Comments and Communications

Geology, Soil Mechanics, and Botany

THE youthful science of soil mechanics properly belongs with the other earth sciences in the geology family, for it deals with the physical properties of the surficial mantle of the earth and the explanation of geological phenomena, but we geologists have neglected our infant, and it has been kidnapped by the engineers. While working in Alaska on frozen ground problems in 1935, I tried, unsuccessfully, to persuade the U. S. Geological Survey and one of the mining companies to start a continuing research project on problems associated with the perennially frozen ground. World War II has emphasized the importance of these problems, and in recent years the Navy, the Army, the U. S. Geological Survey, and other organizations have sponsored much research in this field; but most, if not all, the enthusiastic young scientists who have gone into the work have been handicapped by lack of training in soil mechanics. The illustration given below is typical of many recent publications.

In *Geological Survey Bulletin 974-C, Frost Action and Vegetation Patterns on Seward Peninsula, Alaska* (*1*), a botanist and a geologist have collaborated to give an excellent description of tundra vegetation—and more cooperation of this kind is needed—but the explanations given for the development of cotton grass (*Eriophorum*) tussocks, peat rings, and other features do not conform with our knowledge of the mechanics of frost action.

A tussock, called "niggerhead" in Alaska, consists of a small earth mound topped by a more or less spherical mass of living and dead plant parts, the whole having a height ranging from a few inches to 1½ feet. Tussocks are quite stiff and, when closely spaced, make travel across the tundra very laborious.

The authors state (p. 54) that soil movement results "from frost heaving (vertical expansion), frost thrusting (horizontal expansion) . . . and subsidence during thawing," and (p. 76) they explain the development of the tussock earth mounds as follows:

> During the autumn freezing cycle, the sides of the tussocks and the *Sphagnum* mosses and mineral soil surrounding the tussocks freeze more rapidly than the matted culm bases. . . . Lower moisture content and better insulation due to the presence of dead air spaces account for the slow rate of freezing of the culms and roots. The freezing mineral soil between the tussocks expands and moves laterally into the thawed zone beneath the tussock, forcing it upward (fig. 28G). Repeated cycles of frost thrusting from the intertussock areas raise a mound of mineral soil beneath the tussock and force the proximal portions of the roots vertically out of the soil.

This explanation has also been given for tussocks in Massachusetts marshes (*2*).

Before and during freezing, the pressure at any point below the surface is determined by the weight of the overlying soil, except locally where there is bridging. Therefore, at a depth of a foot or so under a tussock mound, the pressure is greater than at the same level under the surrounding area, and, if the soil were sufficiently fluid to transmit hydraulic pressure, the tussock should sink and the surrounding area be pushed up instead of the reverse. In late August on the Seward Peninsula, when the ground had thawed to a depth of about 1½ feet, a tussock supported the weight of the writer without perceptible settling.

The soil of Seward Peninsula is mostly silt, and when fine-grained soils freeze slowly, water segregates to form layers or lenses of ice consisting of prismatic crystals oriented normal to the surface. The crystals exert pressure in the direction of growth, which is normal to the cooling surface. The upward heaving of soil is not due to change in volume, for similar results have been obtained experimentally with liquids that freeze with decrease in volume. The pressure developed by the growing crystals is determined by the resistance to growth—that is, the weight of the overlying soil. A simple experiment (*3*) has been used to prove that the ice crystals develop a linear, instead of a volumetric, pressure. Fill some glass test tubes with clay saturated with water. Expose half of them to cooling from all directions and they will break, because ice crystals will grow radically inward, exerting pressure against the walls of the tubes. Insulate the other tubes, leaving only the upper surface of the clay exposed to cooling, and the tubes will not break. Ice layers will form in the upper part of the clay, raising the surface, and shrinkage cracks will form in the lower part because of withdrawal of water.

If tussocks owe their height in part to frost heaving, the explanation is probably the same as for the upward migration of stones in soil (*4*), the heaving of fence posts, and similar phenomena. As soil freezes and growing ice crystals lift the surface, the frozen layer may grip a fence post, or other object, and drag it upward, leaving a void at the base. When thawing occurs, the surface soil returns to its original position but the post does not, for it is held up by friction and by partial filling of the void with soil fallen from the sides or washed in by meltwater.

In areas of severe frost-heaving, farmers in early spring give fence posts a few taps with a hammer to drive them down. If they wait several months until the voids are largely filled, the hammer blows are less effective. In Alaska telephone wires are often strung on tripods, as poles are overturned by heaving unless well anchored in the perennially frozen subsoil. Winter wheat is occasionally killed by heaving and exposure of roots, seedling pines have taproots broken, and other forms of vegetation are damaged or killed by frost heaving.

If geology students planning to study problems involving frost action could take a well-designed laboratory course in soil mechanics, we would have fewer papers in which geological phenomena are attributed to horizontal thrusting or expansion in volume; and, also, they might better appreciate the value of experimental, as well as observational, evidence in the solution of geological problems.

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Use of Silicones in Preparation of Samples for Radioactivity Measurement

IN THE preparation of counting samples by evaporation of aliquots of solutions, difficulty is often encountered in obtaining uniform size and position of the final sample spot, because many solutions tend to creep and to spread irregularly on the planchette while being dried. Silicones may be used in two ways to good advantage in the preparation of such samples.

1) For mounting samples on flat metal planchettes, a small amount of silicone grease[1] is rubbed on the surface of the planchette, and all excess is wiped off with a cleansing tissue. The planchette is placed on a motor-driven turntable operating at low speed (10–20 rpm), and the sample is applied to the silicone-treated surface from a micropipette. With ordinary care in application, up to 200 μl of solution may be applied to form a "lens" no larger than 0.5″ in diameter. The planchette can then be removed from the turntable and dried under a heat lamp in the ordinary fashion; very little or no extension of the sample area occurs during drying.

2) For mounting samples on microscope cover glasses, the cleaned cover glass is placed on a motor-driven turntable, which is set in motion. A capillary, containing silicone fluid (Dow-Corning #DC804, diluted with an equal volume of ether) or a solution of Canada balsam in xylene, is lowered so as to deposit a circle of the fluid on the surface of the glass; the capillary is held in a fixture consisting of a stopcock held on a ring stand by a clamp so that reproducible circles can be made. The cover glass thus prepared is allowed to dry, the sample is then spread on the area inside the circle and is dried in the usual fashion. The same technique can also be used with flat metal planchettes. The circles made with silicone-ether mixture dry much more rapidly than do those made with balsam.

It has been the writers' experience that the use of silicones as described here simplifies the preparation of counting samples of uniform area and position. Replicate samples thus prepared are almost always found to give counting rates checking each other within the statistical accuracy to which the counting is done.

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[1] We have found Dow-Corning stopcock grease best for this purpose.

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