Geomorphology Lab: Soil Maps as a Tool for Preliminary Geomorphic Analysis

INTRODUCTION

Soils represent the weathered mantle of unconsolidated surficial material that covers land surfaces. They are comprised of a mixture of mineral and organic matter derived from the physical, chemical, and biologic weathering of bedrock. Soil composition and distribution are important with respect to agricultural practices and land development. The U.S. Soil Conservation Service (now part of the "Natural Resource Conservation Service") is the federal agency that is primarily responsible for the analysis and preservation of this valuable resource. As a result, county soil surveys and soil maps have been prepared for most regions of the U.S. These surveys provide an important data set for geomorphic analysis of landforms and surficial materials.

The main controlling factors that contribute to soil formation are: 1) climate, 2) organic activity (animals / plants), 3) relief / topography, 4) parent material, and 5) time (to remember these think of "**C**limb **O**n **R**ed-**P**urple **T**igers"). Climate refers to amount of rainfall and temperature. Organic activity refers to style of plant growth, microbial activity, and burrowing organisms. Relief / topography refers to the steepness of slope. Parent material refers to the source of weathered material upon which the soils are formed (e.g. bedrock = igneous, sedimentary, metamorphic; surficial regolith = colluvium). Time refers to the residence time of the soil material, essentially the length of time that the soil has been forming without physical interruption. All of these factors contribute to soil characteristics. These are so inter-related that it is difficult to separate out the influences of any one of them. For example, the topography of an area influences the rainfall, the insolation, the drainage, and runoff. All of these factors interact to determine the vegetation and, in turn, all will affect weathering and soil formation (from Morisawa, 1989). Since the five soil-forming factors are of interest to geomorphologists, the work of the soil scientist and geologist is mutually beneficial. The soil scientist must understand the surface geology to interpret the soils, and the geomorphologist must understand the soils to interpret the surficial geology.

SOIL MAPS

Soil surveys are conducted by using topographic maps, air photos, ground surveys, soils excavations, and geologic maps. Soil map units are delineated primarily on the basis of material composition (i.e. texture of the soil) and topographic configuration (steepness of slope, flood-prone areas, etc.). Other parameters include color and soil chemistry. Soil maps are typically published on air photos and created for individual counties and conservation districts. See the attached example of a soil survey map for Polk County, OR. A brief comparison of soils and topographic maps suggests that soils are not randomly distributed, but are intimately related to topography and geomorphic setting. Landforms and geomorphic processes often influence the physical and chemical properties of soils. Hence, if we know the soil and its characteristics we may be able to begin to understand the geomorphic system.

R. 5 W.
R. 4 W.
(Joins sheet 29)
North
Middle
Fork
Ash
Creek
South
MONMOUTH
INDEPENDENCE
water
SILETZ
AND
13
17
18
19
20
24
25
28
29
30

A3—11 to 16 inches; very dark grayish brown (10YR 3/2) heavy silty clay loam, grayish brown (10YR 5/2) dry; common fine distinct yellowish brown (10YR 5/8) mottles; moderate fine and medium subangular blocky structure; hard, firm, sticky and plastic; many very fine roots; many fine and very fine pores; few fine black stains; strongly acid (pH 5.5); clear wavy boundary.

B21g—16 to 25 inches; grayish brown (10YR 5/2) silty clay, light gray (10YR 7/2) dry; many medium prominent strong brown (7.5YR 5/8) mottles; weak coarse prismatic and weak medium and coarse subangular blocky structure; hard, firm, very sticky and very plastic; common fine roots; common fine pores; strongly acid (pH 5.5); clear wavy boundary.

B22g—25 to 36 inches; light gray (10YR 7/1) silty clay, white (10YR 8/1) dry; many medium prominent strong brown (7.5YR 5/8) mottles; weak coarse prismatic structure parting to coarse subangular blocky; hard, firm, very sticky and very plastic; few fine roots; common fine pores; strongly acid (pH 5.5); clear wavy boundary.

B3g—36 to 60 inches; light gray (10YR 7/1) silty clay, white (10YR 8/1) dry; many coarse prominent strong brown (7.5YR 5/8) mottles; weak coarse prismatic structure parting to coarse subangular blocky; hard, firm, very sticky and very plastic; few fine roots; few fine pores; strongly acid (pH 5.5).

