An Introduction to Soil Science

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The Purposes and Functions of Soils

Soils are *natural bodies* made from both mineral and organic materials and capable of supporting plants out-of-doors. Soils have **horizons**, roughly parallel to the earth's surface, that indicate the degree to which materials have been altered and redistributed by water, gravity, and organisms. Individual soils occupy distinct places in the landscape, so we find patterns of soils and landscape features.

Some key concepts:

Soil properties reflect the progressive alteration and redistributions of nutrients, minerals and organic matter over time.

Soils, landscapes and their biota have co-evolved over geologic time.

Soils, landscapes and biota are arranged and respond to the temporal and spatial distributions of water, nutrients and energy.

Landforms (the individual features of the landscape) control the distributions of water, nutrients and energy.

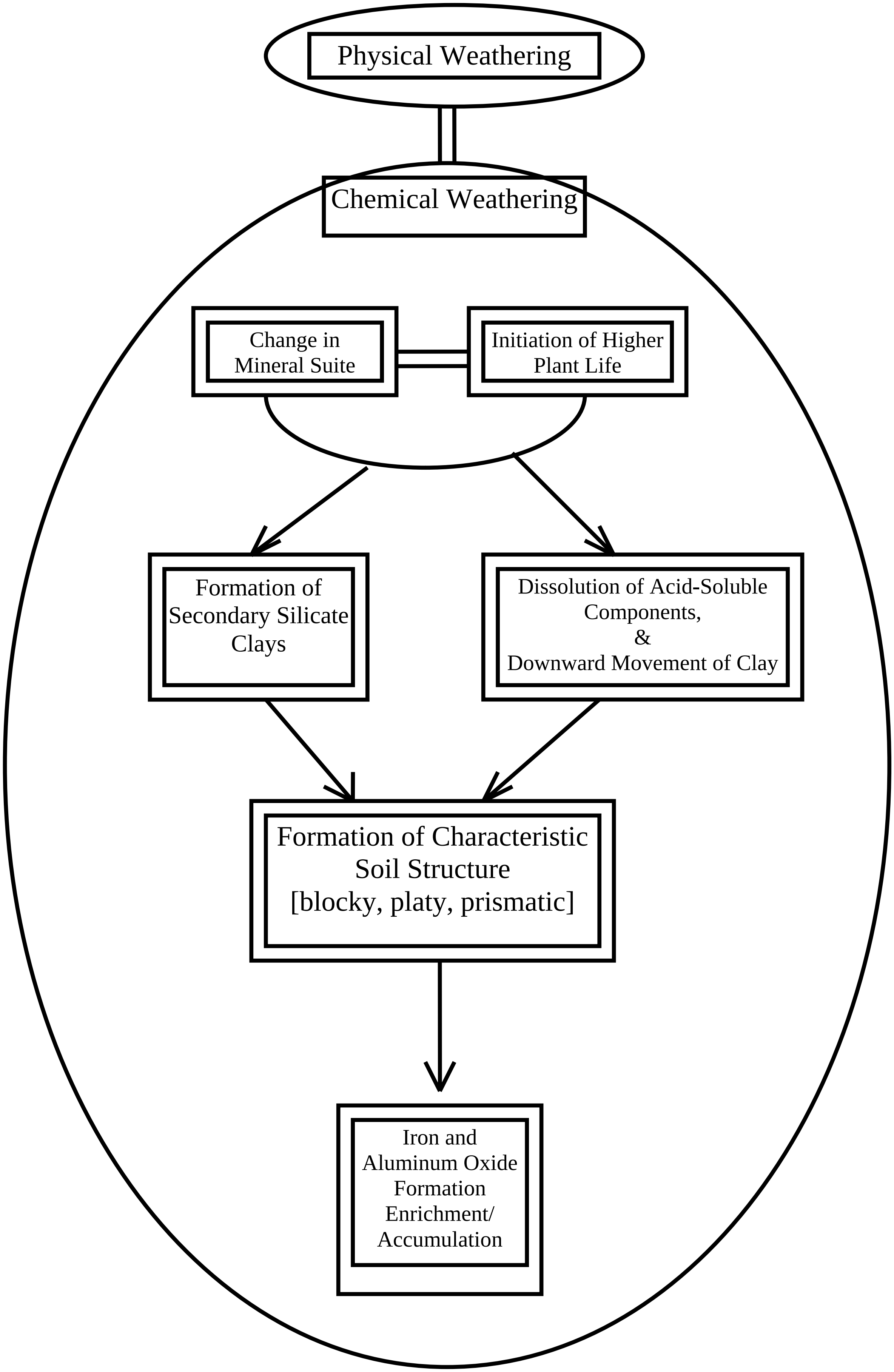
Soils must be considered in the context of their landscapes!

