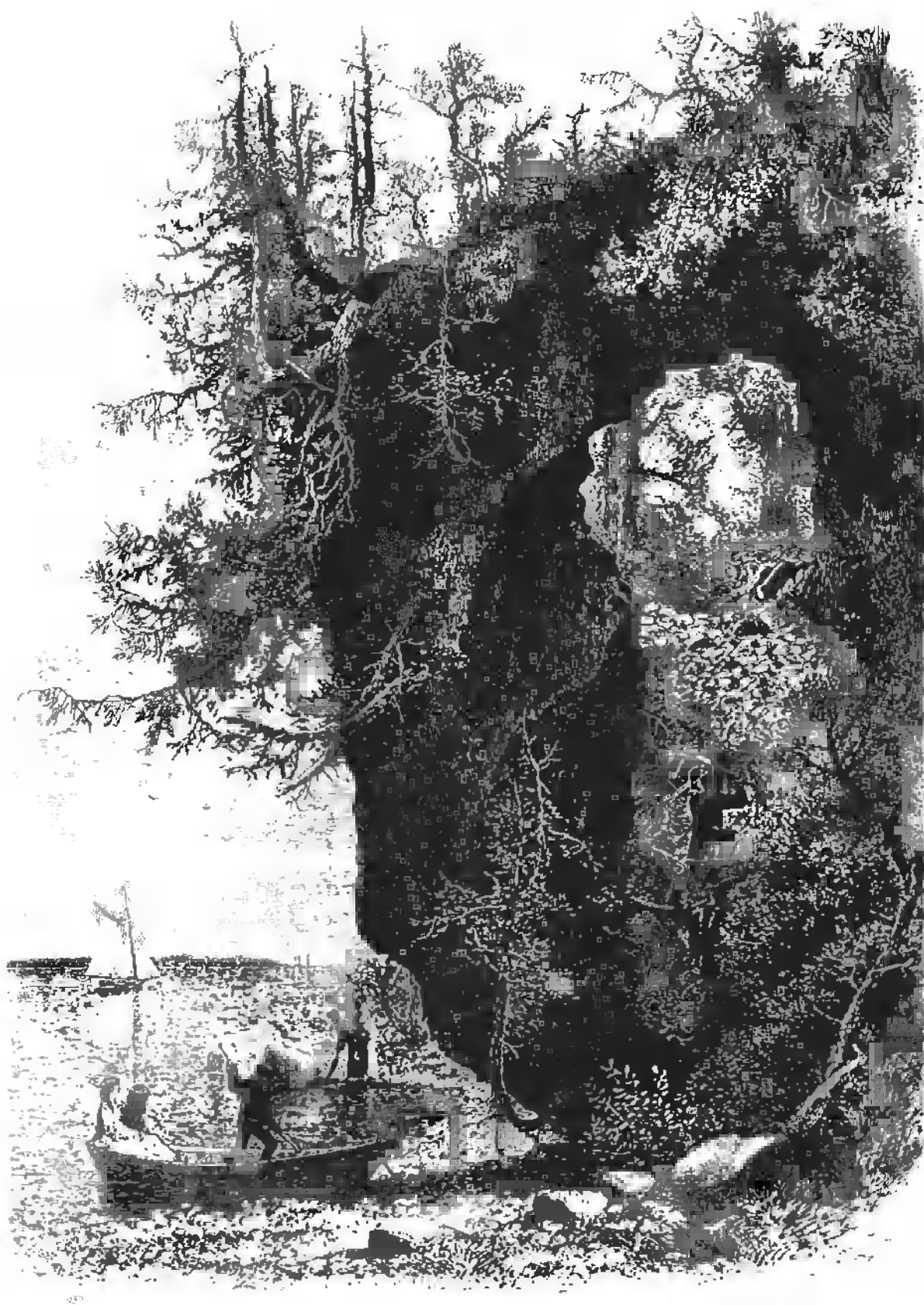


Figure 16: Lithograph of Fairy Arch, a glacial Lake Nipissing shoreline feature (Woolson, 1894, p. 285). This arch was destroyed during road building along the east side of Mackinac Island.

