Geotechnical Engineering

Origin of Soil and Grain Size

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Learning Objectives

a. Origin of soil and grain size
   - Describe the processes of soil and rock formation and types of soil deposits

Outline

- Rocks and soils
- Rock types
- Soil formation
- Soil types
- Soil and clay mineralogy
- Particle size and shape

Rocks and Soils

Rocks and Soils

Rocks

Soils

Rocks and Soils

- Rocks:
  - Most rocks are cemented
  - Most rocks have low porosity
  - Weathering can greatly alter the rocks properties
  - Depending on scale, rocks are considered a discontinuous material
- Soils:
  - Most soils are not cemented
  - Most soils have large porosity
  - Weathering barely alters the soil properties
  - Depending on scale, soils are considered a continuous material

Rock Types

Rock Types

1. Igneous
   - From cooling of molten magma
2. Sedimentary
   - Cemented by pressure or chemical components
3. Metamorphic
   - Rocks transformed due to heat (without melting) and pressure

Igneous Rocks

- From cooling of molten magma
- Type based on:
  - Rate of cooling
    - Rapid cooling → small crystals
  - Location formed
    - Intrusive – cools underground (e.g., Granite)
    - Extrusive – cools on surface (e.g., Rhyolite)
  - Chemical and mineral composition
    - Quartz → Sand, Silts
    - Aluminum, Iron, Magnesium → Clays

Igneous Rocks Classification

Granite

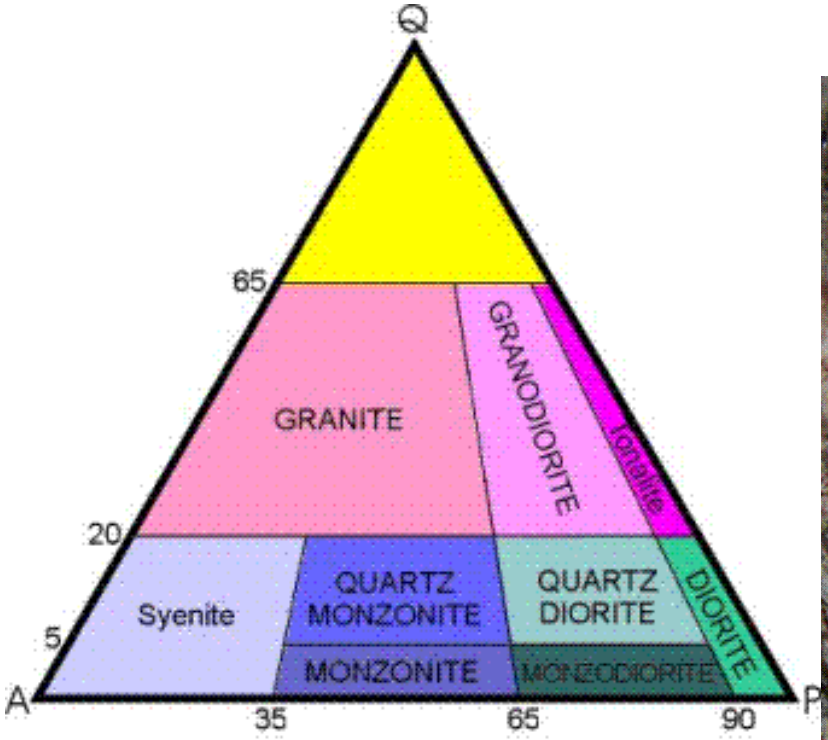
	Felsic (light color)	Intermediate	Mafic (dark color)	Ultramafic
Coarse	Granite	Diorite	Gabbro	Peridotite
Fine	Rhyolite	Andesite	Basalt	
Vesi-cular	Pumice		Scoria	
Glassy	Obsidian			
Minerals Present				
	QUARTZ K-FELDSPAR NA-PLAG	NA-CA PLAG AMPHIBOLE	CA PLAG PYROXENE	PYROXENE OLIVINE

