Imaging interfacial topography and reactivity with X-rays

P. FENTER[1]*, S.S. LEE[1], C. PARK[2], J. CATALANO[3], Z. ZHANG[4] AND N.C. STURCHIO[5]

[1]Chemical Sciences and Engineering, Argonne National Laboratory, Argonne IL 60439. (*correspondence: fenter@anl.gov)
[2]HP-CAT (Geophysical Laboratory, Carnegie Institution of Washington), Argonne, IL
[3]Department of Earth and Planetary Sciences, Washington University at St. Louis, St. Louis, MO
[4]Advanced Photon Source, Argonne National Laboratory, Argonne IL 60439
[5]Department of Earth and Environmental Sciences, University of Illinois at Chicago, Chicago IL

A fundamental understanding of aqueous-mineral interface reactivity is essential for developing robust predictive models that describe elemental transport in the near-surface environment. X-ray reflection interface microscopy (XRIM), a powerful new tool for interfacial studies, has been demonstrated recently at the Advanced Photon Source. XRIM is analogous to a simple optical microsope, but is unique in that it uses the weak interface-reflected X-ray beam to create an image. It therefore incorporates all of the sensitivities of X-ray reflectivity (XR), including sensitivity to interfacial structure and composition, along with the ability to spatially resolve heterogeneous systems and processes. This presentation will review recent and anticipated applications of XRIM as a probe of geochemical processes. Initial studies performed on the orthoclase (001) surface (ex-situ observations of reacted surfaces in air) have demonstrated: the ability to see elementary surface topography with ~100 nm spatial resolution [1]; progress in understanding the basis for the contrast in these XRIM images [2]; and the first application of XRIM to investigate interfacial reactivity [3]. Ongoing success in the use of XRIM as an *in situ* probe of the mineral-water interface will also be presented along with the specific challenges of *in situ* studies, including an intrinsically reduced signal strength and avoiding radiation damage. Future improvements in the XRIM instrument and its use as an *in situ* real-time probe of interfacial processes will be discussed.

[1] Fenter *et al*. (2006) *Nature Physics* **2**(10), 700–704. [2] Fenter *et al*. (2008) *Journal of Synchrotron Radiation* **15**, 558–571. [3] Fenter *et al*. (2010) *Geochimica et Cosmochimica Acta*, in review.

Developing radiocarbon within California mollusk shells as a proxy of upwelling intensity

J.E. FERGUSON[1]*, L. MEYER[2], K.R. JOHNSON[1], G.M. SANTOS[1], K. ACAYLAR[1] AND A. TRIPATI[3]

[1]Department of Earth System Science, University of California, Irvine, Croul Hall, Irvine, CA 92697 (*correspondence: julie.ferguson@uci.edu)
[2]Massachusetts Institute of Technology, Cambridge, MA 02139 (lbmeyer@mit.edu)
[3]Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA 90095-1565

Our understanding of the complex interactions between the California Current strength, upwelling intensity and El Niño Southern Oscillation (ENSO) is currently limited by the short duration of instrumental records and a lack of suitable seasonal-resolution marine archives. Marine mollusk shells provide a seasonal-resolution archive with significant potential.

Living mussels (*Mytilus californianus*) were collected from Newport Beach, California. Sequential samples were micromilled from the outer calcite layer of shell cross-sections and analyzed for stable isotopes, trace elements and radiocarbon. By comparing the geochemical profiles produced from the shells with instrumental records and ocean geochemical measurements, including seawater dissolved inorganic carbon (DIC) radiocarbon, made at a nearby site over several years it is possible to identify empirical relationships between shell geochemistry, upwelling and oceanic variables.

We also present results from *Mytilus californianus* shells collected from Mexico to Oregon following the strong El Niño event of 1997-1998. This event caused a collapse of upwelling and provides an ideal test of the fidelity of these empirical relationships along the west coast of North America at a time of dramatic change within the California Current system.