"Overview of Cambrian Sandstone Environments of Deposition" is the ninth *Pictured Rocks National Lakeshore Resource Report*. Volunteer Geologist Robert Rose' combined a search of current literature with field work to reinterpret the depositional history of the park's bedrock. His work may be challenged or confirmed by future geologic work in the park. He volunteered through the Geologist In Parks program facilitated by the Geologic Resources Division of the National Park Service in Lakewood, CO. Readers comments on this Resource Report are welcome.

Grant A. Petersen
Superintendent

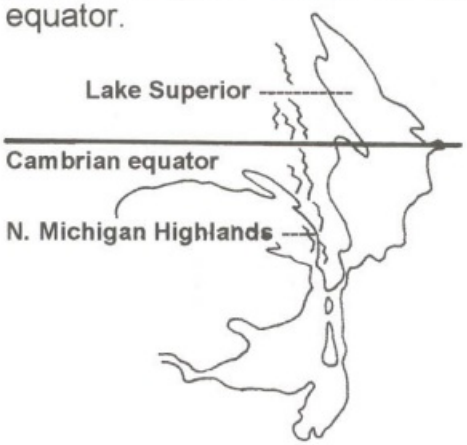
Pictured Rocks Resource Report

PIRO 97-1

Overview of Cambrian Sandstone Environments of Deposition
by Robert Rose' - Volunteer Geologist In Park

The Bedrock Story

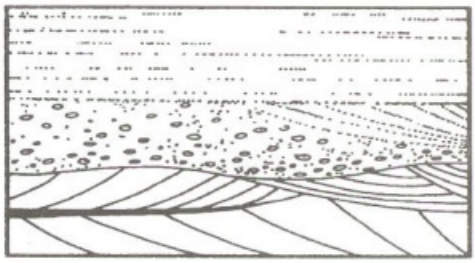
Imagine standing in the tropics looking downslope at a barren, rocky plain as far as you can see. At that time the eastern half of Lake Superior was oriented just 10 degrees south of the equator.



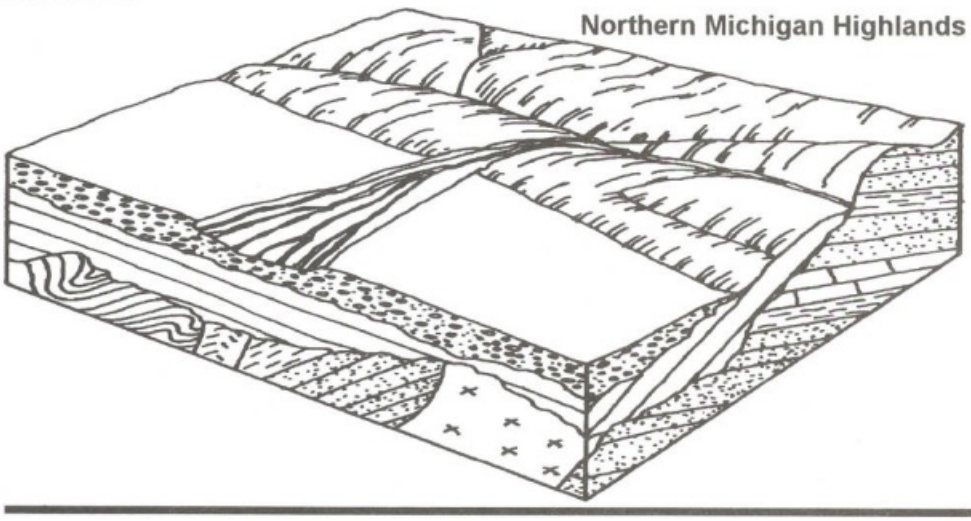
As you turn and look in the opposite direction, barren hills of Central Michigan Highland bedrock and boulders loom in the distance.

It is estimated that these highlands would have been about the height of today's Appalachian mountains. This would have been the scene about 520 million years ago during the Cambrian Era in the area of Pictured Rocks National Lakeshore. Scattered streams carry sand and gravel northward and deposit it upon the barren rocky plain. Even though water is abundant there are no land animals or plants present because they have not yet evolved. Life has been evolving in the oceans but has not yet moved to land.

