Soil 2125 Laboratory Manual - pdf edition

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Preface

> **"Tell me an I forget, teach me and I may remember, involve me and I learn."**
>
> *- Benjamin Franklin*

Laboratory Schedule

Note that the laboratory portion of this course is self-paced. The lab has open hours and is self-paced so you can return as often as needed to complete the lab exercises (Laboratory TA's will be in the lab during all open hours to help you). **Make sure you sign in and out**. Labs take approximately 1-2 hrs to complete. You will sign up for a timeslot of your choice. Open times: W 9:00 AM - 8:30 PM Th 9:00 AM - 8:30 PM F 9:00 AM - 4:30 PM *241 Borlaug Hall*

Lab Teaching Team

Teaching Support and Lab Coordinator

Nora Pearson

pear0747@umn.edu

Office Hours (Zoom):

M 9:35-10:25AM, and by appointment

Laboratory TAs

XXXXX

XXXXX

Logitstics and Laboratory Philosophy

###Whys is this lab self-paced and what does that even mean?

Something here about pedagogy

How will I fit the lab into my schedule?

details here

Anything else?

dunno

1 Soil Texture, Color, and Structure

Objectives

- Use the Bouyoucos hydrometer to determine soil particle distribution.
- Use the textural triangle to determine the soil textural class name.
- Use the texture by "feel" method to determine soil textural classes.
- Determine soil color using Munsell notation.
- Describe different soil structure characteristics and determine the horizon where most commonly found.

Key Words & Concepts

- Blah Blah

1.1 INVESTIGATION A: Using a Hydrometer to Determine Particle Size

1.1.1 Theory

Particle size distribution has become a standard means for characterizing and classifying the fine earth fraction of solid soil particles, and is used to determine the soil texture class. This experiment uses a Bouyoucos hydrometer to measure the density (grams per L) of a liquid mixture ("slurry") of soil and water.

Using the hydrometer allows us to determine soil texture by measuring the grams of the soil particles (sand, silt, and, clay) that remain suspended in the cylinder after a specific period of time. Different sized soil particles are separated by their different sedimentation rates – e.g. larger particles will settle faster in a column of water, while smaller particles remain suspended much longer in the solution (based on Stokes Law).

Watch this video before you start Investigation A

1.1.2 Preparation

The two cylinders in this investigation each contain ***60*** grams of oven-dry dispersed soil – one soil is from an E horizon and one is from a B horizon. After mixing thoroughly with a stir stick, the largest particles (sand) will quickly drop to the bottom of the cylinder. After 40 seconds, only silt and clay particles are left suspended in the water. After two hours only clay-sized particles remain.

Example of a citation Knuth (1984). testing inline citation (Knuth 1984).

1.1.3 Measurements

1.1.3.1 *40 Second Measurement*

1. Carefully use the stirring rod (approximately 18 inches long with a disk on the end) to completely disperse the soil in the cylinder. This requires that you *slowly* lower and lift the stirring rod up and down in the cylinder until ***all the sediment is removed from the bottom of the cylinder.***

2. After stirring, immediately note the time to the nearest second. *Carefully* and *slowly* insert the hydrometer (***the hydrometers are extremely fragile***) into the cylinder. Please refer to the figure on page 2. (*Note*: you may need to use your finger to stop the hydrometer from bobbing).

3. After 40 seconds, read the number (at liquid level) on the hydrometer.

4. This reading must be corrected for temperature. Add 0.4 g/L for each degree above 20°Celcius or subtract 0.4 g/L for each degree below 20°Celcius.

1.1.3.2 *2 Hour Measurement*

1. Due to time constraints, two hour readings will be provided in lab.

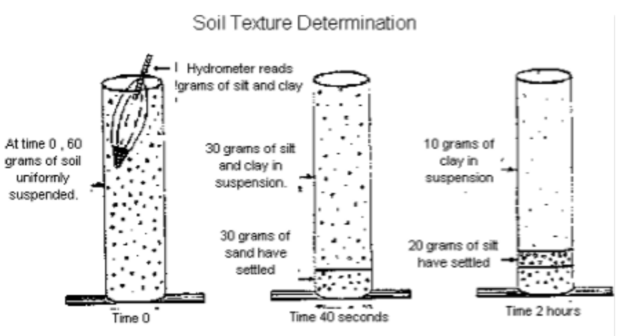

Figure 1.1: Hydrometer Process

(Note: The soil in the diagram has (60-30)/60 x 100= 50% Sand; 10/60 x100= 17% Clay; 100-50-17=33% Silt)

