

## Sandstone mineral accessibility for acid-driven reactions via BSE-EDX imaging

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Accurate quantification of mineral accessibility is key to predicting the acid-driven reactions in sandstones that will take place in the context of geologic sequestration of carbon dioxide. A novel imaging method was developed that combines backscattered electron (BSE) microscopy and energy dispersive X-ray (EDX) mapping in a way that maximizes accuracy and resolution in mineral identification and quantification. The method was used to analyze thin sections of five samples – three sandstones, one conglomerate sandstone, and one shaly sandstone – from the Viking formation in the Alberta Basin (Canada). Porosity, mineral abundance, and mineral accessibility to pore space were determined. This extends our earlier work [1], which used BSE imaging alone and quantified accessibility for broad classifications of mineral categories.

Pore space ranged from 6.6% in the shaly sandstone sample to 19% in one of the sandstone samples. In all cases, quartz was the most abundant mineral (50.1%-87.6%), followed by kaolinite (6.64%-39.0%) and potassium feldspar (1.50%-10.3%). Analysis showed that mineral accessibility is not equal to mineral abundance, the quantity that is commonly used as a surrogate in reactive transport modeling. The accessibility of kaolinite or calcite was an order of magnitude larger than the abundance. The accessibility of K-feldspar, annite or anorthite was one or two orders of magnitude less than the abundance. Different patterns of abundance and accessibility were observed in different types of sandstone. In the shaly sandstone, kaolinite was present as a cement, though fractures sometimes exposed other minerals to pore space. In sandstone and conglomerate sandstone samples, kaolinite was present as a coating, armoring mineral grains from the pore fluid, and reactive minerals were often inclusions in quartz grains. In all three types of samples, almost all of the pore space perimeter (96.9%-99.9%) was in contact with either kaolinite or quartz, both of which are non-reactive under acidic conditions.

[1] Peters (2008) *Chem. Geol.*, doi:10.1016/j.chemgeo.2008.11.014.

## Contaminant transport in complex heterogeneous geological media: New insights through micro-imaging and micro-spectroscopy

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The concern about the behavior of hazardous chemicals in the subsurface environment has resulted in the development of numerous theoretical models incorporating an ever increasing number of reactive transport processes. While the (hypothetical) complexity of the theoretical models increased steadily, the corresponding growth in quantity and quality of experimental investigations did not keep pace, by far. However, reliable experimental data are most crucial regarding model validation and calibration. In particular field-scale data of highly reactive chemicals with large retardation are extremely scarce.

Recent advancements in micro-analytical techniques, in particular synchrotron based x-ray microprobe and tomographic techniques as well as laser ablation ICP-MS open new opportunities in investigating and visualizing the multi-dimensional spreading of strongly retarded chemicals under realistic field conditions.

Within the present study, such microprobe techniques were employed to analyze the field-scale migration of Cs as investigated at the Mont Terri Underground Rock Laboratory. The diffusion pattern from a Cs source into the bulk rock (Opalinus Clay Rock) was studied by complementary techniques including bulk analysis, micro-laser ablation-ICP-MS, as well as synchrotron-based micro-tomography, micro-XRF, micro-XRD and EXAFS. However, the chemical complexity of the geological medium made the application of an advanced detection scheme with superior spectral resolution mandatory.

The host rock material was shown to be a complex mineral composite with an interlinked 3D network structure. This natural chemical and physical (micro-) heterogeneity had a strong impact on the observed reactive transport pattern. Based on the suite of complementary investigations new insights into the diffusion process of highly reactive chemicals in complex natural porous media could be elaborated.