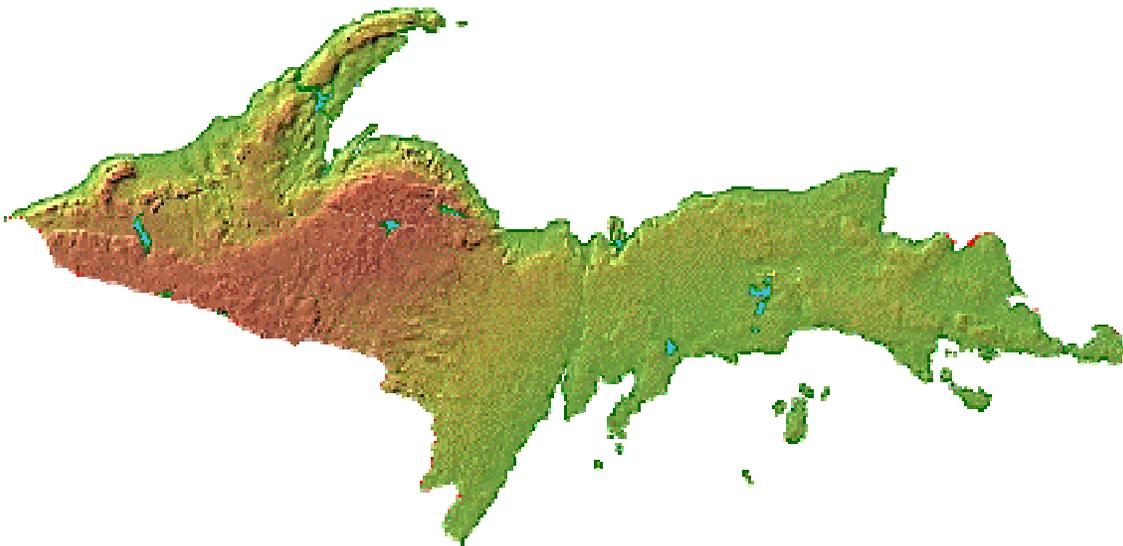




Landforms of the Upper Peninsula, Michigan



*Draft
February, 2006*

*Dwight S. Jerome, Resource Soil Scientist
Upper Peninsula, Michigan Soil Survey Staff
USDA Natural Resources Conservation Service*

The Natural Resources Conservation Service works in partnership with the American people to conserve and sustain natural resources on private lands.

An Equal Opportunity Provider and Employer

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, or marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotope, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, D.C. 202250-9410 or call (202) 720-5964 (voice and TDD). USDA is an equal opportunity provider and employer.

Contents –

Preface	5
Description of the Upper Peninsula	6
Geographic Extent	6
Climate	6
Elevation	7
Land Use	7
Lakes and Streams	7
Physiography and Geology	7
Landform Map	17
Bedrock Geology Map	18
Landform Descriptions	19
Beach Ridges and Dunes	19
Bedrock-controlled Ground Moraine	19
Bedrock-controlled Till Plain	20
Bedrock Ridge Complex	20
Disintegration Moraine	20
Dissected Moraine	20
Dissected Till Plain	21
Drumlinized Ground Moraine	21
Dune-capped Lake Plain	22
End Moraine	22
Flood Plain	22
Fluted Ground Moraine	22
Glacial Delta	23
Glacial Drainage Channel	23
Ground Moraine	23
Ice Margin Complex	23
Kame Terraces	24
Lake Plain	24
Lake Terrace	24
Outwash Fan	24
Outwash Plain	24
Outwash Plain (lowland)	24
Outwash-filled Gap	25
Perched Outwash Plain	25
Pitted Outwash Plain	25
Recessional Moraine	25
River Valley	25
River Valleys and Terraces	26
Sandstone Benches	26
Swamp	26
Till-Floored Lake Plain	26
Tombolo	26
References	28
Acknowledgements	30

Figures	31
Soil Profile Photos	41

Preface

This report was completed for the purpose of providing information, descriptions, and illustrations to accompany the Upper Peninsula (U.P.) landform map. During the course of a soil survey the relationship between soils, landscapes, and landforms is studied extensively. While the main emphasis of a soil survey is to provide detailed soil maps and information used for land use planning, a vast amount of knowledge is also obtained about the physical features of the area. Throughout the survey soil scientists study the glacial history, bedrock geology, and landforms of the survey area. Soil scientists have been traversing the forests and fields of the U.P. for nearly 100 years and have obtained an enormous amount of knowledge about landforms. Few attempts (that we are aware of) have been made to complete a comprehensive U.P. wide landform map. It was determined that an effort would be made to accomplish this. The project has taken several years to complete. This publication remains a draft as future revisions will likely be made during the update of older published soil surveys

The map and report are intended to be an informative document showing the relationships between landforms, landscapes, and soils. However, it was not intended to be a major research project. There are several professionals in the academic and research field who have done in depth studies of landforms in different areas throughout the U.P. We would encourage you to visit your local library, college, university, or internet for further information.

Currently, soil surveys in the United States are conducted on a regional basis known as Major Land Resource Areas (MLRA's). MLRA's are broad regions (usually several counties) that share similar land uses, climate, topography, geology, and soils. Prior to this approach soil surveys were conducted in a county or area without much regard to the soils and landforms in other areas within the same MLRA. Today a major effort is underway to produce an MLRA-wide soil map and database. It has always been recognized that soil types with similar parent material are found on similar landforms. It is important to use consistent methodology in describing, classifying and naming the soils. This same approach was used for the landform map. A major effort was made to produce a landform map that was consistent in the use of terminology and descriptions. In most cases it was determined that the official description of the landforms published in the USDA National Soils Handbook Glossary of Landforms would be used. Further information regarding landforms and the terminology used in this document can be obtained at the following web address:

<http://soils.usda.gov/technical/handbook/contents/part629glossary1.html>

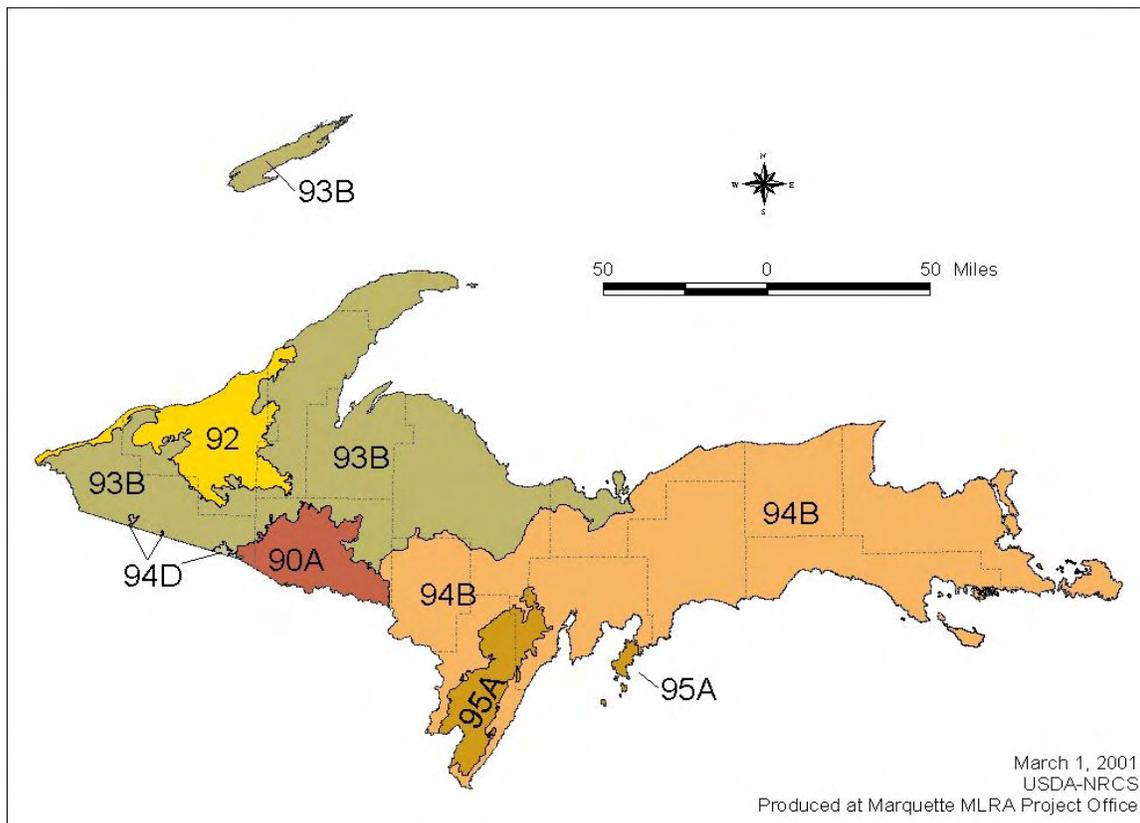
An official record of this document and map will be kept on file at the U.P. MLRA office. We'd like to encourage any comments or suggestions you may have regarding this publication. Please contact us in writing or by phone at:

U.P. MLRA Project Office
USDA Natural Resources Conservation Service
780 Commerce Drive, Suite C
Marquette, MI 49855
(906) 226-8871

Description of the Upper Peninsula –

Geographic Extent

The Upper Peninsula (U.P.) of Michigan encompasses approximately 10,745,472 acres (or 16,790 square miles) and is bordered by three of the Great Lakes: [Lake Superior](#), Lake Michigan and Lake Huron. The peninsula is approximately 336 miles long from east to west and has over 1,000 miles (including Isle Royale) of Great Lakes shoreline. It is located within the Interior Plains Physiographic Division of the Central Lowland Province, Eastern Lake Section and Laurentian Physiographic Division of the Superior Upland Province. It is located within Land Resource Region (LRR) K and Major Land Resource Areas (MLRA) 90A, 92, 93B, 94B, 94D and 95A.



