Temperature Fluctuations Which Accompany Soil-Water Movement

Because temperature is a manifestation of energy and because energy changes always accompany spontaneous movement, it naturally follows that for any spontaneous occurrence involving movement, a temperature fluctuation must occur.

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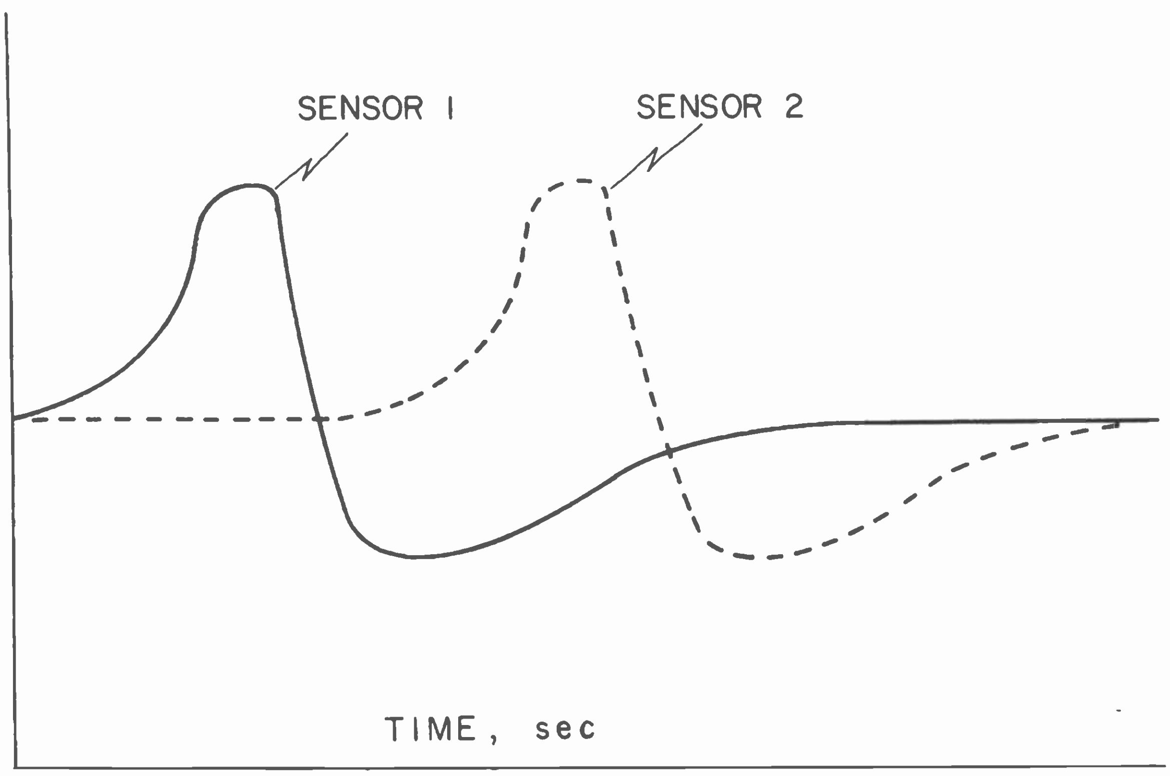

FIGURE 1 — Predicted temperature-time curve for water movement.

