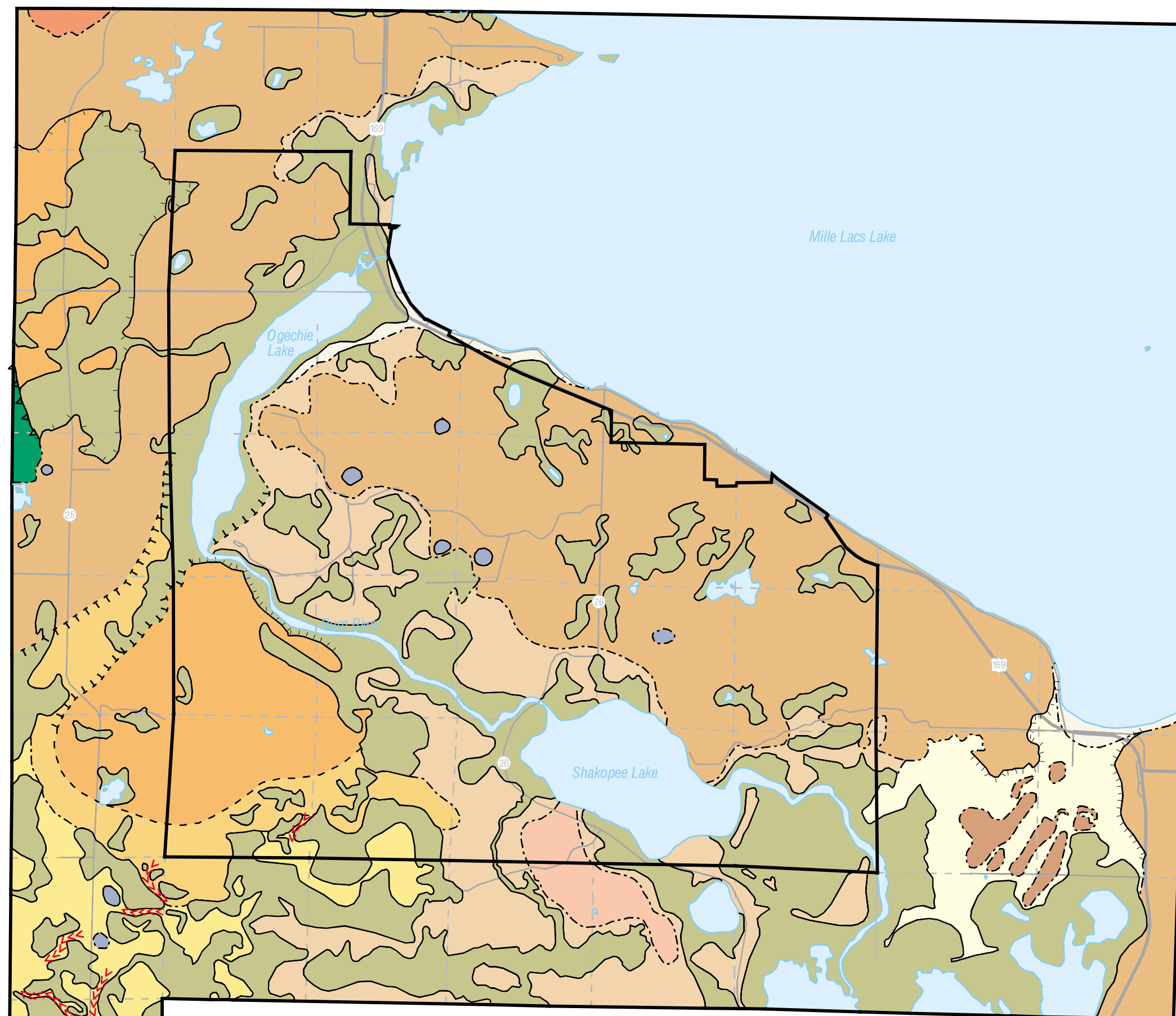
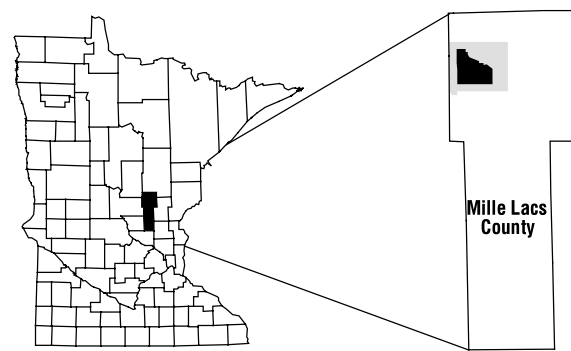
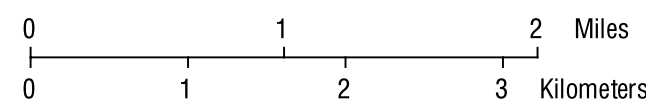


SURFICIAL GEOLOGY MILLE LACS KATHIO STATE PARK

HEATHER ANDERSON
 1998



Scale 1:48,000



GEOLOGIC CONTACT

- Well defined
- - - Inferred
- - - Gradational
- Water

LANDFORMS

- ==== Esker-like ridge
- Outlet channel scarp
- TTTT Buried valley scarp
- ▲ Ice thrust margin
- Ice thrust depression

HOLOCENE

- ORGANIC SOILS: Partially decomposed plant material, includes peat, shallow lakes, and marshes. Found in lowland areas near bodies of water and in small isolated depressions within the moraine.
- WATER: Lakes and streams.

