Lab 1. Soil Characterization/Parent Material

This week's lab will take place in the Soil Lab as well as a soil pit, located near the campus. The soil pit has been dug to facilitate soil profile descriptions. The soil exposed in this pit is formed from different parent material.

Your task will be to identify the soil parent materials and describing the soil horizons by determining the color, pH and texture.

Objectives

- Determine soil color, soil texture, soil structure and soil pH
- Differentiate soil horizons based on field features
- Recognize different types of parent materials
- Connect soil parent material to soil properties

Reading

	14th Ed.	13th Ed.
The Soil Profile and its Layers (Horizons)	1.9	1.9
Mineral (Inorganic) Constituents of Soil	1.13	1.12
Soil Organic Matter	1.14	1.13
Soil Water: A Dynamic Solution	1.15	1.14
Parent Materials	2.3	2.5
Soil Color	4.1	4.1
Soil Texture (Size Distribution of Soil Particles)	4.2	4.2
Soil Textural Classes	4.3	4.3
Structure of Mineral Soils	4.4	4.4

Soil Parent Material in Upstate New York

Most of New York State was covered with ice during the last continental glacial period, the Wisconsin glacial stage. This stage began somewhere from 40,000 to 70,000 years ago, reached a maximum in this region 20,000 years ago and retreated 8,500 to 11,000 years ago. The ice in this region was at least 2500 feet deep at its maximum stage. Picture ice from the Commons, all the way up Buffalo Street, through campus, rising up to the 11th floor of Bradfield. Even that wouldn't be 2000 feet high. Now imagine the force and water that amount of ice would have when moving and melting.

During the Wisconsin glaciation, the moving ice sheet that covered Ithaca scraped the land surfaces and redeposited an unsorted mixture of material (from boulders to clay) on those surfaces. This material, when deposited directly by the moving ice, is called **glacial till**. When this material is sorted and deposited by glacial melt water it is called **glacial outwash**.

Following the retreat of the Wisconsin glaciers from this area, a 980-foot deep glacial lake (Glacial Lake Ithaca) was formed. Lake Ithaca encompassed all of the main Cornell campus, and parts of Ithaca, Newfield, and Caroline (von Engeln 1961, von Engeln, 1960). Sediments accumulated at the bottom of the lake, and beaches and deltas developed at its shoreline. About 70000 years ago, the lake drained and the silt and clay sediments deposited at the bottom of Glacial Lake Ithaca (over glacial till and outwash) were exposed. The parent material of soil developed from this lake-deposited material is called **lacustrine**.

Streams that fed the lake formed **deltas** consisting of coarser material that was deposited as fast moving water slowed upon entering the glacial lake. Coarse material is also found along what were the **beaches** of Glacial Lake Ithaca. Much later, after the lake had drained, new streams formed, cutting down through existing sediments and bedrock. As the streams flooded in spring, they built **terraces** of coarse sediments. In general, sediments deposited by moving water are known as **alluvium**. As the earth surface continued to rebound from the glacial period, these streams cut further down, thus abandoning their old terraces and forming new, younger alluvial terraces.

Each of these parent materials influences soil properties differently. Glacial till deposits are poorly sorted and heterogeneous mixtures of clay, sand, gravel, and boulders with varying texture and mineralogy. Glacial outwash materials are coarse textured and better sorted due to the influence of water, and lacustrine sediments are even more sorted and finer textured. As you characterize soils formed from these different parent materials, look for variations in color, texture, structure, pH and in soil horizons.

