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THE CAUSE OF EROSION

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Much discussion of soil erosion proceeds, I believe, without an accurate conception of what may be the basic cause of the phenomenon.

My boyhood was spent on a farm in the Driftless Area of Wisconsin, so-called because the ice-sheets all avoided this spot. It is a peculiar island of unglaciated terrain, in the midst of surrounding glacial debris. Here, the soils are of clay and sand residue, a disintegration product of the rocks in situ. Here weathering has created dendritic valley and gully systems, all veering towards the ultimate Mississippi.

About the time I began to become interested in the chemistry of soil, by reason of the introduction of the subject into the high-school curriculum, I remember talking to a neighbor about our soil. He was a very intelligent and observing old gentleman who had settled there forty years before on as level a piece of land as was available on the virgin, rolling prairie, and he told me that when he first began to plow the land for corn raising, the gullies as well as the hills would be planted without a sign of erosion by run-off water. The water all appeared to be absorbed into the land.

After fifteen or twenty years, it became necessary to leave the low gully-bottoms in grass to stop the beginning of the erosion. After another fifteen years, ditches were being washed out apace, regardless of the attempts to keep sod in the gullies; and dams of old fence posts and brushwood had to be used to halt the destruction. All this on land originally selected for its gentle slopes, land topographically ideal for farming.

There is one thing here that stands out. Originally *the rain seemed to be entirely absorbed into the ground with no run-off*. Why did the water begin to run off after some years of cropping? I believe in the answer lies the basic cause of soil erosion on this kind of land.

Here we have a clay soil of a type that

baked into hard, unmanageable lumps if plowed when too wet. I remember our neighbor said that when he began cultivating the land the lumps of soil fell apart on drying, whereas later they became hard and tough.

The value of this clue became apparent to me years later, when I had occasion to read E. G. Acheson's account of his investigation of the colloidal state of clay in brick making. He knew that unless straw was used in making bricks they fell apart into fragments upon drying, but he found that its function was not mechanical, as a reinforcing element, but chemical. Straw water held the clay together as well as straw.

Acheson found that clay, mixed into straw water, could not be filtered or settled out. It had become a colloidal solution. However, he also found that soluble salts (electrolytes) nullified the effect of straw water on clays. Now, maybe here is what happened to our neighbor's land. Perhaps the loss of soil salts, through cropping, resulted in the formation of a colloidal state of the soil clay, with the consequent stopping of water absorption. As a result, dried clods were brick-like rather than friable.

Other investigators have found that (1) the addition of electrolytes to an alkaline clay slip (slip is the term potters use for a liquid suspension of clay) will convert the slip to a flocculent state where it can be filter pressed or dewatered without producing a cloudy filtrate. (2) Organic colloids, such as are present in "straw juice" prevent salts from precipitating or flocculating a mineral colloid suspension. A trace of gelatin added to a solution of colloidal gold prevents the precipitation of the latter by the addition of salt.

It seems that certain other mineral salts counteract the action by which a small proportion of organic colloid protects the integrity of a mineral colloid. If such a salt could be applied it would inactivate the organic colloid so that a still larger amount of the colloidal clay would be deflocculated and thus rendered harmless, so far as its tendency to go into suspension is concerned.

Does such a key substance exist in soils? Let us look around at some natural soil conditions. In New England, the spring floods are usually clear water. In parts of Pennsylvania I have seen two mountain streams meeting, carrying spring flood water, where one was crystal clear, the other muddy with clay. We find upon investigation that water running off land with shale or granite subsoils is usually clear, while water running off limestone country is muddy. What might be present in the shale and granite decomposition that affords a soluble salt? We find that alum is made by leaching shale; that alum is present in this clear water that refuses to take up clay. We find that alum is used as a mordant to link dyes to organic colloids, otherwise known as vegetable and animal fibers.

Perhaps the colloid in the soil that promotes the colloidal state of clay, the equivalent of Mr. Acheson's straw extract, is inactivated by this "mordant". Alum has been used to purify drinking water, for it promotes a gelatinous precipitate which "takes with it most of the inorganic impurities, including any coloring matter which may be present." When this process occurred in the soil, it would exhibit itself as a fixation of the salts that were acting as the "mordant".

Alum is present in natural shales, in decomposed granite, in many rocks of volcanic origin. If the water from alum-bearing watersheds is clear, and that from other areas is muddy, why look for some other cause of erosion? If land that had no run-off before the soil minerals were depleted by cropping, and the erosion ceased after the soil minerals were replaced, that is practical confirmation of the theory. And in our own experience we have had just that occur, in some of the run-down land we have built up. The only salts added to the soil in our case were the necessary fertilizing elements commonly used to promote the growth of legumes—lime, raw phosphate rock and compost.

Apparently, normal soils, having the proper salts and colloidal condition of clay content, precipitate out of the water that leaches through it practically all of the organic material that may be present.

E. J. Russell in his Soil Conditions and Plant Growth said: "Practically the whole of the organic matter added to the soil by plant residues or manure remains near the surface unless carried down mechanically or by earthworms. Even when heavy dressings of dung are annually applied at Rothamsted there is after fifty years no appreciable enrichment of the subsoil in nitrogen. The purification of sewage by land treatment affords further illustration of the absorptive power of soil for organic matter."

Evidently, clay absorbs organic matter, which in turn can absorb inorganic salts of ammonium, potassium and phosphates. This would evidently include alum. Apparently, a proper balance between these factors is necessary to maintain an ideal condition of maximum friability of soil clods on drying, with no clay carried off in flood waters.

It seems that we must have organic matter to hold the mineral elements needed by plant life, and we must have mineral salts and clay to hold the organic matter.

It is strange that a complete investigation of the factors that determine the physical properties of soil has been so neglected. It seems to be the key to two most important problems of the land—the problem of erosion, and the problem of maintenance of fertility. Stopping erosion by this method would be really economical. The improved fertility would no doubt defray the costs many times over.

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