SOILS AND THEIR PROFILES

by Roy W. Simonson

Most of us know soil when we see it. But what we think it is depends on who we are. To the southern housewife, soil is the endless stream of red dirt tracked through the house via the shoes of her small son. To a farmer in North Dakota, soil is the black furrow slice turning off each moldboard of his plow. To a highway engineer, it is the loose earth from which he builds a road. To a soil scientist, it is a universe full of challenges. But for most of us, soil is too common to excite our interest from the time we fashion childish mud pies until we finally return to the earth when we die. We take soil for granted, as we do the sun and sky. It's just there, seemingly permanent and immutable. Yet the study of soil, especially in the last century, has shown that the commonplace has uncommon dimensions.

The Soil Mantle

Soil mantles the land surface of the earth except for barren peaks, desert wastes, and fields of perpetual ice and snow. Soil clings to the earth as the rind adheres to an orange; but the earth's rind is far from uniform. Soil may be deep or shallow. Some soil in Brazil is red, while black soil graces the Ukraine. Soil may be sand or clay. Whatever its characteristics, soil is the link between the rock core of our planet and the life on its surface. Without soil, land plants and the animals dependent on them for food could not exist.

This rind cloaking the earth is like a jigsaw puzzle with millions of pieces. Each segment is a "soil body" that occupies a set space. Each segment has three dimensions—length, breadth, and depth. Individual bodies range in size from a few square feet to thousands of acres (one to many thousands of square meters). As a rule, each extends down into the planet for 1 meter or more, and each grades into its neighbors. People grow food and fiber, dig basements, bury treasure, and build roads and trails in these soil bodies.

The millions of soil bodies making up the mantle share some common qualities. Soil consists of mineral matter, organic matter, water, and air. The proportions differ, but the basic components remain the same. A day or two after a rain, a lump of soil from a well-kept garden could be 84% solids and 16% water by weight. The solids could be 80% mineral and 4% organic matter. Air is negligible in the lump's weight. In a cubic foot of soil weighing 75 pounds, the air would weigh a fraction of an ounce. In metric units, such a cube of soil 30 centimeters on a side would contain 32.4 kilograms of solids, 6.2 kilograms of water, and 8 grams of air. By volume, the proportions tell a different story. The lump is half solids, one-fourth water, and one-fourth air. The solid part is only half of the lump; the other half is pore space filled with air and water. When you walk across a garden, you literally walk on air and water as well as earth!

Another shared characteristic of soils is a profile. It consists of two or more layers, one below the other, to a depth of 1 or 2 meters or to hard rock, whichever is shallower. These layers, called horizons, run parallel to the land surface. Each profile with its horizons offers a mute history of the soil at that spot, could we but read all that is written. Deciphering what we can of the record provides knowledge we can apply to the use of soils for our purposes.

Pedologists (soil scientists) have devised methods for examining and describing soil profiles. Initial studies describe what can be seen with the naked eye, felt with the fingers, and measured with simple instruments and tests. Laboratory tests can also be made.

Profiles and Their Horizons

Profiles differ in the kinds, numbers, and distinctness of their horizons. Well-expressed profiles have three to five horizons. Poorly defined ones may have only two or three. A soil horizon may be thick (up to a meter) or thin (less than a centimeter). Most horizons merge with their neighbors, but a few are set apart by abrupt boundaries no thicker than the blade of a paring knife. A soil profile with its horizons is like a layer cake—minus the bands of icing.

The sequence and properties of horizons in a profile strongly affect plant growth. Soils of the higher, level uplands of Mount Vernon, Virginia (George Washington's plantation), have compact and brittle horizons known as fragipans. Beginning at depths near 50 centimeters, the fragipans virtually halt any root penetration—even by trees! The fragipans also restrict water movement, leaving plants with their roots in too much water at some times and suffering from drought at others.

For scientists, profiles are the primary basis for defining the many kinds of soil bodies on the land surface. Knowledge of similarities and differences among profiles then permits classification of soils. Subsequently, soils of one place can be related to those in another, perhaps far-off, spot.

During the past 15 years, major soils of the part of the Amazon basin in eastern Peru have been found to be closely similar to major soils of the Coastal Plain of eastern North Carolina. The soils are all Ultisols, widespread in humid, subtropical, and tropical regions plagued with severe weathering and leaching. The soils are strongly acid and low in plant nutrients. Luckily, such soils respond well to liming, fertilization, and other aspects of good management. So the Peruvian farmer can borrow some good crop management tactics from his North Carolina counterpart.

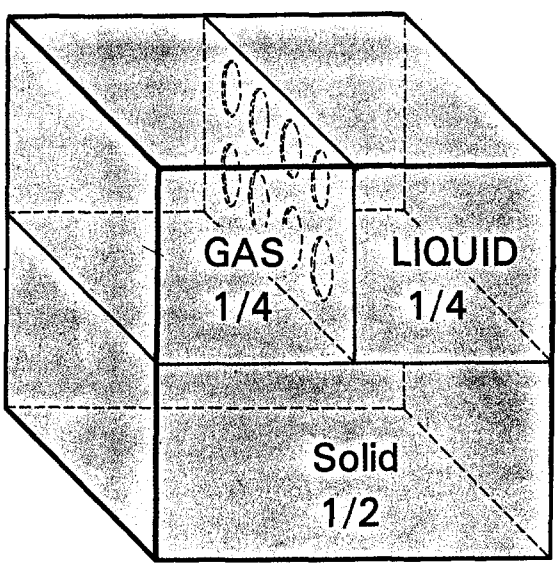

Figure 1. A diagram to show common proportions by volume of solids, liquids, and gases in a lump of soil.

