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AMORPHOUS COATINGS ON SOIL MINERAL SURFACES SORB PHOSPHATE AND SULFATE

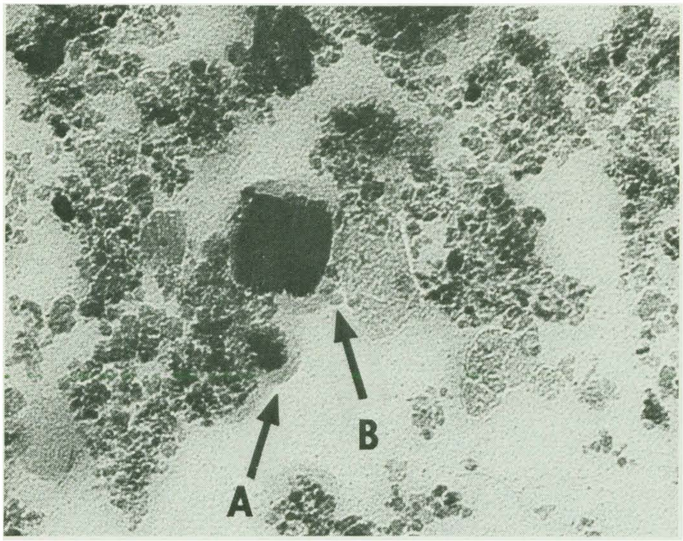

Fig. 1. Gibbsihumox (Halii series) showing highly hydrated gel coatings (A) that have been dehydrated and pulled apart (B).

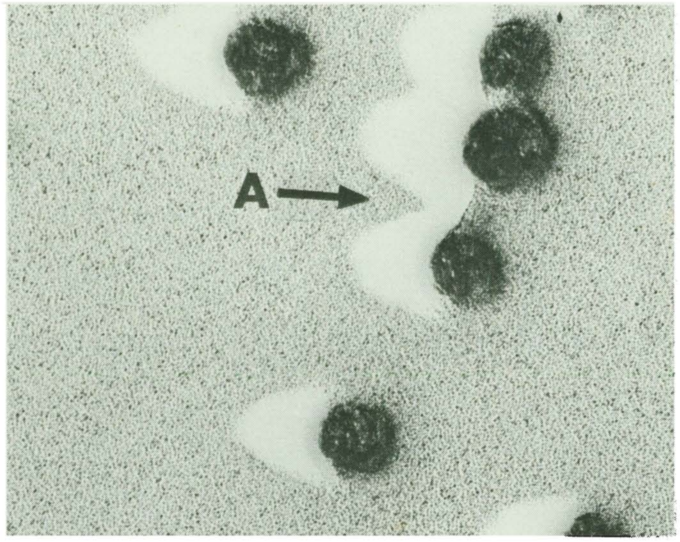

Fig. 2. Soil iron oxide particles shadowgraphed with platinum showing shadows cast by electron transparent coatings. Note overlapping shadows (A) associated with particles that do not touch.

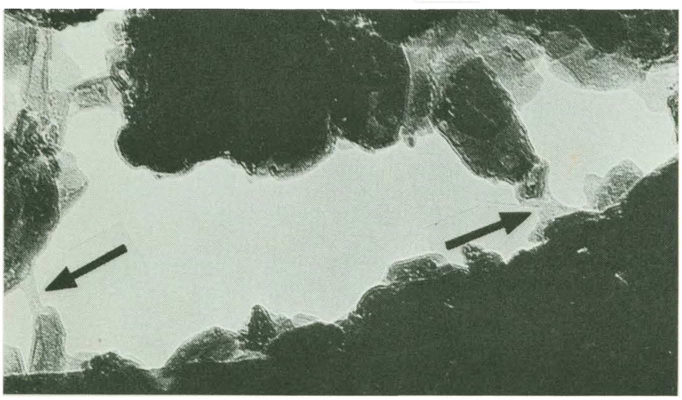

Fig. 3. Particles of halloysite from a Hawaiian Aridisol (Kawaihae Series) suspended by gel material over a hole in the specimen mounting substrate.

Table 1. Relationships among rainfall (a factor in soil formation), the quantity and composition of amorphous materials extracted from soils, and standard phosphate sorption by the soils

Soil series	Rainfall	Total extracted material†	Si content of extracted material	P‡ sorbed
	(mm)	*(%)*	*(%)*	*(μg/g)*
Lualualei	500	2.1	18	85
Molokai	600	1.1	16	145
Lahaina	950	0.9	14	145
Wahiawa	1200	1.0	7	235
Leilehua	1700	0.8	4	330
Paaloa	2300	0.8	2	435

†Repeated extractions with 0.5*M* $CaCl_2$.
‡At a concentration of 0.2 ppm P in solution.

Well-crystallized oxide minerals and layer-silicate clays such as kaolin are not highly reactive with phosphate and sulfate. Nevertheless, phosphate and sulfate are readily sorbed by many soils in which kaolin-type clays predominate. This property is strongly expressed in soils that are formed in weathered volcanic ash. Such soils usually contain a high percentage of amorphous gel-like material that has been desilicated during weathering. Probably all soils are influenced to some degree by amorphous materials. The quantity of such material need not be great if the colloid surfaces are thinly coated.

Gel-like coatings on soil mineral surfaces have been verified by electron microscopy (Figure 1). To verify that the observed coatings were not artifacts produced through preparation and viewing, iron oxide particles from the Alae clay of the Island of Oahu were shadowgraphed. Note that the shadows cast were wider than the clearly visible, dense particles (Figure 2). The gel coatings, which were almost electron-transparent, can be seen as faint halos surrounding the particles in the areas of the shadows. The shadows extended approximately 130Å beyond the surface of the central core. The term "gel-hull" has been used to describe this system.

Gel-like coatings can be seen where they are pulled out into thin strands between particles at the points of the arrows in Figure 3. This suggests that gels have an agglutinating effect on particles.

As gel material becomes silicon-depleted, properties approach those of hydrated oxides of iron and aluminum. These materials are very reactive with phosphate, and, if soil pH is low, great quantities of sulfate may be sorbed also. For example, in the depth increment 30–120 cm, a strongly leached Hydrandept from the Island of Hawaii (Akaka series) contained over 7000 μg SO_4–S per gram dry soil. Phosphate retention by the Akaka soil is even greater than sulfate retention, which is the reason why crops grown on this soil require so much phosphate fertilizer.

Few soils contain as much gel-like material as the Akaka soil. Nevertheless, the influence of amorphous material is probably much more extensive than is generally recognized. The data in Table 1 are an example of the relationship between the composition of gel materials in a group of soils and phosphate retention by the soils. The soils are representative of those used to grow sugarcane on the Island of Oahu. Note that it is the *silicon content* of the extracted material and not the *quantity* of the material that was extracted that is closely correlated with phosphate sorption.

Rollin C. Jones and Robert L. Fox—No. 15, 1978