Connecting Soils and Glacial Geology

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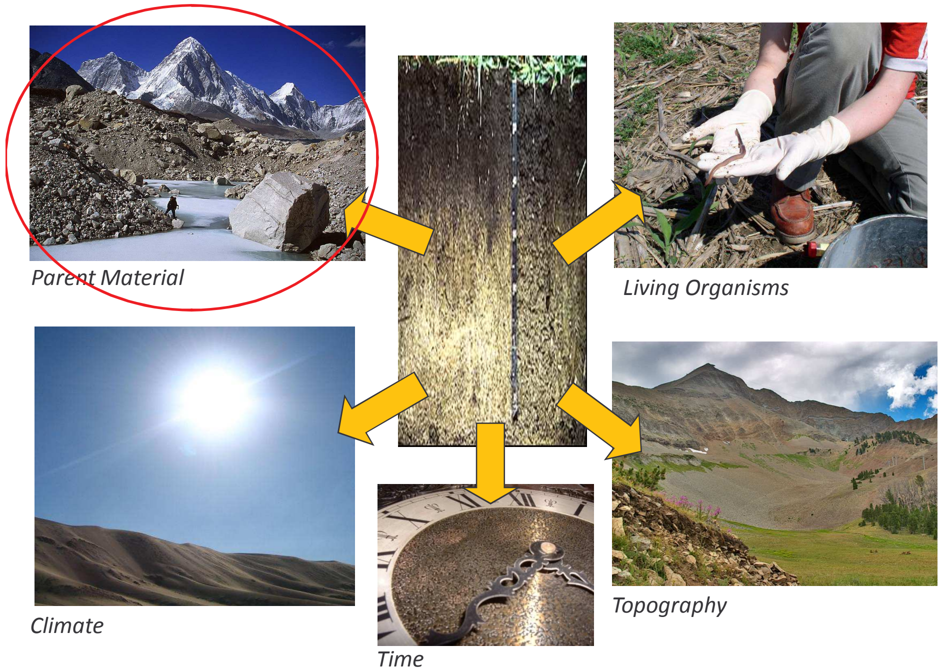
Acknowledgment: Bob Baker, Emeritus Professor, UWRF

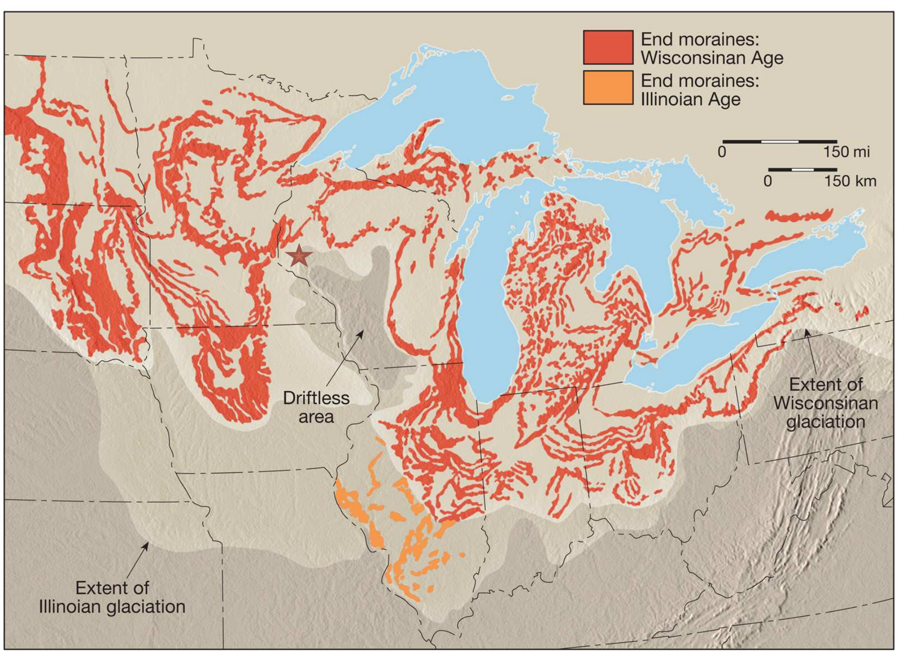
Soil perspectives my students are bringing to my geomorphology course…