1.1.3.3 *Calculations - note: correct readings before calculating sand, silt, and clay!*

$$Sand(\%) = \frac{M_{sample,ovendry} - 40sreading}{M_{sample,ovendry}} x100$$

Table 1.1: Hydrometer Measurement Results

Measurements	Sample 1	Sample 2
Sample mass (oven-dry)	60 g	60 g
40s reading (uncorrected	g/L	g/L
Temperature (C)	g/L	g/L
40s reading (corrected)	C	C
% Sand	%	%
2hr reading (uncorrected)	g/L	g/L
Temperature @2hr (C)	C	C
2hr readng (corrected)	g/L	g/L
% Clay	%	%
% Silt	%	%

1.1.3.4 *Results*

note just trying to cut out tables to see if that works

1.2 INVESTIGATION B: Using the Texture Triangle

1.2.1 Background

A soil's textural class is determined by that soil's respective content of sand, silt, and clay. The USDA textural triangle is used to classify the texture class of a soil. The sides of the soil textural triangle are scaled for the percentages of sand, silt, and clay (0-100%). Clay percentages are read along the lines from left to right across the triangle. Silt is read along the lines from the upper right to lower left. Sand along the lines from lower right to the upper left portion of the triangle. The intersections of the three sides on the triangle give the texture class name. For instance, if you have a soil with 20% clay, 45% silt, and 35% sand it falls in the "loam" textural class name.

1.2.2 Results

Using the soil particle percent data from Investigation A determine the texture class for the soil sam-

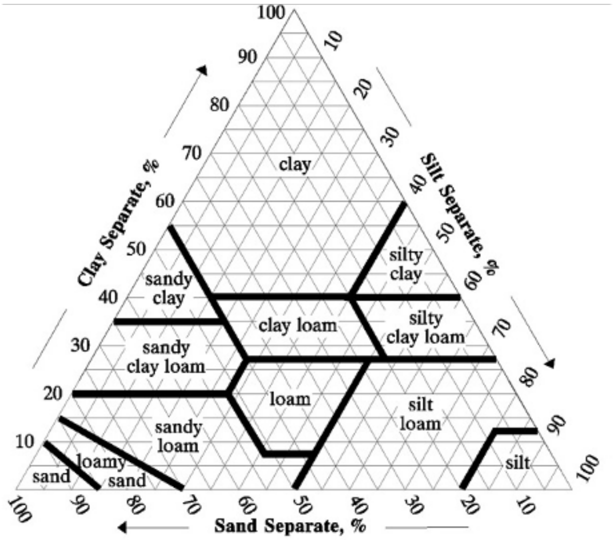

Figure 1.2: USDA Soil Texture Triangle

ples 1 and 2.

2 Mineralogy and Clay Minerals

Objectives

- Draw the structure of clay minerals.
- Understand why the structure of the clay determines the soils physical and chemical properties.
- Describe differences between 1:1 and 2:1 clay minerals.

Key Words & Concepts

- Kaolinite
- Illite
- 1:1
- Octahedral
- Smectite
- Expanding clay
- Tetrahedral
- Vermiculite
- 2:1

2.1 INVESTIGATION A: 3-D Digitized and Model Clay mineral structures

Using the iPads provided, choose the iBook named SOIL 2125 Mineral Structures- Lab 2. Start on the first page, and flip through the iBook. Be sure to read the captions. Turn pages by swiping right or left on the top or bottom. The figures are fully-rotatable 3-D diagrams. You can use your finger on the screen to manipulate them. If you need assistance, ask the TA. **Please navigate with the bookmark or flip back to the very first page (Interactive 1.1) for the next person when you are done.**

Answer the following questions from your observation and reading of the models in the iBook: 1. What other elements are present in the mineral structure of Feldspars that are not present in Quartz?

2. Based on what you know about the stability of the cation-oxygen bonds in the BIG 8 (Lecture 1.5), do you think Feldspars are more or less stable (or resistant to weathering) than Quartz?
3. In the phyllosilicates, how are the Si-tetrahedral sheets and Al-octahedral sheets linked?
4. Why is kaolinite called a 1:1 clay mineral?
5. Why are Micas called 2:1 clay minerals?
6. What occupies the space between layers in Mica or Illite?
7. Are there any other atoms besides Si in the tetrahedral sheets of a Mica or Illite? If so what element?

