Probing the reactivity of clay-edge sites (aluminol to silanol) towards mineral surfaces

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The interaction of bentonite clay colloids with mineral surfaces in the presence of radionuclides may be important pertaining to the long term safety concerns of a nuclear waste repository. Probing aluminol and silanol groups at clay edge sites determining the reactivity and metal interaction are a special focus of research. Colloidal probes modified with Al_2O_3 and SiO_2 particles at the end of the AFM cantilever are used to mimic clay edge sites and estimate forces against mineral surfaces under varying pH and trace metal concentration, here Eu(III). With increasing pH (>6), as expected, a decrease in interaction forces between Al_2O_3 and SiO_2 particles with mineral surfaces (plagioclase, K-feldspar, quartz, biotite) was observed. Though Al_2O_3 and SiO_2 particles have similar adhesion forces towards mineral surfaces, at pH<6, SiO_2-K-feldspar and Al_2O_3-biotite are found to be higher compared to other colloid-mineral interactions. At pH 5, except for quartz, an increase in the [Eu(III)] from 0 to 10^{-5} M resulted in increase of adhesion forces between SiO_2 and mineral surfaces. In case of Al_2O_3, an increase in Eu(III) showed no significant change in interaction forces. At Eu(III) $=10^{-5}$ M, the order of $F_{adh(SiO2)}/F\ F_{adh(Al2O3)}$ for minerals is biotite(11.3 times)>plagioclase(4.55 times)>K-feldspar(3.03 times)>quartz(0.22 times). Interestingly, a change in the magnitude of adhesion forces (1.2 to 2 time) for four different alumina colloidal probes of similar size (8 μm) vs. a smooth biotite (Rq<1.2 nm) was observed, which is attributed to the rough features (of ~10 nm range) along colloidal particle verified by SEM and AFM, which demonstrates the influence of roughness on particle adhesion forces.