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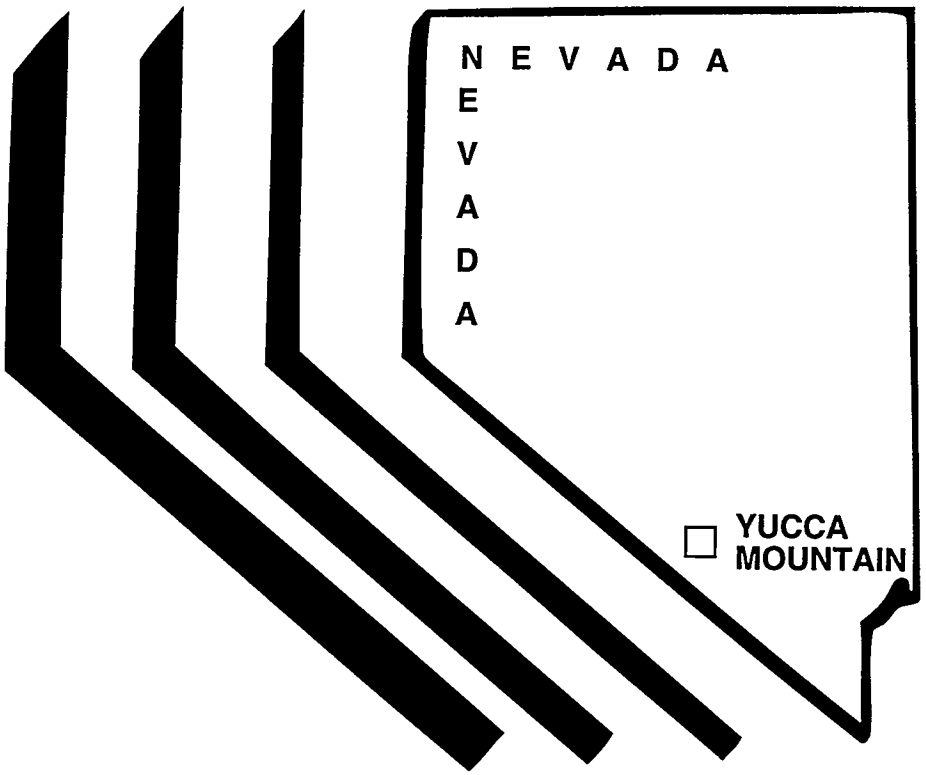
Yucca Mountain Site Characterization Project Bibliography, January–June 1995

An Update

United States Department of Energy



Civilian Radioactive Waste Management Program

Prepared for
Yucca Mountain Site Characterization Office, Las Vegas, Nevada
Office of Civilian Radioactive Waste Management, Washington, D.C.

Prepared by
Office of Scientific and Technical Information
UNITED STATES DEPARTMENT OF ENERGY

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Yucca Mountain Project Bibliography, 1977–1985 (Formerly *Nevada Nuclear Waste Storage Investigations, 1977–1985: A Bibliography*). June 1987. 759 refs. DOE/TIC-3406 (DE86013045).

Nevada Nuclear Waste Storage Investigations, January–June 1987: An Update. March 1988. 120 refs. DOE/TIC-3406(Add.2) (DE88000455).

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Yucca Mountain Site Characterization Project Bibliography, July–December 1990: An Update. May 1991. 200 refs. DOE/OSTI-3406(Suppl.2)(Add.2) (DE91007636).

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Nuclear Fuel Cycle: Reprocessing. September 1984. 555 refs. DOE/TIC-3396(Suppl.1) (DE84013561).

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FOR FURTHER INFORMATION ON THE CIVILIAN RADIOACTIVE WASTE MANAGEMENT PROGRAM

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Yucca Mountain Site Characterization Project Bibliography

ABOUT THIS BIBLIOGRAPHY

Following a reorganization of the Office of Civilian Radioactive Waste Management in 1990, the Yucca Mountain Project was renamed Yucca Mountain Site Characterization Project. The title of this bibliography was also changed to Yucca Mountain Site Characterization Project Bibliography. Prior to August 5, 1988, this project was called the Nevada Nuclear Waste Storage Investigations.

This bibliography contains information on this ongoing project that was added to the Department of Energy's Energy Science and Technology Database from January 1, 1995, through June 30, 1995.

The bibliography is categorized by principal project participating organization. Participant-sponsored subcontractor reports, papers, and articles are included in the sponsoring organization's list. Another section contains information about publications on the Energy Science and Technology Database that were not sponsored by the project but have some relevance to it.

Earlier information on this project can be found in the first bibliography DOE/TIC--3406, which covers 1977--1985, and its supplements, DOE/OSTI--3406(Suppl.1), DOE/OSTI--3406(Suppl.2), DOE/OSTI--3406(Suppl.3), and DOE/OSTI--3406(Suppl.4), which cover information obtained during 1986--1987, 1988--1989, 1990--1991, and 1992--1993, respectively. More recent information can be found in DOE/OSTI--3406(Suppl.4) (Add.1), which covers January 1994 through June 1994, and DOE/OSTI--3406(Suppl.4) (Add.2), which covers July 1994 through December 1994. All entries in the bibliographies are searchable online on the NNW database file. This file can be accessed through the Integrated Technical Information System (ITIS) of the U.S. Department of Energy (DOE).

DOE and DOE contractors can order copies of most Yucca Mountain Site Characterization Project reports and other documents published by the DOE and the principal participant organizations from:
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General information and publications on the national program can be obtained through the Office of Civilian Radioactive Waste Management Toll-Free Information System at 1-800-225-NWPA (6972) (or, in Washington, DC, at 488-5513), or by writing to the OCRWM Information Center, P.O. Box 44375, Washington, DC 20026.

Peter M. Stephan, YMP Managing Editor

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CONTENTS

*Civilian Radioactive Waste Management System, Management & Operating Contractor, Las Vegas.

Bibliography With Abstracts

YUCCA MOUNTAIN SITE CHARACTERIZATION OFFICE

1 **Photogeologic reconnaissance of X-tunnel at Little Skull Mountain.** Voegele, M.D. (SAIC, Las Vegas, NV (United States)). pp. 182-187 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

On June 29, 1992, a magnitude 5.6 earthquake occurred immediately to the south of Little Skull Mountain; the depth of the shock was about 9 kilometers (6 miles). It is the location of an underground structure known as X-tunnel, that once supported deep basing studies for the Air Force in the 1980s. The Nevada Operations Office of US DOE authorized access to the facility on several occasions to allow technical specialists from the Yucca Mountain Site Characterization Project, including geoscientists and engineers, to gather information about possible damage related to the earthquake. Examination of the underground facility in the vicinity of Yucca Mountain indicated little or no damage to the facility. Photogeologic reconnaissance affirmed that the potential for damage to underground facilities is moderated and attenuated by depth below the ground surface.

2 **Science education beyond the classroom.** Harle, E.J. (SAIC, Las Vegas, NV (United States)); Van Natta, D.; Powell, M.L. pp. 217-220 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The Yucca Mountain Site Characterization Project (YMP) sponsors a variety of classroom-oriented projects and activities for teachers who request them. Also available, though, are extra-curricular programs. One notably successful program is a workshop designed to award girl and boy scouts with geology and atomic energy merit badges. There was a tremendous response to this workshop–it attracted 450 requests within the first week of its announcement. Since October 1991, the YMP has sponsored five such girl scout workshops and four boy scout workshops, attended by a total of 400 scouts. These workshops demonstrate that highly technical subjects can be taught simply through hands-on activities. The idea behind them is not to teach scouts what to think but, rather, how to think. For adults meanwhile, the YMP offers a monthly lecture series, with each lecture averaging 45 minutes in length with 35 people in attendance. These lectures center on such subjects as volcanoes, earthquakes and hydrology. They are usually delivered by YMP technical staff members, who have learned that complex technical issues are best addressed in a small-group format.

3 **Selection of the initial access for the Yucca Mountain Exploratory Studies Facility.** Voegele, M.D. (SAIC, Las Vegas, NV (United States)); Simecka, W.B.; Dyer, J.R.; Elkins, N.Z. pp. 300-305 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC08-87NV10576. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Recent appropriations for the Yucca Mountain Site Characterization Project (YMP) have not included sufficient funding to proceed with the full design and implementation of the Exploratory Studies Facility (ESF) concept developed by the US DOE. To proceed with a phased Exploratory Studies Facility design and construction schedule, DOE was required to address the selection of the preferred location for the initial access to the ESF. In the fall of 1991, the DOE examined possible phasing of the underground construction and design activities for the ESF; preliminary criteria that potentially could be used to select the initial access were developed. Subsequent to that, a task force compared the accesses of the ESF to develop a recommendation about whether either access would be more likely to provide relevant geotechnical information about potential unsuitability of the site.

4 **An integrated approach toward characterization of radionuclide transport at Yucca Mountain, Nevada.** Simmons, A.M. (DOE, Las Vegas, NV (United States)). pp. 608-617 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Characterization of potential aqueous radionuclide migration from waste containers to the accessible environment, a distance of 5 km, is a key step in understanding the efficacy of the natural barrier to isolate waste because of regulations which stipulate that the site must be able to isolate waste for 10,000 years. The Yucca Mountain Site Characterization Project (YMP) has an integrated radionuclide migration program that combines investigations to characterize processes that affect radionuclide transport, including solubility, speciation, sorption, diffusion, and dispersion, and studies to investigate aspects of the natural system affecting those processes, such as mineralogy, mineral stability, and water chemistry. The program also includes studies to understand the behavior of the natural system under disturbed conditions of the thermal pulse, which would potentially alter the chemistry of both heated water and rock hundreds of meters away from the potential repository. Even though the program does not take retardation credit for sorption in the near-field, it must understand the nature of chemical reactions occurring between rock and heated water of a very different composition from that under ambient conditions. Possible precipitation of minerals along fractures tens of meters from waste packages has implications for sealing fluid pathways and creating a "cap" around the waste packages. Site models developed to support the determination of the natural barrier's efficacy must then support performance

assessment modeling. Validation testing is necessary to build confidence in these models; testing occurs at all program levels and all scales, from data collection to site and performance assessment modeling. This paper focuses on the integration of results from numerous geochemical investigations into models for understanding transport processes.

5 **Geochemistry for high level waste: An international comparison.** Cloke, P.L. (SAIC, Las Vegas, NV (United States)). pp. 618-625 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

This paper presents a brief summary of some of the recent and on-going geochemical research related to the disposal of high level radioactive waste. For most categories of research (basic chemical reactions, solubilities, thermochemical data, kinetics, modeling, sorption and ion exchange, colloidal phenomena, isotopic studies, migration, and analytical techniques and chemical analyses) benefits would accrue from increased international communication. This is true in spite of the marked difference in rock type and hydrologic setting between the potential US repository and those of other countries because many of the studies address fundamental characteristics, such as sorption, and because most of the relevant chemistry deals with liquid/solid interactions. In some cases, especially the last three categories noted, much of the research is site specific and of primary interest only to the country in which the site lies.

6 **1992: When things began to move at Yucca Mountain.** Gertz, C.P. (DOE, Las Vegas, NV (United States)); Teitelbaum, S. pp. 806-810 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

On June 29, 1992, Little Skull Mountain, Nevada, located 161 kilometers (100 miles) northwest of Las Vegas, sustained a magnitude 5.6 earthquake. The epicenter of this earthquake was located about 20 km from Yucca Mountain, where suitability studies for an underground nuclear waste repository are ongoing. Though some of the older buildings erected nearby were damaged, studies of adjacent mines and tunnels revealed that the earthquake had caused no comparable damage underground. There were no immediately apparent reasons to discount the area as a suitable location for a potential geologic repository for high-level nuclear waste. The US DOE Office of Civilian Radioactive Waste Management (OCRWM) continues its studies of the mountain. Despite concerted and long-standing political opposition within the state of Nevada that has resulted in long delays, the mountain and its environs teemed with scientific activity throughout 1992. The year, 1993, should prove even more eventful for site characterization. This paper will examine progress made on the Yucca Mountain Site Characterization Project (YMP) during 1992 and continuing into 1993.

7 **Investigation in 3-D of stress distribution in a circular tunnel and vertical emplacement holes due to thermal and overburden loading in tuff.** Kandalaft-Ladkany, N. (Univ. of Nevada, Las Vegas, NV (United States)); Wyman, R.V.; Ladkany, S.G.; Ladkany, P.E. pp. 893-899 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Thermal stress and displacement analysis using two 3-D finite element models, one having a coarse mesh and one having a highly detailed mesh are presented. Results are compared to those obtained by a 2-D plane strain finite element analysis using a coarse mesh. Results indicate that thermal stresses are at least an order of magnitude higher than geothermal and overburden stresses combined. Thermal stresses in the near field rock reach a critical level in the vicinity of the canisters and in some areas around the tunnels which may dictate rock bolting. Local rock collapses may prevent the canisters from being retrieved. Interpolated three-dimensional temperature profiles, used in the analysis, are also presented.

8 **Single-hole in situ thermal probe for hydrothermal characterization at Yucca Mountain.** Danko, G. (Univ. of Nevada, Reno, NV (United States)); Buscheck, T.A. pp. 975-985 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract W-7405-ENG-48. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The REKA thermal probe method, which uses a single borehole to measure in situ rock thermophysical properties and provides for efficient and low-cost site characterization, is analyzed for its application to hydrothermal system characterization. It is demonstrated throughout the evaluation of several temperature fields obtained for different thermal zones that the REKA method can be applied to simultaneously determine (1) two independent thermophysical properties, i.e., heat conductivity and thermal diffusivity and (2) a set of heat transport parameters, which can be used to characterize the behavior of a hydrothermal system. Based on the direct meaning of these transport parameters, the components of the heat transport mechanism in a given time and location of the hydrothermal system can be described. This evaluation can be applied to characterizing and quantifying in situ rock dry-out and condensate shedding at the proposed repository site.

9 **Two-way communication: A case study in improving public interactions.** Reilly, B. (SAIC, Las Vegas, NV (United States)); Austin, P. pp. 995-999 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Successful public interaction requires several key elements. They include: A non-intimidating forum for exchanging information, two-way communication, advance preparation to identify what each party wants to learn, and feedback. There is no single approach that guarantees success. Factors such as technical complexity of the issue, level of support by the public, and trust and confidence among the parties all play a role in determining the most workable approach for any particular situation. By focusing on a specific case involving the communication of nuclear waste issues in Nevada, this paper illustrates lessons learned by the US DOE in communicating controversial issues to the public. In particular, this case study traces the

last three years of utilizing various communication approaches with Nevada citizens and identifies an approach that appears to be effective for DOE.

10 **Using an engaging approach to products to help create long-term credibility.** McNeill, G. (SAIC, Las Vegas, NV (United States)); Larkin, E. pp. 1000-1005 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

A long-term, thorough and engaging public information products plan is essential for supporting interaction between Nevadans and the scientists and staff of the US DOE Yucca Mountain Site Characterization Project (YMP). As members of the Institutional and External Affairs office on the YMP in Nevada, our focus is to create successful products for a Nevada audience, in accordance with DOE regulations. Our product plan is broad, but has the same theoretical foundation whether we are developing a new fact sheet of working with a scientist to help him or her communicate effectively. Our goals are to: Create products that help build long-term credibility; communicate honestly about risk; engage the public in meaningful, effective ways; be receptive to hearing Nevadans' concerns and questions; respond in ways that indicate that the public has been heard and respected; and to keep away from the "us" versus "them" orientation, distinguishing our communication approach from others. Explanations of our rationale, products plan, and goals and techniques for achieving them are stated, and related problems are described.

11 **Yucca Mountain student tours: Response, reactions, and results.** Wadkins, M.L. (SAIC, Las Vegas, NV (United States)); Hill, C.R. pp. 1006-1013 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

In March of 1991, the Yucca Mountain Site Characterization Project (YMP) began providing monthly tours for the general public to visit the Yucca Mountain site. The goal of these tours has been to inform the public and to provide direct contact to Project scientists. An overwhelming response has since created a need for expansion of the tour program to meet community demands. This paper describes the development, implementation, and results of the grade 6-12 tour program introduced in the last year to meet the needs of the educational community in particular.

12 **Earthquakes and nuclear waste: A lesson in media relations.** Patrick, S.M. (SAIC, Las Vegas, NV (United States)). pp. 1014-1022 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The Little Skull Mountain earthquake on June 29, 1992 marked the beginning of a challenging period for the US DOE's Yucca Mountain Site Characterization Project's (YMP's) Public Affairs department. We needed to relay complicated and difficult to understand scientific principals in an easily understandable fashion to local and national media who were hungry for detailed information. Volumes of quickly accumulating data was swiftly sorted, interpreted, and placed in context with other data in order to be properly presented. The main difficulty in this situation was attempting to assure that the information presented led to an intellectual and not emotional analysis of the earthquake. This paper will discuss some of the processes undertaken to meet both the needs of local media as well as our own needs.

13 **Testing the spatial neutrality of the REMI net migration equation.** Barr, C.F. (Science Applications International Corp., Las Vegas, NV (United States)); Perrigo, T.A.; Daneshvary, N.; Rickman, D.S. pp. 40-47 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The U.S. Department of Energy (DOE), Yucca Mountain Site Characterization Project Office (YMPO) is conducting socioeconomic studies in the State of Nevada in accordance with the Nuclear Waste Policy Act of 1982, as amended. The main purpose of the socioeconomic program is to avoid or minimize adverse socioeconomic impacts of the Yucca Mountain Site Characterization Project (YMP) on local communities, counties, and the state of Nevada. This objective is being met by collecting data that can be used by the DOE and affected units of local government to monitor economic and demographic variables and forecast changes that may occur as a direct result of the YMP. One of the tools being used to develop population and employment forecasts in Clark, Lincoln, and Nye counties in Nevada is Regional Economic Modeling Inc.'s (REMI) Economic-Demographic Forecasting and Simulation (EDFS) model. The REMI model is widely used in applied economics for: forecasting and planning; economic development; transportation; energy and natural resources; taxation, budget, and welfare; United States policies; and environmental policies. This model was chosen by the DOE because it is a dynamic econometric model based on accepted economic theory and principles, and because of its favorable rating compared to other available models. The dynamic nature of the model offers improvements in forecasting capabilities over input-output models. Because the DOE is making extensive use of the REMI model, it is necessary to evaluate the model's forecasting performance. This study is an empirical test of the restrictions in the REMI model's net migration equation. The REMI model pools the data across regions to estimate net migration into each region. For this study we will examine Clark County net migration. We hypothesize that due to the differences among regions (such as distance, and geographic and cultural features specific to each region), pooling the data across regions may not be appropriate.

14 **The interactive process: A formal means to improved relations.** Benson, A. (Dept. of Energy, Washington, DC (United States)); Seidler, P.E.; Ulick, M.D.; Robison, A.C. pp. 56-57 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper will examine the U.S. Department of Energy's Office of Civilian Radioactive Waste Management's (DOE/OCRWM) continued efforts to improve relations and facilitate communications with officials from Nye County,

Nevada, the site of the proposed Yucca Mountain nuclear waste repository. The Protocol on On-Site Representation establishes certain procedures for interactions between Nye County and DOE/OCRWM specific to the host county. These include on-site representation, the County's ability to conduct independent testing and oversight and the timely exchange of information related to site characterization.

15 **Advertising public outreach–going where the people are.** Bradford, D. (Science Applications International Corp., Las Vegas, NV (United States)); Burns, D. pp. 76-82 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

In a continuing effort to invite new and larger segments of the public to participate in Yucca Mountain Site Characterization Project (YMP) Public Outreach Programs, examination of methods to enhance existing Public Outreach advertising programs began in 1993. Apart from the desire to promote greater public awareness and participation of the YMP, the Project itself is receiving less coverage of its scientific aspects in the local media. Since the public is already comfortable receiving messages in these media, this becomes an additional reason to explore and study advertising as a platform for invitations to the public.

16 **Technology information transfer in public outreach - a new approach.** Peck, J.H. (Science Applications International Corp., Las Vegas, NV (United States)); Wadkins, M.L. pp. 92-97 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The timely and accurate dissemination to the public of information derived from the site characterization activities on the Yucca Mountain Site Characterization Project (YMP) has sometimes been difficult to achieve. The YMP has many participants who are involved in the gathering and analysis of scientific and engineering data for site characterization. The diversity of the scientific disciplines involved, the uncentralized location of the participant organizations, the difficulty of being able to ask the right questions of the right people, and the translation of technical jargon into understandable terms are but a few of the challenges. The public outreach program of the YMP has done an excellent job of compiling and distributing information over the past few years, but, with the diversity and expansion of field activities in the last two years, the job has become more formidable. A new approach to help resolve this obstacle was instituted in April of 1993, and has been successful in achieving a much more timely and user-friendly discussion of technical information for the public. What is the new approach? The assignment of a technical expert to the public outreach staff whose job is to know what is going on, who is doing what, and what the results are. Based on that knowledge, factual summaries can be generated rapidly and presented to the public in the context of the overall project goals and in a form suitable for a wide range of audiences.

17 **Urban versus rural risk perception relating to high-level nuclear waste.** Soden, D.L. (Univ. of Nevada, Las Vegas, NV (United States)). pp. 136-141 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

In this study, the general public's perceptions of risk pertaining to the proposed Yucca Mountain project are investigated across two distinct areas of Nevada– rural and urban. Considerable research has demonstrated that rural Nevada and urban Nevada reflect political and social cultures which lead residents in each region to respond to proposed programs and policies in different ways, Using a multi-dimensional perspective on risk, a preliminary investigation into citizen's attitudes in each region of the state is made.

18 **Growing interest, growing programs, growing pains: Successfully customizing public outreach.** Wadkins, M. (SAIC, Las Vegas, NV (United States)); Hill, C.; Hirsch, T. pp. 232-237 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Since the mid-1980's, the Institutional and External Affairs staff of the Yucca Mountain Site Characterization Project (YMP) has developed, coordinated, and maintained various public outreach programs to carry out the YMP's open door policy of keeping local communities informed. However, public involvement first requires public knowledge and, therefore, various information programs have been established over the past few years. First came the speakers bureau program, then the exhibits and science centers; and then came the tours and school district educational programs. All these programs were geared toward teaching the mainstream general public about the YMP and issues related to things nuclear. Today, the YMP outreach programs are established and known and the demand from the public has seen a shift. Over 150 top scientists and staff from around the country who have come to work at the YMP have joined the outreach participant pool to speak to the public not only about Yucca Mountain, but about their areas of expertise as well. For this reason, the public has realized a great opportunity for a general science and engineering education resource – the YMP staff themselves. In a panel discussion, "Trust and credibility: The central issue", proceedings of the National Conference on Risk Communication, it was shown that university professors and science teachers were among the most trusted individuals in terms of public perception and that government staff and contractors the least trusted. However, when you utilize the core educated knowledge of a YMP scientist in order to teach general science and math, you have, to some extent, placed that individual in an educational role and thus increased trust. The YMP scientists enjoy talking about their general science knowledge and we have found that the public likes to hear about it too.

19 **Potential economic benefits of the Yucca Mountain Project.** Babcock, R.A. (Univ. of Nevada, Reno, NV (United States)). pp. 642-649 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper summarizes a larger document of the same title that examines some of the potential economic benefits that could accrue to the State of Nevada, the affected counties, and various businesses and institutions within the state as a function of the Yucca Mountain project. A copy of the original document is available from the author.

20 **Population estimation techniques for routing analysis.** Sathisan, S.K. (Univ. of Nevada, Las Vegas, NV (United States)); Chagari, A.K. pp. 658-665 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A number of on-site and off-site factors affect the potential siting of a radioactive materials repository at Yucca Mountain, Nevada. Transportation related issues such route selection and design are among them. These involve evaluation of potential risks and impacts, including those related to population. Population characteristics (total population and density) are critical factors in the risk assessment, emergency preparedness and response planning, and ultimately in route designation. This paper presents an application of Geographic Information System (GIS) technology to facilitate such analyses. Specifically, techniques to estimate critical population information are presented. A case study using the highway network in Nevada is used to illustrate the analyses. TIGER coverages are used as the basis for population information at a block level. The data are then synthesized at tract, county and state levels of aggregation. Of particular interest are population estimates for various corridor widths along transport corridors – ranging from 0.5 miles to 20 miles in this paper. A sensitivity analysis based on the level of data aggregation is also presented. The results of these analysis indicate that specific characteristics of the area and its population could be used as indicators to aggregate data appropriately for the analysis.

21 **Experimental heat transfer and fluid flow over drift-emplaced canisters.** Culbreth, W.G. (Univ. of Nevada, Las Vegas, NV (United States)); Pattisam, S. pp. 772-779 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Drift-emplaced waste canisters are under consideration for the long-term storage of high-level spent fuel in the proposed underground repository at Yucca Mountain. These canisters will be placed on pedestals above the floor of the drifts and exchange heat with the walls of the drift and with air circulating through the repository. To assess the requirements of the repository ventilation system, values of the dimensionless convective heat transfer coefficient and the pressure drop across individual canisters were measured in an experimental model of a drift. The results were curvefitted as functions of the spacing between the canisters and the Reynolds number of the flow. Both natural and forced convection effects were investigated.

22 **Simulation of heat transfer around a canister placed horizontally in a drift.** Moujaes, S. (Univ. of Nevada, Las Vegas, NV (United States)); Bhargava, A. pp. 801-808 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The Yucca Mountain Site Characterization Project is investigating the feasibility of locating a high level radioactive nuclear waste repository at Yucca Mountain, Nevada. The bore hole and the in-drift waste emplacement schemes are under evaluation as potential repository drift geometries. This paper presents a two-dimensional analysis of the nuclear waste canister placed horizontally in a drift. Simulation has been carried out for 1000 years and the peak temperatures at the walls of the drift and at the center of the canister have been determined. The effect of the three modes of heat transfer, conduction, natural convection and radiation, is also discussed.

23 **Investigation of stress in a circular tunnel due to overburden and thermal loading of horizontally placed 21 PWR multi purpose canisters.** Kandalaft-Ladkany, N. (Univ. of Nevada, Las Vegas, NV (United States)); Wyman, R.V. pp. 860-867 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 DOE Contract FC08-90NV10872. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The drift of a High Level Nuclear Waste (HLNW) Repository were subjected to 2-D thermal loading resulting from the horizontal emplacement of 125 Ton Multi-Purpose Canisters (MPC). Ten 2-D temperature profiles, resulting from 57 Kw/acre and 114 Kw/acre thermal loading conditions, were used in a finite element analysis of the drift; in which a quadrant of the drift and surrounding rock $\pm$ 100 m above and below the drift were modeled. Our analysis shows that the 114 Kw/acre thermal loading results in compressive stresses around the drift, 60 years after emplacement, that exceed the unconfined compressive strength of the TSW_2 tuff analyzed. Stresses resulting from a 57 Kw/acre thermal loading are within the acceptable limit in tunnel rock. A parametric analysis of the invert backfill material showed that Young's modulus for the invert backfill should closely match that of the surrounding unconfined rock in the tunnel in order to prevent an unacceptable stress rise in both rock and backfill.

24 **Alternative approaches to reliability modeling of a multiple engineered barrier system.** Ananda, M.M.A. (Univ. of Nevada, Las Vegas, NV (United States)); Singh, A.K. pp. 1030-1036 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The lifetime of the engineered barrier system used for containment of high-level radioactive waste will significantly impact the total performance of a geological repository facility. Currently two types of designs are under consideration for an engineered barrier system, single engineered barrier system and multiple engineered barrier system. Multiple engineered barrier system consists of several metal barriers and the waste form (cladding). Some recent work show that a significant improvement of performance can be achieved by utilizing multiple engineered barrier systems. Considering sequential failures for each barrier, we model the reliability

of the multiple engineered barrier system. Weibull and exponential lifetime distributions are used through out the analysis. Furthermore, the number of failed engineered barrier systems in a repository at a given time is modeled using a poisson approximation.

25 **Developing standardized connection analysis techniques for slim hole core rod designs.** Fehr, G. (Science Applications International Corp., Las Vegas, NV (United States)); Bailey, E.I. pp. 1048-1054 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Slim hole core rod design remains essentially in the proprietary domain. API standardization provides the ability to perform engineering analyses and dimensional inspections through the use of documents, ie: Specifications, Bulletins, and Recommended Practices. In order to provide similar engineering capability for non-API slim hole connections, this paper develops the initial phase of what may evolve into an engineering tool to provide at least an indication of relative serviceability between two connection styles for a given application. The starting point for this process will look at bending strength ratios and connection strength calculations. Since empirical data are yet needed to verify the approaches proposed in this paper, it is recognized that the alternatives presented here are only a first step to developing useful rules of thumb which may lead to later standardization.

26 **Impact of nuclear waste traffic on highways.** Sebaaly, P.E. (Univ. of Nevada, Reno, NV (United States)); Siddharthan, R.; Epps, J.A. pp. 1255-1262 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A system was developed to evaluate the impact of nuclear waste traffic on the structural performance of highway pavements throughout the state of Nevada. The associated needs of maintenance and rehabilitations can also be evaluated along with their costs. This paper summarizes the system and provides two sample analyses.

27 **An evaluation of rail access routes to Yucca Mountain.** Sathisan, S.K. (Univ. of Nevada, Las Vegas, NV (United States)); Parentela, E.M. pp. 1270-1277 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper provides a preliminary evaluation and characterization of potential rail routes for the transport of high level radioactive waste from their current storage locations (76 power plants and 4 federal facilities) to the proposed geologic repository at Yucca Mountain, Nevada. Individual routes were determined for shipments from each origin using the INTERLINE model. They were characterized in terms of shipment distance, number of transfers and states transversed. Additionally, specific routing constraints were imposed for a selected subset of the origins to address policy and operational alternatives such as minimizing shipment distance, number of transfers or number of states traversed. Results of the analysis indicate that the imposition of the routing constraint count result in reducing shipment distances, and the number of states traversed. But a tradeoff between these factors and the number of transfers exists.