Major Land Resource Areas in the Upper Peninsula of Michigan

Climate

The climate in the Upper Peninsula (U.P.) is influenced by the proximity of the Great Lakes. Areas closest to the Great Lakes are slightly warmer in the winter and cooler in the summer. The average annual temperature is 39 to 43 degrees F. The average daily summer temperature is 62 degrees F with an average low of 51 degrees F and high of 71 degrees F. The average daily winter temperature is 19 degrees F with an average low of 13 degrees F and high of 28 degrees F. The average annual precipitation is 30 to 36

inches. The growing season is 100 to 150 days. The average annual snowfall is 56 to 218 inches. Snowfall is significantly higher in the northern half of the U.P. Prevailing winds and cooler air masses from the north combined with the warmer waters of Lake Superior create lake effect snow. It is not uncommon for areas such as the Keweenaw Peninsula, eastern Alger County, and northern Luce County to receive a yearly snowfall of 200 to 350 inches.

Elevation

Elevations throughout the U.P. range from approximately 600 feet along the Great Lakes to 1,900 feet inland. The highest elevation, which is also the highest point in Michigan, is 1,979 feet at Mount Arvon in Baraga County.

Land Use

About 5 percent of the land in the Upper Peninsula (U.P.) is used for agriculture. About 50 percent of the agricultural land is cropland. Forage and feed for dairy and other livestock are the principal crops. The remaining lands in the U.P. are forested or in other uses. About 42 percent of the forestland is in federal or state ownership. The main uses are timber and recreation. The Hiawatha and Ottawa National Forests occupy about 17 percent of the U.P. Other federal lands include Isle Royale National Park, Pictured Rocks National Lakeshore, and the Seney National Wildlife Refuge. The population of the U.P. was 363,924 in 2000. The major urban areas are Marquette, Sault Ste. Marie, Escanaba, Iron Mountain, and Houghton.

Lakes and Streams

The Upper Peninsula (U.P.), including Isle Royale, contains approximately 690 watersheds, which drain into Lake Superior, Lake Michigan, and Lake Huron. The lakes along the Michigan-Wisconsin border in Gogebic County are part of the Mississippi River watershed. Some of the major rivers include the Ontonagon, Escanaba, Sturgeon, Menominee, Whitefish, Michigamme, Indian, Manistique, Tahquamenon, and Saint Mary's. Major lakes include Gogebic, Indian, Michigamme, Portage, Torch, North and South Manistique, and Brevort. Large man-made reservoirs include the Michigamme, Peavy, Bond Falls, and Dead River Storage Basins.

Physiography and Geology

The landforms of the Upper Peninsula (U.P.) are a product of the glaciers that occupied the region during the Pleistocene Epoch. During the Wisconsin glacial stage the entire U.P. was covered with a thick sheet of ice that went as far south as southern Indiana and Ohio. A massive deposition of glacial drift and the subsequent melting of the glacial ice combined to create a variety of landforms. Most of the landforms in the U.P. are a result of the last major glacial stage known as the Greatlakean (formerly Valderan). Glacial depositions throughout the U.P. range from 0 to over 500 feet thick. The variety of soils found on each landform formed in material deposited 4,000 to 10,000 years ago.

One of the most common types of glacial deposits found in the U.P. is till. Glacial till refers to unsorted and unstratified drift, generally unconsolidated deposited directly by and underneath a glacier without subsequent reworking by melt water. It is typically a heterogeneous mix of sand, silt, clay, gravel and stones. Several large areas of till deposits called ground moraines occur throughout the U.P. Some of the moraines are referred to locally as the Munising, Newberry, Marquette, Crisp Point, Cooks, Winegar, Six Mile, Keweenaw, Marenisco, Republic, Sagola, Crystal Falls, and Watton Moraines. They were formed by the advancing and receding lobes of ice that covered the U.P. Some of the major ice lobes that were present in the U.P. are referred to as the Ontonagon, Keweenaw Bay, Langlade, Michigamme, Green Bay, and Marquette. One of the last known advances of ice was the Marquette, which occurred about 10,000 years ago. Many of the ground moraines have also been modified by the glacial lakes that occupied the region or are capped with thin eolian deposits.

In some areas the ground moraines feature drumlins, are fluted or strongly dissected, or have a predominance of bedrock. Some other moraine landforms include recessional, end, and disintegration moraines. These landforms indicate where there was a temporary halt in the recession of the ice or where the outer margins of the advancing ice lobes were located. Disintegration moraines indicate areas that developed in supraglacial drift by collapse and flow as the underlying stagnant ice melted.

As the ice melted, vast amounts of melt water left behind glaciofluvial and glaciolacustrine deposits. Glaciofluvial deposits result from flowing water and are typically well sorted, stratified sand and gravelly deposits. Large areas of outwash plains are common in many areas throughout the U.P. Some of the outwash plains consist primarily of well or excessively drained sands while others are dominated by poorly drained sands and organic soils. In some areas the landscape is pitted with numerous kettle lakes and depressions. This was caused by the melting of detached stagnant ice blocks that were partially or wholly buried.

Large portions of the U.P. were covered with water. The melting ice resulted in glacial lakes that covered the lowest lying areas. Some of the glacial lake stages that influenced the landscape of the U.P. are Glacial Lakes Algonquin, Duluth, Minong, Keweenaw, Ontonagon, and Nipissing.

Approximately 9,500 to 11,000 years ago Glacial Lake Algonquin covered a large portion of the U.P. The numerous areas of sandy or clayey lacustrine deposits that are found farthest inland from the present day Great Lakes are sediments from Glacial Lake Algonquin. Most of the eastern half of the U.P. was covered by this lake. Some of the deposits were later covered by outwash from the melting glacier to the north.

Approximately 10,000 years ago a readvance of the glacier occurred with the Marquette advance. In the western U.P. Glacial Lake Ontonagon and later Duluth were formed when the ice occupying the western U.P. began to retreat. Glacial Lake Ontonagon occupied a broad till plain near present day Bruce Crossing. The fine textured lacustrine soils deposited in Glacial Lake Ontonagon are underlain by clayey till. Glacial Lake Duluth occupied the western most part of present day Lake Superior.

Approximately 6,000 to 9,500 years ago the Glacial Lake Minong or Sub-Minong stage occurred. A small portion of the northeastern part of the U.P. near Whitefish Point, Brimley and parts of Isle Royale were influenced by this lake stage. Most of the deposits from the Lake Minong stage have been covered by eolian deposits.

Glacial Lake Nipissing was the last lake stage to occupy the U.P. from 4,000 to 6,000 years ago. Its shoreline is the closest to the present Great Lakes. It is an easily recognized ridge or bluff near the present day beach in many areas.

The glacial lakes were developed in stages as the ice melted. The melting of the glacier was not always gradual or continuous. There were periods of rapid melting and stand stills, as well as readvances during colder periods. As the waters receded from the lakes and drained through outlets, lacustrine deposits were left behind. Some areas are dominated by numerous sand bars that have been re-worked by wind. In other areas till deposits were inundated and re-worked by glacial melt waters and subsequently covered by glacial lakes. Some of these areas are referred to as till-floored lake plains.

As the glacier continued to melt, outlets opened for the glacial lakes left behind. Probably one of the most significant outlets in the U.P. is the AuTrain-Whitefish channel. The melting ice front reached a point where water from Glacial Lake Duluth drained through this large channel. A tremendous amount of water drained from the west, creating deep gorges and scouring many areas down to the underlying bedrock. The Whitefish channel bisects the peninsula and flows southward to present day Lake Michigan near Rapid River.

Some of the landforms in the U.P. are a result of massive concentrations of melt waters that were concentrated at the front of the glacier. These areas are a complex of steeply sloped, high relief deposits composed of glaciofluvial sediments. Areas of ice-contact slopes, ice-contact deltas, head-of-outwash, kame moraines, kame terraces, kettles, outwash fans or small outwash plains can be found in these areas. Some places are comprised of terrace-like ridges consisting of stratified sand and gravel deposited by melt water streams that flowed between the melting glacier and the higher depositional landform.

The forces of wave and wind action combined to create beach ridges and dunes along the Great Lakes shorelines. Remnant beach ridges and dunes formed during earlier lake stages can be found further inland. As the water level of Glacial Lake Nipissing receded to the present day shoreline a series of recessive beach ridges were formed. The ridges are roughly parallel to the shoreline and represent successive positions of the advancing shoreline. Dunes were formed in some places due to the strong persistent winds present along the lakes. The dunes are both active and stabilized. The [Grand Sable Dunes](#) near Grand Marais is the largest area of sand dunes in the U.P.

During post glacial times erosional processes continued to modify the landscape. As vegetation became established areas of organic soils began to form. Water tolerant sedges, grasses, and trees gradually occupied areas where shallow water was left standing. The decaying residue of these plants has accumulated over thousands of years and developed into areas of organic soils. Swamps, bogs and other wetland areas are very common throughout the U.P. Alluvial soils are common along the floodplains of rivers and streams.

The [bedrock](#) of the U.P. is dominantly sedimentary in the eastern half and igneous and metamorphic in the western half. The bedrock formations were formed primarily during the Precambrian, Cambrian, Ordovician and Silurian periods. Numerous rock outcrops occur in areas where the bedrock is close to the surface.

In the western half of the U.P. the bedrock is dominantly Precambrian age igneous and metamorphic rock. Rocks such as granite, gneiss, slate, basalt, schists and volcanics are

common. The iron formations on the Marquette, Menominee, and Gogebic ranges supported an iron mining industry for nearly 100 years. The iron deposits occur in the Negaunee, Ironwood, Loretto and Riverton Iron Formations. Today, only two large open pit mines remain in operation at Palmer and National Mine in Marquette County.

Copper mining was also an important part of the economy in the U.P. for many years. Copper mines were in operation from 1844 to the 1960's. There were numerous copper mines along the Keweenaw Range in Keweenaw, Houghton, and Ontonagon Counties and on Isle Royale. Copper deposits are found in the Portage Lake Volcanics on narrow ridges that are part of the Lake Superior Syncline. The Keweenaw Fault divides the Cambrian sandstone on the east side of the peninsula from the Precambrian Keweenawan age rocks on the west side. The syncline ridge dips downward in a northwest direction beneath Lake Superior and resurfaces again at [Isle Royale](#) and Minnesota. Native Americans originally mined copper and were later followed by European settlers. By the 1960's only three mines remained in operation. The last copper mine at White Pine closed in 1995.

Examples of the Precambrian age bedrock can be seen in many locations throughout the western U.P. Good exposures can be found in the [Porcupine Mountains](#), [Huron Mountains](#), and Trap Hills.

