Compaction and Swelling of Ca-Smectite in Water and in $CaCl_2$ Solutions: Water Activity Measurements and Matrix Resistance to Compaction

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Abstract: Direct water-activity measurements were made for calcium-smectite-$CaCl_2$ mixtures. The samples used were prepared by high-pressure filtration and had water contents <0.60% by weight of clay. For deionized water, the water activity (aw) ranged between 1 and 0.4 and was independent of the pressure history of the clay cake. Good agreement was found with the results of an adsorption isotherm. Samples were also prepared in 1, 3, and 5 M $CaCl_2$ solutions. The final concentration of chloride present in the cakes was measured: substantial anion exclusion was observed. The water activity of the clay-salt mixtures depended on both the water content and the concentration of $CaCl_2$. The data can be well represented by the expression aw = min(aw_o, aw c * x aw s *), where aw_o is the water activity of the brine used to prepare the cake, and aw c * and aw s * are water activities calculated for clay (in absence of salt) and salt (in absence of clay), respectively. The compaction and swelling behavior of a core of the same Ca-smectite was also investigated for pressures (P) between 0.5 and 800 bar. In two compaction-swelling cycles total recovery of the void ratio (e) was observed with, however, large hysteresis in the relationship between e and P. The osmotic pressure developed in the core at equilibrium, evaluated using the water-activity data, was intermediate between the compaction and swelling pressures. Apparently, another force, P_m, linked to irreversible changes in the structure of the matrix was contributing to the resistance to compaction. P_m values agreed with literature results for Ca-smectite suspensions.

Key Words: Calcium chloride • Compaction • Matrix resistance • Rheology • Smectite • Swelling • Water activity

Clays and Clay Minerals; February 1991 v. 39; no. 1; p. 35-42; DOI: 10.1346/CCMN.1991.0390105

Clay Minerals Society (www.clays.org)