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Department of Chemistry

Student Seminar Series

9:45 a.m. Tuesday, February 25, 2014 • 331 Smith Hall

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Lawrence Berkeley National Laboratory

Ultrafast Pump-Probe Studies of Mineral Redox Reactions

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Abstract

Many common metals, including iron and manganese, undergo environmental redox reactions that can strongly influence geochemical and biogeochemical cycles. In particular, metal redox reactions in aqueous geochemical systems typically involve the formation, transformation or dissolution of mineral phases. Thus, metal redox cycling can lead to changes in mineralogy and of the bioavailability of these metals and mineral sorbates. Mineral redox reactions proceed through a combination of chemical steps that can include electron and proton transfer, the breaking or formation of bonds, and mineral phase transformation. Conventional experimental approaches for studying reaction kinetics typically cannot distinguish the rates of intermediate steps. Time-resolved spectroscopic methods are providing new approaches for understanding mechanisms of many reactions including mineral redox cycling. This presentation will give an introduction to pump-probe studies of geochemical reactions, particularly time-resolved X-ray absorption spectroscopy. I will present results from recent studies of the reductive dissolution of four phases of iron(III) oxides and oxyhydroxides, and the photoreductive dissolution of d-MnO_2, a layered manganese(IV) oxide.

Host: Jennifer Soltis

Benjamin Gilbert obtained a bachelor's degree in Natural Sciences from Cambridge University in 1994, and a doctorate from the École Polytechnique Fédérale de Lausanne in 2000. His graduate research was based upon synchrotron x-ray spectromicroscopy studies at the Synchrotron Radiation Center of the University of Wisconsin-Madison, for which he received the SRC Aladdin Lamp Award. He performed post-doctoral research at the University of Wisconsin-Madison and the University of California at Berkeley.

In 2004, he joined the Earth Sciences Division of Lawrence Berkeley National Laboratory and founded the Berkeley Nanogeoscience Center with colleagues Jill Banfield and Glenn Waychunas. In April 2007, he was promoted to a career scientist position.

Gilbert has made important contributions to the rapidly evolving field of nanogeoscience—the study of the properties and geochemical interactions of natural nanoscale minerals. Much of his research involves the development and application of synchrotron x-ray experiments and analysis methods for the study of mineral nanoparticles. Research accomplishments include: the discovery of stable cluster formation by iron oxyhydroxide nanoparticles; observation of structural transformations in ZnS nanoparticles associated with water binding; the identification of nanoscale silicate inclusions in zircons; and x-ray spectroscopic studies of the electronic structure of manganese oxides. More recently, his research has begun to apply ultrafast x-ray methods to study electron transfer to ferric iron oxide nanoparticles with sub-nanosecond temporal resolution. These studies are reported in more than 50 peer-reviewed publications that include collaborations with scientists from many disciplines.