The oldest sedimentary bedrock is the Jacobsville Sandstone Formation. This sandstone was formed in stream and lake sediments eroded from the iron rich Precambrian rocks to the west. The Jacobsville Sandstone is Early to Middle Cambrian age. It consists of red and white-streaked sandstone. The characteristic red and white streaks are due to the oxidation, reduction, and leaching of iron. This sandstone occurs along Lake Superior in Alger, Luce, Chippewa, Marquette, Baraga, Houghton and Keweenaw Counties. Good exposures can be seen at Grand Island, Presque Isle, and along Keweenaw Bay between L'Anse and Baraga. An exposure further inland occurs at the [Sturgeon River Gorge](#).

By the Middle Cambrian Period inland seas were covering much of North America. During the Late Cambrian Period the Munising Sandstone Formation was formed. This sandstone generally consists of white to light gray, dolomitic and glauconitic sandstone, red, green and gray shale, and a basal conglomerate. Dramatic exposures of the [Munising Sandstone](#) can be seen in the cliffs along the [Pictured Rocks National Lakeshore](#) and at many of the waterfalls throughout the area. Possibly one of the most notable waterfalls is the [Upper Tahquamenon Falls](#) in Luce County. The Munising Formation is a narrow band that spans the eastern half of the U.P.

Further south the bedrock formed in marine sediments during the Early Ordovician Period. The dolomitic sandstone and dolomite of the Trempealeau Formation and Prairie du Chien Group were formed during this time period. Exposures of this bedrock can be seen at Laughing Whitefish Falls and Au Train Falls in Alger County. During the Middle Ordovician Period dolomite and limestone bedrock of the Black River and Trenton Group were formed. Exposures of this bedrock can be seen along the Escanaba River below the Bony Falls Dam. During the Late Ordovician Period the Collingwood Shale Member and Richmond Group, which consists of the Big Hill and Stonington Limestone formations, were formed. Numerous exposures of these formations can be seen in the southern half of the Stonington Peninsula.

In the southern part of the eastern U.P. most of the bedrock was formed in the shallow inland seas of the Silurian Period. During the Early and Middle Silurian Periods the rocks of the “Niagara Escarpment” were formed. The Niagara Escarpment refers to the Silurian carbonate rich rocks that are more resistant to weathering, which forms a bedrock “high” with an escarpment that faces outward from the Michigan Basin. The escarpment extends from near Milwaukee, Wisconsin up through the Door Peninsula and into Upper Michigan in the Garden Peninsula. It curves and continues east to the Straits of Mackinac and Drummond Island. From here it curves south to Manitoulin Island, the Bruce Peninsula and Niagara Falls. The Burnt Bluff Group, Manistique Group and Engadine Formation, which are primarily dolomite, make up this region. Good exposures can be seen in the Garden Peninsula at Historical [Fayette State Park](#).

Late Silurian Period bedrock can be found in the Straits of Mackinac area. This bedrock was formed when extensive evaporates were deposited in reefs. The St. Ignace Dolomite and Point aux Chenes Shale occupy this region. Bedrock formed in the Early Devonian Period can also be found in the Straits of Mackinac area. Mackinac Breccia was formed during this period and can be seen along the approach to the Mackinac Bridge, Castle Rock and on Mackinac Island.



Upper Tahquamenon Falls



Pictured Rocks National Lakeshore



Porcupine Mountains



Huron Mountains



Lake Superior coast



Isle Royale National Park



An exposure of Jacobsville Sandstone at Sturgeon River Gorge.



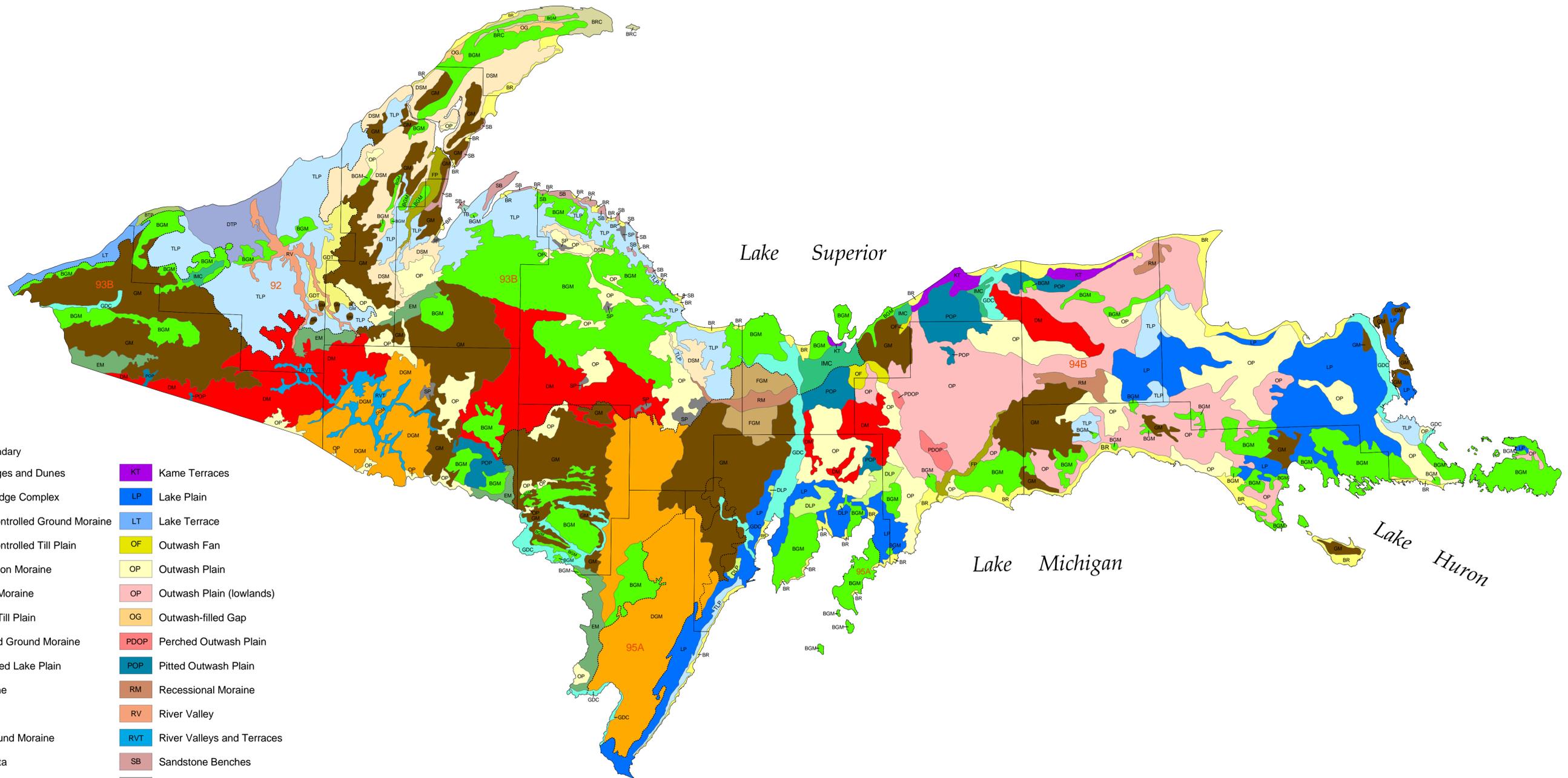
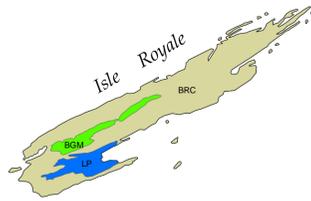
An exposure of Middle Silurian period dolomite of the Burnt Bluff Group at Fayette State Park.



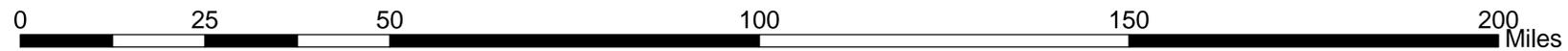
Miner's Castle (Pictured Rocks National Lakeshore) exhibits the two members of the Munising Formation – Miner's Castle Sandstone and Chapel Rock Sandstone.

Landforms of the Upper Peninsula of Michigan

1:750,000



- | | |
|---------------------------------------|--------------------------------|
| MLRA Boundary | KT Kame Terraces |
| BR Beach Ridges and Dunes | LP Lake Plain |
| BRC Bedrock Ridge Complex | LT Lake Terrace |
| BGM Bedrock-controlled Ground Moraine | OF Outwash Fan |
| BTP Bedrock-controlled Till Plain | OP Outwash Plain |
| DM Disintegration Moraine | OP Outwash Plain (lowlands) |
| DSM Dissected Moraine | OG Outwash-filled Gap |
| DTP Dissected Till Plain | PDOP Perched Outwash Plain |
| DGM Drumlinized Ground Moraine | POP Pitted Outwash Plain |
| DLP Dune-capped Lake Plain | RM Recessional Moraine |
| EM End Moraine | RV River Valley |
| FP Floodplain | RVT River Valleys and Terraces |
| FGM Fluted Ground Moraine | SB Sandstone Benches |
| GDT Glacial Delta | SP Swamp |
| GDC Glacial Drainage Channel | TLP Till-floored Lake Plain |
| GM Ground Moraine | TB Tombolo |
| IMC Ice Margin Complex | |



