Soil Texture and Structure

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Soil Mineral Particles

- Mineral Separates
  - Coarse Fraction (Rock Fragments): >2.0 mm diameter
  - Fine Earth Fraction: <2.0 mm diameter
    - Sand: 2.0 – 0.05 mm diameter
    - Silt: 0.5 – 0.002 mm diameter
    - Clay: <0.002 mm diameter
<table>
<thead>
<tr>
<th>Property</th>
<th>Sand</th>
<th>Silt</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size range (mm)</td>
<td>2.0 – 0.05</td>
<td>0.05 – 0.002</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Means of observation</td>
<td>Naked eye</td>
<td>Light microscope</td>
<td>Electron microscope</td>
</tr>
<tr>
<td>Attraction of particles for each other (cohesion)</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Attraction of particles for water (adhesion)</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Water-holding capacity</td>
<td>Low</td>
<td>Medium-High</td>
<td>High</td>
</tr>
<tr>
<td>Aeration</td>
<td>Good</td>
<td>Medium</td>
<td>Poor</td>
</tr>
<tr>
<td>Resistance to pH change</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Nutrient holding capacity</td>
<td>Very Low</td>
<td>Low</td>
<td>Medium-High</td>
</tr>
<tr>
<td>Potential to be compacted</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Susceptibility to wind erosion</td>
<td>Moderate</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Susceptibility to water erosion</td>
<td>Low</td>
<td>High</td>
<td>Depends on degree of aggregation</td>
</tr>
</tbody>
</table>

Adapted from Brady and Weil, 2007
Soil Texture

- Soil Texture - Describes the relative proportions of sand, silt, and clay
- Soil texture classes group soils with similar distributions of particle sizes
- Sand, silt, and clay are texture classes AND particle sizes
- Loam refers to a soil that has equal influence of sand, silt, and clay
Soil Texture

Example:
Clay = 15%
Sand = 20%
Silt = 65%

Silt Loam
Soil Texture

For hydric soil delineation, soil texture classes are often grouped into two categories

- Sandy (sands and loamy sands)
- Loamy/Clayey (sandy loams and finer textures)
Measuring Soil Texture

• In the lab – based on how quickly particles drop out of suspension
• In the field – Texture by Feel
Measuring Soil Texture

• In the lab – based on how quickly particles drop out of suspension
• In the field – Texture by Feel
START

Place approximately 25 g soil in palm. Add water dropwise and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.

Add dry soil to soak up water

Does soil remain in a ball when squeezed?

Is soil too dry?

Is soil too wet?

SAND

Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.

LOAMY SAND

Does soil form a ribbon?

Does soil make a weak ribbon less than 2.5 cm long before breaking?

Does soil make a medium ribbon 2.5-5 cm long before breaking?

Does soil make a strong ribbon 5 cm or longer before breaking?

Excessively wet a small pinch of soil in palm and rub with forefinger.

SANDY LOAM

Does soil feel very gritty?

SANDY CLAY

Does soil feel very gritty?

SANDY LOAM

Does soil feel very smooth?

Silty LOAM

Does soil feel very smooth?

Silty CLAY

Does soil feel very smooth?

Silty LOAM

Neither grittiness nor smoothness predominates.

CLAY

Neither grittiness nor smoothness predominates.

CLAY

Neither grittiness nor smoothness predominates.
Soil Texture – Coarse Fragment Modifiers

• Coarse fragments are described by size and shape

<table>
<thead>
<tr>
<th>Shape and Size</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spherical or Cube-like</td>
<td></td>
</tr>
<tr>
<td>&gt; 2 – 76 mm diameter</td>
<td>Gravel</td>
</tr>
<tr>
<td>&gt; 76 – 250 mm diameter</td>
<td>Cobbles</td>
</tr>
<tr>
<td>&gt; 250 – 600 mm diameter</td>
<td>Stones</td>
</tr>
<tr>
<td>&gt; 600 mm diameter</td>
<td>Boulders</td>
</tr>
<tr>
<td>Flat</td>
<td></td>
</tr>
<tr>
<td>&gt; 2 – 150 mm long</td>
<td>Channers</td>
</tr>
<tr>
<td>&gt; 150 – 380 mm long</td>
<td>Flagstones</td>
</tr>
<tr>
<td>&gt; 380 – 600 mm long</td>
<td>Stones</td>
</tr>
<tr>
<td>&gt; 600 mm long</td>
<td>Boulders</td>
</tr>
</tbody>
</table>
Soil Texture – Coarse Fragment Modifiers

