

Alaska State Envirothon

Soils and Land Use

Alaska Soils/Land Use Learning Objectives

- 1) Understand the importance of soils and appreciate the relatively small amount of soil that exists on Earth.
- 2) Understand the origin and types of soil parent material.
- 3) Understand basic soil forming processes: addition, losses, translocations and transformations.
- 4) Recognize and understand features of Soil Profiles, and be able to use this information to determine basic soil properties and limitations.
- 5) Identify and describe soil characteristics (texture, structure and color, using Munsell color charts).
- 6) Recognize that biological diversity is important for soil health and hence plant and environmental health.
- 7) Understand the procedure for taking a soil sample and conducting nutrient analysis.
- 8) Understand how soil is impacted by point and non-point source pollution and how soil management to agriculture and clean water.

SOIL STUDY GUIDE 2011/2012 School Year

Participants should be familiar with how to use a clinometer to determine slope, a Munsell color book, a textural triangle, and how to describe a soil pit. Students should be able to look at a soil pit and name the horizons they see, determine the soil texture of each horizon, determine the soil name for the soil in each horizon using a Munsell color book, figure out the soil name for the soil in each horizon, and determine the pH of the soil using pH indicators and color charts.

The following glossary is a reference guide. Students do not need to memorize these terms.

Alaska Landforms

| Landform | Description |
|--------------|---|
| Alluvial fan | A low, outspread mass of loose materials and/or rock material, commonly with a shape like an open fan or a segment of a cone, deposited by a stream (best expressed at the place where it issues from a narrow mountain or upland valley; or where a tributary joins or at its junction with the main stream. It is steepest near its apex which points upland and gently and convexly outward (downstream) with a gradual decrease in gradient. |
| Beach | a) A gently sloping zone, typically with a concave profile, of unconsolidated material landward from the low-water line to the place where there is a definite change in physiographic form (such as a cliff) or to the line of permanent vegetation (usually the highest storm waves); a shore of a body of water, formed and washed by waves on sand or gravel; (b) the relatively thick and temporary accumulation of loose water-well-sorted sand and pebbles) accompanied by mud, cobbles, boulders, and smooth fragments, that is in active transit along, or deposited on, the shore zone between the high water. Always a miscellaneous area component. |
| Escarpment | A relatively continuous and steep slope or cliff produced by erosion or faulting and interrupts or breaks the general continuity of more gently sloping land surface. Commonly applied to cliffs produced by differential erosion. May be a soil or miscellaneous component. |
| Flood plain | The nearly level plain that borders a stream and is subject to inundation under flood unless protected artificially. It is usually a constructional landform built of sediments by overflow and lateral migration of the streams. |
| Hill | A generic term for an elevated area of the land surface, rising at least 30 m (100 meters (approx. 1000 ft.) above surrounding lowlands, usually with a nominal summit, bounding slopes, a well-defined, rounded outline and slopes that generally exceed 15 percent. occur as a single, isolated mass or in a group. A hill can be further specified based on magnitude of local relief: 30 - 300 m |
| Mountain | A generic term for an elevated area of the land surface, rising more than 300 meters above lowlands, usually with a nominal summit area relative to bounding slopes and generally steep sides (greater than 25 percent slope) with or without considerable bare-rock exposure. occur as a single, isolated mass or in a group forming a chain or range. Mountains are produced by activity and/or volcanic action and secondarily by differential erosion. |
| Plain | A general term referring to any flat, lowland area. Specifically, any extensive region that is smooth and level gently undulating with a dominant slope less than 15 percent. prominent hills or valleys but sometimes has considerable slope, and usually occurs in surrounding areas. Where dissected, remnants of a plain can form the local upland. Formed by deposition or erosion. |
| Plateau | A comparatively flat area of great extent and elevation; specifically an extensive landform considerably elevated (more than 100 meters) above adjacent lower lying terrain. limited on at least one side by an abrupt descent, has a flat or nearly level surface. A part of a plateau surface is near summit level. |

