Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7739

Quantifying mineral-specific reactive surface areas in intact basalt using SEM imaging

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CO_2 mineralization in oceanic basalts has proven to be a viable and secure technique for controlling atmospheric CO_2 concentrations and preventing the worst consequences of global climate change. However, extrapolating laboratory-measured carbonation rates to the field scale has proven challenging, due to an inability to quantify important, rate-controlling parameters, such as primary mineral reactive surface areas. In particular, bulk surface area techniques, such as BET gas adsorption and geometric SSA calculations, only quantify *total* surface area, rather than mineral-specific surface areas. Here, we quantify the surface area of individual minerals in direct contact with pores in a permeable, porous basalt sample using a combination of backscatter electron imaging (500 nm/pixel) and image processing techniques. The sample was also subjected to CO_2 mineralization experiments (Luhmann et al. 2017), thus permitting direct comparison between our calculated surface areas and those determined through inverse modeling of effluent chemistry. The SEM images were segmented into pores, plagioclase, pyroxenes, olivine, and opaques using the PerGeos software package. Importantly, the grayscale threshold for pores was set so as to permit the inclusion of microfractures (Figure 1), which are vital for fluid percolation and mineral reactions but may also contribute to permeability reductions after mineralization. The pore threshold image was dilated (Figure 2) and processed against each mineral component to create separate mineral-pore edge images. The resultant data set permitted the quantification of areas of mineral-pore contact in cm^2. The resultant specific surface areas of plagioclase are in excellent agreement with those obtained from inverse modeling of effluent chemistries, but several orders of magnitude lower than the whole-rock BET SSA.

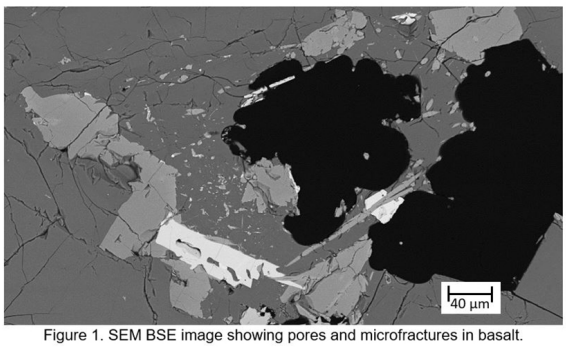

Figure 1. SEM BSE image showing pores and microfractures in basalt.

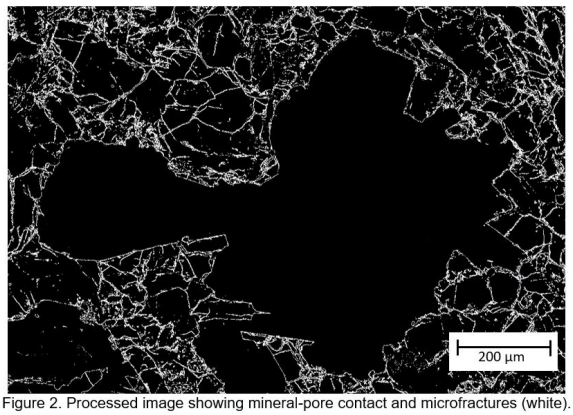

Figure 2. Processed image showing mineral-pore contact and microfractures (white).