28 **Analysis of potential highway routes to Yucca Mountain.** Sathisan, S.K. (Univ. of Nevada, Las Vegas, NV (United States)); Parentela, E.M.; Lee, M.S. pp. 1278-1285 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

States have been provided the authority to designate routes for the transport of highway route controlled quantity shipments of radioactive materials. The state of Nevada is currently evaluating alternative routes for such designation. This paper provides a preliminary assessment of potential system impacts of Nevada's highway route designation for the shipment of High Level Radioactive Waste (HLRW) to the proposed geologic repository at Yucca Mountain, Nevada. A potential route being evaluated by Nevada was used to specify routing constraints for highway shipments to Yucca Mountain. Individual routes were determined for shipments from each origin using the HIGHWAY model for unconstrained and constrained routing scenarios. Results of the analysis indicate that the imposition of the routing constraint would result in increased travel times and shipment distances. These increases range from about 1.25 percent to about 80 percent. However, the magnitude of such increases is highly dependent on the geographic location of the origin.

29 **Natural analogues and performance assessment.** Cloke, P.L. (Science Applications International Corp., Las Vegas, NV (United States)). pp. 1329-1336 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

At a high general level this paper presents a number of data types needed for performance assessment (PA) of the potential high level nuclear waste repository at Yucca Mountain, NV. These include hydrology (e.g., fluxes through a breached waste package and to the accessible environment), geochemistry (e.g. water composition and changes thereto due to corrosion and waste dissolution; radionuclide solubilities), the engineered barrier system (e.g. rates and times of container failure; degradation of concrete), the source term, and disruptive scenarios. Some characteristics of three natural analogues, specifically the Taupo Volcanic Zone (New Zealand), Pena Blanca (Mexico), and Cigar Lake (Canada) are then compared against these needs. Each of these sites possesses the potential to provide insights about the long term behavior of the natural system in relation to a few of these characteristics and data needs. The characteristics that pertain to performance at Yucca Mountain differ from site to site and largely do not overlap each other. The paper presents one way of evaluating the potential applicability of studies at a specific site to PA. The way in which such studies would be used by PA is not discussed.

30 **Planning and management of change.** Nelson, R.M. Jr. (Department of Energy, Las Vegas, NV (United States)); Statton, C.T.; St. Clair, R.K. pp. 1722-1730 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The 1990s promise to be a decade of change. In business, the focus will be on restructuring for purposes of improved productivity and efficiency. The Department of Energy (DOE) has recognized that change is on the horizon. The Yucca Mountain Project, carried out under the Office of Civilian Radioactive Waste Management (OCRWM) within the DOE is under new leadership. This new leadership is restructuring its operations to provide better focus, greater efficiency, meaningful products demonstrating progress and a more open operational environment. Criticisms of past operations have been reviewed and evaluated such that the new management organization derives benefit from the past. In recognition that management concerns may be manifested in other areas, Yucca Mountain Project management believes that reorganization is necessary to maximize efficiency. In designing the new organization, a high priority has been placed upon making changes which enable the federal leadership to exercise appropriate control and make participants more responsible and accountable for their work. Transition to the new organization will be implemented in four phases: (1) establishing the management construct, (2) defining roles and responsibilities of functional management, (3) development of the task performance teams, and (4) subsequent evolution of the "project team" as a whole. A program-wide strategic plan is being prepared which includes a variety of revisions to the program of the past. This plan charts the path the Department will follow in fulfilling its mission. The vision of the new management developed by the DOE focuses on the creation of "teams," both a management team and task performance teams. The new management team will be tasked with implementing the plan.

31 **Subsurface transport modeling of the Savannah River and Yucca Mountain Sites.** Dunlap, B.E. (Univ. of Nevada, Las Vegas, NV (United States)); Pepper, D.W.; Stephenson, D.E. pp. 1848-1853 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

An adaptive two-dimensional finite element method is used to model groundwater flow and contaminant transport in variably saturated porous media. The model is applied to known groundwater contamination at the Savannah River Site, which consists of multiple ground strata. A simulation of the proposed Yucca Mountain Repository Site is also executed to assess potential burial of radioactive waste.

32 **Active versus passive radon monitoring at the Yucca Mountain site.** Griffin, M.D. (Science Applications International Corp., Las Vegas, NV (United States)). pp. 1953-1958 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Federal Regulations have mandated that a baseline assessment for the Yucca Mountain Site be performed. This includes the detection and monitoring of specific radionuclides present at the site. These radionuclides include radon 222, a decay progeny of naturally occurring uranium. Two radon monitoring systems are utilized at the Yucca Mountain site to detect ambient levels of radon. The first is a passive time integrated system, and the second is a continuous radon monitoring (CRM) system.

33 **Development of functional characteristics of vehicle mounted plastic scintillation system.** Follette, J.G. (Science Applications International Corp., Las Vegas, NV (United States)); Briggs, C.T.; Tappen, J.J. pp. 1964-1970 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

To meet the Yucca Mountain Site Characterization Project Office preactivity survey schedules, increase efficiency, and reduce labor costs, SAIC implemented the use of a Vehicle Mounted Radiation Detector (VMRD). The VMRD consists of two systems, a Global Positioning System (GPS) and a Radiation Detection System (RDS). This paper focuses on the functional characteristics of the RDS. The functional characteristics of the TSA Model GPRS-100 Vehicle Mounted Global Positioning Radiometric Scanner were studied. The tests performed during this study were limited to gamma ray energies between 275 keV and 1275 keV, and source strengths between 16 kBq and 318 kBq. The system's efficiency as a function of vehicle speed, gamma ray energy, detector height, and source activity are presented. The system's efficiency as a function of detector height for Cs-137 ranged from 3.14% for a detector height for Cs-137 ranged from 3.14% for a detector height of 15 cm, to 0.91% for a detector height of 60 cm. The system's efficiency is not dependent upon gamma ray energy or source activity for the sources used in this study. It was determined that the system's efficiency as a function of speed falls within a predictable range dependent upon detector height and vehicle speed. For performing large area preactivity surveys a detector height of 60 cm and vehicle speed of less than 2.5 m/s will optimize this system's efficiency.

34 **Investigation of faulted tunnel models by combined photoelasticity and finite element analysis.** Ladkany, S.G. (Univ. of Nevada, Las Vegas, NV (United States)); Huang, Yuping. pp. 1979-1986 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract FC08-90NV10872. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Models of square and circular tunnels with short faults cutting through their surfaces are investigated by photoelasticity. These models, when duplicated by finite element analysis can predict the stress states of square or circular faulted tunnels adequately. Finite element analysis, using gap elements, may be used to investigate full size faulted tunnel system.

35 **Uniaxial strength testing of Calico Hills tuff, Yucca Mountain: Preliminary results.** Li, Qizhi (Univ. of Nevada, Reno, NV (United States)); Schultz, R.A. pp. 2106-2111 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A detailed investigation of the strength properties of Calico Hills tuff was undertaken to further characterize the behavior of this unit. Uniaxial compression test on 47 samples of massive and reworked tuff show a dependence of peak strength and Young's modulus on the total porosity, and thus on the geologic history of the Calico Hills tuff. Controlled deformation of test specimens documents axial splitting and faulting as failure mechanisms in the post-peak region of these brittle tuffs.

36 **Site characterization and related activities at the potential high-level radioactive waste repository site at Yucca Mountain, Nevada.** Gertz, C.P. (Department of Energy, Las Vegas, NV (United States)); Nelson, R.M. Jr.; Blanchard, M.B.; Cloke, P.L. pp. 2291-2296 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The Yucca Mountain Site Characterization Project (YMP) involves a complex set of activities and issues. These include the Exploratory Studies Facility (ESF), site characterization surface-based testing, performance assessment, public outreach and information services, conceptual design of a potential repository, compliance with regulations, environmental issues, transportation of nuclear wastes, and systems engineering. Integration among the scientific and technical activities requires constant attention to keep work focused on determining the suitability of the site and on avoiding irretrievable loss of data. All activities must be conducted with due regard to quality assurance and safety and health. This paper provides a brief summary of the status of these activities as of December, 1993.

37 (DOE/NV/10872–T158) **A floristic survey of Yucca Mountain and vicinity, Nye County, Nevada.** Niles, W.E.; Leary, P.J.; Holland, J.S.; Landau, F.H. Nevada Univ., Las Vegas, NV (United States). Dec 1994. 51p. Sponsored by USDOE, Washington, DC (United States). DOE Contract FC08-90NV10872. Order Number DE95007343. Source: OSTI; NTIS; INIS; GPO Dep.

A survey of the vascular flora of Yucca Mountain and vicinity, Nye County, Nevada, was conducted from March to June 1994. An annotated checklist of recorded taxa was compiled. Voucher plant specimens were collected and accessioned into the Herbarium at the University of Nevada, Las Vegas. Collection data accompanying these specimens were entered into that herbarium's electronic data base. Combined results from this survey and the works of other investigators reveal the presence of a total of 325 specific and intraspecific taxa within the area, these allocated to 162 genera and 53 families. Owing to drought conditions prevalent throughout the area, the annual floristic component was largely absent during the period of study, and it is likely much under-represented in the tabulation of results. No taxon currently listed as threatened or endangered under the Endangered Species Act was encountered during this study. Several candidate species for listing under this Act were present, and distributional data for these were recorded. No change in the status of these candidate species is recommended as the result of this survey.

38 (DOE/NV/10872–T160) **Analytical laboratory and mobile sampling platform. Progress report, October 1, 1994–December 31, 1994.** Stetzenbach, K. Nevada Univ., Las Vegas, NV (United States). Harry Reid Center for Environmental Studies. [1994]. 8p. Sponsored by USDOE, Washington, DC (United States). DOE Contract FC08-90NV10872. Order Number DE95007341. Source: OSTI; NTIS; GPO Dep.

This paper is a quarterly report describing the use of a new soil gas collection device which allows the collection of soil gas in the field for later analysis in the laboratory. It describes the installation of this sampling device and the procedure for setting the probe, extraction of soil gas beneath the surface, and sealing of the soil gas for transport. The sites used for initial testing was the top of Yucca Mountain and Crystal Spring in Ash Meadows National Wildlife Refuge. The results from this initial test showed no volatile matter present in the soil at these locations.

39 (DOE/NV/10872–T163) **Identification and characterization of conservative organic tracers for use as hydrologic tracers for the Yucca Mountain site characterization study. Progress report, October 1, 1994–December 31, 1994.** Stetzenbach, K.; Farnham, I. Nevada Univ., Las Vegas, NV (United States). Harry Reid Center for Environmental Studies. [1994]. 26p. Sponsored by USDOE, Washington, DC (United States). DOE Contract FC08-90NV10872. Order Number DE95007338. Source: OSTI; NTIS; GPO Dep.

The bromide anion has been used extensively as a tracer for mapping the flow of groundwater. It has proven to be both a safe and reliable groundwater tracer. The goal in this study is to find several tracing compounds with characteristics similar to the bromide anion to be used in multiple well tracing tests. Four groups of fluorinated organic acids were selected as candidates for groundwater tracers. These groups include fluorinated benzoic acids (FBA), fluorinated salicylic acids (FSA), fluorinated toluic acids (FTA), and fluorinated cinnamic acids (FCA). These compounds have been shown to move readily with the flow of water and do not adsorb to soil. They are also non-toxic. In this study, the retention of the fluorinated organic acids on to a soil column is compared to that of the bromide ion. The time required for the elution of each analyte from the soil column is measured using a UV-Vis detector. The soils consist of the light, medium, and dark tuffs used in the batch study. The work performed during this quarter consists of the continuation of the batch studies for the fluorinated benzoic acids and column studies for several potential tracer compounds.

40 (DOE/NV/11417–6) **Great Basin Paleoenvironmental Studies Project: Technical progress report, Second quarter (Year 2), September–December 1994.** Nevada Univ., Reno, NV (United States). Desert Research Inst. [1994]. 9p. Sponsored by USDOE, Washington, DC (United States). DOE Contract FC08-93NV11417. Order Number DE95005122. Source: OSTI; NTIS; GPO Dep.

The paleobiotic and geomorphic records are being examined for the local and regional impact of past climates to assess Yucca Mountain's suitability as a high-level nuclear waste repository. In particular these data are being used to

provide estimates of the timing, duration and extremes of past periods of moister climate for use in hydrological models of local and regional recharge that are being formulated by USGS and other hydrologists for the Yucca Mountain area. The project includes botanical, faunal, and geomorphic components that will be integrated to accomplish this goal.

41 (DOE/NV/11432–T4) **TBM tunneling on the Yucca Mountain Project.** Morris, J.P. (Kiewit Construction Co., Las Vegas, NV (United States)); Hansmire, W.H. Reynolds Electrical and Engineering Co., Inc., Las Vegas, NV (United States). [1995]. 19p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC08-94NV11432. Order Number DE95008139. Source: OSTI; NTIS; INIS; GPO Dep.

The US Department of Energy's (DOE) Yucca Mountain Project (YMP) is a scientific endeavor to determine the suitability of Yucca Mountain for the first long-term, high-level nuclear waste repository in the United States. The current status of this long-term project from the construction perspective is described. A key element is construction of the Exploratory Studies Facility (ESF) Tunnel, which is being excavated with a 7.6 m (25 ft) diameter tunnel boring machine (TBM). Development of the ESF may include the excavation of over 15 km (9.3 mi) of tunnel varying in size from 3.0 to 7.6 m (10 to 25 ft). Prior to construction, extensive constructability reviews were an interactive part of the final design. The intent was to establish a constructable design that met the long-term stability requirements for radiological safety of a future repository, while maintaining flexibility for the scientific investigations and acceptable tunneling productivity.

42 (DOE/OSTI–3406(Suppl.4)) **Yucca Mountain Site Characterization Project bibliography, 1992–1994. Supplement 4.** USDOE Office of Scientific and Technical Information, Oak Ridge, TN (United States). Jun 1992. 304p. Sponsored by USDOE, Washington, DC (United States). Order Number DE94005360. Source: OSTI; NTIS; INIS; GPO Dep.

Following a reorganization of the Office of Civilian Radioactive Waste Management in 1990, the Yucca Mountain Project was renamed Yucca Mountain Site Characterization Project. The title of this bibliography was also changed to Yucca Mountain Site Characterization Project Bibliography. Prior to August 5, 1988, this project was called the Nevada Nuclear Waste Storage Investigations. This bibliography contains information on this ongoing project that was added to the Department of Energy's Energy Science and Technology Database from January 1, 1992, through December 31, 1993. The bibliography is categorized by principal project participating organization. Participant-sponsored subcontractor reports, papers, and articles are included in the sponsoring organization's list. Another section contains information about publications on the Energy Science and Technology Database that were not sponsored by the project but have some relevance to it. Earlier information on this project can be found in the first bibliography DOE/TIC-3406, which covers 1977–1985, and its three supplements DOE/OSTI-3406(Suppl.1), DOE/OSTI-3406(Suppl.2), and DOE/OSTI-3406(Suppl.3), which cover information obtained during 1986–1987, 1988–1989, and 1990–1991, respectively. All entries in the bibliographies are searchable online on the NNW database file. This file can be accessed through the Integrated Technical Information System (ITIS) of the US Department of Energy (DOE).

43 (DOE/OSTI–3406-Suppl.4-Add.1) **Yucca Mountain Site Characterization Project Bibliography, January–June 1993. An update: Supplement 4, Addendum 1.** Stephan, P.M. (ed.). USDOE Office of Scientific and Technical Information, Oak Ridge, TN (United States). Jan 1995. 31p. Sponsored by USDOE, Washington, DC (United States). Order Number DE94014499. Source: OSTI; NTIS; INIS; GPO Dep.

Following a reorganization of the Office of Civilian Radioactive Waste Management in 1990, the Yucca Mountain Project was renamed Yucca Mountain Site Characterization Project. The title of this bibliography was also changed to Yucca Mountain Site Characterization Project Bibliography. Prior to August 5, 1988, this project was called the Nevada Nuclear Waste Storage Investigations. This bibliography contains information on this ongoing project that was added to the Department of Energy's Energy Science and Technology Database from January 1, 1994 through June 30, 1994. The bibliography is categorized by principal project participating organization. Participant-sponsored subcontractor reports, papers,and articles are included in the sponsoring organization's list. Another section contains information about publications on the Energy Science and Technology Database that were not sponsored by the project but have some relevance to it.

44 (DOE/RW–0463) **Site characterization progress report, April 1, 1994–September 30, 1994: Yucca Mountain, Nevada. Volume 11.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (United States). Mar 1995. 405p. Sponsored by USDOE, Washington, DC (United States). Order Number DE95010517. Source: OSTI; NTIS; INIS; GPO Dep.

The Civil Radioactive Waste Management Program was restructured to provide a new approach to the evaluation of the site for development as a repository and to its licensing. Funding was increased for FY 95, with most of the increase going to the Yucca Mountain site characterization project. During this period, significant progress was made in surface-based testing, advanced conceptual design, performance assessment, planning, licensing support system development activities, and construction of the Exploratory Studies Facility. The report is divided into the following sections: introduction, programmatic activities, site programs, repository design, waste package, performance assessment, and exploratory studies facility design/construction.

45 (DOE/YMSCO–002) **Applications of natural analogue studies to Yucca Mountain as a potential high level radioactive waste repository.** Science Applications International Corp., Las Vegas, NV (United States). Feb 1995. 29p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC08-87NV10576. Order Number DE95009812. Source: OSTI; NTIS; INIS; GPO Dep.

The 5-member group convened in Las Vegas, Nov. 11-13, 1991, to clarify the extent to which studies of natural analogues can assist the Yucca Mountain site characterization (SC) project. This document is to provide guidance and recommendations to DOE for the implementation of natural analogue studies in the SC program. Performance assessment, integrity of engineered barriers, and communication to the public and the scientific community are stressed. The reference design being developed by Babcock & Wilcox Fuel Company are reviewed. Guidelines for selecting natural analogues are given. Quality assurance is discussed. Recommendations are given for developing an effective natural analogue program within the SC program.

46 (EGG–11265-2035) **The effect of drought on four plant communities in the northern Mojave Desert.** Schultz, B.W. (Desert Research Inst., Reno, NV (United States)); Ostler, W.K. EG and G Energy Measurements, Inc., Las Vegas, NV (United States). [1993]. 18p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC08-93NV11265. (CONF-9310276–12: 8. wildland shrub and arid land restoration symposium, Las Vegas, NV (United States), 19-21 Oct 1993). Order Number DE95004166. Source: OSTI; NTIS; GPO Dep.

Desert plant communities contain many perennial plant species that are well adapted to arid environments; therefore, one would intuitively believe that perennial desert species readily survive drought conditions. Abundant research on plant-soil-water relationships in North American deserts has shown that many species can maintain water uptake and growth when the soil-water potential is low. Little research, however, has focused on how prolonged drought conditions affect plant species in vegetation associations in desert ecosystems. A prolonged and widespread drought occurred in much of the western United States, including the Northern Mojave Desert, from 1987 through 1991. During this drought period vegetation characterization studies, initiated in 1990, by the US Department of Energy (DOE) at Yucca Mountain, Nevada, allowed EG and G Energy Measurements to collect data that could be used to infer how both desert vegetation associations and desert plant species reacted to a prolonged drought. This paper presents the preliminary results.

47 (PNC-TN–1100-94-003, pp. IV/19-IV/28) **Total system performance assessment for Yucca Mountain.** Boak, J.M. (USDOE Yucca Mountain Site Characterization Project Office, Las Vegas, NV (United States)). Power Reactor and Nuclear Fuel Development Corp., Tokyo (Japan). 1994. (CONF-9311199–: International workshop on research and development of geological disposal, Tokai (Japan), 15-19 Nov 1993). In *Proceedings of technical session on research and development of geological disposal.* 379p. Order Number DE95757546. Source: OSTI; NTIS; INIS.

As part of the U.S. Department of Energy's evaluation of site suitability for a potential high-level radioactive waste repository, the long-term behavior of the mined geologic disposal system must be determined. This determination requires a knowledge of the characteristics of the present natural system, waste-package and engineered-system designs, a description of the environment around the emplacement zone, and descriptions of possible perturbations that may affect the nature of the engineered and natural systems. In 1991, participants in the Yucca Mountain Site Characterization Project completed a preliminary assessment of the likely performance of a potential repository at Yucca Mountain, Nevada. This preliminary assessment evaluated aqueous and gaseous flow, future climatic conditions, and disturbances to the system by basaltic volcanism and inadvertent human intrusion. A second total system performance evaluation is currently in progress. This second iteration is building on the previous analyses in a number of ways. More recent site characterization information and a much more complex model representing the source term are being incorporated. Multiple waste package designs, emplacement modes, and areal power densities are being analyzed. (author).

48 **Yucca Mountain reveals its secrets to scientists.** Gertz, C.P. (Yucca Mountain Site Characterization Project, Las Vegas, NV (United States)); Teitelbaum, S. *Forum for Applied Research and Public Policy;* 9(3): 106-112 (Fal 1994).

US nuclear power plants have generated some 20,000 metric tons of waste, according to Carl P. Gertz, former Department of Energy (DOE) project manager for Yucca Mountain Site Characterization, and Sheldon Teitelbaum, senior writer for the Las Vegas-based Science Application International Corporation. In the search for disposal methods, DOE fixed on Yucca Mountain, Nevada, a "sprawling heap of volcanic tuff" situated on a parcel of federally owned land 90 miles northwest of Las Vegas. The authors maintain that Yucca Mountain's sparse population, dry climate, deep watertable, and 5,000-foot-thick layer of compressed volcanic rock may make it a suitable long-term storage facility. Nevertheless, Gertz and Teitelbaum say, much research must be done before the site is formally adopted as a repository and begins to receive shipments of high-level nuclear waste.

CRWMS M&O, LAS VEGAS

49 **Operational considerations in drift emplacement of waste packages.** Benton, H.A. (B&W Fuel Co., Las Vegas, NV (United States)). pp. 544-550 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

This paper discusses the operational considerations as well as the advantages and disadvantages of emplacing waste packages in drifts in a repository. The considerations apply particularly to the potential repository for spent nuclear fuel and high-level waste glass at Yucca Mountain, although most of the considerations and the advantages and disadvantages discussed in this paper do not necessarily represent the official views of the DOE or of the Management and Operations Contractor, since most of these considerations are still under active discussion and the final decisions will not be made for some time - perhaps years. This paper describes the issues, suggests some principles upon which decisions should be based, and states some of the most significant advantages and disadvantages of the emplacement modes, and the associated waste package types and thermal loadings.

50 **Waste Packager and Areal Power Density Approximator (WPA3) computer code.** King, J. (TRW Environmental Safety Systems Inc., Vienna, VA (United States)); Rhodes, C.; Byrne, J. pp. 563-567 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Areal Power Density (APDs) can be used in conjunction with spent fuel characteristics to predict temperature profiles in the proposed Mines Geologic Disposal System (MGDS) at Yucca Mountain. A microcomputer-based computer code called Waste Packager and Areal Power Density (APD) Approximator (WPA3) has been developed to compute waste package inventories and track individual assembly characteristics so that heat output at any point in time can be

calculated. The waste package inventories are emplaced using a simple, serial emplacement model to estimate overall APDs and Local APDs (LAPDs) for a realistic, time-phased emplacement of an actual waste stream produced by a system-level model. WPA3 can also be used to aggregate individual waste packages into equivalent, lumped source terms for more realistic and robust thermal analyses.

51 **Systems implications of repository thermal loading.** Gottlieb, P. (TRW Environmental Safety Systems Inc., Vienna, VA (United States)); Packer, B.; King, J.; Bailey, W. pp. 874-879 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

A study was conducted to determine if implementation of a hot, cold or intermediate repository thermal loading strategy would have specific impacts on the overall civilian Radioactive Waste Management System. For the three thermal loading strategies examined, no significant impacts were found for the waste acceptance, transportation, or storage elements of the system unless it becomes necessary (1) to thermally levelize the waste stream by blending spent fuel or acceptance or at the MRS, (2) to age spent fuel before emplacement, or unless the utilities require acceptance of youngest fuel first. Impacts on the MGDS were found to fall into three categories: Waste package capacity, underground emplacement area requirements, and performance assessment issues (not addressed in this study).

52 **Demonstration of safety for geologic disposal.** Taylor, E.C. (TRW Environmental Safety Systems, Vienna, VA (United States)); Ramspott, L.D.; Sprecher, W.M. pp. 199-207 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

The US Department of Energy (DOE) is developing a nuclear waste management system that will accept high-level radioactive waste, transport it, store it, and ultimately emplace it in a deep geologic repository. The key activity now is determining whether Yucca Mountain, Nevada is suitable as a site for the repository. If so, the crucial technological advance will be the demonstration that disposal of nuclear waste will be safe for thousands of years after closure. This paper assesses the impact of regulatory developments, legal developments, and scientific developments on such a demonstration.

53 **A critically educated public explores high level radioactive waste management.** Blum, J.E. (TRW Environmental Safety Systems, Inc., Las Vegas, NV (United States)). pp. 224-231 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

It is vital to the citizens of Nevada that they and their children are given an opportunity to explore all sides of the characterization of Yucca Mountain as a potential repository site for spent nuclear fuel. The state-wide, national and international implications demand a reasoned and complete approach to this issue, which has become emotionally and irrationally charged and fueled by incomplete perception and information. The purpose of this paper is to provide curriculum suggestions and recommend concomitant policy developments that will lead to the implementation of a Critical Thinking (CT) approach to High Level Radioactive Waste Management.

54 **Integration of regulations and science for HLW disposal.** Ramspott, L.D. (TRW Environmental Safety Systems, Inc., Livermore, CA (United States)). pp. 292-295 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

It is difficult to integrate the uncertain, experimental, and evolving nature of science with the specificity that characterizes regulations. The scientific community has criticized the EPA standard and the NRC implementing regulation for being overly prescriptive and inflexible. On the other hand, some interest groups see flexibility as permission to subjugate safety to schedule and cost considerations. A proposed integration is based on three ideas that arc specific to Yucca Mountain: (1) total containment of waste over long time-periods is a simple concept that is amenable to regulation, (2) partial mitigation of releases over long time-periods is a complex concept that is not readily amenable to regulation, and (3) retrievably placing waste in the unsaturated zone presents an opportunity for building assurance about containment with long-term confirmatory measurements. A complete safety argument can be presented to obtain a construction authorization, with uncertainty to be reduced and resolved prior to closure of repository. The focus of regulatory concern in the construction authorization phase of licensing would be on measurements that demonstrate the conceptual repository will prevent water from reaching the waste for a very long time. In this demonstration, large-scale long-term effects of waste heat on water would be treated theoretically. In the confirmatory period leading to closure, the regulatory focus would be on measurements that provide assurance that the repository as designed and built will indefinitely limit the contact of water with waste to negligible amounts. In this demonstration, large-scale long-term effects of waste heat on water would be driven by emplaced waste.

55 **Integrating scientific results for a post-closure safety demonstration.** Taylor, E.C. (TRW Environmental Safety Systems, Inc., Vienna, VA (United States)); Ramspott, L.D.; Sinnock, S.; Sprecher, W.M. pp. 301-305 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The U.S. Department of Energy (DOE) is developing a nuclear waste management system that will accept high-level radioactive waste, transport it, store it, and ultimately emplace it in a deep geologic repository. The key activity now is determining whether Yucca Mountain, Nevada is suitable as a site for the repository. If so, the crucial technological advance will be the demonstration that disposal of nuclear waste will be safe for thousands of years after closure. Recent regulatory, legal, and scientific developments imply that the safety demonstration must be simple. The scientific developments taken together support a simple set of

hypotheses that constitute a post-closure safety argument for a repository at Yucca Mountain. If the understanding of Yucca Mountain hydrology presented in the Site Characterization Plan proves correct, then these hypotheses might be confirmed by combining results of Surface-Based Testing with early testing results in the Exploratory Studies Facility.

56 **Robust EBS design and source-term analysis for the partially saturated Yucca Mountain Site.** Apted, M. (Intera Information Technologies, Inc., Denver, CO (United States)). pp. 485-490 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The concept of robust repository design and assessment is examined. Successful demonstration of decoupling of near-field and far-field performance is a central principle in achieving robustness. An innovative design for the engineered barrier system (EBS) for the partially saturated conditions at Yucca Mountain is described based on this principle of robustness.

57 **Ventilation considerations for repository subsurface advanced conceptual design.** Yang, H. (Morrison Knudsen Corp., Las Vegas, NV (United States)); Bhattacharyya, K.K. pp. 530-537 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A number of preliminary concepts of underground ventilation have been developed recently, as a part of the initial studies of the Advanced Conceptual Design (ACD) for the potential nuclear waste repository at Yucca Mountain. This paper presents the ventilation considerations for the current repository subsurface ACD, and analyzes the methodology that may be applied to future design efforts. The introductory study concentrates on the requirements of air flow rates and the concepts of ventilating air distribution. Analysis includes ventilation considerations for three typical operations stages of the repository: initial excavation, operations (development and emplacement simultaneously), and retrieval of waste. Temperature variations of the ventilating air due to different modes of heat transfer between underground rock, airflow, and waste packages are investigated. This initial ventilation study provides a fundamental first step toward a comprehensive ventilation study for the ACD.

58 **FY93 thermal loading systems study.** Saterlie, S.F. (TRW Environmental Safety Systems, Las Vegas, NV (United States)); Thomson, B.H. pp. 573-585 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 DOE Contract AC01-91RW00134. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The ability to meet the overall performance requirements for the proposed Mined Geologic Disposal System (MGDS) at Yucca Mountain, Nevada, requires the two major subsystems (natural barriers and engineered barriers) to positively contribute to containment and radionuclide migration retardation. In addition to the postclosure performance, the proposed repository must meet certain preclosure requirements of safety, retrievability, operability, and also must take into consideration cost and schedule. The thermal loading strategy chosen for such a repository may significantly affect both the postclosure and preclosure performance of the proposed repository. The FY93 Thermal Loading Systems Study was conducted to start developing the structured, detailed technical basis that will be ultimately required to make a thermal loading decision. Various thermal analyses were done and hydrothermal predictions made to evaluate effects on postclosure performance, operability, monitoring, cost, and worker safety. The results show that sufficient technical justification exists so that a recommendation can be made to narrow the range of thermal loading to between 24 and 100 MTU/acre. To emplace waste below 24 MTU/acre would require more area for the full 63,000 MTU of spent nuclear fuel than exists in the primary area plus the three most likely expansion areas of the Site Characterization Plan Conceptual Design of a Repository (SCP CDR). Compelling evidence was found that, above 100 MTU/acre, the conditions would be "too hot" with most of the thermal goals being violated.