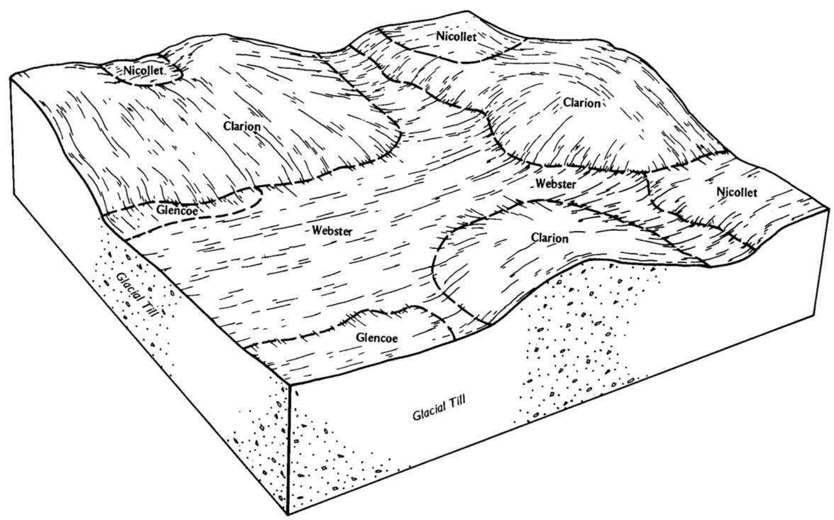
- Overburden
- Agriculture

- My bias: soils can tell detailed stories about the landscape

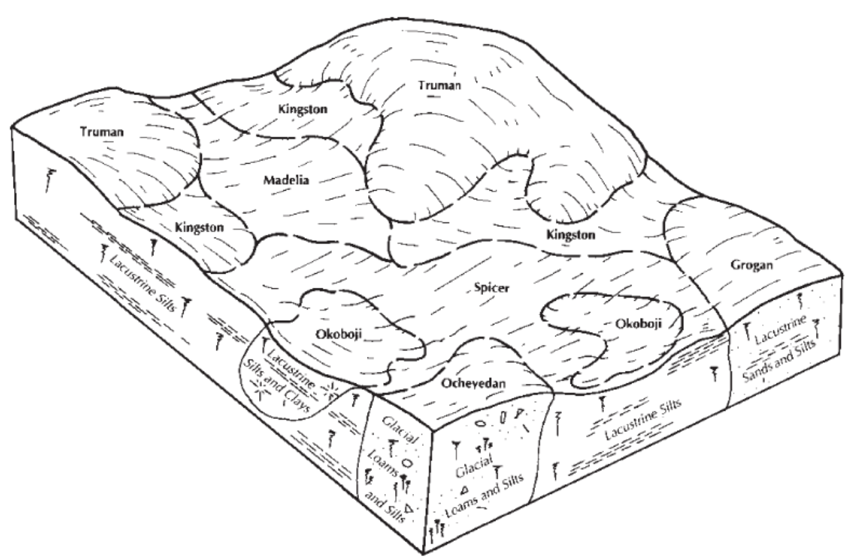
- Generally little time/attention in geology courses
- **Tool for geomorphologists**

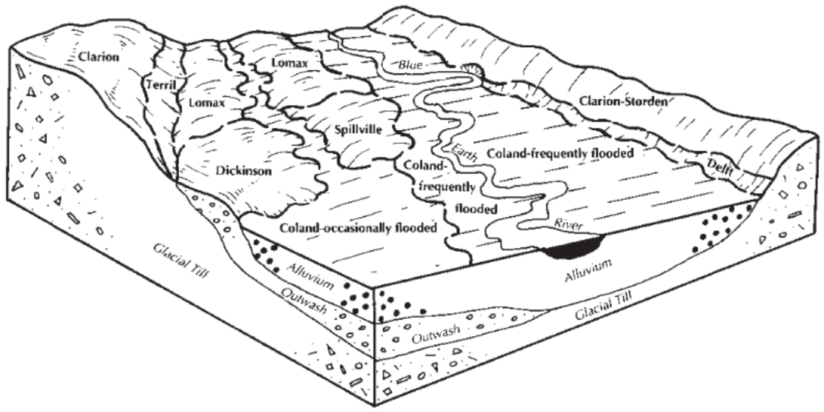

Parent Material
Living Organisms
Climate
Time
Topography


End moraines: Wisconsinan Age
End moraines: Illinoian Age
0
150 mi
0
150 km
Driftless area
Extent of Wisconsinan glaciation
Extent of Illinoian glaciation



Soil series (mappable unit)= unique type of soil





CLARION SERIES

The Clarion series consists of very deep, moderately well drained soils on uplands. These soils formed in glacial till. Slopes range from 1 to 9 percent. Mean annual air temperature is about 8 degrees C (47 degrees F). Mean annual precipitation is about 74 centimeters (29 inches).

