

# STRUCTURAL OXYGEN- AND HYDROGEN-ISOTOPE EXCHANGE IN SMECTITE-BEARING CLAYS

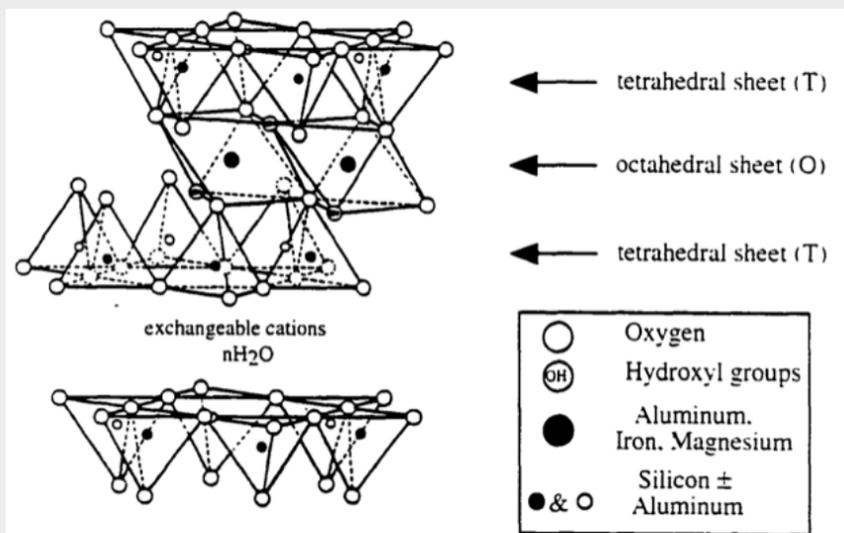
The isotopic signatures of hydrogen- and oxygen-isotopes found in the pore water of clays can give us information about the age and origin of both the water and the rocks. Was the water there when the rocks were formed? If not, where did it come from and how did it get there?

Some rocks, such as clay-bearing rocks, have minerals containing hydroxyl groups (OH) within their crystalline structures, whose oxygen (O) and hydrogen (H) isotopes may exchange with those of the pore water. If this occurs, how can we be certain of the origin of the pore water based on its isotopic signature?

The degree to which the O- and H- isotope composition of entrapped pore water and rocks may be altered is based on: the temperature of the system, the duration of the interaction, and the extent of contact

(Longstaffe F.J., Clark, I.D., & Chauvin S. 2017)

Smectite-bearing clays readily retain pore water and are commonly called swelling clays.