59 **Thermal response of the waste package/MPC and EBS.** Bahney, R.H. III (B&W Fuel Co./Management and Operating Contractor, Las Vegas, NV (United States)); Doering, T.W. pp. 809-815 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Thermal evaluations of the multi-Purpose Canister in repository emplacement have been performed by the Yucca Mountain Site Characterization Project Managing and Operating Contractor (YMP-M&O). Thermal effects have been a major study area of the Mined Geologic Disposal System (MGDS). In the past the project has concentrated primarily on borehole-emplaced waste packages, but the Multi-Purpose Canister (MPC) with a capacity of twenty-one pressurized water reactor (PWR) fuel assemblies (or more) will likely be drift emplaced with a multi-barrier disposal container or overpack. This study investigates the thermal behavior of the waste package/MPC and its effect on the repository near-field. Results indicate that peak internal temperatures occur one to five years post emplacement, and the timing of the peak is highly dependent on the choice of design basis fuel and thermal loading. The maximum acceptable capacity of the MPC, with ten year old fuel, was determined to be twenty-one PWRs based on the current peak temperature goal of 350°C; however, higher capacities can be achieved if older fuel is substituted.

60 **Long term nuclear criticality potential in waste packages.** Thomas, D.A. (B&W Fuel Co./Management and Operating Contractor, Las Vegas, NV (United States)); Doering, T.W. pp. 838-844 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Title 10 CFR 60.131.(b).(7) requires that the radioactive waste disposed of in the Mined Geologic Disposal System (MGDS) remain subcritical during the period of isolation. The period of waste isolation, approximately 10,000 years, represents a time period greater than any previously examined for criticality control of spent fuel. Change in the

criticality potential over long time periods for the Multi-Purpose Canister (MPC) waste package conceptual design has been examined and methods of criticality control over this time have been investigated.

61 **Implications of waste package heat output distributions resulting from waste stream variability.** King, J.F. (TRW Environmental Safety Systems, Inc., Vienna, VA (United States)); Rhodes, C.J.; Saterlie, S.F. pp. 868-876 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper describes work performed by the Office of Civilian Radioactive Waste Management (OCRWM) Management and Operating (M&O) Contractor. The work presented in this paper resulted from waste stream analyses conducted in support of the M&O Phase 1 and 2 Repository Thermal Loading Studies. These analyses integrated system design with underground design. The Phase 1 study in particular examined the effects of various system configurations and operating concepts on the waste stream arriving at the proposed repository at Yucca Mountain.

62 **Site characterization plan thermal goals reevaluation.** Saterlie, S.F. (TRW Environmental Safety Systems, Las Vegas, NV (United States)); Garza, J.C. de la. pp. 882-889 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 DOE Contract AC01-91RW00134. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Because performance standards are not established for the Yucca Mountain Site (the Environmental Protection Agency (EPA) standards have been remanded), it is necessary to define surrogate or derived criteria to evaluate performance. The Site Characterization Plan (SCP) in 1988 attempted to define surrogate criteria that could be used to establish repository performance. Since that time, new knowledge has become available and some additional analyses of thermal loading have been performed. Thus it became clear that the thermal goals established in the SCP should be reevaluated. This paper reports on a two month effort undertaken to reevaluate the SCP thermal goals using an expert Working Group. Fifteen thermal goals identified in various sections of the SCP were evaluated by the Working Group. It was recommended that two goals be deleted: (1) to keep borehole wall temperature < 275 degrees C and keep the mid-drift temperature < 100 degrees C. It was also recommended that one goal be added to establish a thermal loading that would not degrade the Upper Paintbrush Tuff Formation (Lowermost Tiva Canyon; Yucca Mountain; Pah Canyon; and Uppermost Topopah Spring Members) (Vitric nonwelded) (PTn) barrier. Two other thermal goals and a process statement were reworded to afford compatibility with any emplacement mode, not just the vertical borehole. A recommendation was made to increase the conservatism of a goal to limit potential impact on the surface environment by limiting temperature rise to < 2 degrees C rather than < 6 degrees C. This revised set of goals was used in the Thermal Loading Systems Study.

63 **Waste package materials selection process.** Roy, A.K. (B&W Fuel Co./M&O Contractor, Las Vegas, NV (United States)); Fish, R.L.; McCright, R.D. pp. 993-999 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The office of Civilian Radioactive Waste Management (OCRWM) of the United States Department of Energy (US-DOE) is evaluating a site at Yucca Mountain in Southern Nevada to determine its suitability as a mined geologic disposal system (MGDS) for the disposal of high-level nuclear waste (HLW). The B&W Fuel Company (BWFC), as a part of the Management and Operating (M&O) team in support of the Yucca Mountain Site Characterization Project (YMP), is responsible for designing and developing the waste package for this potential repository. As part of this effort, Lawrence Livermore National Laboratory (LLNL) is responsible for testing materials and developing models for the materials to be used in the waste package. This paper is aimed at presenting the selection process for materials needed in fabricating the different components of the waste package.

64 **Subrepository scale hydrothermal analysis in support of total system performance assessment at Yucca Mountain.** Mishra, S. (CRWMS M&O/INTERA Inc., Las Vegas, NV (United States)). pp. 1202-1213 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 DOE Contract AC01-91RW00134. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A coupled thermo-hydrologic model is developed to investigate the impact of emplacing high-level nuclear wastes on heat and fluid flow at the subrepository scale, and to develop abstracted results for input to the current total system performance assessment (TSPA) of Yucca Mountain. Numerical computations are carried out in 2-D axisymmetric geometry, using a range of thermal loads, to generate spatial/temporal evolutions in temperature and saturation fields within individual emplacement panels. These results are analyzed to understand the general nature of liquid movement in the repository due to waste heat, and also to define various temperature dependent mechanistic and phenomenological coefficients for predicting waste package and geosphere performance.

65 **Radiation effects from uranium ore bodies.** Duguid, J.O. (Intera, Inc., Vienna, VA (United States)). pp. 1337-1343 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

An approach to developing environmental regulations for high-level waste repositories is by comparison of the effects of natural analogs to the effects of a geologic repository. This paper examines representative uranium ore bodies based on the premise that a geologic repository should pose no more risk than the unmined uranium ore from which the waste was derived. The US Environmental Protection Agency (EPA) initially examined the effects of uranium ore bodies in developing standards for repositories, and later

dropped the comparison in their supporting documentation of the standard (40 CFR 191). Because of the Nuclear Waste Policy Act of 1992, regulations for a repository at Yucca Mountain are again being considered, and information on the effects of uranium ore bodies may contribute to new standard development. This paper develops two repository equivalent uranium ore bodies (in chemically reducing and oxidizing environments) and examines the doses to an individual based on drinking groundwater down gradient from these representative ore deposits. The number of health effects integrated over 10,000 years and the ore body releases are also calculated and compared to the EPA Standard.

66 **Repository program licensing approach.** Williamson, T.M. (Duke Engineering and Services, Inc., Las Vegas, NV (United States)); Gil, A.V. pp. 1585-1592 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Yucca Mountain, Nevada is currently being studied by the US Department of Energy (DOE) as a potential site for a mined geologic repository for high-level nuclear waste. DOE has the responsibility to determine the suitability of the site and to develop a license application (LA) for authorization to construct the potential repository. If the site is suitable, the license application would be submitted to the US Nuclear Regulatory Commission (NRC). The repository program licensing approach is focused on the timely acquisition of information needed in licensing and the resolution of potential licensing issues with the NRC staff. Licensing involves an iterative process requiring refinements as data are acquired, analyzed, and evaluated. The repository licensing approach presented in this paper ensures that the information is available when needed to facilitate the licensing process. Identifying the information needed to evaluate compliance with the performance objectives in 10 CFR 60, monitoring the acquisition of such information, and developing a successful license application are integral elements of DOE's repository program licensing approach. Activities to characterize the site are being systematically conducted as planned in the Site Characterization Plan (SCP). In addition, DOE is implementing the issue resolution initiative, the license application annotated outline (LAAO) process, and interim licensability evaluations to update the early planning in the SCP and to focus site characterization, design, and performance assessment activities on the acquisition of information needed for a site suitability determination and licensing. Collectively, the issue resolution initiative, LAAO process, and interim licensability evaluations are key elements of a transition to the iterative process to answer the question: "When do we have enough data to support licensing?"

67 **Systems engineering applied to the development of the Yucca Mountain project design requirements documents.** Rindskopf, M.S. (TRW Environmental Safety Systems, Inc., Las Vegas, NV (United States)); Royer, D.C. pp. 1634-1640 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The Department of Energy's (DOE) Office of Civilian Radioactive Waste Management (OCRWM) along with its Management and Operating Contractor (M&O) developed a new document hierarchy. The development of the documents, which make up the primary elements of the Yucca Mountain Site Characterization Project requirements baseline, was performed using Systems Engineering Processes tailored to meet the needs of the Yucca Mountain Site Characterization Project.

68 **DOE's topical report on a methodology to assess vibratory ground motion and fault displacement hazards at the Yucca Mountain site.** Fenster, D.F. (TRW Environmental Safety Systems Inc., Vienna, VA (United States)); Quittmeyer, R.C. pp. 2260-2265 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The DOE's Office of Civilian Radioactive Waste Management is in the process of characterizing the Yucca Mountain site, Nye County, Nevada, to evaluate its suitability for development of a geologic repository for spent fuel and high-level radioactive waste. If the site is found suitable, much of these data and analyses can be used in an application for a license to the Nuclear Regulatory Commission. The topical report and methodology described in this paper represent a revision of the deterministic and probabilistic approaches to assessing seismic hazards described in DOE's Site Characterization Report. The proposed probabilistic methodology incorporates experience gained while siting and licensing nuclear power plants and other critical facilities during the past decade. In contrast to the traditional deterministic approach, this methodology incorporates all available geologic, geophysical, and seismological data; frequency of occurrence; and variability and uncertainty in both conceptual models and parameters. It also integrates the hazard from all potential sources. Probabilistic approaches have been used primarily to assess hazards from vibratory ground motion, but this approach also applies to assessing fault displacement hazards. The proposed methodology will provide input for design of surface and subsurface facilities (pre- and postclosure periods) and for performance assessment.

69 (DOE/RW/00134–T15-Vol.1-Rev.1) **FY 93 thermal loading systems study final report: Volume 1. Revision 1.** Saterlie, S.F.; Thomson, B.H. TRW Environmental Safety Systems, Inc., Las Vegas, NV (United States). 29 Aug 1994. 188p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC01-91RW00134. Order Number DE95006912. Source: OSTI; NTIS; INIS; GPO Dep.

The ability to meet the overall performance requirements for the proposed Mined Geology Disposal System at Yucca Mountain, Nevada requires the two major subsystem (natural barriers and engineered barriers) to positively contribute to containment and radionuclide isolation. In addition to the postclosure performance the proposed repository must meet preclosure requirements of safety, retrievability, and operability. Cost and schedule were also considered. The thermal loading strategy chosen may significantly affect both the postclosure and preclosure performance of the proposed repository. Although the current Site Characterization Plan reference case is 57 kilowatts (kW)/acre, other thermal loading strategies (different areal mass loadings) have been

proposed which possess both advantages and disadvantages. The objectives of the FY 1993 Thermal Loading Study were to (1) place bounds on the thermal loading which would establish the loading regime that is "too hot" and the loading regime that is "too cold", to (2) "grade" or evaluate the performance, as a function of thermal loading, of the repository to contain high level wastes against performance criteria and to (3) evaluate the performance of the various options with respect to cost, safety, and operability. Additionally, the effort was to (4) identify important uncertainties that need to be resolved by tests and/or analyses in order to complete a performance assessment on the effects of thermal loading. The FY 1993 Thermal Loading Study was conducted from December 1, 1992 to December 30, 1993 and this final report provides the findings of the study. Volume 1 contains the Introduction; Performance requirements; Input and assumptions; Near-field thermal analysis; Far-field thermal analysis; Cost analysis; Other considerations; System analysis; Additional thermal analysis; and Conclusions and recommendations. 71 refs., 54 figs.

70 (DOE/RW/00134-T15-Vol.2-Rev.1) **FY 93 thermal loading systems study final report: Volume 2. Revision 1.** TRW Environmental Safety Systems, Inc., Las Vegas, NV (United States). 29 Aug 1994. 256p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC01-91RW00134. Order Number DE95006913. Source: OSTI; NTIS; INIS; GPO Dep.

The ability to meet the overall performance requirements for the proposed Mined Geology Disposal System at Yucca Mountain, Nevada requires the two major subsystem (natural barriers and engineered barriers) to positively contribute to containment and radionuclide isolation. In addition to the postclosure performance the proposed repository must meet preclosure requirements of safety, retrievability, and operability. Cost and schedule were also considered. The thermal loading strategy chosen may significantly affect both the postclosure and preclosure performance of the proposed repository. Although the current Site Characterization Plan reference case is 57 kilowatts (kW)/acre, other thermal loading strategies (different areal mass loadings) have been proposed which possess both advantages and disadvantages. The objectives of the FY 1993 Thermal Loading Study were to (1) place bounds on the thermal loading which would establish the loading regime that is "too hot" and the loading regime that is "too cold", to (2) "grade" or evaluate the performance, as a function of thermal loading, of the repository to contain high level wastes against performance criteria and to (3) evaluate the performance of the various options with respect to cost, safety, and operability. Additionally, the effort was to (4) identify important uncertainties that need to be resolved by tests and/or analyses in order to complete a performance assessment on the effects of thermal loading. The FY 1993 Thermal Loading Study was conducted from December 1, 1992 to December 30, 1993 and this final report provides the findings of the study. Volume 2 consists of 10 appendices which contain the following: Waste Stream Analysis; Waste Package Design Inputs; Subsurface Design Inputs; Thermal-Hydrologic Model Inputs; Near-Field Calculations; Far-Field; Reliability of Electronics as a Function of Temperature; Cost Analysis Details; Geochemistry; and Areas of Uncertainty in Thermal Loading.

71 (DOE/RW/00134-T16) **Yucca Mountain Site Characterization Project technical data catalog: Quarterly supplement.** TRW, Inc., Fairfax, VA (United States). 31 Dec 1994. 151p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC01-91RW00134. Order Number DE95007580. Source: OSTI; NTIS; GPO Dep.

The Department of Energy (DOE)/Nuclear Regulatory Commission (NRC) Site-Specific Procedural Agreement for Geologic Repository Site Investigation and Characterization Program requires the DOE to develop and maintain a catalog of data which will be updated and provided to the NRC at least quarterly. This catalog is to include a description of the data; the time (date), place, and method of acquisition; and where the data may be examined. The Yucca Mountain Site Characterization Project (YMP) Technical Data Catalog is published and distributed-in accordance with the requirements of the Site-Specific Agreement. The YMP Technical Data Catalog is a report based on reference information contained in the YMP Automated Technical Data Tracking System (ATDT). The reference information is provided by Participants for data acquired or developed in support of the YMP. The Technical Data Catalog is updated quarterly and distributed in the month following the end of each quarter. A complete revision to the catalog is published at the end of each fiscal year. Supplements to the end-of-year edition are published each quarter. These supplements provide information related to new data items not included in previous quarterly updates and data items affected by changes to previously published reference information. The Technical Data Catalog, dated September 30, 1994, should be retained as the baseline document for the supplements until the end-of-year revision is published and distributed in October 1995.

72 **Release modes and processes relevant to source-term calculations at Yucca Mountain.** Apted, M.J. (Intera Information Technologies, Denver (United States)). *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 1-19 (1994).

Special issue Yucca Mountain.

The feasibility of permanent disposal of radioactive high-level waste (HLW) in repositories located in deep geologic formations is being studied world-wide. The most credible release pathway is interaction between groundwater and nuclear waste forms, followed by migration of radionuclide-bearing groundwater to the accessible environment. Under hydrologically unsaturated conditions, vapor transport of volatile radionuclides is also possible. The near-field encompasses the waste packages composed of engineered barriers, while the far-field includes the natural barriers. Taken together, these two subsystems define a series of multiple, redundant barriers that act to assure the safe isolation of nuclear waste. In the U.S., the Department of energy (DOE) is investigating the feasibility of safe, long-term disposal of high-level nuclear waste at the Yucca Mountain site in Nevada. The proposed repository horizon is located in non-welded tuffs within the unsaturated zone (i.e. above the water table) at Yucca Mountain. The purpose of this paper is to describe the source-term models for radionuclide release from waste packages at Yucca Mountain site. The first section describes the conceptual release modes that are relevant for this site and waste package design, based on a consideration of the performance of currently proposed engineered barriers under expected and unexpected conditions. No attempt is made to asses the reasonableness nor probability of occurrence for any specific release mode. The following section reviews the waste-form characteristics that are required to model and constrain the release of radionuclides from the waste package. The next section present mathematical models for the conceptual release modes, selected from those that have been implemented into a probabilistic total system assessment code developed for

the Electric Power Research Institute (EPRI). (author) 4 figs., 35 refs.

LOS ALAMOS NATIONAL LABORATORY

73 Testing models of flow and transport in unsaturated porous media. Springer, E.P. (Los Alamos National Lab., NM (United States)); Hopkins, P.L.; Siegel, M.D.; Glass, R.J. pp. 336-347 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The design of an intermediate-scale flow and transport experiment in an unsaturated porous media is described. This experiment will be conducted a 3-m-diameter by 6-m-long caisson filled with silica sand. The study has been designed to minimize uncertainties in the conceptual model governing flow and transport of nonreactive tracers and to evaluate predictions of field tracer migration using laboratory data. Data from laboratory characterization of hydraulic and geochemical properties of the sand and tracer were used in preliminary modeling and sensitivity analyses to determine optimal fluid flux, influent tracer concentrations, and locations of sensors and sampling devices. Alternative approaches to compare observed and predicted data for model evaluation are discussed.

74 Prioritization of ESF testing and integration with design and construction. Elkins, N.Z. (Los Alamos National Lab., Las Vegas, NV (United States)). pp. 521-523 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The developmental strategy for underground site characterization testing in the Exploratory studies Facility (ESF) of the Yucca Mountain Site Characterization Program is outlined. The history and rationale behind ESF test program development, and each step in the test prioritization and planning process leading up to field implementation, is described. A major challenge for the Yucca Mountain Site Characterization Project Office (YMPO) is the definition and implementation of a testing program that is fully responsive to major characterization objectives and milestones while optimally integrated with, and minimally impactive to, ESF design construction activity. The outlined strategy provides YMPO a technically sound, defensible process for defining, planning, integrating, and ultimately fielding a comprehensive underground testing program in the ESF.

75 Control of tracers, fluids, and materials for the Yucca Mountain Site Characterization Project. Kalia, H.N. (Los Alamos National Lab., Las Vegas, NV (United States)). pp. 524-529 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

This paper describes use and control of tracers, fluids, and materials (TFM) at the Yucca Mountain Site Characterization Project, Management of TFM is necessary to ensure that site characterization activity does not introduce TFM that may have impact on Yucca Mountain's ability to isolate high-level radioactive waste from the accessible environment. All participants must identify TFM used for testing and construction and have the TFM evaluated to ascertain any impact on waste isolation capabilities of the site or on adjacent tests. Two data bases are created to track TFM: a working data base managed by Los Alamos National Lab. and a permanent data base managed by EG&G, which will contain information on actual TFM used.

76 Exploratory studies facility test implementation and integration with construction and design. Boak, D.M. (Los Alamos National Lab., Las Vegas, NV (United States)); Elkins, N.Z.; Kovach, R.; Oliver, R.D. pp. 1770-1773 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The Exploratory Studies Facility (ESF) is a critical component of the US Department of Energy's Yucca Mountain Site Characterization Project Office (YMPO) program to identify and characterize a potentially suitable site for licensing and construction of the nation's first geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. The mission of the ESF is to conduct a site characterization program that (1) is fully integrated with ESF design and construction, (2) minimizes potential adverse impacts to other tests, (3) protects waste isolation capabilities of the site, and (4) protects the environment. Tests performed in the ESF include unique, irretrievable data collection and in situ site characterization activities which provide a critical complement to surface-based and laboratory tests. In addition, the site characterization program must ensure that critical, irretrievable data are gathered with minimal impacts to other portions of the project and that a process exists for real-time integration of tests. Underground testing in the ESF began concurrently with construction of the ESF north ramp starter tunnel in 1993. This paper discusses the implementation of ESF north ramp starter tunnel tests, planning and implementation of radial borehole and hydrochemistry tests in the first test alcove, and real-time integration of tests with design, construction, and long-term site characterization test planning.

77 Selenite transport in unsaturated tuff from Yucca Mountain. Conca, J.L. (WSU Tri-Cities, Richland, WA (United States)); Triay, I.R. pp. 2175-2182 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Direct measurements of unsaturated selenite retardation coefficients and unsaturated hydraulic conductivity were obtained on two tuff samples from Yucca Mountain using the UFA™ technology. The retardation factor for the selenite species was only 2.5 in both Yucca Mountain vitric member at 62.6% saturation and zeolitized nonwelded tuff from G-tunnel at 52.8% saturation with respect to J-13 well water from the Nevada Test Site contaminated with selenium at 1.31 mg/l (ppm). In batch tests on the same material using 1.2 mg/l (ppm), the average K_d was determined to be 13, giving retardation factors higher than the UFA column breakthrough tests by an order of magnitude. The difference could result from preferential flow paths in the UFA column

as might occur in the field or differences in residence times between the two types of tests. The unsaturated hydraulic conductivities during the experiments were 2.49×10^{-8} cm/s for the Yucca Mountain vitric member and 1.16×10^{-8} cm/s for the zeolited nonwelded tuff.

78 **Radionuclide release rates from natural analogues of spent nuclear fuel.** Curtis, D.B. (Los Alamos National Lab., NM (United States)); Fabryka-Martin, J.; Dixon, P.; Aguilar, R.; Cramer, J. pp. 2228-2236 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Measurements of ^{99}Tc, ^{129}I, ^{239}Pu and U concentrations in rock samples from uranium deposits at Cigar Lake and Koongarra have been used to estimate radionuclide release rates from uranium minerals. Rates of release have been immeasurably slow at Cigar Lake. At Koongarra release rates appear to have been faster, producing small deficiencies of ^{99}Tc, and larger ones of ^{129}I. The differences in model radionuclide release rates are consistent with expected differences in uranium mineral degradation rates produced by the differing hydrogeochemical environments at the two sites. The model release rates are orders of magnitude less than those used to simulate mineral alteration rates in the initial Sandia Total Safety Performance Assessment.

79 **Inferences of paleoenvironment from petrographic, chemical and stable-isotope studies of calcretes and fracture calcites.** Vaniman, D.T. (Los Alamos National Lab., NM (United States)); Whelan, J.F. pp. 2730-2737 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Past research has indicated a genetic connection between calcite formed in calcretes at the surface of Yucca Mountain, Nevada, and calcites deposited in underlying fractures of the unsaturated zone. This common genesis suggests that paleoenvironmental information, as well as the timing and pathways of past recharge episodes, might be obtained from studies of the deposits in both the calcretes and the unsaturated fractures. Chemical and isotopic modification of calcite-precipitating fluids appears to begin at the surface, largely under the influence of plant roots and their decay products. Chemical characteristics of the deeper calcites are either initiated or largely defined within the first few meters of fluid migration into the unsaturated tuffs beneath the calcretes. However, petrographic and isotopic data indicate a very unique low-$\delta^{13}C$ microenvironment that is localized at the upper surfaces of the calcretes. These surfaces form an interface in the soil horizon where infiltration may pond above the underlying carbonate "plug". In order to decipher the chemistry and petrology of past recharge events, it is important to first understand microenvironments such as this that contribute to mineral precipitation/dissolution events in the pedogenic environment.

80 (LA–11844-MS) **The Yucca Mountain Project prototype air-coring test, U12g tunnel, Nevada test site.** Ray, J.M. (Los Alamos National Lab., NM (United States)); Newsom, J.C. Los Alamos National Lab., NM (United States). Dec 1994. 140p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. Order Number DE95005745. Source: OSTI; NTIS; INIS; GPO Dep.

The Prototype Air-Coring Test was conducted at the Nevada Test Site (NTS) G-Tunnel facility to evaluate standard coring techniques, modified slightly for air circulation, for use in testing at a prospective nuclear waste repository at Yucca Mountain, Nevada. Air-coring technology allows sampling of subsurface lithology with minimal perturbation to ambient characteristic such as that required for exploratory holes near aquifers, environmental applications, and site characterization work. Two horizontal holes were cored, one 50 ft long and the other 150 ft long, in densely welded fractured tuff to simulate the difficult drilling conditions anticipated at Yucca Mountain. Drilling data from seven holes on three other prototype tests in nonwelded tuff were also collected for comparison. The test was used to establish preliminary standards of performance for drilling and dust collection equipment and to assess procedural efficiencies. The Longyear-38 drill achieved 97% recovery for HQ-size core (~2.5 in.), and the Atlas Copco dust collector (DCT-90) captured 1500 lb of fugitive dust in a mine environment with only minor modifications. Average hole production rates were 6-8 ft per 6-h shift in welded tuff and almost 20 ft per shift on deeper holes in nonwelded tuff. Lexan liners were successfully used to encapsulate core samples during the coring process and protect core properties effectively. The Prototype Air-Coring Test demonstrated that horizontal air coring in fractured welded tuff (to at least 150 ft) can be safely accomplished by proper selection, integration, and minor modification of standard drilling equipment, using appropriate procedures and engineering controls. The test also indicated that rig logistics, equipment, and methods need improvement before attempting a large-scale dry drilling program at Yucca Mountain.

81 (LA–12803-MS) **Field guide to fracture-lining minerals at Yucca Mountain, Nevada.** Carlos, B.A. Los Alamos National Lab., NM (United States). Dec 1994. 12p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. Order Number DE95010669. Source: OSTI; NTIS; INIS; GPO Dep.

This guide is intended to provide descriptions useful to those researchers who are logging core or mapping fractures with aid of a hand lens or binocular microscope. Many minerals are fine-grained and cannot be distinguished at 10x magnification, but the information contained in this guide should at least allow the possibilities to be constrained. Although some of these minerals are more easily identified using hardness or acid tests, the descriptions do not include information on hardness or response to acid because scratching and use of acid on core are not permitted at the drill site or in the sample management facility. Because these descriptions are intended for use in the field, they are organized by visual properties rather than by mineralogy or chemistry. Five primary groups are used, and individual minerals are discussed within the visual-characteristic groups.

82 (LA–12810-MS) **Mineralogic variation in drill core UE-25 UZ#16, Yucca Mountain, Nevada.** Chipera, S.J.; Vaniman, D.T.; Carlos, B.A.; Bish, D.L. Los Alamos National Lab., NM (United States). Feb 1995. 39p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. Order Number DE95008371. Source: OSTI; NTIS; INIS; GPO Dep.

Quantitative X-ray powder diffraction methods have been used to analyze 108 samples from drill core UE-25 UZ#16 at Yucca Mountain, Nevada. This drill hole, located within the imbricate fault zone east of the potential Yucca Mountain repository site, confirms the authors' previous knowledge of gross-scale mineral distributions at Yucca Mountain and provides insight into possible shallow pathways for hydrologic recharge into the potential host rock. Analyses of samples from UE-25 UZ#16 have shown that the distribution of major zeolitized horizons, of silica phases, and of glassy tuffs are similar to those noted in nearby drill cores. However, the continuous core and closer sample spacing in UE-25 UZ#16 provide a more exact determination of mineral stratigraphy, particularly in hydrologically important units such as the Paintbrush bedded tuffs above the Topopah Spring Tuff and in the upper vitrophyre of the Topopah Spring Tuff. The discovery of matrix zeolitization in the devitrified Topopah Spring Tuff of UE25 UZ#16 shows that some unexpected mineralogic features can still be encountered in the exploration of Yucca Mountain and emphasizes the importance of obtaining a more complete three-dimensional model of Yucca Mountain mineralogy.

83 (LA–12894-MS) **Ion exchange and dehydration experimental studies of clinoptilolite: Implications to zeolite dating.** WoldeGabriel, G. Los Alamos National Lab., NM (United States). Feb 1995. 20p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. Order Number DE95007726. Source: OSTI; NTIS; INIS; GPO Dep.

Variable effects were noted on the argon (Ar) and potassium (K) contents of clinoptilolite fractions used in ion-exchange and dehydration experiments. The K contents of clinoptilolite fractions were differently affected during cation exchange with Ca-, Cs-, K-, and Na-chloride solutions. Ar was generally less affected during these experiments, except for a Na-clinoptitolite fraction exchanged for five days. Loss of Ar during organic heavy-liquid treatment and cleaning using acetone and deionized water does occur, as indicated by comparing the amounts of radiogenic Ar of treated and untreated fractions. Moreover, a regular decrease in radiogenic Ar contents was noted in clinoptilolite fractions during dehydration experiments at different temperatures for 16 hours. Comparable losses do not occur from saturated samples that were heated in 100 C for more than five months. Water appears to play a vital role in stabilizing the clinoptilolite framework structure and in the retention of Ar. The radiogenic Ar depletion pattern noted in clinoptilolite fractions dehydrated in unsaturated environment at different temperatures is similar to variations in the amount of radiogenic Ar observed in clinoptilolite samples from the unsaturated zone of an altered tuff. These results can be used to evaluate the extent of zeolitic water (and hence Ar) retention in unsaturated geologic settings. The utility of alkali zeolites (e.g., phillipsite, clinoptilolite, and mordenite) from low-temperature, open-hydrologic alteration as potential dateable minerals was evaluated using the K/Ar method as part of the Yucca Mountain Site Characterization Project, which is evaluating Yucca Mountain, Nevada, as a potential high-level radioactive waste repository site.

84 (LA–12897-MS) **^{13}C and ^{17}O NMR binding constant studies of uranyl carbonate complexes in near-neutral aqueous solution. Yucca Mountain Project Milestone Report 3351.** Clark, D.L.; Newton, T.W.; Palmer, P.D.; Zwick, B.D. Los Alamos National Lab., NM (United States). Jan 1995. 56p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. Order Number DE95008109. Source: OSTI; NTIS; INIS; GPO Dep.