Alaska Landform Features

| Feature | Description |
|---------------------|---|
| bar | A small, sinuous or arcuate ridge-like lineation on a flood plain and like it by small channels or troughs; caused by fluvial processes on flood plains; and is a constituent part of bar & channel topography. See point bar. |
| bench | A platform-like, nearly level to gently inclined erosional surface of strata in areas where valleys are cut in alternating strong and weak strata on essentially horizontal attitude. Structural benches are bedrock benches, stream terraces, have no geomorphic implication of former, partial erosion controls, nor do they represent a stage of flood-plain development for stream channel trenching. |
| channel | Small, trough-like, arcuate or sinuous channels separated by small ridges by fluvial processes and common to flood plains; and is a constituent part of channel topography. See bar, levee, point bar. |
| circle | A form of patterned ground whose horizontal mesh is dominantly circular, sorted circle. |
| cirque | A steep-walled, half bowl-like recess or hollow, crescent-shaped depression commonly situated at the head of a glaciated mountain valley or on a mountain, and produced by the erosive activity of a mountain glacier. See small round lake (tarn). |
| depression | Any relatively sunken part of the Earth's surface; especially a low area bounded by higher ground. A closed depression has no natural outlet for surface drainage (e.g. sinkhole). An open depression has a natural outlet for surface drainage. |
| drainageway | A general term for a course or channel along which water moves. Includes relatively small, roughly linear or arcuate depressions that move water at some time, and either lacks a defined channel (e.g. head slope, swale) or has a defined channel (e.g. low order streams). |
| earth hummock | A type of hummock consisting predominantly of a core of silty and sandy material and showing evidence of cryoturbation. Earth hummocks are a type of patterned ground. See turf hummock, nonsorted circle. |
| fan terrace | The major portion of an alluvial fan and not including the active flood plain. |
| flood plain | The active flood plain on an alluvial fan and not including the fan terrace. |
| frost boil | A small mound of fresh soil material formed by frost action. A type of patterned ground commonly found in fine-grained sediment underlain by permafrost and affected by seasonal frost. See nonsorted circle. |
| high-center polygon | A polygon whose center is raised relative to its boundary. See low-center polygon. |
| ice wedge polygon | Patterned ground in areas of ice wedges. These polygons are common in permafrost areas and may be high-centered or low-centered. |
| kame terrace | A terrace-like ridge consisting of stratified sand and gravel deposited by a stream flowing between a melting glacier and a higher valley wall standing after the disappearance of the ice. It is commonly pitted by an irregular ice-contact slope. |
| kettle | A steep-sided, bowl-shaped depression commonly without surface drainage. |