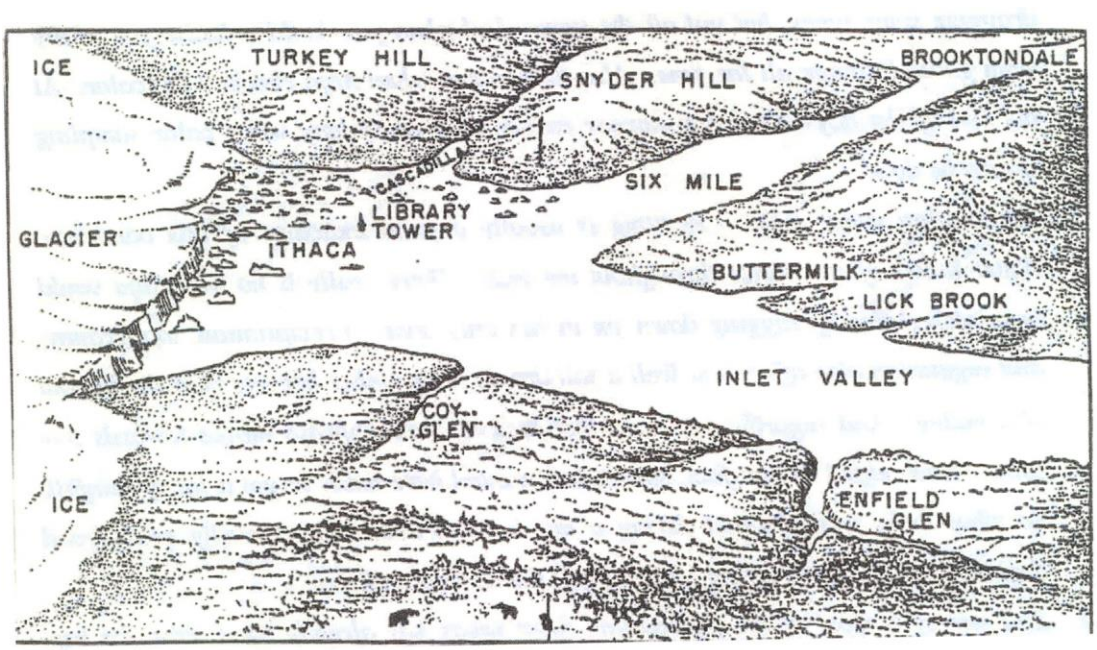


Figure 1. View from West Hill of Glacial Lake Ithaca
(From Cornell Plantations "When icebergs were floating over the Cornell Plantations" by O.D. von Engeln)

Soil Properties: Color, Structure and Texture

Color is the most obvious of soil properties and it provides important clues about organic matter, drainage, and other soil conditions. A darker color can indicate more organic matter is present compared to soil of a lighter color. Often the surface horizon, called the epipedon, has a darker color than the subsoil due to higher organic matter content.

How do we characterize soil color? With the aid of the Munsell Soil Color Chart we can distinguish a soil's color according to its hue, chroma, and value. Soil hues range from red ® to yellow-red (YR) to yellow (Y) and sometimes green-yellow (GY) or even green (G). Hue is subdivided by prefixes from 0 to 10 and all Munsell soil color books have pages 1 OR< 2.5R, 5YR, 7.5YR, 10YR, 2.5Y, and 5Y. Temperate region soils tend to have a 10YR hue whereas warmer climates have both redder soils (10R) and yellower (2.5Y, 5Y) soils: Color value for soil ranges from 0 for absolute black and 10 for absolute white; gray has a number 5. The chroma scale for soil ranges from 0 for neutral or gray colors to 8 for bright colors.

To use the Munsell Color Book, take a soil sample and locate the appropriate hue page. The hue notation is listed on the upper right hand corner of the page. Next hold the soil near the color chips and locate the appropriate value (left-hand side) and chroma (bottom of page). The same soil when dry tends to have a higher value and chroma than when wet. This is why both wet and dry soil color are often determined. Also color determination is best done during the middle of the day. The sample may appear redder early or late in the day when the sun is low in the sky.

Another easily observable property of soil is soil **structure**. There are six basic types of soil structure: platy, prismatic, blocky, granular, loose structureless, and compacted structureless. Bare in mind these are idealized types – structure in the field will generally resemble one of these types but don't get frustrated if you don't see these exact forms in the field. The more profiles you observe, the easier determining structure becomes.