Rhyolite,

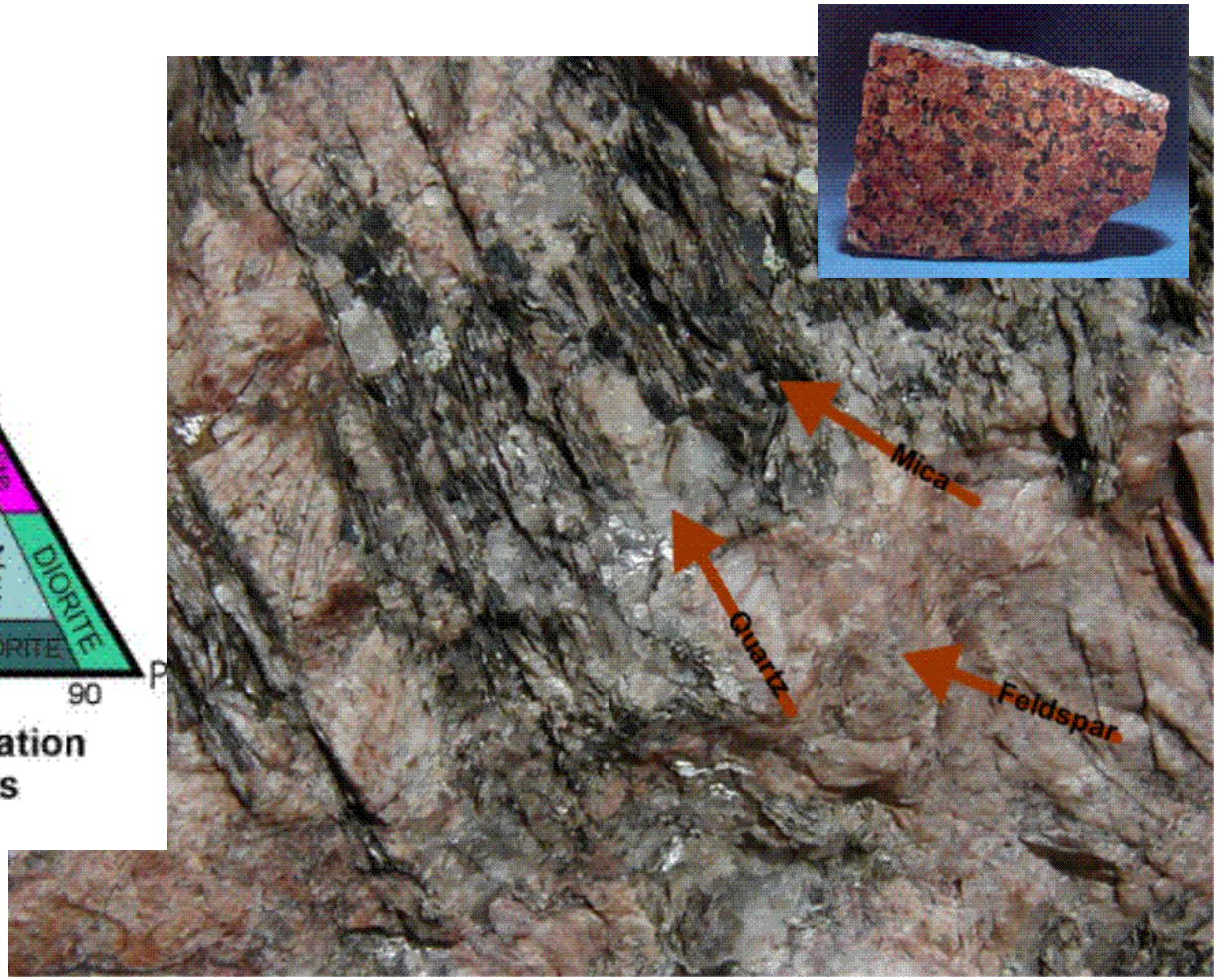
Andesite

Basalt

Intrusive Igneous Rocks Classification



Highly Modified IUGS Classification of Phaneritic Igneous Rocks



A: Alkalai feldspar

P: Plagioclase feldspar

Q: Quartz

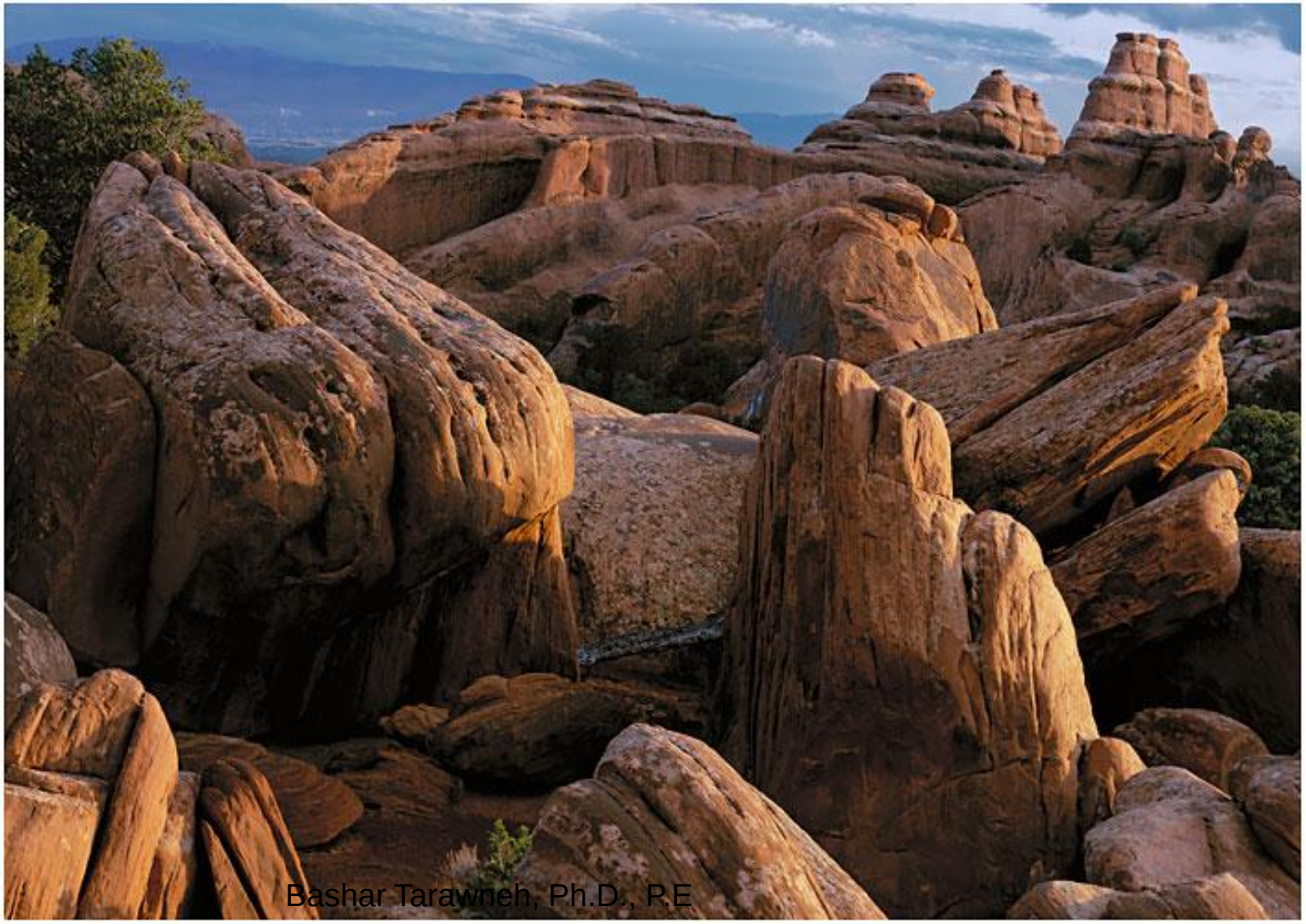
Granite: contains many minerals

Sedimentary Rocks

- Cemented by pressure or chemical component
- Common types:
  - Detrital sedimentary rocks
    - Cementation agents carried in ground water
      - Shale → formed from clays
      - Sandstone → formed from sand
  - Chemical sedimentary rocks
    - Formed by chemical processes
      - Carbonates: Limestone → calcium carbonate
      - Evaporites: Gysum → $CaSO_4$
      - Chert: Chert → fine-grained silica

Detrital Sedimentary Rocks; Shale

Detrital Sedimentary Rocks; Sandstone



Chemical Sedimentary Rocks

Calcium Carbonate

(a) Limestone