| Feature | Description |
|------------------------|--|
| nivation hollow | A shallow, non-cliffed depression or hollow on a mountain side permanently or intermittently occupied by a snow bank or snow patch and produced by nivation. If the snow completely melts each summer the hollow is deepened; otherwise not; may be a cirque precursor if further enlarged and deepened by alpine glaciation. |
| nonsorted circle | A type of patterned ground whose mesh (shape) is dominantly circular and has a nonsorted appearance due to the absence of a border of coarse fragments. Vegetation characteristically outlines the pattern by forming a bordering ridge. Diameters commonly range from 0.5 to 3 m. Nonsorted circles include earth hummocks, turf hummocks, and frost boils. Nonsorted circles have various origins. Some, such as earth hummocks and frost boils, involve cryoturbation activity and differential heave of frost-susceptible materials. See earth hummock, frost boil, sorted circle, turf hummock. |
| palsa | An elliptical dome-like permafrost mound containing alternating layers of ice lenses and peat or mineral soil, commonly 3-10 m high and 2-25 m long, occurring in subarctic bogs of the tundra and often surrounded by wet sedge meadow and water. Plural - palsen. See peat plateau. |
| peat plateau | A generally flat-topped expanse of peat, elevated above the general surface of a peatland, and containing segregated ice that may or may not extend downward into the underlying mineral soil. Controversy exists as to whether peat plateaus and palsen are morphological variations of the same feature. See palsa. |
| point bar | One of a series of low, arcuate ridges of sand and gravel developed on the inside of a growing meander by the slow addition of individual accretions accompanying migration of the channel toward the outer bank. See bar, channel. |
| polygon | A type of patterned ground consisting of a closed, roughly equidimensional figure bounded by more or less straight sides; some sides may be irregular. See high-center polygon, low-center polygon, ice-wedge polygon, nonsorted circle, sorted circle. NRC" |
| shrub-coppice dune | A small, streamlined dune that forms around brush and clump vegetation. |
| solifluction lobe | An isolated tongue-shaped feature up to 25 m wide and 150 m or more long, formed by rapid solifluction on certain sections of a slope showing variations in gradient. This feature commonly has a steep (e.g. 15-60 degrees) front and a relatively smooth upper surface. |
| sorted circle | A type of patterned ground whose mesh (shape) is largely circular and has a sorted appearance commonly due to a border of coarse fragments surrounding finer material, occurring either singly or in groups. Diameters range from a few centimeters to more than 10 meters. The coarse fragment border may be 35 cm high and 8 to 12 cm wide. See nonsorted circle. |
| stripe | "A type of patterned ground; one of the alternating bands of fine and coarse surface material, or of rock or soil and vegetation-covered ground, commonly found on steeper slopes. It is usually straight, but may be sinuous or branching. |
| swale | (a) A shallow, open depression in unconsolidated materials which lacks a defined channel but can funnel overland or subsurface flow into a drainageway. Soils in swales tend to be more moist and thicker (cummulic) compared to surrounding soils. (b) A small, shallow, typically closed depression in an undulating ground moraine formed by uneven glacial deposition. |
| thermokarst depression | A hollow in the ground resulting from subsidence following the local melting of ground ice in a permafrost region. |
| turf hummock | A hummock consisting of vegetation and organic matter with or without a core of mineral soil or stones. Compare - earth hummock, nonsorted circle. |
| | |

Introduction to Soils

Soils are a naturally occurring composition (mixture) of air, water, minerals, and organic materials (including countless organisms), formed at the surface of land and extending into the edges of water bodies. Soils have a definite texture, structure, color, and composition.

The exact composition of soil changes from one location to another (for example, think of soils in a hot desert vs. soils in a cold swamp). The following is the average composition by volume of the major soil ingredients:

- 45% Minerals (clay, silt, sand, gravel, stones).
- 25% Water (the amount varies depending upon precipitation and the water-holding capacity of the soil).
- 25% Air (an essential ingredient for living organisms).
- 5% Organic matter or humus (comprised of dead plant and animal material and billions of living organisms that inhabit the soil).

How does soil form?

Soils develop as a result of the interactions of climate, living organisms, and landscape position as they influence parent material decomposition over time. Differences in climate, parent material, landscape position, and living organisms from one location to another as well as the amount of time the material has been in place all influence the soil-forming process.

The **five soil-forming factors** are:

- **C**limate,
- **P**arent material,
- **O**rganisms,
- **R**elief, also called Landscape position, and
- **T**ime.

Soil = [f] CPORT (Soil is a function of CPORT)

Note: sometimes "CPORT" is called "CLORPT"

Climate

Temperature and moisture influence the speed of chemical reactions, which in turn help control how fast rocks weather and dead organisms decompose. Soils develop faster in warm, moist climates, and slowest in cold or arid ones.

Parent Material

Every soil "inherits" traits from the parent material from which it formed. Parent material refers to everything from unconsolidated organic matter (such as decaying vegetation and organisms accumulating on the lake bed or ocean floor) to mineral material (like ash or lava ejected from a volcano). The material could have been bedrock that weathered in place, or smaller materials carried by flooding rivers, moving glaciers, or blowing winds.

Parent material has a strong effect on the type of soil developed as well as the rate at which development takes place. Soil development may take place quicker in materials that are more permeable to water. Dense, clayey materials can be resistant to soil formation processes. Parent material is changed through biological, chemical, and physical processes (What processes might take place in estuaries?).

