Soil and Weathering – Laboratory 4

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(name)

Background

Soils are ubiquitous features of the Earth's surface. You run into them daily, but probably give them little notice or think of them as the "stuff" that your mother or grandmother plant their vegetables or flowers in. However, with a little thought you might reach the conclusion that without soils much if not all of the terrestrial animal life of our planet would not be able to survive! With that draconian thought behind us let's begin our study of soils.

The United States Department of Agriculture National Resources Conservation Service (NRCS) defines a soil as follows.

> Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment
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> The upper limit of soil is the boundary between soil and air, shallow water, live plants, or plant materials that have not begun to decompose. Areas are not considered to have soil if the surface is permanently covered by water too deep (typically more than 2.5 meters) for the growth of rooted plants.
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> The lower boundary that separates soil from the nonsoil underneath is most difficult to define. Soil consists of horizons near the earth's surface that, in contrast to the underlying parent material, have been altered by the interactions of climate, relief, and living organisms over time. Commonly, soil grades at its lower boundary to hard rock or to earthy materials virtually devoid of animals, roots, or other marks of biological activity. For purposes of classification, the lower boundary of soil is arbitrarily set at 200 cm.

The Master Horizons

The factors that lead to the formation of a soil are discussed in Chapter 5 of Notes on Planet Earth which can be accessed at the following link: http://www.geology.sdsu.edu/visualgeology/geology101/. These factors act in various combinations to produce a soil that is commonly layered in appearance. Each layer is designated a **master horizon**, and a vertical section cut through a soil reveals its **profile**. The various layers visible in a soil profile are in part due to eluviation and illuviation. **Eluviation** refers to the removal of soil material in suspension or in solution. In contrast, **illuviation** refers to the deposition or precipitation of soil material from suspension or from solution respectively.

The uppermost layer, designated the **O horizon,** commonly is represented by a layer of organic litter including variably decomposed dead plant and animal matter (Figure 1). Generally, the O horizon is present in forested areas, but is absent in grassland and desert regions.

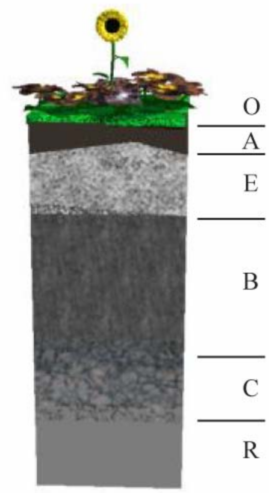

Figure 1. The master horizons of soil taxonomy.

Below the O horizon is a mixed mineral and organic layer termed the **A horizon** (Figure 1). Due to contained organic matter it is typically darker in color than horizons lying beneath it. In addition, the A horizon is generally coarser grained than underlying horizons as fine grained components have been removed from it through leaching and translocation to lower horizons. The A horizon is often referred to as the zone of leaching.

Sometime lying beneath the A horizon is a lighter colored layer characterized by abundant quartz and sand and silt-sized particles. This layer is referred to as the **E horizon** (Figure 1). It's relatively uniform grain size, abundance of quartz, and light color is attributed to the removal of clays and iron and aluminum oxides through eluviation. E horizons are common in forested regions but not in grassland or desert regions.

Lying below the E and A horizons is a layer where translocated ions and clays accumulate through the process of illuviation. This layer is designated the **B horizon**, and is sometimes referred to as the zone of accumulation (Figure 1). Often in humid climates iron and aluminum oxides accumulate in the B horizon. In contrast, in arid and semiarid regions calcium carbonate or calcium sulfate deposits accumulate in the B.

The **C horizon** is unconsolidated material underlying the A and B horizons (Figure 1). Material in the C horizon is loose enough to be dug with a shovel, but often retains some of the attributes of the parent material.

Unweathered parental material lying below the C horizon makes up the R horizon (Figure 1).