(b) Gypsum

Precipitation of $CaSO_4$ due to evaporation of ocean water

Rock Salt

(c) Halite

(d) Chert

Fine-grained Silica

Biochemical Sedimentary Rocks

Reefal Limestone

Metamorphic Rocks

- Rocks transformed due to heat (without melting) and pressure
- Tend to have foliated-texture (very thin layers):
  - Preferred shear planes
    - Granite (igneous) → metamorphs to Gneiss
    - Shale (sedimentary) → Slate

Metamorphic Rocks

Gneiss

Slate

Rocks Cycle

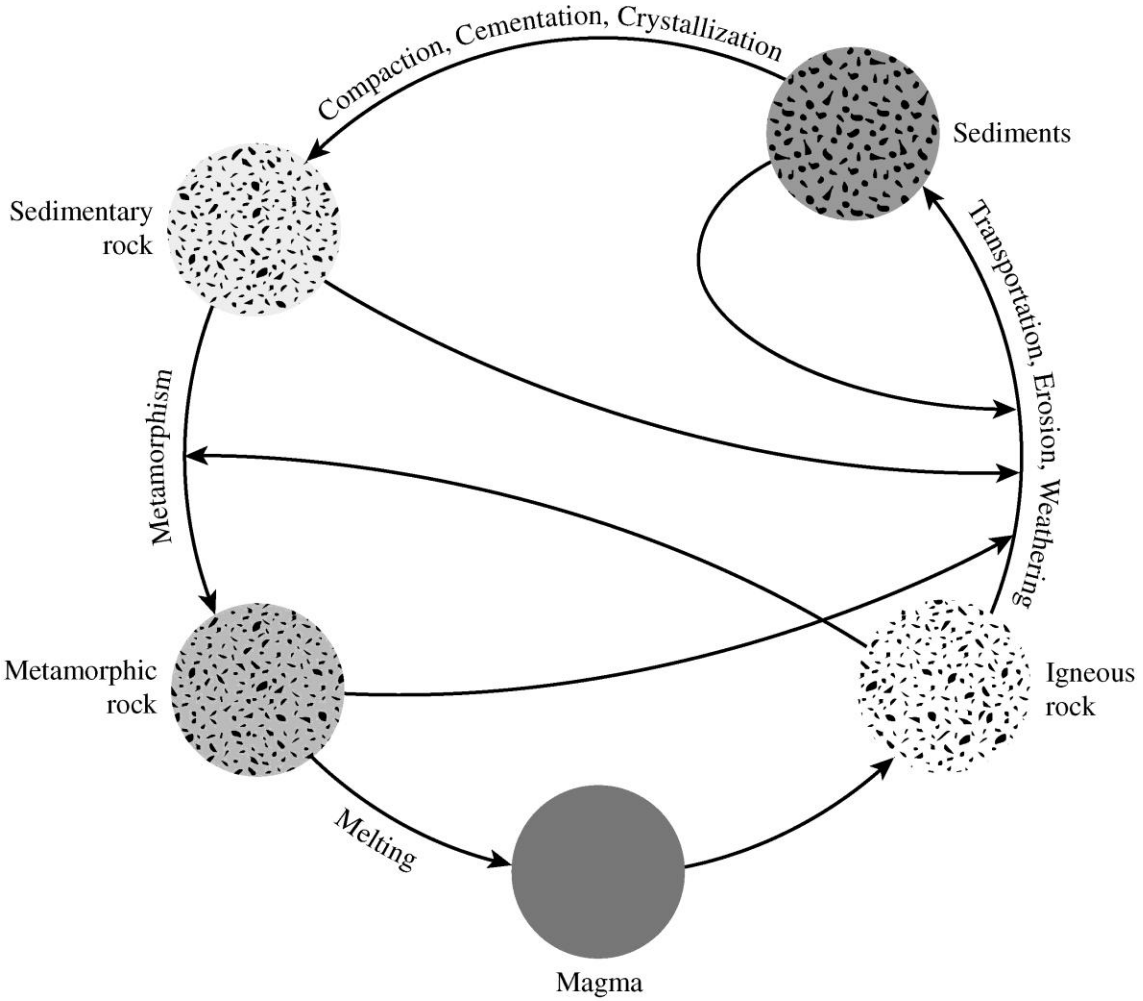


Figure 2.1 Rock cycle

Soil Formation

Soil Formation

- Soils are formed by:
  - Weathering of rocks
    - Mechanical weathering
      (e.g., contraction-expansion,
      impact, erosion, ice formation, etc.)
    - Chemical weathering
      (e.g. carbonation, oxidation, etc.)
    - Both mechanical and chemical weathering
  - Decomposition of organic materials

