CNWRA **A center of excellence in earth sciences and engineering**

A Division of Southwest Research Institute
6220 Culebra Road • San Antonio, Texas, U.S.A. 78228-5166
(210) 522-5160 • Fax (210) 522-5155

September 7, 2001
Contract No. NRC–02–97–009

U.S. Nuclear Regulatory Commission
ATTN: Mrs. Deborah A. DeMarco
Two White Flint North
11545 Rockville Pike
Mail Stop T8A23
Rockville, MD 20852

Subject: Programmatic Review of Abstracts

Dear Mrs. DeMarco:

The enclosed abstracts are being submitted for programmatic review. Due to time constraints, these abstracts have already been submitted electronically for presentation at the American Geophysical Union Fall Meeting to be held December 10–14, 2001. If NRC staff review finds deficiencies with any of the abstracts, they will be withdrawn. The titles of these abstracts are on the attached list.

Please advise me of the results of your programmatic review. Your cooperation in this matter is appreciated.

Sincerely,

Budhi Sagar
Technical Director

/lg
Enclosures

cc:

J. Linehan	T. Essig	W. Patrick
B. Meehan	K. Stablein	CNWRA Directors
E. Whitt	D. Brooks	CNWRA Element Mgrs
J. Greeves	B. Leslie	T. Nagy (SwRI Contracts)
J. Piccone	N. Coleman	P. Maldonado
W. Reamer		

Washington Office • Twinbrook Metro Plaza #210
12300 Twinbrook Parkway • Rockville, Maryland 20852-1606

ABSTRACTS SUBMITTED TO THE AMERICAN GEOPHYSICAL UNION FALL MEETING TO BE HELD DECEMBER 10–14, 2001

Title	Author(s)	Project Number
Detachment Faulting in the Western Basin and Range: New Geometric, Thermal, and Temporal Constraints from the Bare Mountain Region in Southwestern Nevada	D. Ferrill J. Stamatakos A. Morris R. Donelick A.Blythe	20.01402.471
Fault Block Deformation Resulting from Fault Displacement Gradients at Yucca Mountain, Nevada	A. Morris D. Ferrill N. Franklin D. Sims D. Waiting J. Stamatakos	20.01402.471
Geophysical Investigation of a Sinkhole in the Amargosa Desert, Nevada	S. Sandberg N. Rogers J. Stamatakos P. La Femina C. Connor	20.01402.471
Integration of Satellite Imagery, Hydrologic, and Topographic Information to Simulate Long-Term Environmental Change Near Yucca Mountain, Nevada to Determine Suitability for Future Agricultural Purposes	M. Smith R. Fedors D. Farrell Requested abstract be retracted	20.01402.761
Choice of Regulatory Criteria for the Proposed Radioactive Waste Repository at Yucca Mountain, Nevada, USA	S. Mohanty T. McCartin R. Codell	20.01402.761
Unsaturated Flow Through Fractured and Nonwelded Tuffs	R. Fedors J. Evans D. Or J. Heath K. Keighley-Bradbury	20.01402.861
Effects of Topography and Soil Depth on Runon and Focused Infiltration: Upper Split Wash Watershed, Nevada	D. Woolhiser R. Fedors S. Stothoff	20.01402.861

ABSTRACTS SUBMITTED TO THE AMERICAN GEOPHYSICAL UNION FALL MEETING TO BE HELD DECEMBER 10–14, 2001		
Title	**Author(s)**	**Project Number**
Resolution of the Hydraulic Connection Between the Volcanic/Alluvial Aquifer and the Paleozoic Aquifer at Yucca Mountain Using Temperature and Hydraulic Head Data	R. Green A. Woodbury	20.01402.861
Summary of Geophysical Field Investigations to Constrain the Geologic Structure and Hydrologic Characteristics of Fortymile Wash Essential for Assessing the Performance of the Proposed High-Level Nuclear Waste Repository at Yucca Mountain, Nevada	D. Farrell P. La Femina J. Winterle M. Hill D. Sims M Smith W. Illman R. Green S. Sandberg N. Rogers	20.01402.861
Monte Carlo Analyses of Unsaturated Flow in Thick Vadose Zones of Layered, Fractured Rocks	W. Illman D. Hughson	20.01402.861
Colloid-facilitated Radionuclide Transport: A Regulatory Perspective	W. Dam D. Pickett R. Codell T. Nicholson	20.01402.871
Significance of Kinetics for Sorption on Inorganic Colloids: Modeling and Data Interpretation Issues	S. Painter V. Cvetkovic D. Pickett D. Turner	20.01402.871

