Goldschmidt 2024 Abstract
https://doi.org/10.46427/gold2024.23716

Microreactors for in-situ study of olivine dissolution rates under conditions relevant to enhanced weathering

LOES KLEINSMIT[1], JOSHUA T. LOESSBERG-ZAHL[1], JOHAN G. BOMER[1], POL C.M. KNOPS[2], JEROEN C. VOLLENBROEK[1], ROALD M. TIGGELAAR[1] AND MATHIEU ODIJK[1]

[1]University of Twente

[2]Paebbl

Presenting Author: m.h.kleinsmit@utwente.nl

Introduction

Enhanced weathering of silicate minerals, such as olivine, is recognized as a promising carbon dioxide removal technology for addressing climate change [1]. Despite its potential, wide-scale application of the technology has thus far been hampered by slow dissolution kinetics associated with the formation of a passivating surface layer [2]. To advance the understanding of this passivation layer formation mechanism, we developed a silicon/glass microreactor that enables in-situ quantitative analysis of the dissolution rate of olivine under enhanced weathering conditions (T = 155°C, P = 185 bar) [3]. We envision that this microreactor will enable study of the influence of novel physicochemical conditions on passivation layer formation, such as (UV-)light intensity, shear force, electric field strength, and the presence of supercritical CO_2.

Method

Olivine particles are trapped in the reactor area (Figure 1) where they dissolve in an acidic, aqueous flow, releasing magnesium ions according to the dissolution reaction equation: $MgSiO_4$ + $4H^+$ -> H_4SiO_4 + 2 Mg^{2+} [4]. A second flow containing a magnesium-sensitive fluorophore is introduced parallel to the first. On the interface between the two fluids, diffusive mixing takes place, resulting in a fluorescence intensity that is linearly proportional to the magnesium ion concentration.

Results

The experimental work shows a linear response between fluorescence intensity at the interface and magnesium ion concentration for concentrations up to 1250µM (Figure 2), at pressures up to 50 bar and temperatures up to 135°C. Preliminary experimental work showed the feasibility of detecting magnesium ions in the sub-10 micromolar range.

References

[1] - R. S. Haszeldine et. al., Phil. Trans. R. Soc. A., 2018
[2] - H. King et. al., Environ. Sci. Technol. 2010
[3] - W.K. O'Connor, SME Annual Meeting & Exhibit, 2001
[4] - N.C. Johnson et. al., Chemical Geology, 2014

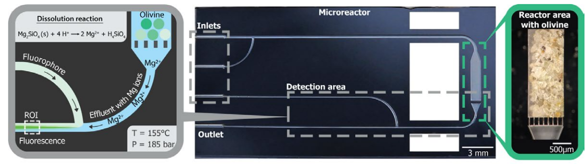

Figure 1 | Left: Schematic of operational principle as described in the method. **Center:** Cleanroom fabricated microreactor. **Right:** Olivine particles loaded in the reactor area.

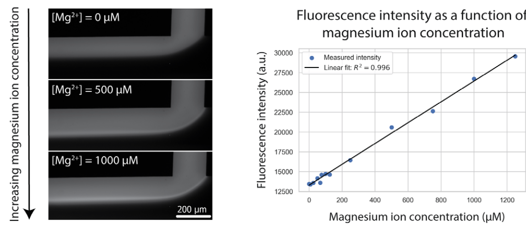

Figure 2 | Left: Fluorescence intensity on the interface increases for increasing $[Mg^{2+}]$. **Right:** Linear relationship between the maximum fluorescence intensity on the interface and $[Mg^{2+}]$ using standard magnesium chloride solutions.