3rd International Conference on Tomography of Materials and Structures
Lund, Sweden, 26-30 June 2017, ICTMS2017-62

IDENTIFYING BIO-MEDIATED LOW TEMPERATURE ALTERATION IN BASALTIC ROCKS

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Keywords: X-ray tomography, reactive percolation experiments, basalt, endolithic microbial communities

Summary: Reactive percolation experiments, with pre- and post experiment µCT scanning, on solid basaltic rock can be used to identify the extent to which low temperature basalt alteration is microbially mediated. Comparison between 3D data from two experiments, one sterile and one inoculated with subsurface microbes, indicate that the manner and magnitude of alteration differs when the rocks are host to active microbial communities.

1. INTRODUCTION

Understanding bioaccessible porosity within basaltic rocks and how it evolves when exposed to fluid percolation is a key factor in understanding how deep subsurface basalts can host microbial communities, and ultimately what role these communities may play in low temperature basalt alteration. Alteration occurring via fluid circulation is a key process of carbon fixation through the formation of solid carbonates[1]. Carbonation of basalts is being explored as potential avenue of permanent carbon storage[1]. At this time, it is known that basalt-hosted microbial communities have the capacity to fix carbon into biomass, and that they are involved in low temperature alteration[2]. The extent of their involvement, and the manner in which they influence alteration rates and products is unknown.

In the deep subsurface communities of microorganisms are energy, nutrient, and space limited[3,4]. Bioaccessible porosity provides space for microbial communities, in the form of biofilm, to exist and grow, additionally pores and fractures also provide access to minerals surfaces which can supply energy and nutrients. While porosity evolves with abiotic fluid percolation it is also influenced by microbial communities found within the rock[3]. However, the magnitude to which basalt alteration is driven or mediated by microorganisms is poorly understood.

2. EXPERIMENTAL METHOD

In order to characterize how porosity evolves in response to fluid percolation, and to identify the role microorganisms play, two reactive experiments mimicking fluid circulation in the subsurface were designed and implemented. One experiment was performed under sterile conditions and the other with a microbial inoculate derived from a ground water enrichment culture. For both, a reactor chamber with 5 cores (core size: 15 mm diameter and 29 mm long) of basaltic rock was prepared. The experiments were performed with a CO_2 partial pressure of 6 bar at 35°C and 30 bar of pressure for 21 days each.

The first two cores for each experiment were scanned both before and after the experiments on the EasyTom XL Duo set at the IC2MP (Plateforme Caractérisation de matériaux), Université de Poitiers, resulting voxel size ~13 µm. The physical changes which occurred during the experiments were visualized by aligning the pre- and post-experiment scans of the cores using landmark based registration, and quantified using mass balance measurements.

To better resolve changes in material at mineral:mineral and mineral:pore interfaces synchrotron radiation X-ray tomographic microscopy (SRXTM) was performed at the TOMCAT beamline, Swiss Light Source, on material from both experiments. These data sets, voxel size 332 nm, allow for resolution of sub-µm features.

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3. RESULTS

In both the abiotic and inoculated experiments a range of dissolution features have been identified and material migration within large pores has been observed, however the µCT scans only resolved macro porosity and bulk mineral features within the cores. Nevertheless, material migration within pore space, and some dissolution features are visible in data volumes from both experiments (Figure 1). SRXTM data allowed for the resolution of micrometer to sub-micrometer scale porosity, and more detailed visualization of the interfaces between different phases. Combining these two data sets suggests that both abiotically and biologically mediated alteration occurs at the micrometer to sub-micrometer scale when observed a short temporal period. These results combined with chemical analyses on fluids from the experiments show that low temperature basalt alteration is not the same in sterile and non-sterile systems. This suggests that future applications of carbon storage within basalts at low temperatures should account for any bio-effects endemic microbial communities may have on fluid-rock interactions within the selected substrate.

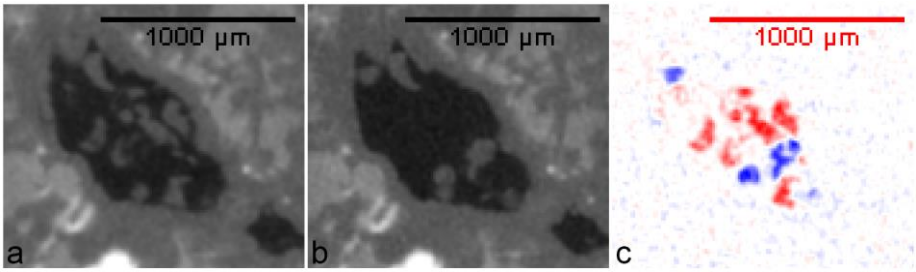

Figure 1: Material migration or dissolution visible within a pore. a) a slice within the middle of a pore from before the abiotic experiment, b) a slice showing the middle of a pore after the experiment, c) observed material migration or movement within the pore. Red reflects material in place before the experiment which is no longer present. Blue shows material present after the experiment but not before.

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