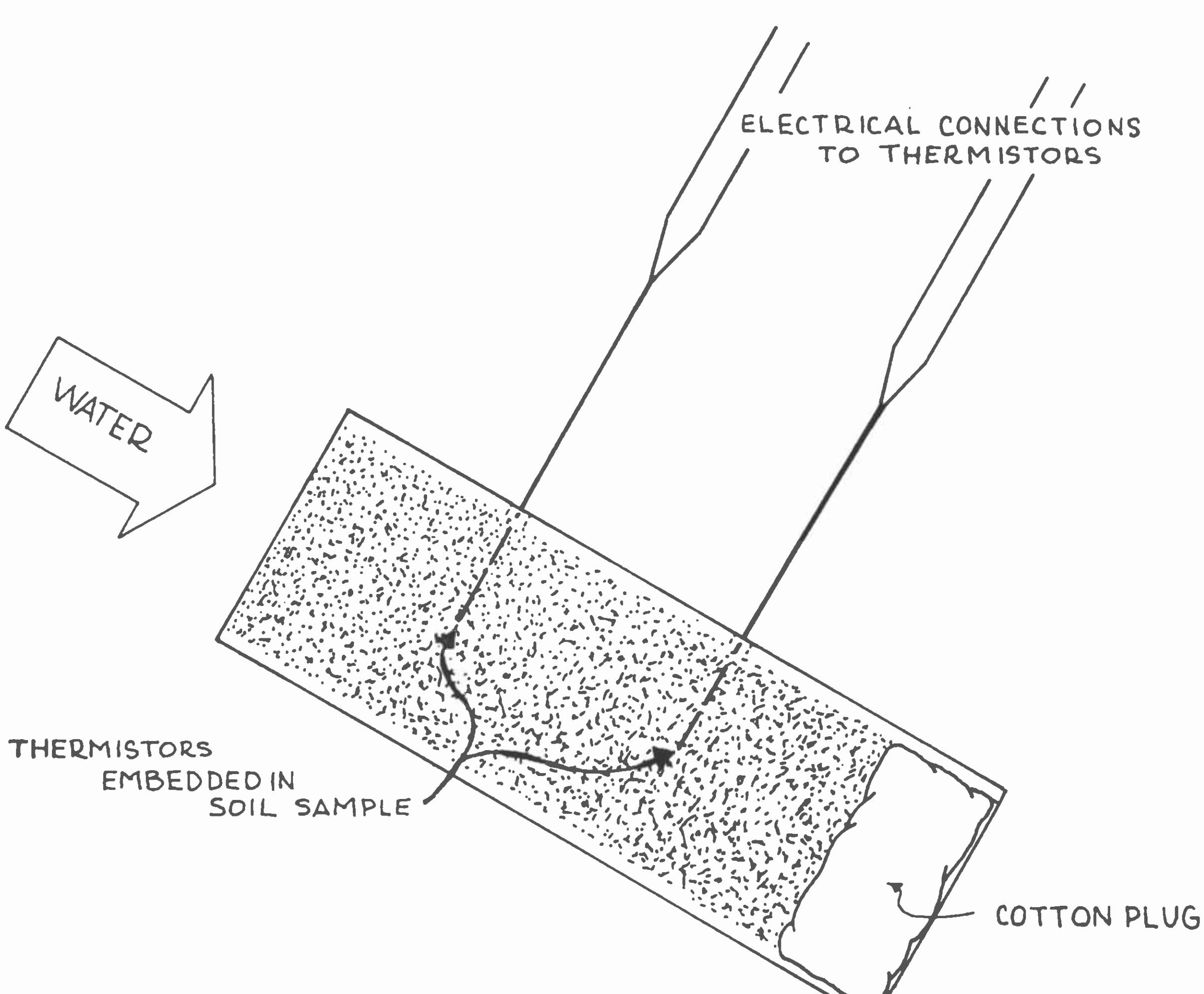

FIGURE 2 — Diagram of soil sample in plastic tube container.

"So what?" is the question quite naturally framed when this generalization is stated in connection for example, with thirsty furrows absorbing an irrigation stream, on the one hand, and their stubborn refusal to accept it on the other.

But there is a direct connection, however obscured it may seem. It is because of the sureness of this connection that the simple experiment described below was done. The result was to provide an important new method of studying the microscopic mechanisms responsible for differences in the ability of soils to "take water." Many other processes involving movement of water also can be advantageously probed by this technique.

Both Vapor and Liquid

When water moves about in soils and sediments, it does so both as a vapor and as a liquid. When the medium is unsaturated with water, that is to say when there are interconnecting air spaces, movement of vapor and liquid may occur simultaneously. Now, let us imagine ourselves to be located at a certain point within a dry portion of a soil toward which liquid water is moving.

If we only had the eyes for it, we would see that *as the liquid moves toward us,* vapor continually leaves the advancing liquid front, diffuses as a gas ahead of it, collides with the particle surfaces which give shape to the pores and, finally, is adsorbed on the surfaces of the soil particles about us, forming a thin water film over which the advancing liquid can move easily. We would then notice the temperature rising as a consequence of this adsorption.

As soon as the liquid front arrived, however, the temperature at our point would drop sharply due to the cooling effected on it by the process of evaporation which previously had furnished the vapor. On the basis of this thought Experiment 1 would then predict temperature-time curves like those shown in Figure 1 for two points in a dry soil toward which water was moving.

Temperatures Rise and Fall

The initial rise in temperature at

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Dr. Anderson is a former member of the staff of the Department of Agricultural Chemistry and Soils. The above article was prepared by him when he was here, and is published at request of the department's head, Dr. W. H. Fuller.

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"Sensor 1" we ascribe to adsorption of the diffusing water vapor on the particles. The subsequent sharp temperature drop, on the other hand, we ascribe to the arrival of the cooled liquid. Both vapor and liquid by this time are advancing toward "Sensor 2" where a similar effect is noted.

If such a temperature effect really exists and is measurable, it could be used to study many hitherto unanswerable questions regarding the various processes of water movement in soils, sediments and other porous materials.

To determine whether this predicted temperature effect could be detected, a small plastic tube was cut as shown in Figure 2. Mounted in it were two tiny thermistors* to serve as temperature sensitive elements. This tube served as a sample holder, and made it possible to introduce the water easily and to observe its movement through the sample. The two thermistors then were connected to a recording instrument which converted their impulses to temperature readings.

*Thermistors are semi-conductors which have extreme sensitivity to temperature. They offer one of the most sensitive means of detecting temperature differences presently available.