Texture is the relative proportion of sand, silt and clay particles that make up soil. Soils having a moderate amount of sand, silt and clay are called loams. There are 12 soil texture classes: sand (S), loamy sand (LS), sandy loam (SL), loam (L), silt loam (SiL), silt (Si), sandy clay loam (SCL), clay loam (CL), silty clay loam (SiCL), sandy clay (SC), silty clay (SiC), and clay (C) (Staff 1993).

In the field, the texture-by-feel method is used to determine soil texture (See Soil Guide in Field Kit). A small soil sample is gradually wetted and kneaded to determine textural class. Since this is a tactile evaluation, experience is essential. Don't expect to get this on the first try. Throughout the first four labs there will be ample opportunities to perfect your methodology.

Soil pH is a measure of how acid (pH <7) or basic (pH > 7) the soil is. A method of measuring soil pH in the field is to place soil in a spot plate and add an indicator dye until the soil is saturated. The soil is mixed with the indicator dye, which changes color depending on the soil pH. This color is then compared to a reference color card to determine the pH.

Soil Horizons: O, A, E, B, C

Color, structure and texture are used to distinguish soil horizons. There are five master soil horizons, O, A, E, B, and C, that can be found above regolith. A profile may have all or some of these horizons.

The **O horizon** is the uppermost layer and is usually fond only in areas that have some sort of permanent vegetation. It is a layer of plant litter lying on the surface of the mineral soil. Considerable decomposition or organic matter takes place in this horizon, giving the O horizon its characteristic dark color.

The **A horizon**, if present, lies beneath the O horizon and is darker than the underlying horizons (although not as dark as the O) due to accumulation of organic matter in the soil surface. Leaching is most intense in the soil surface and causes solutes to move down the profile to the underlying horizons.

Some soils have an **E horizon** below the A horizon. An E horizon does not accumulate organic matter yet is subject to leaching, resulting in a lighter color than the A or B horizon.

Underlying these horizons is the **B horizon**. This layer accumulates materials from the overlying layers and like the E horizon is low in organic matter (although not as light in color). The B horizon is often identified by its structure, usually blocky or prismatic.

Finally there is the **C horizon**. This layer of parent material is least affected by the soil forming processes.

Exercise A. Three Field Characterization Methodologies

Familiarization of the field methods of hand texturing, color identification and pH.

Materials

- Soil samples from TAs
- Water bottle
- Munsell Color books
- Cornell pH test kits

Steps

1. Determine texture by feel method for each of the samples and record.
2. Determine field color using Munsell Color Book.
3. Determine field pH using the Cornell pH Test Kit.

Exercise B. Profile Description

Materials

- spatula
- measuring tape
- water bottle
- Munsell color chart
- pH kit
- muffin tin

