SSRL Environmental Remediation Science Program

Stanford Synchrotron Radiation Laboratory
Subsurface Science Scientific Focus Area (SFA)

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EXECUTIVE SUMMARY

The success of natural attenuation and *in-situ* remediation strategies depends upon a complex interplay of dynamic molecular-scale biogeochemical processes in the subsurface. Our understanding of these processes is typically poor, with numerous knowledge gaps that present significant barriers to developing remediation approaches required for site closure.

The SSRL Environmental Remediation Science Program will focus on important natural solid phases and fundamental biogeochemical processes that control the stability and fate of priority metal contaminants in the subsurface. The key concept that will guide this project is:

> *The chemical dynamics and stability of complex environmental solid phases (UO2, PuO2, and Fe(II,III)(hydr-)oxides), and therefore their capacities to perform as long-term sinks for U and Pu, are governed by their molecular- and nano-scale structures and compositions, which are influenced substantially by reaction with ground water solutes. Because these environmental solids often exhibit nanoscale dimensions, their surface properties and dynamics may profoundly influence their "bulk" energetics, as will as their surface adsorptive capacities. However, little is known about the surface structure of environmental nanoparticles, nor about the impact of natural organic matter and microbial biofilm coatings on the reactivity of environmental particles such as UO2 and iron oxides. Therefore, this concept must be extended to account for nanoparticle surface structure and the effect of sorbed (organic or inorganic) molecules or surface coatings on nanoparticle reactivity.*

Research will focus on UO2 and reduced U(IV) solids because of their importance to natural attenuation and stimulated *in-situ* subsurface remediation strategies for U contamination, and on Fe(II,III)(hydr-)oxides because of their importance as reactive and enigmatic facilitators of biogeochemical processes and as contaminant sinks. Elucidation of the fundamental relationships between the molecular-scale structures and reactivity of these solids will provide insights to rationalize their environmental behavior, the mechanisms by which contaminants may be redistributed or immobilized within/onto these solids during redox cycling, and to improve the stability and yield of UO_2 or PuO_2 in the subsurface during natural attenuation or stimulated bioreduction treatments. This project focuses primarily on U because of its importance as a subsurface contaminant at DOE sites. Other priority contaminants to be investigated include: Pu, Cr, Sr, Pb, and As. The research program will be undertaken using a combination of synchrotron, aqueous chemical, radioanalytical, and microscopic techniques. An important aspect of this program will be the development and support of synchrotron methods that are required to accomplish the research and are critically or uniquely required for subsurface remediation science. The SSRL SFA will also support site-specific molecular-scale contaminant characterization, transport, and remediation research at the Hanford site, Los Alamos National Laboratory, and Fry Canyon, Utah. **The long-term objective of this program is to contribute qualitative and quantitative knowledge of key subsurface biogeochemical processes governing the sub-**

surface behavior of these contaminants, based on rigorous and leading-edge fundamental scientific research, that helps gain public and regulatory acceptance of nuclear legacy site characterization, remediation, and closure.