Abstract for Fall 2001 meeting of the AmericanGeophysical Union.

Detachment faulting in the western Basin and Range: New geometric, thermal, and temporal constraints from the Bare Mountain region in southwestern Nevada

David A. Ferrill and **John A. Stamatakos**, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas 78238; **Alan P. Morris**, Department of Earth and Physical Sciences, The University of Texas at San Antonio, San Antonio, Texas 78249; **Raymond A. Donelick**, Department of Geology and Geophysics, University of Idaho, Moscow, Idaho 83844; **Ann E. Blythe**, Department of Geological Sciences, University of Southern California, Los Angeles, California 90089

Zircon and apatite fission-track cooling ages for 50 samples taken from Bare Mountain and surrounding areas of southern Nevada, analyzed in conjunction with structural and paleomagnetic data and calcite deformation geothermometry data, provide new constraints on the timing and distribution of detachment faulting in the western Basin and Range. Our results show that: (i) Bare Mountain was tilted to the east or northeast, probably during Middle Miocene extension, prior to development of the Bullfrog Hills detachment system. (ii) Bare Mountain cooled through the fission-track closure temperature for fluorine-rich apatite (115-125 °C) more or less as a unit at 8 to 17 Ma. (iii) Northwest Bare Mountain cooled through the zircon closure temperature (250 °C) at 8 to 17 Ma, whereas the rest of the mountain cooled through this temperature between the Late Paleozoic and the Eocene. The combination of tilting at Bare Mountain and the apatite and zircon fission-track cooling ages indicates the presence of a west-dipping breakaway fault at Bare Mountain at around 15 Ma. New apatite fission-track cooling ages from Yucca Flat, Frenchman Flat, Mount Sterling, the Striped Hills, the Resting Springs Range, and the Funeral Mountains, when combined with published apatite ages, constrain the regional position of a west-dipping breakaway fault and exhumed footwall. The current position of the trailing edge of the hanging wall of this system is the Death Valley – Furnace Creek fault system. Migration rates of the cooling front in the footwall of this system range from 4.0 mm/yr at the latitude of Bare Mountain to 7.3 mm/yr at the latitude of central Death Valley.

* Work performed at the CNWRA for the U.S. NRC under contract number NRC-02-97-009. This is an independent product of the CNWRA and does not necessarily reflect the views or regulatory position of the NRC.

Abstract for AGU Annual meeting 2001

Fault block deformation resulting from fault displacement gradients at Yucca Mountain, Nevada

[1]Morris, A. P., [2]Ferrill, D. A., [2]Franklin, N., [2]Sims, D. W., [2]Waiting, D., [2]Stamatakos, J.

[1] Department of Earth and Environmental Science, University of Texas at San Antonio, TX 78249
[2] CNWRA, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78238

Displacement gradients on normal faults generate cutoff-line-parallel length changes. Yucca Mountain, Nevada is cut by numerous NS trending normal faults that exhibit steep displacement gradients. We apply a new method for quantifying the strain that develops adjacent to faults as a result of displacement variations, to Yucca Mountain, Nevada. Using existing maps and the Department of Energy's 3D Geologic Framework Model as sources of high precision data we have analyzed the likely state of strain of the fault blocks in Yucca Mountain. The results indicate that the strain is sensitive to the ambient stress field and the resultant slip directions at the time of fault formation, and to the orientation of the principal rock units prior to faulting. Assuming that at the time of faulting the volcanic tuffs were horizontal, and the stress field was conducive to EW-directed extension, zones of potentially high strain are identified. At least three of these are zones of intense deformation: the West Ridge connecting fault system between the Northern Windy Wash and Fatigue Wash faults, the ridges between Solitario Canyon and Fatigue Wash, and the fault block between the Iron Ridge and Solitario Canyon faults. This approach is being used to assess the intensity of deformation within fault blocks that are considered part of the Department of Energy's extended definition of blocks suitable for the U.S.A.'s potential high level nuclear waste repository.

