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Rodrigo F. Embile, Jr., Ingar F. Walder, John J. Mahoney

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Forsterite and pyrrhotite dissolution rates in a tailings deposit obtained from column leaching experiments and inverse modeling: A novel method for a mine tailings sample

Rodrigo F. Embile Jr.[1,2], Ingar F. Walder[1,2], and John J. Mahoney[3]
[1]*New Mexico Institute of Mining and Technology, Socorro NM, USA 87801*
[2]*Kjeøy Research and Education Center, Vestbygd, Norway 8412*
[3]*Mahoney Geochemical Consulting LLC, Lakewood CO, USA 80226*

Abstract

The dissolution rates of forsterite and pyrrhotite in a mine tailings deposit as a function of pH were obtained using kinetic testing (leaching test) and PHREEQC inverse modeling. Leach columns containing nickel sulfide mine tailings from four locations in a tailings deposit were subjected to weekly flushing with distilled water. The dissolved moles of forsterite and pyrrhotite were obtained based on the assumption that bulk of the Mg^{2+} and SO_4^{2-} present in the leachate come from the dissolution of forsterite and pyrrhotite, respectively. The moles dissolved during a steady-state dissolution period were normalized by the BET and geometric surface areas. The dissolution rate with respect to pH was obtained by regressing the plot of log(rate) and log(H^+).

This relatively simple method of obtaining dissolution rate of minerals from a heterogeneous material such as mine tailings can be applied to other settings as long as proper mineralogical characterization and modeling constraints are taken into account. The obtained dissolution rates can then be used in reactive transport modeling for the prediction of long-term leachate chemistry of the tailings.

Keywords: Forsterite; pyrrhotite; dissolution rate; kinetic test; inverse model

1 Introduction

Mineral dissolution rates are typically obtained from experimental studies in laboratory settings using pure minerals under controlled conditions such as temperature, pH, solution composition and mineral surface area. In a heterogeneous material such as mine tailings, individual mineral dissolution rates are difficult to assess (CEN, 2012). This study aims to obtain mineral dissolution rates of forsterite and pyrrhotite in a mine tailings deposit as a function of pH using a relatively simple method of long-term kinetic or leaching test (CEN, 2012) and PHREEQC (Parkhurst and Appelo, 2013) inverse modeling. The variation in dissolution rates as a result of using BET and geometric surface areas to normalize the rates is also explored.

Kinetic testing or column leach tests generally provide solute release rates that provide an estimate of mineral dissolution rates. This method is considered crude and has notable uncertainties due to lack of mass balance constraints. By solving mass balance equations, inverse modeling codes such as PHREEQC can be used to evaluate possible mineral dissolution or precipitation reactions from a known material as long as the input and output solutions are known (Glynn and Brown, 1996; Plummer et al., 1991). Previous investigations using PHREEQC inverse modeling typically dealt with large scale studies such as those of Lecomte et al. (2005); Uliana and Sharp (2001); Eary et al. (2003); Belkhiri et al. (2010) and Sharif et al. (2008). This study uses inverse modeling on a smaller scale such as in leach columns containing mine tailings.