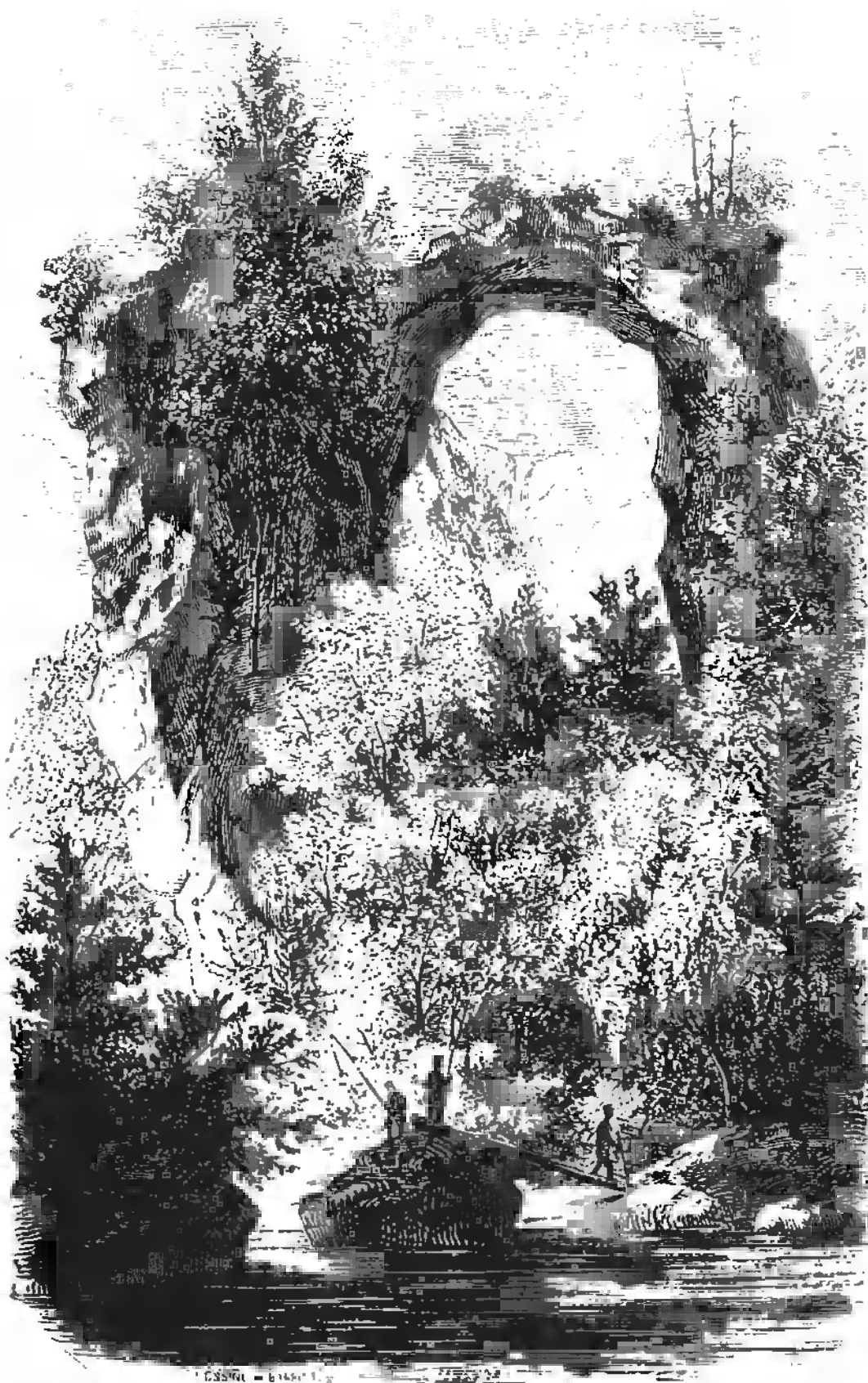


Figure 17: Lithograph of Arch Rock from the shore of Lake Huron (Disturnell, 1875). This is a glacial Lake Nipissing feature.

Stop 2: Arch Rock

Arch Rock is located on the east side of Mackinac Island and is the best known rock formation on the island (Figures 17 and 18). The limestone arch is butted against seacliffs of glacial Lake Nipissing to the north and a promontory of Mackinac breccia that projects out from the cliff face but remains attached. The top of the arch is approximately 140 feet above Lake Huron and the top of the buttress that projects out from the cliff is 105 feet above present-day Lake Huron (Winchell, 1861, p. 210; Van Fleet, 1970, p. 147; 1882, p. 24). Arch Rock has a span of 40 to 50 feet (Van Fleet, 1882, p. 20).

Arch Rock is composed of highly fractured limestone. Many of the fractures have been sealed with man-made cement. The northern abutment has been reinforced with man-made cement and rock. In the spring, loose fragments that have fallen from the arch commonly lie below the structure. The highly fractured appearance of the limestone prompted McKenny (1959 [1827], p. 390) and Foster and Whitney (1851, p. 163) to predict a very short life for the arch. In terms of geologic time, this will likely be true.