Work supported by the U.S. NRC (contract NRC-02-97-009) This work is an independent product of the CNWRA and does not necessarily represent the regulatory position of the NRC.

For fall AGU, 2001

Geophysical Investigation of a Sinkhole in the Amargosa Desert, Nevada

S. K. Sandberg, University of Southern Maine, Gorham, ME
N. T. Rogers, Geophysical Solutions, Albuquerque, NM
J. A. Stamatakos, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, TX
P. C. La Femina, University of Miami, Miami, FL
C. B. Connor, University of South Florida, Tampa, FL

A sinkhole (10 m opening, 20 m length, and 10 m depth) is exposed within the Quaternary alluvial fill in the Amargosa desert in southern Nevada, approximately 500 m north-northeast of the Horse Tooth discharge deposit. We employed a variety of geophysical methods to investigate the structural setting of the sinkhole in order to evaluate formative hypotheses, including the possible role of groundwater discharge. Geophysical methods included total-field magnetics, very low frequency electromagnetics (VLF), terrain conductivity (horizontal loop electromagnetics), spontaneous polarization (SP), transient electromagnetics (TEM), mise-a-la-masse resistivity, and magnetometric resistivity (MMR). Total-field magnetic data were collected at two scales. A regional coverage of an area approximately 1.4 km by 1.4 km surrounding the sinkhole consisted of lines spaced 100 m apart. Data along the lines were gathered at 3-5 m intervals. Measurement locations were controlled by real-time differential GPS readings. A local magnetic survey of the area immediately adjacent to the sinkhole consisted of profiles 20 m apart, with a discrete station spacing of 2 m. Magnetic anomalies up to 1500 nT are identifiable based on strong normal- and reversed-polarity remanent magnetizations in the underlying bedrock tuff. Formation of the sinkhole appears to be related to complex interaction of N-S and NW-SE faults. Magnetic anomalies depict complexly faulted tuff dominated by north-south striking extensional faults. Similar fault patterns occur near the Horse Tooth discharge deposit. Near the sinkhole, a NW-trending magnetic anomaly appears to be associated with the surficial expression of the sinkhole. Terrain conductivity data show near-surface structure and lithologic changes at the sinkhole. VLF data, when converted to current density, show similar trends. However, VLF current density modeled from deeper in the section indicates a NW-SE range-front fault to the west of the sinkhole. Mise-a-la-masse data also distinctly show a response from this fault. Profiles of TEM central loop soundings were inverted to depth sections that provide details of the fault blocks in section. A comparison between magnetics data and TEM depth sections allows a detailed view the range-front fault. The SP method did not provide a coherent response near the sinkhole, possibly because the present groundwater depth is 16 m, below the depth of resolution for SP.

Work supported by the U.S. NRC (Contract NRC-02-97-009). This work is an independent product of the CNWRA and does not necessarily reflect the views or regulatory positions of the NRC.

Choice of Regulatory Criteria for the Proposed Radioactive Waste Repository at Yucca Mountain, Nevada, USA

Sitakanta Mohanty[1], Timothy J. McCartin[2], Richard B. Codell[2]
[1]Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute, 6220 Culebra Road
San Antonio, Texas 78238, USA
smohanty@swri.org, Fax: (210)522-5155

[2]U.S. Nuclear Regulatory Commission , Washington, DC, USA

Keywords:
Waste Management
Uncertainty Analysis
Risk Assessment
System Modeling
Nuclear Fuel Cycle and Waste Management

The U.S. Nuclear Regulatory Commission (NRC) is developing regulatory perspectives for a potential high-level waste repository at Yucca Mountain, Nevada, USA that would be constructed by the U.S. Department of Energy (DOE). The proposed regulations on which a potential license would be granted are "risk-informed and performance-based". It is necessary to choose a suitable performance measure in order to implement this criterion. This paper evaluates two performance measures; one used for the demonstration of compliance, and the other for sensitivity analyses.