Living organisms

Plants affect soil development by supplying upper layers with organic matter, recycling nutrients from lower to upper layers, and helping to prevent erosion. In general, deep rooted plants contribute more to soil development than shallow rooted ones because the passages they create allow greater water movement, which in turn aids in leaching. Leaves, twigs, and bark from large plants fall onto the soil and are broken down by fungi, bacteria, insects, earthworms, and burrowing animals. These organisms eat and break down organic matter

releasing plant nutrients. Some change certain elements, such as sulfur and nitrogen, into usable forms for plants. Roots produce carbon dioxide that mixes with water and forms an acid that wears away rock. Just a small change in plant cover (like when noxious or invasive plants take over a patch of ground) can alter the path of soil development for that location, changing it for better or worse (a highly subjective issue among people)!

Microscopic organisms, tiny root hairs, and the complex chemicals they produce also act as a kind of glue to hold soil particles together in aggregates. Well-aggregated soil is ideal for providing the right combination of air and water to plant roots.

Relief (or Landscape position)

Shape of the land, and the direction it faces (called *aspect*) makes a difference in the amount of solar energy the soil surface receives each day, and likewise, in the amount of moisture held there. Deep soils may form at the bottom of a hill because gravity and water move soil particles down-slope. Wetter areas may have conditions that will inhibit proper root growth for plants that require a balance of soil oxygen, water, and nutrients. Generally, for most of North America, soils on north-facing slopes tend to be cooler and wetter than soils on south-facing slopes.

Steepness, shape, and length of slope are important because they influence the rate at which water flows into or off the soil.

Time

Time is required for horizon formation. The longer a soil surface has been exposed to soil-forming agents, the greater the development of the soil profile. Soils in recent alluvial or windblown materials, or soils on steep slopes where erosion has been active may show very little horizon development.

Soils on older, stable surfaces generally have well-defined horizons because the rate of soil formation has exceeded the rate of geologic erosion or deposition. As soils age, many original minerals are destroyed. Many new ones are formed. Soils become more leached, more acid, and more clayey. In many well-drained soils, the B horizons tend to become redder in color with time (found in "From the Surface Down," NRCS).

Soil Physical Properties

There are many soil properties that help us describe and manage soils. Some of the important physical properties are described below (revised from, SSSA, at www.soils.org/files/about-soils/soils-overview.pdf):

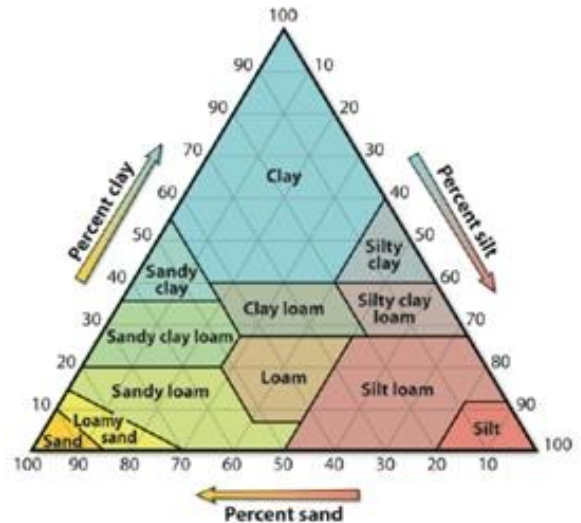
Texture

The particles that make up soil are categorized into three groups by size: sand, silt, and clay. Sand particles are the largest and clay particles the smallest. Most soils are a combination of the three. The relative percentages of sand, silt, and clay are what give soil its texture.

A clay loam texture soil, for example, has nearly equal parts of sand, silt, and clay.

- Sand - 2.0 to 0.05 mm
- Silt - 0.05 to 0.002 mm
- Clay - less than 0.002 mm

There are 12 soil textural classes represented on the soil texture triangle. This triangle is used so that terms like "clay" or "loam" always have the same meaning. Each texture corresponds to specific percentages of sand, silt, or clay. Knowing the texture helps us manage the soil.



Structure

Soil Structure is the arrangement of soil particles into small clusters or clumps, and are technically called peds or aggregates. Sand, silt, clay and organic matter can stick together to form peds. Depending on the moisture and temperature conditions, composition, and other physical factors, peds may have various shapes (for example, granular, blocky, platy, and others). Structure is also related to pore space in the soil, and influences organism growth, and air/water movement.