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, mesic Typic Hapludolls

TYPICAL PEDON: Clarion loam, on a convex upland with a slope of 4 percent, in a cultivated field. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 18 centimeters (7 inches); black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; many roots; about 3 percent gravel; slightly acid; abrupt smooth boundary.

A1--18 to 30 centimeters (7 to 12 inches); very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; weak fine subangular blocky structure; friable; many roots; about 3 percent gravel; common worm casts; slightly acid; gradual smooth boundary.

A2--30 to 46 centimeters (12 to 18 inches); dark brown (10YR 3/3) loam, brown (10YR 4/3) dry; weak fine subangular blocky structure; friable; many roots; many distinct very dark grayish brown (10YR 3/2) coats on faces of peds; about 3 percent gravel; slightly acid; gradual smooth boundary. [Combined thickness of the A horizon is 25 to 51 centimeters (10 to 20 inches).]

Bw1--46 to 66 centimeters (18 to 26 inches); dark yellowish brown (10YR 4/4) loam; weak fine subangular blocky structure; friable; many roots; many fine pores; common distinct dark brown (10YR 3/3) coats on faces of peds; about 3 percent gravel; neutral; gradual smooth boundary.

Bw2--66 to 91 centimeters (26 to 36 inches); dark yellowish brown (10YR 4/4) loam; weak medium subangular blocky structure; friable; common roots; many fine pores; about 3 percent gravel; neutral; gradual smooth boundary. [Combined thickness of the Bw horizon is 20 to 71 centimeters (8 to 28 inches).]

C1--91 to 132 centimeters (36 to 52 inches); yellowish brown (10YR 5/4) loam; massive; friable; few calcium carbonate masses; few fine distinct yellowish brown (10YR 5/6) Fe concentrations; few fine distinct light brownish gray (2.5Y 6/2) Fe depletions; about 3 percent gravel; strongly effervescent; moderately alkaline; gradual smooth boundary.

C2--132 to 152 centimeters (52 to 60 inches); yellowish brown (10YR 5/4) loam; massive; friable; common roots; many fine pores; common fine distinct light brownish gray (2.5Y 6/2) Fe depletions; common fine distinct yellowish brown (10YR 5/6) Fe concentrations; about 3 percent gravel; strongly effervescent; moderately alkaline.

Activity Goals and Objectives

1. Navigate and obtain information from a county-level Soil Survey (paper or online)
2. Be familiar with the type of information that can be obtained from a Soil Survey
3. Identify and interpret landforms using both a topographic and soils map
4. Construct a surfical (glacial) geology map utilizing soils information
5. Appreciate the connection between geoscience disciplines

Activity Walk-Thru

Part I

- become familiar with site (location, history, geology, climate, etc.)
- navigate Soil Survey
- obtain information from Soil Survey

1. When did explorer's first settle Oneida County? What was the primary industry in the county in the early settlement years?
2. What physiographic region is Oneida County located? Briefly describe the region.
3. Find the following climate statistics:
   A. Avg. Annual Temperature: ______________________________
   B. Max. Temperature: ______________________________
   C. Min. Temperature: ______________________________
   D. Avg. Annual Precipitation: ______________________________
   E. Avg. Annual Snowfall: ______________________________

CHISAGO COUNTY is in east-central Minnesota on the Wisconsin border (fig. 1). It has a total area of 265,200 acres. In 1980, the population of the county was 25,717. Center City, the county seat, had a population of 1,972.

About 61 percent of Chisago County is used as cropland or pasture. About 27 percent is woodland, and 12 percent is urban land or idle land.

General Nature of the County

This section provides general information concerning Chisago County. It describes physiography, relief, and drainage; history; and climate.

Physiography, Relief, and Drainage

The varied impact of glacial movement through the survey area has resulted in a diverse land surface. The direction of major glacial advance was from west to east. As the glaciers retreated to the west, the glacial meltwater tended to flow toward the east. This drainage pattern continues to the present time, and most surface drainage flows toward the St. Croix River. A few drainageways in the county, such as the Sunrise River, flow toward the north. The Sunrise River originally flowed south as an overflow channel from the St. Croix River, during the period when Glacial Lake Duluth was draining *(9)*.