Note how water (WAT) and other cations (in this case Na) occupy the interlayer of the Vermiculites and Smectites. Unlike Kaolinite and Micas/Illites, Vermiculite/Smectites are shrinking and swelling (or expanding) clays because they have a weak enough negative charge that hydrated ions and water can enter the interlayer space. Smectites can expand even more than vermiculites because they have a lower negative charge so the positively charged cations that hold the layers together are few and the layers can disperse far apart.

2.2 INVESTIGATION B: Clay Mineral Block Structures

Draw the mineral structure of the two clay minerals listed below using your lecture notes. Your drawing should include: tetrahedral sheets, octahedral sheets and labeled interlayers.

Table 2.1: Clay Mineral Structures

Clay	Drawing
Kaolinite (1:1)	
Smectite (2:1)	

Table 2.2: Clay Charges

Clay attracted to which electrode	Charge on clay

note just trying to cut out tables to see if that works

Explain why Kaolinite does not expand and Smectite does expand.

Draw a picture to aid your explanation.

2.3 INVESTIGATION C: Clay Mineral Charges

1. Insert the electrodes (which are connected to the battery) into the clay slurry.
2. Wait ~ 1-2 minutes.
3. Pull the electrodes out and determine the charge (positive or negative) of the clay mineral in the beaker. Wires are attached to the electrodes of the battery – black is positive and white is negative. The clay will be attracted to the opposite charge of the battery electrode (positive attracted to negative).
4. Clean the wires off once you are done with this investigation.

2.4 INVESTIGATION D: Clay Charge, Ion Charge, and Flocculation

1. Shake up each of the 3 pre-made tubes containing a slurry of a clay-enriched B horizon in eastern MN with 20ml of either deionized H2O, NaCl, or AlCl3. The deionized H2O contains no cations, the NaCl solution contains Na+ ions, and the AlCl3 solution contains Al3+ ions.
2. Wait 5 minutes and watch each tube for the formation of colloids (clay particles held together by electrical attraction to an ion) – when they form, you should be able to see them with your naked eye. The clay colloids will start to settle to the bottom, whereas in the absence of colloid formation the clays will stay in suspension.

Table 2.3: Observing Clay Flocculation

Slurry	Ion	Water Clarity
DI-H20	None	
NaCl	Na+	
AlCl3	Al3+	

Record your observations in the table below. PAY ATTENTION TO THE CLARITY OF THE LIQUID AT THE TOP OF EACH TUBE OF SLURRYS AFTER 5 MINUTES. High clarity indicates the absence of suspended clay particles, while cloudy liquid indicates that clay particles are still floating around in suspension and have not settled out.

Interpret the results of Investigation D based on what you know about the charge on clays and the ionic potential of cations. What accounts for the differences observed? Hint: Look at the lecture slides on clay mineralogy. The answer has to do with the charge on clay particles and the strength of the charge on the cation in solution.

2.5 INVESTIGATION E: Shrink/Swell Observation

1. Take two Dixie cups. Label one “Kaolinite” and the other “Smectite”.
2. Place a teaspoon of Wyoming bentonite in the “Smectite” cup (WY Bentonite is a type of smectite often used in engineering applications) and a teaspoon of Kaolinite in the “Kaolinite” cup.

Table 2.4: Examples of Clay Soils

Dominant Clay Mineral in Soil	Moist Characteristics	Dry Characteristics	General Locations of Soil in U

3. Using the graduated cylinder, add 20 ml of distilled H2O to each cup and stir with the pencil provided. (If the clay is not saturated, continue to add water in 10 ml increments and stir until you see excess water on the bottom).

Describe what happens to each of the clays. How much water (ml) could you add to each before there was excess water?

Explain this below using what you know about the properties of the major clay mineral groups and the difference between Kaolinites and Smectites.

2.6 INVESTIGATION F: Clay Soils

Two soils have been set out for you to look at. One is dominated by Kaolinite clays and one by Smectite clays. Both soils have a clay percentage greater than 35%. Unlike the Kaolinite and Smectite clays in Investigation E, which are from mined geological deposits, these are real soil materials (dominated by each of these different clay types) and so they have color associated with them which is not due to the clay minerals alone.

Note the wetted and dried samples of each and describe what you see in terms of its behavior. Describe the characteristics of each.

2.7 INVESTIGATION G: Article

Read the short article provided. What was one of the clay minerals that solved the double murder mystery?

3 Summary

In summary, this book has no content whatsoever.

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References

Knuth, Donald E. 1984. "Literate Programming." *Comput. J.* 27 (2): 97–111. https://doi.org/10.1093/comjnl/27.2.97.