Soil Color

Soil color is influenced primarily by soil mineralogy. For example, soils high in iron are deep orange-brown to yellowish-brown. Soils that are high in organic matter are dark brown or black. Color can also tell us how a soil "behaves" under certain moisture and temperature conditions. For example, a soil that drains well is brightly colored, while a soil that is often wet and soggy will have a mottled pattern of grays, reds, and yellows.

What are Soil Horizons? Together, a Profile!

There are different types of soil, each with its own set of characteristics. Dig down deep into any soil, and you'll see that it is made of layers, or horizons (O, A, E, B, C, R). Put the horizons together, and they form a soil profile. Like a biography, each profile tells a story about the life of a soil. Most soils have three major horizons (A, B, C) and some have an organic horizon (O). The horizons are (revised from, SSSA, at www.soils.org/files/about-soils/soils-overview.pdf):

O - (humus or organic) It consists of fresh and decaying plant residue from such sources as leaves, needles, twigs, moss, lichens, and other organic material accumulations. The O horizon is thin in some soils, thick in others, and not present at all in others. Some organic materials were deposited under water, as in estuaries and wetlands.

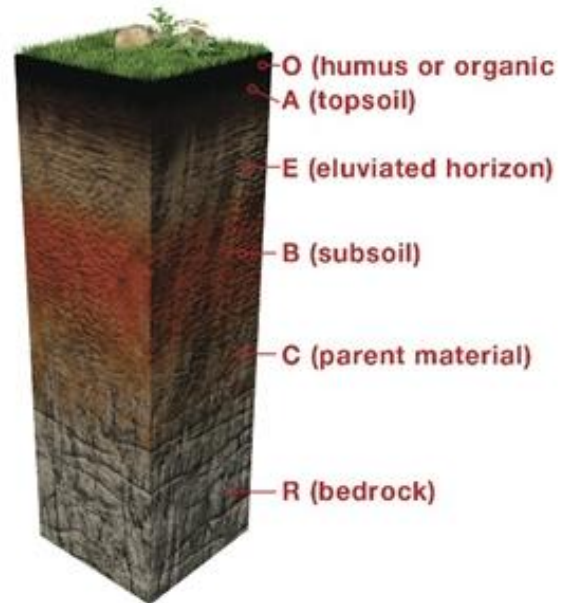
A - (topsoil) Mostly minerals from parent material with organic matter incorporated. A good material for plants and other organisms to live. This horizon is where most root activity occurs and is usually the most productive layer of soil. It may be referred to as a *surface layer* in a soil survey.

E - (eluviated) Leached of clay, minerals, and organic matter, leaving a concentration of sand and silt particles of resistant materials. This layer is not found in young soils (much Alaska) but is often found in older soils and forest soils. It can be confused with recent volcanic ash deposits like those seen in soil profiles from Kodiak Island, deposited June 6-8, 1912 by the volcano "Novarupta" (located 90 miles W of Kodiak city, on the Alaska Peninsula).

B - (subsoil) Rich in minerals that leached (moved down) from the A or E horizons and accumulated here.

C - (parent material) The deposit at Earth's surface from which the soil developed. Partially disintegrated parent material and mineral particles are in this horizon.

R - (bedrock) The lowest horizon. Bedrock can be within a few inches of the surface or many feet below the surface. Where bedrock is very



deep, and below normal depths of observation, an R horizon is not described in. This is not soil and is located under the C horizon.

The Earth's Skin

The boundary that separates soil from the nonsoil underneath is difficult to define. Soils consists of horizons (layers) near the Earth's surface that in contrast to the underlying parent materials, have been altered by the interactions of climate, relief, and living organisms over time. Typically, a soil ped changes at its lower boundary to hard rock, or to materials virtually devoid of animals, roots, or other marks of biological activity. In locations with water, areas are not considered to have soil if the surface is permanently covered by water too deep for the growth of rooted plants. Estuaries, tidal flats, wetlands ... also have soils, even though they are frequently covered by water.