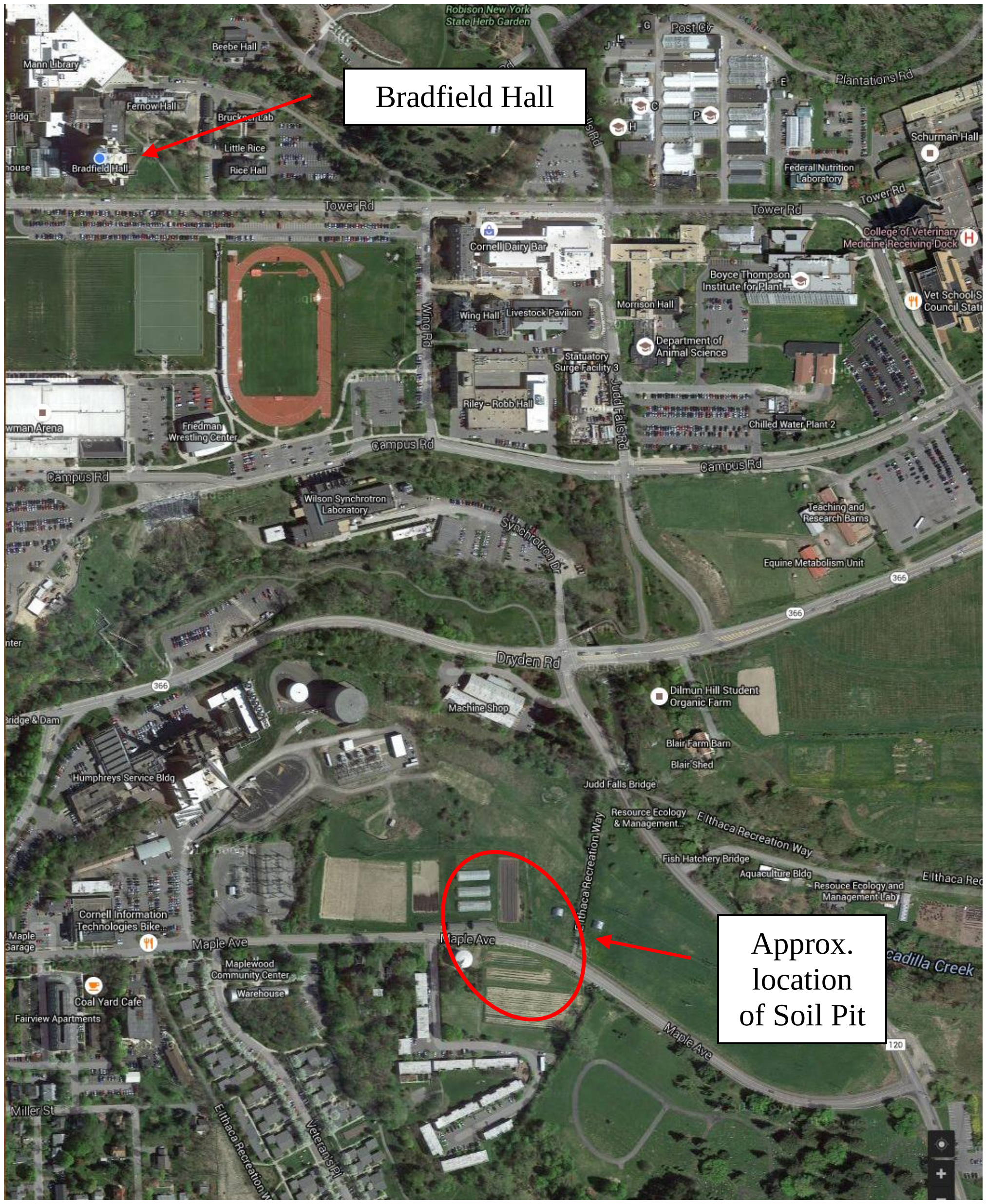
Steps

1. Make a preliminary differentiation of the soil horizons based on color and structure and record in Table 1.
2. Measure the depth from the surface to the top and bottom of each horizon.
3. Record presence or absence of roots in each horizon.
4. Take a sample of each horizon and place in muffin tin.
5. Moisten some soil from each horizon and determine the wet soil color of each horizon using the Munsell color chart. Record results.
6. Use the texture by feel method to determine the soil texture of each horizon. Record results.
7. Determine soil pH according to instructions.
8. Based on your analysis of soil color, structure and texture decide whether to accept or revise your determination of soil horizons.
9. Make a sketch of the soil horizons to scale and indicate the variability in depth that you see across the face of the profile.
10. Describe the landscape/topography in which the soil pit is found.
11. Determine the parent material of this soil – see exercise C.

Exercise C. Maps – this exercise will help you determine nature and sources of parent materials

Materials “Soil survey of Cornell University property and adjacent areas”

Steps



1. Check the location of the soil pit on the Cornell University Property map (Figure 2 – pg. 23).
2. Determine the parent material from Figure 1 – *Parent materials of soils of the area* (pg. 5) and compare that to your field assessment of parent material for the site.
3. Determine which of the 6 soil maps (A1, A2, B1, B2, C1, C2) you need to refer to in order to determine the soil pit location. Find this map, locate the soil pit and determine the map symbol for that location. Then check the Map legend (pg. 24-25) to determine the soil series name for that symbol.
4. Once you have determined the soil name, (this is the Soil Series) read the descriptions of the corresponding soil series and soil phases (pg. 8-22) and compare these to your descriptions.

