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Build-up of Accessory Mineral Layers During Erosion of Buffer Material

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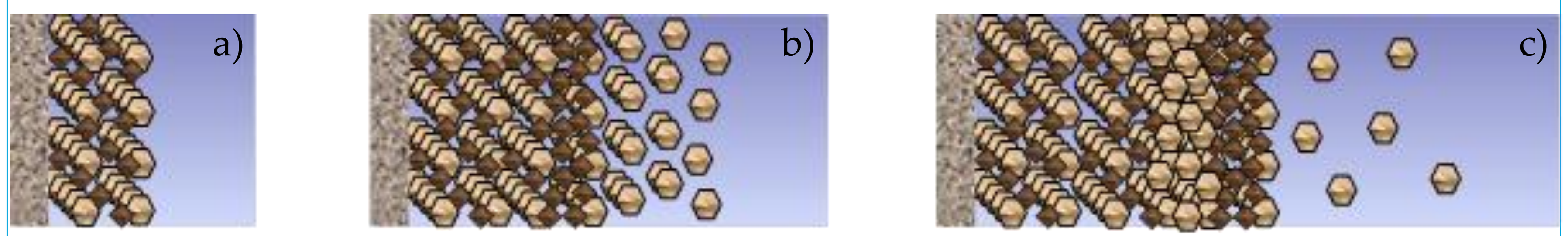
INTRODUCTION

Following erosive loss of colloidal montmorillonite through contact with dilute groundwater at a transmissive fracture interface, accessory phases within bentonite, such as quartz, feldspar, etc., might remain behind and form a filter bed or cake. As more and more montmorillonite is lost, the thickness of the accessory mineral bed may increase and the continued transport of montmorillonite slows and possibly stops if the porosity of the filter bed is sufficiently compressed. As the accessory mineral filter bed retains montmorillonite colloids, a filter cake composed of montmorillonite itself may also be formed. Ultimately, depending on their extent, properties, and durability, such processes may provide the bentonite buffer system with an inherent, self-filtration mechanism which serves to limit the effects of colloidal erosion.