Two major rivers run through Chisago County. The St. Croix River is the largest river in the region. It flows from north to south and serves as the eastern boundary of the county and the state. The Sunrise River flows

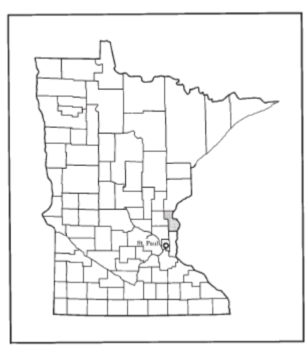


Figure 1.—Location of Chisago County in Minnesota.

920 to 980 feet above sea level, but a few areas are about 1,000 feet above sea level. Most of the deep lakes in these regions are 20 to 40 feet deep, but some, such as South Center Lake, are about 100 feet deep. The shallower lakes average less than 20 feet in depth.

The central region of the county, which is part of the Anoka Sand Plain, is generally nearly level. It is approximately 840 to 900 feet above sea level.

The fourth region bounds the first three regions on the east and parallels the St. Croix River. This region has a wide variety of landforms, including bogs, flood plains, and outwash plains. The slope in this region ranges from level to steep. Elevation ranges from approximately 850 feet above sea level in the north to 700 feet above sea level in the south. The southeastern edge of this region, along the St. Croix River, has the steepest slopes, and bedrock is exposed in some areas. This region has a sharp elevation break averaging 40 to 50 feet that separates the uplands from the old St. Croix River Valley.

History

The original inhabitants of the survey area, in about 1000 B.C., were Mound Builders. Much later the Dakota inhabited the area, but they were eventually replaced by the Chippewa. Chisago County, which was organized in 1851, derived its name from the word "Ki-chi-saga," which the Chippewa used to describe the area north of Center City as "fair and lovely waters" *(5)*. Center City, which was established during the 1850's, was the first permanent Swedish settlement in Minnesota *(3)*.

Taylors Falls was the site of a French fort from 1700 to 1703. Two occurrences helped to make Taylors Falls

Branch was the center of the Potato Belt.

Agriculture is still a dominant land use in the county, but because of industrial growth and the proximity to the Twin Cities metropolitan area, urban development has increased. The development of major highways throughout the county has contributed to this growth. Most of the urban expansion has taken place along these corridors *(3, 4, 5)*.

Climate

Table 1 gives data on temperature and precipitation for the survey area as recorded at Cambridge, Minnesota, in the period 1951 to 1984. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter, the average temperature is 13 degrees F and the average daily minimum temperature is 3 degrees. The lowest temperature on record, which occurred at Cambridge on January 9, 1977, is -41 degrees. In summer, the average temperature is 68 degrees and the average daily maximum temperature is 79 degrees. The highest recorded temperature, which occurred at Cambridge on June 30, 1963, is 100 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

Activity Walk-Thru

Part II

- define soil terminology and understand the soil mapping process
- begin connecting soils and landforms

4. What is a soil series?
5. What is a map unit? Are soil map units pure? Why or why not?
6. What is a soil association?
7. What landform(s) is associated with the Magnor-Greenwood-Cable association?
8. Where is the Magnor-Greenwood-Cable association found in Oneida County?
9. Name three other landforms/features found in Oneida County?

Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Barrens. Areas of vegetation that occur along or adjacent to oak openings. Barrens are maintained with fire and provide a buffer between prairie and woodland. The vegetation in these areas is a mixture of tall grass prairie, hazel, rose, and herbs.

Basal till. Compact glacial till deposited beneath the ice.

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K),

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

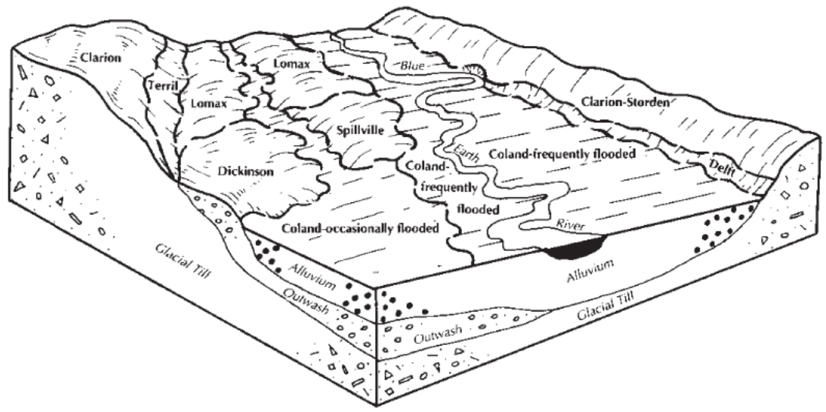
The soils in the survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the