The performance assessments conducted by the licensee in support of any potential license application will use probabilistic methods to simulate a range of possible, future behaviors of the repository system. Each possible future behavior of the repository system is represented by a curve describing the annual dose to the reasonably maximally exposed individual (RMEI) as a function of time. Because none of these possible futures can be demonstrated to describe the actual future behavior of the repository system, the proposed regulation specifies that compliance demonstration will be based on calculations of the largest annual dose to the RMEI, who is assumed to intercept potential releases from the repository during the compliance period. These calculations will result in a large number of individual model runs that must be analyzed and interpreted in terms of the regulations.

For the demonstration of compliance, NRC chose the "peak of the mean" approach. In this approach, the dose is averaged over all realizations at each instant in time, and the highest value of the average curve chosen. NRC chose this performance measure because it is a direct measure of risk; i.e., it takes into account both the hazard of the dose to which the affected person or group was exposed, and the probability of being exposed. This provision has been incorporated into the proposed NRC high-level waste rule, 10CFR63. However, the regulators must still guard against potential pitfalls such as risk dilution; e.g., a wider distribution in a poorly known parameter may cause a spread in the timing of the peak, and hence lower the peak of the mean.

In order to assure that potential problems in the compliance demonstration such as risk dilution are taken into account, NRC will rely on a variety of other analyses with its performance assessment models. For sensitivity analyses (which includes regression and importance analyses), NRC will rely, in some cases, on peak values of individual runs. These values provide better discrimination power for determining the

most important parameters than the mean curve used in the compliance demonstration. This paper will present a range of techniques used in compliance demonstration and sensitivity analyses with emphasis on conservatism and risk dilution. Also, the paper will include results from the most likely scenario as well as the scenarios involving disruptive events such as volcanism.

Unsaturated Flow Through Fractured and Nonwelded Tuffs

R.W. Fedors (CNWRA, 6220 Culebra Road, San Antonio, TX 78238; 210-522-6818; e-mail: rfedors@swri.org), J. Evans and Dani Or (Utah State University), Craig Forster (University of Utah), J. Heath and K. Keighley-Bradbury (Utah State University).

The nonwelded tuff units at Yucca Mountain, the site of the proposed high-level radioactive waste repository, play a prominent role in percolation through the unsaturated zone to the repository horizon. The nonwelded Paintbrush Tuff (PTn) unit, which overlies the repository, is assumed to spatially and temporally dampen episodic pulses moving downward through the Tiva Canyon moderately welded tuffs. Numerical model simulations show that a porous, permeable nonwelded tuff matrix (PTn) may attenuate rapid, transient fracture flow from the Tiva Canyon tuff; hence, a steady state assumption is often made for unsaturated flow through the fractured tuffs of YM.

Primary heterogeneity or secondary discontinuities (e.g., fractures and faults), however, could lead to preferential flow paths through the PTn and into the Topopah Spring welded tuff (TSw) below. The presence of bomb-pulse chlorine-36 below the PTn and the dilute chemical composition of the perched water below the proposed repository suggest that a significant percentage of episodic infiltration follows fast pathways through the PTn.