1987_bedrock_geology

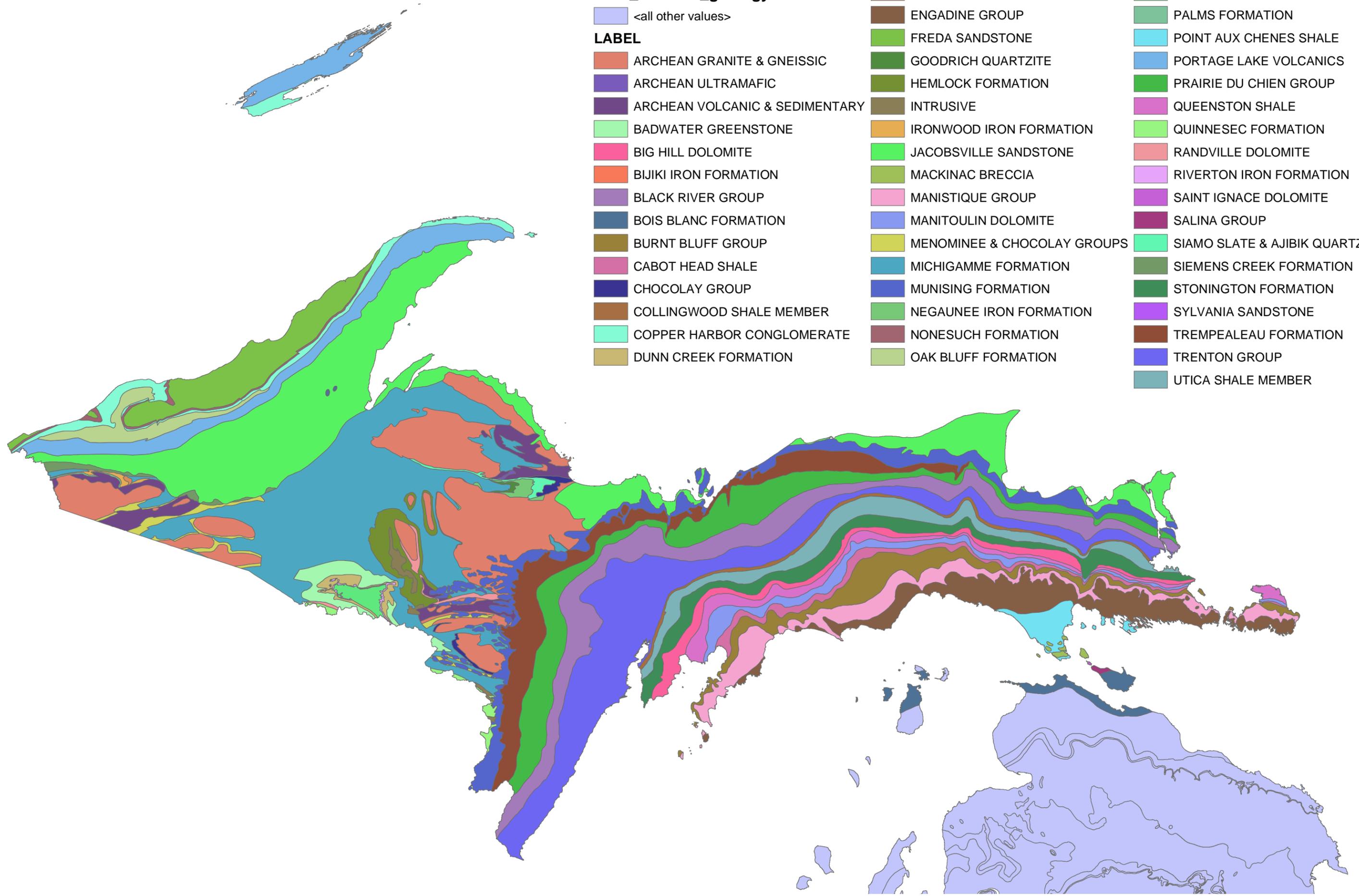
<all other values>

LABEL

- ARCHEAN GRANITE & GNEISSIC
- ARCHEAN ULTRAMAFIC
- ARCHEAN VOLCANIC & SEDIMENTARY
- BADWATER GREENSTONE
- BIG HILL DOLOMITE
- BIJIKI IRON FORMATION
- BLACK RIVER GROUP
- BOIS BLANC FORMATION
- BURNT BLUFF GROUP
- CABOT HEAD SHALE
- CHOCOLAY GROUP
- COLLINGWOOD SHALE MEMBER
- COPPER HARBOR CONGLOMERATE
- DUNN CREEK FORMATION

- EMPEROR VOLCANIC COMPLEX
- ENGADINE GROUP
- FREDA SANDSTONE
- GOODRICH QUARTZITE
- HEMLOCK FORMATION
- INTRUSIVE
- IRONWOOD IRON FORMATION
- JACOBSVILLE SANDSTONE
- MACKINAC BRECCIA
- MANISTIQUE GROUP
- MANITOULIN DOLOMITE
- MENOMINEE & CHOCOLAY GROUPS
- MICHIGAMME FORMATION
- MUNISING FORMATION
- NEGAUNEE IRON FORMATION
- NONESUCH FORMATION
- OAK BLUFF FORMATION

- PAINT RIVER GROUP
- PALMS FORMATION
- POINT AUX CHENES SHALE
- PORTAGE LAKE VOLCANICS
- PRAIRIE DU CHIEN GROUP
- QUEENSTON SHALE
- QUINNESEC FORMATION
- RANDVILLE DOLOMITE
- RIVERTON IRON FORMATION
- SAINTE IGNAZIE DOLOMITE
- SALINA GROUP
- SIAMO SLATE & AJIBIK QUARTZITE
- SIEMENS CREEK FORMATION
- STONINGTON FORMATION
- SYLVANIA SANDSTONE
- TREMPEALEAU FORMATION
- TRENTON GROUP
- UTICA SHALE MEMBER



Landform Descriptions:

Beach Ridges and Dunes [Fig. 1](#), [Fig. 2](#)

A low, essentially continuous ridge of beach or beach and dune material heaped up by the action of waves and currents on the backshore of a beach, beyond the present limit of storm waves, and occurring singly or as one of a series of approximately parallel deposits. The ridges are roughly parallel to the shoreline and represent successive positions of the advancing shoreline. Many of the higher ridges are dunes that formed due to the prevailing winds present along the lakes. The dunes are both active and stabilized. Major areas of dunes along Lake Superior can be found at the [Grand Sable Dunes](#) near Grand Marais. Other locations along Lake Superior that feature dunes and beach ridge features are at Deer Park, Whitefish Point, Great Sand Bay, Au Train, and Big Bay. Along the Lake Michigan shoreline examples of dunes can be found between Brevort and Pt. Aux Chenes. In some locations the beach ridges consist primarily of gravelly, cobbly and channery soils that formed in wave-worked till or outwash deposits. Some of these areas are also shallow to bedrock.

¹**Major Soil Series:** Deer Park, Eastport, Kinross, Dawson, Alpena, St. Ignace, Esau, Seul Choix, Manistique, Shelldrake, Wurtsmith, Rubicon, Yellowdog



Grand Sable Dunes

Bedrock-controlled Ground Moraine [Fig. 3](#)

This landform consists of thin till deposits overlying bedrock. In some areas a predominance of sandy drift overlies the bedrock. Rock outcrops are common. Deeper soils occur where the underlying bedrock is steep and irregular. In some places there is an abundance of small outwash-filled channels associated with this landform. The underlying bedrock is predominantly Cambrian, Ordovician, and Silurian age sandstone,

dolomite, and limestone in the eastern half of the Upper Peninsula. In the western Upper Peninsula the bedrock is dominantly Precambrian age igneous and metamorphic rock. The Gogebic, Marquette, and Menominee Iron Ranges and the Keweenaw Copper Range occur within this landform. Examples of this landform can be found in the [Pictured Rocks National Lakeshore](#), Stonington Peninsula, Garden Peninsula, Drummond Island, Peshekee Highlands, [Huron Mountains](#), [Porcupine Mountains](#), and the Keweenaw Peninsula.

Major Soil Series: Arcadian, Amadon, Gulliver, Shingleton, Trout Bay, Longrie, Onota, Summerville, [Furlong](#), Ishpeming, Potagannissing, Nahma, Ensign, Chippeny, Peshekee, Michigamme, Dishno, Keewaydin, Champion, Deerton, Buckroe, Jeske, Gongeau, Sauxhead

Bedrock-controlled Till Plain

This landform occurs on the north-facing slope between the [Porcupine Mountains](#) and Lake Superior. It consists of thin lake-modified till plain deposits overlying bedrock. The bedrock is primarily siltstone and sandstone. Freda Sandstone, Nonesuch Formation and Copper Harbor Conglomerate occupy this region. Post glacial lake shorelines are also a component of this landform.

Major Soil Series: Flintsteel (P), Loggerhead (P), Belding, Michigamme, Oldman

Bedrock Ridge Complex [Fig. 4](#)

This landform consists of a complex of bedrock ridges, outcrops, benches, beach ridges and terraces. The bedrock is dominantly Copper Harbor Conglomerate and basalt. This landform exhibits a trellis drainage pattern. It occurs in Keweenaw County and on Isle Royale. There are many narrow islands and bays, especially on Isle Royale, along the Lake Superior coast.

Major Soil Series: Arcadian, Nipissing

Disintegration Moraine [Fig. 5](#)

A drift topography characterized by chaotic mounds and pits, generally randomly oriented, developed in supraglacial drift by collapse and flow as the underlying stagnant ice melted. Slopes may be steep and unstable and there will be used and unused stream courses and lake depressions interspersed with morainic ridges. Consequently, there will be rapid or abrupt changes between materials of differing lithology. The landscape is typically pitted with numerous depressions. These depressions are small areas of organic soils, lakes, or are dry. This landform occurs in several counties in the Upper Peninsula.

Major Soil Series: [Kalkaska](#), [Garlic](#), Dillingham, [Greenwood](#), Dawson, Goodman, Sundog, Rubicon, Keweenaw, Sagola, Zimmerman, [Rousseau](#), Cathro

Dissected Moraine [Fig. 6](#)

A ground moraine characterized by a dendritic pattern of hilly to very steep ridges and ravines. Ephemeral streams are common. This landform consists of till and

glaciolacustrine deposits. In some places sandy outwash soils are a component of this landform due to the proximity of the rapidly melting glacier and the influence of glacial lakes. Sandy and silty stratified soils are common in some places while coarse-loamy till is dominant in others.

