Assessing reactive surface areas in glacial sediments

M. ELWOOD MADDEN*[1], R. FUNDERBURG[1], Y. J. JOO[1], J. MILLER[1], A. ELWOOD MADDEN[1], B. HALL[2], K. MARRA[3] AND G. SOREGHAN[1]

[1]Geology and Geophysics, University of Oklahoma, Norman, OK USA (melwood@ou.edu)

[2]Climate Change Institute and School of Earth and Climate Sciences,, University of Maine, Orono, ME USA

[3]USGS, Denver, CO, USA

Reactive surface area of primary phases in sediment and rock is a critical variable required for determining weathering rates and fluxes within the critical zone. However, previous work has shown geometric surface area measurements based on grain size distributions often underestimate the reactive surface area of sediments, while gas adsorption surface areas determined using the BET method may over-estimate reactive surface area, especially in fine-grained sediments. Here we test the reactivity of two size fractions from glacial drift from the Antarctic Dry Valleys to determine if BET surface area measurements can be used to assess reactive surface area of glacial sediments.

Glacial drift sediments were collected at the base of Denton Glacier, Wright Valley, Antarctica and remained frozen prior to analysis. The sediments were wet sieved to separate gravel, sand, fine sand, and mud (<62μm) fractions, and treated to remove carbonates and organics; mud and very fine sand fractions were freeze dried. All size fractions were outgassed at 323 K for 4 hours prior to N_2 adsorption BET analysis using a Quantachrome Nova 2000e. We then compared the reactivity surface of the sand and mud components by placing equal BET-determined surface areas (0.8 m^2/g) of each size fraction in separate reactors with 50 ml of ultrapure water (TRIS buffered to pH 9), and measured K^+, Na^+, Ca^+, Fe^+, and Al^+ concentrations after 5-15days using flame AA.

Results show that glacial sand and mud with equivalent BET-surface areas dissolve equally over the timeframe of these experiments, indicating that BET surface area accurately measures reactive surface within glacially-dominated sediments, despite greater than two orders of magnitude difference between BET and geometric surface areas. Indeed, physical weathering within glacial systems appears to produce comparable densities of reactive sites, regardless of grain size. These results underscore the role of physically weathered fine-grained sediments in producing high solute fluxes within glacially-dominated watersheds.