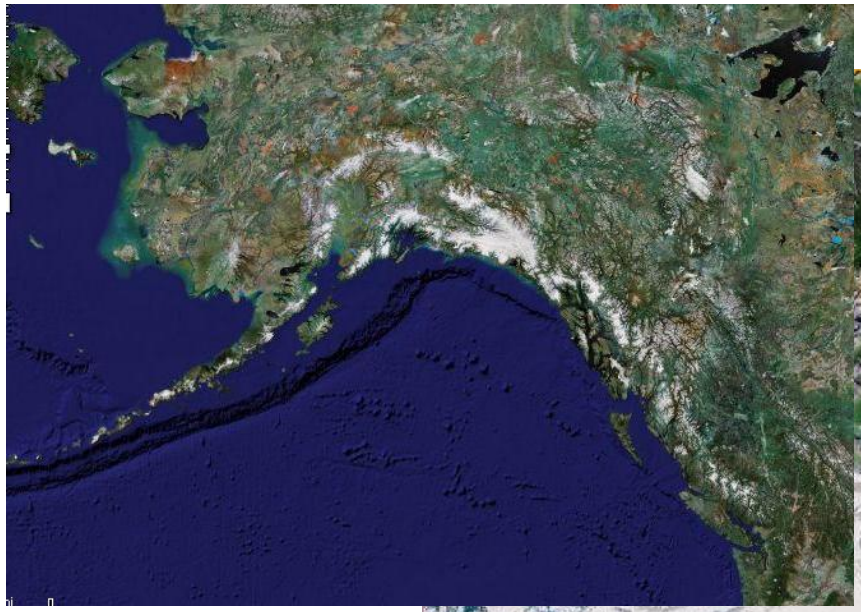
Natural Soils

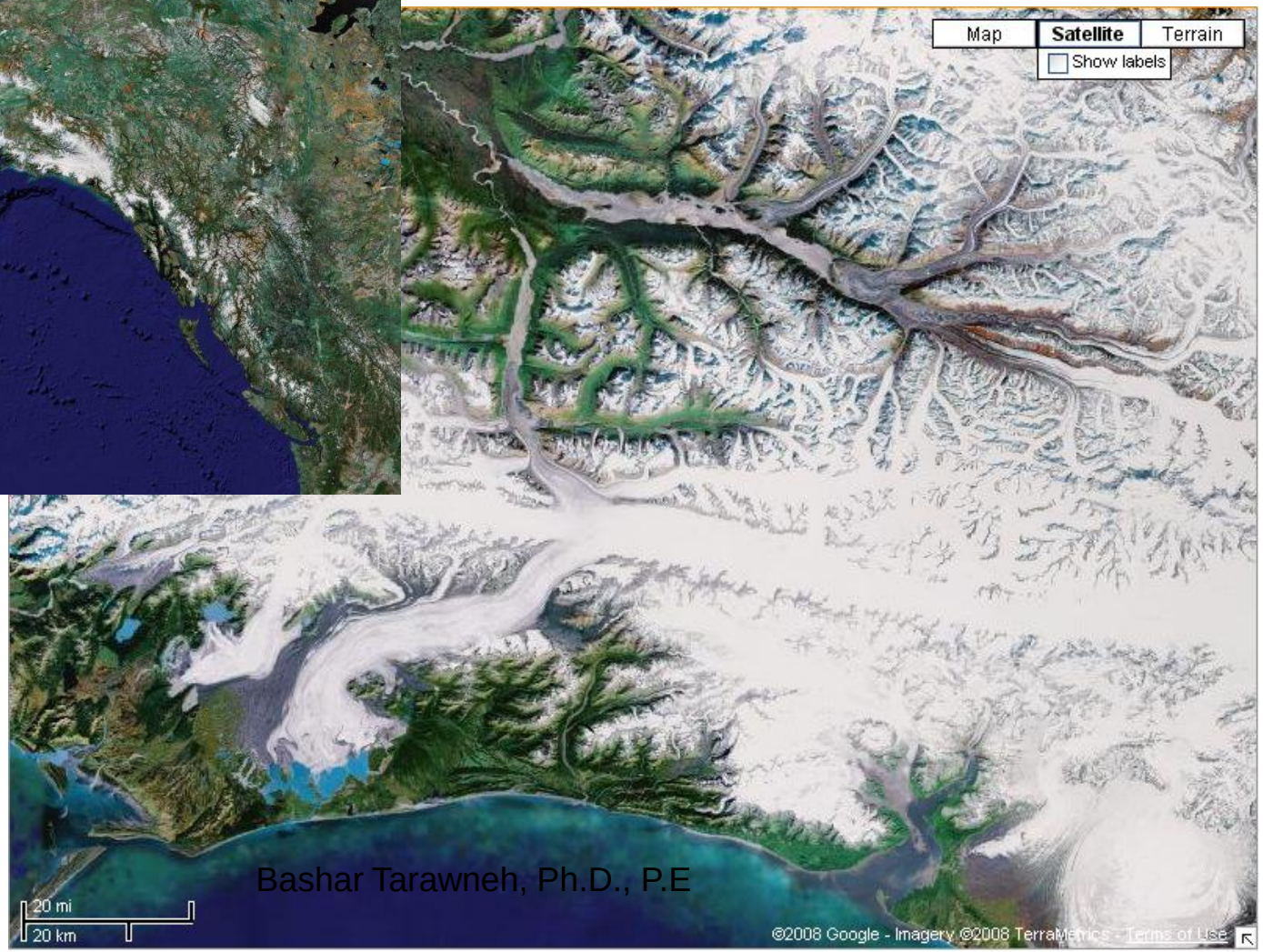
Organic Soils

Soil Formation

- Weathered soils are classified into:
  - Transported soils:
    - Glacial (glaciers)
    - Alluvial (running water)
    - Fluvial (river deposits)
    - Lacustrine (lake deposits)
    - Marine (sea and ocean deposits)
    - Aeolian (wind)
    - Gravity or colluvial (gravity; steep slopes)
  - Residual (not transported) soils:
    - From hard rocks such as granite
    - From chemical rocks such as limestone