There are 12 major orders of soil defined in Soil Taxonomy. The orders are

(1) Alfisols
(2) Andisols
(3) Aridsols
(4) Entisols
(5) Gelisols
(6) Histosols
(7) Inceptisols
(8) Mollisols
(9) Oxisols
(10) Spodosols
(11) Ultisols
(12) Vertisols

Mollisols are soils that represent the foundation of the agricultural mid-continental part of the United States. They are a soil that is also relatively common in the Peninsular Ranges, southern California, and are characterized by a thick, dark surface horizon that represents the long-term addition of organic materials. They are the most extensive of the soil orders in the United States (Gardiner and Miller, 2004), and are the state soils for Illinois, Iowa, Kansas, Montana, Nebraska, North Dakota, Oklahoma, and South Dakota. Below we will study samples collected from a profile of a Mollisol in the Peninsular Ranges.

The Lab

The soil profile that we will study is located off old Highway 8 (Figure 2).

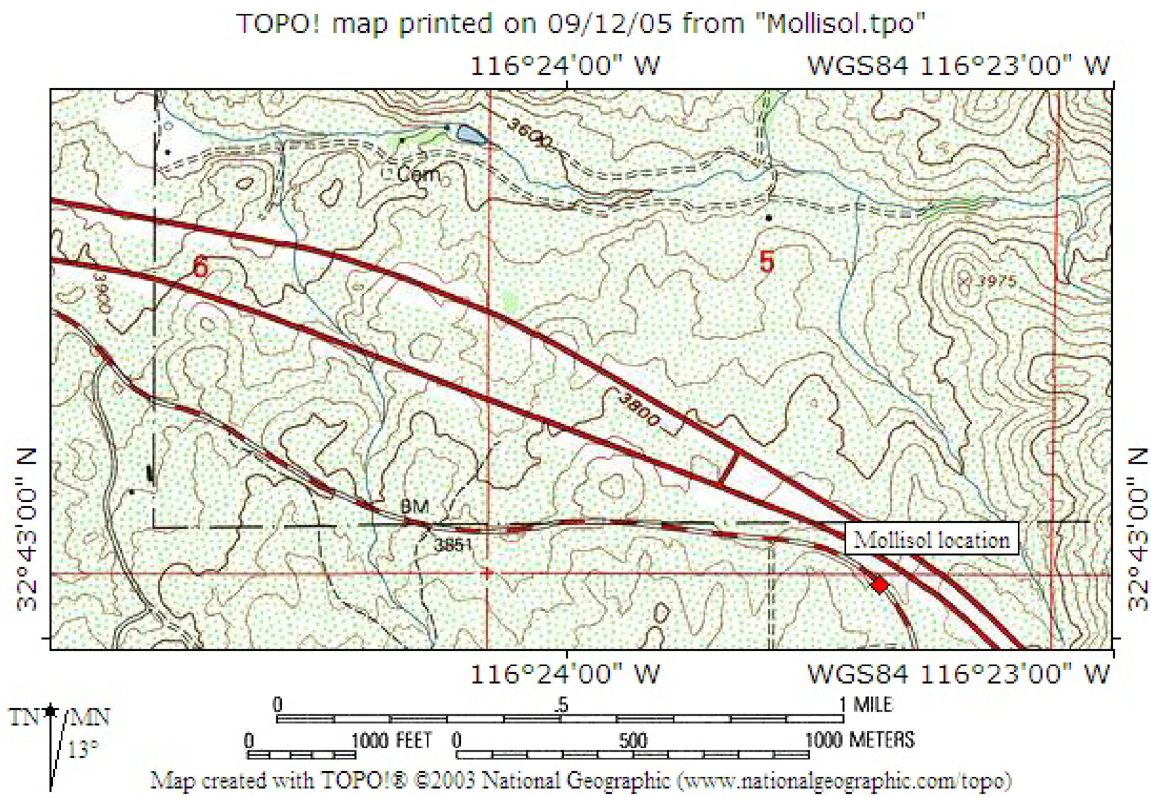

Figure 2. Location of sampled soil profile. Photographs of profile are included as Figures 3 – 7.

The sampled profile consists of 4 prominent layers that are labeled (1), (2), (3), and (4) in Figure 3. Samples of each layer will be provided by your lab instructor for your study. Figures 4 through 8 are close up views of each layer as they appear in the field.