The Cambrian Munising Formation which forms the cliffs at Pictured Rocks National Lakeshore (PRNL) is approximately 200 feet thick. Because of distinctive internal sedimentary features, weathering characteristics and heavy mineral content, this formation can be subdivided into three parts called members. From the oldest to the youngest (bottom to top) they are the Basal Conglomerate, Chapel Rock and Miners Castle. The Munising Formation rests on the underlying Jacobsville Formation unconformably; meaning there was a substantial period of erosion and weathering between the end of Jacobsville deposition and the beginning of Munising deposition (millions of years).



Jacobsville - Munising unconformity



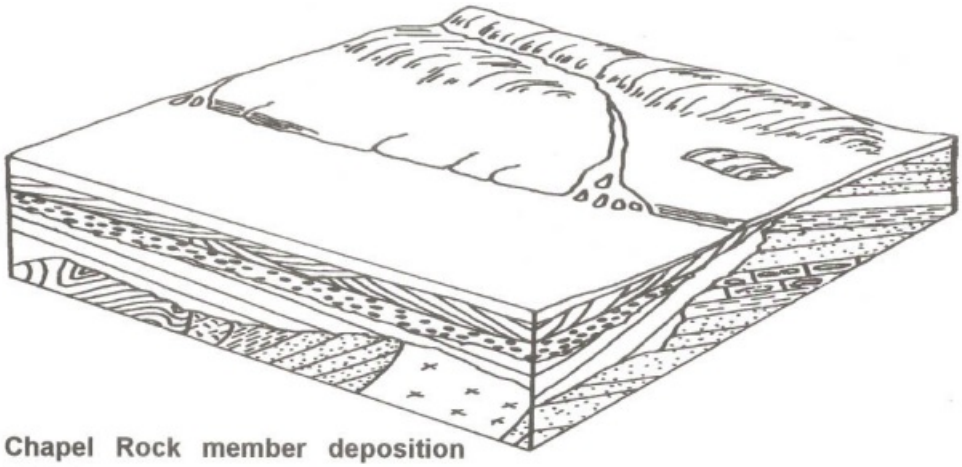
Northern Michigan Highlands

The Jacobsville Formation was deposited by streams in a moist and humid environment so that after deposition the iron-bearing minerals were altered to a red color. During the period of non-deposition before the Cambrian Munising Formation was deposited, alteration of the red rocks created the banded red and white sandstones we see in the Jacobsville today.

Weathering and erosion over several million years created mature sediments of siliceous sand and gravel which were deposited by streams (similar to the Colville or Canning rivers on the North Slope of Alaska) on the barren, rocky plain developed on the Jacobsville Formation. These deposits form the Basal Conglomerate member, which ranges up to 13 feet thick, and is made of gravel and sand. It is best seen in the cliffs on the eastern side of Grand Island, near the base of Sable Falls and in the area of Grand Portal Point.

Feeding and resting traces of trilobites seen on mudstone bedding planes are the only evidence for the marine nature of some of the Chapel Rock member. These trace fossils are best observed at the east end of Miners Beach and west end of Mosquito Beach.

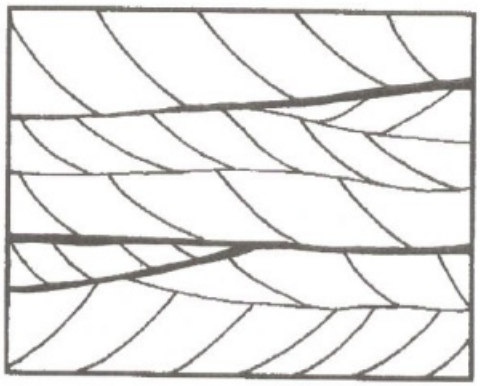
Mud cracks are preserved in the mudstones too, sometimes overlaying ripple marks. The cracks indicate drying, shrinking and cracking of the sediment, but do not specifically indicate whether the mud was deposited under marine or non-marine influence. Good examples of mud cracks are found on west Mosquito Beach. Continued encroachment of the sea caused the submergence of most of the Northern Michigan Highlands (only islands were left).



Chapel Rock member deposition scene

A character change from the Basal Conglomerate to Chapel Rock member signals a rapid encroachment of the Cambrian marine coastline. Marine delta, beach, dune and tidal environments contributed to the deposition of 40-60 feet of light salmon-colored quartzose sandstone.

Near the bottom, siliceous gravel is present as lenses and isolated clasts (gravel-sized rock fragments) in the sandstone imply river deposition. This characteristic is seen in the lower part of the cliffs at Chapel Rock and Grand Portal Point. Beach, dune and river sedimentation features can been seen in the upper part of the member at the east end of Miners Beach and west Mosquito Beach.



