

Explore the apparent gap between field and lab dissolution rate: A study of the Navajo sandstone

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It is well known that the dissolution rates of silicate minerals in natural systems are 2-5 orders of magnitude slower than rates measured in the laboratory experiments^[1-2]. Among the possible factors, the treatment of reactants in laboratory experiments via crushing and grinding may be one of the culprits, which generates high energy sites on mineral grain surfaces that may artificially increase orders of magnitude of the reaction rates^[3]. It is therefore useful to measure dissolution rates on field, “intact” grains. This was achieved by using Si isotope-doping method in a flow-through reactors^[4-5] that increased orders of magnitude detection sensitivity than traditional rate measurements using Si concentrations. MC-ICP-MS is applied to measure silicon isotope ratios, and other cations are measured by ICP-MS and ICP-OES.

The results from experiments on two types of the Navajo sandstone samples indicated that the dissolution rates of “intact grains” of the Navajo sandstone samples are measurable in laboratory. We further explore the dissolution rate in solutions similar to situ groundwater and in diluted solution to explore environmental factors. Moreover, The reaction-transport processes in the aquifer (“environmental factors”) were simulated by geochemical modeling, in order to reveal the Navajo sandstone dissolution progress in natural conditions. Combining experimental and geochemical modeling results, the limitation of surface characteristics of the natural samples on dissolution rates, and reasons for discrepancy of dissolution rate between laboratory environment and natural environment are explored.

[1] Zhu et al., 2004 Water-Rock Interaction

[2] Zhu 2005 GCA 69(6)

[3] Lüttge 2006, Journal of Electron Spectroscopy and Related Phenomena 150(2-3)

[4] Gruber et al., 2013 GCA, 104

[5] Zhu et al., 2016 GCA, 445