Classroom Activity: Soil Color

Supplies: Munsell Color Book
Variety of soil samples with distinctly different colors

To get a variety of soil colors, you can ask friends and colleagues to send you soil samples from their region; flat rate boxes are great for Ziploc bags filled with soil. If you're traveling, keep your eye out for different soil colors that you can bring back home with you for this activity.

Separate the soil sample in labeled cups. Petrie dishes with lids work great, but you can also simply lay out piles of the soil on a paper liner.

Label each soil sample with a distinct name. The labels could be simple A, B, C; or you could name it by its texture type (link to other activity), its soil taxonomy name, or the region of its origin.

Students use Munsell color books to code out the colors of the soil samples. They write down their answers on a form. Students compare their findings with your and other students color determinations.

Discuss your findings:

Did everyone agree? How do the answers differ?

Did everyone agree on the same Value, but disagreed on the Hue?

Is it harder to find the color code of darker soils or lighter soils?

What does the soil color tell you about where that soil came from?

Color is a clue to the soil's chemical content and water drainage.

| Color | Meaning |
|----------------------|---|
| Black, Dark Brown | Rich in organic matter (carbon is black) - good growing medium Typically found in "A" horizon |
| Yellow/Reddish Brown | Oxidized iron like rust - clue to parent material mineralogy |
| Grey | Depleted of iron because it all washed away - clue to drainage (factor for suitability of a site for building, or making wetland determination) Typically found in very wet, saturated soils - like estuaries! |
| Bluish Grey | Iron is present, but it has been chemically changed by anaerobic microbes into a different form. Typically found in seasonally wet, saturated soils |
| White | Carbonates, silica, volcanic ash - clue to parent material mineralogy |

How to identify soil color:

Soil color is identified by its Hue Value/Chroma. Example: 10YR 5/4.

Each soil color ID corresponds to a specific and unique color name. The color name for 10YR 5/4 is yellowish brown.

Hue is the pigment of color, based on its position on the Universal Color System color wheel. Each page of the Munsell Color Book represents one hue. The number 2.5, 5, 7.5, or 10 says how close the color is to pure color, such as red (R), orange (or yellow-red - YR) or yellow (Y). For example, 10 YR is pure orange, while 7.5 Y is 75% closer to pure yellow with just a smidgen of orange still in it.

Value is amount of light reflected on a scale from 0 (dark black) to 10 (pure white). Each column of tiles on each page of the Munsell Color Book represents the different values of the same Hue and Chroma. The Value of a soil goes down when it gets wet because water absorbs light and makes it darker. Since this is the only color parameter that changes when a soil gets wet, you can check your answer by color coding a soil first when it's dry and then again after it's wet and see if the soil still matches the darker version tile (down the column) of the Hue and Chroma you selected.

Chroma is the intensity of the color pigment on a scale of 0 (neutral diluted color) to 20 (intense pure color). Each row of tiles on each page of the Munsell Color Book represents the different values of the same Hue and Value.

Classroom Activity: Soil Texture

Supplies: Soil sample(s) - have plenty for everyone to make a ball in their hand
Water squirt bottle
Paper towels for cleanup
Soil Texture-by-Feel Flowchart (attached handout)
Soil Texture Triangle (attached handout)

Separate the soil sample in labeled cups, each with a distinct name. The labels could be simple A, B, C; or you could name it by its color (link to other activity), or the region of its origin.

Students follow the handout with decision flowchart to come up with name of soil texture, such as Sandy Clay or Loamy Sand.

Students then use the textual triangle handout to determine what percentage of sand, silt, and clay is in sample. They write down their answers on a form.

Discuss your findings:

Did everyone agree? How do the answers differ?