Assignment

Answer the following questions:

1. What is the name of the Soil Series?

2. A sketch of the soil, with horizons identified and drawn to scale. Include this on a separate page and it should be large enough to identify horizon descriptions.

3. A profile description (Table 1) including depth of horizons, color, texture and presence of roots.

Table 1. Profile Description: Site 1

Horizon	Depth (cm)	Texture	Wet color	pH	Roots (+/-)

4. A description of the nature/source and distribution of the soil parent material(s). Report on what you found on site, we discussed, as well as described in the CU Soil Survey. You will be graded on your completeness, not the length… your description need not be longer than 100 to 200 words.

Appendix A

ARKPORT SERIES

The Arkport series consist of very deep, well drained soils formed in glacio-fluvial deposits having a high content of fine and very fine sand. These soils have thin horizontal bands of loamy material in the subsoil. Saturated hydraulic conductivity is high throughout the mineral soil. Slope ranges from 0 to 60 percent. The mean annual temperature is 48 degrees F. and the mean precipitation is about 38 inches.

TAXONOMIC CLASS: Coarse-loamy, mixed, active, mesic Lamellic Hapludalfs

TYPICAL PEDON: Arkport very fine sandy loam on a 5 percent slope in a cultivated field. (Colors are for moist soil unless otherwise noted).

Ap -- 0 to 9 inches; brown (7.5YR 4/2) very fine sandy loam; weak fine granular structure; very friable; few medium and common fine roots; 1 percent very fine pebbles; moderately acid; abrupt smooth boundary. (7 to 12 inches thick.)

BE1 -- 9 to 15 inches; brown (7.5YR 5/4) very fine sandy loam; weak fine granular structure; friable; common medium roots; many fine pores; moderately acid; gradual wavy boundary.

BE2 -- 15 to 28 inches; brown (7.5YR 5/4) loamy very fine sand in intricate pattern with brown (7.5YR 5/2) clean very fine sand and few reddish brown (5YR 4/3) very fine sandy loam lamellae 1/16 inch thick and 3 to 6 inches long; massive; very friable; common fine and few medium roots; strongly acid; abrupt wavy boundary. (Combined thickness of the BE horizons is 0 to 23 inches thick.)

E and Bt1 -- 28 to 45 inches; light reddish brown (5YR 6/3) very fine sand E material; massive; very friable; reddish brown (5YR 5/4) very fine sandy loam Bt material as lamellae 1/16 to 4 inches thick that total 6 inches in thickness; massive; firm; few medium roots; strongly acid; abrupt wavy boundary.

E and Bt2 -- 45 to 58 inches; light reddish brown (5YR 6/3) loamy fine sand intricately patterned with reddish brown (5YR 4/4) wavy, branching, crudely horizontal lamellae 1/16 to 1/2 inch thick that total 1 1/2 inches in thickness; massive; very friable; lamellae are firm and slightly plastic; few roots; strongly acid; abrupt wavy boundary.

E and Bt3 -- 58 to 92 inches; pinkish gray (5YR 6/2) loamy fine sand patterned with dark reddish brown (5YR 3/4) fine sandy loam, thin, wavy, horizontal, branching lamellae that total 1 inch in thickness and by reddish brown (5YR 4/4) very fine sandy loam 1/2 inch thick lamellae that total 4 inches in thickness; massive; very friable and friable; few roots in upper part; moderately acid; clear wavy boundary. (Combined thickness of the E and Bt horizons is 15 to 70 inches.)