The nonwelded tuffs are poorly exposed at YM, hence, work at an analog site for the PTn was initiated using the basal Bishop Tuff units near Bishop, CA. As at YM, the basal Bishop Tuff includes matrix-supported, massive ignimbrites and clast-supported, bedded deposits. To address the question of possible preferential or focused flow through nonwelded tuffs, field and laboratory studies were performed on the Bishop Tuff. First, geologic and hydrologic examination of the basal Bishop Tuff units was needed to establish them as a credible PTn analog. Second, the nature of faulting and fracturing was examined as a function of texture in the nonwelded tuffs. Third, different field and laboratory tests were used to establish the effect of fractures on flow through nonwelded tuffs. The influence of primary lithology, texture, and faults/fractures on fluid flow through nonwelded tuffs was assessed using data from in situ infiltrometer, permeameter, and tracer tests and laboratory hydrologic tests. No preferential flow was noted in the tracer test profiles completed in the highly permeable bedded tuffs. In the massive ignimbrites, flow constrained by filled fractures in the nonwelded tuff led to a two-fold increase in the vertical-to-horizontal anisotropic bulk permeability ratio over flow in non-fractured tuffs.

[Work performed by CNWRA under contract NRC-02-97-009 does not necessarily reflect the views or positions of NRC].

H37 Session: Environmental Vadose Zone Hydrology (Posters Only)

Effects of Topography and Soil Depth on Runon and Focused Infiltration: Upper Split Wash Watershed, Nevada

D. A. Woolhiser (1631 Barnwood Dr., Fort Collins, CO 80525; 970-482-7810; e-mail: woolhiserd@aol.com), R. Fedors (CNWRA, 6220 Culebra Road, San Antonio, TX 78238), and S. Stothoff (Stothoff Environmental Modeling, 880 Lockland Ave., Winston-Salem, NC 27103).

A modeling study of surface and near surface hydrology of a small watershed, upper Split Wash, overlying the potential Yucca Mountain (YM), Nevada high level nuclear waste repository was carried out. The objective was to evaluate the interaction of topography and soil depth across a small watershed and the hillslope process of runoff-runon. Zones of focused infiltration can result from the phenomenon of runon leading to localized deep percolation. The distribution of percolation fluxes within YM has a significant impact on repository performance.

The KINEROS2 surface runoff model was used to calculate distributed Hortonian and saturation-induced overland flow using 9-years of tipping bucket precipitation data and 100-years of simulated precipitation. In the KINEROS2 model, watershed geometry is described by cascades of plane elements contributing lateral or upper boundary flow to trapezoidal channel elements. The Smith-Parlange model is used for infiltration and saturated and unsaturated flow were assumed to be in the vertical direction. Plane and channel geometries for the Upper Split Wash watershed (0.25 km^2), were determined from topographic maps and field measurements. Soil depths, soil and bedrock hydraulic parameters, initial water contents, and Mannings "n" for plane and channels were based on a combination of field measurements and values reported in the literature.

Runoff was simulated for all storms that had intensities greater than the saturated hydraulic conductivity of the soil or had a total depth that could saturate the shallowest soils. Simulated runoff per unit area for the measured precipitation compared reasonably well with measurements at nearby watersheds. For the upper Split Wash watershed, the runoff-runon phenomenon was important during the infrequent saturation-induced overland flow events but was not important for Hortonian runoff. Focused infiltration into channel alluvium and underlying bedrock occurred for both types of runoff. Statistical distributions of hillslope and bedrock infiltration during runoff events for three hillslope positions and two seasons were examined and implications for focused shallow infiltration will be discussed for both present-day and future climate conditions.

[Work performed by CNWRA under contract NRC-02-97-009 does not necessarily reflect the views or positions of NRC].

<u>H36 Session: Recharge and Vadose Zone Processes in Semiarid and Arid Regions</u>

Resolution of the Hydraulic Connection between the Volcanic/Alluvial Aquifer and the Paleozoic Aquifer at Yucca Mountain using Temperature and Hydraulic Head Data

by Ronald T. Green and Allan D. Woodbury

Yucca Mountain, Nevada is the location of the proposed geologic repository for high-level nuclear waste in the United States. If radionuclides are released from the repository, they are expected to flow vertically through the vadose zone then laterally through the saturated zone. Flow in the saturated zone is generally to the south from Yucca Mountain toward Amargosa Valley. The performance of the repository will be evaluated in terms of radionuclide dose predicted at a distance of 18 km from the proposed repository. The predicted dose rates are sensitive to groundwater travel times and flux rates.