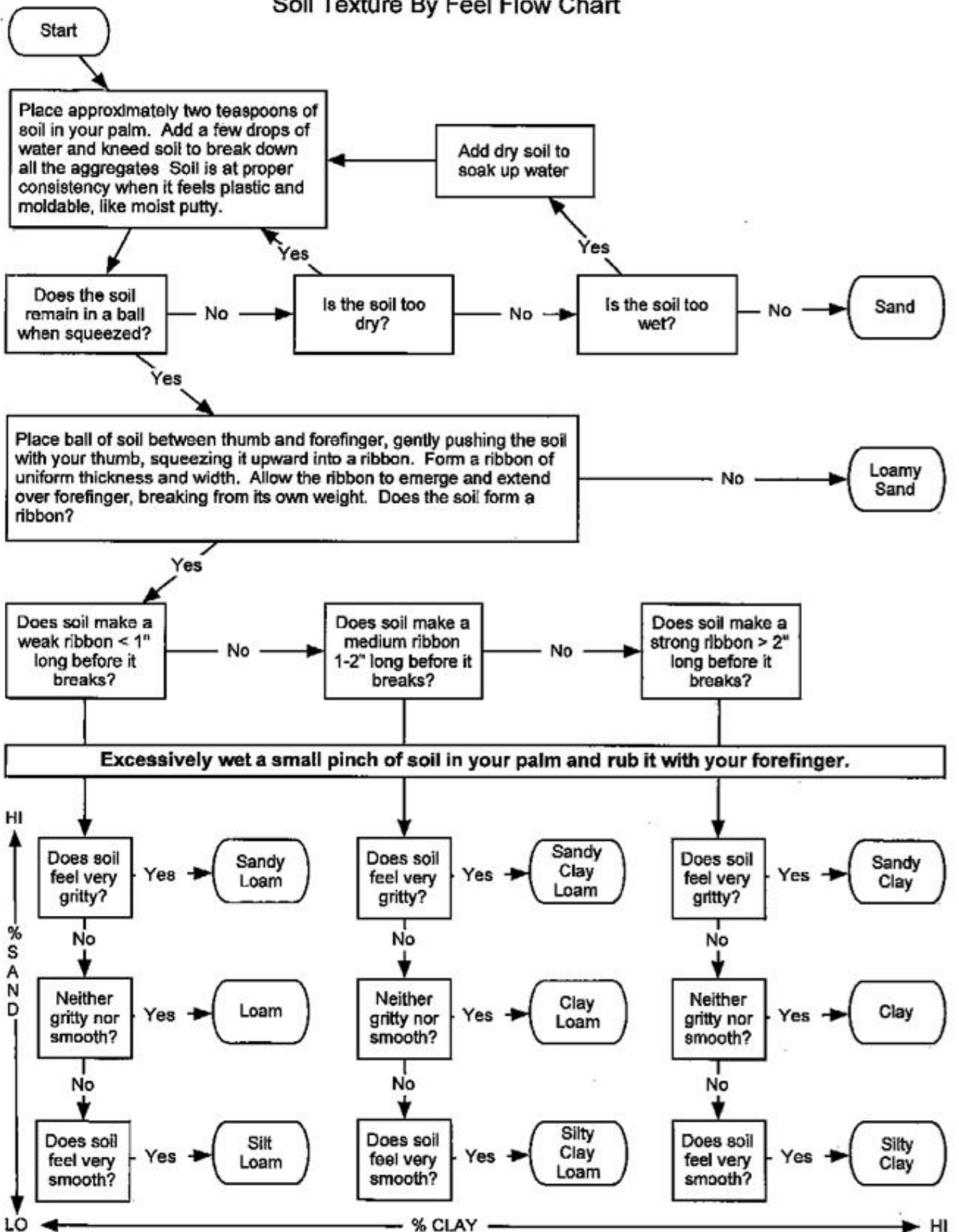
You can't feel silt, so how did you know how much silt was in sample?