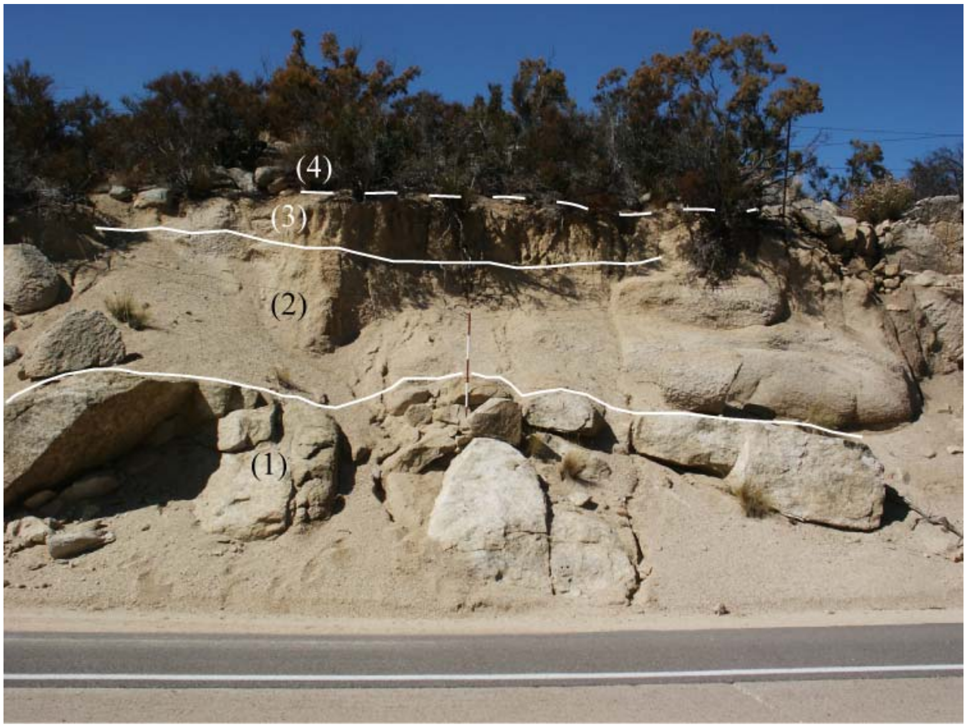

Figure 3. Mollisol profile, Peninsular Ranges, southern California. Note the layers designated (1), (2), (3), and (4). The staff is 5 feet in length.

Figure 4. Close up view of layer (1) and contact with layer (2). Note staff for reference. The red and white strips are each 1 foot in length.

Figure 5. Close up view of layer (2) and contact with layer (3).

Figure 6. Close up of layer (3). Root structure on left is also visible in Figure 5.

Figure 7. Close up of layer (4). In the photograph layer (4) is the dark gray layer appearing near the top of the staff. The above photograph was taken to the right of the images shown in Figures 3 – 6.

Look closely at the example of layer (1) and describe its general characteristics below, and indicate what master horizon you would assign it to.

Description for layer (1) goes here

Below provide a description of the sample of layer (2). In your description please include answers to the following: How do biotite and/or hornblende appear in this layer? Is layer (2) harder or softer than layer (3)? What master horizon would you assign it to?

Description for layer (2) goes here

When biotite and hornblende are observed in exposures of weathered plutonic, rocks they commonly appear to be stained a brick-red color. Why is this so?

Both biotite and hornblende contain iron (Fe). During weathering Fe is freed from the silicate structures of biotite and hornblende, reacting with oxygen in the atmosphere according to the following equation.

4Fe (released from biotite or hornblende) $+ 3O_2$ *(gas)* $= 2Fe_2O_3$ *(hematite)*

In the above equation, Fe_2O_3 is representative of the mineral hematite. Is there any evidence in the sample from layers (1) and (2) for the formation of hematite and the above reaction having occurred?

Below provide a description of the sample of layer (3). In your description please provide the answers to the following questions: How does layer 3 differ from layer (2)? What master horizon would you assign it to?

Description for layer (3) goes here

Please briefly describe below the characteristics of layer (4), and make sure that your description includes answers to the following questions. How does layer (4) differ from layer (3)? Compare the density of roots in Figures 6 and 7 in layer (3) to the density of fine root structures that are visible in your sample of layer (4). Is there a difference in color between layers (3) and (4)? What master horizon would you assign it to?

Description for layer (4) goes here

Briefly explain below how you think that the soil profile that you studied today developed?