Alaskan Glaciers





Glacial Erratics

Glacial Till

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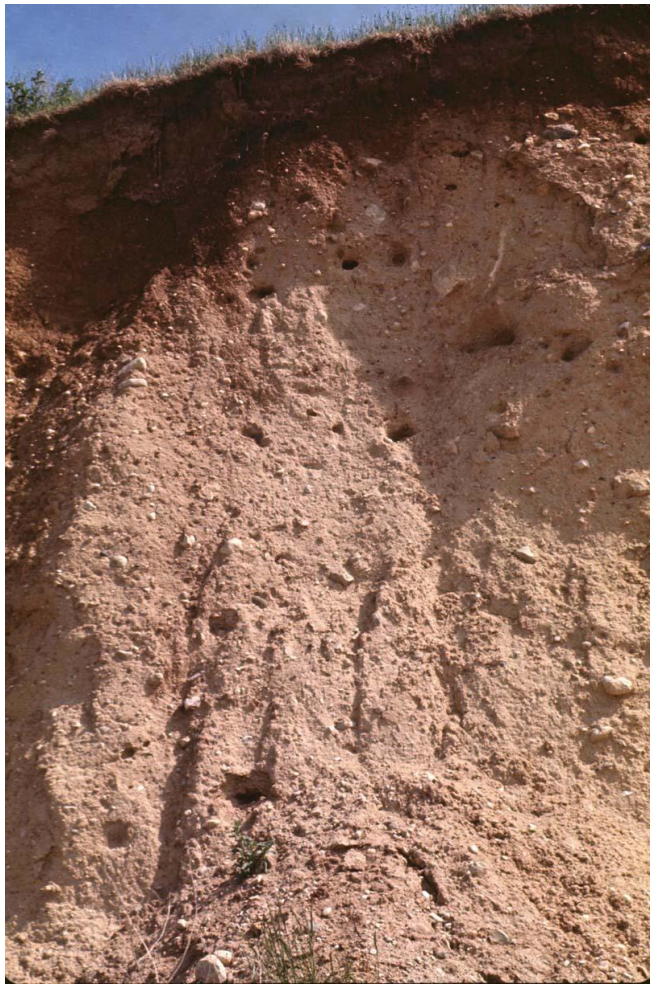
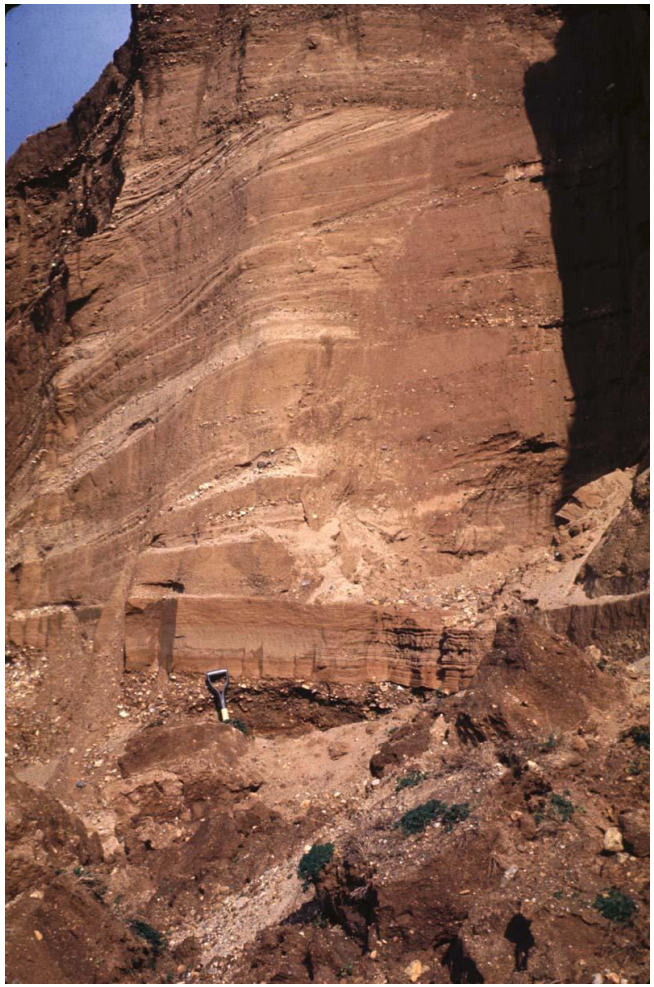