Large sets of cross bedding in the Chapel rock member

Bcttom Currents

This caused a change in the source of sand from the Highlands nearby to the Canadian Shield farther away. This change also caused a dramatic increase in garnet content (heavy minerals) now found in the Miners Castle member, which is a way to differentiate it from the Chapel Rock member. This garnet content is now being concentrated on Sand Point beaches as streaks of red sand.

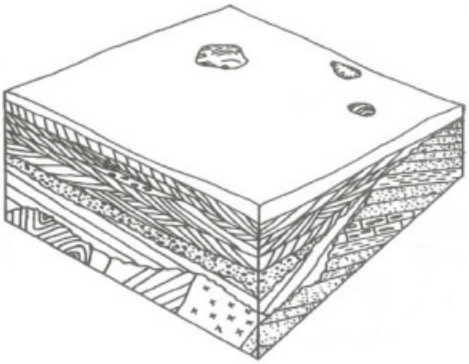
Trilobite tracks or "cruziana"

The accompanying black sand (magnetite, hematite and ilmenite) probably comes from the Chapel rock and Jacobsville Formations.

The Miners Castle is the uppermost member of the Munising Formation and is about 140 feet thick. The lower three-quarters is predominantly constructed of thin (4-5 inch) cross-bedded units with associated thin clay laminae becoming interbedded with burrowed units toward the top. This interbedding results in the alternating of cross-bedded, slightly burrowed cross-bedded and entirely burrowed/homogenized sandstone beds. The burrowing was done by worms, clams, snails, sea urchins and other animals. These beds can be seen at Miners Castle. The remaining one-quarter of the member is comprised of white, thin-bedded, cross-bedded, clean, crumbly quartz-rich sandstone.

It is more resistant than the lower three-quarters of the member and is easily seen at Bridal Veil Falls at the top of the cliff as a white vertical cliff.

The Miners Castle member represents deposition in a tropical, shallow marine shelf and on high-energy submerged bars created by bottom currents flowing along the ocean bottom from the Canadian Shield area. The clay contributions probably came from the rapidly disappearing Highlands.



Miners Castle member depositional scene

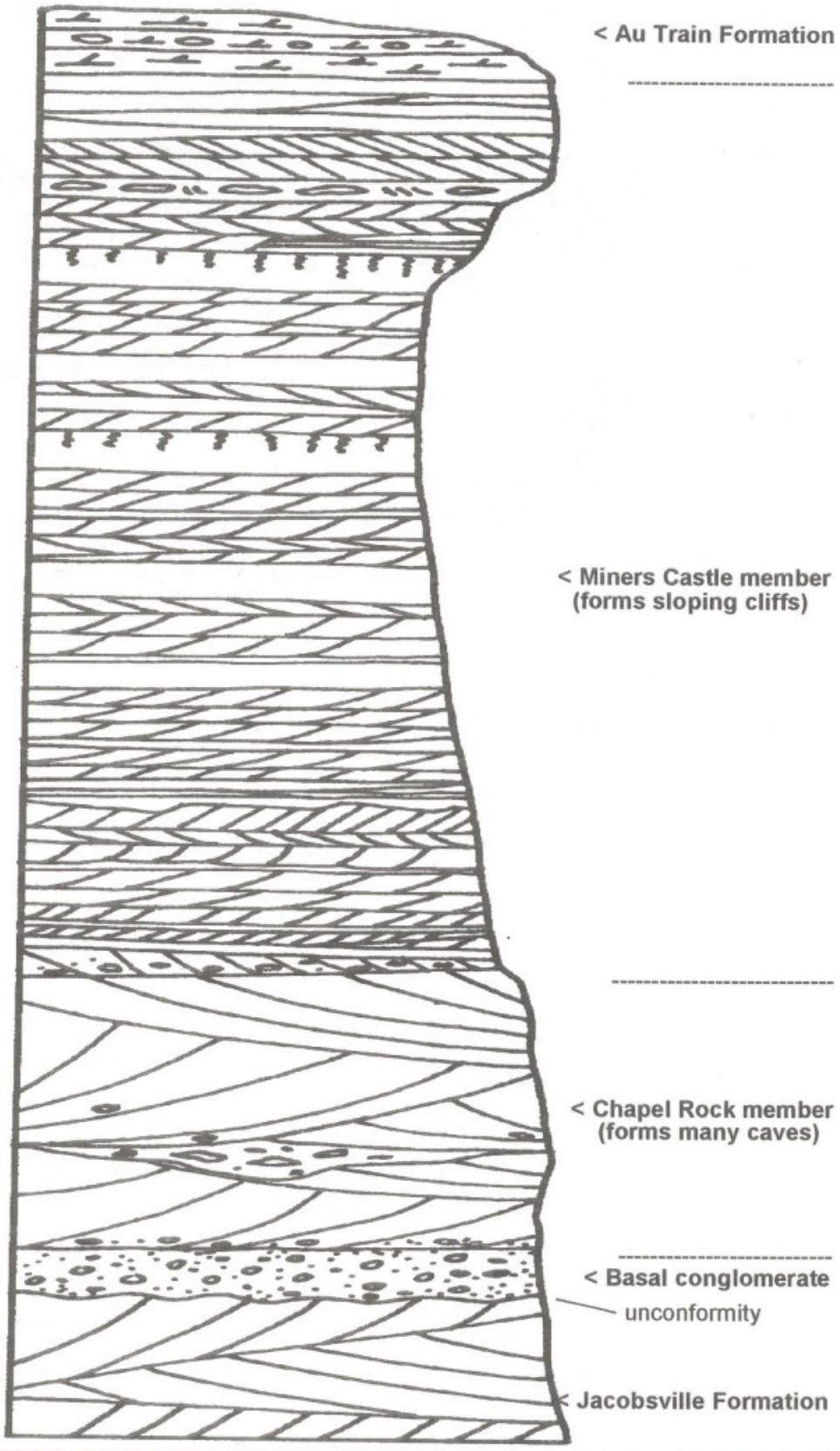
The entire Miners Castle member can be seen at Bridal veil Falls and the area southwest of it to east Miners Beach. Trilobite and brachiopod fossils of the late Cambrian age have been found in rocks equivalent to the upper Miners Castle rocks in an area adjacent to Pictured Rocks National Lakeshore. The fossils indicate shallow marine conditions.