Valuable structural information, much of it unavailable by other methods, can be obtained about complexes in solution through NMR spectroscopy. From chemical shift and intensity measurements of complexed species, NMR can serve as a species-specific structural probe for molecules in solution and can be used to validate thermodynamic constants used in geochemical modeling. Fourier-transform nuclear magnetic resonance (FT-NMR) spectroscopy has been employed to study the speciation of uranium(VI) ions in aqueous carbonate solutions as a function of pH, ionic strength, carbonate concentration, uranium concentration, and temperature. Carbon-13 and oxygen-17 NMR spectroscopy were used to monitor the fractions, and hence thermodynamic binding constants of two different uranyl species $UO_2(CO_3)_3^{4-}$ and $(UO_2)_3(CO_3)_6^{6-}$ in aqueous solution. Synthetic buffer solutions were prepared under the ionic strength conditions used in the NMR studies in order to obtain an accurate measure of the hydrogen ion concentration, and a discussion of $pH = -\log(a_{H^+})$ versus $p[H] = -\log[H+]$ is provided. It is shown that for quantitative studies, the quantity p[H] needs to be used. Fourteen uranium(VI) binding constants recommended by the OECD NEA literature review were corrected to the ionic strengths employed in the NMR study using specific ion interaction theory (SIT), and the predicted species distributions were compared with the actual species observed by multinuclear NMR. Agreement between observed and predicted stability fields is excellent. This establishes the utility of multinuclear NMR as a species-specific tool for the study of the actinide carbonate complexation constants, and serves as a means for validating the recommendations provided by the OECD NEA.

85 (LA–12908-MS) **Status of volcanism studies for the Yucca Mountain Site Characterization Project.** Crowe, B. (Los Alamos National Lab., NM (United States)); Perry, F.; Murrell, M.; Poths, J.; Valentine, G.A.; Wells, S.; Bowker, L.; Finnegan, K.; Geissman, J.; McFadden, L. Los Alamos National Lab., NM (United States). Feb 1995. 396p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. Order Number DE95009090. Source: OSTI; NTIS; INIS; GPO Dep.

Chapter 1 introduces the volcanism issue for the Yucca Mountain site and provides the reader with an overview of the organization, content, and significant conclusions of this report. The risk of future basaltic volcanism is the primary topic of concern including both events that intersect a potential repository and events that occur near or within the waste isolation system of a repository. Chapter 2 describes the volcanic history of the Yucca Mountain region (YMR) and emphasizes the Pliocene and Quaternary volcanic record, the interval of primary concern for volcanic risk assessment. The Lathrop Wells volcanic center is described in detail because it is the youngest basalt center in the YMR. Chapter 3 describes the tectonic setting of the YMR and presents and assesses the significance of multiple alternative tectonic models. Geophysical data are described for the YMR and are used as an aid to understand the distribution of basaltic volcanic centers. Chapter 4 discusses the petrologic and geochemical features of basaltic volcanism in the YMR, the southern Great Basin and the Basin and Range province. The long time of activity and characteristic small volume of the Postcaldera basalt of the YMR result in one of the lowest eruptive rates in a volcanic field in the southwest United

States. Chapter 5 summarizes current concepts of the segregation, ascent, and eruption of basalt magma. Chapter 6 summarizes the history of volcanism studies (1979 through early 1994), including work for the Yucca Mountain Site Characterization Project and overview studies by the state of Nevada and the Nuclear Regulatory Commission. Chapter 7 summarizes probabilistic volcanic hazard assessment using a three-part conditional probability model. Chapter 8 describes remaining volcanism work judged to be needed to complete characterization studies for the YMR. Chapter 9 summarizes the conclusions of this volcanism status report.

86 (LA–12917-PR) **Laboratory and field studies related to the Hydrologic Resources Management Program. Progress report, October 1, 1993–September 30, 1994.** Thompson, J.L. (ed.). Los Alamos National Lab., NM (United States). Mar 1995. 24p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. Order Number DE95007675. Source: OSTI; NTIS; INIS; GPO Dep.

This report describes the work done at Los Alamos in FY 1994 for the Hydrologic Resources Management Program, a multi-organization project funded by the US Department of Energy/Nevada Operations Office. The authors participated in cooperative collaborations with University of California (UC), Berkeley, the Yucca Mountain Project, the Underground Test Area Operable Unit, and other participating organizations within the Hydrologic Resources Management Program (HRMP). They provided operational support to the Nevada Test Site (NTS) organizations by testing a water-evaporation system, championing the use of high-sensitivity logging equipment during drillbacks, and participating in the planning and execution of drilling operations at two nuclear test sites. Los Alamos personnel cooperated in preparing a proposal to drill beside and under a nuclear test located in unsaturated media. The authors gave assistance in laboratory work related to colloid migration and actinide sorption. In conjunction with personnel from the Lawrence Livermore Laboratory, they collected water samples from 10 wells at the NTS that are known to contain radionuclides. Their analyses of these samples suggest that radionuclides may not be moving away from cavity zones at appreciable rates. Recent field sampling shows clearly the need to purge wells of materials introduced during drilling and illustrates the inconsistency between water samples taken by bailing and those taken by pumping. 36 refs.

87 (LA-SUB–94-34) **Preparation for kinetic measurements on the silicates of the Yucca Mountain potential repository. [Final report], June 15, 1993–September 30, 1993.** Los Alamos National Lab., NM (United States); Pennsylvania State Univ., University Park, PA (United States). Ore Deposits Research Section. [1993]. 37p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. Order Number DE94017049. Source: OSTI; NTIS; INIS; GPO Dep.

Part 1, "The Preparation of Clinoptilolite, Mordenite and Analcime," summarized progress made during the contract period on preparing Na-end member clinoptilolite, mordenite, and analcime. The objective is to use the prepared zeolites to determine rates of dissolution and precipitation in laboratory flow-through systems in both this lab to 350 C and by the geochemists at Yale University to about 80 C. Because clinoptilolite represents the most complicated phase of these three zeolites and it is most abundant at Yucca Mountain, the authors have concentrated most of their efforts on its preparation. They have collected, high-concentration natural clinoptilolite samples. A hindered settling technique that takes advantage of the relatively low specific gravity of clinoptilolite coupled with ultrasonic cleaning in deionized water has been employed. This material is now a mixed Na-K zeolite which must then be converted to the pure Na-end member composition. In Part 2, "Draft Manuscript on the Heterogeneous Kinetics of Cristobalite," experiments on the rates of reactions of dissolution and precipitation of cristobalite were carried at 150–300 C. Results show that cristobalite may precipitate from hydrothermal solution if the concentration of $Si(OH)_4$ exceeds that at quartz saturation and is less than that of amorphous silica saturation and if there are cristobalite nuclei present. Such nuclei may occur where there has been devitrification of volcanic glasses, for example. Cristobalite has refused to crystallize in the absence of such nuclei. Steady state concentrations were reached experimentally after starting at 150 ° with initially supersaturated solutions and at 200 C starting with either supersaturated or undersaturated solutions. From the steady state conditions, equilibrium constants can be derived.

88 (LA-UR–94-3303) **Effect of natural organic materials on cadmium and neptunium sorption.** Kung, K.S.; Triay, I.R. Los Alamos National Lab., NM (United States). [1994]. 13p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. (CONF-9409231–1: NEA workshop on binding models-organics, Bad Zurach (Switzerland), 14-16 Sep 1994). Order Number DE95000843. Source: OSTI; NTIS; INIS; GPO Dep.

In a batch sorption study of the effect of naturally occurring organic materials on the sorption of cadmium and neptunium on oxides and tuff surfaces, the model sorbents were synthetic goethite, boehmite, amorphous silicon oxides, and a crushed tuff material from Yucca Mountain, Nevada. An amino acid, 3-(3,4-dihydroxypheny)-DL-alanine (DOPA), and an aquatic-originated fulvic material, Nordic aquatic fulvic acid (NAFA), were used as model organic chemicals. Sorption isotherm results showed that DOPA sorption followed the order aluminum oxide > iron oxide > silicon oxide and that the amount of DOAP sorption for a given sorbent increased as the solution pH was raised. The sorption of cadmium and neptunium on the iron oxide was about ten times higher than that on the aluminum oxide. The sorption of cadmium and neptunium on natural tuff material was much lower than that on aluminum and iron oxides. The sorption of cadmium on iron and aluminum oxides was found to be influenced by the presence of DOPA, and increasing the amount of DOPA coating resulted in higher cadmium sorption on aluminum oxide. However, for iron oxide, cadmium sorption decreased with increasing DOPA concentration. The presence of the model organic materials DOPA and NAFA did not affect the sorption of neptunium on tuff material or on the iron and aluminum oxides. Spectroscopic results indicate that cadmium complexes strongly with DOPA. Therefore, the effect of the organic material, DOPA, on the cadmium sorption is readily observed. However, neptunium is possibly complexed weakly with organic material. Thus, DOPA and NAFA have little effect on neptunium sorption on all sorbents selected for study.

89 (LA-UR–94-3820) **Fracture coatings in Topopah Spring Tuff along drill hole wash.** Carlos, B.A.; Chipera, S.J.; Bish, D.L. Los Alamos National Lab., NM (United States). [1994]. 5p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. (CONF-950570–1: International high-level radioactive waste management conference: progress toward understanding,

Las Vegas, NV (United States), 1-5 May 1995). Order Number DE95003692. Source: OSTI; NTIS; INIS; GPO Dep.

Fracture-lining minerals are being studied as part of site characterization to determine the suitability of Yucca Mountain, Nevada as a potential high level nuclear waste repository. Fracture coatings in the Paintbrush Group provide information on potential flow paths above the water table both toward and away from the potential repository and provide information on the distribution of fracture-lining minerals needed to model thermal effects of waste emplacement. Fracture coatings within the predominantly non-zeolitic Paintbrush Group vary both with depth and laterally across Yucca Mountain, whereas fracture coatings in tuffs below the Paintbrush Group are related to the mineralogy of the tuffs and follow a consistent pattern of distribution with predominantly quartz, calcite, and manganese oxides in the devitrified intervals and mordenite and clinoptilolite in the zeolitic intervals. The zeolites stellerite and heulandite are more abundant in fractures in the Topopah Spring Tuff in drill holes USW G-1 and UE-25 a#l, located along Drill Hole Wash (at the northern end of Yucca Mountain) than in core from other parts of Yucca Mountain. Buesch et al. (2) present evidence for a complex fault system along Drill Hole Wash. To investigate the possibility that the abundant fracture-lining zeolites in USW G-1 and UE-25 a# 1 are related to the Drill Hole Wash fault, the Topopah Spring Tuff was examined in drill cores from USW UZ-14, USW G-1, USW NRG-7/7a, and UE-25 a#l.

90 (LA-UR-95-572) **Significance of apparent discrepanices in water ages derived from atmospheric radionuclides at Yucca Mountain, Nevada.** Liu, B. (Los Alamos National Lab., NM (United States)); Fabryka-Martin, J.; Wolfsberg, A.; Robinson, B.; Sharma, P. Los Alamos National Lab., NM (United States). 23 Feb 1995. 11p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-36. (CONF-9505188--1: 1995 American Institute of Hydrology annual meeting, Denver, CO (United States), 14-18 May 1995). Order Number DE95007886. Source: OSTI; NTIS; INIS; GPO Dep.

Cosmogenic ^{36}Cl and ^{14}C produced in the atmosphere are being used to estimate water residence times in the unsaturated zone at Yucca Mountain. Results thus far show a systematic discordance in that ^{14}C-based ages are generally one to two orders of magnitude younger than ^{36}Cl-based ages. This lack of concordance probably arises from one or more of the following reasons: (1) different transport mechanisms, e.g., vapor transport for ^{14}C; (2) different magnitudes and timing of bomb-pulse signals; (3) mixing of waters from different flow paths; and (4) possibly inadequate methods for correcting for the effect of sample contamination by carbon or chlorine from sources other than the infiltrating water. Preliminary numerical simulation results using the FEHMN code suggest that spatial variation in infiltration rates can enhance lateral flow and mixing that leads to discordance in apparent ages depending on the dating technique. Examples are presented to show that disparate radiometric ages are inevitable and to be expected where mixing of waters of markedly different ages occurs.

91 **A strategy for validating a concept model for radionuclide migration in the saturated zone beneath Yucca Mountain.** Robinson, B.A. (Los Alamos National Laboratory, Earth and Environmental Sciences Div., Los Alamos (United States)). *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 73-96 (1994).

Special issue Yucca Mountain.

A conceptual model for radionuclide migration in the saturated zone beneath Yucca Mountain is presented. The available hydrologic data from the site is compiled to present a qualitative picture of transport of radionuclides horizontally within the first 100-200 m of the saturated zone. The transport model consists of flow within fractures and interchange of dissolved species between the fractures and surrounding matrix blocks via molecular diffusion. A parametric study illustrates that at the groundwater conditions expected to exist in the saturated zone, radionuclide will have ample time to diffuse fully within the matrix blocks. The result is a predicted solute transport time several orders of magnitude greater than the groundwater travel time (GWTT). To validate this model, a suite of interwell tracer tests are proposed at various flow rates and with conservative and sorbing species. Numerical simulations show that these tests will allow us to discriminate between a matrix diffusion model and a more conventional continuum transport model. (author) 8 figs., tabs., 35 refs.

92 **The use of selectivity coefficients to estimate modified Langmuir isotherm parameters as a function of experimental conditions.** Polzer, W.L. (Los Alamos National Laboratory, Earth and Environmental Sciences Div., Los Alamos (United States)); Essington, E.H.; Fellenz, K.M.; McLeod, J.R. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 107-128 (1994).

Special issue Yucca Mountain.

Modified Langmuir isotherm parameters (K_D and β) were fitted to experimentally determined selectivity coefficients to test relationship between them. Reasonable estimates of K_D and β values were obtained for a wide range of assumed solid-liquid ratios (W/V) and initial concentrations of competing solute (C_{B0}). The results indicate that at low initial concentrations K_D decreases and β increases as C_{B0} increases. A more pronounced effect is observed at lower W/V values for K_D and at higher W/V values for β. At low C_{B0} values, both K_D and β decrease as W/V increases. At higher C_{B0} values, K_D and β are not affected by W/V. Results also indicate that a linear K_D can be strongly affected by W/V and C_{B0}. The effect of both parameters have been documented in the literature. The relationship between the modified Langmuir isotherm parameters and experimentally determined selectivity coefficients provides a method that optimizes the information obtained from the adsorption modeling of experimental data. (author) 11 figs., 2 tabs., 21 refs.

93 **Three-dimensional simulations of radionuclide transport at Yucca Mountain.** Birdsell, K.H. (Los Alamos National Lab., NM (United States)); Eggert, K.G.; Travis, B.J. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 165-192 (1994).

Special issue Yucca Mountain.

This paper presents preliminary transport calculations for radionuclide movement at Yucca Mountain. The simulations were run with TRACRN using approximately 30 000 finite-difference zones to represent the unsaturated and saturated zones underlying the potential repository in three dimensions. The results are used to study the sensitivity of radionuclide migration to uncertainties in several factors that affect transport through porous media. These factors include recharge rate, dispersivity length scale, radionuclide species, and source term. The calculations show that the transport of weakly sorbing species like ^{99}Tc and ^{129}I is highly sensitive to all of these factors. The transport of strongly sorbing species like ^{135}Cs is limited by retardation and is therefore fairly insensitive to these factors. In addition

to showing the sensitivity of transport to physical processes, the results show that the calculations themselves are sensitive to problem dimensionality. The calculations indicate that modeling in three dimensions provides faster breakthrough than modeling in one or two dimensions. (author) 30 figs., 2 tabs., 13 refs.

LAWRENCE LIVERMORE NATIONAL LABORATORY

94 (ANL/CMT/CP–83895) **Behavior of spent fuel under unsaturated conditions.** Finn, P.A. (Argonne National Lab., IL (United States). Chemical Technology Div.); Hoh, J.C.; Bates, J.K.; Wolf, S.F. Argonne National Lab., IL (United States). [1994]. 10p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-31109-ENG-38. (CONF-941207–33: Spent nuclear fuel meeting: challenges and initiatives, Salt Lake City, UT (United States), 14-16 Dec 1994). Order Number DE95009899. Source: OSTI; NTIS; INIS; GPO Dep.

To evaluate the performance of spent fuel in the potential repository at Yucca Mountain, Nevada, spent fuel fragments are being exposed to small and intermittent amounts of simulated groundwater under unsaturated conditions. Both the leachate and the visual appearance of the spent fuel have been characterized for 581 days of testing. The amount of Am and Cm measured in the leachates was one to two orders of magnitude greater than that released from spent fuel under saturated conditions. The cause of this difference has not been firmly identified but may be attributable to the presence of large amounts of actinide-containing colloids in the leachate of the unsaturated tests.

95 (ANL/DIS/TM–17) **Stigma models: Testing hypotheses of how images of Nevada are acquired and values are attached to them.** Jenkins-Smith, H.C. (New Mexico Univ., Albuquerque, NM (United States)). Argonne National Lab., IL (United States). Decision and Information Sciences Div.; New Mexico Univ., Albuquerque, NM (United States). Dec 1994. 72p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-31109-ENG-38. Order Number DE95004985. Source: OSTI; NTIS; INIS; GPO Dep.

This report analyzes data from surveys on the effects that images associated with nuclear power and waste (i.e., nuclear images) have on people's preference to vacation in Nevada. The analysis was stimulated by a model of imagery and stigma which assumes that information about a potentially hazardous facility generates signals that elicit negative images about the place in which it is located. Individuals give these images negative values (valences) that lessen their desire to vacation, relocate, or retire in that place. The model has been used to argue that the proposed Yucca Mountain high-level nuclear waste repository could elicit images of nuclear waste that would stigmatize Nevada and thus impose substantial economic losses there. This report proposes a revised model that assumes that the acquisition and valuation of images depend on individuals' ideological and cultural predispositions and that the ways in which new images will affect their preferences and behavior partly depend on these predispositions. The report tests these hypotheses: (1) individuals with distinct cultural and ideological predispositions have different propensities for acquiring nuclear images, (2) these people attach different valences to these images, (3) the variations in these valences are important, and (4) the valences of the different categories of images within an individual's image sets for a place correlate very well. The analysis largely confirms these hypotheses, indicating that the stigma model should be revised to (1) consider the relevant ideological and cultural predispositions of the people who will potentially acquire and attach value to the image, (2) specify the kinds of images that previously attracted people to the host state, and (3) consider interactions between the old and potential new images of the place. 37 refs., 18 figs., 17 tabs.

96 **Drift emplaced waste package thermal response.** Ruffner, D.J. (Lawrence Livermore National Lab., CA (United States)); Johnson, G.L.; Platt, E.A.; Blink, J.A.; Doering, T.W. pp. 538-543 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract W-7405-ENG-48. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Thermal calculations of the effects of radioactive waste decay heat on the potential repository at Yucca Mountain, Nevada, have been conducted by the Yucca Mountain Site Characterization Project (YMP) at Lawrence Livermore National Lab. (LLNL) in conjunction with the B&W Fuel Co. For a number of waste package spacings, these 3D transient calculations use the TOPAZ3D code to predict drift wall temperatures to 10,000 years following emplacement. Systematic temperature variation occurs as a function of fuel age at emplacement and Areal Mass Loading (AML) during the first few centuries after emplacement. After about 1000 years, emplacement age is not a strong driver on rock temperature; AML has a larger impact. High AMLs occur when large waste packages are emplaced end-to-end in drifts. Drift emplacement of equivalent packages results in lower rock temperatures than borehole emplacement. For an emplacement scheme with 50% of the drift length occupied by packages, an AML of 138 MTU/acre is about three times higher than the Site Characterization Plan-Conceptual Design (SCP-CD) value. With this higher AML (requiring only 1/3 of the SCP-CD repository footprint), peak drift wall temperatures do not exceed 160°C, but rock temperatures exceed the boiling point of water for about 3000 years. These TOPAZ3D results have been compared with reasonable agreement with two other computer codes.

97 **The analysis of repository-heat-driven hydrothermal flow at Yucca Mountain.** Buscheck, T.A. (Lawrence Livermore National Lab., CA (United States)); Nitao, J.J. pp. 847-867 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract W-7405-ENG-48. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

To safely and permanently store high-level nuclear waste, the potential Yucca Mountain repository site must mitigate the release and transport of radionuclides for tens of thousands of years. In the failure scenario of greatest concern, water would contact the waste package (WP), accelerate its failure rate, and eventually transport radionuclides to the water table. In a concept called the "extended-dry repository," decay heat arising from radioactive waste extends the time before liquid water can contact a WP. Recent modeling and theoretical advances in nonisothermal, multiphase fracture-matrix flow have demonstrated (1) the critical importance of capillary pressure disequilibrium between fracture and matrix flow, and (2) that radioactive decay heat plays a dominant

role in the ability of the engineered and natural barriers to contain and isolate radionuclides. Our analyses indicate that the thermo-hydrological performance of both the unsaturated zone (UZ) and saturated zone (SZ) will be dominated by repository-heat-driven hydrothermal flow for tens of thousands of years. For thermal loads resulting in extended-dry repository conditions, UZ performance is primarily sensitive to the thermal properties and thermal loading conditions and much less sensitive to the thermal properties and thermal loading conditions and much less sensitive to the highly spatially and temporally variable ambient hydrologic properties and conditions. The magnitude of repository-heat-driven buoyancy flow in the SZ is far more dependent on the total mass of emplaced spent nuclear fuel (SNF) than on the details of SNF emplacement, such as the Areal Power Density [(APD) expressed in kW/acre] or SNF age.

98 **Initial results from dissolution testing of various air-oxidized spent fuels.** Gray, W.J. (Pacific Northwest Labs., Richland, WA (United States)); Thomas, L.E. pp. 391-398 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 DOE Contract AC06-76RL01830. From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

Flowthrough dissolution tests have been conducted on two different light-water-reactor spent fuels oxidized to U_4O_{9+x} or U_3O_8. Oxidation had a bigger impact on the dissolution of U and a smaller impact on the dissolution of $T_c$from the fuel with higher burnup and higher fission gas release. Possible reasons for the observed differences in test results are discussed, but clarification awaits results from tests on other fuels, which are in progress.

99 **Testing long-term predictions from hydrogeochemical models.** Glassley, W.E. (Lawrence Livermore National Lab., CA (United States)); Bruton, C.J.; Bourcier, W.L. pp. 805-810 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 DOE Contract W-7405-ENG-48. From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

Thermally induced flow of liquid water and water vapor at the potential repository site at Yucca Mountain, Nevada, will extend hundreds of meters away from the repository edge. The resultant transfer of heat and mass will sufficiently perturb the ambient conditions such that a variety of mineralogical and chemical reactions will occur that may modify hydrological properties. The consequences of this "coupling" of geochemical and hydrological processes will vary through time, and will occur to different degrees in four regimes ($T < T_{boiling}$; $T = T_{boiling}$; $T > T_{boiling}$; cooling) that will develop within the repository block. The dominant processes in the regimes differ, and reflect the local balance between: (1) kinetics and equilibrium; (2) dissolution and precipitation; (3) evaporation and boiling; and (4) fluid flow in matrix and fractures. Simulations were conducted of the evolution of these regimes, using laboratory derived kinetics and thermodynamic data, and site specific mineralogical and hydrological properties. These simulations identify regions where chemical and mineralogical equilibrium is likely to be achieved, and where net changes in hydrological properties will be concentrated. Tests of the results of these simulations have been initiated using field data from the Taupo Volcanic Zone, New Zealand. A preliminary series of calculations suggest that relative changes in porosity of as much as ± 20% to 30% may be possible for rocks with an initial porosity of 10%.

100 **Experimental investigation of hydrous pyrolysis of diesel fuel and the effect of pyrolysis products on performance of the candidate nuclear waste repository at Yucca Mountain.** Jackson, K.J. (Lawrence Livermore National Lab., CA (United States)); Carroll, S.A. pp. 841-847 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 DOE Contract W-7405-ENG-48. From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

It is thought that a significant amount of diesel fuel and other hydrocarbon-rich phases may remain inside the candidate nuclear waste repository at Yucca Mountain after construction and subsequent emplacement of radioactive waste. Although the proposed repository horizon is above the water table, the remnant hydrocarbon phases may react with hydrothermal solutions generated by high temperature conditions that will prevail for a period of time in the repository. The preliminary experimental results of this study show that diesel fuel hydrous pyrolysis is minimal at 200°C and 70 bars. The composition of the diesel fuel remained constant throughout the experiment and the concentration of carboxylic acids in the aqueous phases was only slightly above the detection limit (1-2 ppm) of the analytical technique.

101 **On the benefits of an integrated nuclear complex for Nevada.** Blink, J.A. (Lawrence Livermore National Lab., NM (United States)); Halsey, W.G. pp. 18-25 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

An integrated nuclear complex is proposed for location at the Nevada Test Site. In addition to solving the nuclear waste disposal problem, this complex would tremendously enhance the southern Nevada economy, and it would provide low cost electricity to each resident and business in the affected counties. Nuclear industry and the national economy would benefit because the complex would demonstrate the new generation of safer nuclear power plants and revitalize the industry. Many spin-offs of the complex would be possible, including research into nuclear fusion and a world class medical facility for southern Nevada. For such a complex to become a reality, the cycle of distrust between the federal government and the State of Nevada must be broken. The paper concludes with a discussion of implementation through a public process led by state officials and culminating in a voter referendum.

102 **Evaluation of thermo-hydrological performance in support of the thermal loading systems study.** Buscheck, T.A. (Lawrence Livermore National Lab., CA (United States)); Nitao, J.J.; Saterlie, S.F. pp. 592-610 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Heat generated as a result of emplacing spent nuclear fuel will significantly affect the pre- and post-closure performance of the Mined Geological Disposal System (MGDS) at the potential repository site in Yucca Mountain. Understanding thermo-hydrological behavior under repository thermal loads is essential in (a) planning and conducting the site characterization and testing program, (b) designing the repository and engineered barrier system, and (c) assessing performance. The greatest concern for hydrological performance is sources of water that would contact a waste package, accelerate its failure rate, and eventually transport radionuclides to the water table. The primary sources of liquid water are: (1) natural infiltration, (2) condensate generated under boiling conditions, and (3) condensate generated under sub-boiling conditions. Buoyant vapor flow, occurring either on a sub-repository scale or on a mountain scale, may affect the generation of the second and third sources of liquid water. A system of connected fractures facilitates repository-heat-driven gas and liquid flow as well as natural infiltration. With the use of repository-scale and sub-repository-scale models, we analyze thermo-hydrological behavior for Areal Mass Loadings (AMLs) of 24.2, 35.9, 55.3, 83.4, and 110.5 MTU/acre for a wide range of bulk permeability. We examine the temporal and spatial extent of the temperature and saturation changes during the first 100,000 yr. We also examine the sensitivity of mountain scale moisture redistribution to a range of AMLs and bulk permeabilities. In addition, we investigate how boiling and buoyant, gas-phase convection influence thermo-hydrological behavior in the vicinity of emplacement drifts containing spent nuclear fuel. The effort was done in support of a thermal loading systems study being performed to evaluate the impact of various thermal loads on the MGDS.

103 Rationale for determining spent fuel acquisitions for repository testing. Marschman, S.C. (Pacific Northwest Lab., Richland, WA (United States)); Einziger, R.E.; Stout, R.B. pp. 1074-1079 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 DOE Contract AC06-76RL01830. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A rationale for selecting commercial spent nuclear fuels for use as testing materials for the Yucca Mountain Project was developed. A review of experimental data from fuel performance testing was conducted and performance-affecting attributes pertinent to storage and disposal conditions were identified. These were used to form the basis for a fuel-selection strategy designed to ensure adequate and representative samples are available for storage- and disposal-relevant testing.

104 Engineered barrier environment, Yucca Mountain. Wilder, D.G. (Lawrence Livermore National Lab., CA (United States)). pp. 1179-1187 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The suitability of Yucca Mountain (YM) as a potential nuclear waste repository site will ultimately depend on how well it provides for isolation of the waste. Analysis of isolation capabilities of YM must consider interactions between natural and engineered systems. In addition, environmental conditions are important to EBS design, materials testing, selection, design criteria, and waste-form characterization. Studies of environmental interactions with the EBS, have emphasized processes and changed (not ambient) conditions resulting from interaction with waste, since these are the pertinent conditions for the EBS. The results of these studies indicate that the radioactive heat-of-decay from spent nuclear fuel will play a dominant role in the performance of a potential repository at Yucca Mountain. In addition, coupled hydrothermal-geochemical phenomena may significantly affect the performance of natural barriers surrounding the repository. Depending on the thermal-loading management strategy, as well as site conditions, repository heat may either substantially increase the likelihood of water contacting waste packages, with an associated potential increased magnitude of release and transport of radionuclides, or preclude, or at least minimize, these effects for extended periods of time, perhaps as much as hundreds of thousand years.

105 Integrated modelling of near field and engineered barrier system processes. Lamont, A. (Lawrence Livermore National Lab., CA (United States)); Gansemer, J. pp. 1195-1201 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The Yucca Mountain Integrating Model (YMIM) is an integrated model of the Engineered Barrier System. It has been developed to assist project managers at LLNL in identifying areas where research emphasis should be placed. The model was designed to be highly modular so that a model of an individual process could be easily modified or replaced without interfering with the models of other processes. The modules modelling container failure and the dissolution of nuclides include particularly detailed, temperature dependent models of their corresponding processes.

106 The testing of thermal-mechanical-hydrological-chemical processes using a large block. Lin, W. (Lawrence Livermore National Lab., CA (United States)); Wilder, D.G.; Blink, J.A.; Blair, S.C.; Buscheck, T.A.; Chestnut, D.A.; Glassley, W.E.; Lee, K.; Roberts, J.J. pp. 1938-1945 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The radioactive decay heat from nuclear waste packages may, depending on the thermal load, create coupled thermal-mechanical-hydrological-chemical (TMHC) processes in the near-field environment of a repository. A group of tests on a large block (LBT) are planned to provide a timely opportunity to test and calibrate some of the TMHC model concepts. The LBT is advantageous for testing and verifying model concepts because the boundary conditions are controlled, and the block can be characterized before and after the experiment. A block of Topopah Spring tuff of about 3 x 3 x 4.5 m will be sawed and isolated at Fran Ridge, Nevada Test Site. Small blocks of the rock adjacent to the large block will be collected for laboratory testing of

some individual thermal-mechanical, hydrological, and chemical processes. A constant load of about 4 MPAa will be applied to the top and sides of the large block. The sides will be sealed with moisture and thermal barriers. The large block will be heated with heater in boreholes and guard heaters on the sides so that a dry-out zone and a condensate zone will exist simultaneously. Temperature, moisture content, pore pressure, chemical composition, stress and displacement will be measured through out the block during the heating and cool-down phases. The results from the experiments on small blocks and the tests on the large block will provide a better understanding of some concepts of the coupled TMHC processes. The progress of the project is also presented in this paper.