Not every Soil Survey has these ☹

Activity Walk-Thru

Part III

- link soil types and landforms
- link soil properties and landforms

10. What is soil series is represented by the symbol Go?
11. What landform(s) is Go associated with? What are the textural characteristics of the sediments/soil for this series?
12. Soil Go and several others contain "silty" material. What is the most likely name and origin of this material considering the surficial history of the region?
13. What is soil series is represented by the symbol Pe?
14. What type of landform(s) is mapunit Pe generally associated with? What are the textural characteristics of the sediments/soil for this series?

GOODMAN SERIES

The Goodman series consists of very deep well drained soils formed in loess and in the underlying till mostly on drumlins and moraines. Permeability is moderate in the silty mantle and in the loamy till and is moderately rapid in the loamy sand till. Slopes range from 1 to 45 percent. Mean annual precipitation is about 30 inches. Mean annual air temperature is about 42 degrees F.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, frigid Alfic Haplorthods

TYPICAL PEDON: Goodman silt loam, very stony - on a convex southeast-facing 23 percent slope in a woodland at an elevation of about 1,825 feet. (Colors are for moist soil unless otherwise stated.)

Oe--0 to 1 inches; very dark grayish brown (10YR 3/2) mucky peat (hemic material which is a mat of partially decomposed forest litter); about 40 percent fiber and 20 percent rubbed; weak fine granular structure; very friable; common fine and few medium roots; strongly acid; abrupt wavy boundary. (0 to 3 inches thick)

A--1 to 3 inches; black (10YR 2/1) silt loam, gray (10YR 5/1) dry; weak fine granular structure; friable; common fine and few medium roots; strongly acid; abrupt smooth boundary. (0 to 5 inches thick)

E--3 to 5 inches; dark grayish brown (10YR 4/2) silt loam, light gray (10YR 7/2) dry; weak medium platy structure; friable; few fine and medium roots; strongly acid; abrupt smooth boundary. (1 to 6 inches thick)

Bs--5 to 12 inches; brown (7.5YR 4/4) silt loam; weak medium subangular blocky structure; friable; few fine and medium roots; very strongly acid; abrupt smooth boundary. (4 to 22 inches thick)

E/B--12 to 19 inches; about 75 percent pale brown (10YR 6/3) silt loam (E), very pale brown (10YR 7/3) dry; weak medium subangular blocky structure; friable; extends as tongues into and surrounds remnants of brown (7.5YR 4/4) silt loam (Bt); moderate medium subangular blocky structure; friable; few fine roots; strongly acid; clear wavy boundary. (Glossic horizon - 6 to more than 80 inches thick)

Bt1--19 to 25 inches; brown (7.5YR 4/4) silt loam; moderate medium subangular blocky structure; friable; few fine roots; common faint dark brown (7.5YR 3/4) clay films on faces of peds; very strongly acid; abrupt smooth boundary. (0 to 20 inches thick).

2Bt2--25 to 41 inches; strong brown (7.5YR 4/6) sandy loam, coarse fragments moderate medium subangular blocky structure; friable; few fine roots; few faint dark brown (7.5YR 3/4) clay films on faces of peds; about 3 percent gravel and 1 percent cobbles; strongly acid; clear wavy boundary.

2Bt3--41 to 51 inches; brown (7.5YR 4/4) loamy sand; weak medium subangular blocky structure; very friable; few faint dark brown (7.5YR 3/4) clay bridges between sand grains; about 10 percent gravel and 1 percent cobbles; strongly acid; gradual wavy boundary. (Combined thickness of the 2Bt horizon ranges from 0 to 35 inches.)

2C--51 to 61 inches; brown (7.5YR 5/4) loamy sand ; massive; very friable; about 10 percent gravel and 1 percent cobbles; strongly acid.