Soils are important because they:
--Filter water
--Regulate the flow of rivers
--Provide habitat for millions of species of organisms
--Provide water, nutrients and support for plants
--Sequester carbon from the atmosphere
--Serve as a "compost bin" for the Earth
--Moderate and regulate distributions of solar energy
--Provide a historical record of the influences of climate and living organisms upon the parent
--material from/in which the soil is formed.

Weathering, Parent Materials & Soil Genesis

Pedogenesis (soil formation) is a complex process that does not follow a linear path of development. While some soils do form in place, most soils form in mineral or organic substrates (parent materials) that have been displaced from their source of origin. Let's talk about some key factors regarding weathering and soil formation.

<u>Cycle of Soil Development</u>- [*General Conceptual Model*]



Soil Mineralogy influences the rate of soil formation and the chemical and physical properties of the soil that forms from the minerals.

Five Factors of Soil Formation

1) Parent Material
2) Climate
3) Topography
4) Biotic Activity
5) Time

Jenny, Hans. 1941. Factors of soil formation: a system of quantitative pedology. New York: McGraw-Hill. 281 p.

It is helpful to consider four basic processes as a framework for understanding how the five soil forming factors affect soil development.

Four Processes Integral to Soil Formation

1) Additions [surface or subsurface]
2) Removals [ditto]
3) Transformations [chemical weathering, turnover]
4) Translocations [secondary clay minerals, base cations]

Simonson, Roy W. 1959. Outlining of a generalized theory of soil genesis. Soil Sci. Soc. Am. Proc. 23:152-156.

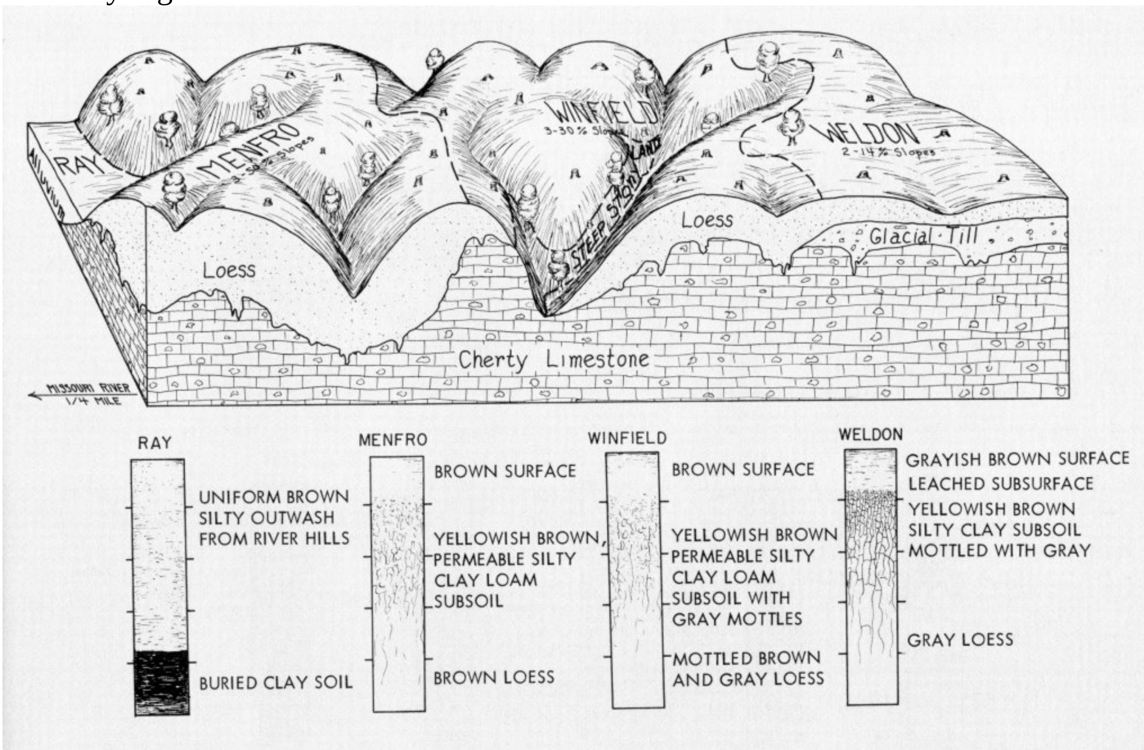
--- By considering ***Processes*** we can better understand how the biotic activity [BA] factor or any other factor influences soil properties.