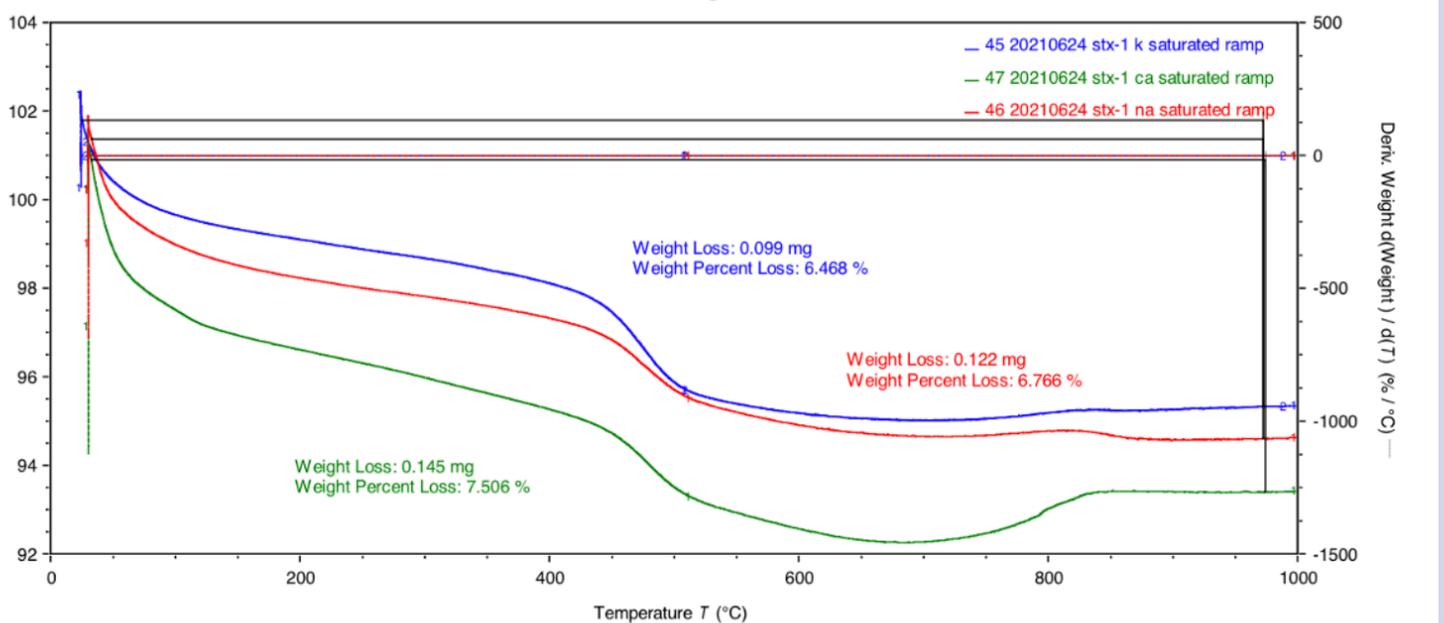


**Smectite Mineral Structure (Grim R.E. 1968)**. The exchangeable cation has implications on how tightly the clays hold onto pore water (Fagan, R. 2001). The amount of pore water available for exchange may influence the isotopic signatures of the OH groups found in the clays.

## Observing Exchange: Preliminary Observations

Measuring the O- and H- isotopic compositions of smectite bearing clays is no simple task. Since the hydroxyls found in the rock are part of its crystalline structure, the samples must first be heated to remove pore water and then further heated for dehydroxylation to occur (Guggenheim, S., Koster van Groos, A.F., 2001). However, since smectites are swelling clays and have high residual water retention, it is important to observe the effect of cation saturation on water retention and, consequently, isotopic exchange. Preliminary runs to observe dehydroxylation of a smectite standard sourced from the Clay Mineral Society is shown below:

SIX-1 Weight % Loss



Weight percent loss in STx-1 K-saturated, Ca-saturated, and Na-saturated samples. Dehydroxylation typically occurs at approximately 600 degrees Celsius. Note the difference in water loss among saturated samples due to their ability to retain water.

With a method in place to remove the structural oxygen and hydrogen from samples for isotopic analysis, exchange experiments may begin. Using a water of known isotopic composition clays will interact with the water under variable time and temperature conditions. These experiments provide a benchmark for methods of examining rock-water isotopic exchange and measuring isotope values.

### Works Cited:

Fagan, R. (2001). *Oxygen- and Hydrogen-Isotope Study of Hydroxyl-Group Behavior in Standard Smectite and Kaolinite*. (Unpublished doctoral dissertation). University of Western Ontario, London, Ontario, Canada.

Longstaffe F.J., Clark, I.D., & Chauvin S. (2017). Investigation of clay-water H- & O-isotope interactions in fine-grained sedimentary rocks. Nuclear Waste Management Organization 15th Annual Geoscience Seminar, Toronto, Ontario, Canada, June 7-8, 2017.

Grim, R. E. (1968). *Clay mineralogy*. (2d ed.). New York: McGraw-Hill.

Guggenheim, S., Koster van Groos, A.F. (2001). Baseline studies of the clay minerals society source clays: Thermal analysis. *Clays Clay Miner.* 49, 433-443. <https://doi.org/10.1346/CCMN.2001.0490509>

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