PLEISTOCENE

Sediments associated with the Superior Lobe during the Automba Phase

- BEACH SEDIMENTS: Well sorted, fine sand, with occasional layers of silt and gravel. Red-brown in color. Forms a relatively flat surface with a gentle slope toward water bodies. Found in Mille Lacs Lake bays or along an historical shore line near the 1260 elevation contour. Interpreted as sediments deposited during long lasting lake levels.
- SEDIMENTS OF CHANNEL LAG: Fine to coarse sand and gravel with some silt and clay layers, moderately sorted; may have local accumulations of organic soils or silt mantle. Forms a flat lowland. Found in an abandoned outlet of Lake Mille Lacs. Interpreted as an erosional and depositional feature. Water eroded an outlet through a sand and gravel layer then deposited its sediment load as lake levels dropped. Unit thickness is difficult to determine since it overlies another unit of sand and gravel. The sediments are capped by a patchy layer of till. The till is from a Superior lobe origin and may represent a brief advancement of glacial ice.
- SEDIMENTS OF CHANNEL BARS: Fine to medium sand and gravel with occasional silt layers, well sorted. Red-brown in color. Forms streamlined highlands found in the abandoned channel. Interpreted as depositional features that are associated with sediments of channel lag. This deposit is also capped by till.
- SEDIMENTS OF KAMES: Fine to coarse sand and gravel, some silt layers, poorly to moderately sorted. Form conical hills 30-50 feet high. Found scattered throughout the moraine. Interpreted as ice stagnation features; holes on the glaciers surface transported water and sediments to the glacier base. May also have a till cap.
- SEDIMENTS OF ICE WALLED LAKES: Fine sand and silt with occasional pebbles and dropstones, well sorted. Sediments have laminar bedding. Buff to red-brown in color. Forms a flat-topped circular hill. Found connected with ice walled outwash stream system. Interpreted as an ice-contact depositional feature; depressions on or in glacial ice pool water and trap sediments.
- OUTWASH: Medium to fine sand and gravel with cobbles, poorly to moderately sorted. Red-brown in color. Forms gentle and steep slopes with scattered depressions or pits created by ice blocks incorporated in the outwash. Found along the outer edge of the moraine with some streams flowing under or in ice. Interpreted as sediments deposited by glacial meltwater around and near stagnant ice.
- PITTED OUTWASH: Fine sand and gravel with occasional layers of silt and pebbles, well to moderately sorted. Red-brown in color. Forms a flat surface with an abundance of scattered pits. Found as an isolated area of glacial meltwater deposition to the north of the mapping area. Interpreted as meltwater that has been slightly pooled due to poor drainage.
- PITTED OUTWASH WITH A TILL CAP: Fine sand and gravel with lesser amounts of silt, moderately sorted. Red-brown in color. Land surface is gently rolling with an abundance of scattered pits. Small depressions along the surface may contain layers of organic sediments. Found near a lake basin and may have been modified by running water. Covered by a patchy cap of till of varying thickness.
- TILL: Typically a loam textured till; ranges from loamy sand to clay. Red-brown in color except for the upper foot of the unit where leaching caused the color to be light gray. Till is compact and retains moisture. Depth of deposit ranges between 10-50 feet. Forms a hummocky topography; local deposits of organic soils may accumulate in the depressions of hummocks. Found in the majority of the study area. Geologic contacts between till types are gradational. Interpreted as sediments deposited from subglacial ice. Partially forms the Mille Lacs moraine.
- Meltout till: Till with a sandy loamy texture, lower content of silt than previously described. Local inclusions of moderately sorted sand and gravel. Red-brown, oxidizes to a rust-brown in color and upper foot is leached light gray. Well drained and crumbly. Forms gently rolling hills with some hummocks and fewer depressions. Found near a glacial margin and grades into flowtill. Geologic contact is gradational. Interpreted as a large collection of englacial and supraglacial sediments deposited as the ice melts. Partially forms the Mille Lacs moraine.
- Flow till: Till with a generally sandy loamy texture. Red-brown color with the upper foot leached light gray. Forms elongated ridges sloping toward lower elevations. Found on the outer margins of the moraine and grades into outwash. Interpreted as till redeposited by the forces of gravity (slumping).
- Till with stream and/or lake modified surfaces: Till with patchy mantle of various sediments. Mantle includes organics, silt, sand, and gravel. Texture is similar to "till" described above. Red-brown in color. Forms flat lowlands bordering organic soils. Found along channels and bays of Mille Lacs Lake. Interpreted as till that was partially eroded by running water.

Sediments associated with the Rainy Lobe during the St. Croix Phase

- THRUSTED OUTWASH: Sand and gravel with lesser amounts of silt, varying degrees of sorting from well to moderate. "Salt and pepper" coloration. Unit is faulted, thrust and collapsed. The thickness is generally greater than 60 feet. Landforms vary from steep to flat, depending on the degree of thrusting. Found as a limited surficial exposure; however unit is deposited over an extensive area. Interpreted as outwash deposited during the retreat of the Rainy lobe that was thrust during a later advance of the Superior lobe. This unit provides most of the topographic expression of the Mille Lacs moraine.

Surficial geology based on an interpretation of aerial photography, field work, and delineation by Heather Anderson.

Database design and cartography by Renee Johnson.

Base map: Lakes and rivers from National Wetland Inventory, U.S. Fish and Wildlife Service, compiled at 1:24000 from aerial photography (1979-1988) and spot field checking.
 Public Land Survey - PLS Project, Minnesota Department of Natural Resources, Division of Minerals.
 Roads from State of Minnesota Basemap, Department of Transportation Surveying and Mapping BaseMap Development Group.