107 Electrical properties of Topopah Spring tuff as a function of saturation. Roberts, J.J. (Lawrence Livermore National Lab., CA (United States)); Lin, Wunan. pp. 2112-2120 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Estimates of water content in unsaturated regions based on electrical properties such as resistivity and dielectric permittivity depend on reliable laboratory measurements. We report measurements on three tuffs from Yucca Mountain, Nevada as a function of water saturation at 23°C. Hysteresis is observed between the wetting and drying phases. Measurements made over a range of frequency verify measurements made at a single frequency and provide additional information about conduction mechanisms and microstructural parameters.

108 What do we mean by a "Cold Repository"?. Halsey, W.G. (Lawrence Livermore National Lab., CA (United States)). pp. 2183-2188 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The topic of thermal loading of a potential repository at Yucca Mountain in Nevada has been the subject of intense discussion within the project technical community. While terms such as "Hot Repository" and "Cold Repository" are frequently used, they have not been clearly defined. In particular, the definition of a cold repository has remained the opinion of each individual. This has led to confusion and misunderstanding. In this paper, a number of observed definitions for a cold repository are discussed along with the technical implications, assumptions and inconsistencies. Finally, a common language is suggested.

109 Identifying significant uncertainties in thermally dependent processes for repository performance analysis. Gansemer, J.D. (Lawrence Livermore National Lab., CA (United States)); Lamont, A. pp. 2197-2206 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

In order to study the performance of the potential Yucca Mountain Nuclear Waste Repository, scientific investigations are being conducted to reduce the uncertainty about process models and system parameters. This paper is intended to demonstrate a method for determining a strategy for the cost effective management of these investigations. It is not meant to be a complete study of all processes and interactions, but does outline a method which can be applied to more in-depth investigations.

110 A performance goal-based seismic design philosophy for waste repository facilities. Hossain, Q.A. (Lawrence Livermore National Lab., CA (United States)). pp. 2266-2271 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A performance goal-based seismic design philosophy, compatible with DOE's present natural phenomena hazards mitigation and "graded approach" philosophy, has been proposed for high level nuclear waste repository facilities. The rationale, evolution, and the desirable features of this method have been described. Why and how the method should and can be applied to the design of a repository facility are also discussed.

111 The impact of buoyant, gas-phase flow and heterogeneity on thermo-hydrological behavior at Yucca Mountain. Buscheck, T.A. (Lawrence Livermore National Lab., CA (United States)); Nitao, J.J. pp. 2450-2474 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract W-7405-ENG-48. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

To safely and permanently store high-level nuclear waste, the potential Yucca Mountain repository system must mitigate the release and transport of radionuclides for tens of thousands of years. In the failure scenario of greatest concern, water would contact a waste package, accelerate its failure rate, and eventually transport radionuclides to the water table. Our analyses have demonstrated that the only significant source of liquid water is fracture flow from: (1) natural infiltration, (2) condensate drainage generated under boiling conditions, and (3) condensate drainage generated under sub-boiling conditions. The first source of liquid water arises from the ambient system; the second and third sources are generated by repository heat. Buoyant, gas-phase flow, occurring either on a sub-repository scale or on a mountain scale, may play an important role in generating the second and third sources of liquid water. By considering a wide range in bulk permeability of the fractured rock, we identify a threshold bulk permeability at which buoyant, gas-phase convection begins to dominate hydrological behavior. At 10 times this threshold, convection begins to dominate thermal behavior. These effects can dominate moisture movement in the unsaturated zone on the order of 100,000 yr. We find that the development of a large above-boiling zone suppresses the effects of buoyant vapor flow. Zones of sharply contrasting bulk permeability also influence condensate generation and drainage. Of particular concern are conditions that focus vapor flow and condensate drainage, which could result in persistent refluxing at the repository,

causing water to drip onto waste packages. These effects can occur under both sub-boiling and boiling conditions. Long-term in situ heater tests are required to diagnose the potential for major repository-heat-driven sources of fracture flow.

112 (PNL-SA-23965) **Development and feasibility of a waste package coupled reactive transport model (AREST-CT).** Engel, D.W.; McGrail, B.P.; Fort, J.A.; Roberts, J.S. Pacific Northwest Lab., Richland, WA (United States). May 1994. 9p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC06-76RL01830. (CONF-940553-83: International high-level radioactive waste management conference, Las Vegas, NV (United States), 22-26 May 1994). Order Number DE95007260. Source: OSTI; NTIS; INIS; GPO Dep.

Most models that analyze the waste package and engineered barrier system (near-field) of an underground geologic repository assume constant boundary conditions at the waste form surface and constant chemical properties of the groundwater. These models are useful for preliminary modeling, iterative modeling to estimate uncertainties, and as a source for a total systems analysis. However, the chemical behavior of the system is a very important factor in the containment and release of radionuclides, and one needs to understand the underlying processes involved. Therefore, the authors are developing a model to couple the calculation of the chemical properties with the reactive transport which can be used to assess the near-field. This report describes the models being implemented and presents some simple analyses demonstrating the feasibility of the chemical and coupled transport models.

113 (UCRL-ID-108314-Rev.1) **Preliminary waste form characteristics report Version 1.0. Revision 1.** Stout, R.B.; Leider, H.R. (eds.). Lawrence Livermore National Lab., CA (United States). 11 Oct 1991. 499p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. Order Number DE95006371. Source: OSTI; NTIS; INIS; GPO Dep.

This report focuses on radioactive waste form characteristics that will be used to design a waste package and an engineered barrier system (EBS) for a suitable repository as part of the Yucca Mountain Project. The term waste form refers to irradiated reactor fuel, other high-level waste (HLW) in various physical forms, and other radioactive materials (other than HLW) which are received for emplacement in a geologic repository. Any encapsulating of stabilizing matrix is also referred to as a waste form.

114 (UCRL-ID-118009) **Field-based tests of geochemical modeling codes using New Zealand hydrothermal systems.** Bruton, C.J.; Glassley, W.E.; Bourcier, W.L. Lawrence Livermore National Lab., CA (United States). Jun 1994. 10p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. Order Number DE95005658. Source: OSTI; NTIS; INIS; GPO Dep.

Hydrothermal systems in the Taupo Volcanic Zone, North Island, New Zealand are being used as field-based modeling exercises for the EQ3/6 geochemical modeling code package. Comparisons of the observed state and evolution of the hydrothermal systems with predictions of fluid-solid equilibria made using geochemical modeling codes will determine how the codes can be used to predict the chemical and mineralogical response of the environment to nuclear waste emplacement. Field-based exercises allow us to test the models on time scales unattainable in the laboratory. Preliminary predictions of mineral assemblages in equilibrium with fluids sampled from wells in the Wairakei and Kawerau geothermal field suggest that affinity-temperature diagrams must be used in conjunction with EQ6 to minimize the effect of uncertainties in thermodynamic and kinetic data on code predictions.

115 (UCRL-JC-115341) **Geomechanics investigations in support of the large block test at Fran Ridge, Nye County, Nevada.** Blair, S.C.; Berge, P.; Kansa, E.; Lin, Wunan; Roberts, J. Lawrence Livermore National Lab., CA (United States). 21 Jul 1994. 8p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. (CONF-950435-1: 2. international conference on mechanics of jointed and faulted rock, Vienna (Austria), 10-14 Apr 1995). Order Number DE94017413. Source: OSTI; NTIS; INIS; GPO Dep.

The Yucca Mountain Site Characterization Project is investigating the Topopah Spring Tuff at Yucca Mountain, Nevada for its suitability as a host rock for the disposal of high level nuclear wastes. The Lawrence Livermore National Laboratory is planning a large block test (LBT) to investigate coupled thermal-mechanical-hydrological and geochemical processes that may occur in the repository near-field environment.

116 (UCRL-JC-116429) **The importance of thermal loading conditions to waste package performance at Yucca Mountain.** Buscheck, T.A.; Nitao, J.J. Lawrence Livermore National Lab., CA (United States). Oct 1994. 8p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. (CONF-941075-7: 18. international symposium on the scientific basis for nuclear waste management, Kyoto (Japan), 23-27 Oct 1994). Order Number DE95006440. Source: OSTI; NTIS; INIS; GPO Dep.

Temperature and relative humidity are primary environmental factors affecting waste package corrosion rates for the potential repository in the unsaturated zone at Yucca Mountain, Nevada. Under ambient conditions, the repository environment is quite humid. If relative humidity is low enough (<70%), corrosion will be minimal. Under humid conditions, corrosion is reduced if the temperature is low (<60 C). Using the V-TOUGH code, the authors model thermo-hydrological flow to investigate the effect of repository heat on temperature and relative humidity in the repository for a wide range of thermal loads. These calculations indicate that repository heat may substantially reduce relative humidity on the waste package, over hundreds of years for low thermal loads and over tens of thousands of year for high thermal loads. Temperatures associated with a given relative humidity decrease with increasing thermal load. Thermal load distributions can be optimized to yield a more uniform reduction in relative humidity during the boiling period.

117 (UCRL-JC-116435) **Stochastic modeling of the influence of environment on pitting corrosion damage of radioactive-waste containers.** Henshall, G.A. Lawrence Livermore National Lab., CA (United States). Jun 1994. 8p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. (CONF-941075-5: 18. international symposium on the scientific basis for nuclear waste management, Kyoto (Japan), 23-27 Oct 1994). Order Number DE95002395. Source: OSTI; NTIS; INIS; GPO Dep.

A physically-based, phenomenological stochastic model for pit initiation and growth is presented as a potential tool for predicting the degradation of high-level radioactive-waste

containers by aqueous pitting corrosion. Included in the model are simple phenomenological equations describing the dependence of the controlling stochastic parameters on the applied (or corrosion) potential, chloride ion concentration, and absolute temperature. Results from this model are presented that demonstrate its ability to simulate several important environmental effects on pitting.

118 (UCRL-JC–118689) **Integrated Corrosion Facility for long-term testing of candidate materials for high-level radioactive waste containment.** Estill, J.C.; Dalder, E.N.C.; Gdowski, G.E.; McCright, R.D. Lawrence Livermore National Lab., CA (United States). Oct 1994. 4p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. (CONF-950570–3: International high-level radioactive waste management conference: progress toward understanding, Las Vegas, NV (United States), 1-5 May 1995). Order Number DE95005921. Source: OSTI; NTIS; INIS; GPO Dep.

A long-term-testing facility, the Integrated Corrosion Facility (I.C.F.), is being developed to investigate the corrosion behavior of candidate construction materials for high-level-radioactive waste packages for the potential repository at Yucca Mountain, Nevada. Corrosion phenomena will be characterized in environments considered possible under various scenarios of water contact with the waste packages. The testing of the materials will be conducted both in the liquid and high humidity vapor phases at 60 and 90°C. Three classes of materials with different degrees of corrosion resistance will be investigated in order to encompass the various design configurations of waste packages. The facility is expected to be in operation for a minimum of five years, and operation could be extended to longer times if warranted. A sufficient number of specimens will be emplaced in the test environments so that some can be removed and characterized periodically. The corrosion phenomena to be characterized are general, localized, galvanic, and stress corrosion cracking. The long-term data obtained from this study will be used in corrosion mechanism modeling, performance assessment, and waste package design. Three classes of materials are under consideration. The corrosion resistant materials are high-nickel alloys and titanium alloys; the corrosion allowance materials are low-alloy and carbon steels; and the intermediate corrosion resistant materials are copper-nickel alloys.

119 (UCRL-JC–119116) **Permeability of fractured tuff as functions of temperature and confining pressure.** Roberts, J.J.; Lin, Wunan. Lawrence Livermore National Lab., CA (United States). Oct 1994. 5p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. (CONF-950570–16: International high-level radioactive waste management conference: progress toward understanding, Las Vegas, NV (United States), 1-5 May 1995). Order Number DE95006432. Source: OSTI; NTIS; INIS; GPO Dep.

Understanding the transport properties of water through fractured rock is critical to predicting and modeling the hydrothermal performance of a geologic nuclear waste repository. Previous studies indicate that intact Topopah Spring tuff from Yucca Mountain, Nevada has a low permeability, $\sim 1 \times 10^{-18}$ m^2 (~1 microDarcy). A single fracture in the tuff increases the permeability to $\sim 100 \times 10^{-15}$ m^2 (hundreds of milliDarcies). However, fracture healing may occur when high temperature water flows through the fracture lowering the permeability by one or more orders of magnitude. We report progress on laboratory experiments on permeability of fractured Topopah Spring tuff as functions of confining pressure, temperature, and water/rock ratio.

120 (UCRL-JC–119119) **Effect of areal power density and relative humidity on corrosion resistant container performance.** Gansemer, J.D. Lawrence Livermore National Lab., CA (United States). Oct 1994. 3p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. (CONF-950570–9: International high-level radioactive waste management conference: progress toward understanding, Las Vegas, NV (United States), 1-5 May 1995). Order Number DE95006433. Source: OSTI; NTIS; INIS; GPO Dep.

The impact of the rewetting process on the performance of waste containers at the Yucca Mountain repository is analyzed. This paper explores the impact of the temperature-humidity relationships on pitting corrosion failure of stainless steel containers for different areal power densities (APDs)in the repository. It compares the likely performance of containers in a repository with a low APD, 55 Kw/acre, and a high APD, 110 kW/acre.

121 (UCRL-JC–119131) **Synthesis of tobermorite: A cement phase expected under repository conditions.** Martin, S.I. Lawrence Livermore National Lab., CA (United States). Nov 1994. 5p. Sponsored by USDOE, Washington, DC (United States). DOE Contract W-7405-ENG-48. (CONF-950570–2: International high-level radioactive waste management conference: progress toward understanding, Las Vegas, NV (United States), 1-5 May 1995). Order Number DE95005917. Source: OSTI; NTIS; INIS; GPO Dep.

In this study I have synthesized tobermorite, $Ca_5Si_6O_{16}(OH)_2.4H_20$, a principal crystalline phase expected to form in cementitious materials subjected to elevated temperatures in a potential nuclear waste repository. Fluids interacting with these materials may have a profound effect on the integrity of the waste package and on transport of radionuclides. At ambient temperature, Portland cement reacts with water to form an amorphous calcium-silicate-hydrate (C-S-H) gel. At elevated temperatures, crystalline phases of various hydration states form. The C-S-H system has not been well characterized at elevated temperatures up to 250°C, which has been considered a bounding temperature for the potential Yucca Mountain repository. Physical, chemical, and thermodynamic data for these cement minerals that are predicted to be stable at these temperatures must be obtained from synthetic or natural samples to help predict fluid chemistry. For some of these minerals natural samples are difficult to obtain in sufficient quantity and purity. Therefore, monomineralic phases must be synthesized in order to unambiguously define their behavior. The synthetic or natural phases will be characterized as part of a comprehensive study to define the behavior of cementitious materials in a repository environment.

122 **Hydrologic impact of exploratory shaft extension into nonwelded tuff.** Nichols, W.E. (Pacific Northwest Laboratory, Geoscience Dep., Richland (United States)); Freshley, M.D.; Rockhold, M.L. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 21-44 (1994). Special issue Yucca Mountain.

The Calico Hills nonwelded unit of volcanic tuff at Yucca Mountain, Nevada is considered a primary natural barrier to radionuclide migration between a potential high-level nuclear waste repository at Yucca Mountain and the regional water table. Numerical simulations using a verified and

benchmarked code of unsaturated flow in nonwelded volcanic tuff were performed in support of a risk/benefit analysis to assess the hydrologic impact of extending exploratory shafts into the Calico Hills nonwelded unit for characterization purposes. Additional characterization of the Calico Hills nonwelded unit would improve the accuracy of model predictions of its performance as a natural barrier to radionuclide migration, while the presence of shaft(s) required to characterize the unit may reduce the effectiveness of the barrier. Numerical simulations were used to predict that the presence of a shaft and the surrounding modified permeability zone caused by shaft construction would reduce travel time for water in a radial zone with a diameter for approximately 40 m by at least 58% compared to undisturbed conditions. The results show that the choice of backfill materials used to seal the shaft will be the most important factor in design to exploratory shafts with respect to hydrologic impacts. Heterogeneities, in the form of layers of contrasting hydraulic properties, may also be important in the vicinity of a shaft where differences may result in preferential paths for water flow. (author) 17 figs., 1 tab., 19 refs.

123 Calculated compositions of porewater affected by a nuclear waste repository in a tuff geologic environment from 0 to 10,000 years. Criscenti, L.C. (Pacific Northwest Lab., Richland, WA (United States)); Arthur, R.C. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 231-246 (1994).

Special issue Yucca Mountain.

Porewater compositions were estimated for an environment assuming that high-level radioactive waste has been stored for 10,000 years under geologic conditions analogous to those at the Yucca Mountain site in Nevada. The porewater compositions calculated with the EQ3/EQ6 geochemical code are intended for use in preliminary performance assessments of borosilicate glass waste packages. The porewater compositions were calculated using water-rock interaction models that are loosely coupled with two time-temperature periods in the host rocks: a cooling period between 900 years and 3,000 years after repository closure and an isothermal period from 3,000 years to 10,000 years. Significant changes in water composition are predicted to occur during the initial period of water-rock interaction; for example, the pH of the porewater increases from 6.4 to 9.1. Constant porewater compositions are predicted during the isothermal period. The results suggest that major changes in porewater composition will occur over a relatively short time frame and that these changes will persevere throughout the repository lifetime. (author) 5 figs., 3 tabs., 28 refs.

SANDIA NATIONAL LABORATORIES

124 Sensitivity analyses for total-system performance assessment. Wilson, M.L. (Sandia National Labs., Albuquerque, NM (United States)). pp. 14-21 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

As a follow-on to Sandia's 1991 preliminary total-system performance assessment of the Yucca Mountain site, this paper presents results of some sensitivity analyses that were done using results from the 1991 study. Two conceptual models of unsaturated-zone flow and transport at Yucca Mountain were included in the study, including both aqueous and gaseous releases. The sensitivities are quite different for the two models. For the composite-porosity model, the results are most sensitive to groundwater percolation flux, gaseous transport time, container lifetime, and fuel-matrix-alteration rate. For the weeps model, the results are most sensitive to parameters used to characterize fracture flow (fracture aperture and fracture connectivity) and infiltration (percolation flux and weep-episode factor).

125 Numerical methods for fluid flow in unsaturated heterogeneous tuff. Robey, T.H. (Spectra Research Institute, Albuquerque, NM (United States)). pp. 138-145 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

A numerical approach for modeling unsaturated flow is developed for heterogeneous simulations of fractured tuff generated using a geostatistical method. Cross correlations of hydrologic properties and upscaling of moisture retention curves is discussed. The approach is demonstrated for a study of infiltration at Yucca Mountain.

126 The most likely groundwater flux through the unsaturated tuff matrix at USW H-1. Gauthier, J.H. (Spectra Research Institute, Albuquerque, NM (United States)). pp. 146-151 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Using a probabilistic inverse method, an estimate is made of the groundwater flux through the unsaturated tuff matrix at drill hole USW H-1 in Yucca Mountain. The most likely flux is found to be between 0 and 0.01 mm/yr-virtually a hydrostatic condition. This result is consistent at all elevations where in-situ data are available, including an upper nonwelded strata. This study has implications for flow-model validation and future data collection.

127 Investigation of fracture-matrix interaction: Preliminary experiments in a simple system. Foltz, S.D. (Univ. of New Mexico, Albuquerque, NM (United States)); Tidwell, V.C.; Glass, R.J.; Sobolik, S.R. pp. 328-335 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Paramount to the modeling of unsaturated flow and transport through fractured porous media is a clear understanding of the processes controlling fracture-matrix interaction. As a first step toward such an understanding, two preliminary experiments have been performed to investigate the influence of matrix imbibition on water percolation through unsaturated fractures in the plane normal to the fracture. Test systems consisted of thin slabs of either tuff or an analog material cut by a single vertical fracture into which a constant fluid flux was introduced. Transient moisture content and solute concentration fields were imaged by means

of x-ray absorption. Flow fields associated with the two different media were significantly different owing to differences in material properties relative to the imposed flux. Richards' equation was found to be a valid means of modeling the imbibition of water into the tuff matrix from a saturated fracture for the current experiment.

128 **Preliminary characterization of materials for a reactive transport model validation experiment.** Siegel, M.D. (Sandia National Labs., Albuquerque, NM (United States)); Ward, D.B.; Cheng, W.C.; Bryant, C.; Chocas, C.S.; Reynolds, C.G. pp. 348-365 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The geochemical properties of a porous sand and several tracers (Ni, Br, and Li) have been characterized for use in a caisson experiment designed to validate sorption models used in models of reactive transport. The surfaces of the sand grains have been examined by a combination of techniques including potentiometric titration, acid leaching, optical microscopy, and scanning electron microscopy with energy-dispersive spectroscopy. The surface studies indicate the presence of small amounts of carbonate, kaolinite and iron-oxyhydroxides. Adsorption of nickel, lithium and bromide by the sand was measured using batch techniques. Bromide was not sorbed by the sand. A linear (K_d) or an isotherm sorption model may adequately describe transport of Li; however, a model describing the changes of pH and the concentrations of other solution species as a function of time and position within the caisson and the concomitant effects on Ni sorption may be required for accurate predictions of nickel transport.

129 **Scenario development for performance assessment - some questions for the near-field modelers.** Barr, G.E. (Sandia National Labs., Albuquerque, NM (United States)); Barnard, R.W. pp. 478-484 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

In an attempt to achieve completeness and consistency, the performance-assessment analyses developed by the Yucca Mountain Project are tied to scenarios described in event trees. Development of scenarios requires describing the constituent features, events, and processes in detail. Several features and processes occurring at the waste packages and the rock immediately surrounding the packages (i.e., the near field) have been identified: The effects of radiation on fluids in the near-field rock, the path-dependency of rock-water interactions, and the partitioning of contaminant transport between colloids and solutes. This paper discusses some questions regarding these processes that the near-field performance-assessment modelers will need to have answered to specify those portions of scenarios dealing with the near field.

130 **Implications of stability analysis for heat transfer at Yucca Mountain.** Ross, B. (Disposal Safety Inc., Washington, DC (United States)); Zhang, Y.; Lu, N. pp. 584-589 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

An analytical solution has been obtained to the stability problem for an infinite horizontal layer of gas with its humidity constrained to 100%. Latent heat transfer makes convective heat transfer much more important for this moist gas than for a dry gas. The critical Rayleigh number for the onset of convective flow in the moist gas, with a lower no-flow boundary at 97°C and an upper no-flow boundary at 27°C, is 0.18, much less than the value of $4n^2$ for a dry gas. Although the heat source at Yucca Mountain will be finite in extent, the solution for an infinite horizontal layer still gives a useful criterion for the qualitative importance of convective heat transfer. The critical Rayleigh number of 0.18 corresponds to a permeability of 4×10^{-12} m^2 if other parameters are given values measured at Yucca Mountain. This value falls roughly in the middle of the range of measured permeabilities. The analysis also gives a time constant for the onset of convection, which at twice the critical Rayleigh number of 1000 yr. Thus convection will probably make an important contribution to heat transfer at Yucca Mountain if the rock permeability falls in the upper portion of the range of measurements to date, but only at times after a few hundred or thousand years.

131 **Comparison of predicted far-field temperatures for discrete and smeared heat sources.** Ryder, E.E. (Sandia National Labs., Albuquerque, NM (United States)). pp. 841-846 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

A fundamental concern in the design of the potential repository at Yucca Mountain, Nevada is the response of the host rock to the emplacement of heat-generating waste. The thermal perturbation of the rock mass has implications regarding the structural hydrologic, and geochemical performance of the potential repository. The phenomenological coupling of many of these performance aspects makes repository thermal modeling a difficult task. For many of the more complex, coupled models, it is often necessary to reduce the geometry of the potential repository to a smeared heat-source approximation. Such simplifications have impacts on induced thermal profiles that in turn may influence other predicted responses through one- or two-way thermal couplings. The effect of waste emplacement layout on host-rock thermal response was chosen as the primary emphasis of this study. Using a consistent set of modeling and input assumptions, far-field thermal response predictions were made for discrete-source as well as plate source approximations of the repository geometry. Input values used in the simulations are consistent with a design-basis areal power density (APD) of 80 kW/acre as would be achieved assuming a 2010 emplacement start date, a levelized receipt schedule, and a limitation on available area as published in previous design studies. It was found that edge effects resulting from general repository layout have a significant influence on the shapes and extents of isothermal profiles, and should be accounted for in far-field modeling efforts.

132 **The results of near-field thermal and mechanical calculations of thermal loading schemes.** Holland, J.F. (Technadyne Engineering Consultants Inc., Albuquerque,

NM (United States)). pp. 868-873 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Two waste emplacement schemes, borehole and in-drift, are under evaluation as potential repository drift geometries for the Yucca Mountain Site Characterization Project. Calculations were performed to examine the systems implications of various thermal loadings on the near- and far-field repository environments. This paper reports the results of two-dimensional finite element analyses of the near-field thermal and structural response of the potential repository. Thermal calculations were run to 1000 years and mechanical calculations were run to 75 years, the time when the drifts will be backfilled. Local areal power densities (LAPDs) of 57, 80, and 100 kW/acre were used in the calculations. Both emplacement schemes meet current near-field thermal performance goals for all loadings examined. The mechanical calculations predict no intact rock failure, limited joint slippage around the drifts, and closure of apertures for vertical fractures above and below the drifts.

133 **Influence of deterministic geologic trends on spatial variability of hydrologic properties in volcanic tuff.** Rautman, C.A. (Sandia National Labs., Albuquerque, NM (United States)); Flint, A.L.; Chornack, M.P.; Istok, J.D.; Flint, L.E. pp. 921-929 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Hydrologic properties have been measured on outcrop samples taken from a detailed, two-dimensional grid covering a 1.4 km outcrop exposure of the 10-m thick nonwelded-to-welded, shardy base microstratigraphic unit of the Tiva Canyon Member of the Paintbrush Tuff of Miocene age at Yucca Mountain, Nevada. These data allow quantification of spatial trends in rock matrix properties that exist in this important hydrologic unit. Geologic investigation, combined with statistical and geostatistical analyses of the numerical data, indicates that spatial variability of matrix properties is related to deterministic geologic processes that operated throughout the region. Linear vertical trends in hydrologic properties are strongly developed in the shardy base microstratigraphic unit, and they are more accurately modeled using the concept of a thickness-normalized stratigraphic elevation within the unit, rather than absolute elevation. Hydrologic properties appear to be correlated over distances of 0.25 to 0.3 of the unit thickness after removing the deterministic vertical trend. The use of stratigraphic elevation allows scaling of identical trends by unit thickness, which may be of particular importance in a basal, topography-blanketing unit such as this one. Horizontal changes in hydrologic properties do not appear to form obvious trends within the limited lateral geographic extent of the ash-flow environment that was examined. Matrix properties appear to be correlated horizontally over distances between 100 and 400 m. The existence and quantitative description of these trends and patterns of vertical spatial continuity should increase confidence in models of hydrologic properties and groundwater flow in this area that may be constructed to support the design of a potential high-level nuclear waste repository at Yucca Mountain.

134 **Rock mass mechanical property estimation strategy for the Yucca Mountain Site Characterization Project.** Lin, M. (J.F.T. Agapito & Associates Inc., Grand Junction, CO (United States)); Brechtel, C.E.; Hardy, M.P.; Bauer, S.J. pp. 937-942 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Rock mass mechanical properties are required in the design of repository drifts and ramps to assess the impact of thermal loads from the heat-generating wastes on excavation performance and long-term structural stability. The ramps, exploratory drifts and repository excavations will intersect both welded and nonwelded tuffs with varying abundances of fractures, degree of welding and lithophyisal content. Rock mass mechanical properties are dependent on both intact rock properties and joint characteristics, and were derived from empirically based relationships of laboratory determined intact rock properties and rock mass quality indices (Q and RMR). Definition and verification of these empirical relationships is considered critical to the drift design methodology because planned thermomechanical testing in the Exploratory Studies Facility (ESF) is limited. Rock mass quality determinations may provide the only practical vehicle for assessment of the effects of variability in drift performance under thermal loads. This paper presents a method of estimating the rock mass properties for the welded and nonwelded tuffs based on currently available information on intact rock and joint characteristics at the Yucca Mountain site. Variability of the expected ground conditions at the potential repository horizon (the TSw2 thermomechanical unit) and in the Calico Hills nonwelded tuffs is accommodated by defining five rock mass quality categories in each unit based upon assumed and observed distributions of the data.

135 **Instrumentation requirements for the ESF thermomechanical experiments.** Pott, J. (Sandia National Labs., Albuquerque, NM (United States)); Brechtel, C.E. pp. 967-974 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

In situ thermomechanical experiments are planned as part of the Yucca Mountain Site Characterization Project that require instruments to measure stress and displacement at temperatures that exceed the typical specifications of existing geotechnical instruments. A high degree of instrument reliability will also be required to satisfy the objectives of the experiments, therefore a study was undertaken to identify areas where improvement in instrument performance was required. A preliminary list of instruments required for the experiments was developed, based on existing test planning and analysis. Projected temperature requirements were compared to specifications of existing instruments to identify instrumentation development needs. Different instrument technologies, not currently employed in geotechnical instrumentation, were reviewed to identify potential improvements of existing designs for the high temperature environment. Technologies with strong potentials to improve instrument performance with relatively high reliability include graphite fiber composite materials, fiber optics, and video imagery.

136 Scale dependence of effective media properties. Tidwell, V.C. (Sandia National Labs., Albuquerque, NM (United States)); VonDoemming, J.D.; Martinez, K. pp. 1059-1065 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC04-76DP00789. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

For problems where media properties are measured at one scale and applied at another, scaling laws or models must be used in order to define effective properties at the scale of interest. The accuracy of such models will play a critical role in predicting flow and transport through the Yucca Mountain Test Site given the sensitivity of these calculations to the input property fields. Therefore, a research program has been established to gain a fundamental understanding of how properties scale with the aim of developing and testing models that describe scaling behavior in a quantitative manner. Scaling of constitutive rock properties is investigated through physical experimentation involving the collection of suites of gas permeability data measured over a range of discrete scales. Also, various physical characteristics of property heterogeneity and the means by which the heterogeneity is measured and described are systematically investigated to evaluate their influence on scaling behavior. This paper summarizes the approach that is being taken toward this goal and presents the results of a scoping study that was conducted to evaluate the feasibility of the proposed research.