Soil Parent Materials

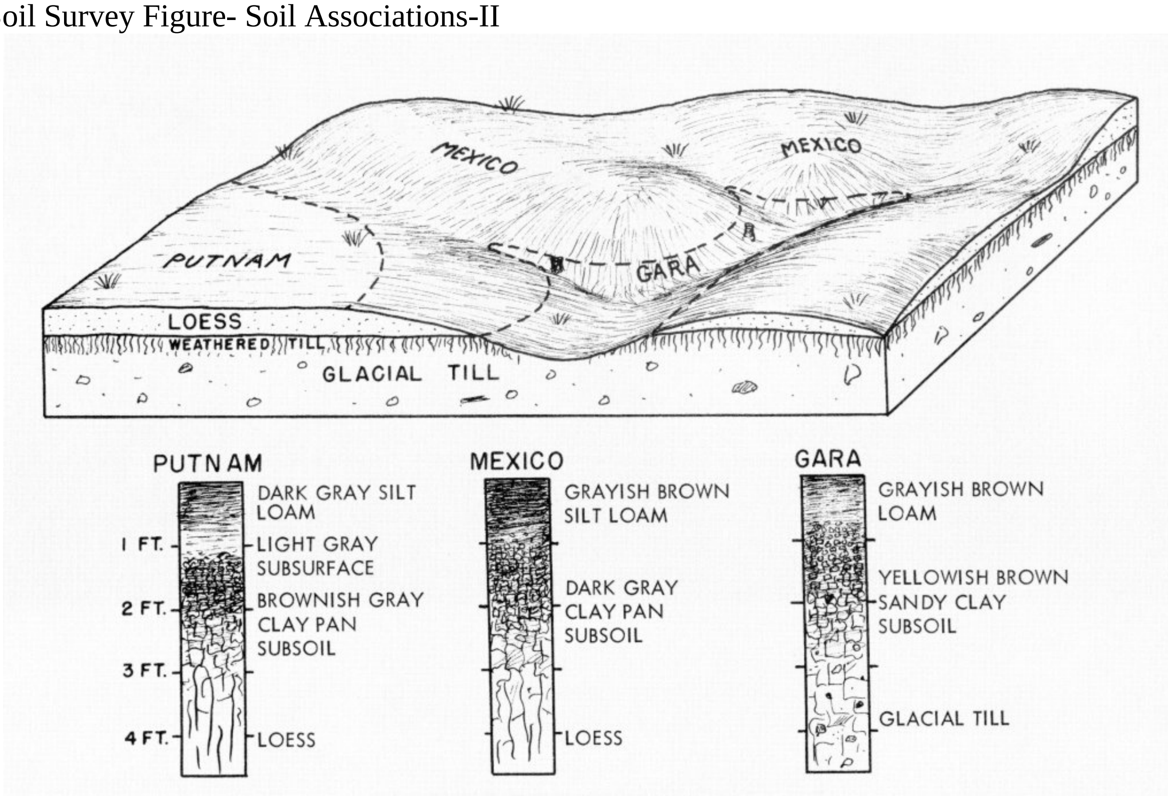
Parent materials for soils are the mineral or organic substrates in which a soil forms. Parent materials are classified primarily by their mode of deposition; however, **Organic** parent materials are distinguished by their low mineral content. Below are some common types of soil parent materials:

1. **Residuum**- soils formed in residuum are soils that form in mineral strata in place.
2. **Glacial till**- soils formed in residual minerals left behind by glaciers
3. **Loess** (pronounced "lus")- soils formed in silt-sized particles that are deposited by wind. Loess is one type of "eolian" parent material.
4. **Alluvium**- soils formed in river sediment deposits
5. **Colluvium**- soils formed in deposits that resulted from mass movement due to gravity, not water
6. **Marine**- soils formed in the residues of ancient sea beds (now dry land)
7. **Lacustrine**- soils formed in residues of ancient lakes (now dry land)

Soil Survey Figure- Soil Associations-I



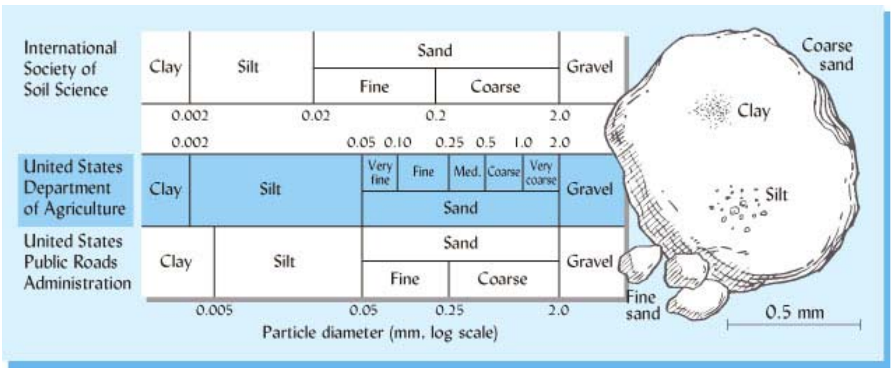
Soil Survey Figure- Soil Associations-II



Soil Texture & Structure

Soil texture is highly correlated with a range of soil chemical and physical properties. Fine textured soils with high clay contents generally have higher nutrient and water holding capacities than do coarse textured soils. However, fine textured soils often do not have drainage characteristics that are ideal for plant growth, especially if the soil does not have good **structure**. While ***texture can be determined through quantitative analyses***, ***structure is described in more qualitative terms*** (blocky, subangular blocky, prismatic, granular, etc.). Maintaining good soil structure is important for plant growth. Texture really does not change over a period of only a couple of hundred years or so, but structure can be changed rapidly, especially through management practices. Here is some basic information about soil texture.

Texture is generally used to reference the proportions of sand, silt, and clay. The particle sizes in each of these three **soil separates** ranges between specific limits. The distinctions among the size groups are more or less arbitrary. They have been arrived at after many trials in developing classes that can be used consistently, conveniently, and best describe the nature of the separates. The scheme we will use is that adopted by the United States Department of Agriculture (USDA). Another scheme of soil separate classification is used by the International Society of Soil Science (ISSS).



Source: Brady & Weil, 2003.