Moderately Fine-Grained Glacial Till



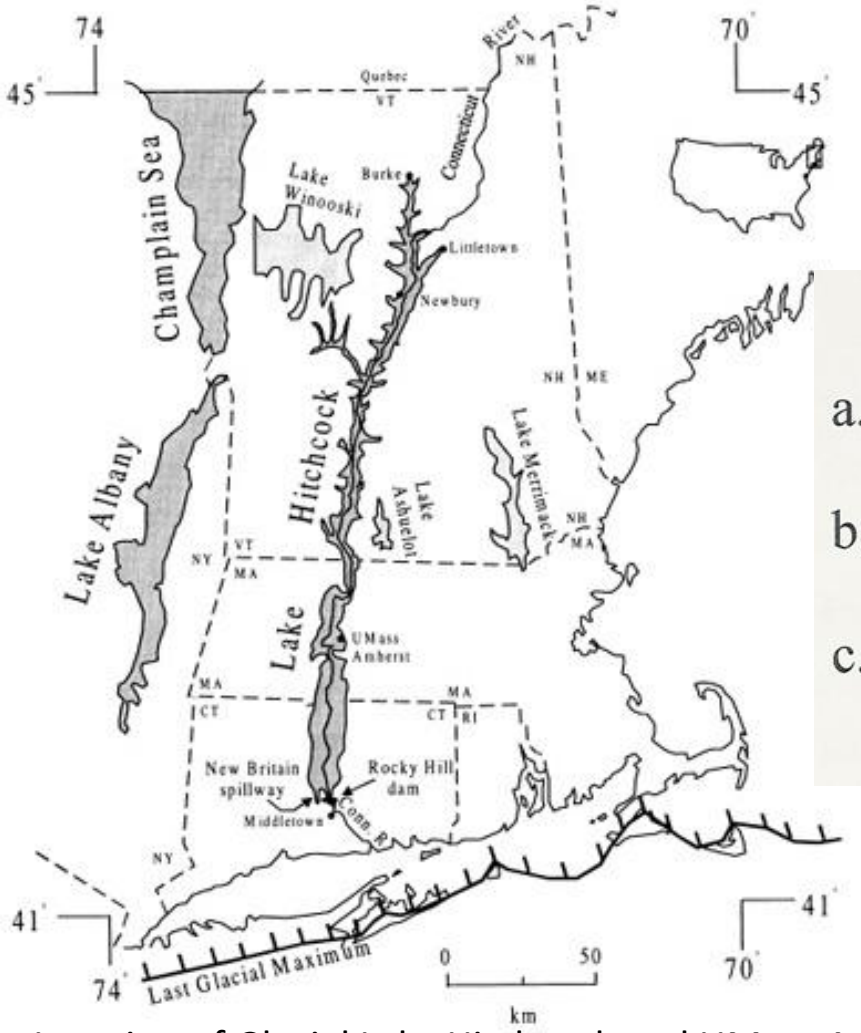
Finer-grained Glacio-fluvial Outwash

Alluvial (Running Water) Fan

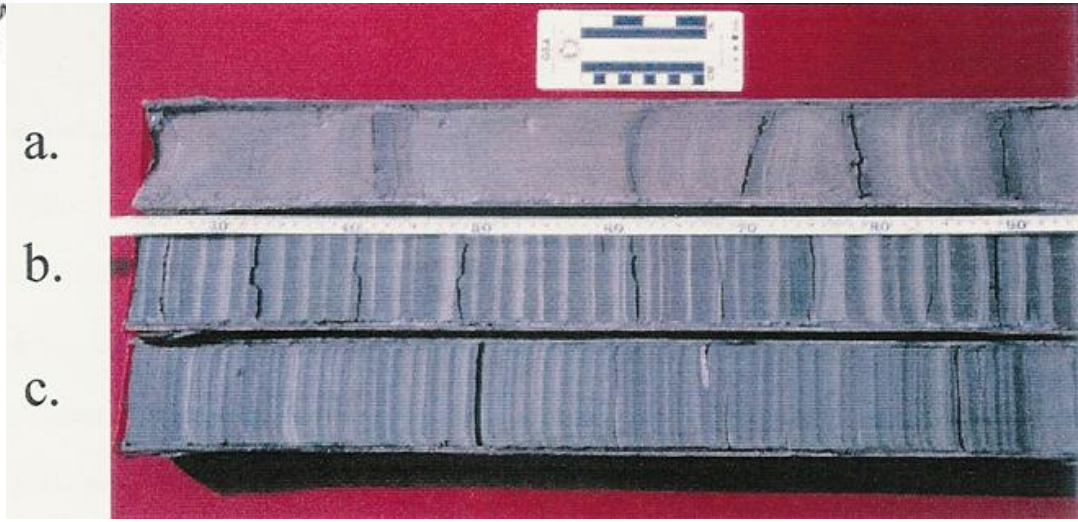
Fluvial (River) Deposit

Glacio-Lacustrine Deposit

Glacio-Lacustrine Deposit

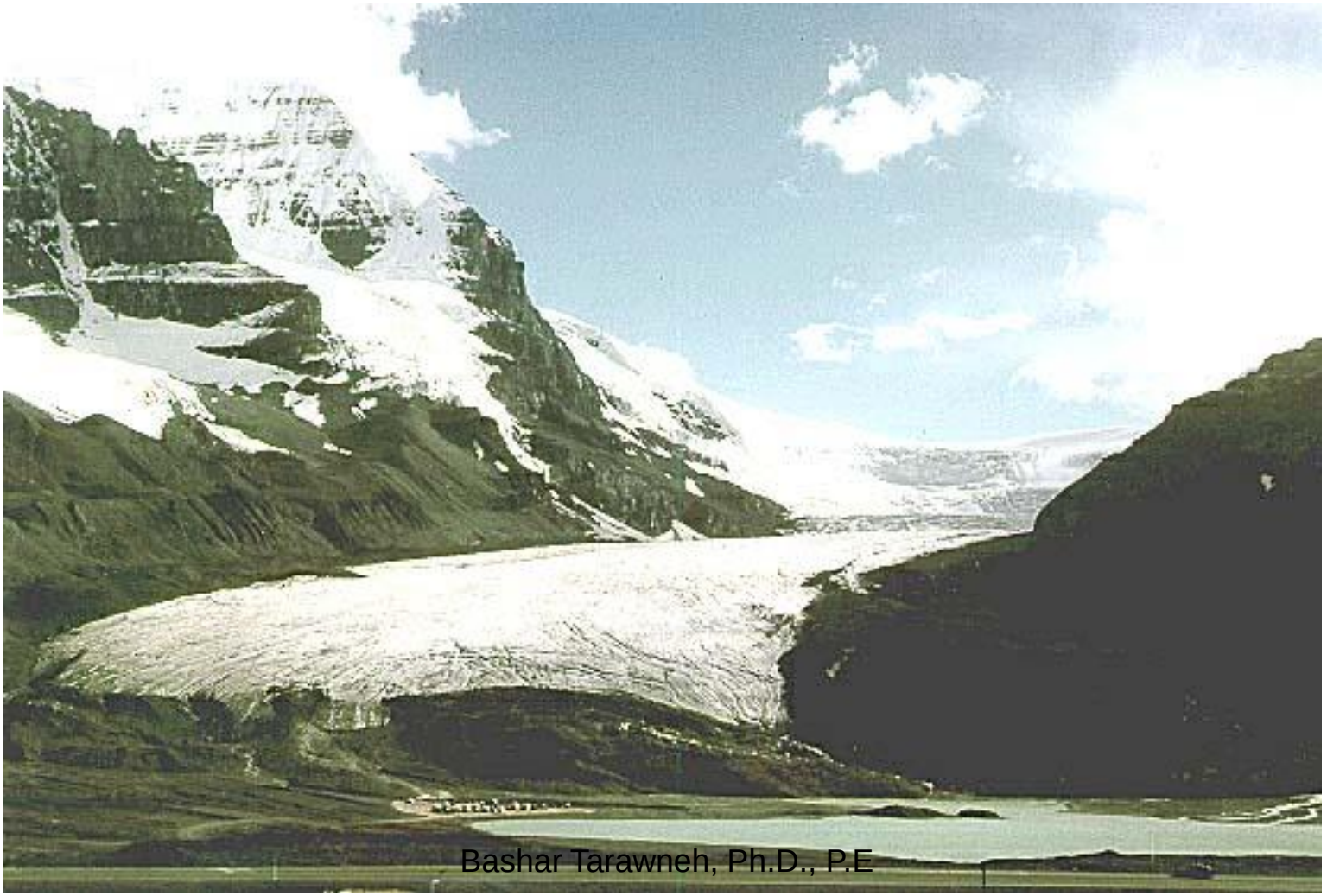


Location of Glacial Lake Hitchcock and UMass Amherst NGES Site (from Rittenour 1999).



Photograph of cross-section cores from UMass Amherst NGES at (a) 32 m, (b) 7.6 m, and (c) 3 m depth.

Moraine (Sea) Deposit – Long Island



Colluvial Deposits – Grand Canyon

Residual Soils

Soil Formation

