THERMAL STABILITY

Some of the repository minerals most susceptible to thermal alteration (change due to exposure to heat) are the same minerals responsible for sorption characteristics important to repository performance. Many of the minerals that are important in sorption and ion exchange reactions (e.g., clay minerals and zeolites) contain large amounts of water as part of the mineral structure. When these minerals are heated, the water is boiled off and contributes to the volume of water that can transport soluble wastes away from the repository. If the minerals are exposed to a large and rapid temperature rise, they may be irreversibly altered in ways that often reduce their sorption and ion exchange capacities. In this activity, we use the clay mineral vermiculite to demonstrate one mineral's dramatic range of responses to heat exposure.

Naturally occurring vermiculite is saturated with magnesium ions and, thus, loaded with interlayer water. If such a vermiculite is exposed to a solution containing potassium during ion exchange, the Mg^{2+} is expelled along with its water and K^{+} enters the interlayer. However, without the cushion of surrounding water molecules, the clay mineral layers collapse around the K^{+}. Once the mineral structure collapses, the cation exchange capacity of the vermiculite decreases--especially toward hydrated cations like Mg^{2+}.

If magnesium and potassium saturated vermiculites are exposed to a substantial (300-400 °C [570-750° F]) temperature rise, the large amounts of water surrounding the magnesium ion and small amounts of interlayer water trapped within the potassium saturated vermiculite will be vaporized and leave the clay. However, the reactions of the two clays to heat are dramatically different. The Mg-vermiculite behaves like popcorn and the K-vermiculite behaves like a grilled cheese sandwich. Water inside a popcorn kernel, when heated, ruptures the kernel in its effort to escape as steam. The steam violently escaping from the Mg-vermiculite structure "pops" the clay structure. On the other hand, when K-vermiculite is exposed to the same heat, the small amount of water escapes quietly and the clay layers move closer together just as the slices of bread (clay layers) move together as the interlayer cheese melts.