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CALCIUM SATURATION AND ANAEROBIC BACTERIA AS POSSIBLE FACTORS IN GLEIZATION[1]

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The agencies and chemical changes concerned in the production of the blue-gray horizon in the deeper part of the soil profile, commonly spoken of as "glei development," have provoked much discussion.[3] This process of gleization has regularly been associated with standing water and the consequent iron reduction to give the gray color. Calcium as a nutrient for the responsible bacteria has not been suggested, and as a contributing factor, calcium has not been segregated.

Since this horizon usually consists of a sticky, compact, and structureless clayey mass, its water retention is generally high and movement through it very slow. Its location deep in the solum would exclude influences by atmospheric oxygen but would not necessarily prohibit the infiltration from the soil surface of energy-supplying materials of organic origin. These might serve for use by anaerobic bacteria. Since recent studies emphasize the encouraging role of mineral nutrients, particularly of calcium, in organic matter decomposition and the diminished decomposition, or organic matter accumulation, under limited calcium supply,[4] it seems possible that gleization occurs in the zone where the three factors, ample calcium, organic matter infiltration, and standing water, all operate jointly for anaerobiosis.

That this may be true is suggested by an observation of clay standing under water. Putnam subsoil had been treated with acid and washed thoroughly to produce the resulting acid clay. Three lots in suspension were then treated separately with calcium hydroxide, magnesium hydroxide, and aluminum hydroxide. All were preserved under waterlogged conditions. After 3 months, the samples of the calcium-treated clay and of the magnesium-treated clay had developed the bluish-gray color resembling that of glei. The sample treated with aluminum showed no color change throughout its depth.[5]

[1] Contribution from the department of soils, Missouri Agricultural Experiment Station, Columbia, Missouri. Journal Series No. 701.

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[3] Joffe, J. S. 1936 Pedology, pp. 328–344. Rutgers University Press, New Brunswick, N. J.

[4] Albrecht, W. A. 1938 Nitrate production in soils as influenced by cropping and soil treatments. Missouri Agr. Exp. Sta. Res. Bul. 294.

[5] The differences in the samples were first observed and drawn to attention by Hans Winterkorn, research associate professor of soil mechanics, University of Missouri.

Since these clays contain some relatively stable organic matter representing the residue of microbial action which has been moved downward by podzolization, such organic residue would of necessity be relatively deficient in calcium and in magnesium as bacterial nutrients. It would still be of service as a source of microbial energy, however, and the promotion of microbial growth might occur when these mineral shortages were restored.

That an attack on this organic material by anaerobic microorganisms occurred where the calcium and magnesium were applied to the clay was indicated by the color change, and pointed to the reduction of the iron for the organic matter oxidation. Where neither calcium nor magnesium was applied to serve as nutrient bases, but where aluminum, a nonnutrient, or potassium was substituted, these anaerobic performances were not initiated.

That the exchangeable calcium plays a role is suggested by some studies by Wilde, of the Wisconsin Experiment Station.[6] Calculations from his determinations of exchangeable calcium in different horizons of alpha, beta, and gamma glei soils show that the glei horizon occurs where the calcium saturation of the clay was increasing in the successively deeper layers approaching the glei layer. In one of his soils, which he assigns to the Colby series, the percentage of calcium saturation in the zone of glei formation was slightly less than 50 per cent. In another, assigned by him to the Miami series, it was above this figure.

That at least 50 per cent calcium saturation of the clay should be required to foster anaerobic bacterial activity is in interesting agreement with the approximate 50 per cent calcium saturation of colloidal clay required for significant growth and nitrogen fixation by soybeans. It raises the question whether the profile horizons above that of glei formation are not simply of too low a degree of calcium saturation for microbial activity, so that the percolating organic matter is not of service until it has moved downward to the horizon of sufficient calcium saturation and the corresponding relative saturation of other bases.

These observations prompted a simple laboratory test. Untreated Putnam clay and Putnam clay saturated with different cations were taken in equal amounts and mixed with equal amounts of the humus compound extracted from a calcium-deficient soil. They were all stored under water. The soil given calcium became gray. No significant color change occurred in the clay saturated with aluminum, potassium, or hydrogen, or in the untreated clay.

These changes were noticeable in less than 4 weeks and became very distinct in 8 weeks or at the intervals of closer observation. After this latter period the stoppers were removed, cleaned, and the upper part of the cylinder cleaned in connection with the examination for odors. A distinct odor of hydrogen sulfide was detected over the calcium clay. It was less noticeable but yet present over the natural and potassium clay. There was none over the hydro-

[6] Wilde, S. A. 1940 Classification of gley soils for the purpose of forest management and reforestation. *Ecology* 21: 34–44.

gen clay or the aluminum clay. The stoppers bore dark stains corresponding to the hydrogen sulfide production. The supernatant liquids gave corresponding suggestions of iron in solution after enough time following the odor test had allowed them to clarify. Opalescence, suggesting colloidal iron, appeared over the natural and potassium clays, and a rusty-colored flocculate was over the gray-colored calcium clay. Thin horizons of gray color, of intensity corresponding to that of the calcium clay, appeared at the top of the natural and potassium clay columns (plate 1). Here the production of soluble iron is suggested, not in an acid soil, but rather at the maximum in the neutral clay saturated with calcium and providing nutritive conditions encouraging microbial performances.

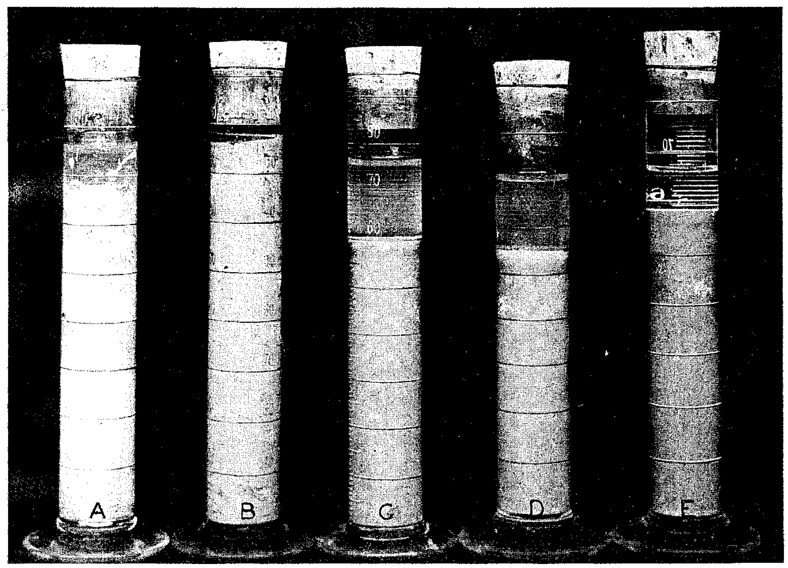
These observations and tests suggest that the process of gleization may center about the presence of calcium in sufficient degrees of saturation of the clay to serve in the bacterial nutrition if the horizon of standing water is to leave its historic record as a bluish gray layer. When such calcium is absent, and apparently because of this calcium deficiency in the bacterial ration, the event of standing water remains unrecorded, regardless of the period of its presence or the possible percolation of the organic matter downward to it.

This hypothesis regarding the importance of the degree of calcium saturation in the process of gleization is submitted not as a proved fact but in the hope that students of soils in the field will test it either for verification and acceptance or for disproval and discard.

PLATE 1

GLEIZATION OF PUTNAM CLAY

Clays saturated with (A) calcium, (B) aluminum, (C) potassium, (D) no cation, and (E) hydrogen. Gleization, or gray color production, occurred only in the calcium clay.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