Comments on "Freezing Effects on Aggregate Stability Affected by Texture, Mineralogy, and Organic Matter"

A portion of the discussion in the paper by Lehrsch et al. (1991) is devoted to water movement in freezing soil as a mechanism for reducing aggregate stability. Some important implications of the water redistribution, however, were not pointed out. The following items are offered for consideration in planning future experiments to study the effects of freezing and thawing on aggregate stability.

1. Decreases in aggregate stability that occur during freezing or thawing result from water contents sufficiently large to separate soil particles. This requires water film pressures to exceed the ambient air pressure, so disruption occurs only when local water contents (liquid plus ice) exceed the initial volume fraction of pore space in the unfrozen soil.

2. Water redistribution during freezing and thawing is the principle factor causing changes in aggregate stability. Therefore, unsaturated hydraulic conductivity, soil heat flux, overburden, and osmotic pressures are the most important factors associated with decreases in aggregate stability.

3. PC software is now readily available to estimate the water redistribution during soil freezing. For example, ICE-1 (available at cost from the International Groundwater Modeling Center, Golden, CO) only requires the operator to supply some soil physical parameters, surface temperature, overburden, initial osmotic pressure, and water content.

4. Scoping calculations with this type of software is very useful for planning soil aggregation experiments or for estimating the effects of freezing under a wide variety of field conditions. One finds, for example, that most of the action occurs within a few tenths of a degree below the freezing point of soil water and the forces developed by very small thermal gradients overwhelm the forces required for aggregate disruption in moist soils. Importance of the unsaturated hydraulic conductivity and the soil heat flux cannot be overemphasized.

5. When one freezes an isolated soil sample some parts of the sample always become wetter and others get drier. Thus aggregate stability may decrease in part of the sample while increasing elsewhere. Analysis of the sample as a single unit yields only the average of these opposing changes. Future experiments will require the analysis of thin layers of each sample with respect to water content and thermal history as well as aggregate stability.

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The authors thank Dr. Cary for elaborating on some aspects of their study. Measurements of unsaturated hydraulic conductivities and soil heat fluxes would have improved our study by, for example, enabling us to quantify the growth rate of an ice crystal or lens. We concur that the analysis of thin layers of soil should be a part of the design of future experiments studying freezing-induced aggregate stability changes. We also recommend that, in the future, soil samples be frozen slowly to a temperature of −7 or −5 °C. A slower freezing rate will allow migration of more liquid water to the freezing zone and thus greater dying of the unfrozen soil from which the water flowed.

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References