RESEARCH INFRASTRUCTURE IMPROVEMENT (RII 4)
PROPOSAL DEVELOPMENT PROCESS

SCIENCE WHITE PAPER

FOR DISCUSSION
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TITLE: URANIUM RESEARCH FOR ENERGY, WATER AND THE ENVIRONMENT

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Uranium Research for Energy, Water and the Environment

White paper draft for New Mexico NSF EPSCoR

Introduction

Research on the speciation, mobility, and bioavailability of uranium in the environment addresses key problems facing the state of New Mexico and the United States in developing energy resources, understanding our environment and protecting water resources. Improved understanding of the biogeochemistry and transport of uranium in the environment coupled with development of technologies for water treatment and site remediation will improve both our ability to mine and process uranium and our ability to deal with the consequences of past and future mining and processing.

From an energy production standpoint, the US mountain west has substantial deposits of uranium ore which are too deep or too low in U content to be mined economically using conventional techniques (surface- or shaft-mining). In situ leaching (ISL) has been proposed as a safer and more economical alternative to these mining methods. In ISL, an oxidizing solution is pumped into U(IV) ore deposits where it extracts soluble U(VI); the U-rich solution is then pumped to the surface where the uranium is concentrated and purified. The ability to quantitatively mobilize and extract the uranium depends on its reactivity and speciation in solution.

Like other forms of mining, ISL releases uranium from ore deposits and creates the possibility of groundwater contamination. In conventional mining, this contamination is normally found in mine runoff and in tailings piles near mines and mills; in ISL, the intentional mobilization of U for extraction constitutes contamination of the groundwater in and near the ore deposit. In either case, remediation of the site depends upon being able to control the uranium mobility- either to remove completely the U content of the ore or, more commonly, to immobilize the U remaining after mining is complete. Current immobilization technologies in use or under research include chemical precipitation of U(VI) and the chemical or biological reduction of U(VI) to U(IV) and precipitation of insoluble uraninite (U(IV) oxide). At ISL sites in Wyoming and Texas, none of these methods has successfully remediated the groundwater to the US EPA MCL after mining operations ceased.

Historically, uranium mining in the desert southwest has contributed to environmental degradation by widespread, low-level uranium contamination of water sources, topsoil and even building materials. Windblown U-bearing dust remains a human and animal health hazard in old mining districts, and near old mining areas. Although exposure routes are not always clear, elevated U levels in sheep and humans have been observed on the Navajo (Dine') reservation.

Better understanding of U spatial distribution and biogeochemical transformation would help to understand this contamination problem.

Some of the opportunities and difficulties presented by uranium in the southwest are legal or medical in nature; however, many are scientific or engineering problems. These include

I. How does uranium biogeochemistry affect its natural mobility in the environment?
II. How does uranium move from contaminated sites into ecosystems?
III. How can mobile, soluble U(VI) be rendered immobile?
IV. How can immobile, solid U(IV) be quantitatively and completely mobilized?

Possible research projects

A. Biogeochemical mechanism of U immobilization by reduction and precipitation as uraninite. While lab studies indicate that uraninite precipitation rapidly follows reduction and bioreduction, field studies find large quantities of mono-nuclear U(IV), which incompatible with rapid precipitation. Slow precipitation kinetics call into question the efficacy of bioattenuation as a remediation scheme for U-contaminated groundwater.

B. Kinetics of subsurface uranium redox im/mobilization.
Reactive transport models which assume uniform hydrologic and chemical properties typically overestimate rates of uranium transport and reaction and underestimate the time required for remediation. More realistic models which incorporate heterogeneity in both reactivity and hydrologic parameters are slower and more difficult to parameterize. Improved modeling techniques could provide more accurate estimates of environmental processes and more reliable confidence intervals for those estimates.

C. Uranium transport and transformations in arid ecosystems.
Uranium mining in the Colorado plateau has created a patchwork of contamination sources which are poorly characterized. Through aeolian and anthropogenic transport and probably other mechanisms, U contamination has moved into inhabited areas of the Dine reservation. Determining the mechanisms and rates of this transport will help the US and Navajo EPA locate and prioritize contaminated sites for clean-up.

D. Development of uranium im/mobilization technologies for mining and remediation
Current technologies for reducing groundwater U mobility following ISL have not been able to reach drinking water levels (MCL is 30 ppb), which makes the use of ISL near drinking water aquifers very risky. Improved methods of immobilization (sealing) or of mobilization (sweeping) would greatly improve the safety of uranium mining by ISL and aid efforts in cleaning legacy mining sites throughout the west.

E. Development of uranium removal technologies for drinking water treatment.
Current ion-exchange methods of removing uranium from drinking water supplies successfully remove uranyl ion but produce radioactive resins for which disposal is difficult and expensive. Potential groundwater sources for some rural communities are thus effectively unavailable. Improved uranium removal technology which allowed simpler handling and allowed recovery of the concentrated uranium would benefit these communities and others which have had U contamination in their drinking water.

Required Infrastructure

ICP-MS facility with HPLC and solid sample introduction systems for measuring environmental levels of U and aqueous speciation (UNM, NMT)

KPA (kinetic phosphorescence analyzer) for field uranium detection