137 Analyses of releases due to drilling at the potential Yucca Mountain repository. Barnard, R.W. (Sandia National Labs., Albuquerque, NM (United States)). pp. 1292-1297 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Radionuclide releases due to drilling into the potential Yucca Mountain nuclear-waste repository have been evaluated as part of a recent total-system performance assessment. The probability that a drilling event intersects a waste package is a function of the sizes of the drill bit and the waste package, and the density of placement of the containers in the repository. The magnitude of the release is modeled as a random function that also depends on the amount of decay the radionuclides have undergone. Four cases have been analyzed, representing the combinations of two waste-package designs (small-capacity, thin-wall, vertically emplaced; and large-capacity, thick-wall, horizontally emplaced) and two repository layouts (lower thermal power dissipation, low waste-package placement density; and higher thermal power dissipation, high waste-package placement density). The results show a fairly pronounced dependence on waste-package design and slight dependence on repository layout. Given the assumptions in the model, releases from the larger containers are 4-5 times greater than from the smaller packages.

138 Appropriateness of one-dimensional calculations for repository analysis. Eaton, R.R. (Sandia National Labs., Albuquerque, NM (United States)). pp. 1492-1500 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper brings into focus the result of numerous studies that have addressed issues associated with the validity of assumptions which are used to justify reducing the dimensionality of numerical calculations of water flow through Yucca Mountain, NV. It is shown that in many cases, one-dimensional modeling is more rigorous than previously assumed.

139 Some results from the second iteration of total-system performance assessment for Yucca Mountain. Wilson, M.L. (Sandia National Labs., Albuquerque, NM (United States)). pp. 1655-1662 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The second preliminary total-system performance assessment for the potential radioactive-waste-repository site at Yucca Mountain has recently been completed. This paper summarizes results for nominal aqueous and gaseous releases using the composite-porosity flow model. The results are found to be sensitive to the type of unsaturated-zone flow, to percolation flux and climate change, to saturated-zone dilution, to container-wetting processes and container-corrosion processes, to fuel-matrix alteration rate and radionuclide solubilities (especially for ^{237}Np), and to bulk permeability and retardation of gases ^{14}C. There are areas that should be given priority in the site-characterization program. Specific recommendations are given in the full report of the study.

140 An updated fracture-flow model for total-system performance assessment of Yucca Mountain. Gauthier, J.H. (SPECTRA Research Institute, Albuquerque, NM (United States)). pp. 1663-1670 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Improvements have been made to the fracture-flow model being used in the total-system performance assessment of a potential high-level radioactive waste repository at Yucca Mountain, Nevada. The "weeps model" now includes (1) weeps of varied sizes, (2) flow-pattern fluctuations caused by climate change, and (3) flow-pattern perturbations caused by repository heat generation. Comparison with the original weeps model indicates that allowing weeps of varied sizes substantially reduces the number of weeps and the number of containers contacted by weeps. However, flow-pattern perturbations caused by either climate change or repository heat generation greatly increases the number of containers contacted by weeps. In preliminary total-system calculations, using a phenomenological container-failure and radionuclide-release model, the weeps model predicts that radionuclide releases from a high-level radioactive waste repository at Yucca Mountain will be below the EPA standard specified in 40 CFR 191, but that the maximum radiation dose to an individual could be significant. Specific data from the site are required to determine the validity of

the weep-flow mechanism and to better determine the parameters to which the dose calculation is sensitive.

141 Constraining local 3-D models of the saturated-zone, Yucca Mountain, Nevada. Barr, G.E. (Sandia National Labs., Albuquerque, NM (United States)); Shannon, S.A. pp. 1814-1821 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A qualitative three-dimensional analysis of the saturated zone flow system was performed for a 8 km x 8 km region including the potential Yucca Mountain repository site. Certain recognized geologic features of unknown hydraulic properties were introduced to assess the general response of the flow field to these features. Two of these features, the Solitario Canyon fault and the proposed fault in Drill Hole Wash, appear to constrain flow and allow calibration.

142 Modeling infiltration into a tuff matrix from a saturated vertical fracture. Ho, C.K. (Sandia National Labs., Albuquerque, NM (United States)). pp. 1897-1904 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The evaluation of Yucca Mountain as a potential high-level radioactive waste repository relies on predictive hydrologic models in unsaturated tuff surrounding the proposed site. Saturation profiles resulting from TOUGH2 numerical simulations of water infiltration into a tuff matrix from a saturated vertical fracture have been compared to experimental results. The purpose was to determine the sensitivity of the infiltration on local heterogeneities and different representations of two-phase characteristic curves used by the model. Findings indicate that the use of simplified (linearized) capillary pressure curves with rigorous (van Genuchten) relative permeability curves resulted in a more computationally efficient solution without a loss in accuracy. However, linearized forms of the relative permeability functions produced poor results, regardless of the form of the capillary pressure function. In addition, numerical simulations revealed that the presence of local heterogeneities in the tuff caused non-uniform saturation distributions and wetting fronts in the matrix.

143 Fracture-matrix interaction in Topopah Spring Tuff: Experiment and numerical analysis. Glass, R.J. (Sandia National Labs., Albuquerque, NM (United States)); Tidwell, V.C.; Flint, A.L.; Peplinski, W.; Castro, Y. pp. 1905-1914 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Fracture-matrix interaction is investigated through combined physical and numerical experimentation. Two slabs of Topopah Spring Tuff are mated to form a vertical saw cut fracture to which water is supplied. X-ray imaging is used to obtain the matrix porosity field and transient saturation fields as water moves from the fracture into the matrix. Porosity, hydraulic conductivity, and pressure/saturation relations of the matrix are measured on small cores taken from adjacent rock. Correlations between hydraulic properties and porosity are developed and modeled. Numerical simulations using TOUGH2 are accomplished with a series of property fields of increasing detail. Property fields are modeled using the measured porosity field divided into 1, 3, 5, 11, and 21 porosity groups with the hydraulic properties assigned from the developed correlations and the average porosity within each group. Comparison with experimental results allows us to begin to evaluate current matrix property measurement techniques, specific matrix property models, property estimation procedures, and effects of matrix property variability.

144 Thermal and seismic impacts on the North Ramp at Yucca Mountain. Lin, M. (J.F.T. Agapito & Associates, Inc., Grand Junction, CO (United States)); Hardy, M.P.; Jung, J. pp. 1971-1978 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The impacts of thermal and seismic loads on the stability of the Exploratory Studies Facility North Ramp at Yucca Mountain were assessed using both empirical and analytical approaches. This paper presents the methods and results of the analyses. Thermal loads were first calculated using the computer code STRES3D. This code calculates the conductive heat transfer through a semi-infinite elastic, isotropic, homogeneous solid and the resulting thermally-induced stresses. The calculated thermal loads, combined with simulated earthquake motion, were then modeled using UDEC and DYNA3D, numerical codes with dynamic simulation capabilities. The thermal- and seismic-induced yield zones were post-processed and presented for assessment of damage. Uncoupled bolt stress analysis was also conducted to evaluate the seismic impact on the ground support components.

145 Mechanical and bulk properties in support of ESF design issues. Price, R.H. (Sandia National Labs., Albuquerque, NM (United States)); Martin, R.J. III; Boyd, P.J.; Noel, J.S. pp. 1987-1992 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

An intensive laboratory investigation is determining the mechanical properties of tuffs for the Yucca Mountain Site Characterization Project (YMP). Most recently, experiments have been performed on tuff samples from a series of drill holes along the proposed alignment of the Exploratory Study Facilities (ESF) north ramp. Unconfined compression and indirect tension experiments were performed and the results are being analyzed with the help of bulk property information. The results on samples from five of the drill holes are presented here. In general, the properties vary widely, but are highly dependent on the sample porosity.

146 Construction monitoring activities in the ESF starter tunnel. Pott, J. (Sandia National Labs., Albuquerque, NM (United States)); Carlisle, S. pp. 1993-1998 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States)

(1994). pp. 1048 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

In situ design verification activities are being conducted in the North Ramp Starter Tunnel of the Yucca Mountain Project Exploratory Studies Facility. These activities include: monitoring the peak particle velocities and evaluating the damage to the rock mass associated with construction blasting, assessing the rock mass quality surrounding the tunnel, monitoring the performance of the installed ground support, and monitoring the stability of the tunnel. In this paper, examples of the data that have been collected and preliminary conclusions from the data are presented.

147 **Wetting phase permeability in a partially saturated horizontal fracture.** Nicholl, M.J. (Sandia National Labs., Albuquerque, NM (United States)); Glass, R.J. pp. 2007-2019 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Fractures within geologic media can dominate the hydraulic properties of the system. Therefore, conceptual models used to assess the potential for radio-nuclide migration in unsaturated fractured rock such as that composing Yucca Mountain, Nevada, must be consistent with flow processes in individual fractures. A major obstacle to the understanding and simulation of unsaturated fracture flow is the paucity of physical data on both fracture aperture structure and relative permeability. An experimental procedure is developed for collecting detailed data on aperture and phase structure from a transparent analog fracture. To facilitate understanding of basic processes and provide a basis for development of effective property models, the simplest possible rough-walled fracture is used. Stable phase structures of varying complexity are created within the horizontal analog fracture. Wetting phase permeability is measured under steady-state conditions. A process based model for wetting phase relative permeability is then explored. Contributions of the following processes to reduced wetting phase permeability under unsaturated conditions are considered: reduction in cross-sectional flow area, increased path length, localized flow restriction, and preferential occupation of large apertures by the non-wetting phase.

148 **Detailed characterization and preliminary adsorption model for materials for an intermediate-scale reactive-transport experiment.** Ward, D.B. (Univ. of New Mexico, Albuquerque, NM (United States)); Bryan, C.R.; Siegel, M.D. pp. 2048-2062 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

An intermediate-scale transport-model experiment, involving the migration of fluid and tracers (Li, Br, Ni) through a 6-m-high × 3-m-diameter caisson filled with Wedron 510 sand, is being carried out for the Yucca Mountain Site Characterization Project. The surface chemistry of the sand has been studied and a preliminary surface-complexation model of Ni adsorption has been formulated for use in transport calculations. XPS and leaching studies suggest that the surface of the quartz sand is partially covered by thin layers of Fe-oxyhydroxide and Ca-Mg carbonate and by flakes of kaolinite. Ni adsorption by the sand is strongly pH-dependent, showing no adsorption at pH 5 and near-total adsorption at pH 7. Ni adsorption edges for goethite and quartz, two components of the sand were also measured. Ni adsorption on pure quartz is only moderately pH-dependent and differs in shape and location from that of the sand, whereas Ni adsorption by goethite is strongly pH-dependent. A triple-layer surface-complexation model developed for goethite provides a good fit to the Ni-adsorption curve of the sand. Based on this model, the apparent surface area of the Fe-oxyhydroxide coating is estimated to be ~560 m^2/g, compatible with its occurrence as amorphous Fe-oxyhydroxide. Potentiometric titrations on the sand also differ from those of pure quartz and suggest that the effective surface area of the sand may be significantly greater than that measured by N_2-BET gas adsorption. Attempts to model the adsorption characteristics of the bulk sand in terms of the properties of pure end member components suggest that much of the sand surface is inert. Although the exact mechanisms of Ni adsorption remain ambiguous, this preliminary adsorption model provides an initial set of parameters that can be used in transport calculations.

149 **Modeling a ponded infiltration experiment at Yucca Mountain, NV.** Hudson, D.B. (Foothill Engineering, Inc., Mercury, NV (United States)); Guertal, W.R.; Flint, A.L. pp. 2168-2174 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

One-dimensional and two-dimensional radial flow numerical models were used to evaluate the results for a 60.5 h ponded infiltration experiment done around a 24 m deep, 0.15 m diameter, cased borehole at Yucca Mountain, NV. Nine distinct morphological horizons in the soil profile has been identified; physical and hydraulic properties had been measured for each horizon; and a porosity profile at the borehole had been measured. During the infiltration experiment, 10 cm of water was ponded in a 3.5 m diameter infiltrometer around the borehole, the volume of water applied was measured, and water content profiles were measured with a neutron moisture meter. The infiltrometer applied 86.9 cm of water during the first 60.5 h of infiltration, but only 52.8 cm of additional water was measured in the borehole profiles. Assuming a linear relationship between cumulative infiltration (I) and the square root of time ($t^{0.5}$), an experimental sorptivity of 11.5 cm h^{-1} was estimated for the first 4.5 h of infiltration. An assumed washout zone around the borehole casing accounted for the discrepancy between the measured water content profiles and the applied water. A uniform property, 1-D model with an applied flux upper boundary described by the sorptivity confirmed the probable washout zone, and indicated that significant lateral flow into the dry soil around the infiltrometer could occur. A 2-D radial flow model with the same properties and upper boundary demonstrated that significant lateral flow occurred. The upper boundary in this model caused the upper portion of the profile to drain. This suggested using a saturated upper boundary to keep the upper portion of the profile saturated. When the saturated upper boundary was used, the permeability of the soil was decreased from the measured value of

3.28 E-11 m^2 to 1.5E-12 m^2 so that the simulated wetting front at a similar depth as the observed wetting front after 60.5 h.

150 Effect of fractures on repository dryout. Eaton, R.R. (Sandia National Labs., Albuquerque, NM (United States)). pp. 2442-2449 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Calculations of water flow through Yucca Mountain show significant dryout and water perching in the vicinity of the proposed nuclear waste repository. These calculations also show that the extent of the dryout and perched water zones is a strong function of the material characteristics which are used to represent the fracture zones. The results show that for 100 μm fracture case appreciable dryout and perched regions exist. When 1 μm fractures are used no dryout or perched regions are calculated.

151 Studies of non-isothermal flow in saturated and partially saturated porous media. Ho, C.K. (Sandia National Labs., Albuquerque, NM (United States)); Maki, K.S.; Glass, R.J. pp. 2481-2491 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Coupled thermal and hydrologic flow processes in unsaturated fractured rocks are important in the evaluation of Yucca Mountain as a potential repository for high level nuclear waste. Physical and numerical experiments have been performed to investigate the behavior of non-isothermal flow in two-dimensional saturated and partially saturated porous media. The physical experiments were performed to identify non-isothermal flow fields and temperature distributions in fully saturated, half-saturated, and residually saturated two-dimensional porous media with bottom heating and top cooling. Two counter-rotating liquid-phase convective cells were observed to develop in the saturated regions of all three cases. Gas-phase convection was also evidenced in the unsaturated regions of the partially saturated experiments. TOUGH2 numerical simulations of the saturated case were found to be strongly dependent on the assumed boundary conditions of the physical system. Models including heat losses through the boundaries of the test cell produced temperature and flow fields that were in better agreement with the observed temperature and flow fields than models that assumed insulated boundary conditions. A sensitivity analysis also showed that a reduction of the bulk permeability of the porous media in the numerical simulations depressed the effect of convection, flattening the temperature profiles across the test cell.

152 Scaling behavior of gas permeability measurements in volcanic tuffs. Tidwell, V.C. (Sandia National Labs., Albuquerque, NM (United States)). pp. 2500-2509 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

One of the critical issues facing the Yucca Mountain site characterization and performance assessment programs is the manner in which property scaling is addressed. Property scaling becomes an issue whenever heterogeneous media properties are measured at one scale but applied at another. A research program has been established to challenge current understanding of property scaling with the aim of developing and testing models that describe scaling behavior in a quantitative manner. Scaling of constitutive rock properties is investigated through physical experimentation involving the collection of suites of gas-permeability data measured over a range of discrete scales. The approach is to systematically isolate those factors believed to influence property scaling and investigate their relative contributions to overall scaling behavior. Two blocks of tuff, each exhibiting differing heterogeneity structure, have recently been examined. Results of the investigation show very different scaling behavior, as exhibited by changes in the distribution functions and variograms, for the two tuff samples. Even for the relatively narrow range of measurement scales employed significant changes in the distribution functions, variograms, and summary statistics occurred. Because such data descriptors will likely play an important role in calculating effective media properties, these results demonstrate both the need to understand and accurately model scaling behavior.

153 Development of stochastic indicator models of lithology, Yucca Mountain, Nevada. Rautman, C.A. (Sandia National Labs., Albuquerque, NM (United States)); Robey, T.H. pp. 2510-2519 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC04-94AL85000. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Indicator geostatistical techniques have been used to produce a number of fully three-dimensional stochastic simulations of large-scale lithologic categories at the Yucca Mountain site. Each realization reproduces the available drill hole data used to condition the simulation. Information is propagated away from each point of observation in accordance with a mathematical model of spatial continuity inferred through soft data taken from published geologic cross sections. Variations among the simulated models collectively represent uncertainty in the lithology at unsampled locations. These stochastic models succeed in capturing many major features of welded-nonwelded lithologic framework of Yucca Mountain. However, contacts between welded and nonwelded rock types for individual simulations appear more complex than suggested by field observation, and a number of probable numerical artifacts exist in these models. Many of the apparent discrepancies between the simulated models and the general geology of Yucca Mountain represent characterization uncertainty, and can be traced to the sparse site data used to condition the simulations. Several vertical stratigraphic columns have been extracted from the three-dimensional stochastic models for use in simplified total-system performance assessment exercises. Simple, manual adjustments are required to eliminate the more obvious simulation artifacts and to impose stratigraphic framework provided by the indicator models.

154 Modeling heterogeneous unsaturated porous media flow at Yucca Mountain. Robey, T.H. (Spectra Research Institute, Albuquerque, NM (United States)). pp. 2678-2684 of High Level Radioactive Waste Management:

Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Geologic systems are inherently heterogeneous and this heterogeneity can have a significant impact on unsaturated flow through porous media. Most previous efforts to model groundwater flow through Yucca Mountain have used stratigraphic units with homogeneous properties. However, modeling heterogeneous porous and fractured tuff in a more realistic manner requires numerical methods for generating heterogeneous simulations of the media, scaling of material properties from core scale to computational scale, and flow modeling that allows channeling. The Yucca Mountain test case of the INTRAVAL project is used to test the numerical approaches. Geostatistical methods are used to generate more realistic representations of the stratigraphic units and heterogeneity within units is generated using sampling from property distributions. Scaling problems are reduced using an adaptive grid that minimizes heterogeneity within each flow element. A flow code based on the dual mixed-finite-element method that allows for heterogeneity and channeling is employed. In the Yucca Mountain test case, the simulated volumetric water contents matched the measured values at drill hole USW UZ-16 except in the non-welded portion of Prow Pass.

155 **Paleoclimate validation of a numerical climate model.** Schelling, F.J. (Sandia National Labs., Las Vegas, NV (United States)); Church, H.W.; Zak, B.D.; Thompson, S.L. pp. 2746-2749 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

An analysis planned to validate regional climate model results for a past climate state at Yucca Mountain, Nevada, against paleoclimate evidence for the period is described. This analysis, which will use the GENESIS model of global climate nested with the RegCM2 regional climate nested with the RegCM2 regional climate model, is part of a larger study for DOE's Yucca Mountain Site Characterization Project that is evaluating the impacts of long term future climate change on performance of the potential high level nuclear waste repository at Yucca Mountain. The planned analysis and anticipated results are presented.

156 (SAND–92-2186) **Scenarios constructed for nominal flow in the presence of a repository at Yucca Mountain and vicinity.** Barr, G.E. (Sandia National Labs., Albuquerque, NM (United States)); Hunter, R.L.; Dunn, E.; Flint, A. Sandia National Labs., Albuquerque, NM (United States). Mar 1995. 218p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. Order Number DE95009315. Source: OSTI; NTIS; INIS; GPO Dep.

Scenario development for the system performance assessment of the Yucca Mountain Site Characterization Project defines a scenario as a well-posed problem connecting an initiating event with radionuclide release to the accessible environment by a logical and physically possible combination or sequence of features, events, and processes. Drawing on the advice and assistance of the Project's principal investigators (PIs), a collection of release scenarios initiated by the nominal ground-water flow occurring in the vicinity of the potential Yucca Mountain high-level-waste repository is developed and described in pictorial form. This collection of scenarios is intended to provide a framework to assist PIs in recognizing essential field and calculational analyses, to assist performance assessment in providing guidance to site characterization, and to continue the effort to exhaustively identify all features, events, and processes important to releases. It represents a step in the iterative process of identifying what details of the potential site are important for safe disposal. 67 refs.

157 (SAND–93-3997) **A review of the available technologies for sealing a potential underground nuclear waste repository at Yucca Mountain, Nevada.** Fernandez, J.A. (Sandia National Labs., Albuquerque, NM (United States)); Richardson, A.M. Sandia National Labs., Albuquerque, NM (United States). Nov 1994. 420p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. Order Number DE95008439. Source: OSTI; NTIS; INIS; GPO Dep.

The purpose of this report is to assess the availability of technologies to seal underground openings. The technologies are needed to seal the potential high-level radioactive waste repository at Yucca Mountain. Technologies are evaluated for three basic categories of seal components: backfill (general fill and graded fill), bulkheads, and grout curtains. Not only is placement of seal components assessed, but also preconditioning of the placement area and seal component durability. The approach taken was: First, review selected sealing case histories (literature searches and site visits) from the mining, civil, and defense industries; second, determine whether reasonably available technologies to seal the potential repository exist; and finally, identify deficiencies in existing technologies. It is concluded that reasonably available technologies do exist to place backfill, bulkheads, and grout curtains. Technologies also exist to precondition areas where seal components are to be placed. However, if final performance requirements are stringent for these engineered structures, some existing technologies may need to be developed. Deficiencies currently do exist in technologies that demonstrate the long-term durability and performance of seal components. Case histories do not currently exist that demonstrate the placement of seal components in greatly elevated thermal and high-radiation environments and in areas where ground support (rock bolts and concrete liners) has been removed. The as-placed, in situ material properties for sealing materials appropriate to Yucca Mountain are not available.

158 (SAND–93-4020) **Bulk and mechanical properties of the Paintbrush tuff recovered from borehole USW NRG-6: Data report.** Martin, R.J. (New England Research, Inc., White River Junction, VT (United States)); Boyd, P.J.; Noel, J.S.; Price, R.H. Sandia National Labs., Albuquerque, NM (United States). Nov 1994. 105p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. Order Number DE95004385. Source: OSTI; NTIS; INIS; GPO Dep.

Experimental results are presented for bulk and mechanical properties measurements on specimens of the Paintbrush tuff recovered from borehole USW NRG-6 at Yucca Mountain, Nevada. Measurements have been performed on four thermal/mechanical units, TCw, PTn, TSw1 and TSw2. On each specimen the following bulk properties have been reported: dry bulk density, saturated bulk density, average grain density, and porosity. Unconfined

compression to failure, confined compression to failure, and indirect tensile strength tests were performed on selected specimens recovered from the borehole. In addition, compressional and shear wave velocities were measured on specimens designated for unconfined compression and confined compression experiments. Measurements were conducted at room temperature on nominally water saturated specimens; however, some specimens of PTn were tested in a room dry condition. The nominal strain rate for the fracture experiments was 10^{-5} s $^{-1}$.

159 (SAND–93-7106C) **Mountain scale modeling of transient, coupled gas flow, heat transfer and carbon-14 migration.** Lu, Ning (Disposal Safety, Inc., Washington, DC (United States)); Ross, B. Sandia National Labs., Albuquerque, NM (United States). [1993]. 7p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. (CONF-9309228–13: Focus 93: site characterization and model validation, Las Vegas, NV (United States), 26-29 Sep 1993). Order Number DE95003351. Source: OSTI; NTIS; INIS; GPO Dep.

We simulate mountain-scale coupled heat transfer and gas flow at Yucca Mountain. A coupled rock-gas flow and heat transfer model, TGIF2, is used to simulate mountain-scale two-dimensional transient heat transfer and gas flow. The model is first verified against an analytical solution for the problem of an infinite horizontal layer of fluid heated from below. Our numerical results match very well with the analytical solution. Then, we obtain transient temperature and gas flow distributions inside the mountain. These distributions are used by a transient semianalytical particle tracker to obtain carbon-14 travel times for particles starting at different locations within the repository. Assuming that the repository is filled with 30-year-old waste at an initial areal power density of 57 kw/acre, we find that repository temperatures remain above 60°C for more than 10,000 years. Carbon-14 travel times to the surface are mostly less than 1000 years, for particles starting at any time within the first 10,000 years.

160 (SAND–93-7109) **Development of models for fast fluid pathways through unsaturated heterogeneous porous media.** Robey, T.H. (Spectra Research Inst., Albuquerque, NM (United States)). Sandia National Labs., Albuquerque, NM (United States). Nov 1994. 112p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. Order Number DE95004269. Source: OSTI; NTIS; INIS; GPO Dep.

The pre-waste-emplacement ground water travel time requirement is a regulatory criterion that specifies ground water travel time to the accessible environment shall be greater than 1,000 years. Satisfying the ground water travel time criterion for the potential repository at Yucca Mountain requires the study of fast travel path formation in the unsaturated zone and development of models that simulate the formation of fast paths. Conceptual models for unsaturated flow that have been used for total-systems performance assessment generally fall into the categories of composite-porosity or fracture models. The actual hydrologic conditions at Yucca Mountain are thought to lie somewhere between the extremes of these two types of models. The current study considers the effects of heterogeneities on composite-porosity models and seeks to develop numerical methods (and models) that can produce locally saturated zones where fracture flow can occur. The credibility of the model and numerical methods is investigated by using test data from the INTRAVAL project (Swedish Nuclear Inspectorate, 1992) to attempt to predict in-situ volumetric water content at specific locations in Yucca Mountain. Work based on the numerical methods presented in this study is eventually intended to allow the calculation of ground water travel times in heterogeneous media. 60 refs.

161 (SAND–94-2243C) **Mechanical and bulk properties of intact rock collected in the laboratory in support of the Yucca Mountain Site Characterization Project.** Price, R.H. (Sandia National Labs., Albuquerque, NM (United States)); Martin, R.J. III; Boyd, P.J.; Boinott, G.N. Sandia National Labs., Albuquerque, NM (United States). [1994]. 12p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. (CONF-9409238–1: Workshop on rock mechanics, Rockville, MD (United States), 19-20 Sep 1994). Order Number DE95001883. Source: OSTI; NTIS; INIS; GPO Dep.

A comprehensive laboratory investigation is determining the mechanical properties of tuffs for the Yucca Mountain Site Characterization Project (YMP). Most recently, experiments have been performed on tuff samples from a series of drill holes along the planned alignment of the Exploratory Study Facilities (ESF) north ramp. Unconfined compression and indirect tension experiments were performed and the results are being analyzed with the help of bulk property information. The results on samples from eight of the drill holes are presented. In general, the properties vary widely, but are highly dependent on the sample porosity. The developed relationships between mechanical properties and porosity are powerful tools in the effort to model the rock mass response of Yucca Mountain to the emplacement of the potential high-level radioactive waste repository.

162 (SAND–94-2384C) **Frictional sliding in layered rock: Preliminary experiments on stacked Lexan plates.** Perry, K.E. Jr. (Idaho National Engineering Laboratory, Idaho Falls, ID (United States). Fracture Behavior Group); Epstein, J.S.; Jung, J. Sandia National Labs., Albuquerque, NM (United States). [1995]. 10p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. (CONF-950655–1: 35. US symposium on rock mechanics, South Lake Tahoe, NV (United States), 4-7 Jun 1995). Order Number DE95003632. Source: OSTI; NTIS; INIS; GPO Dep.

Understanding the mechanical behavior of jointed-rock masses is of critical importance to designing and predicting the performance of a potential nuclear waste repositiry. To this end we have studied the frictional sliding between simulated rock joints using phase shifting moire interferometry. Preliminary calibration models were made from stacks of Lexan plates that were sand-blasted to provide a uniform frictional interface. Load was applied monotonically and phase shifted moire fringe patterns were recorded at three different load states. Plots of slip along the interfaces for the model are presented to demonstrate the ability of the photomechanics technique to provide precise measurements of in-plane displacement, and ultimately the slip between the plates.

163 (SAND–94-2970C) **Variability of the physical properties of tuff at Yucca Mountain, NV.** Boyd, P.J. (New England Research, Inc., White River Junction, VT (United States)); Martin, R.J. III; Price, R.H. Sandia National Labs., Albuquerque, NM (United States). [1994]. 9p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. (CONF-950655–7: 35. US symposium on rock mechanics, South Lake Tahoe, NV (United States),

4-7 Jun 1995). Order Number DE95009445. Source: OSTI; NTIS; INIS; GPO Dep.

Lateral and vertical variabilities in the bulk and mechanical properties of silicic volcanic tuff at the potential nuclear waste repository site in Yucca Mountain, NV have been evaluated. Laboratory measurements have been performed on tuff specimens recovered from boreholes located to support the design of the Exploratory Studies Facility/North Ramp. The data include dry and saturated bulk densities, average grain density, porosity, compressional and shear wave velocities, elastic moduli, and compressional and tensional fracture strengths. Data from eight boreholes aligned in a northwest-southeast direction have been collected under the required quality assurance program. Three boreholes have penetrated the potential repository horizon. The information collected provides for an accurate appraisal of the variability of rock properties in the vicinity of the boreholes. As expected, there is substantial variability in the bulk and mechanical properties of the tuff with depth (lithology). This is due to variations in gross characteristics of the tuffs (e.g., cooling units, mode of deposition, etc.), as well as smaller scale features (welding, porosity, and internal structures) that have developed as a result of depositional and post-depositional mechanisms. An evaluation of the lateral variability in bulk and mechanical properties is somewhat limited, at this time, due to a lack of borehole control to the north and south (parallel to the depositional flow direction). Initial observations indicate that there is minimal lateral variability within lithologic units. There are observable differences however, that can be related to variability in specific properties (e.g., porosity, and internal structures).

164 A preliminary total-system performance assessment for the potential repository site Yucca Mountain. Wilson, M.L. (Sandia National Labs., Albuquerque, NM (United States)); Barnard, R.W.; Dockerey, H.A.; Gauthier, J.H. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 45-72 (1994).

Special issue Yucca Mountain.