Soil Textural Classes

Rarely do soils consist entirely of a single separate, but instead are a mixture. **Textural classes** are based on different combinations of ***sand, silt, and clay***. The twelve basic textural classes in order of increasing proportions of the fine separates and with appropriate abbreviations are:

1. Sand (s)	**7. Sandy clay loam (scl)**
2. Loamy sand (ls)	**8. Clay loam (cl)**
3. Sandy loam (sl)	**9. Silty clay loam (sicl)**
4. Loam (l)	**10. Sandy clay (sc)**
5. Silt loam (sil)	**11. Silty clay (sic)**

6. Silt (si) 12. Clay (c)

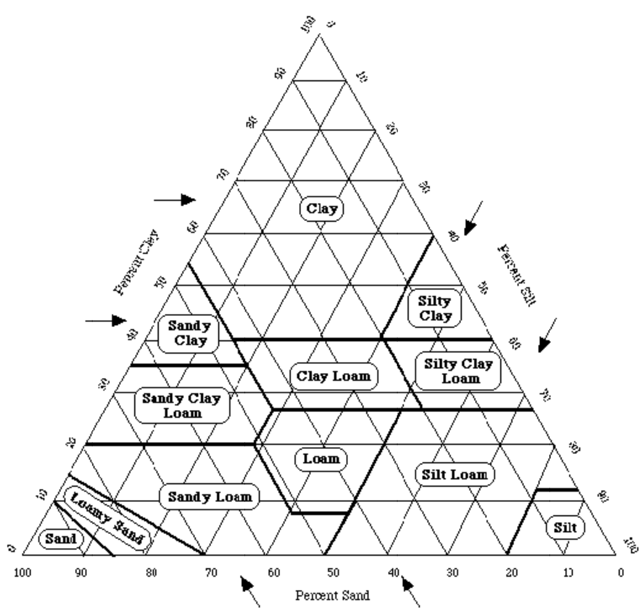
The term loam refers to soils having a moderate amount of sand, silt, and clay. Thus, loamy soils have textural properties intermediate to the properties of the individual separates. A sandy loam soil has a soil texture somewhat coarser than a loam and a loamy sand soil has a texture somewhat finer than a sand. Those textural classes with the term sand in the name are often modified to indicate the fineness of the sand. A very coarse sand, for example, will have different properties than a very fine sand. The ranges of sand sizes used by the USDA are below:

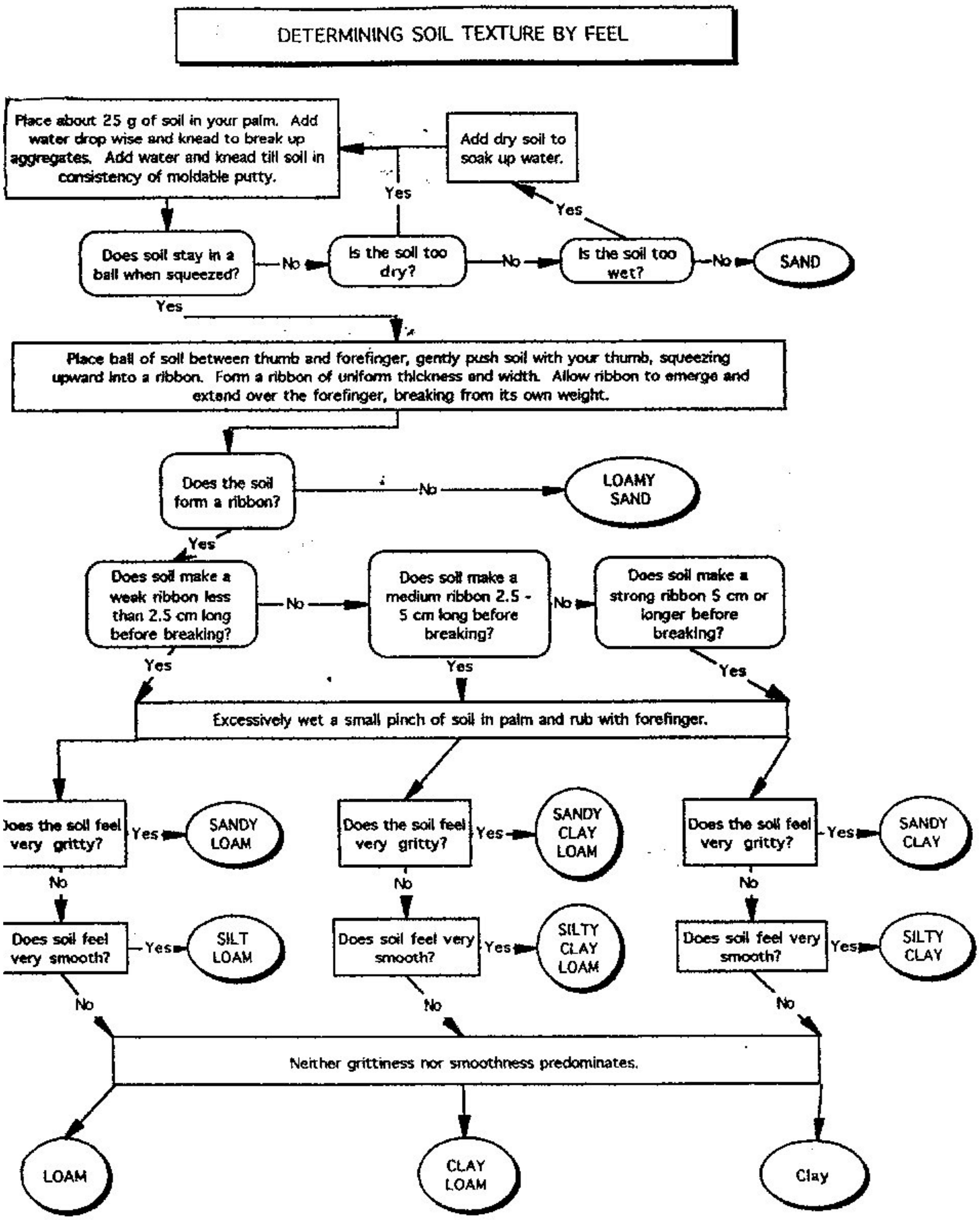
Size limits on sand separates used by the USDA.

Sand Separate	Particle Diameter (mm)
Very Coarse sand	**2.0-1.0**
Coarse sand	**1.0-0.5**
Medium sand	**0.5-0.25**
Fine sand	**0.25-0.10**
Very fine sand	**0.10-0.05**