Major Soil Series: [Garlic](#), Alcona, Voelker, [Rousseau](#), Ocqueoc, Munising, [Yalmer](#), Keweenaw, [Kalkaska](#), Waiska, [Sporley](#)

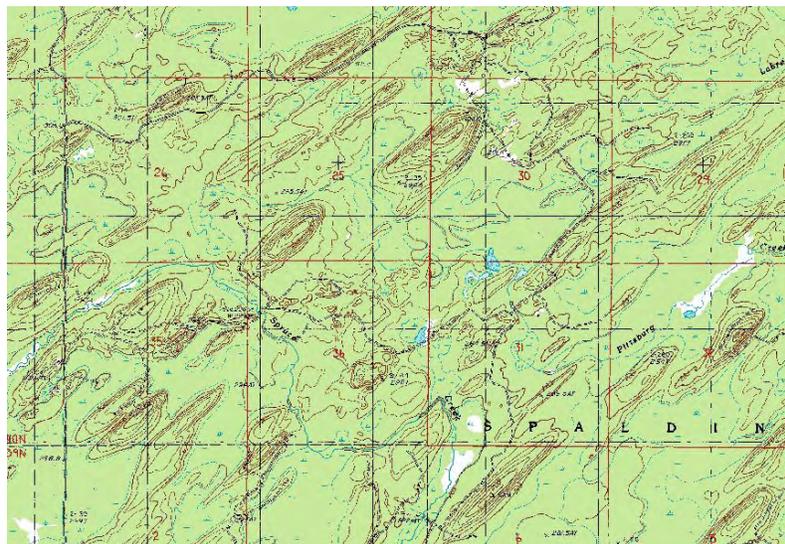
Dissected Till Plain [Fig. 7](#)

A broad lake-modified till plain that is dissected by numerous parallel drainages flowing to Lake Superior. The soils formed predominantly in silty and loamy lacustrine deposits overlying clayey till. This landform was occupied by both Glacial Lakes Algonquin and Duluth.

Major Soil Series: Big Iron (P), Flintsteel (P), Gull Point (P), Watton

Drumlinized Ground Moraine [Fig. 8](#)

A till plain characterized by numerous elongated oval hills of compact, loamy glacial till, which are generally oriented in a northeast-southwest direction. The drumlins are products of streamline (laminar) flow of the glacier, which molded the sub glacial floor through a combination of erosion and deposition. Areas of sandy and gravelly outwash soils in the form of eskers or channels of outwash, along with large areas of organic soils occur between the drumlins. Bedrock breaks the surface intermittently on this landform, particularly along rivers and streams. The dominantly loamy soils of this landform are characterized by acid to neutral solums 20 to 40 inches thick over dense calcareous loamy till. Some minor areas of soils shallow or moderately deep to bedrock occur on the flats.



This landform occurs in Menominee County, southern Marquette County, western Delta County, eastern Dickinson County, and Iron County. It is part of two large drumlin fields that continue southward into Wisconsin.

Major Soil Series: Onaway, Emmet, Pemene, Nadeau, Ensley, Wabeno

Dune-capped Lake Plain [Fig. 9](#)

This landform marks the floor of Glacial Lake Algonquin. It consists of sandy lake bed deposits interspersed with wind-worked sand bars or dunes. The dunes have stabilized and are no longer actively forming. They occur as large linear ridges generally oriented in an east-west direction surrounded by organic soils. This landform occurs predominantly in Delta County.

Major Soil Series: [Rousseau](#), Proper, [Greenwood](#), Tawas, Carbondale

End Moraine

A system of ice contact ridges that form the outer margins of the Marenisco, Winegar, and Watton Moraines. This landform was formed in deposits left at the front of an advancing ice sheet. Ice lobes such as the Keweenaw Bay, Langlade and Green Bay periodically retreated and advanced leaving a series of ridges. The soils here formed predominantly in loamy till, but areas of sandy and gravelly soils occur due to the extensive reworking of till that was pushed ahead and deposited by the ice. This landform occurs primarily in western Menominee County, and southern Baraga, Houghton, and Ontonagon Counties.

Major Soil Series: Emmet, Pemene, Nadeau, Alstad, Kallio, [Watton](#)

Floodplain [Fig. 10](#)

A nearly level plain that borders a river and is subject to inundation under flood stage conditions. It consists of sediments deposited during overflow and lateral migration of the stream. Some typical floodplain features are oxbows, meander scars, back swamps, and levees. Floodplains exist along numerous rivers and streams throughout the Upper Peninsula, but they are generally too narrow or numerous to delineate. Also, rivers and streams in younger stages of development do not exhibit broad floodplain features. The major [glacial drainage channels](#) were also delineated as a separate landform. An example of the floodplain landform can be found along the Manistique River in Schoolcraft County and the Sturgeon River in Baraga and Houghton Counties.

Major Soil Series: [Arnheim](#), Sturgeon, [Moquah](#), Pelkie, Winterfield, Neconish, Tawas

Fluted Ground Moraine [Fig. 11](#)

A till plain consisting of calcareous, loamy glacial till with parallel grooves and ridges. The grooves are generally oriented in a north-south direction, indicating the direction of the ice movement. Dolomite and limestone bedrock underlie this landform, coming to the surface in places. This landform occurs in southwestern Alger County, southeastern Marquette County, and northwestern Delta County.

Major Soil Series: Shoepac, Trenary, [Reade](#), Charlevoix, Ensley

Glacial Delta

This landform was formed in sandy outwash from melt water streams that flowed off the Six Mile and Watton Moraines. The sandy outwash sediments were deposited in areas occupied by Glacial Lake Ontonagon.

Major Soil Series: Rubicon, [Rousseau](#), Vilas

Glacial Drainage Channel [Fig. 12](#)

This landform consists of large drainage channels that were formed from extensive amounts of melt water present during deglaciation. These channels were outlets of glacial lakes that occupied parts of the Upper Peninsula and the surrounding region. The channels typically consist of a series of outwash or bedrock terraces with a current stream channel in the bottom. The large volumes of water that moved through these channels scoured some areas down to the underlying bedrock and deposited gravelly and cobbly outwash deposits in other places. In some areas the glacial drainage channels contain alluvial sediments that formed during periods of slower moving water. Some glacial drainage channels were blocked periodically. In some cases melting ceased long enough to enable lacustrine soils to form in stagnant waters. Examples of this landform can be found along the Whitefish River, Menominee River, Pine Creek, and Saint Mary's River.

Major Soil Series: Eben, Traunik, Waiska, Summerville, Chippeny, Longrie, Nahma, Ermatinger, Wega

Ground Moraine [Fig. 13](#)

An extensive, fairly even layer of till, having an uneven or undulating surface; a deposit of rock and mineral debris dragged along, in, on or beneath a glacier and emplaced by processes including basal lodgment and released from down wasting stagnant ice by ablation. In some areas the ground moraine consists of large, relatively flat till plains and in other areas the landscape is quite hilly. This landform occurs throughout the entire Upper Peninsula. Some moraines are known locally and referred to as the Munising, Newberry, Cooks, Crisp Point, Marquette, Watton, Six Mile, Winegar, Keweenaw, Marenisco, Republic, Sagola, and Crystal Falls moraines.

Major Soil Series: Greylock, Cookson, Graveraet, Trenary, Mashek, Emmet, Ensley, Charlevoix, Pemene, Munising, Bodi, Chesbrough, Champion, Gogebic, Net

Ice Margin Complex

An assemblage of landforms constructed proximal to a relatively static, rapidly wasting glacier. Constituent landforms include head-of-outwash, ice-contact slope, ice-contact delta, kame, kame moraine, kame terrace, kettle, outwash fan and small outwash plains. Glaciofluvial sediments are dominant, but glaciolacustrine sediments and till are also present. This landform occurs in Alger County. It formed due to the rapid melting of glacial ice that was formed during the Marquette advance.

Major Soil Series: [Garlic](#), Blue Lake, Voelker, Cusino

Kame Terraces [Fig. 14](#)

A series terrace-like ridges consisting of stratified sand and gravel deposited by a melt water stream flowing between a melting glacier and a higher landform. Also included in this landform are small areas of glacial drainage channels in depressions and drainageways. Examples of this landform can be found in Alger County in the Beaver Basin area and eastward into Luce County.

Major Soil Series: [Kalkaska](#), Cusino, Carbondale, Tawas

Lake Plain [Fig. 15](#)

This is a nearly level plain that occurs in areas that were covered with water from Glacial Lake Algonquin. The soils on this landform formed predominantly in sandy lacustrine deposits. However, in Chippewa and Mackinac Counties it consists of well sorted, fine textured, stratified deposits.

Major Soil Series: Rubicon, [Rousseau](#), Croswell, [Halfaday](#), [Au Gres](#), Roscommon, Markey, Tawas, Ingalls, Anninias, Zandi, Rudyard, Pickford, [Ontonagon](#)

Lake Terrace

This is a step-like surface that is bordered by Lake Superior. It represents the recessional positions of the lake prior to the current lake elevation. It is strongly dissected with numerous intermittent and perennial streams. Rock outcrops occur in some of the drainageways. The soils on this landform formed predominantly in lake-modified till deposits.

Major Soil Series: Flintsteel (P), Rockland (P), Loggerhead (P), Big Iron (P), Arcadian, Alcona

Outwash Fan

A fan-shaped area of outwash adjacent to an ice margin complex and ice contact slope. The sandy outwash was deposited by glacial melt water streams from rapidly melting ice. This landform was formed from outwash from the Marquette advance. It occurs along the border of Alger and Schoolcraft Counties.

Major Soil Series: [Kalkaska](#), Rubicon

Outwash Plain [Fig. 16](#)

An extensive plain consisting of sandy glaciofluvial material. This landform is formed from vast quantities of glacial melt water overloaded with soil and rock debris. The outwash deposits consist primarily of sand and gravel in well-stratified layers. This landform is very common throughout the Upper Peninsula.

Major Soil Series: Rubicon, Grayling, [Kalkaska](#), Adams, Amasa, Karlin, Pence, Vilas

Outwash Plain (lowland) [Fig. 17](#)

This landform was initially a lake plain and was later covered by outwash deposits. It occurs in extensive lowland areas, and consists of soils that are predominantly poorly or very poorly drained. Organic soils are common. These areas were occupied by Glacial Lake Algonquin. As lake levels receded and ice melted the area was covered by outwash from glacial deposits to the north. In some areas this landform is interspersed with wind-worked sand bars or dunes. This landform occupies a large portion of Schoolcraft, Luce and Mackinac Counties. The Seney National Wildlife Refuge is located entirely within this landform.

Major Soil Series: Markey, Deford, Dawson, [Rousseau](#), Proper, Kinross

Outwash-filled Gap

This landform occurs in Keweenaw County. It consists of glaciofluvial and glaciolacustrine deposits. These areas formed where the flow of glacial melt water was controlled by gaps in the Copper Range or where melt water streams formed kame terraces between the ice and steep side slopes. This landform consists of a complex of several landforms formed in glacial outwash such as deltas, eskers, kames, terraces and lake plains. These landforms by themselves were too small to delineate.

