A Model of Clay Swelling and Tactoid Formation

W. B. Kleijn and J. D. Oster

U.S. Salinity Laboratory, United States Department of Agriculture Agricultural Research Service, Riverside, California 92501, and Department of Soil and Environmental Sciences, Riverside, California 92521

Abstract: An electrostatic model for the stability of clay tactoids (stacks of parallel clay platelets at ~10 Å separation) in an aqueous solution has been developed. The counter ions located in the interstitial water layers are assumed to be in equilibrium with the bulk solution. Generally, the counter-ion charge density is slightly different in magnitude from the platelet charge density. Approximating the discrete charges by homogeneously charged planes, a one-dimensional potential distribution can be calculated. From this the Gibbs energy of electrostatic interaction (using single platelets as a reference) can be computed. The model predicts that clay minerals with high (vermiculite, mica) and low (pyrophyllite, talc) degrees of cationic substitution form stable tactoids. For smectites, charge density, electrolyte concentration, and counterion species determine the swelling characteristics. At a particular charge density, lower valences of the counter ions and lower electrolyte concentrations lead to increased swelling. If tactoids are formed, the number of platelets is governed by a dynamic equilibrium between electrostatic forces, van der Waals forces, and external forces, such as shear forces due to hydrodynamic flow.

Key Words: Electrostatic forces • Mica • Pyrophyllite • Tactoid • Talc • Swelling • Vermiculite

Clays and Clay Minerals; October 1982 v. 30; no. 5; p. 383-390; DOI: 10.1346/CCMN.1982.0300509

Clay Minerals Society (www.clays.org)