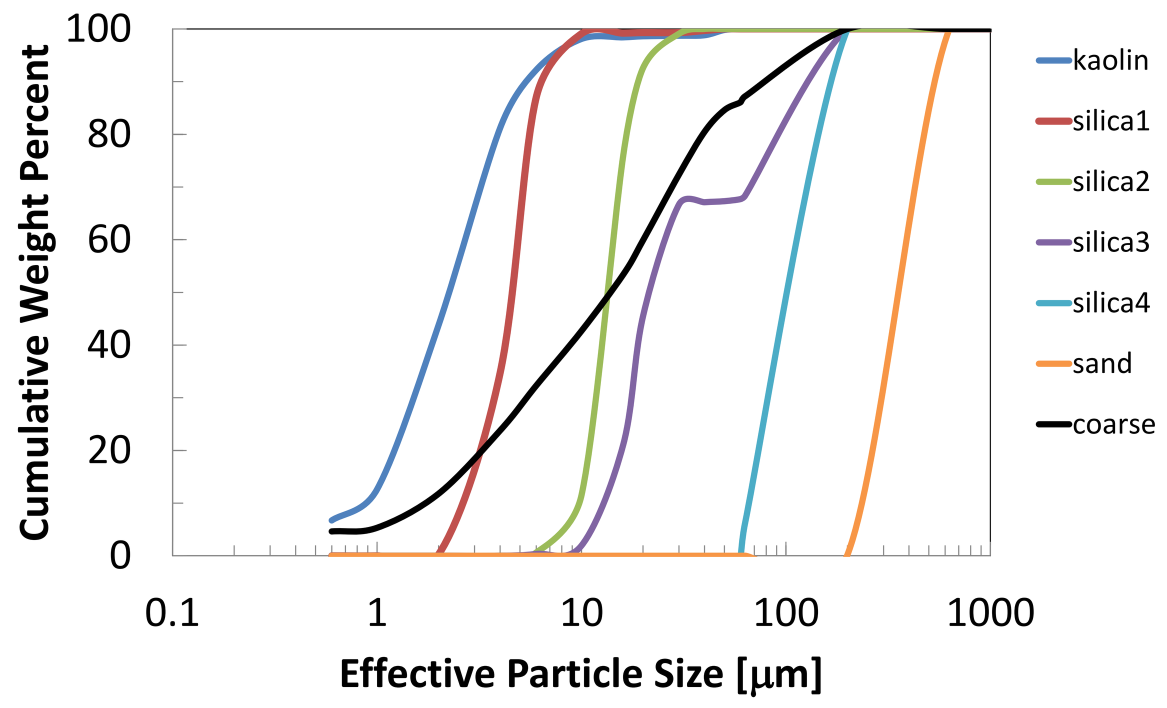
CONCEPTUAL VIEW



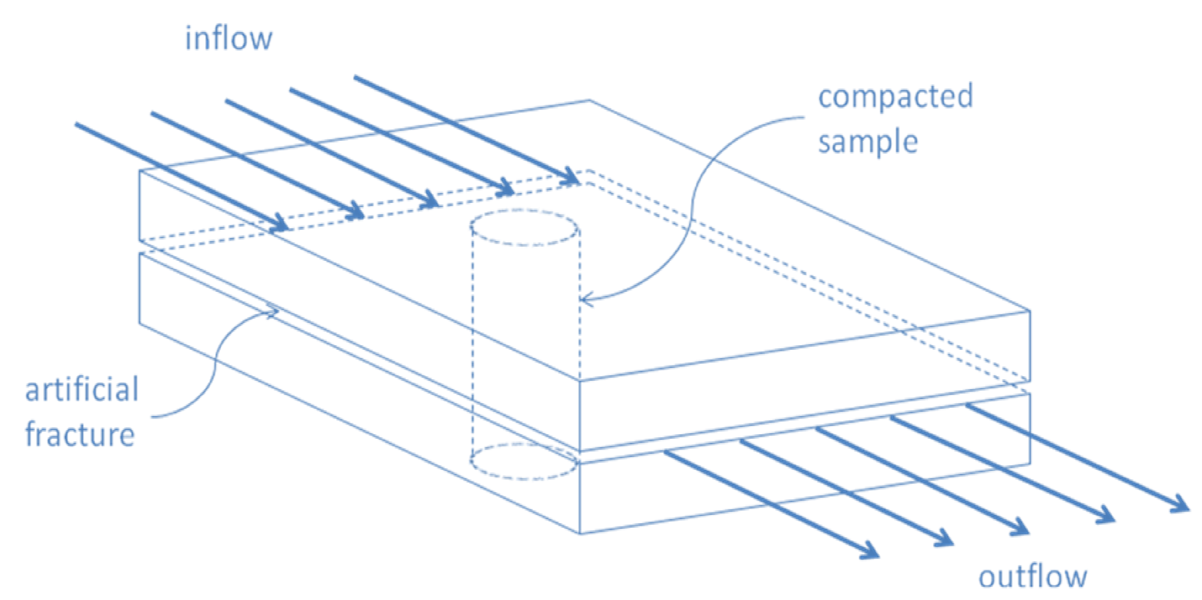
Conceptual view of a) extrusion of bentonite buffer material into an intersecting fracture, b) subsequent montmorilllonite erosion and accessory mineral filter bed formation, and c) montmorillonite filter cake formation. Montmorillonite colloids are represented as tan hexagons, accessory mineral particles as brown diamonds, and compacted bentonite buffer by the solid block on the left.

MATERIALS AND METHODS

In order to examine whether the erosion of bentonite material through contact with dilute groundwater at a transmissive fracture interface could intrinsically result in 1) the formation of an accessory mineral filter bed and cake and/or 2) filter caking of montmorillonite itself, a series of laboratory tests were performed in a flow-through, horizontal, 1 mm aperture, artificial fracture system. Bentonite buffer material was simulated by using mixtures (75/25 weight percent ratio) of purified sodium montmorillonite and various additives serving as accessory mineral proxies (kaolin, quartz sand, chromatographic silica). A test was also performed using MX-80 bentonite washed free of soluble material and thoroughly exchanged with sodium cations. The fracture erosion tests were performed using a Grimsel groundwater simulant (relative to Na^{+} and Ca^{2+} concentration only) contact solution at an average flow rate of 0.09 ml/min through the system.