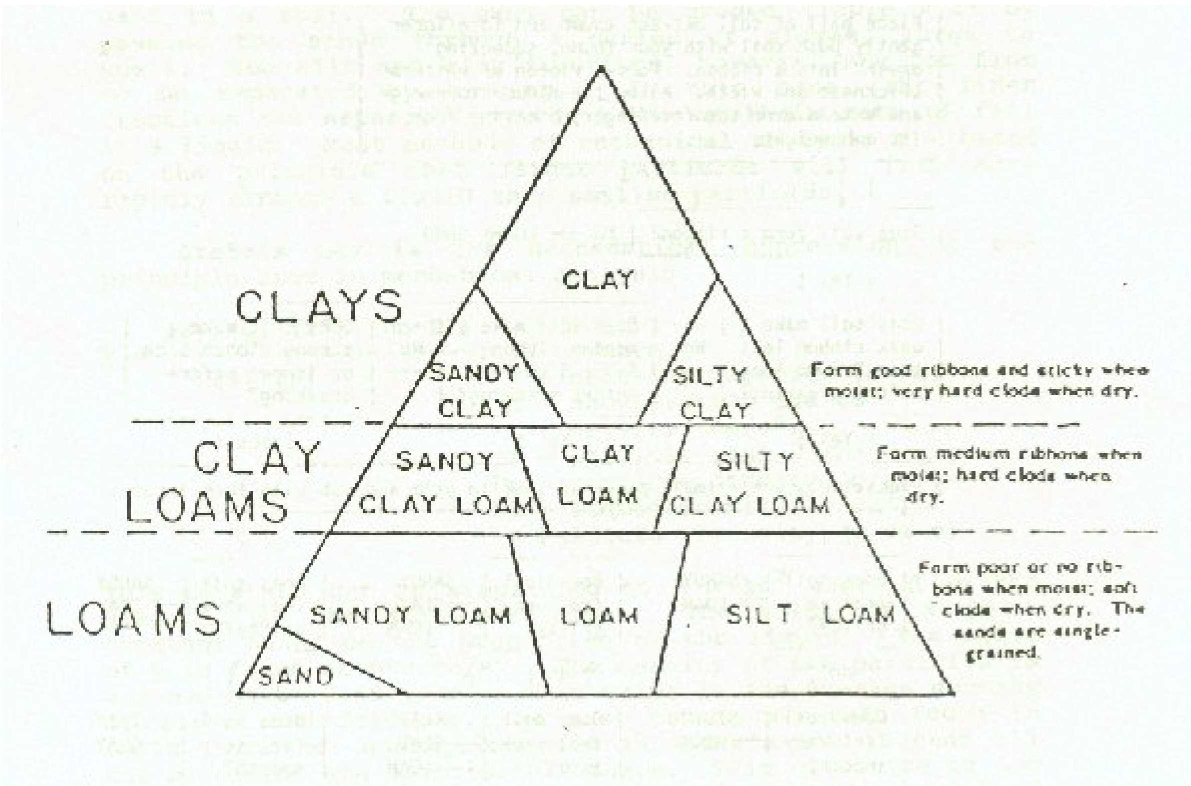
Actually, soil texture describes the proportions of soil particles less than 2 mm in diameter and larger than 2 mm in diameter. The separates larger than 2 mm in diameter, or **coarse fragments**, are described using terms such as stony, cobbly, gravelly, slaty, cherty, and flaggy. Each term has a precise meaning reflecting the size, shape, and composition of the coarse fragments.

