201-2 8:35 AM Vaniman, David T.

SUFFICIENT AND NECESSARY: THE SITE-SPECIFIC CHARACTERIZATION OF GEOCHEMICAL PROCESSES

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The long-term behavior of a potential hazardous or radioactive waste site is a critical factor in site evaluation, but this information is notoriously difficult to obtain. Mineralogical and geochemical analyses can provide data on properties of a site that are either difficult to model accurately or are not embodied in models that are based on incomplete or faulty concepts. For example, determination of long-term or cumulative fluid flux can be constrained where cation-exchanging minerals such as zeolites have acted over geologic time scales as efficient accumulators of cations from solutions with approximately known cation concentration. Another important but often ignored property, mineral surface-mediated heavy-metal redox reactions, can be demonstrated where Pu analogs such as Ce have been shown to be removed from solution as Ce4+ by Mn-oxides. Sites where Ce has accumulated can be mapped to determine specific horizons or features where other heavy metals may accumulate. Such maps can be critical in evaluating remediation approaches or repository design. In some instances, the effective distance over which metals are removed from solution can be demonstrated where a 'passive' accumulator such as calcite records diminishing concentrations of redox-sensitive metals in groundwater with distance from a dissolution source. Use of geochemical observations to establish a history of long-term site performance provides a level of understanding that can augment short-duration field tests and can be used to evaluate models of long-term performance. In addition, geochemical and mineralogical data can supplement the results of modeling, particularly emphasizing processes that have not been modeled (e.g., strong retention of heavy metals by trace fracture-lining minerals). Results from modeling can be tested when a predicted outcome is either supported or contradicted by geochemical evidence (e.g., predicted impermeability of zeolitized tuffs versus geochemical evidence for through-flow). Perhaps the greatest benefit of site-specific geochemical evaluation is the demonstration to analysts, regulators, and the public that a defensible data-based understanding of the long-term behavior of a site has been obtained using data obtained from the site.

201-3 8:50 AM Leslie, Bret W.

USING RISK INFORMATION TO DETERMINE THE NEED FOR ADDITIONAL GEOCHEMICAL INFORMATION FOR THE PROPOSED YUCCA MOUNTAIN REPOSITORY

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The U.S. Department of Energy (DOE) intends to apply for a license to construct a repository for high-level radioactive waste at Yucca Mountain, Nevada. The U.S. Nuclear Regulatory Commission (NRC) is an independent regulatory agency and has established a regulation for the proposed repository. The regulation uses a risk-informed and performance-based strategy that protects the public and the environment. The regulation requires the use of a performance assessment to judge the safety of the repository for 10,000 years. The DOE has completed performance assessments of the potential repository. The NRC has evaluated the assessments, including the supporting data. Where the NRC judges, based on a risk-informed, performance-based approach, the DOE's approach and technical bases are inadequate, the NRC requires the DOE provide additional information.

The DOE needs to use geochemical information in the performance assessment to describe how engineered barriers degrade and to describe radionuclide transport. What information is required to assess adequately the repository performance and how much information is required will vary dependent upon the information's importance to risk. Retardation of radionuclides in the saturated zone at Yucca Mountain is a fundamental part of the DOE's performance assessment. From a risk-informed perspective the NRC staff would focus on those radionuclides that DOE models show contribute to the dose to the reasonably maximally exposed individual within the period of compliance. The NRC staff would also assess whether the DOE had provided a technical basis for retarded radionuclides which did not contribute to dose within 10,000 years. Those geochemical species that are important to degradation of engineered barriers are also the focus of the NRC's risk-informed geochemical review of DOE's performance assessment. However, the NRC's review of the DOE's treatment of geochemical information is focused on whether degradation of the engineered barriers contributes to the dose to the reasonably maximally exposed individual within the period of compliance. Examples of calculations that use risk information to constrain what geochemical information is needed from the DOE will be discussed.

The regulation is available at http://www.nrc.gov/waste/hlw-disposal.htm

201-4 9:10 AM Browning, Lauren

ON THE ADEQUACY OF SITE CHARACTERIZATION AND OTHER DATA TO CONSTRAIN REACTIVE TRANSPORT MODELS OF THE UNSATURATED ZONE AT YUCCA MOUNTAIN, NEVADA

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Reactive transport models are commonly used to constrain predictions of the long-term performance of Yucca Mountain as a possible high level waste repository. Some of these models evaluate coupled thermal-hydrological-chemical processes over 10,000 years to predict the flux and chemistry of water that might seep into a repository drift and initiate aqueous corrosion of the drip shields and waste packages. In principle, reactive transport models can provide robust predictions of the evolution of the system because they are theoretically based. However, these models have substantial uncertainties, which have proven difficult to quantify. In addition to questions regarding the uniqueness of the conceptual model, a typical reactive transport model may require hundreds of uncertain parameters. Thus, confidence in the models must be established by successful applications. An essential primary test of a reactive transport model of Yucca Mountain is that it can reasonably represent the ambient hydrogeochemical system. A vast amount of site characterization data has been collected at Yucca Mountain. Yet, comparison of reactive transport model results to ambient natural system characteristics is challenging, because of the slow hydrologic and geochemical evolution of natural water-rock systems, which requires consideration of subtle differences in the rates of chemical reactions over long periods of time. A primary focus of this paper is to discuss development of a calibrated, one-dimensional dual permeability reactive transport model for the ambient system at Yucca Mountain. This work illustrates some of the difficulties of developing an ambient system model for Yucca Mountain, and raises cautions about the reliability of predictions by more complex reactive transport models that superimpose effects of transient thermal perturbations on ambient system conditions.