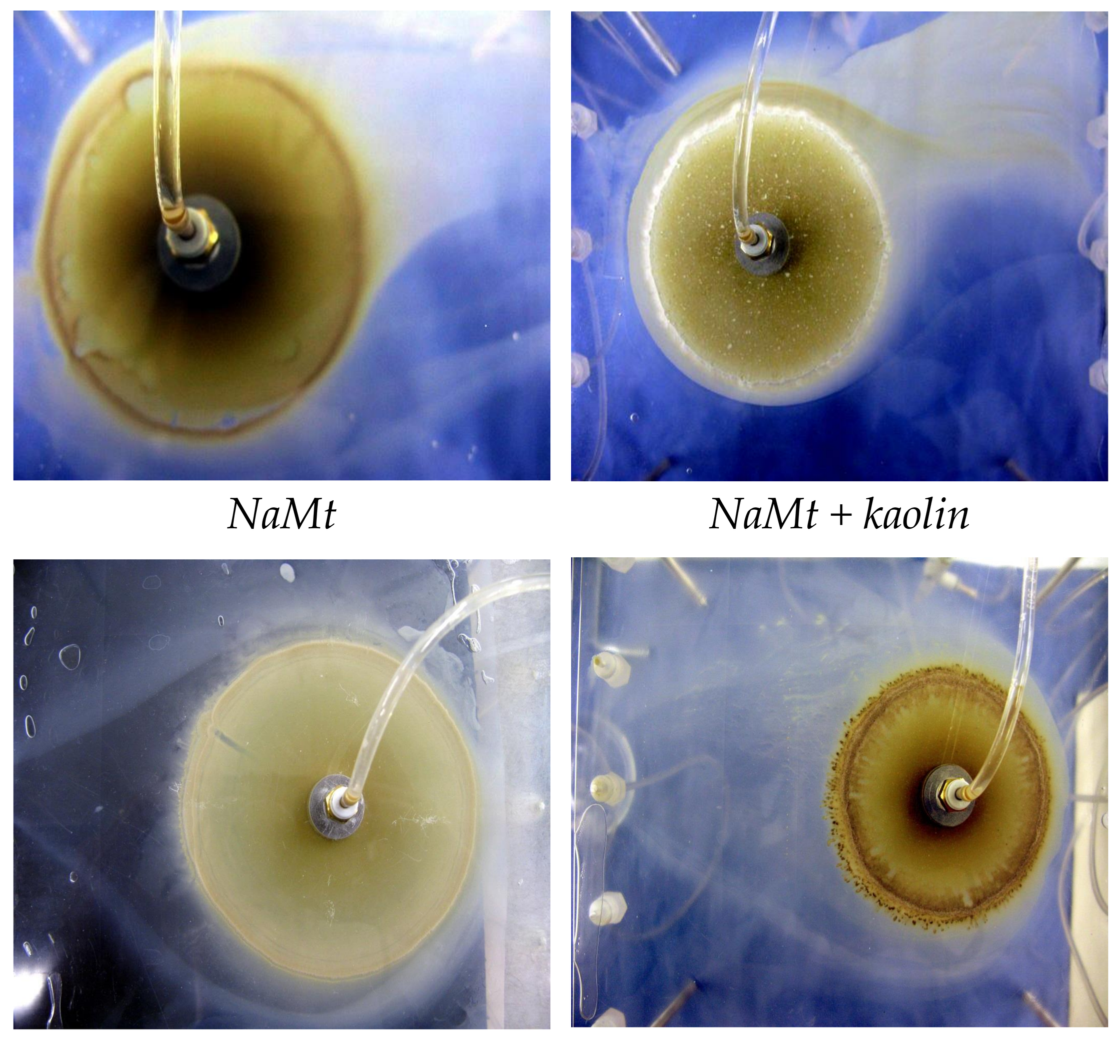
Effective particle size distribution of the added "accessory" minerals and bentonite coarse fraction from sedigraph analysis



Schematic representation of the flow-through, artificial fracture test system.