These soils are saturated in winter and, unless drained, have a water table within 12 inches of the surface early in spring. The umbric epipedon ranges from 10 inches to 20 inches in thickness.

The A horizon has value of 2 or 3 moist and 4 or 5 dry and faint to prominent mottles. The B horizon has hue of 10YR or 2.5Y, value of 4 or 5 moist and 5 or 6 dry, chroma of 1 or 2 moist and dry and distinct to prominent mottles. It is silty clay or silty clay loam and is more than 35 percent clay.

Briedwell series

The Briedwell series consists of deep, well drained soils on terraces. These soils formed in mixed gravelly alluvium. Slopes are 0 to 20 percent. The mean annual precipitation is about 50 inches, and the mean annual air temperature is about 51 degrees F.

Typical pedon of Briedwell silt loam, 0 to 3 percent slopes, about 1/2 mile west of the Buell Community, NW1/4SW1/4 sec. 28, T. 6 S., R. 6 W.:

A11—0 to 5 inches; dark brown (7.5YR 3/2) silt loam, dark brown (7.5YR 4/3) dry; moderate very fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine interstitial pores; 5 percent pebbles; medium acid (pH 6.0); clear smooth boundary.

A12—5 to 10 inches; dark brown (7.5YR 3/2) silty clay loam, dark brown (7.5YR 4/3) dry; moderate very fine and fine subangular blocky structure; hard, firm, sticky and plastic; many very fine roots; many very fine tubular pores; 5 percent pebbles; medium acid (pH 6.0); clear wavy boundary.

B1—10 to 17 inches; dark brown (7.5YR 3/2) gravelly clay loam, brown (7.5YR 3/2) dry; moderate fine subangular blocky structure; firm, sticky and plastic; common fine roots; common very fine tubular pores; 30 percent pebbles and 10 percent cobbles; medium acid (pH 5.8); clear wavy boundary.

IIB2—17 to 31 inches; dark brown (7.5YR 3/4) very gravelly clay loam, brown (7.5YR 5/4) dry; moderate fine subangular blocky structure; hard, firm, sticky and plastic; common fine roots; moderate fine tubular pores; 35 percent pebbles and 25 percent cobbles; medium acid (pH 5.8); clear wavy boundary.

IIB3—31 to 45 inches; brown (7.5YR 4/4) very gravelly clay loam; reddish brown (7.5YR 5/4) dry; moderate very fine and fine subangular blocky structure; hard, firm, sticky and plastic; few very fine roots; common very fine pores; 40 percent pebbles and 30 percent cobbles; medium acid (pH 5.8); abrupt wavy boundary.

IIC—45 to 60 inches; variegated reddish brown (7.5YR 4/4) yellowish red (7.5YR 5/6), and brown (7.5YR 4/4) very gravelly loam; massive; slightly hard, friable, slightly sticky and slightly plastic; 85 percent pebbles and 5 percent cobbles; medium acid (pH 6.0).

The A horizon has hue of 7.5YR or 10YR, value of 4 or 5 dry, and chroma of 2 or 3.

The B horizon has hue of 10YR or 7.5YR, value of 3 or 4 moist and 5 or 6 dry, and chroma of 3 or 4 moist and dry. It is heavy loam, clay loam, or silty clay loam and is 15 to 40 percent pebbles.

Camas series

The Camas series consists of deep, excessively drained soils on flood plains. These soils formed in recent sandy and gravelly alluvium. Slopes are 0 to 3 percent. The mean annual precipitation is about 45 inches, and the mean annual air temperature is about 53 degrees F.

Typical pedon of Camas gravelly sandy loam, 2 miles northeast of Independence, SW1/4NW1/4 sec. 14, T. 8 S., R. 9 W.:

Ap—0 to 7 inches; dark brown (10YR 3/3) gravelly sandy loam, brown (10YR 4/3) dry; moderate very fine granular structure; slightly hard, friable; many fine roots; many irregular pores; 20 percent pebbles; slightly acid (pH 6.4); clear smooth boundary.

Figure 4.—Profile of Briedwell silt loam, 3 to 12 percent slopes.

Figure 5.—Profile of Hazelair silt loam, 3 to 12 percent slopes. Wide vertical cracks in the subsoil are caused by a high shrink-swell clay.