Major Soil Series: [Garlic](#), Waiska, Alcona

Perched Outwash Plain

This is an [outwash plain](#) that was incised by waters from a later period of glacial melting and stands several meters or more above the surrounding lowlands. This landform occurs in two segments in western Schoolcraft County.

Major Soil Series: Rubicon, [Kalkaska](#), McMillan

Pitted Outwash Plain [Fig. 18](#)

An outwash plain marked by many irregular depressions such as kettles and shallow pits formed by melting of large ice blocks incorporated in the sandy outwash. This landform contains numerous kettle lakes. Examples of this landform can be found in Alger, Delta, Luce, and Schoolcraft Counties.

Major Soil Series: [Kalkaska](#), Rubicon, Dawson, Tawas

Recessional Moraine

This landform marks the outer edge of the Marquette advance. It was formed during a temporary halt in the final retreat of the Marquette lobe. It consists of sandy and gravelly outwash and loamy lodgment till. Examples of this landform can be found in Alger, Marquette, and Luce Counties.

Major Soil Series: Amasa, Traunik, Kiva, Shoepac, Graveraet, Trenary

River Valley

A steep elongated depression carved by a river during the course of its development. The valley sides are steeply sloped. The valley bottom has floodplain features. Landslides from seepage and undercutting of the stream bank during periods of heavy runoff occur in some places on this landform. This landform occurs along the Ontonagon River in Ontonagon and Houghton County.

Major Soil Series: Rockland, [Watton](#), [Arnheim](#), [Moquah](#)

River Valleys and Terraces

This landform occurs primarily along the Paint and Iron Rivers in Iron County. The fast flowing glacial melt waters scoured periglacial valleys. Sand and gravel filled the valleys as the discharge slowed and created a river valley and series of terraces.

Major Soil Series: Pence, Lode, Waucedah, Cathro, Lupton

Sandstone Benches

This landform consists of thin deposits of sandy and loamy drift and residual soils over sandstone bedrock. Most of this landform was covered by glacial lakes. Glaciolacustrine and glaciofluvial processes have greatly influenced the soils. Rock outcrops are common. Red and brown Jacobsville sandstone dominates this landform. This landform occurs primarily within a short distance of Lake Superior.

Major Soil Series: Abbaye, Jacobsville, Zeba, Buckroe, Sauxhead, Deerton, Yellowdog, Burt, Betsy Bay

Swamp

An area of low, saturated ground, intermittently or permanently covered with water, and predominantly vegetated by shrubs and trees, with or without the accumulation of peat or muck. This landform typically occurs within other landforms such as ground moraines, lake plains, and outwash plains.

Major Soil Series: Carbondale, Tawas, [Greenwood](#)

Till-Floored Lake Plain

This landform was formed when sand, silt, and till deposits were reworked by glacial melt waters. Most of the landform was covered by glacial lakes and was later exposed when the water level lowered. Wave action of the glacial lake waters along with other glaciofluvial processes resulted in the mixing and reworking of existing glacial drift deposits. This created a landform that has soils that are extremely variable within short distances. Some areas are dominantly fine textured soils while others are coarse textured deposits.

Major Soil Series: [Rousseau](#), Ingalls, Wallace, Alcona, Posen, Froberg, [Yalmer](#)

Tombolo [Fig. 19](#)

A sand, gravel bar or barrier that connects an island with the mainland or another island. Pequaming Point is connected to mainland by a tombolo consisting of sandy beach ridge-swale complex and marsh. Other tombolos are present on Grand Island and at Presque Isle, but were too small to delineate.

Major Soil Series: Croswell, Au Gres

References

- Dorr, John and Eschman, Donald F. 1970. Geology of Michigan. The University of Michigan Press.
- Farrand, William R. University of Michigan. 1988. The Glacial Lakes around Michigan. Michigan Department of Environmental Quality, Geological Survey Division. Bulletin 4.
- Farrand, William R. and Bell, D.L. 1982. University of Michigan. Quaternary Geology of Northern Michigan.
- Martin, Helen. 1957. Geologic Map of Michigan. Michigan Department of Conservation.
- Jordan, James K. 2000. United States Department of Agriculture, Forest Service North Central Forest Experiment Station. Landtype Associations of the Western Upper Peninsula, Michigan.
- United States Department of Agriculture, Natural Resources Conservation Service. 1997. Soil Survey of Mackinac County, Michigan.
- United States Department of Agriculture, Natural Resources Conservation Service. 1997. Soil Survey of Iron County, Michigan.
- United States Department of Agriculture, Natural Resources Conservation Service. 2003. Soil Survey of Alger County, Michigan, Interim Report.
- United States Department of Agriculture, Natural Resources Conservation Service. 1996. Soil Survey of Marquette County, Michigan, Interim Report.
- United States Department of Agriculture, Soil Conservation Service. 1989. Soil Survey of Menominee County, Michigan.
- United States Department of Agriculture, Soil Conservation Service. 1989. Soil Survey of Dickinson County, Michigan.
- United States Department of Agriculture, Natural Resources Conservation Service. 1992. Soil Survey of Chippewa County, Michigan.
- United States Department of Agriculture, Soil Conservation Service. 1977, 1994. Soil Survey of Delta County and Hiawatha National forest of Alger and Schoolcraft Counties, Michigan.
- United States Department of Agriculture, Natural Resources Conservation Service. National Soil Survey Handbook, Glossary of Landforms.

United States Department of Agriculture, Soil Conservation Service. Agricultural Handbook 296. 1981. Land Resource Regions and Major Land Resource Areas of the United States.

Acknowledgements:

This publication is the collaborative efforts of the USDA Natural Resources Conservation Service soil survey staff in the Upper Peninsula. A significant portion of this document was completed with the support of Lawrence M. Carey, MLRA Project Leader, USDA Natural Resources Conservation Service in Marquette, Michigan and Douglas A. Wysocki, Research Soil Scientist from the USDA-NRCS National Soil Survey Center in Lincoln, Nebraska. Both Doug and Larry spent several years working with the Upper Peninsula soil survey staff studying landforms, soils, reviewing maps and landform descriptions. Other individuals that were vitally important in providing the years of field work necessary for producing this publication were the soil scientists on the various soil surveys throughout the Upper Peninsula. This map and document would not have been possible without their efforts. Their work on soil surveys studying landforms and mapping soils provided the background information necessary for this publication. Those individuals who have worked on soil surveys in the Upper Peninsula are: Soil Survey Project Leaders - Loren Berndt, Joseph Calus, J. Scott Eversoll, Lyle Linsemier, William Perkis, Charles Schwenner, Stephen Tardy, and Gregory Whitney; Soil Scientists - Jamie Antoniewicz, William Anzalone, Thomas Bauer, Thomas Berndt, Matthew Bromley, Donald Buchanan, Lawrence Carey, Gerald Davis, Robert Evon, Mark Farina, Eric Gano, Karl Hausler, Dwight Jerome, Martin Kroell III, Richard Larson, Sara Mase, Richard Nielson, Craig Outwater, Larry Perrault, Thomas Purkey, Jon Quisler, Dennis Robinson, James Robinson, Steve Rodock, Darin Silkworth, Anthony Smith, Gregory Thoen, David White, Jessica Weis, Gerald Wigger, Kenneth Wikgren, and Daniel Wing.

Photo Credits:

Upper Tahquamenon Falls – Dwight Jerome
Pictured Rocks National Lakeshore – Chuck Schwenner
Porcupine Mountains – Dwight Jerome
Huron Mountains – Dwight Jerome
Lake Superior coast – Dwight Jerome
Isle Royale National Park – Dwight Jerome
Miners Castle – Dwight Jerome
Sturgeon River Gorge – Dwight Jerome
Fayette State Park – Dwight Jerome
Grand Sable Dunes – National Park Service

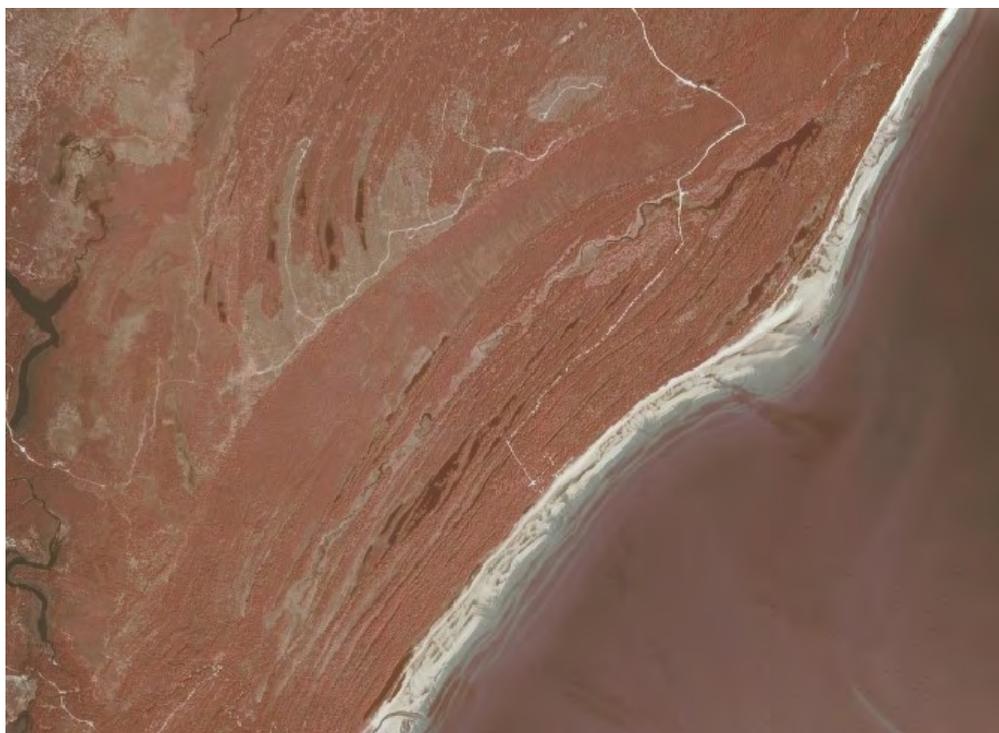


Fig. 1 - *Beach Ridges* along Lake Michigan in Mackinac County.