Figure 18: Lithograph of Arch Rock in the moonlight looking up from Lake Huron through the arch that forms part of the glacial Lake Nipissing sea cliffs (Woolson, 1894, p. 279).

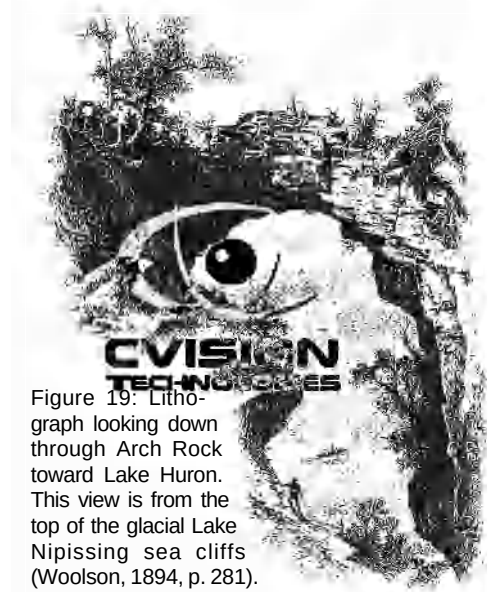


Figure 19: Lithograph looking down through Arch Rock toward Lake Huron. This view is from the top of the glacial Lake Nipissing sea cliffs (Woolson, 1894, p. 281).

At the base of the promontory which forms the south abutment to Arch Rock, there is a small arch known as the Sannillac Arch. This arch is named after an Indian warrior named Sannillac, who is the subject of a poem by Henry Whiting that was published in 1831 (Wood, 1918, p. 588-589).

In front of Arch Rock on the lake side of the shoreline road there is a large boulder of Mackinac breccia that has broken free of the promontory. This boulder has been referred to as Gitchie Manitou (Stanley, 1945, p. 51).

Stop 3: Eagle Point Cave

Eagle Point Cave is located approximately two miles northwest beyond Arch Rock. Take Lake Shore Road to Scott's Shore Road; turn inland approximately 500 feet to Scott's Road. The cave is situated approximately 1000 feet south of the junction of Scott's Shore Road and Scott's Road on the west side of the Scott's Road. The site of this cave was once used for some unknown purpose. The remains of concrete steps are found in front of the cave and the floor of the cave has been leveled using logs and dirt fill.

Eagle Point Cave occurs in Mackinac breccia and is represented by a large amphitheater-type opening in the breccia. Eagle Point Cave is typical of most of the shoreline features described on the island as caves. These caves are commonly amphitheater-type openings of very limited depth that have resulted from lakeshore weathering-erosion processes. Eagle Point Cave is a glacial Lake Nipissing shoreline feature.

Optional

After the visit to Eagle Point Cave one can return to the junction of Scott's Shore Road and Scott's Road and continue north for 200-300 feet where approximately 100-150 feet west of the road is a small promontory of bedrock in which the former Scott's Cave was displayed. This cave has either caved-in or become filled-in and relatively little remains to view. The site warrants some restoration effort. Stanley (1945, p. 47) published a good photograph of the cave when it was exposed for viewing. This cave occurred in the same glacial Lake Nipissing shoreline bluff as Eagle Point Cave. One can walk a trail along the top of the bluff from one cave to the other.

Scott's Cave was named after Captain Thomas Scott of the British 53rd Regiment who was stationed at Fort Mackinac in 1787 (Wood, 1918, p.591).

Scott's Road occurs along a flat land surface representing the action of glacial Lake Nipissing. Scott's Road continues around the northern portion of Mackinac Island but remains relatively unscenic. Return to the Lake Shore Road and continue north around the island to British Landing.

Stop 4: Pulpit Rock



Figure 20: Pulpit Rock, a glacial Lake Nipissing shoreline feature on the northwest corner of Mackinac Island. This sea stack occurs 50 to 75 feet west of the wave-cut bench, representing beach erosion of unconsolidated material of glacial Lake Nipissing (Allen, 1891).

Pulpit Rock (Figure 7), at present better known as Friendship Altar, is located a short distance northeast of British Landing along the western end of Scott's Road. The vertical standing rock formation consists of Mackinac breccia standing approximately 10 feet in front of the bluff formed by glacial Lake Nipissing. While the most commonly used name for this rock unit is Friendship Altar, the outcrop is vertical standing like a pulpit and not horizontal lying as an altar would be. The author prefers the term "Pulpit Rock" because it best describes the outcrop shape or form. Wood (1918, p.536-537) mentions that both names, Pulpit Rock and Friendship Altar, have been applied to this outcropping near British Landing. But, he also suggests the term "Pulpit Rock" may have been applied to another exposure known as Vista Rock in the area of Sugar Loaf. Vista Rock, as indicated on the map of Wood (1918), is a poorly exposed outcrop that does not resemble a pulpit and, perhaps, is an outcrop of no particular note.