Soil Textural Triangle



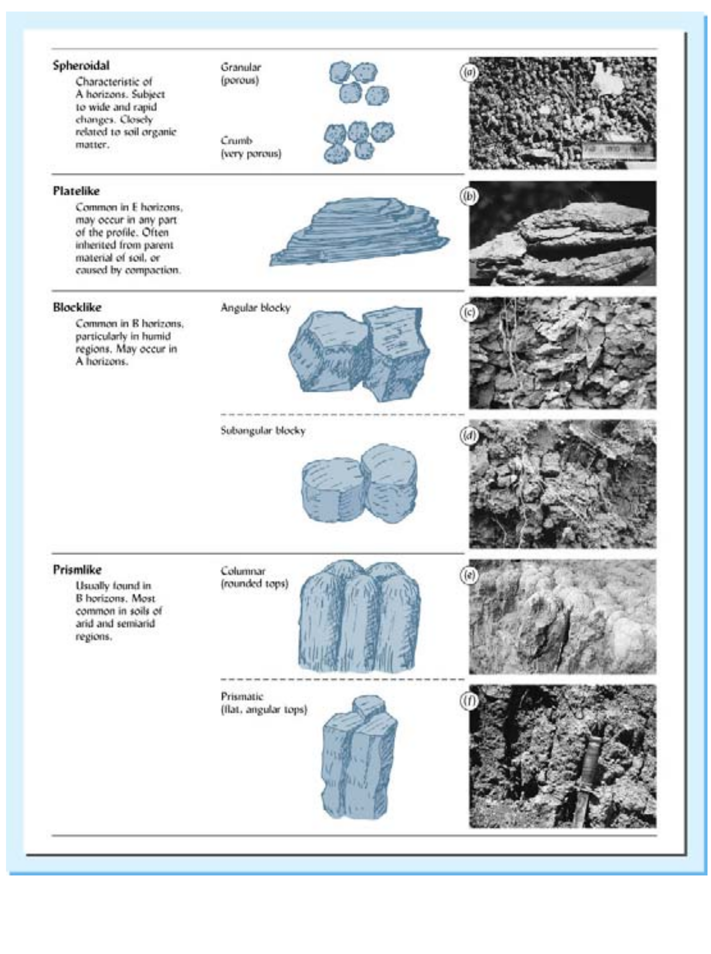


Flow chart for determining soil texture by feel. (After Thien, S. J. 1979. A flow diagram for teaching texture-by-feel analysis. J. Agron. Educ. 8:54-55.)



Soil Structure

As I mentioned earlier, soil structure, unlike texture, is characterized by qualitative descriptions instead of quantitative measurements. Below is a figure with some common structural characterizations.



Source:
Brady & Weil, 2003.

Soil Color

We'll make use of Munsell color charts and determine the color (hue, value, chroma) of samples that I'll provide.

Legal Descriptions- Overview

U.S. Public-Lands Survey

- Started in 1785
- Used in 30 states
- Not included: original 13 + Hawaii, Kentucky, Tennessee, Texas, West Virginia

Townships

- Primary units
- Six mile square
- total of 36 square miles
- each square mile is a section

Standard lines Initial Point Principal Meridian

- North - South

Base Line

- East - West

Correction Lines Township and Range Lines

- Numbered from the Initial Point
- T2S, R4E
- T5N, R2W
- T1S, R5W

Sections

- 36 sections in a Township
- Numbered 1-36
- Most are a 1 mile square
- Slightly smaller at correction lines

Division of Section

- Each section is approximately 640 acres
- 43,560 square feet equal 1 acre
- Fractions of the section
    - North half, Southwest quarter, North half of the southeast quarter

<u>Soil Survey- History and Use</u>

Soil Survey History

SOIL SURVEY 1899 1999 CENTENNIAL

The Centennial of Soil Survey

The National Cooperative Soil Survey has just reached the century mark. The Agricultural Appropriations Act of 1896 authorized the Federal government to conduct "…investigations of soils and their relationship to climate and organic life, and the development of methods to determine texture and composition of soils in the field and laboratory." Federal soil scientists soon began forming partnerships with States and land grant universities to study and inventory the Nation's soils. The first soil surveys were begun in 1899 in the Pecos Valley of New Mexico, the Salt Lake Valley of Utah, the Connecticut Valley of Connecticut and Massachusetts, and in Cecil County, Maryland.

It soon became clear that a scientific system to classify and name soils was needed to properly coordinate a national soil survey program. A soil classification system was published in 1938. However, this system soon proved to be inadequate. As a result, work on a more modern system was started in the 1950's. This work resulted in the publication of <u>Soil Taxonomy</u> in 1975. The 1975 edition of <u>Soil Taxonomy</u> recognized 10 soil orders—the highest category in the classification system. In 1998, <u>Soil Taxonomy</u> was revised to include a total of 12 soil orders.

This calendar of soil orders was created as part of our special celebration of the Soil Survey Centennial. Each month of the calendar highlights one of the 12 soil orders.
In addition to highlighting the soils of America, this calendar helps commemorate a Federal, State and local partnership that has lasted 100 years—and is still going strong. This partnership has enabled us to acquire a vast amount of information about our Nation's soils. In this centennial year, we extend our sincere appreciation to the many dedicated people who have helped make the National Cooperative Soil Survey a success.

Pearlie S. Reed
Chief
Natural Resources Conservation Service

USDA NRCS
Natural Resources Conservation Service

Use of Soil Surveys

We will practice using hardcopy soil surveys, and then we will explore the new online web-based soil survey database.

The URL to the NRCS Web Soil Survey is:

http://websoilsurvey.nrcs.usda.gov/app/