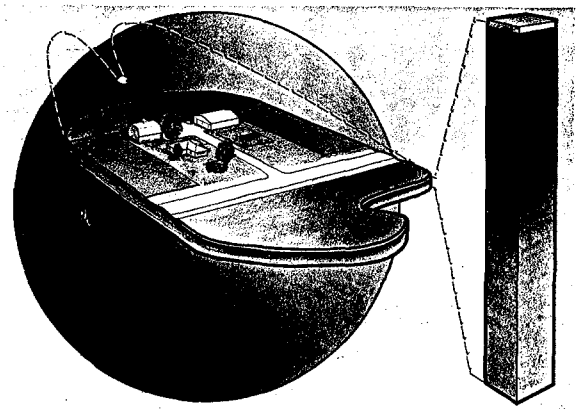

Figure 2. A sketch to show (a) how a soil body is related to the rind of the earth and (b) how a profile is related to that body.

Soil Shorthand

Pedologists have developed a system for labeling the major kinds of horizons in soil profiles. The original soil shorthand was devised about 100 years ago by the Russian Dokuchaeiv. He labeled the three horizons from the surface downward with the letters A, B, and C. His testing ground—the steppes near Moscow—was similar to the soils of central North Dakota. He named the dark surface layer the A horizon and the deepest layer, a meter or so below the surface, the C horizon. The transition layer between the two was called the B horizon. This was only the first of many proposed systems for labelling soil horizons.

Today the principal labels used for major horizons of mineral soils in the United States are A, E, B, and C. The letter O is less widely used to designate surface horizons of organic matter. Hard rock is labeled R, though it is not really a horizon. Use of R in a profile description signals that the soil is abbreviated by rock.

The O horizon, existing on the surface, if present at all, consists mostly of plant residues in various stages of decay. At one extreme it may be no more than a thin layer of forest litter, or it may be as thick as 15 centimeters (6 inches). A range of 1 to 7 centimeters is most common. The O horizons are found chiefly under forest vegetation in humid, cool, and cool-temperate regions, such as New England.

Either at the surface or just below an O horizon, the A horizon is richest in humus and living matter (mainly fine roots and microorganisms) among the mineral soil horizons. Yet some substances have been lost through eluviation as water moved downward through the profile. Most A horizons are 3 to 40 centimeters thick, with a range up to 60 centimeters (2 feet). They are found in most—but not all—soils. These horizons are prominent in Mollisols, the major soils of the prairies of North America, the steppes of the Soviet Union, and the pampas of Argentina. These soils have long been and still are prime producers of cereal grains.

The E horizon (formerly called an A2 horizon) normally lies below an A or O horizon but above a B horizon. The letter E is from eluviation, which means "washing out." The E horizon is paler than its neighbors, having lost substances in both solution and suspension as water trickled downward through the soil. Most E horizons are 3 to 15 centimeters thick, with a full range from ½ centimeter to 1 meter. E horizons are common but not universal in soils under forests and largely absent from those of prairies. Widespread in the northern forest zones of Russia, E horizons were once thought to be the ash left by forest fires. Peasants called the soils Podzols, taken from words meaning "sub-ash" or "ash-beneath." That name was adopted by early pedologists and is still used in the Soviet Union.

The B horizon underlies an A or E horizon. It harbors less life than either and is commonly lower in organic matter. Wetting fronts due to rain may stop and leave substances in this horizon. Occasional fronts pass through and carry some substances even deeper. Some B horizons gain one or more of clay, iron and aluminum oxides, and organic matter. These become horizons of accumulation, present in many soils. In other profiles, the B horizons are marked only by stronger colors and structure grades, having gained little or nothing and having lost some substances. Most B horizons are 8 to 60 centimeters thick, with a range from 2 to 100 centimeters. A great majority of the world's soil have B horizons.

The C horizon lies deepest, below both A and B horizons in the profile. It consists of weathered, usually disintegrated rock, sharing a few properties with horizons above. Infrequent wetting fronts traveling through bring small quantities of substances into the C horizon and carry some out. The C horizon earned the name "soil parent material" or "mother rock (roche mere)" because it was long believed to be much like the materials from which the overlying horizons were formed. The uppermost 30 to 60 centimeters below the A and B horizons are usually considered the C horizon. Most soils have C horizons. Exceptions are the occasional profiles in which the A or B horizons rest directly on hard rock.

Soil horizons may be further subdivided in detailed studies. And some kinds of A, E, and B horizons are given specific names because of their distinctive properties and special significance. But the basic horizons discussed here provide an introduction to the complexity and organization that exist in the soils beneath our feet.

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