Stop 5: Chimney Rock

Continuing along the shoreline road for approximately two miles one passes numerous raised beaches of former glacial Lake Nipissing and of present-day Lake Huron (Figure 21). Bluffs and sea cliffs of the former glacial Lake Nipissing begin to appear south of Heriot Point (Wood, 1918). A prominent vertical rock formation, sometimes referred to as Sunset Rock, occurs approximately $\frac{1}{4}$ mile from where these bluffs begin to appear along the shoreline road. The name “Chimney Rock” is the original name of this shoreline exposure and the name “Sunset Rock” appears to be of recent origin, perhaps generated by whomever built the platform on the top of the formation. The name “Sunset Rock” appears on this platform outlined by dark pebbles set in concrete used in building the structure. The author uses the term “Chimney Rock” since it is of historical usage and is a very good description of the appearance of the exposure. This feature has only recently become part of the Mackinac State Historical Park holdings and accessible to the public. This was largely due to the efforts of David Armour, PhD, former deputy director of Mackinac State Historic Parks.

Van Fleet (1870, p. 144; 1882, p. 24) and Wood (1918, p. 521) have cited Alexander Winchell, professor of geology at the University of Michigan (Winchell, 1870) and a former state geologist for the State of Michigan (Winchell, 1861), as describing this rock exposure as “one of the most remarkable masses of rock in this or any other state”. The author has failed to identify the original source for this comment.

Chimney Rock is a promontory of Mackinac breccia developed by selective erosion and removal of less resistant limestone enveloping the more indurated breccia forming the vertical column of rock making up Chimney Rock by glacial Lake Nipissing. The breccia column remains attached to the headlands, so Chimney Rock is not a sea stack. The top of Chimney Rock was originally 131 feet above the level of Lake Huron (Van Fleet, 1870, p. 147, 1882, p. 24; Winchell, 1861, p. 210). It is unknown whether those that built the platform on Chimney Rock vandalized the upper portion of the chimney-like rock outcrop thereby altering the original profile.



Figure 21: Lithograph of Chimney Rock, a glacial Lake Nipissing shoreline feature. The viewing platform that has been constructed on top of this formation may have damaged the original profile as shown in this lithograph (Woolson, 1894, p. 283).

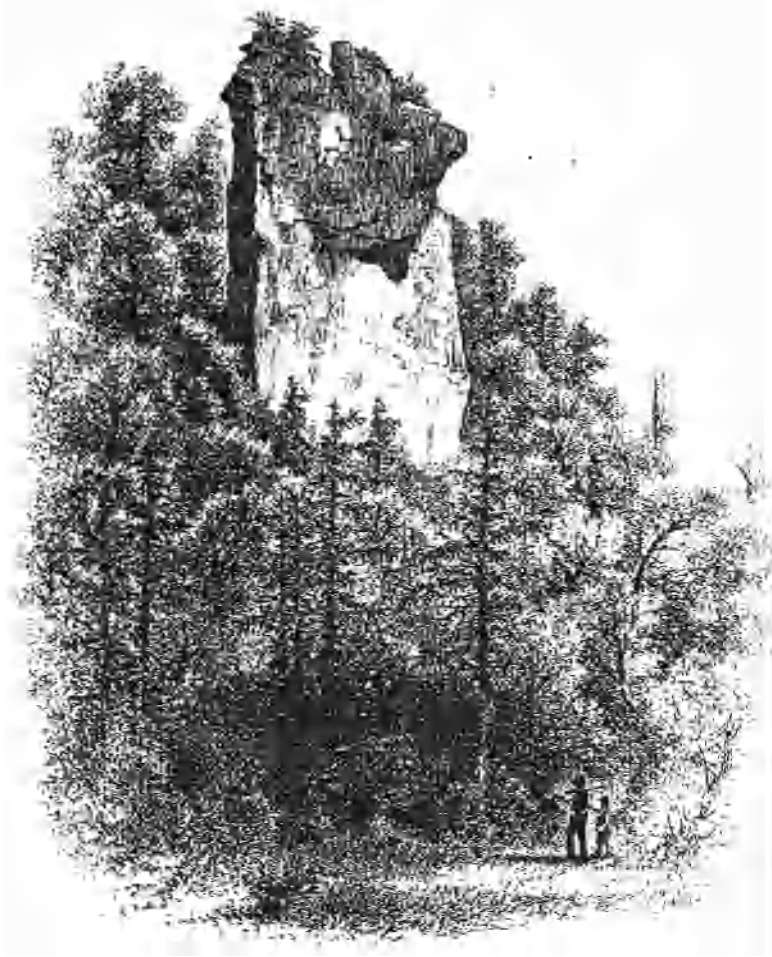


Figure 22: Lithograph of Lover's Leap, a glacial Lake Nipissing shoreline feature (Woolson, 1894, p. 288).

