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[1] Lloyd, A. G., *Nature*, **183**, 109 (1959).
[2] Duff, R. B., *J. Chem. Soc.*, 1597 (1949).
[3] Khym, J. X., and Cohn, W. E., *J. Amer. Chem. Soc.*, **75**, 1153 (1953).
[4] Lemieux, R. V., Bishop, C. T., and Pelletier, G. E., *Canad. J. Chem.*, **34**, 1365 (1956).
[5] Trevelyan, W. E., Procter, D. P., and Harrison, J. S., *Nature*, **166**, 444 (1950).

SOIL SCIENCE

Stability of Soil Crumbs

Tiulin[1] showed that the stability of soil crumbs in water is greater from grassland than from corresponding arable soils. Since then, much work has been done to find out how this increase in stability is brought about by the soil organic matter. A review of this work is given by Baver[2]. In recent years it has been discovered that small additions to the soil of various synthetic polymers, called soil conditioners, also stabilize soil crumbs. The polymers can be either non-ionic, such as polyvinyl alcohol[3], or carboxylated polymers, such as polyacrylic acid[4].

It is now suggested that both soil organic matter and soil conditioners increase the stability of soil crumbs by linking together the principal constituents of the crumbs, the domains of orientated clay and the quartz particles. The linkages will be from the surfaces of the quartz to either the external basal or external edge surfaces of the clay domains, forming inter-crystalline or peripheral complexes[5,6] respectively (Fig. 1).

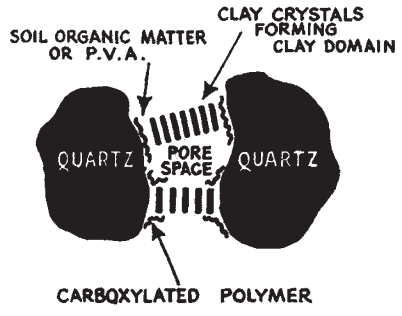

Fig. 1. P.V.A., polyvinyl alcohol

The model proposed satisfies the following known features of soil-crumb behaviour.

(1) The arrangement of the soil matrix is the same in both arable and grassland crumbs, both kinds of crumbs yielding similar thin sections[7] and similar moisture-release curves[8]. Untreated and conditioner-treated crumbs also give similar moisture-release curves[9]. (2) The crystalline water uptake and, therefore, the crystalline swelling of the clay is the same in arable and grassland crumbs, as well as crumbs stabilized by a carboxylated polymer[7]. (3) Slaking of the grassland or of conditioner-treated crumbs is reduced[10], for the stresses set up on wetting a dry crumb due to the crystalline swelling of the clay will be shared between several clay domains, through their linkages to the same quartz particles. (4) If the clay is sodium-saturated, the diffuse double-layer swelling is reduced sufficiently by the proposed quartz–organic material–clay linkages to prevent dispersion of the grassland or conditioner-treated crumbs in water[11]. (5) Remoulding grassland or conditioner-treated crumbs by breaking further quartz–clay linkages reduces the strength of the crumbs as measured by any conventional wet sieving or dispersion technique[12].

The model also offers a satisfactory way of accounting for the physical action and economy of soil conditioners. When a solution of a soil conditioner is added to a dry crumb, the consequent slaking will break the weakest clay–quartz bonds, so producing readily available sites for adsorption of the polymer. These sites are, at the same time, the most advantageous for increasing crumb stability.

The detailed presentation of this model with some of its consequences will be published elsewhere[13]. The model is incomplete, in that the chemistry of the linkage of the organic material to the quartz is not specified. There are other methods of stabilizing crumbs, for example, by using quaternary ammonium salts to inhibit the crystalline swelling of the clay[14].

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[1] Tiulin, A. F., Perm. Agric. Exp. Sta. Report 2, 77 (1924).
[2] Baver, L. D., "Soil Physics", 139 (J. Wiley and Sons, New York, 1956).
[3] Geogheghan, M. J., Fourth Intern. Congr. Soil Sci., **4**, 198 (1950).
[4] Hedrick, R. M., and Mowry, D. T., *Soil Sci.*, **73**, 427 (1952).
[5] Emerson, W. W., *Nature*, **176**, 461 (1955).
[6] Emerson, W. W., *J. Agric. Sci.*, **47**, 117 (1956).
[7] Dettmann, M. G., M.Sc. thesis, University of London (1957.)
[8] Jamison, V. C., and Kroth, E. M., *Proc. Soil Sci. Soc. Amer.*, **22**, 189 (1958).
[9] Peters, D. B., Hagan, R. M., and Bodman, G. B., *Soil Sci.*, **75**, 467 (1953).
[10] Low, A. J., *J. Soil Sci.*, **6**, 172 (1955).
[11] Emerson, W. W., *J. Soil Sci.*, **5**, 240 (1954).
[12] Laws, W. D., *Proc. Soil Sci. Soc. Amer.*, **18**, 379 (1954).
[13] Emerson, W. W., and Dettmann, M. G. (in the press).
[14] Grossi, F. X., and Woolsey, J. L., *Indust. and Chem.*, 2253 (1955).

Latent Interparticle Forces in Clays

Work in colloid science is usually concerned with clays in suspension, where external stresses are negligible. Experimental work in soil mechanics has shown that in consolidated and compacted clays both the existing external effective stress and the stress history are most important in determining soil properties[1,2].

If the pressure of pore water in a saturated clay is zero, the external stress σ_E must be balanced by a net intergranular repulsion σ_I:

$$\sigma_E - \sigma_I = 0 \qquad (1)$$

Fig. 1 shows the virgin consolidation curve *ABCDE* and three rebound curves *BF*, *CG* and *DH* for a clay initially prepared at a high water content. Each point on the virgin consolidation curve and on any rebound curve is an equilibrium point with zero pressure of pore water. At any voids ratio e_1, σ_E may have any value within a wide range (for example, σ_a, σ_b, σ_c, etc.), the maximum being the virgin consolidation value σ_{NC}. It follows from equation (1)