The saturated zone to the south of Yucca Mountain is complex, but for regulatory purposes it can be simplified to consist of three major units: (1) an overlying volcanic aquifer near Yucca Mountain that is believed to transition to an alluvial aquifer to the south near Amargosa Valley; (2) underlain by a thick series of low permeable volcanic units; and (3) the underlying regional Paleozoic aquifer. The intervening volcanic layer is thought to be sufficiently thick and of sufficient low permeability near Yucca Mountain to effectively prohibit any significant hydraulic communication between the upper volcanic/alluvial and the lower Paleozoic aquifers. However, there is insufficient geologic evidence to the south, closer to Amargosa Valley, to confirm whether the intervening layer continues to prohibit or restrict inter-aquifer flow. In particular, there is neither sufficient hydraulic conductivity information for the confining unit separating the aquifers, nor hydraulic head data from the underlying Paleozoic aquifer to resolve the nature of this hydraulic connection. Given that the Paleozoic aquifer has approximately 40 times the flux of the volcanic/alluvial aquifer, even modest upward groundwater flow from the Paleozoic aquifer could significantly alter either the direction or rate of flow in the volcanic/alluvial aquifer. Use of both hydraulic head and temperature data reduce the uncertainty in the hydraulic connection between the two aquifers. In conjunction with standard calibration, the system of equations that couple heat and mass transfer are inverted using Full-Bayesian techniques (Woodbury and Rubin, WRR 36(1), 2000).

ACKNOWLEDGMENTS
This work was performed at the CNWRA on behalf of the NRC office of Nuclear Material Safety and Safeguards, Division of Waste Management under contract No. NRC-02-97-009. This paper does not necessarily reflect the views or regulatory position of the NRC.

AGU ABSTRACT

Summary of Geophysical Field Investigations to Constrain the Geologic Structure and Hydrologic Characteristics of Fortymile Wash Essential for Assessing the Performance of the Proposed High-Level Nuclear Waste Repository at Yucca Mountain, Nevada

D.A. Farrell, P. La Femina, J. Winterle, M. Hill, D. Sims, M. Smith, W. Illman, R. Green
S. Sandberg, N. Rogers

The U.S. Department of Energy (DOE) is currently evaluating Yucca Mountain, located in southwestern Nevada, as a possible geologic high-level nuclear waste repository with a performance period of 10,000 years. Groundwater flow and possible radionuclide transport from Yucca Mountain within the saturated zone will be influenced by the geologic structure and the hydrogeologic characteristics of the subsurface in the vicinity of the site. An understanding of these characteristics is essential to evaluating the performance of the repository. South of Yucca Mountain, along the anticipated radionuclide transport pathway, uncertainties in structural geology, hydrogeologic models, and supporting data (for example, the location of the watertable transition from tuff to valley-fill, and the architecture of the basin) impact site performance assessment calculations. Some of these uncertainties will be reduced by the point information provided by the well drilling program currently being carried out by Nye County, Nevada. However, geologic and hydrologic uncertainties remain within inter-well regions which extend over several tens of square kilometers. In recognition of the uncertainties inherent in analyses based upon relatively sparse point data available for Fortymile Wash, the Center for Nuclear Waste Regulatory Analyses and the Nuclear Regulatory Commission have developed a surface geophysics program that targets the inter-well regions utilizing gravity, magnetic, electrical resistivity, and electromagnetic measurements to support confirmatory analyses and performance assessment calculations. This presentation describes various aspects of these surveys and their results. In particular, the presentation presents new models for the structure of the Fortymile Wash (including an improved mapping of the tuff valley-fill interface) based on the integrated geophysical approach and provides an independent basis for the watertable configuration over the region. By combining the watertable data with the improved structural model the watertable transition point from the tuff to the valley is better constrained. In addition, the presentation describes the application of the data to the continued development of a hydrologic framework model that incorporates characteristics of the wash and is used to support hydrogeologic modeling.