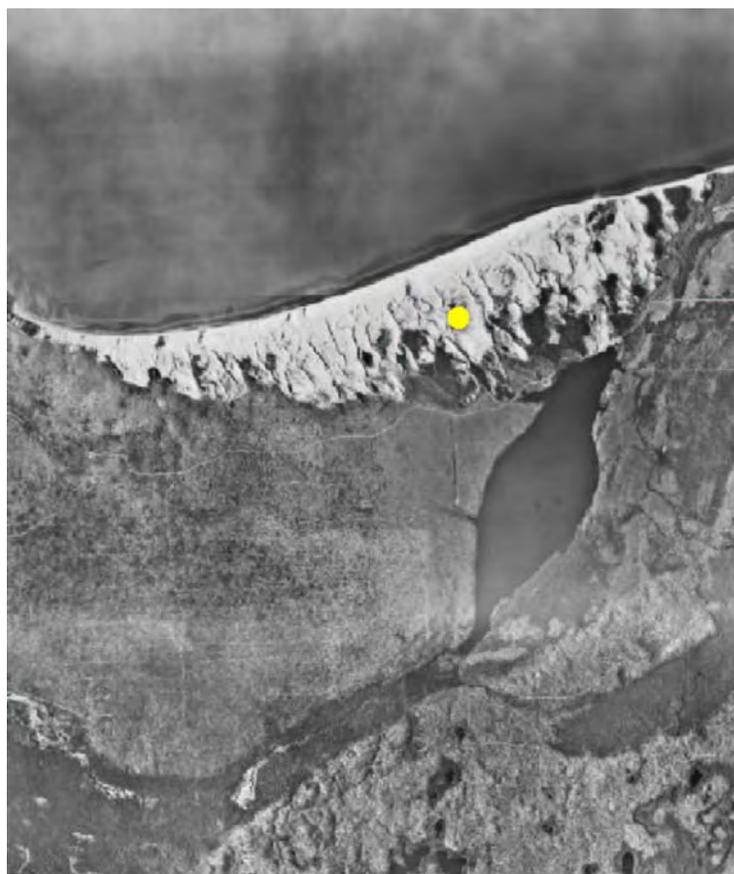


Fig. 2 – Grand Sable Dunes, Alger County.



Fig. 3 – *Bedrock-controlled Ground Moraine in Marquette County.*

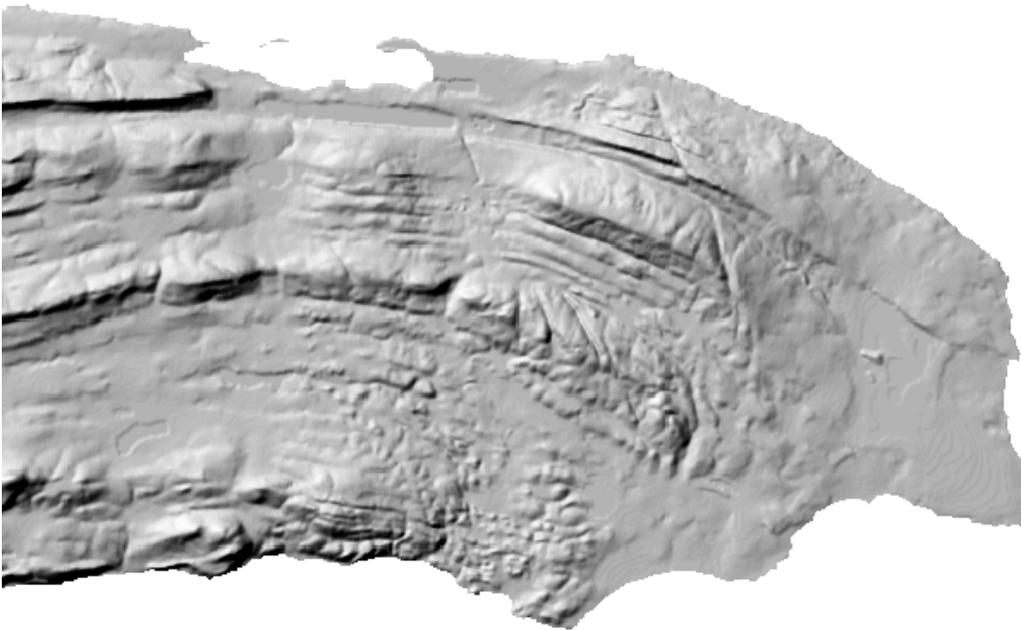


Fig. 4 – A digital elevation model of the tip of the Keweenaw Peninsula showing the *Bedrock Ridge Complex.*



Fig. 5 – *Disintegration Moraine* in eastern Alger County.

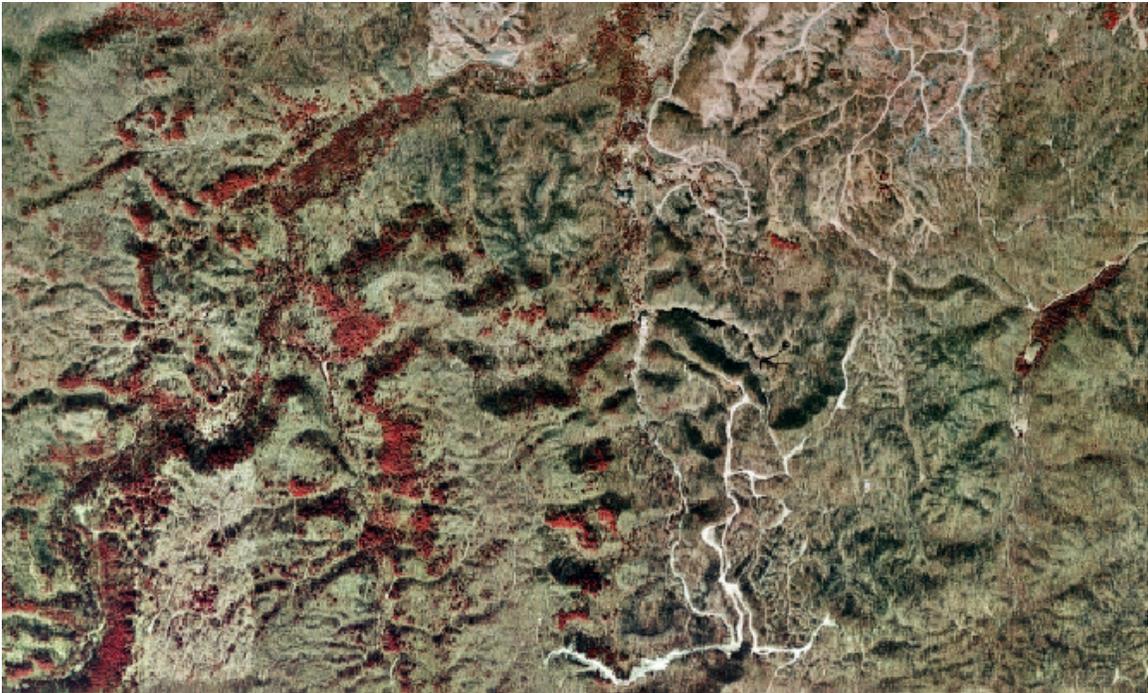


Fig. 6 – *Dissected Moraine* in Marquette County.

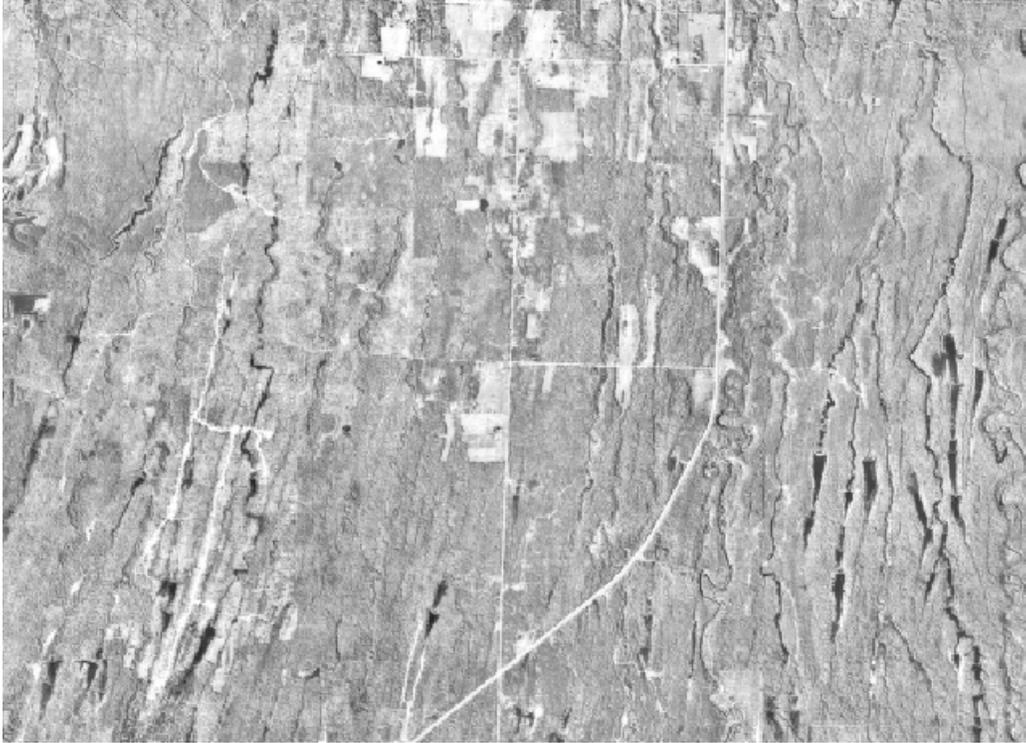


Fig. 7 – *Dissected Till Plain* in Ontonagon County.



Fig. 8 – *Drumlinized Ground Moraine* in northern Menominee County.



Fig. 9 – *Dune-capped Lake Plain* in Delta County.



Fig. 10 – *Floodplain* along the Manistique River in Schoolcraft County.



Fig. 11 – *Fluted Ground Moraine* in Alger County.



Fig. 12 – *Glacial Drainage Channel* along the Whitefish River in Alger County.



Fig. 13 – *Ground Moraine* in Luce County.