PENCE SERIES

The Pence series consists of very deep somewhat excessively drained soils which are shallow to stratified sandy outwash. They formed in a thin mantle of loamy alluvium or eolian deposits and in the underlying stratified sand or stratified sandy outwash on glacial lake plains, outwash terraces, outwash plains, eskers, and kames within moraines. Permeability is moderate or moderately rapid in the loamy mantle and rapid or very rapid in the sandy outwash. Slopes range from 0 to 50 percent. Mean annual precipitation is about 30 inches. Mean annual air temperature is about 42 degrees F.

TAXONOMIC CLASS: Sandy, isotic, frigid Typic Haplorthods

TYPICAL PEDON: Pence sandy loam - on a northwest-facing slope of 11 percent in an abandoned pasture at an elevation of about 1,675 feet. (Colors are for moist soil unless otherwise stated.)

A--0 to 3 inches; dark reddish brown (5YR 3/2) sandy loam, reddish gray (5YR 5/2) dry; weak fine subangular blocky structure; very friable; many roots; common white (5YR 8/1) sand grains; about 10 percent gravel; moderately acid; abrupt smooth boundary. (0 to 4 inches thick)

E--3 to 8 inches; brown (7.5YR 4/2) sandy loam, pinkish gray (7.5YR 7/2) dry; weak fine subangular blocky structure; very friable; many roots; about 10 percent gravel; strongly acid; clear wavy boundary. (0 to 5 inches thick)

Bs1--8 to 11 inches; dark reddish brown (5YR 3/4) gravelly sandy loam; weak medium subangular blocky structure; very friable; common roots; about 15 percent gravel; moderately acid; clear wavy boundary.

Bs2--11 to 15 inches; reddish brown (5YR 4/4) gravelly sandy loam; weak fine and medium subangular blocky structure; common roots; very friable; about 15 percent gravel; strongly acid; clear wavy boundary. (Combined thickness of the Bs horizons is 4 to 19 inches.)

2BC--15 to 21 inches; yellowish red (5YR 4/6), yellowish red (5YR 5/6) gravelly coarse sand; weak coarse subangular blocky structure; very friable; few roots; about 25 percent gravel; strongly acid; clear wavy boundary. (0 to 13 inches thick)

2C--21 to 60 inches; stratified yellowish red (5YR 5/6) and reddish yellow (5YR 6/6) gravelly coarse sand; with thin strata of light reddish brown (5YR 6/4) coarse sand and sand; single grain; loose; about 25 percent gravel; strongly acid.

15. Using the tables in the center of the Soil Survey, compare "Woodlot Management and Productivity" for the Go and Pe soil series. Is there a linkage between landscape/landform and vegetation?

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
182 Halder	---	Redosier dogwood, American cranberrybush, lilac, northern whitecedar.	White spruce, eastern redcedar, Siberian crabapple, black spruce.	Red pine, eastern white pine, jack pine.	Silver maple, eastern cottonwood.
204B, 204C, 204D, 204F Cushing	---	Redosier dogwood, Siberian peashrub, lilac, Amur maple.	Northern whitecedar, eastern redcedar, Manchurian crabapple, blue spruce, white spruce.	Green ash, red pine, eastern white pine, silver maple.	Eastern cottonwood.
207B, 207C, 207D, 207E Nymore	Lilac, Siberian peashrub.	Eastern redcedar, Manchurian crabapple, Siberian crabapple.	Red pine, Russian-olive, green ash.	Eastern white pine, jack pine.	---
265 Soderville	---	Redosier dogwood, American cranberrybush, lilac, northern whitecedar.	White spruce, black spruce, eastern redcedar, Siberian crabapple.	Red pine, eastern white pine, jack pine.	Silver maple, eastern cottonwood.
274 Newson	---	Siberian peashrub, redosier dogwood.	Tamarack, black ash, black spruce.	Golden willow, white willow, eastern cottonwood.	---
292 Alstad	---	Siberian peashrub, American cranberrybush, redosier dogwood, lilac.	Eastern redcedar, white spruce, black spruce, Siberian crabapple.	Jack pine, red pine, eastern white pine, green ash.	Silver maple, eastern cottonwood.
325 Prebish	---	Redosier dogwood, Siberian peashrub.	Tamarack, black ash, black spruce, green ash.	Golden willow, white willow, eastern cottonwood.	---