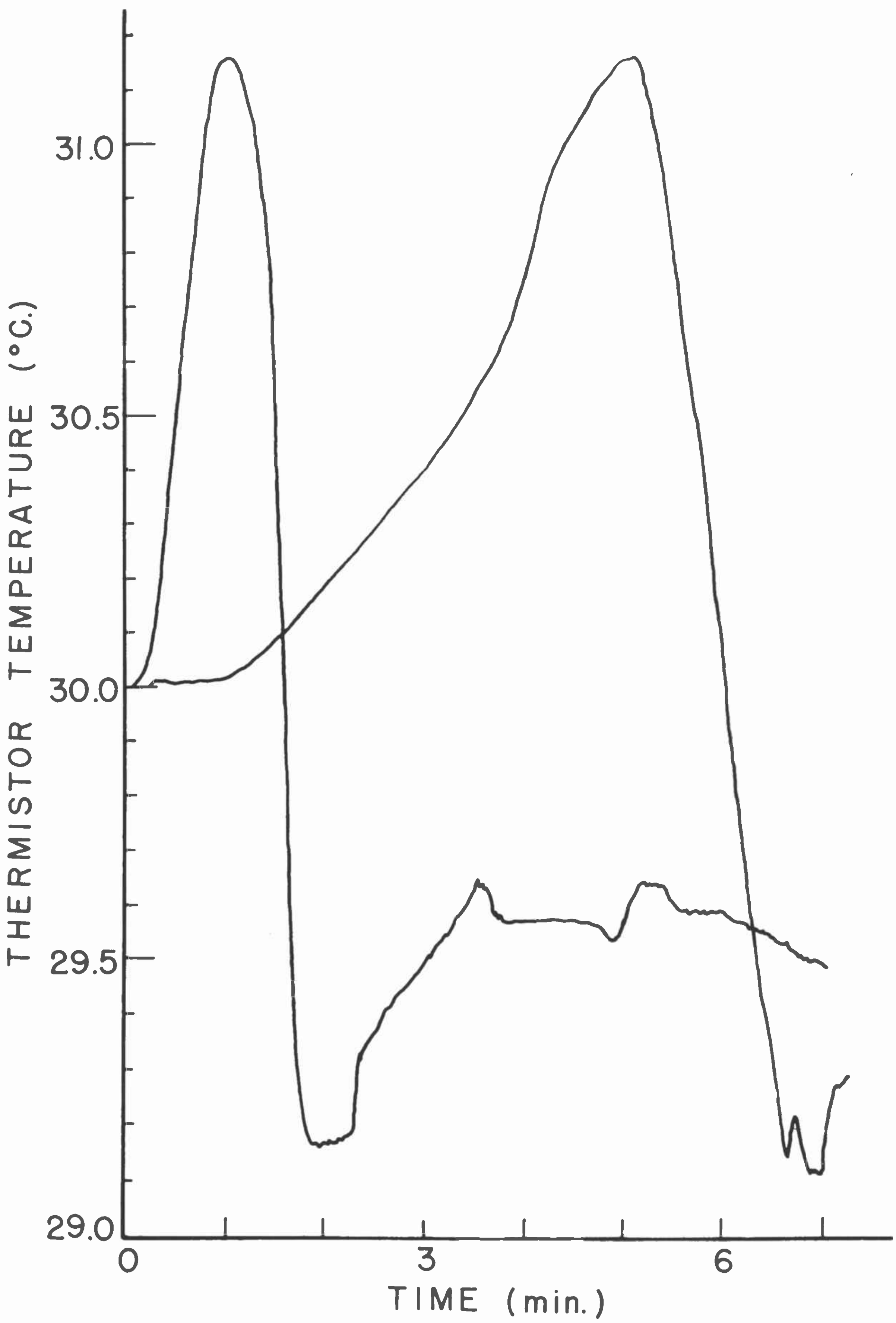

FIGURE 3 — Observed temperature-time curves for water moving in kaolinite.

A typical tracing from the recorder showing the temperature changes when water moves through a kaolinite clay sample is shown in Figure 3. Each small chart division represents 0.1° C, so that the entire chart width represents 2.0° C.

EDITOR'S NOTE: Some sort of record has been established with this article. It was written before Dr. Anderson went to a civilian assignment with an army scientific group at Dartmouth, New Hampshire. Months elapsed, and the article was in type when Dr. Anderson, enroute to a meeting in California, stopped off at the U of A campus in Tucson to visit former colleagues. When he checked galley proofs of his article, he corrected the spelling of his first name. (We'd left out the "w"). In 40 years of editing this was the first time we ever had an author come over 3,000 miles to make one correction on a galley proof!

Although this tracing is not as symetrical and even as our diagram, our expectations are nevertheless confirmed. And we have, in the detection of this phenomena, developed a new tool to help in unraveling the mystery surrounding the details of water movement in porous substances such as soils and sediments.

Ariz. Credit Use Rises

Farmers and ranchers in Arizona used more credit in 1963 than in 1962, and more than in any other year. Preliminary figures for the amount of credit outstanding January 1, 1964, indicate non-realestate institutional loans oustanding in the state were up $40 million, or 27 percent, from a year earlier.

Cotton Income Down – '63

Gross income from the 1963 Arizona cotton crop declined nearly 7 percent from the previous year despite a 3 percent increase in price. The 1962 income was $172,293,000 and the 1963 income is expected to be $160,161,000. The reduced income resulted from a 4 percent cut in total allotted acres and a nearly 6 percent decline in average yields per acre harvested.