- Formation process impacts:
  - Shape
  - Size and gradation
  - Chemical composition
- The previous strongly influence engineering behavior

Soil Types

Soil Types

- Soils are categorized based on particle size and electrical activity.

Table 1. Soil Types – Particle Size and Activity

Type	Particle Size (mm)	Electrically Active?
Coarse-Grained		
Gravel	4.75 – 76.2	No
Sand	0.075 – 4.75	No
Fine-Grained		
Silt	< 0.075	No
Clay	< 0.075	Yes

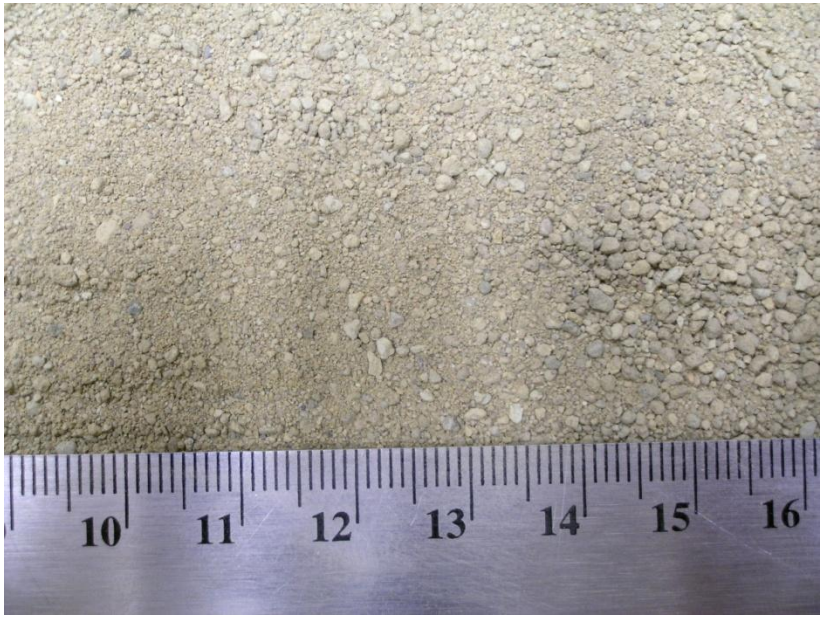
- Use plasticity to differentiate between silt and clay.

Examples

Example 1

What type of soils are the following?