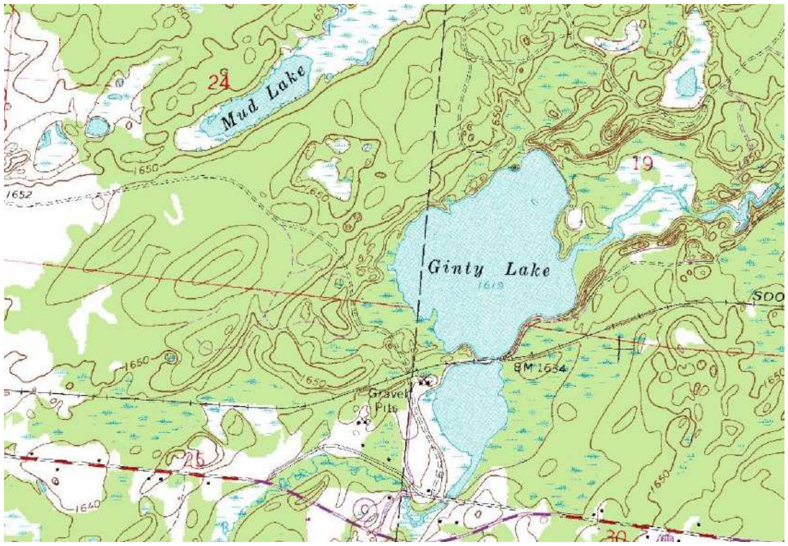
Activity Walk-Thru

Part IV…putting it all together

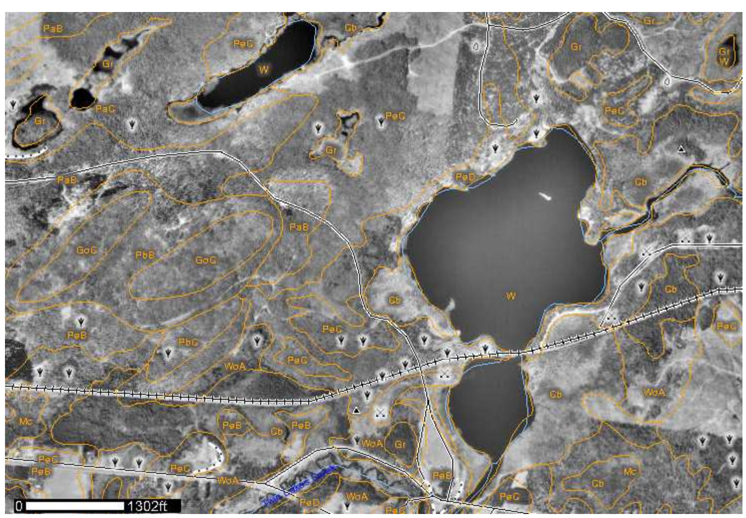
- soil and landform interpretation
- construct a surfical geology map

16. The next exercise will involve developing a surficial geology/landform map using information from the soil map. A topographic map of Starks Quadrangle is provided for developing the landform map. Use information provided on mapsheet #64 from the Oneida soil survey and your knowledge of landforms to construct the map. Your map legend should include the following features: kames, kettles, ice-walled lake plains (look hard), outwash plains, drumlins, esker, and moraines (be specific). Use colored pencils to delineate the different landforms.

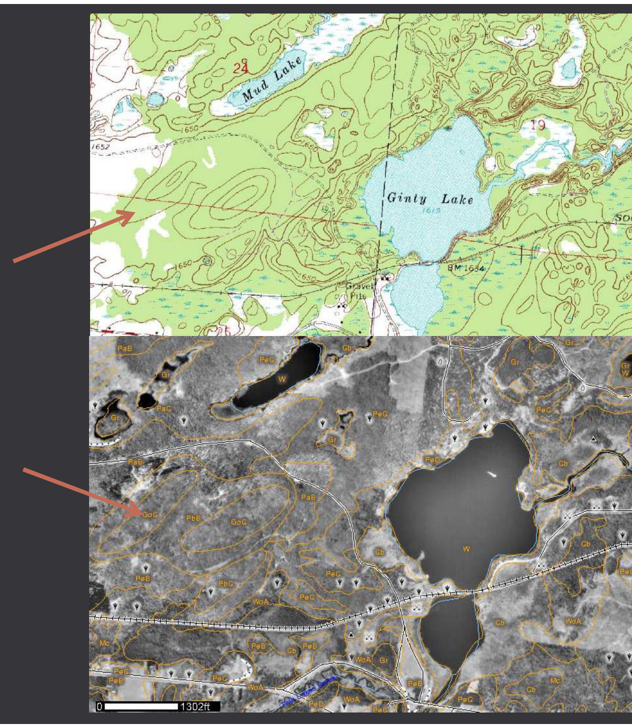
Monico 15' Quadrangle (Oneida County, Wisconsin)