C -- 92 to 106 inches; pinkish gray (5YR 6/2) fine sand; single grain; loose; slightly acid.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 40 to 100 inches. Depth to bedrock is greater than 60 inches. Depth to carbonates ranges from 36 to more than 120 inches. Depth to the uppermost lamellae ranges from 9 to 30 inches. Very fine sand plus silt ranges from 30 to 80 percent, and fine sand and coarser is greater than 15 percent throughout the soil. Rock fragments are usually absent but can range up to 10 percent.

The Ap horizon has hue of 10YR through 7.5YR, value of 3 through 5, and chroma of 2 or 3. Texture is loamy fine sand, fine sand, loamy very fine sand, very fine sandy loam, fine sandy loam, sandy loam or silt loam. It has weak or moderate, fine to coarse granular structure and is very friable or friable. Reaction ranges from very strongly acid through neutral. Wooded or uncultivated areas have an A horizon 1 to 4 inches thick with hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 or 2.

The BE horizon has hue of 10YR through 5YR, value of 4 through 6, and chroma of 3 through 8. Texture is loamy fine sand, very fine sand, loamy very fine sand, fine sandy loam, or very fine sandy loam. The horizon is massive or single grain or has very weak or weak, fine or medium, granular or subangular blocky structure. It is loose to friable. Reaction ranges from very strongly acid through neutral. Some pedons have a Bw or E horizon in place of the BE horizon.

The E part of the E and Bt horizon has hue of 2.5Y through 5YR, value of 4 through 7 and chroma of 2 through 4. Texture is fine sand to loamy very fine sand. It is structureless or has weak or very weak granular or subangular blocky structure and is loose to very friable. The Bt part of the E and Bt horizon has hue of 5YR through 10YR, value of 3 through 5, and chroma of 2 through 6. Texture is silt loam or very fine sandy loam to loamy fine sand. It is massive or it has weak fine or medium blocky or platy structure, and is friable or firm. The E and Bt horizons range from strongly acid through neutral.

The C horizon has hue of 5YR through 10YR, value of 4 through 6 and chroma of 2 through 4. Texture is sand, loamy sand, fine sand, loamy fine sand, very fine sand or loamy very fine sand. It is massive or single grain with loose to friable consistence. Some pedons have thin layers of coarse silt. It ranges from moderately acid through moderately alkaline.

GEOGRAPHIC SETTING: The Arkport soils are nearly level to steep soils on the tops and sides of glacial deltas and glacio-fluvial sand plains, and on dunes and beach ridges. Slope ranges from 0 to 60 percent. The soil formed in water-sorted deposits having a high content of fine and very fine sand. The climate is humid and cool temperate. Mean annual precipitation ranges from 28 to 40 inches. Mean annual temperature ranges from 46 to 50 degrees F. The frost-free period ranges from 140 to 200 days. Elevation ranges from 300 to 900 feet above sea level.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. The potential for surface runoff is low to high. Saturated hydraulic conductivity is high throughout the mineral soil.

REMARKS: Diagnostic horizons and other features recognized in the typical pedon:
1) Ochric Epipedon - from 0 to 9 inches (Ap horizon).
2) Argillic horizon - thin horizontal lamellae totaling more than 6 inches in thickness from 28 to 80 inches (E and Bt horizons).

References

Brady, N.C., and Weil, R. R. (2002). The Nature and Properties of Soil, Simon & Schuster, Upper Saddle River, New Jersey.

Cline, M.G. (1974). “Geology and soils of New York: a simplified account”, Cornell University, Ithaca, NY.

Cline, M.G. and Bloom, A.L. (1966). Soil survey of Cornell University property and adjacent areas. Cornell Miscellaneous Bulletin 68, Cornell University, Ithaca, NY.

Staff, S. S. D. (1993). Soil Survey Manual, United States Department of Agriculture, Washington, DC.

Von Engeln, O.D. (1960). “when icebergs were floating over the Cornell Plantations.” The Cornell Plantations, XVI (3), 35-43.

Von Engeln, O.D. (1961). The Finger Lakes Region its origin and nature, Cornell University Press, Ithaca, NY.