The transition from the Munising Formation to the resistant caprock of the Au Train Formation is easy to detect from a distance because of the difference in color (brown versus white) and its irregular weathering characteristics.

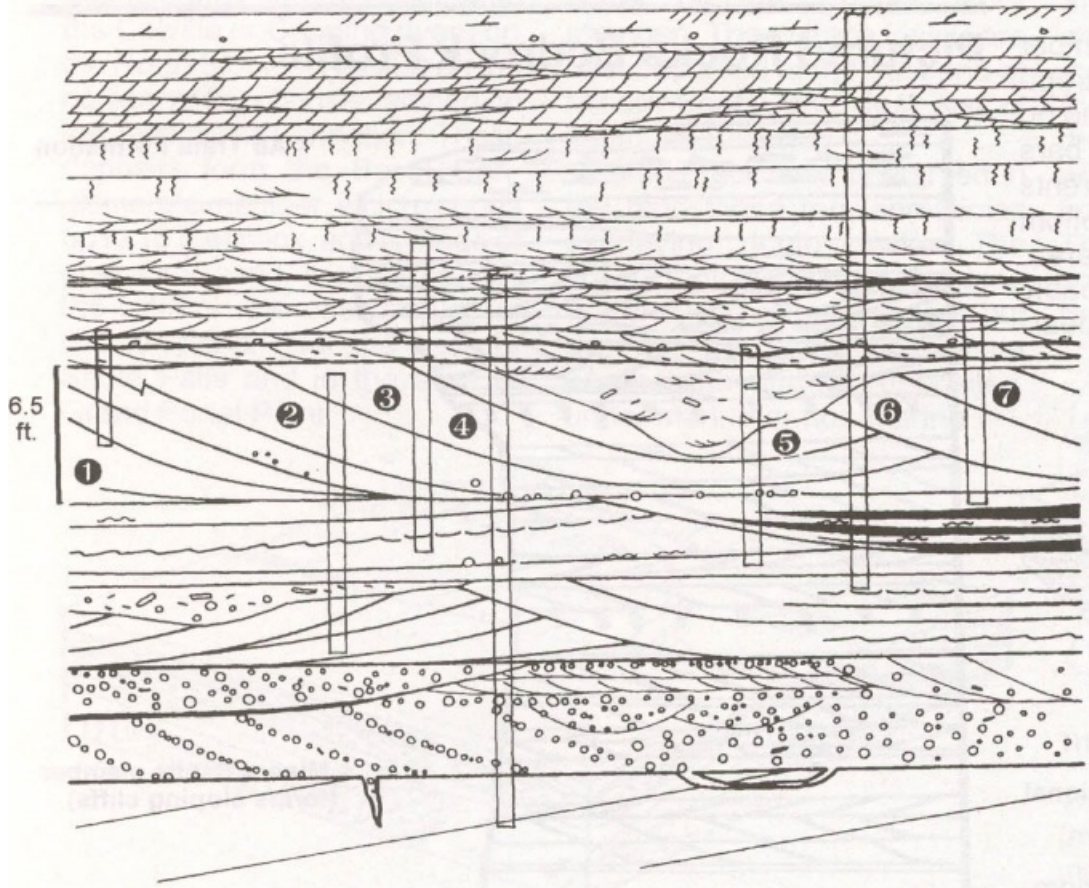
The basal Au Train Formation is composed of cross-bedded quartz sandstone with light brown dolomitic cement making it firmer than the underlying Miners Castle member. In addition to fossils, there are dolomitic sandstone and siliceous pebbles in some of these sandstones.