Acknowledgments

This work was performed at the CNWRA on behalf of the NRC office of Nuclear Material Safety and Safeguards, Division of Waste Management under contract No. NRC-02-97-009. This paper does not necessarily reflect the views or regulatory position of the NRC.

Monte Carlo analyses of unsaturated flow in thick vadose zones of layered, fractured rocks

Walter A. Illman, Department of Geoscience, University of Iowa, Iowa City IA, 52242
Debra L. Hughson, Center for Nuclear Waste Regulatory Analyses, San Antonio, TX, 78238-5166, USA

We conducted Monte Carlo simulations of flow in unsaturated fractured rocks using a two-phase, non-isothermal, flow simulator. In this simulator the fractured rock is idealized as a dual-continuum porous media, in which the matrix and fracture constitute two distinct continua represented by two overlapping, interacting numerical grids. Darcy's law and the area of the matrix-fracture interface open to flow govern the exchange of fluids between the two continua. To investigate the applicability of the dual-continuum approach for modeling unsaturated flow in a thick vadose zone of fractured rocks, we applied the model to site data collected from Yucca Mountain. We use grid blocks with dimensions of 1m that is commensurate with the support volume of fracture permeabilities estimated from single-hole pneumatic injection tests. We investigated the consequences of simplifying fracture permeability on unsaturated flow by comparing the model results using uniform formation properties to a stochastic model that represents spatial variability of the fracture permeability within the layers as a multivariate lognormal random field. In both models, the water flux boundary condition was varied to simulate the effects of variable recharge rates.

We found that the variability in fracture permeability causes the development of preferential flow paths in the fracture continuum for the welded tuff units and in the matrix continuum for the nonwelded unit. The magnitude of variance in fracture permeability correlates well with the degree of flow focusing. Water flow rates in preferential flow pathways have been found to be locally very high (more than ten times the input flow rate). Flow focusing due to the development of preferential pathways increases saturation locally. This local increase in saturation causes an increase in relative hydraulic conductivity along the pathway and may reduce the wetted surface area for fracture-matrix interaction.

Comparison of results obtained from the homogeneous and heterogeneous model of unsaturated flow through thick vadose zones shows that deep percolation can take place rapidly through persistent, preferential flow paths. These pathways are hard to detect and may carry large volumes of water. Simplification of site hydrogeology may lead to erroneous conclusions on the spatial and temporal distribution of unsaturated flow through thick, fractured vadose zones.

This work, funded by the U.S. Nuclear Regulatory Commission (NRC), is an independent product of the Center for Nuclear Waste Regulatory Analyses and does not necessarily reflect the views or regulatory position of the NRC.

Session: Environmental Colloids H46

Colloid-facilitated radionuclide transport: a regulatory perspective

W.L. Dam[1], D.A. Pickett[2], R.B. Codell[1], and T.J. Nicholson[1]
[1]U.S. Nuclear Regulatory Commission, Washington, DC
[2]CNWRA, Southwest Research Institute, San Antonio, TX

Various hydrogeologic-geochemical-microbial conditions and processes affect migration of radionuclides sorbed onto microparticles or native colloid-sized radionuclide particles. The U.S. Nuclear Regulatory Commission (NRC) is responsible for protecting public health, safety, and the environment at numerous nuclear facilities including a potential high-level nuclear waste disposal site. To fulfill these obligations, NRC needs to understand the mechanisms controlling radionuclide release and transport and their importance to safety. The current focus of NRC staff reviews and technical interactions dealing with colloid-facilitated transport relates to the potential nuclear waste repository in Yucca Mountain, Nevada.

NRC staff performed bounding calculations to quantify radionuclide releases available for transport to potential receptors from a Yucca Mountain repository. Preliminary analyses suggest insignificant doses of plutonium and americium could be derived from the glass waste form, which makes up a small part of the overall inventory consisting primarily of spent nuclear fuel. Using surface complexation models, NRC staff found that colloids can potentially lower actinide retardation factors by up to several orders of magnitude. Performance assessment calculations, in which colloidal transport of plutonium and americium was simulated by assuming no sorption or matrix diffusion, indicated no effect of colloids on human dose within the 10,000 year compliance period due largely to long waste package lifetimes, with peak expected dose increasing to 70 mrem/y at 40,000 years.