We present a preliminary performance assessment of Yucca Mountain, Nevada, U.S.A., as a potential site for a radioactive-waste repository. Models and results are discussed for four basic categories of processes and events: groundwater flow and aqueous transport, gas flow and gaseous transport, human intrusion, and basaltic volcanism. Calculated releases of radioactivity to the accessible environment are compared with U.S. Environmental Protection Agency requirements. The preliminary results show releases from human intrusion and volcanisms to fall well below the regulatory limits, though not all aspects of those categories have yet been considered. Calculated releases for nominal gaseous transport (of $^{14}CO_2$) are closest to the limits, indicating that models and data relating to gaseous releases may need to receive higher priority. (author) 15 figs., 33 refs.

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165 Modeling of strongly heat-driven flow processes at a potential high-level nuclear waste repository at Yucca Mountain, Nevada. Pruess, K. (Lawrence Berkeley Lab., CA (United States)); Tsang, Y. pp. 568-575 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC03-76SF00098. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Two complementary numerical models for analyzing high-level nuclear waste emplacement at Yucca Mountain have been developed. A vertical cross-sectional (X-Z) model permits a realistic representation of hydrogeologic features, such as alternating tilting layers of welded and non-welded tuffs, fault zones, and surface topography. An alternative radially symmetric (R-Z) model is more limited in its ability to describe the hydrogeology of the site, but is better suited to model heat transfer in the host rock. Our models include a comprehensive description of multiphase fluid and heat flow processes, including strong enhancements of vapor diffusion from pore-level phase change effects. The neighborhood of the repository is found to partially dry out from the waste heat. A condensation halo of large liquid saturation forms around the drying zone, from which liquid flows downward at large rates. System response to infiltration from the surface and to ventilation of mined openings is evaluated. The impact of the various flow processes on the waste isolation capabilities of the site is discussed.

166 The role of fault zone in affecting multiphase flow at Yucca Mountain. Tsang, Y.W. (Lawrence Berkeley Lab., CA (United States)); Pruess, K.; Wang, J.S.Y. pp. 660-666 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC03-76SF00098. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Within Yucca Mountain, the potential High Level Nuclear-Waste Repository site, there are large scale fault zones, most notably the Ghost Dance Fault. The effect of such high-permeability, large-scale discontinuities on the flow and transport is a question of concern in assessing the ability of the site to isolate radio-nuclides from the biosphere. In this paper, we present a numerical study to investigate the role of the fault in affecting both the liquid and gas phase flows in the natural state at Yucca Mountain prior to waste emplacement, as well as after the waste emplacement when the fluid flow is strongly heat-driven. Our study shows that if the characteristic curves of the Ghost Dance Fault obey the same relationship between saturated permeability and capillary scaling parameter, is as observed from the measured data of Yucca Mountain welded and nonwelded tuffs, Apache Leap tuffs, and Las Cruces soil, then a large saturated permeability of the Ghost Dance Fault will play little role in channeling water into the fault, or in enhancing the flow of water down the fault. However, the Fault may greatly enhance the upward gas flow after emplacement of waste. This may have implications on the transport of gaseous radio-nuclides such as C^{14}. The results of this study also focus attention on the need for field measurements of fluid flow in the fault zones.

167 Studies of the role of fault zones on fluid flow using the site-scale numerical model of Yucca Mountain. Wittwer, C.S. (Lawrence Berkeley Lab., CA (United States)); Chen, G.; Bodvarsson, G.S. pp. 667-674 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC03-76SF00098. From 10. international high-level radioactive

waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The three-dimensional grid of the site-scale model developed for the unsaturated zone at Yucca Mountain was used to perform two-dimensional simulations with the TOUGH2 computer program. The grid geometry consists of seventeen non-uniform layers which represent the lithological variations within the four main welded and non-welded hydrogeological units. The fault zones are explicitely modeled as porous medium using various assumptions regarding their permeabilities and characteristic curves. Matrix flow is approximated using the van Genuchten model, and the equivalent continuum approximation is used to account for fracture flow in the welded units. Steady state simulations are performed with various uniform infiltration rates. The results are interpreted in terms of the effect of the fault characteristics on the moisture flow distribution, and on the location and formation of preferential pathways.

168 Geohydrologic data and models of Rainier Mesa and their implications to Yucca Mountain. Wang, J.S.Y. (Lawrence Berkeley Lab., CA (United States)); Cook, N.G.W.; Wollenberg, H.A.; Carnahan, C.L.; Javandel, I.; Tsang, C.F. pp. 675-681 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC03-76SF00098. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The geohydrologic data collected at Rainier Mesa provide the only extensive observations in tunnels presently available on flow and transport in tuff units similar to those of a potential nuclear waste repository at Yucca Mountain. This information can, therefore, be of great value in planning the Exploratory Studies Facility (ESF) testing in underground drifts at Yucca Mountain. In this paper, we compare the geohydrologic characteristics of tuff units of these two sites and summarize the hydrochemical data indicating the presence of nearly meteoric water in Rainier Mesa tunnels. A simple analytic model is used to evaluate the possibility of propagating transient pulses of water along fractures or faults through the Paintbrush nonwelded tuff unit to reach the tunnel beds below. The results suggest that fast flow could occur without significant mixing between meteoric fracture water and matrix pore water. The implications of these findings on planning for the ESF Calico Hills study at Yucca Mountain are discussed.

169 An inverse procedure for estimating the unsaturated hydraulic conductivities of volcanic tuffs. Zimmerman, R.W. (Lawrence Berkeley Lab., CA (United States)); Bodvarsson, G.S.; Flint, A.L.; Flint, L.E. pp. 1052-1058 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 DOE Contract AC03-76SF00098. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

A procedure is developed for estimating the hydraulic conductivity function of unsaturated volcanic tuff, using measurements of the sorptivity and capillary pressure functions. The method assumes that the sorptivity is a linear function of the initial saturation, as is suggested by experimental data. The procedure is tested on a vitrified tuff from the Calico Hills unit at Yucca Mountain, and the predicted conductivities are in reasonable agreement with measured values. Further tests of this method are needed to establish whether or not it can be routinely used for conductivity predictions.

170 Photothermal deflection spectroscopy investigations of uranium electrochemistry - II. Rudnicki, J.D. (Lawrence Berkeley Lab., CA (United States)); Russo, R.E. pp. 431-436 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

Photothermal Deflection Spectroscopy (PDS) has been applied to the study of uranium oxide electrochemistry. PDS measures the optical absorption of the sample surface and concentration gradients formed in the electrolyte. Both of these measurements are performed in situ under dynamic conditions. The combination of these two measurements provides information that can be used to infer the mechanism of the UO_2 surface chemistry. These studies of the uranium dissolution mechanism are performed in pH 10.5 sodium sulfate electrolytes at 22°C. The electrolytes are free from oxygen, and complexing species. Our results suggest that dissolution of UO_2 can occur at oxidizing potentials as low as -300 mV vs. saturated calomel electrode (SCE). The optical absorption and concentration gradient results provide evidence for a substantial surface change that occurs at an oxidation potential of +300 mV. The results show that the surface layer formed by this change dissolves slowly by a non-electrochemical reaction.

171 Analysis of flow along anisotropic fractures in partially saturated media. Wang, J.S.Y. (Lawrence Berkeley Lab., CA (United States)); Cox, B.L. pp. 1915-1921 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Potential fast flow paths could exist along fractures and faults below washes or other localized recharge areas. When a finite amount of water percolates downward, the imbibition process will remove water from the fracture into the unsaturated tuff matrix, especially in nonwelded units with large porosity and high sorptivity. The anisotropic characteristics of a fault sample, the flow path distribution, and the matrix imbibition effect on fracture flows are analyzed. For the Paintbrush nonwelded bedded tuff unit, the saturation in the middle of a wash is higher than the values measured in boreholes on the side-slopes. The implications of calculated results for the interpretation of saturation distribution in the wash are discussed.

172 Approximating the imbibition and absorption behavior of a distribution of matrix blocks by an equivalent spherical block. Zimmerman, R.W. (Lawrence Berkeley Lab., CA (United States)); Bodvarsson, G.S. pp. 2030-2037 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC03-76SF00098. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The matrix blocks in the fractured unites at Yucca Mountain are the regions of rock material that are formed by the

sets of intersecting fractures. A theoretical study is presented of the effect of matrix block shape and matrix block size distribution on liquid inbibition and solute absorption in a fractured rock mass. It is shown that the behavior of an individual irregularly-shaped matrix block can be modeled with reasonable accuracy by using the results for a spherical matrix block, if one uses an effective radius $\bar{a} = 3V/a$, where V is the volume of the block and A is its surface area. In the early-time regime of matrix imbibition, it is shown that a collection of blocks of different sizes can be modeled by a single equivalent block, with an equivalent radius of $\langle a^{-1} \rangle^{-1}$, where the average is taken on a volumetrically-weighted basis. In an intermediate time regime, it is shown for the case where the radii are normally distributed that the equivalent radius is reasonably well approximated by the mean radius $\langle a \rangle$. In the long-time limit, where no equivalent radius can be rigorously defined, an asymptotic expression is derived for the cumulative diffusion as a function of the mean and the standard deviation of the radius distribution function.

173 **Preliminary analysis of three-dimensional moisture flow within Yucca Mountain, Nevada.** Bodvarsson, G. (Lawrence Berkeley Lab., CA (United States)); Chen, Gang; Wittwer, C. pp. 2038-2047 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC03-76SF00098. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The continuous development of the three-dimensional site-scale model of Yucca Mountain, Nevada is described. Three-dimensional moisture flow simulations are conducted, that show how the stratigraphic units and faults offsets and properties at Yucca Mountain created complex three-dimensional flow patterns. Even for areally uniform infiltration rates, these geological complexities result in large lateral flow components and often concentrated flow into the water table. When the major faults are assumed to act as capillary barriers, moisture buildup occurs close to the faults. Conversely, when the faults are assumed to readily absorb water and allow for vertical migration, lateral flow is greatly enhanced and relatively dry conditions are found in the rock matrix adjacent to the faults. These results suggest that careful observations of saturations and rock matrix conditions in rock masses near major faults may help determine the hydrological characteristics of the faults. The site-scale model has been used to predict conditions in wells UZ-16 and other wells, in order to investigate the predictive capabilities of the model. Gas flow and the geothermal gradient have been incorporated into the model.

174 **A study of two phase flow in fracture networks.** Karasaki, K. (Lawrence Berkeley Labs., CA (United States)); Pruess, K.; Vomvoris, S.; Segan, S. pp. 2633-2638 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AC03-76SF00098. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Accurate characterization of the two-phase flow behavior of the fractured rock mass is vital to the safety of a potential high level nuclear waste repository in the unsaturated, fractured welded tuff at Yucca Mountain, NV. A tool for studying the two-phase flow properties of a fracture networks was developed. It is based on a simple mechanistic model in which the capillary pressure of a fracture is a unique function of the aperture. Whether a particular fracture element is occupied by wetting fluid or non-wetting fluid is determined by allowability and accessibility criteria. Relative permeability characteristics of a simulated fracture network were investigated using the model. Different assumptions are examined regarding the interactions between phases. In all cases, strong phase interference was observed. Hysteresis effects and irreducible saturation were also explained based on the model.

175 **Phenomenological studies of two-phase flow processes for nuclear waste isolation.** Pruess, K. (Lawrence Berkeley Lab., CA (United States)); Finsterle, S.; Persoff, P.; Oldenburg, C. pp. 2639-2647 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The U.S. civilian radioactive waste management program is unique in its focus on a site in the unsaturated zone, at Yucca Mountain, Nevada. Two-phase flow phenomena can also play an important role in repositories beneath the water table where gas is generated by corrosion, hydrolysis, and biological degradation of the waste packages. An integrated program has been initiated to enhance our understanding of two-phase flow behavior in fractured rock masses. The studies include two-phase (gas-liquid) flow experiments in laboratory specimens of natural rock fractures, analysis and modeling of heterogeneity and instability effects in two-phase flow, and design and interpretation of field experiments by means of numerical simulation. We present results that identify important aspects of two-phase flow behavior on different space and time scales which are relevant to nuclear waste disposal in both unsaturated and saturated formations.

176 (LBL–35976) **Hydraulic conductivity of rock fractures.** Zimmerman, R.W.; Bodvarsson, G.S. Lawrence Berkeley Lab., CA (United States). Oct 1994. 66p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC03-76SF00098. Order Number DE95004815. Source: OSTI; NTIS; INIS; GPO Dep.

Yucca Mountain, Nevada contains numerous geological units that are highly fractured. A clear understanding of the hydraulic conductivity of fractures has been identified as an important scientific problem that must be addressed during the site characterization process. The problem of the flow of a single-phase fluid through a rough-walled rock fracture is discussed within the context of rigorous fluid mechanics. The derivation of the cubic law is given as the solution to the Navier-Stokes equations for flow between smooth, parallel plates, the only fracture geometry that is amenable to exact treatment. The various geometric and kinetic conditions that are necessary in order for the Navier-Stokes equations to be replaced by the more tractable lubrication or Hele-Shaw equations are studied and quantified. Various analytical and numerical results are reviewed pertaining to the problem of relating the effective hydraulic aperture to the statistics of the aperture distribution. These studies all lead to the conclusion that the effective hydraulic aperture is always less than the mean aperture, by a factor that depends on the

ratio of the mean value of the aperture to its standard deviation. The tortuosity effect caused by regions where the rock walls are in contact with each other is studied using the Hele-Shaw equations, leading to a simple correction factor that depends on the area fraction occupied by the contact regions. Finally, the predicted hydraulic apertures are compared to measured values for eight data sets from the literature for which aperture and conductivity data were available on the same fracture. It is found that reasonably accurate predictions of hydraulic conductivity can be made based solely on the first two moments of the aperture distribution function, and the proportion of contact area. 68 refs.

177 (LBL–36467) **Combined analysis of surface reflection imaging and vertical seismic profiling at Yucca Mountain, Nevada.** Daley, T.M. (Lawrence Berkeley Lab., CA (United States). Earth Sciences Div.); Majer, E.L.; Karageorgi, E. Lawrence Berkeley Lab., CA (United States). Aug 1994. 44p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC03-76SF00098. Order Number DE95006724. Source: OSTI; NTIS; INIS; GPO Dep.

This report presents results from surface and borehole seismic profiling performed by the Lawrence Berkeley Laboratory (LBL) on Yucca Mountain. This work was performed as part of the site characterization effort for the potential high-level nuclear waste repository. Their objective was to provide seismic imaging from the near surface (200 to 300 ft. depth) to the repository horizon and below, if possible. Among the issues addressed by this seismic imaging work are location and depth of fracturing and faulting, geologic identification of reflecting horizons, and spatial continuity of reflecting horizons. The authors believe their results are generally positive, with tome specific successes. This was the first attempt at this scale using modem seismic imaging techniques to determine geologic features on Yucca Mountain. The principle purpose of this report is to present the interpretation of the seismic reflection section in a geologic context. Three surface reflection profiles were acquired and processed as part of this study. Because of environmental concerns, all three lines were on preexisting roads. Line 1 crossed the mapped surface trace of the Ghost Dance fault and it was intended to study the dip and depth extent of the fault system. Line 2 was acquired along Drill Hole wash and was intended to help the ESF north ramp design activities. Line 3 was acquired along Yucca Crest and was designed to image geologic horizons which were thought to be less faulted along the ridge. Unfortunately, line 3 proved to have poor data quality, in part because of winds, poor field conditions and limited time. Their processing and interpretation efforts were focused on lines 1 and 2 and their associated VSP studies.

178 (LBL–36614) **Progress on flow visualization and relative permeability measurement in transparent replicas of natural fractures from Yucca Mountain.** Persoff, P. (Lawrence Berkeley Lab., CA (United States). Earth Sciences Div.); Pruess, K.; Petersen, L.P. Lawrence Berkeley Lab., CA (United States). Jan 1995. 27p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC03-76SF00098. Order Number DE95006723. Source: OSTI; NTIS; INIS; GPO Dep.

Small sections (75 mm x 75 mm) of two natural rock fractures from outcrop boulders of Tiva Canyon tuff have been reproduced as transparent replicas. Aperture maps were drawn from images of the replicas filled with dye. Apertures were measured by the areas occupied by liquid drops of known volume. For both these fractures, the average aperture is about 350 μm, while the hydraulic aperture is less (72 and 130 μm). Two-phase (air-water) flow experiments have been conducted in these replicas to measure relative permeability and capillary pressures. The results obtained confirm the results of previous fracture experiments, and theoretical analysis, that the sum of relative permeabilities is much less than 1 at intermediate saturations. The welded tuffs in the vadose zone of Yucca Mountain, Nevada, are being investigated as the potential site of a geological repository for high-level nuclear wastes.

179 **Development of a three-dimensional site-scale model for the unsaturated zone at Yucca Mountain, Nevada.** Wittwer, C.S. (Lawrence Berkeley Laboratory, Earth Sciences Div., Berkeley (United States)); Bodvarsson, G.S.; Chornack, M.P.; Flint, A.L.; Flint, L.E.; Lewis, B.D.; Spengler, R.W.; Rautmann, C.A. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 147-164 (1994).

Special issue Yucca Mountain.

A three-dimensional model of moisture flow within the highly heterogeneous, porous and fractured tuffs of the unsaturated zone at Yucca Mountain is being developed. This site-scale model covers an area of about 30 km^2 and is bounded by major faults at the east and west. A detailed numerical grid has been developed based on the locations of boreholes, on the spatial distribution of different infiltration zones, hydrogeological units and water level data, and on the offset of the volcanic tuffs due to major faults. Hydrogeologic contour-and isopachs maps, are presented for the different infiltration zones, and for the base of the Tiva Canyon, the Paintbrush, and the Topopah Spring hydrogeological units. One- and two-dimensional simulations have been performed using the TOUGH2 computer code to test the geometry and the accuracy of the model-grid, which consists of about 5000 gridblocks distributed among 17 non-uniform vertical layers representing the four main hydrogeological units of the unsaturated zone. (author) 11 figs., 1 tab., 21 refs.

180 **Accuracy and efficiency of a semi-analytical dual-porosity simulator for flow in unsaturated fractured rock masses.** Zimmerman, R.W. (Lawrence Berkeley Laboratory, Earth Sciences Div., Berkeley (United States)); Chen, G.; Bodvarsson, G. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 193-208 (1994).

Special issue Yucca Mountain.

A semi-analytical dual-porosity simulator for unsaturated flow in fractured rock masses has been developed. Fluid flow between the fracture network and the matrix blocks is described by analytical expressions that have been derived from approximate solutions to the imbibition equation. These expressions have been programmed into an unsaturated flow simulator, TOUGH, as a source/sink term. Flow processes are then simulated using only fracture elements in the computational grid. The modified code is used to simulate flow along single fractures, and infiltration into pervasively fractured formations. Comparisons are made with simulations carried out using discretization of both the fractures and matrix blocks. The new semi-analytical code is shown to be accurate, and typically requires an order of magnitude less computational time. (author) figs., tabs., refs.

181 **Technical issues relevant to hydrological performance assessment at Yucca Mountain: a hierarchial**

perspective. Narasimhan, T.N. (Lawrence Berkeley Laboratory, Earth Science Div., Berkeley (United States)); Wang, J.S.Y. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 209-229 (1994).

Special issue Yucca Mountain.

Hydrological Performance Assessment (PA) is an important component of Yucca Mountain Site Characterization Project (YMP). The goal of PA is to assess, as far quantitatively as possible, whether radioactive contaminants will be released to the groundwater and transported to the accessible environment in adverse quantities should a potential repository for high level radioactive wastes (HLW) be constructed and operated at Yucca Mountain. Ideally, it would be desirable to demonstrate with certitude, using scientific data, that the wastes could be safely contained at the site over a 10,000-year time frame. Nevertheless, the scientific issues involved are many and the necessary data cannot be gathered and interpreted over the next several years to answer all the questions. Yet, available evidence suggests that the site has many attributes favorable for long-term containment of high level radioactive wastes. Under the circumstances, phased, long-term approach to site characterization appears prudent. Integral to such an approach will be long-term data acquisition and monitoring, should construction be permitted. Considering the complex, difficult-to-access nature of earth systems, the long-term approach should provide for an open-endedness to accommodate unforeseen contingencies which may come to light during long-term monitoring. To guide data acquisition and monitoring, it is necessary to identify the various technical issues relevant to repository performance. We present these issues in a systematic, hierarchial frame-work. (author) 1 fig., 14 refs.

U.S. GEOLOGICAL SURVEY

182 The influence of seasonal climatic variability on shallow infiltration at Yucca Mountain. Hevesi, J.A. (Geological Survey, Mercury, NV (United States)); Flint, A.L. pp. 122-131 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Yucca Mountain, Nevada, is currently being evaluated as a potential location for an underground high-level nuclear waste repository, and the characterization of natural infiltration at this arid site is required. To analyze infiltration and the redistribution of moisture in alluvial deposits at Yucca Mountain, water content profiles at a 13.5 meter deep borehole were measured at monthly intervals using a neutron moisture probe. Measured profiles for the period 1/11/90 to 10/07/92 indicated increases in water content to a maximum depth of 1.8 meters in response to winter-season precipitation events, followed by a more gradual drying of the wetted zone due to evapotranspiration and possible downward percolation. Below a depth of 1.8 meters, a gradual drying trend was indicated for the entire measurement period by a small but consistent decrease in water contents throughout the profile. To analyze the influence of a longer climatic record on the water content profile, a one dimensional numerical model of unsaturated flow was calibrated to the measured water content profiles using measured daily precipitation and estimated potential evapotranspiration. The use of a 7.1 meter deep root-zone and a moisture dependent evapotranspiration function in the model provided a close agreement between the simulated and measured profiles for the 990 day calibration period. A 15 year record of daily precipitation and air temperatures at Desert Rock Airport, approximately 30 miles southeast of the study site, was used to provide a hypothetical climatic record for Yucca Mountains. Multiplying daily precipitation by factors of 0.5, 1.0, 1.5, 2.0, and 2.5 provided variations of the hypothetical record for investigating the influence of climatic variability on the moisture profile. Results indicated a maximum penetration of the simulated wetting front to a depth of 6.9 meters in response to the occurrence of two consecutive anomalously wet years.

183 The influence of long term climate change on net infiltration at Yucca Mountain, Nevada. Flint, A.L. (Geological Survey, Mercury, NV (United States)); Hevesi, J.A.; Flint, L.E. pp. 152-159 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Net infiltration and recharge at Yucca Mountain, Nevada, a potential site for a high level nuclear waste repository, are determined both by the rock properties and past and future changes in climate. A 1-dimensional model was constructed to represent a borehole being drilled through the unsaturated zone. The rock properties were matched to the lithologies expected to be encountered in the borehole. As current paleoclimate theory assumes that ^{18}O increases with wetter and cooler global climates, a past climate scenario, built on depletion of ^{18}O from ocean sediments was used as a basis for climate change over the past 700,000 years. The climate change was simulated by assigning net infiltration values as a linear function of ^{18}O. Assuming the rock properties, lithologies, and climate scenarios are correct, simulations indicated that Yucca Mountain is not in steady state equilibrium at the surface (<75 meters) when compared to measured data, but that the system could be at steady state conditions at depths of >250 meters. Based on the cyclic climate inputs, the near surface is currently in a long term drying trend (for the last 3,000 years) yet recharge into the water table is continuing to occur at an average rate equivalent to the average input rate of the climate model, indicating that conditions at depth are damped out over very long time periods. The Paintbrush Tuff nonwelded units, positioned between the Tiva Canyon and Topopah Spring welded tuff Members, do not appear to act as a capillary barrier and therefore would not perch water. The low porosity vitric caprock and basal vitrophyre of the Topopah Spring Member, however, act as restrictive layers. The higher porosity rock directly above the caprock reduces the potential for the caprock to perch water leaving the basal vitrophyre as the most likely location for perched water to develop.

184 Geophysical investigation of concealed faults near Yucca Mountain, southwest Nevada. Ponce, D.A. (Geological Survey, Menlo Park, CA (United States)). pp. 168-174 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Detailed gravity and ground magnetic data collected along surveyed traverses across Midway Valley, on the eastern flank of Yucca Mountain, Nevada reveal that these methods can be used to delineate concealed faults. These studies are part of an effort to evaluate faulting in the vicinity of the

proposed surface facilities for a potential nuclear waste repository at Yucca Mountain. The largest gravity and magnetic anomaly in the vicinity of Midway Valley is associated with the Paintbrush fault on the west flank of Alice Ridge. Geophysical data infer a vertical offset of about 200 m (650 ft). Another prominent gravity and magnetic anomaly is associated with the Bow Ridge fault in the western part of Midway Valley.

185 **Carbon isotopic data from test hole USW UZ-1, Yucca Mountain, Nevada.** Yang, I.C. (Geological Survey, Denver, CO (United States)); Peters, C.A.; Thorstenson, D.C. pp. 401-406 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Rock-CO_2-gas analyses in test hole USW UZ-1 at Yucca Mountain indicate that gas movement in the unsaturated zone is likely through a dry-fracture system with little porewater or caliche-calcite interaction. This is because near-surface $\sigma^{13}C$ values are of biogenic origin and have changed little throughout the total depth. Post-bomb ^{14}C activity is observed to the depth of about 12 m. An abrupt change in plotted ^{14}C/depth slope is seen at 61 m. The less steep upper segment corresponds to the zone with greater porosity and moisture content, and consequently more tortuosity, with an estimated traveltime of 1.27 cm/yr; the steeper sloped zone corresponding to the lower segment has smaller porosity and moisture content but larger fracture density for gas transport, with an estimated traveltime of 3.26 cm/yr.

186 **Structural character of the Ghost Dance Fault, Yucca Mountain, Nevada.** Spengler, R.W. (Geological Survey, Denver, CO (United States)); Braun, C.A.; Linden, R.M.; Martin, L.G.; Ross-Brown, D.M.; Blackburn, R.L. pp. 653-659 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Detailed structural mapping of an area that straddles the southern part of the Ghost Dance Fault has revealed the presence of several additional subparallel to anastomosing faults. These faults, mapped at a scale of 1:240, are: (1) dominantly north-trending, (2) present on both the upthrown and downthrown sides of the surface trace of the Ghost Dance fault, (3) near-vertical features that commonly offset strata down to the west by 3 to 6 m (10 to 20 ft), and (4) commonly spaced 15 to 46 m (50 to 150 ft) apart. The zone also exhibits a structural fabric, containing an abundance of northwest-trending fractures. The width of the zone appears to be at least 213 m (700 ft) near the southernmost boundary of the study area but remains unknown near the northern extent of the study area, where the width of the study area is only 183 m (600 ft).

187 **Development of 3-D lithostratigraphic and confidence models at Yucca Mountain, Nevada.** Beusch, D.C. (Geological Survey, Las Vegas, NV (United States)); Nelson, J.E.; Dickerson, R.P.; Spengler, R.W. pp. 943-948 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Computerized three-dimensional geologic models of potential high-level nuclear waste repositories such as Yucca Mountain, Nevada, are important for visualizing the complex interplay of (1) thickness and facies variations in lithostratigraphic units and (2) the disruption of these units by faults. The concept of a "model of confidence" in the lithostratigraphic model is introduced to show where data are located versus regions where interpolations are included. Models of confidence can be based on (1) expert judgment, (2) geostatistical analysis, or (3) a simplified combination of these two methods. Linking of lithostratigraphic models and models of confidence provide guidelines for future characterization and modeling activities, as well as for design and construction of the Exploratory Studies Facility.

188 **Estimation of water-filled and air-filled porosity in the unsaturated zone, Yucca Mountain, Nevada.** Nelson, P.H. (Geological Survey, Denver, CO (United States)). pp. 949-954 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Water content and porosity vary considerably within the unsaturated zone at Yucca Mountain. Measurement of these quantities has been based on core samples. A log-based approach offers the advantage of in-situ measurements, continuous throughout the borehole. This paper describes an algorithm which determines the air-filled and water-filled porosities from density and dielectric logs. The responses of density and dielectric logs are formulated in terms of the matrix properties, air-filled porosity and water-filled porosity. Porosity values obtained from logs from borehole USW G-2 are in reasonable agreement with estimates from core determinations.

189 **Effects of core sealing methods on the preservation of pore water.** Striffler, P. (Geological Survey, Denver, CO (United States)); Peters, C.A. pp. 960-966 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Five general core sealing methods (using Protecore, Lexan, wax, Protecore with wax, and Protecore with Lexan) were studied over a two year period to determine their moisture retention capabilities. Results indicate that the multibarrier methods (Protecore with wax and Protecore with Lexan) and the single barrier methods (Protecore and wax) provide successful means of retaining moisture in cores. Additional testing indicated that a tight wrap of Saran is effective in: (1) protecting the outer vapor barriers from puncture, (2) containing any condensate in close proximity to where it was condensed, and (3) retarding condensation. Tests conducted to determine the moisture adsorption potential of wax and the use of applying a positive or negative pressure to Protecore packets proved inconclusive, but warrant further investigation. The importance of proper and timely handling of core samples in the field, including refrigeration and weighing of samples, can not be overstated.

190 **Integrated geology and preliminary cross section along the north ramp of the exploratory studies facility, Yucca Mountain.** Buesch, D.C. (Geological Survey, Las Vegas, NV (United States)); Dickerson, R.P.; Drake,

R.M.; Spengler, R.W. pp. 1055-1065 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The Exploratory Studies Facility is a major part of the site characterization activities at Yucca Mountain, Nevada, and the north ramp is the first phase of construction. The N61W trending north ramp will transect the Bow Ridge and Drill Hole Wash faults and numerous minor faults, and traverses two thick welded tuffs and several nonwelded tuff units. A preliminary cross section along the north ramp was created by integration of geologic map relations, lithostratigraphic data from core collected from boreholes, and surface and borehole geophysical data. The Bow Ridge fault is a west-dipping normal fault with about 410 feet of dip-slip separation. East-dipping strata in the hanging wall adjacent to the fault is contrary to early structural interpretations. West of the Bow Ridge fault the ramp might traverse about 220 ± 65 feet of nonlithified tuffaceous material. Geometry of the Drill Hole Wash fault is not known, but is modeled in part as two strands that juxtapose different thicknesses and facies of formations with a complex sense of movement.