This abstract is an independent product of the CNWRA and does not necessarily reflect the views or regulatory position of the NRC.

201-5 9:25 AM Fedors, Randall

THE COLD-TRAP PROCESS AND ITS EFFECT ON MOISTURE DISTRIBUTION AND CHEMISTRY OF WATER IN DRIFTS

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The quantity and chemistry of water contacting waste packages (WP) stored underground in drifts are important factors for determining the performance of the proposed high-level radioactive waste repository at Yucca Mountain, Nevada. Elevated temperatures and high concentrations of some halogens are known to enhance or initiate drip shield (DS) and WP corrosion. The cold-trap process describes a mechanism for in-drift water movement, providing localized liquid water that may contact the DS and WP, and after WP failure, providing a liquid water pathway for radionuclide transport away from the drifts.

The cold-trap process involves evaporation from warm areas, movement of vapor driven by thermal gradients, and condensation on cool or hygroscopic surfaces. Predicting moisture movement associated with the cold trap process is complex. Natural convection, when acting in concert with thermal radiation, conduction, and latent heat transfer, is poorly understood. In regard to chemistry, condensate associated with the cold-trap process is essentially pure water with a pH dependent on the atmospheric CO2(g) content. However, mixing of waters from different sources (e.g., condensation and seepage), each of which may have contacted and reacted with different materials (substrate, residues, or dust), makes it difficult to predict chemical compositions of the water in drifts.

The cold trap process was evaluated in a scaled laboratory model of a heated drift using thermocouples, relative humidity probes, and anemometers to measure environmental conditions. Preliminary results from the laboratory test support results from an analytical solution of air flow patterns and condensation rate. A computational fluid dynamics code and a two-phase porous media code were calibrated to expand predictive capabilities beyond the results measured in the laboratory experiment. This presentation will summarize existing published work on the cold trap process, present preliminary results from scaled laboratory experiments and corresponding modeling, and highlight the large data gap that exists for building confidence in a thermal-hydrologic-chemical modeling approach.

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201-6 9:40 AM Farrell, David A.

DATA SUFFICIENCY, EIS DEVELOPMENT, AND REGULATORY DECISION MAKING: THE ROLE OF GIS

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Data collection, processing, and interpretation are important aspects in the development of environmental impact statements (EISs), and in regulatory decision-making. From a cost-benefit perspective, there exists an optimal amount of data that is required for these tasks. While little data can lead to inappropriate actions and poor decisions, excessive data collection can lead to increased project cost with minimal benefit. Geographic information systems (GISs) provide a tool for categorizing and organizing spatio-temporal data at sites. Visualization of this data within a well organized GIS provides an important approach to assessing data sufficiency through visual examinations of the spatial and temporal distributions of the data at the scales of the processes active at the site; the hazards present at the site; and vulnerable regions, ecologies, and communities that may be affected by the site. Through spatio-temporal data processing, visualization, and comparison within a GIS framework, important data gaps and uncertainties may be identified. This work presents a GIS/three-dimensional visualization and modeling system that is consistent with U.S. Nuclear Regulatory Commission (NRC) and the Council for Environmental Equality regulations for preparing EISs that are consistent with the guidance outlined in the National Environmental Policy Act. The GIS/three-dimensional visualization and modeling system incorporates a wide range of spatio-temporal data; supports data visualization, processing and integration; is applicable to regulatory decision-makering; and is portable. This system has been used in NRC evaluations of data sufficiency and accuracy.

201-7 10:10 AM Langmuir, Donald

ARSENIC RELEASES FROM BURIED URANIUM MILL TAILINGS AT MCCLEAN LAKE: APPLICATION OF GEOCHEMICAL CONCEPTS AND LICENSE APPROVAL BY THE CANADIAN GOVERNMENT

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Approval of an operating license for the McClean Lake uranium mill and tailings disposal site in northern Saskatchewan, required that Cogema Resources Inc. be able to limit and predict maximum As concentrations that could be released from their tailings management facility (TMF) to ground and surface waters for up to 10,000 years. The approach to such prediction involved applying the concepts of thermodynamic equilibrium and chemical kinetics to arsenic-controlling reactions. These reactions were studied in the laboratory as a function of the Fe/As ratio, pH and aging time of processed acid mill raffinates and neutralized tailings discharged from the mill. Arsenic concentrations of <1-2 mg/L in limed tailings (pH 7-8) were found controlled chiefly by the precipitation of ferric and nickel arsenate solids (scorodite and annabergite), and crystallization of the scorodite with time. The experimental results and associated geochemical modeling persuaded the regulators to grant an operating license for the mill and TMF in 1999. The license required that As concentrations in the TMF be monitored for a number of years to validate the laboratory and modeling results, and that As released from TMF pore waters to local ground waters not exceed 5 mg/L. Sampling and analysis of pore waters and solids after two years of TMF operation has confirmed the laboratory results and predictive modeling. The conditional licensing approach taken by the Canadian regulators is the only sensible way to license waste facilities in geological environments that have long-term performance requirements.