Stop 6: Devil's Kitchen and Lover's Leap

Continuing along the shoreline road for $\frac{1}{2}$ to $\frac{3}{4}$ mile, one comes to the Devil's Kitchen. Devil's Kitchen represents an amphitheater-like opening in a large outcrop of Mackinac breccia. This feature is the product of recent interaction of the shoreline of Mackinac Island and the waters of Lake Huron. Earlier erosion by glacial Lake Nipissing may have also had an influence.

Lover's Leap occurs on the wave-cut bluff behind and slightly west of Devil's Kitchen. It remains private property and, thus, is unavailable for examination (Figure 22). Lover's Leap is composed of Mackinac breccia and is comparable to Chimney Rock in appearance and origin. The top of Lover's Leap is 145 feet above the present level of Lake Huron (Van Fleet, 1870, p. 147; 1882, p. 24; Winchell, 1861, p. 210).

Inner Island Tour

Upon completion of the visit at Devil's Kitchen, one continues back towards the village on Mackinac Island. As we approach the village, turn left onto Mahoney Ave. and continue to Cadotte Ave. Turn left on Cadotte Ave. and travel to Huron Road passed the Grand Hotel. Turn right on Huron Road and continue to the eastern side of Mackinac Island to continue an inner island tour dominated by features related to glacial Lake Algonquin. Huron Road passes along the top of east bluff that represents the effects of glacial Lake Nipissing. Along Huron Road, the first stop will be Robinson's Folly (Stop 1) where participants can view Lake Huron from the top of the rock formation. From Robinson's Folly, the group will continue to Arch Rock (Stop 2). The revisit of Stop 2 allows participants to view Arch Rock from above.

Stop 7: Sugar Loaf

From the revisit of Arch Rock, one continues into the interior of Mackinac Island along Rifle Range Road to Sugar Loaf Road (Figures 23 and 24). Continue along Sugar Loaf Road to Sugar Loaf. Sugar Loaf is a sea stack that is the product of glacial Lake Algonquin. This sea stack is composed of Mackinac breccia and is separated from the headlands of the former glacial Lake Algonquin by approximately 300 feet. The sea cliffs to the west are composed of breccia. The wooden stairs from the former terrace of glacial Lake Algonquin allow great access to the cliffs where the details of the breccia can be closely examined. The stairs continue to the top of the sea cliff known as Point Lookout where an excellent overall view of Sugar Loaf and Lake Huron is possible.

The Lake Algonquin terrace around the Sugar Loaf is approximately 140-150 feet above the present Lake Huron. The top of the Sugar Loaf is 855.81 feet above sea level or 274.94 feet above the present level of Lake Huron (Stanley, 1945, p. 65, 72). The base of Sugar Loaf is approximately 134 feet above Lake Huron (Van Fleet, 1870, p. 20-21; 1882, p. 140). Wood (1918, p. 594-595) indicates the Sugar Loaf is 79 feet high using the road as a base.

The conical shaped sea stack reportedly received its name from honey bees that constructed a hive in the formation (Wood, 1918, p. 595).