• Rock Fragment Modifiers are added to the texture class when the volume of rock fragments is greater than 15%

<table>
<thead>
<tr>
<th>Rock Fragments by Volume</th>
<th>Modifier</th>
<th>Example Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15%</td>
<td>No texture class modifier</td>
<td>loam</td>
</tr>
<tr>
<td>15% to &lt; 35%</td>
<td>Use fragment-size adjective</td>
<td>gravelly loam</td>
</tr>
<tr>
<td>35% to &lt; 60%</td>
<td>Use “very” with fragment-size adjective</td>
<td>very gravelly loam</td>
</tr>
<tr>
<td>60% to &lt; 90%</td>
<td>Use “extremely” with fragment-size adjective</td>
<td>extremely gravelly loam</td>
</tr>
<tr>
<td>≥ 90%</td>
<td>No modifier. Use the fragment-size class in lieu of texture</td>
<td>gravel</td>
</tr>
</tbody>
</table>
Mineral vs. Organic Soil Material

- Mineral soils form from rocks or materials transported by wind, water, landslides, or ice
- Organic soils form from plant debris
Distinguishing Organic and Mineral Soil Materials

Organic Soils:
• Feels greasy or slippery when rubbed between fingers
• Often stain fingers when rubbed
• Porous and squishy – can be compressed
• Light in weight (low density)
• Range from pudding-like muck to fibrous peats
• Almost no internal strength

Mineral Soils:
• Feel gritty or sticky, but not greasy
• Resists compression
• Heavier than organic soils when water is removed
• Maintains internal structure (forms distinct peds)
Distinguishing Organic and Mineral Soil Materials

Organic Matter = \frac{\text{Organic Carbon}}{0.58}

Organic

Mucky-Modified

Mineral

Mineral

Clay (%)

Organic Carbon (%)
Organic Soil Material

Distinguished by degree of decomposition

<table>
<thead>
<tr>
<th>Organic Soil</th>
<th>Description</th>
<th>Fiber content after rubbing</th>
<th>Soil Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibric</td>
<td>Slightly decomposed</td>
<td>≥ 40%</td>
<td>Peat</td>
</tr>
<tr>
<td>Hemic</td>
<td>Moderately decomposed</td>
<td>17 to &lt; 40%</td>
<td>Mucky Peat</td>
</tr>
<tr>
<td>Sapric</td>
<td>Highly decomposed</td>
<td>&lt; 17%</td>
<td>Muck</td>
</tr>
</tbody>
</table>

Photo Courtesy John Kelley, NRCS
Soil Structure

• Describes the aggregation and arrangement of primary soil particles (e.g. mineral grains) into secondary units or peds
• Characterized by size, shape, and degree of distinctness (grade)
• Form as a result of pedogenic processes
Granular Soil Structure

- Associated with organic-rich, near-surface mineral horizons
- Roughly spherical, crumb shaped peds, typically 1 – 5 mm in diameter
- High porosity and permeability
Platy Soil Structure

- Thin, plate-like peds, aligned parallel to the soil surface
- If well developed can impede infiltration

http://www.soilsofcanada.ca/
Blocky Soil Structure

- Angular or Sub-Angular
- Common to subsoil horizons
- Held together by coatings of translocation materials, such as clays
- Structure often maintained by root channels between peds
Prismatic Soil Structure

- Vertically oriented, elongated blocks or prisms

Columnar Soil Structure

- Similar to prismatic structure, but prism tops are rounded
- Found in soils with high amounts of exchangeable sodium
Structureless

Massive

Single Grain
Soil Structure and Hydraulic Conductivity

U.S. Department of Agriculture
Soil Texture and Structure

- Used to describe physical characteristics of the soil, in soil profile descriptions and to differentiate horizons
  - Texture - size of primary particles
    - Mineral soil – relative proportion of sand, silt, and clay
    - Organic soil – based on the degree of decomposition
  - Structure – describes the aggregation of mineral grains into secondary units or peds

- May reflect natural pedogenic processes (e.g. weathering, illuviation) or disturbances (e.g. compaction)

- Influence porosity and pore connectivity
  - Aeration
  - Water storage
  - Water movement into and through the soil (infiltration, permeability, and hydraulic conductivity)
  - Root penetration and ability of plants to access water, air, and nutrients
Questions?