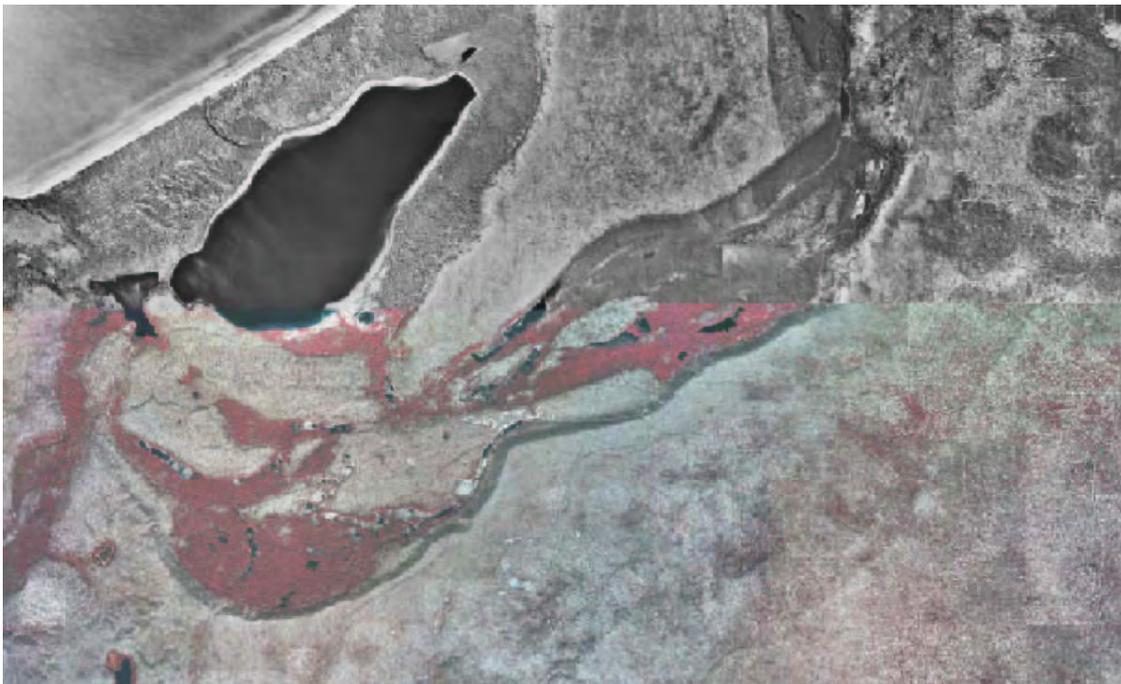


Fig. 14 – *Kame Terraces* near Beaver Lake in Alger County.



Fig. 15 – *Lake Plain* in eastern Chippewa County. The clayey soils of this landform have been surface ditched and used for pasture and hayland.



Fig. 16 – *Outwash Plain* in northern Schoolcraft County. The sandy soils of this landform support large stands of jack pines, which are managed by clear-cutting.



Fig. 17 – *Outwash Plain (lowland)* in Schoolcraft County. Glacial Lake Algonquin occupied this region. It was later covered by outwash from melting glaciers to the north. The landform is characterized by numerous large wetlands. The Strangmoor Bog is shown here in the Seney National Wildlife Refuge.

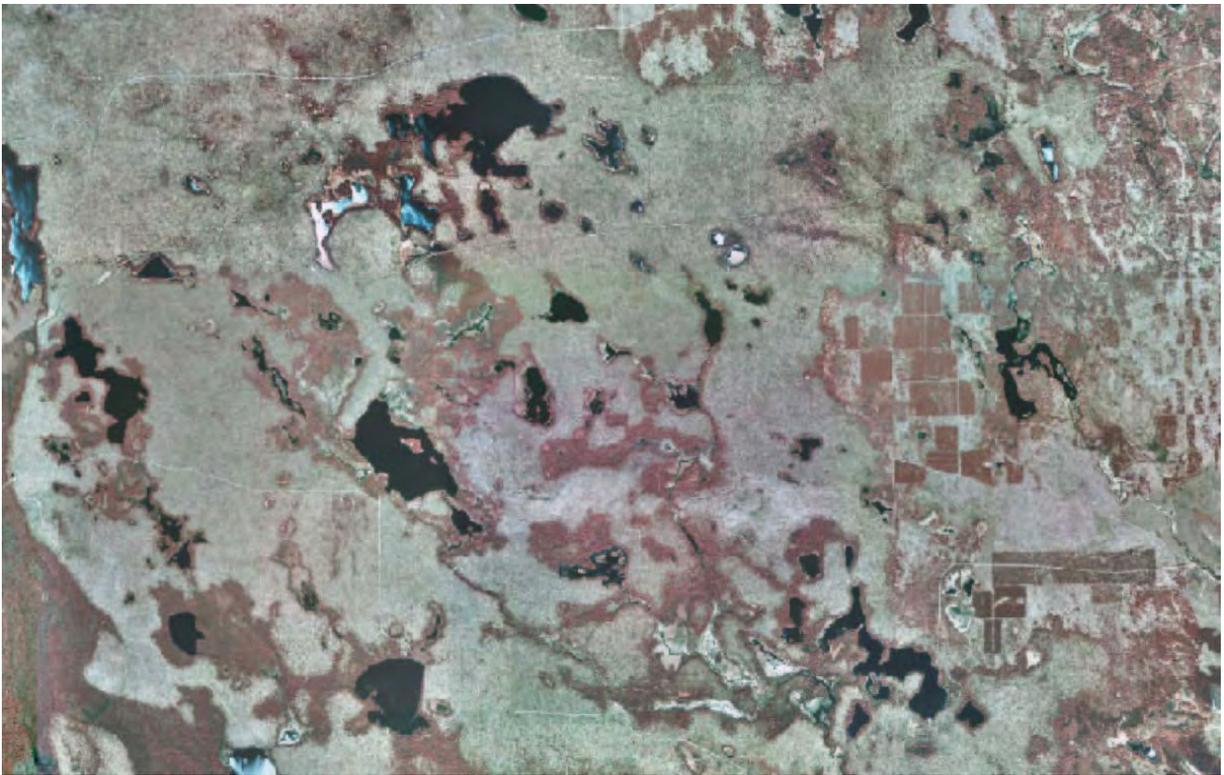


Fig. 18 – *Pitted Outwash Plain* in Alger and Schoolcraft Counties.



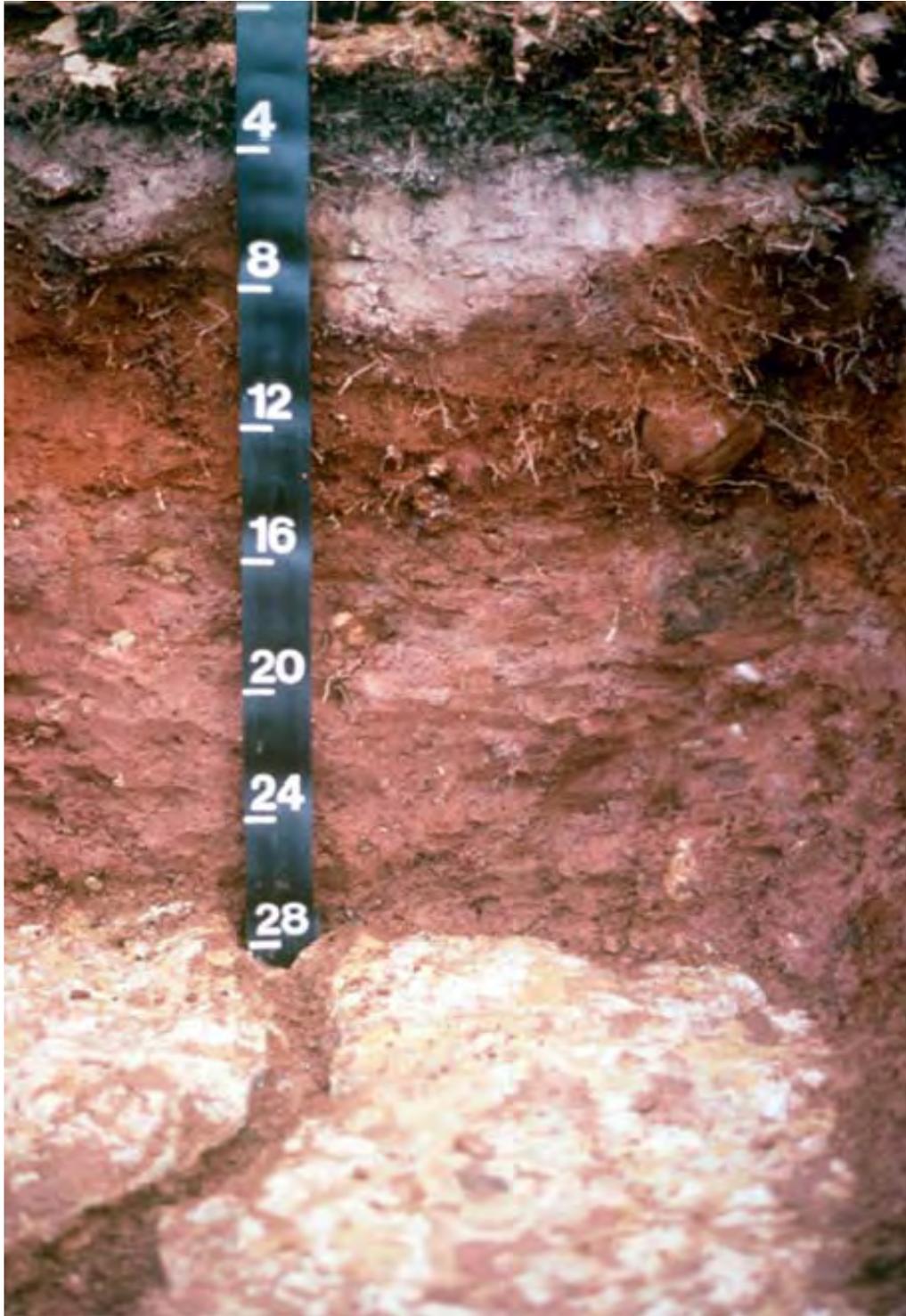
Fig. 19 – A *Tombolo* connects Pequaming Point to mainland in Baraga County.



Garlic Series



Kalkaska Series



Reade Series



Au Gres Series



Stutts Series



Furlong Series



Arnheim Series



Greenwood Series



Rousseau Series



Halfaday Series



Ontonagon Series



Watton Series



Sporley Series



Yalmer Series



Moquah Series

¹ Soil series descriptions can be obtained on the internet at: www.soils.usda.gov