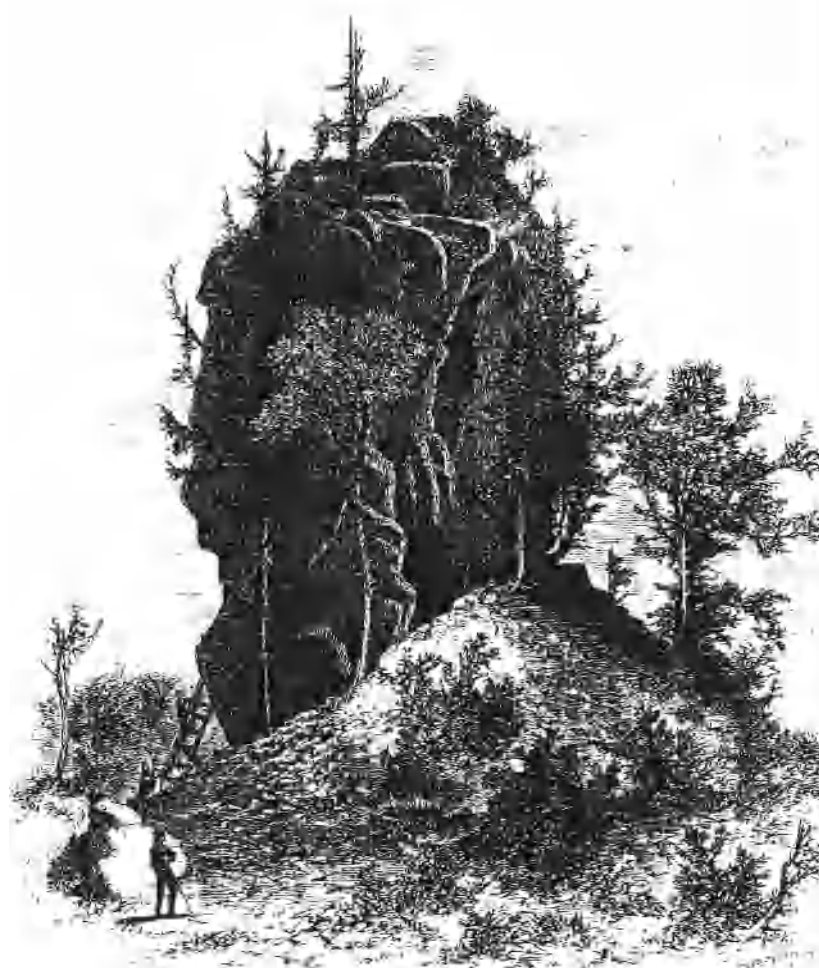


Figure 23: Lithograph of Sugar Loaf, a glacial Lake Algonquin shoreline feature. View is of the west side (Woolson, 1894, p. 287).