LAB EXERCISE

Soil maps provide a basic tool for a preliminary understanding of the geomorphology and surficial geology in a given area. In this exercise, we will work as a group to systematically analyze soils data for our immediate neighborhood in Polk County, OR. The results of this exercise will ultimately be used to derive a generalized geomorphic map of the local area.

Procedures

Part I. Investigation of Landform-Soil Relationships.

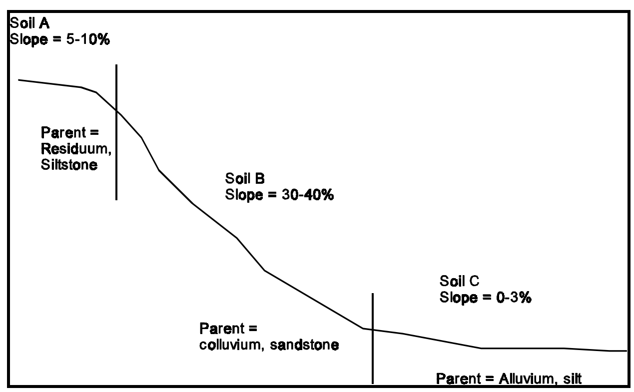
1) Examine the portion of the Monmouth, OR 7.5 minute topographic map shown on the 8.5 x 11 transparency (provided by your instructor). This area extends from just west of Helmick State Park to east of Parker, near Davidson Hill. Soil map units and descriptions are also provided for this area.

2) Using the topographic transparency as an overlay, lightly draw in the soils map polygons using a red, fine-tip felt marker. Neatly label the soils polygons on the overlay.

3) With the graph paper provided, draw two topographic profiles along lines A-A' and B-B'. Use a horizontal scale of 1" = 2000 ft (i.e. 1:24,000) and a vertical scale of 1" = 1000 ft (i.e. a vertical exaggeration of x2).

4) Show the soil associations on your profile by marking the map unit boundaries with a vertical line. Above your profile line, label the soil units and identify the range of associated slope gradients. Below your profile line, label the parent materials of the associated soils.

EXAMPLE PROFILE



5) Based on your cross-sections and soil associations:

A. List the general soils-landform associations that you observe on the profile.

B. Describe the locations and soils units that would be most suitable for home building and explain why.

C. Which soils units have the highest potential for erosion after plowing?

D. Which soils units have the highest potential for flooding?

Part II. Soils as a Tool for Identifying Alluvial Terraces

Examine the Geologic Map of the Monmouth Quadrangle provided by the instructor. Compare to the topographic maps and the attached soil survey information. Based on your comparison, answer the following questions:

(6) Provide a geologic description for the following Luckiamute valley stratigraphic units: Qtlt, Qtm, and Qth. In your description include age, landform, material, and process of deposition.

(7) Specifically relate the above geologic units to the soil survey units. Check the photocopied soils explanations and fill in the table below:

Geologic Unit	Soils Unit(s)	Soil Parent	Soil Texture	Thickness of B horizon	Clay / Iron Content of B horizon
Qtlt					
Qtm					
Qth					

Other Observations Here:

(8) How does the relative degree of soil development, particularly with respect to clay / iron content, relate the the geologic units. Explain in detail.

(9) Do you see a relationship between the height of the geologic unit above the active river channel, and the degree of soil profile development? Explain your answer.

(10) Based on your observations, discuss how soil survey data can be used to guide geomorphic mapping along a river valley.

Appendix I - Brief Overview of Soils

I. Terms and Definitions

A. Regolith- All rock-weathering products at the earth's surface; generally the unconsolidated mantle of material above bedrock.

B. **Soil**- a weathered mantle of unconsolidated earth material, covering land surfaces of the earth. Comprised of a mixture of mineral and organic matter, derived from the physical, chemical and biologic weathering/decomposition of bedrock.

** Soils form on / in regolith **

Characteristics:

1. Horizonation: development of distinct textural, color, and compositional zones within the surface regolith

C. Parent Material - the original rock or surface deposit from which the soil was derived.

1) e.g. Bedrock Parent = igneous, sedimentary, metamorphic
2) e.g. surface deposit = alluvium, colluvium, loess

D. Pedogenesis: a 3-dollar term that generically refers to the process of soil formation.

1) leaching- process of water dissolution of ions/nutrients from soil, may actually result in ionic depletion of certain soil horizons depending on conditions of water migration.