(a)



(b)

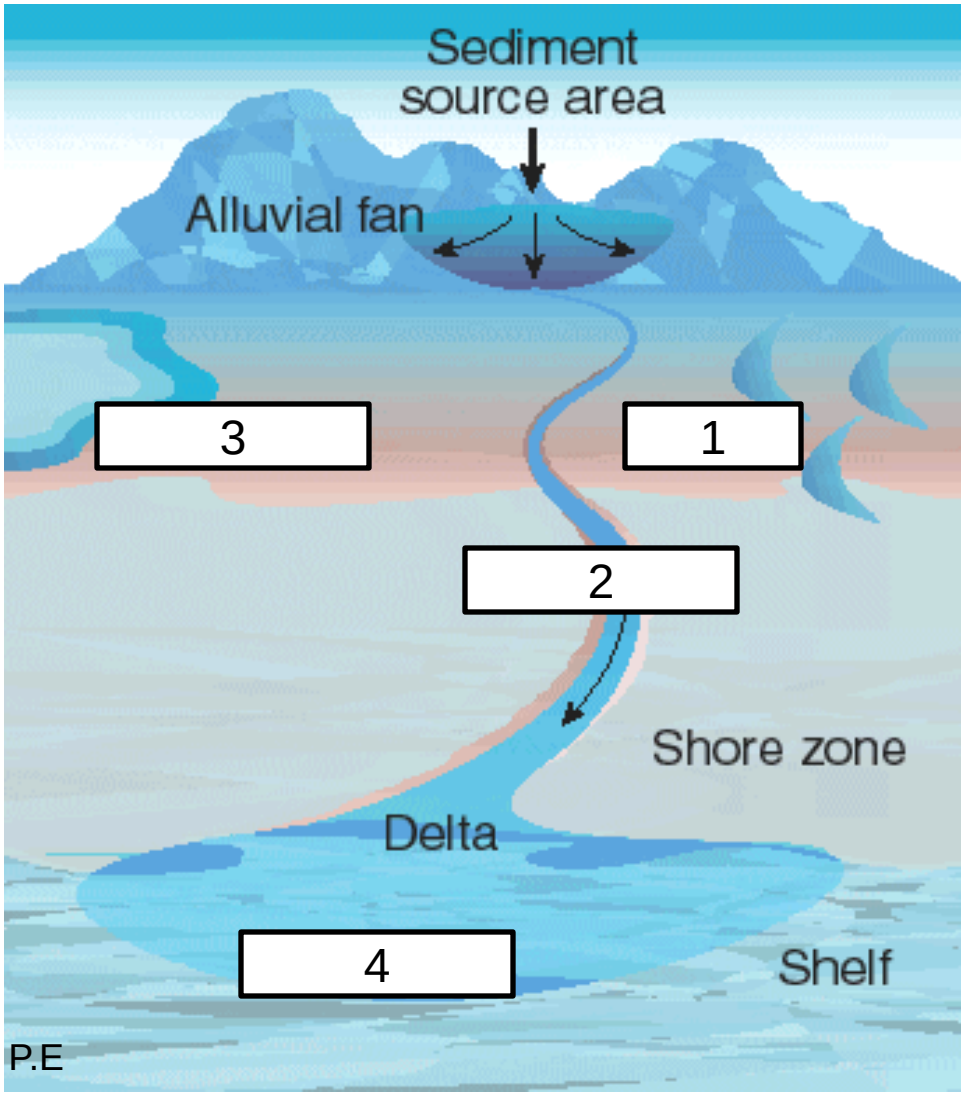
Example 2

The river shown in the following slide is resulted from heavy rainfall in the mountains. Given that:

- Soil 1 is weathered soil carried by the wind and deposited in the location indicated in the schematic;
- Soil 2 consists of river deposits;
- Soil 3 consists of lake deposits; and
- Soil 4 consists of sea deposits.

Identify the type of each of the previous soils by geological formation. Describe briefly the shape and packing of the particles in Soils 2 and 3.

Example 2 (Cont.)

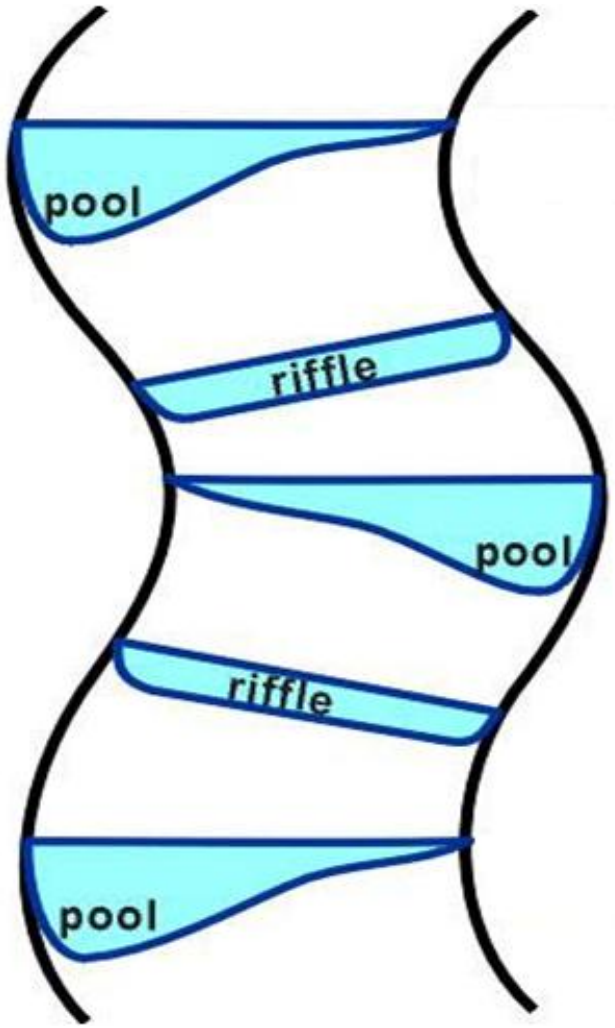


Solution to Example 2

Example 3

The following schematic depicts a non-straight river.

- Identify the locations where (a) erosion and (b) deposition will be evident.
- Given that riffles have high flow rates, what type of soil do you expect to see at these riffles.



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