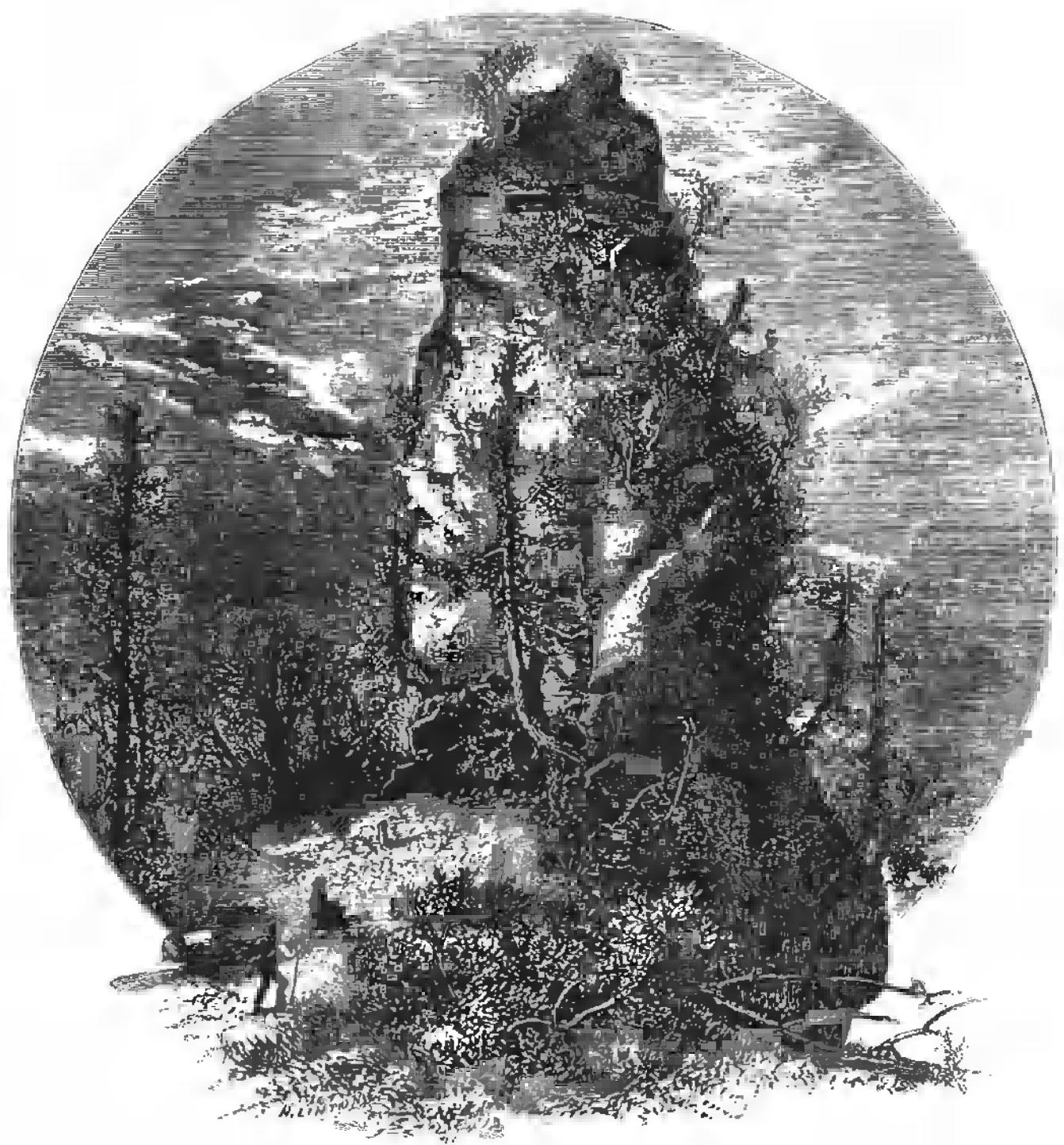


Figure 24: Lithograph of Sugar Loaf, a glacial Lake Algonquin shoreline feature. View is of the east side (Woolson, 1894, p. 286).

Stop 7: Skull Cave

From Sugar Loaf, we continue along Sugar Loaf Road to Rifle Range Road and east to the junction of Rifle Range Road and Garrison Road.

Skull Cave is a crumbling sea stack that has a large amphitheater-like opening. This feature is composed of Mackinac breccia and is the result of glacial Lake Algonquin. The sea stack has a summit of 831 feet above sea level, is between 15 and 25 feet high, and is separated from the headland of the former Lake Algonquin sea cliff and bluff by 50 feet (Stanley, 1945, p.26-27).

Skull Cave is named after an experience by Alexander Henry, a fur trader who survived the massacre in 1763 of the British garrison at Fort Michilmackinac in Mackinaw City. Henry was sequestered in this cave by Wawatam, a Chippewa Indian, thus saving him from massacre at the Fort. Henry found the cave full of human bones and skulls and was very happy to leave his place of refuge at his earliest opportunity. It is unknown whether the bones are the result of burial or ceremonial sacrifice. Wood (1918, p. 592) stated that Alexander Henry was of the opinion that the bones were from prisoners devoured at war feasts, but there is no evidence as to which interpretation is most probable. Slight variations in this story occur in almost all discussions of Skull Cave.

Stop 8: Crack-in-the-Island and Cave-of-the-Woods

From Skull Cave, continue north along Garrison Road to State Road and turn left. Continue along this State Road until you reach Island Trail that leads from the road to the west. This trail is accessible with a trail bike but is very rough; caution is recommended. Crack-in-the-Island and Cave-of-the-Woods lie approximately ¼ mile west of State Road and at the edge of Mackinac Island Airport. They are separated by only a few tens of feet.

Crack-in-the-Island is a solution crack in the limestone that, at this location, is on the order of one foot wide and 1-2 feet deep. Wood (1918, p. 523) described the crack as a deep fissure several feet wide, but the crack as seen today does not fit that description. Wood (1918) indicates these solution cracks occur in several other places on the island.

Cave-in-the Woods is an amphitheater-shaped opening or sea cave in Mackinac breccia formed by glacial Lake Algonquin that sits approximately 140 feet above the level of present-day Lake Huron (Porter and Nelhiebel, 1984, p. 47).

Upon completion of the examination of this site, return along the trail to State Road. Even though it is longer in distance, the easiest way back to town and the ferry docks is to continue north along State Road, which rejoins with Garrison Road and continues on towards British Landing. This route is down hill through the center of the island and, then, relatively flat along the perimeter of the island, Lake Shore Road. At British Landing, turn left on to Lake Shore Road and return to the ferry docks, a distance of several miles that passes previous stops illustrating glacial Lake Nipissing shore features. If time permits, it is suggested to tour Fort Mackinac, a Revolutionary War fort.

Additional Suggestions

The tour of Mackinac Island is designed to visit all prominent glacial-lake modified bedrock outcroppings on the island in a single day. At the visitor's discretion and convenience, some outcroppings in and near the city of St. Ignace on the mainland of the Upper Peninsula are worth visiting. St. Anthony's Rock occurs in a parkette behind the business establishments lining the main street of the city. This is a sea stack of Mackinac breccia formed by glacial Lake Nipissing. It sits several yards in front of a Lake Nipissing cut headland. Castle Rock located just north of St. Ignace is a commercial property that permits tourists of the area to obtain a view from its high vantage point. Castle Rock is a prominent promontory that remains attached to the glacial Lake Nipissing headlands and is, thus, not a true sea stack. Landes et. al. (1945, p. 136) classify Castle Rock as being an indurated transformational breccia, which lies immediately east of megabreccia that is regional in extent. Landes et al. (1945, p. 125) report that the best place to see the various styles of regional brecciation is from the road cut leading to the north entrance of the Mackinac Bridge. Landes et. al. (1945) provides the most complete description of the geology of Mackinac Island and the surrounding area.