1) eluviation- process of removing soil particles by the action of downward percolating soil water

2) illuviation- process of particle deposition and accumulation by percolating soil water

E. Buried Soil / "Paleosol" - an older soil horizon that shows evidence of burial by the products of a younger geomorphic event. Example: a floodplain soil that is buried with fresh alluvium during a subsequent flood event.

F. Geomorphic Process-Materials Terms:
1) Colluvium = weathered regolith that has been transported by mass-wasting processes
2) Residuum = *in-situ* weathered regolith, that has NOT experienced significant transport
3) Alluvium = unconsolidated regolith that has been transported by fluvial (river) processes
4) Loess = wind-blown silt

**Note: Soils may develop on any of these surficial materials. Evidence for pedogenesis is primarily recognized by horizon development.

II. SOIL COMPOSITION

A. **Inorganic Mineral Matter**

Comprises the bulk of soil composition in the form of mineral matter. The inorganic fraction of soil is classified according to grain size and mineral composition. Mineral components include:

1. **clay-sized particles** (< 4 um diameter) consisting of hydrated aluminosilicates known as clay minerals.

    a. clay mineral properties include: colloidal size (>molecules but smaller than can be viewed with unaided eye), great surface area, sheet-like aluminosilicate crystal structure, net negative ionic charge between clay silicate sheets, high cation exchange potential, high capacity for water retention

2. **sand and silt-sized** (4 um - 2 mm diameter) particles that may vary in mineral composition according to the composition of the parent bedrock. Quartz, feldspar and mica are common rock-weathered derivatives.

3. **gravel** = all clasts greater 2 mm in diameter (granules, pebbles, cobbles, boulders)

B. Organic Matter: comprises less than 5% of total soil composition, however plays a major role of influencing biochemical soil processes, and rendering soil a highly effective growth medium

1. orgainic soil constituents include: dead and undecomposed plant and animal tissue, more fully decomposed organic humus, living plant and animal organisms including roots, burrowing organisms, microorganisms and bacteria.

soil bacteria are responsible for the composting/decomposition process as well as serving as an innoculant for the stimulation of plant nitrogen fixation from the atmosphere.

plant litter- leaf material, root matter and stems

humus- dark colored (brown or black), gelatinous, chemically decomposed (hence chemically stable) organic matter.

Humic and organic matter is important for loosening soil texture and improving water retention capacity of soil, hence improving it as a growing medium

C. Porosity/Soil Air

Porosity- the degree of void-space present in the soil, represented by an open interstitial network of void spaces between soil particles.

A loose, "average" soil is composed of 40-50% porosity

D. Soil Water- soil moisture content generally varies in direct relation to climatic conditions, surface vegetation and the physical structure of the soil.

SOIL PROPERTIES

A. Color: Indicative of chemical and mineralogic nature of soil

1. 175 gradations of soil color recognized (Munsell color chart)
    a. Black = humic content
    b. Red or Yellow = iron oxide staining
    c. Gray or White = indicative of ion leaching or depleted soils
        White in arid climate = alkali precipitates (carbonates)

B. Texture: based on sieve analysis identifying sand, silt and clay composition of soil

1. Loam = equal admixtures of each
2. clay loam, silty clay, sandy clay, sand loam, silt loam, etc.

    a. effects engineering properties of soil/moisture-drainage

C. Structure: shape and character of aggregate soil masses or "peds"

1. size, shape and cohesion of peds influences drainage, aeration, soil porosity, and soil permeability

SOIL PROFILES

A. Soil Horizons: Throug the weathering process, soil tends to segregate into vertically characteristic layers in response to chemical and physical processes

1) Horizons: distinctively recognizable soil layers with unique chemical and physical properties

2) Soil growth and formation viewed as progressing in a downward direction, i.e. thickness of soil profile increases from surface downward with time (thickening downward).

B. Soil Profile: characteristic horizons

1. O horizon: immediate surface layer composed of organic matter
2. A horizon: organic + mineral horizon, dark brown to black in color
3. E horizon: zone of leaching or "eluviation", lighter in color, leached of iron and aluminum.
4. B horizon: zone of accumulation or "illuviation", receiving zone of transported iron, aluminum and clay from above, often a reddish clayey horizon.
5. C horizon: regolith or unconsolidated parent material, below root zone, weathered bedrock, in decay
6. R horizon: consolidated bedrock