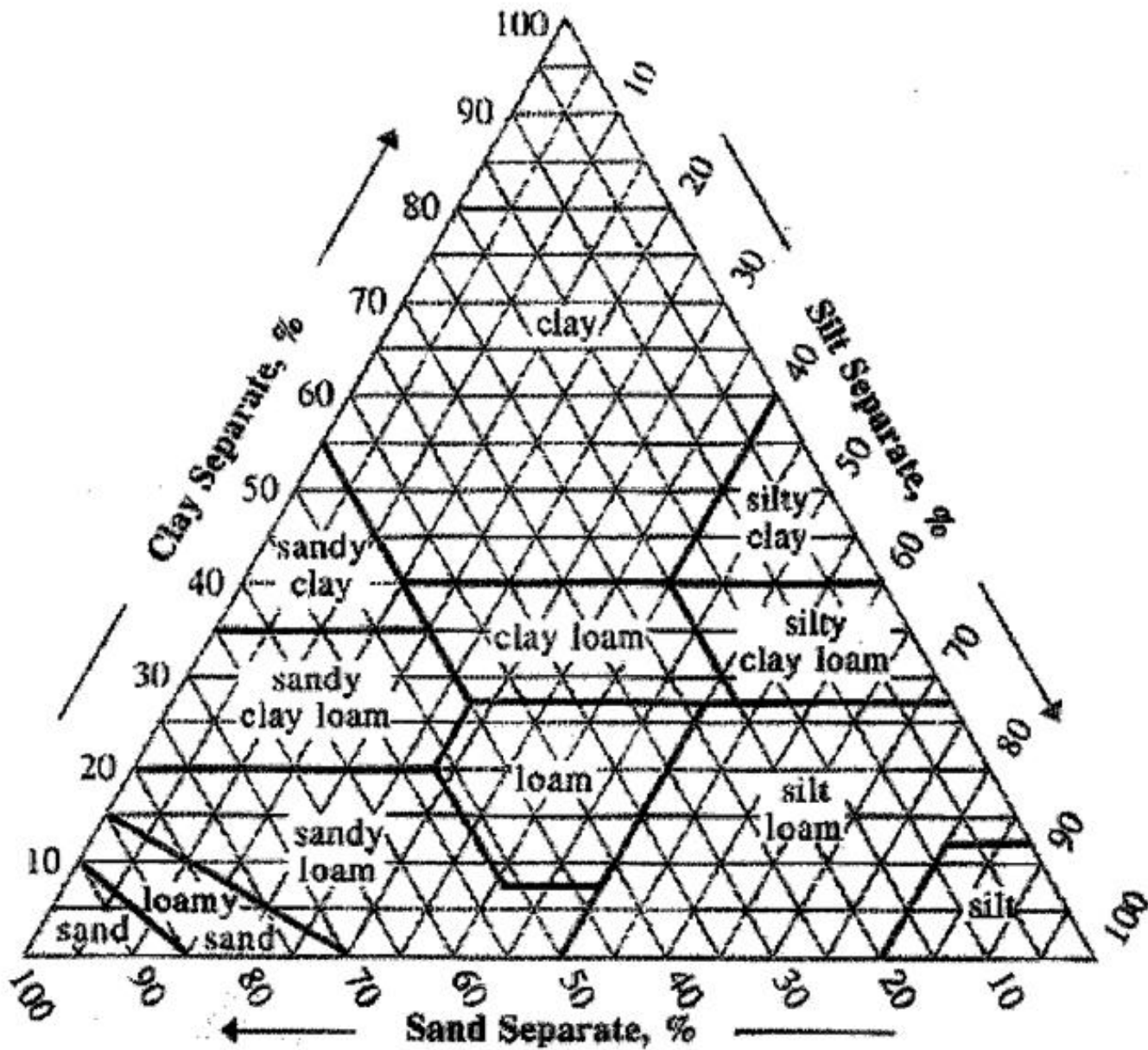
What does the soil texture tell you about the suitability of that soil for what you want to do at that site?

Texture describes the size of particles in soil. This relates to size of the pores in soil, which effects how water moves through the soil.

| Texture | Feeling/Meaning |
|---------|---|
| Sand | Gritty - grains feel like sugar Large particles stack up to make large pores. Drains water fast. Low nutrient and water holding ability is bad for agriculture. Fast drainage is good for landfills, septic tank fields. |
| Silt | Smooth - dry grains feel like ground flour or corn starch Easy to erode - land management issue |
| Clay | Heavy, sticky - grains too small to feel Tiny particles stack up to make tiny pores. Holds onto water. Chemically active with huge surface area - holds nutrients, good for agriculture Poor water drainage is bad for landfills, septic tank fields |

Soil Texture By Feel Flow Chart





COMPARISON OF PARTICLE SIZE SCALES