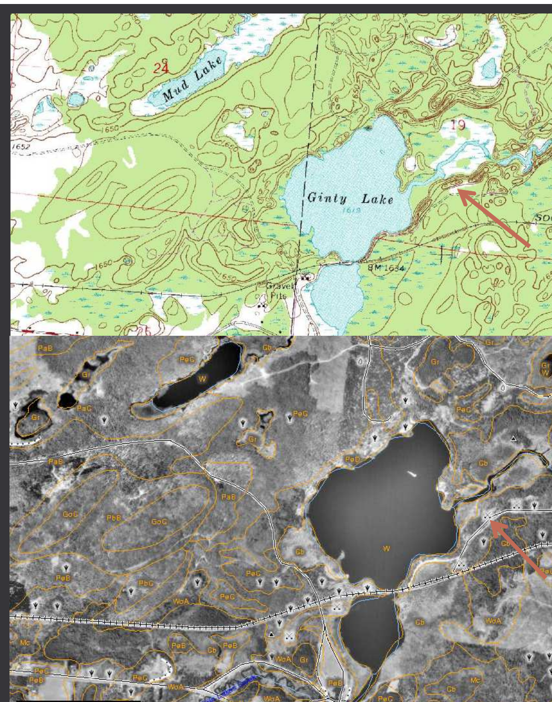
Mapsheet #64 (Oneida County, Wisconsin)



Drumlins (Goodman)



Esker



Outwash and Pitted Outwash Plains (Pence)

A Couple Notes…

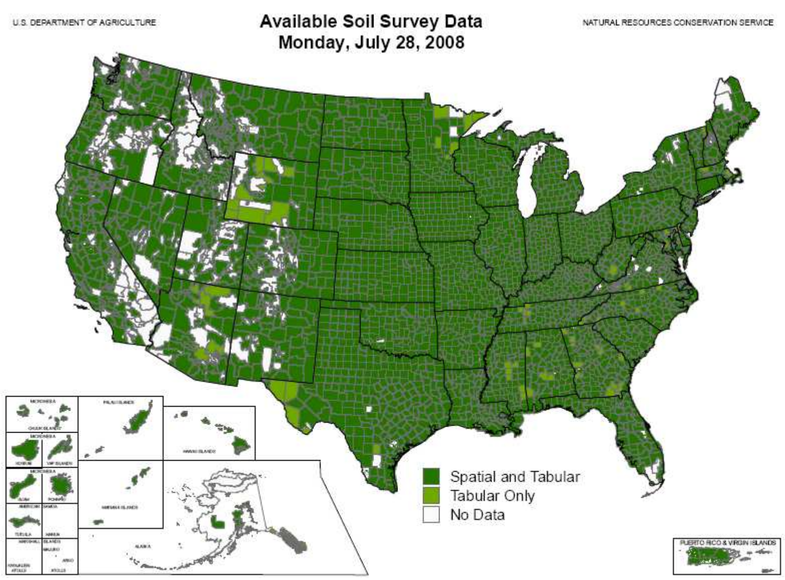
- Help students get started to avoid frustration
- Be available to answer questions and provide guidance
- Both datasets have information to tell– use them together

Activity Walk-Thru

Part V
- additional interpretations

17. What was the direction of ice flow in the region? How can you tell?
18. Draw the symbols used on mapsheet #64 and describe them. Are they associated with any specific landform(s)?
19. Which ice advance is the till located on Map Sheet #64 most likely associated with? Support your answer by proving rationale.


Adapting to Your Classroom


U.S. DEPARTMENT OF AGRICULTURE
Available Soil Survey Data
Monday, July 28, 2008
NATURAL RESOURCES CONSERVATION SERVICE
Spatial and Tabular
Tabular Only
No Data


Adapting to Your Classroom
1. Straight adaption with Oneida, Wisconsin
- request soil survey from NRCS (I can help)
2. Design specific for your area
- coastal, eolian, etc.
- bedrock
- be creative
3. Campus soils activity
4. Focus on soil properties
5. Pre-field activity