Bibliography

- Allen, E.A.; 1891. A Jolly trip; or, where we went and what we saw last summer; Central Publishing House, Atlanta, Georgia, 266p.
- Anonymous, 1899. The Standard Guide, Mackinac Island and Northern Lake Resorts; Foster and Reynolds, 88 p.
- Disturnell, J., 1875. Island of Mackinac; Philadelphia, 96 p.
- Dorr Jr., John A. and Eschman, Donald F., 1970. p. 176-217; in Geology of Michigan; University of Michigan Press, Ann Arbor, Michigan; 475 p.
- Foster, J. W. and Whitney, J.D., 1851, p. 163-166; in Report on the Geology of Lake Superior Land district; A. Boyd Hamilton, Washington D.C., 456p. with illustrations
- Landes, K. K., Ehlers, G. M. and Stanley, G. M., 1945. Geology of the Mackinac Straits Region and subsurface geology of Northern southern Peninsula; State of Michigan Department of Conservation, Geological Survey Division; pub. 44, Geological Serial 37, 204 p.
- Leverett, F. and Taylor, F.B., 1915. p. 452-453; in The Pleistocene of Indiana and Michigan and the History of the Great Lakes; United States Geological Survey Monograph, v. 53
- McKenny, Thomas L., 1827. Sketches of a tour to the Lakes; Ross and Haines Inc., Minneapolis, Minnesota, 1959, 493 p.
- Meade, William C., 1897[1986]. Early Mackinac. A sketch Historical and Descriptive with Introductory essay by Larry Massie; Re-published 1986 by Avery Color Studios, Au Train, Michigan, 184 p.
- NOTE: Early Mackinac was first published in 1897 and then revised and published in 1901 and 1912
- Porter, Phil and Nelhiebel, Victor, R., 1984. The Wonder of Mackinac, Mackinac Island State Park Commission, Pendall Printing Inc., 52 p.
- Russell, Israel C., 1905, p. 44-45, 55-57, 102-104; in A geological reconnaissance along the north shore of Lakes Huron and Michigan; Report of the State Board of Geological Survey of Michigan for the year 1904, Wynkoop Hallenbeck Crawford Co., Lansing, Michigan
- Sheldon, Frances D., 1959. Geology of Mackinac Island and lower and middle Devonian south of the Straits of Mackinac, Michigan; Michigan Basin Geological Society Guide Book; 63 p.
- Stanley, G.M., 1938. The submerged Valley through Mackinac Straits; Journal of Geology, v. 46, n. 7, p. 966-974
- Stanley, George M., 1945. Pre-Historic Mackinac Island; State of Michigan Department of Conservation, Geological Survey Division, Publication 43, Geological Series 36, 74p.
- Taylor, F.B., 1892. The highest old shoreline on Mackinac Island; American Journal of Science, v. 43, p. 210-218
- Taylor, Frank B., 1915. Old shorelines of Mackinac Island and their relations to the Lake History; Geological Society America Bulletin (abst), v. 26, p. 68-70
- Van Fleet, J. A., 1870. Old and New Mackinac; Courier Steam Printing-house, Ann Arbor; 176 p.
- Van Fleet, J. A.; 1882. Mackinaw Region and Adjacent Localities; Lever Print, Detroit, Michigan, 49 p.
- Winchell, A., 1861. First Biennial Report of the Progress of the Geological Survey of Michigan Geology, Zoology and Botany of the lower Peninsula; Geological survey of Michigan, 339 p.
- Winchell, Alexander, 1870. p. 247-245; in Sketches of Creation; Harper and Brothers, New York, 459 p.
- Wood, Edwin O., 1918. Historic Mackinac; The Historical, Picturesque and Legendary Features of the Mackinac Country; The MacMillan Company, New York, 540 p.
- Woolson, Constance F., 1894. Mackinac, p. 279-291; in Picturesque America, No. 5, March 17, 1894, (previously published 1872), Artist F. T. Woodward; D. Appleton, Publishers

References not cited

Schoolcraft, Henry R. 1832 [1953]. Narrative Journal of travels through the northwestern regions of the United States extending from Detroit through the great chain of American lakes to the sources of the Mississippi River in the year 1820; Republished Michigan State College Press, 1953, edited by Mentor L. Williams, 520 p.

Strickland, W.P. 1860. Old Mackinac or the Fortress of the Lakes; James Challen and Son, Philadelphia, 404 p.