

Iodide interactions with clay minerals: The effect of cation exchange capacity and clay texture

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Clay minerals are good candidates for nuclear waste isolation as they have low permeabilities, favorable swelling properties, and high cation exchange capacities (CEC). In waste isolation designs, iodine-129 is particularly problematic. Anions are not typically considered to interact with clays as it is assumed that the fixed negative charge associated with clays repels the dissolved anion, iodide. This assumption makes iodine-129 a major component of receptor dose at time scales >10,000 years beyond disposal. This lack of interaction is corroborated by many batch studies, but diffusion experiments in compacted clays have shown iodide retardation relative to chloride. The reasons for this are unknown; however, several hypotheses include: redox transformation controls on sorption behavior, complex surface charge environments due to overlapping charge domains, and sorption to ancillary minerals or weathering products.

Typical studies to examine radionuclide partitioning focus on the use of a single clay mineral, and describe radionuclide uptake on a clay mineral within traditional concepts of surface complexation and ion exchange. This approach has been wildly successful at describing cation interactions with clays, but is complicated by practical and conceptual concerns when studying iodide interactions. Alternatively, we studied iodide interactions with a suite of clay minerals representing several solid phase chemistries, and two distinct textures. In this scenario, the independent variable becomes the CEC.

Batch iodide uptake experiments were completed with seven clays from the Clay Bank Repository, Purdue University. The seven clays include kaolinite, ripidolite, illite, illite/smectite mixed layer, montmorillonite, sepiolite, and palygorskite. The CEC was determined for each clay mineral using the methylene blue method. Iodide uptake was characterized for all seven clays in a range of symmetric electrolytes at variable concentrations. The results show clear connections between iodide uptake and CEC. Larger CEC values have smaller iodide uptake consistent with charge repulsion arguments. However the variability as a function of electrolyte identity and concentration suggests a mechanism based on ion-pair formation in the interlayer space. There was also a clear difference in iodide uptake behavior between the two major clay textures considered. Ion pairing may be a significant factor in describing ion migration through fine grained media.

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