Au Train rocks are best seen as large boulders ringing the parking lot at Chapel trailhead.

Pictured Rocks Bedrock Profile



Pictured Rocks Cliff Face



Au Train Formation

Miners Castle Member

Chapel Rock Member

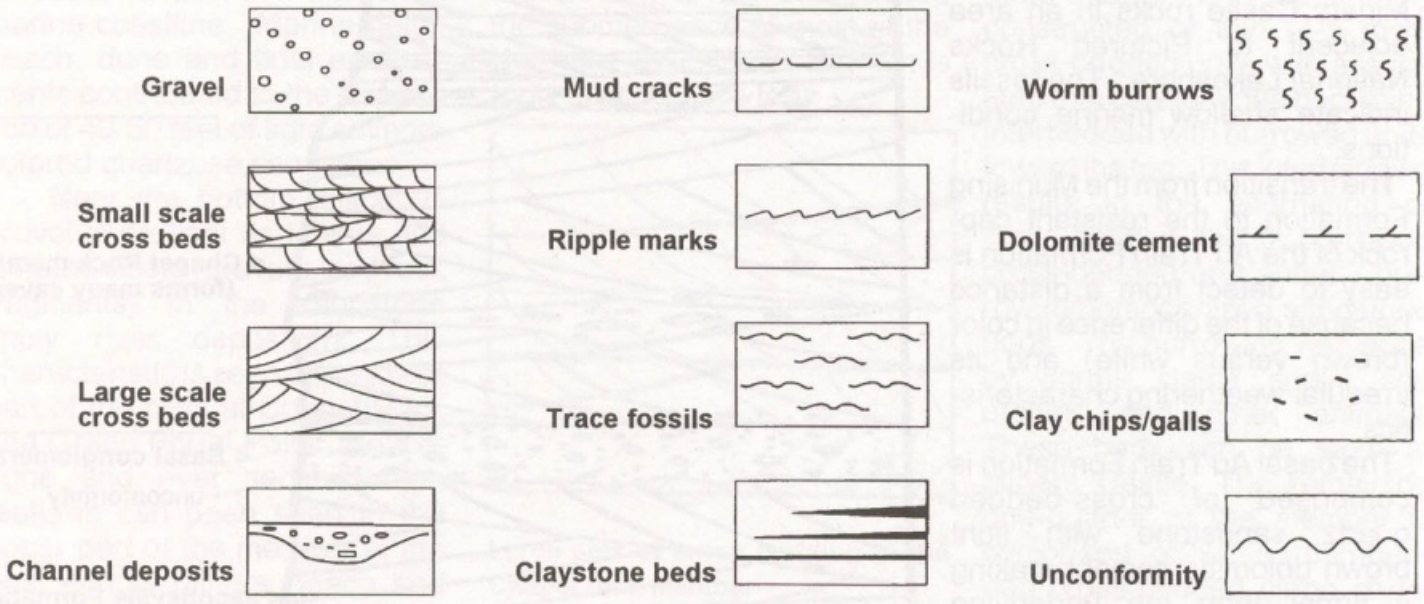
Basal Conglomerate Member

Jacobsville Sandstone Formation

Munising Formation

1. East Miners Beach
2. Chapel Rock
3. Miners Castle
4. Grand Portal Point
5. West Mosquito Beach
6. Bridalveil Falls
7. West Miners Beach

(After Haddox, 1982 - Bob Rose', 1997 - not to scale)



*U.S.GPO:1997-557-237/60003