NRC staff have identified information gaps and developed technical agreements with the U.S. Department of Energy (DOE) to ensure sufficient information will be presented in any potential future Yucca Mountain license application. DOE has agreed to identify which radionuclides could be transported via colloids, incorporate uncertainties in colloid formation, release and transport parameters, and conceptual models, and address the applicability of field data using synthetic microspheres as colloid analogs.

NRC is currently investigating approaches to colloid modeling in order to help evaluate DOE's approach. One alternative approach uses DOE laboratory data to invoke kinetic controls on reversible radionuclide attachment to colloids. A kinetic approach in which desorption from colloids is slow may help assess whether DOE's instantaneous equilibrium approach for reversible attachment, as well as their application of irreversible attachment to only a small portion of the radionuclide inventory, are reasonable and conservative. An approach to examine microbial processes would also contribute to considerations of leaching of radionuclides and colloid formation. Reducing uncertainties in colloid release and transport processes should help in better understanding their importance to repository performance.

This work is an independent product and does not necessarily reflect the views or regulatory position of the NRC. CNWRA participation was funded under contract No. NRC-02-97-009.

Significance of kinetics for sorption on inorganic colloids: Modeling and data interpretation issues

Scott Painter[1], Vladimir Cvetkovic[2], David Pickett[1] and David Turner[1]

[1]CNWRA, Southwest Research Institute, San Antonio, Texas
[2]Royal Institute of Technology, Stockholm, Sweden

Irreversible or slowly reversible attachment to inorganic colloids is a process that may enhance radionuclide transport in the environment. An understanding of sorption kinetics is critical in evaluating this process. A two-site kinetic model for sorption on inorganic colloids is developed and used to evaluate laboratory data. This model was developed as an alternative to the equilibrium colloid sorption model employed by the U.S. Department of Energy (DOE) in their performance assessment for the proposed repository for high-level nuclear waste at Yucca Mountain, Nevada. The model quantifies linear first-order sorption on two types of hypothetical sites (fast and slow) characterized by two pairs of rates (forward and reverse). We use the model to explore data requirements for long-term predictive calculations and to evaluate laboratory kinetic sorption data of Lu et al. Five batch sorption data sets are considered with Pu(V) as the tracer and montmorillonite, hematite, silica, and smectite as colloids. Using asymptotic results applicable on the 240 hour time-scale of the experiments, a robust estimation procedure is developed for the fast-site partitioning coefficient and the slow forward rate. The estimated range for the partition coefficient is 1.1-76 L/g; the range for the slow forward rate is 0.0017-0.02 L/h. Comparison of one-site and two-site sorption interpretations reveals the difficulty in discriminating between the two models for montmorillonite and to a lesser extent for hematite. For silica and smectite the two-site model clearly provides a better representation of the data as compared with a single site model. Kinetic data for silica are available for different colloid concentrations (0.2 g/L and 1.0 g/L). For the range of experimental conditions considered, the forward rate appears to be independent of the colloid concentration. The slow reverse rate cannot be estimated on the time scale of the experiments; we estimate the detection limits for the kinetic rates and show that the uncertainty associated with the reverse rate leads to large uncertainty in predictive calculations of colloid facilitated transport. The implications of this model for radionuclide transport will help in evaluating the appropriateness of DOE colloid models. This abstract documents work performed in part by the Center for Nuclear Waste Regulatory Analyses under contract No. NRC–02–97–009. The report is an independent product and does not reflect the regulatory position of the NRC.

Reference:

Lu et al. Adsorption of actinides onto colloids as a function of time, temperature, ionic strength and colloid concentration. Los Alamos Report LA–UR–00–5121.Los Alamos, NM: Los Alamos National Laboratory. October 2000.