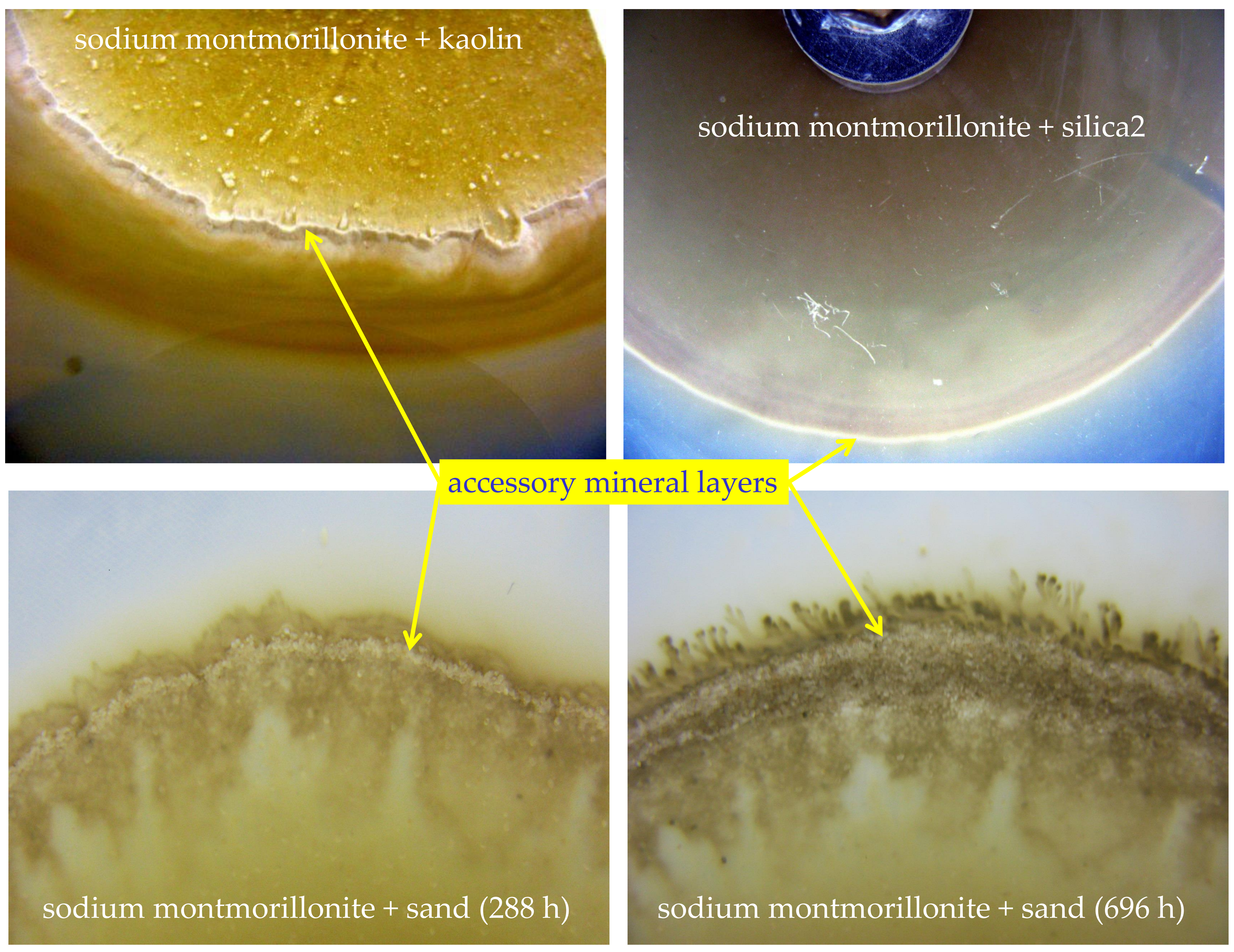
TEST CONDITIONS

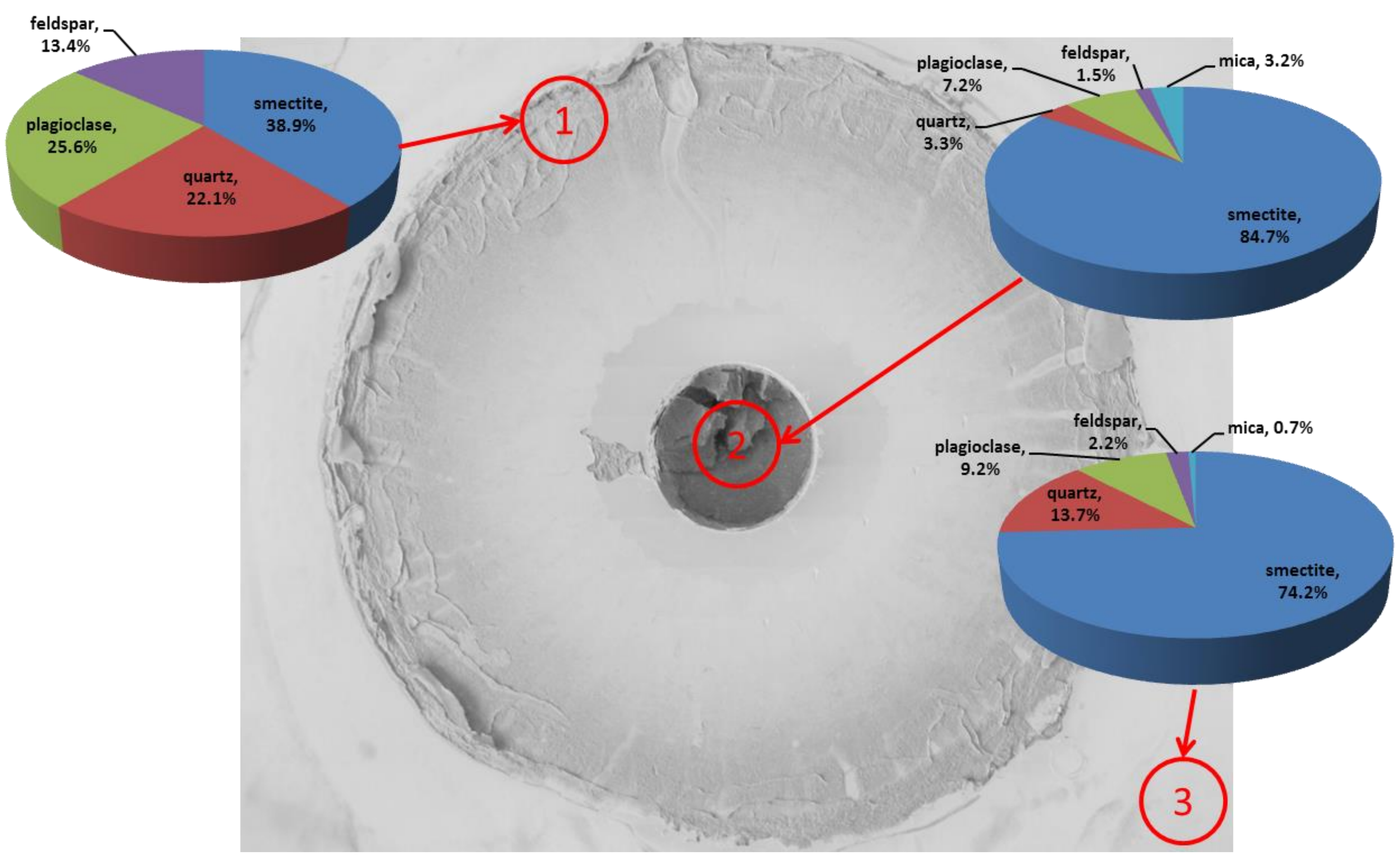
The tests are designed to lead to the development of eroding clay conditions, i.e., sodium montmorillonite (NaMt) against a dilute solution (Grimsel groundwater simulant).



NaMt · *NaMt + kaolin* · *NaMt + silica2* · *NaMt + sand*

RESULTS





Flow-through test in artificial fracture with conditioned MX-80 after drying overlaid with mineralogical composition results from samples at the indicated positions. Sample material at erosion interface (1) contains a larger fraction of accessory minerals than starting material (2).

CONCLUSIONS

These results provide evidence that, following erosive loss of colloidal montmorillonite through contact with dilute groundwater at a transmissive fracture interface, accesory phases (from within bentonite) remain behind and form layers which increase in thickness with erosion time. Moreover, these bed layers were found to be stable over the course of the tests. However, no significant attentuation of the erosion of montmorillonite was observed in the tests with added accessory materials relative to montmorillonite alone in a 1 mm aperture fracture; the mineral layers may not fill the entire aperture.

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