THERMAL STABILITY

All minerals and the rocks that contain them undergo some alteration as a result of exposure to elevated temperature. In most cases, the alteration is not very dramatic until very high temperatures are reached. However, some minerals, particularly the minerals involved in ion exchange reactions, are susceptible to alteration at fairly low temperatures. Because clay minerals and zeolites — major factors in a rock's ion exchange capacity — contain a lot of water in their structure, they are susceptible to dehydration or water loss at temperatures as low as 100 °C. Dehydration not only changes the exchange capacity of a mineral, it also generates liquid water in the pores surrounding the repository that may act to conduct heat produced by decaying radioactive waste. The same water may also have a corrosive effect on the canisters containing the spent fuel rods.

A dramatic demonstration of dehydration is offered by the exfoliation or flaking of vermiculite, a commonly occurring clay mineral. Although vermiculite is not a common mineral in the rocks of the proposed repository, its behavior when exposed to a sudden temperature increase is a graphic example of a type of thermal alteration. Clay minerals are aluminum-silicon compounds (aluminosilicates) like zeolites but, unlike zeolites, are constructed of layers held together by interlayer, exchangeable cations — just as mortar holds the cinderblocks together to construct the foundation of a house. Vermiculite has a large capacity for cation exchange.

Cations in water are surrounded by oriented water molecules. Some cations like the magnesium ion, (Mg^{2+}) which is an interlayer cation of vermiculite, hold this water, called "waters of hydration," tightly. This attraction is weaker between water molecules and other cations like the potassium ion (K^{+}). During the cation exchange reaction, the magnesium ion keeps its waters of hydration and leaves the interlayer, whereas the potassium ion loses its water of hydration and takes its place. Much of the water in clay minerals is found in the interlayer and is associated with exchange ions such as Mg^{2+}.

The purpose of this activity is to demonstrate a dramatic mineral alteration resulting from exposure to a sudden temperature increase. It is important to realize that the temperature rise used in this experiment is much larger than any anticipated in and around the proposed repository.