191 Oil and gas exploration near Yucca Mountain, southern Nevada. Grow, J.A. (Geological Survey, Denver, CO (United States)); Barker, C.E.; Harris, A.G. pp. 1298-1315 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Three oil exploration wells were drilled within 20 km of Yucca Mountain in 1991. Conodont samples from two of these new wells and 190 locations near Yucca Mountain and have been analyzed for color alteration indices (CAI), which can be correlated to thermal maturity and petroleum generation. Cambrian through Triassic rocks in the vicinity of Yucca Mountain have experienced temperatures too high to be capable of generating oil, except for a narrow zone (20 x 100 km) northeast of Yucca Mountain, where Mississippian through Triassic rocks are just within the upper limit of the oil generating window. Organic geochemical samples from the Mississippian Eleana Formation in this zone have low total organic carbon and low hydrogen indices, which, combined with overall pattern of CAI values, indicates that the entire Cambrian through Triassic sedimentary column is unfavorable as oil source rocks. While much of the Cambrian through Triassic rocks have thermal potential for gas, extensive Late Tertiary faulting at Yucca Mountain suggest that seals might be inadequate for retaining gas. No commercial gas fields have been found to date in Nevada or adjacent parts of California. Organic geochemistry on samples from a few Tertiary lacustrine deposits do show high carbon and hydrogen indices. However, the lacustrine deposits in these basin and range type valleys lack long range continuity and none of the present Nevada oil fields produce from such Tertiary valley-fill.

192 Isotopic tracers of gold deposition in paleozoic limestones, southern Nevada. Peterman, Z.E. (Geological Survey, Denver, CO (United States)); Widmann, B.L.; Marshall, B.D.; Aleinikoff, J.N.; Futa, K.; Mahan, S.A. pp. 1316-1323 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Strontium isotopic analyses of barren and mineralized Paleozoic carbonate rocks show that hydrothermal fluids added radiogenic strontium (^{87}Sr) to the mineralized zones. At Bare Mountain, samples collected from mineralized areas have $\delta^{87}Sr_t$ values (per mil deviation from primary marine values) ranging from +3.0 to +23.0 (mean of this log-normal distribution is +7.0), whereas unmineralized carbonate rocks have $\delta^{87}Sr_t$ values of -0.6 to +2.9 (mean of +1.07±1.03). In other ranges (Striped Hills, Spring Mountains, and ranges in the vicinity of Indian Springs Valley), $\delta^{87}Sr_t$ values of the unmineralized carbonate rocks are even lower and virtually indistinguishable from primary marine values. This correlation of elevated $\delta^{87}Sr_t$ values with mineralized zones provides a useful technique for assessing the mineral potential of the Paleozoic basement beneath Yucca Mountain, and may find broader use in mineral exploration in the Basin and Range province as a whole.

193 Ground-water recharge in Fortymile Wash near Yucca Mountain, Nevada, 1992-93. Savard, C.S. (Geological Survey, Mercury, NV (United States)). pp. 1805-1813 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Ground-water recharge occurred after five separate streamflow event periods in the Pah Canyon area of Fortymile Wash approximately 10 kilometers from Yucca Mountain, Nevada during 1992-93. Ground-water levels rose in two wells, UE-29 a No.1 and UE-29 a No.2, and one neutron-access borehole, UE-29 UZN-91, after each streamflow event period. A maximum rise of 2.9 meters occurred at UE-29 a No.1 thirteen days after the largest streamflow event where depth to water changed from 27.3 to 24.4 meters. Water levels fluctuated 3.89 meters in UE-29 a No.1, 2.92 meters in UE-29 a No.2, and 2.10 meters in UE-29 UZN-91 during the period January, 1992 to September, 1993. During two of the streamflow event periods, one in 1992 and one in 1993, there was flow around the neutron-access borehole located in the Fortymile Wash channel. Three other streamflow event periods were documented in Pah Canyon Wash but the streamflow infiltrated prior to reaching the neutron-access borehole location. Volumetric-water-content profiles were measured periodically in the neutron-access borehole. After the 1992 streamflow event period, water content increased in the upper six meters of the unsaturated zone. After the 1993 streamflow event period, water content increased in the entire unsaturated section, approximately 16 meters thick at the neutron-access borehole. Water levels in the neutron-access borehole rose even when there was no apparent water movement through the unsaturated zone as inferred by changes in the volumetric-water contents. This rise is attributed to ground-water recharge from nearby infiltration of Pah Canyon Wash streamflow. A groundwater mound probably formed beneath Pah Canyon Wash and spread laterally as evidence by larger rises in water levels in UE-29 a No.1

and UE-29 a No.2, which are closer to Pah Canyon Wash than UE-29 UZN-91.

194 **Fluid inclusion studies of calcite veins from Yucca Mountain, Nevada, Tuffs: Environment of formation.** Roedder, E. (Harvard Univ., Cambridge, MA (United States)); Whelan, J.F.; Vaniman, D.T. pp. 1854-1860 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Calcite vein and vug fillings at fourth depths (130-314m), all above the present water table in USW G-1 bore hole at Yucca Mountain, Nevada, contain primary fluid inclusions with variable vapor/liquid ratios: most of these inclusions are either full of liquid or full of vapor. The liquid-filled inclusions show that most of the host calcite crystallized from fluids at <100°C. The vapor-filled inclusions provide evidence that a separate vapor phase was present in the fluid during crystallization. Studies of these vapor-filled inclusions on the microscope crushing stage were interpreted in an earlier paper as indicating trapping of an air-water-CO_2 vapor phase at "100°C". Our new studies reveal the additional presence of major methane in the vapor-filled inclusion, indicating even lower temperatures of trapping, perhaps at near-surface temperatures. They also show that the host calcite crystals grew from a flowing film of water on the walls of fractures open to the atmosphere, the vapor-filled inclusions representing bubbles that exsolved from this film onto the crystal surface.

195 **Evidence for a welded tuff in the rhyolite of Calico Hills.** Dickerson, R.P. (Science Applications International Corp., Golden, CO (United States)); Hunter, W.C. pp. 1861-1868 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A welded pyroclastic deposit has been identified in the Rhyolite of Calico Hills near Yucca Mountain, Nevada, where only lava flows and nonwelded pyroclastic deposits were previously described. Field data from Fortymile Wash show that nonwelded, bedded tuff grades upward into partially welded massive tuff, and thence into densely welded vitrophyre. Petrographic data show a progressive decrease in inter- and intragranular porosity and amount of vapor-phase minerals, with increasing welding. Pumice fragments are first deformed, then develop diffuse boundaries which become increasingly obscure with progressive welding. The most densely welded rock is a perlitic vitrophyre. The origin of this welded tuff is not clear, as it could represent an ignimbrite or a tuff fused beneath a thick lava flow.

196 **Petrographic and geochemical characteristics of a section through the Tiva Canyon Tuff at Antler Ridge, Yucca Mountain, Nevada.** Singer, F.R. (Science Applications International Corp., Golden, CO (United States)); Widmann, B.L.; Dickerson, R.P.; Byers, F.M. Jr. pp. 1869-1879 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The Tiva Canyon Tuff of the Paintbrush Group of Miocene age caps much of Yucca Mountain, Nevada and is a compositionally zoned, compound cooling, pyroclastic flow that ranges from a dominantly high-silica rhyolitic base to a quartz-latitic caprock. Petrographic and geochemical studies have focused on rigorously defining the internal stratigraphy of this unit to support the detailed mapping of the Ghost Dance fault and other structures in the central fault block of Yucca Mountain. This study shows that devitrification textures and vapor phase mineralogy, in addition to other physical attributes such as pumice variability (flattening) and crystal content, can be used as distinguishing criteria to better define lithologic zones within the Tiva Canyon Tuff. In addition, the study also shows that the petrographic textures and chemistry of the groundmass vary systematically within recognizable lithologic zones and may be used to characterize and vertically divide litho-stratigraphic zones within the Tiva Canyon Tuff.

197 **Observations of water movement in a block of fractured welded tuff.** Thamir, F. (Geological Survey, Denver, CO (United States)); Kwicklis, E.M.; Hampson, D.; Anderton, S. pp. 2020-2029 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A laboratory water infiltration experiment through a block of fractured, moderately welded volcanic tuff was conducted at different boundary pressures. The block measured 47.5 cm long × 54.3 cm wide × 80.6 cm high. The purpose of the experiment was: (a) to test an instrumentation scheme for a field test, and (b) to make flow measurements through a fractured network at different boundary pressures to understand mechanisms that affect fracture flow. The upper boundary water pressure was decreased in steps; each step lasted several weeks where the pressure was kept steady. Water inflow and outflow rates were measured for each boundary condition. Entrapped air was found to impede water movement. The gas phase in the fracture network was found to not be continuous; its pressure within the network was not known. The matric potential values could not be measured with tensionmeters alone since a known gas pressure is required. Long-term input and output flow rates were equal. Outflow rate did not stabilize during the test period; it continued to decrease, even when the upper boundary water pressure was kept steady. No relation between boundary pressure and flow rate was established. Bacteria, which was found in the outflow, possibly caused variations in the behavior. Trapped air caused the outflow to periodically decrease or stop; however, outflow rates following the interruptions did not change long-term trends.

198 **A borehole instrumentation program for characterization of unsaturated-zone percolation.** Kume, J. (Geological Survey, Denver, CO (United States)); Rousseau, J.P. pp. 2076-2083 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A borehole instrumentation and monitoring program has been designed by the U.S. Geological Survey to support site characterization of unsaturated-zone percolation at Yucca Mountain, Nye County, Nevada. This program provides a means of defining the unsaturated-zone fluid flow (liquid and gas) potential field in a setting that incorporates large-scale stratigraphic and structural features, and the influences of geothermal heat flow and atmospheric pressure changes. Data derived from this program will be used to evaluate the suitability of Yucca Mountain as a mined geologic-repository for the storage of high-level, radioactive waste. These data include in-situ temperature, pneumatic pressure, and water potential. In addition, the instrumentation program provides facilities for gas-sampling, gas-tracer diffusion testing, water-injection testing, water-level monitoring, neutron moisture-meter monitoring, temperature profiling, and in-situ recalibration of the downhole sensors. The program included testing and development of: (1) precision sensors for measurement, (2) a downhole instrumentation-station-apparatus to hose the sensors, recalibrate sensors in-situ, and allow access to instrument stations for other testing purposes, and (3) surface-based support and instrumentation facilities.

199 **Evaluation of a 6-wire thermocouple psychrometer for determination of in-situ water potentials.** Loskot, C.L. (Geological Survey, Denver, CO (United States)); Rousseau, J.P.; Kurzmack, M.A. pp. 2084-2091 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A 6-wire, Peltier-type thermocouple psychrometer was designed and evaluated by the U.S. Geological Survey for monitoring in-situ water potentials in dry-drilled boreholes in the unsaturated zone at Yucca Mountain, Nye County, Nevada. The psychrometer consists of a wet-bulb, chromel-constantan, sensing junction and a separate dry-bulb, copper-constantan, reference junction. Two additional reference junctions are formed where the chromel and constantan wires of the wet-bulb sensing junction are soldered to separate, paired, copper, lead wires. In contrast, in the standard 3-wire thermocouple psychrometer, both the wet bulb and dry bulb share a common wire. The new design has resulted in a psychrometer that has an expanded range and greater reliability, sensitivity, and accuracy compared to the standard model.

200 **Hydrologic property alterations due to elevated temperatures at Yucca Mountain.** Flint, A.L. (Geological Survey, Mercury, NV (United States)); Nash, M.H.; Nash, M.S. pp. 2101-2105 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Drying experiments were conducted on fifty core samples of welded tuff and fifty core samples of zeolitic, nonwelded tuff. Initially, all core samples were vacuum saturated, and weights and volumes were measured. The samples were dried in a relative humidity oven at 60 degrees C and 45 percent relative humidity. Sorptivity was measured to obtain information on flow properties. The samples from each type of tuff were divided into five sets of ten samples with similar mean porosities. Each sample set was subjected to a different drying temperature; 60, 105, 200, 300 or 400 degrees C with the fifth group left as a control. After drying, the samples were resaturated and all the measurements repeated. Calculated porosity, particle density, and sorptivity increased; and bulk density decreased with increasing temperature. Air and water permeability increased on the nonwelded tuff samples, however air permeability was unchanged for the welded tuff. All bulk properties recovered to the original values following drying, while the flow properties (sorptivity and air and water permeability) were permanently altered. At the completion of the flow measurements, one core from each temperature treatment, was cut into small disks. Water retention curves were measured on these disks (subsamples). There were no differences in measured water retention curves due to drying at different temperatures.

201 **Late cenozoic evolution of Fortymile Ash: Major change in drainage pattern in the Yucca Mountain, Nevada region during late miocene volcanism.** Lundstrom, S.C. (Geological Survey, Las Vegas, NV (United States)); Warren, R.G. pp. 2121-2130 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Analysis of sedimentary provenance and altitude distribution of volcanic strata along Fortymile Wash, the primary desert wash east of Yucca Mountain, NV, indicates a major change in surface drainage basins related to late Miocene volcanic disruption. This event resulted in the establishment of the modern Fortymile Wash basin before 3 Ma, and probably by latest Miocene time. An understanding of this event is useful for evaluation of extensive alluviation east of Yucca Mountain and its relation to paleoclimate, hydrology and tectonics. To the northeast of Yucca Mountain, Fortymile Wash provides southward surface drainage from 60% of the area of the 11 Ma Timber Mountain caldera via Fortymile Canyon, a major breach in the caldera wall. In the southeast caldera moat, the distribution of volcanic units that predate and include the 9.4 Ma Thirsty Canyon Group and the characteristics of intercalated sediments indicate a northward paleoslope and sediment transport from a major drainage divide near Dome Mountain, a shield volcano now deeply incised by Fortymile Canyon. Eruption of the Thirsty Canyon Group from the Black Mountain area, 10 km northwest of the Timber Mountain caldera, is likely to have dammed a counterclockwise drainage system of the east moat. Following drainage disruption, the east moat filled with sediment up to the level of a new southward outlet at the saddle between Dome Mountain and the onlapping rhyolite of Shoshone Mountain. An older canyon south of this saddle received the overflow from the east moat and became the throughgoing Fortymile Canyon, integrating the east moat basin with a lower base level in Jackass Flats. Well-integrated southward drainage existed by the time the trachybasalt flows of Buckboard Mesa (2.8 Ma) were emplaced, because basal elevations of these flows slope southward about 100 m above modern Fortymile Wash.

202 **A gas sampling system for withdrawing humid gases from deep boreholes.** Rousseau, J.P. (Geological Survey, Denver, CO (United States)); Thordarson, W.; Kurzmack, M.A. pp. 2139-2145 of High Level Radioactive Waste Management: Proceedings of the fifth annual international

conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A gas sampling system, designed to withdraw nearly vapor-saturated gases (93 to 100% relative humidity) from deep, unsaturated zone boreholes, was developed by the U.S. Geological Survey for use in the unsaturated zone borehole instrumentation and monitoring program at Yucca Mountain, Nye County, Nevada. This gas sampling system will be used to: (1) sample formation rock gases in support of the unsaturated zone hydrochemical characterization program; and (2) verify downhole, thermocouple psychrometer measurements of water potential in support of the unsaturated zone borehole instrumentation and monitoring program. Using this sampling system, nearly vapor-saturated formation rock-gases can be withdrawn from deep boreholes without condensing water vapor in the sampling tubes, and fractionating heavy isotopes of oxygen, hydrogen, and carbon. The sampling system described in this paper uses a dry carrier-gas (nitrogen) to lower the dew point temperature of the formation rock-gas at its source. Mixing of the dry carrier gas with the source gas takes place inside a specially designed downhole instrument station apparatus (DISA). Nitrogen inflow is regulated in a manner that lowers the dew point temperature of the source gas to a temperature that is colder than the coldest temperature that the mixed gas will experience in moving from warmer, deeper depths, to colder, shallower depths near the land surface. A test of this gas sampling system was conducted in December, 1992, in a 12.2 meter deep borehole that was instrumented in October, 1991. The water potential calculated using this system reproduced in-situ measurements of water potential to within five percent of the average value, as recorded by two thermocouple psychrometers that had been in operation for over 12 months.

203 Gravity and magnetic investigations of Yucca Wash, southwest Nevada. Langenheim, V.E. (Geological Survey, Menlo Park, CA (United States)); Ponce, D.A. pp. 2272-2278 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Gravity and ground magnetic data collected across Yucca Wash do not indicate major vertical offsets along the inferred Yucca Wash fault. A 300- to 600-nT magnetic high whose source is buried at shallow depth coincides geographically with the relatively abrupt change in the elevation of the water table north of a proposed high-level radioactive waste repository site at Yucca Mountain.

204 Shallow infiltration processes in arid watersheds at Yucca Mountain, Nevada. Flint, L.E. (Geological Survey, Mercury, NV (United States)); Flint, A.L.; Hevesi, J.A. pp. 2315-2322 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A conceptual model of shallow infiltration processes at Yucca Mountain, Nevada, was developed for use in hydrologic flow models to characterize net infiltration (the penetration of the wetting front below the zone influenced by evapotranspiration). The model categorizes the surface of the site into four infiltration zones. These zones were identified as ridgetops, sideslopes, terraces, and active channels on the basis of water-content changes with depth and time. The maximum depth of measured water-content change at a specific site is a function of surface storage capacity, the timing and magnitude of precipitation, evapotranspiration, and the degree of saturation of surficial materials overlying fractured bedrock. Measured water-content profiles for the four zones indicated that the potential for net infiltration is higher when evapotranspiration is low (i.e. winter, cloudy periods), where surface concentration of water is likely to occur (i.e. depressions, channels), where surface storage capacity is low, and where fractured bedrock is close to the surface.

205 Verification of a 1-dimensional model for predicting shallow infiltration at Yucca Mountain. Hevesi, J. (Geological Survey, Mercury, NV (United States)); Flint, A.L.; Flint, L.E. pp. 2323-2332 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A characterization of net infiltration rates is needed for site-scale evaluation of groundwater flow at Yucca Mountain, Nevada. Shallow infiltration caused by precipitation may be a potential source of net infiltration. A 1-dimensional finite difference model of shallow infiltration with a moisture-dependent evapotranspiration function and a hypothetical root-zone was calibrated and verified using measured water content profiles, measured precipitation, and estimated potential evapotranspiration. Monthly water content profiles obtained from January 1990 through October 1993 were measured by geophysical logging of 3 boreholes located in the alluvium channel of Pagany Wash on Yucca Mountain. The profiles indicated seasonal wetting and drying of the alluvium in response to winter season precipitation and summer season evapotranspiration above a depth of 2.5 meters. A gradual drying trend below a depth of 2.5 meters was interpreted as long-term redistribution and/or evapotranspiration following a deep infiltration event caused by runoff in Pagany Wash during 1984. An initial model, calibrated using the 1990 to 1992 record, did not provide a satisfactory prediction of water content profiles measured in 1993 following a relatively wet winter season. A recalibrated model using a modified, seasonally-dependent evapotranspiration function provided an improved fit to the total record. The new model provided a satisfactory verification using water content changes measured at a distance of 6 meters from the calibration site, but was less satisfactory in predicting changes at a distance of 18 meters.

206 Simulation of flow in the unsaturated zone beneath Pagany Wash, Yucca Mountain. Kwicklis, E.M. (Geological Survey, Lakewood, CO (United States)); Healy, R.W.; Flint, A.L. pp. 2341-2351 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A one-dimensional numerical model was created to simulate water movement beneath Pagany Wash, Yucca Mountain, Nevada. Model stratigraphy and properties were based on data obtained from boreholes UE-25 UZ No. 4

and UE-25 UZ No. 5, which was drilled in the alluvial channel and bedrock sideslope of Pagany Wash. Although unable to account for multidimensional or preferential flowpaths beneath the wash, the model proved a useful conceptual tool with which to develop hypotheses and, in some cases, provide bounding calculations. The model indicated that liquid flux decreases with depth in the upper 120 m beneath the wash, with fluxes of several tens mm/yr in the nonwelded base of the Tiva Canyon Member and fluxes on the order of a tenth mm/yr in the upper Topopah Spring Member. Capillary barrier effects were indicated by the model to significantly delay the entry of large fluxes into the potential repository horizon during periods of increasing net infiltration, and to inhibit rapid drainage of water from the nonwelded and bedded intervals into the potential repository horizon during periods of moisture redistribution. Lateral moisture redistribution can be expected to be promoted by these effects.

207 Spatial distribution of potential near surface moisture flux at Yucca Mountain. Flint, A.L. (Geologic Survey, Mercury, NV (United States)); Flint, L.E. pp. 2352-2358 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

An estimate of the areal distribution of present-day surface liquid moisture flux at Yucca Mountain was made using field measured water contents and laboratory measured rock properties. Using available data for physical and hydrologic properties (porosity, saturated hydraulic conductivity, moisture retention functions) of the volcanic rocks, surface lithologic units that are hydrologically similar were delineated. Moisture retention and relative permeability functions were assigned to each surface unit based on the similarity of the mean porosity and saturated hydraulic conductivity of the surface unit to laboratory samples of the same lithology. The potential flux into the mountain was estimated for each surface hydrologic unit using the mean saturated hydraulic conductivity for each unit and assuming all matrix flow. Using measured moisture profiles for each of the surface units, estimates were made of the depth at which seasonal fluctuations diminish and steady state downward flux conditions are likely to exist. The hydrologic properties at that depth were used with the current relative saturation of the tuff, to estimate flux as the unsaturated hydraulic conductivity. This method assumes a unit gradient. The range in estimated flux was 0.02 mm/yr for the welded Tiva Canyon to 13.4 mm/yr for the nonwelded Paintbrush Tuff. The areally averaged flux was 1.4 mm/yr. The major zones of high flux occur to the north of the potential repository boundary where the nonwelded tuffs are exposed in the major drainages.

208 The Sundance fault: A newly recognized shear zone at Yucca Mountain, Nevada. Spengler, R.W. (Geological Survey, Denver, CO (United States)); Braun, C.A.; Martin, L.G.; Weisenberg, C.W. pp. 2359-2366 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Ongoing detailed mapping at a scale of 1:240 of structural features within the potential repository area indicates the presence of several previously unrecognized structural features. Minor north-trending west-side-down faults occur east and west of the Ghost Dance fault and suggest a total width of the Ghost Dance fault system of nearly 366 m (1200 ft). A zone of near-vertical N30°-40° W-trending faults, at least 274 m (900 ft) wide, has been identified in the northern part of our study area and may traverse across the potential repository area. On the basis of a preliminary analysis of available data, we propose to name this zone the "Sundance fault system" and the dominant structure, occurring near the middle of the zone, the "Sundance fault". Some field relations suggest left-stepping deflections of north-trending faults along a pre-existing northwest-trending structural fabric. Other field observations suggest that the "Sundance fault system" offsets the Ghost Dance fault system in an apparent right lateral sense by at least 52 m (170 ft). Additional detailed field studies are needed to better understand structural complexities at Yucca Mountain.

209 Structural character of the northern segment of the Paintbrush Canyon fault, Yucca Mountain, Nevada. Dickerson, R.P. (Science Applications International Corp., Golden, CO (United States)); Spengler, R.W. pp. 2367-2372 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Detailed mapping of exposed features along the northern part of the Paintbrush Canyon fault was initiated to aid in construction of the computer-assisted three-dimensional lithostratigraphic model of Yucca Mountain, to contribute to kinematic reconstruction of the tectonic history of the Paintbrush Canyon fault, and to assist in the interpretation of geophysical data from Midway Valley. Yucca Mountain is segmented into relatively intact blocks of east-dipping Miocene volcanic strata, bounded by north-striking, west-dipping high-angle normal faults. The Paintbrush Canyon fault, representing the easternmost block-bounding normal fault, separates Fran Ridge from Midway Valley and continues northward across Yucca Wash to at least the southern margin of the Timber Mountain Caldera complex. South of Yucca Wash, the Paintbrush Canyon Fault is largely concealed beneath thick Quaternary deposits. Bedrock exposures to the north reveal a complex fault, zone, displaying local north- and west-trending grabens, and rhombic pull-apart features. The fault scarp, discontinuously exposed along a mapped length of 8 km north of Yucca Wash, dips westward by 41° to 74°. Maximum vertical offset of the Rhyolite of Comb Peak along the fault measures about 210 m in Paintbrush Canyon and, on the basis of drill hole information, vertical offset of the Topopoah Spring Tuff is about 360 m near the northern part of Fran Ridge. Observed displacement along the fault in Paintbrush Canyon is down to the west with a component of left-lateral oblique slip. Unlike previously proposed tectonic models, strata adjacent to the fault dip to the east. Quaternary deposits do not appear displaced along the fault scarp north of Yucca Wash, but are displaced in trenches south of Yucca Wash.

210 Preliminary results of paleoseismic investigations of Quaternary faults on eastern Yucca Mountain, Nye County, Nevada. Menges, C.M. (Geological Survey, Denver, CO (United States)); Oswald, J.A.; Coe, J.A.; Whitney, J.W.; Swan, F.H.; Wesling, J.R.; Thomas, A.P. pp. 2373-2390 of High Level Radioactive Waste Management:

Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Site characterization of the potential nuclear waste repository at Yucca Mountain, Nevada, requires detailed knowledge of the displacement histories of nearby Quaternary faults. Ongoing paleoseismic studies provide data on the amount and rates of Quaternary activity on the Paintbrush Canyon, Bow Ridge, and Stagecoach Road faults along the eastern margin of the mountain over varying time spans of 0-700 ka to perhaps 0-30 ka, depending on the site. Preliminary stratigraphic interpretations of deposits and deformation at many logged trenches and natural exposures indicate that each of these faults have experienced from 3 to 8 surface-rupturing earthquakes associated with variable dip-slip displacements per event ranging from 5 to 115 cm, and commonly in the range of 20 to 85 cm. Cumulative dip-slip offsets of units with broadly assigned ages of 100-200 ka are typically less than 200 cm, although accounting for the effects of possible left normal-oblique slip could increase these displacements by factors of 1.1 to 1.7. Current age constraints indicate recurrence intervals of 10^4 to 10^5 years (commonly between 30 and 80 k.y.) and slip rates of 0.001 to 0.08 mm/yr (typically 0.01-0.02 mm/yr). Based on available timing data, the ages of the most recent ruptures among the faults; they appear younger on the Stagecoach Road Fault (~ 5.20 ka) relative to the southern Paintbrush Canyon and Bow Ridge faults (~ 30-100 ka).

211 Preliminary U-series disequilibrium and thermoluminescence ages of surficial deposits and paleosols associated with Quaternary faults, eastern Yucca Mountain. Paces, J.B. (Geological Survey, Denver, CO (United States)); Menges, C.M.; Bush, C.A.; Futa, K.; Millard, H.T.; Maat, P.B.; Whitney, J.W.; Widmann, B.; Wesling, J.R. pp. 2391-2401 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Geochronological control is an essential component of paleoseismic evaluation of faults in the Yucca Mountain region. New U-series disequilibrium and thermoluminescence age estimates for pedogenic deposits that bracket surface-rupture events are presented from four sites exposing the Paintbrush Canyon, Bow Ridge and Stagecoach Road faults. Ages show an internal consistency with stratigraphic relationships as well as an overall concordancy between the two independent geochronometers. Age estimates are therefore interpreted to date depositional events or episodes of pedogenic carbonate mobility that can be used to establish a paleoseismic fault chronology. Ultimately, this type of chronological information will be used to evaluate seismic hazards at Yucca Mountain.

212 Use of an analog site near Raymond, California, to develop equipment and methods for characterizing a potential high-level, nuclear waste repository site at Yucca Mountain, Nevada. Umari, A.M.J. (Geological Survey, Denver, CO (United States)); Geldon, A.; Patterson, G.; Gemmell, J.; Earle, J.; Darnell, J. pp. 2413-2422 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Yucca Mountain, Nevada, currently is being investigated by the U.S. Geological Survey as a potential site for a high-level nuclear waste repository. Planned hydraulic-stress and tracer tests in fractured, tuffaceous rocks below the water table at Yucca Mountain will require work at depths in excess of 1,300 feet. To facilitate prototype testing of equipment and methods to be used in aquifer tests at Yucca Mountain, an analog site was selected in the foothills of the Sierra Nevada near Raymond, California. Two of nine 250- to 300-feet deep wells drilled into fractured, granitic rocks at the Raymond site have been instrumented with packers, pressure transducers, and other equipment that will be used at Yucca Mountain. Aquifer tests conducted at the Raymond site to date have demonstrated a need to modify some of the equipment and methods conceived for use at Yucca Mountain.

213 A preliminary characterization of the spatial variability of precipitation at Yucca Mountain, Nevada. Hevesi, J.A. (Geological Survey, Mercury, NV (United States)); Flint, A.L.; Ambos, D.S. pp. 2520-2529 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Isohyetal maps of precipitation and numerical models for simulating precipitation are needed to help characterize natural infiltration at Yucca Mountain, Nevada. A geostatistical analysis of measured precipitation accumulated from storm periods. Precipitation was measured during a 3.8 year period from January 1990 to October, 1993 using a network of precipitation gages. A total of 34 winter-type storms and 12 summer-type storm, categorized using synoptic weather records, were analyzed using the 1st and 2nd statistical moments and sample variograms. Average standardized variograms indicated good spatial correlation for both storm types with only slight differences in the general spatial structure. Coefficients of variation and average relative variograms indicated that summer storms are characterized by greater variability as compared to winter storms. Models were fitted to the average summer and winter standarized variograms for each storm using the mean storm depth and the coefficient of variation as scaling parameters. Isohyetal maps of 4 representative storms were created using the standarized models. Results indicate that standarized models can be used to simulate the spatial distribution of precipitation depth, provided that the 1st and 2nd moments are known or can be estimated, and that identifiable deterministic trends can be included in the models. A single, fixed model representing the spatial variability of precipitation at Yucca Mountain is not recommended.

214 Molluscs as climate indicators: Preliminary stable isotope and community analysis. Sharpe, S.E. (Desert Research Institute, Reno, NV (United States)); Forester, R.M.; Whelan, J.F.; McConnaughey, T. pp. 2538-2544 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Gastropods (snails) live in many terrestrial environments where sufficient humid shelter exists to protect them from desiccation. We have found gastropods living on the mountains of southern Nevada above 1800 m, but not below, to about 2700 m, the highest elevation collected. The $\delta^{18}O$ value of terrestrial snail shells provides a way to estimate the $\delta^{18}O$ value of precipitation and from that the source of the water. Comparisons of modern and fossil snail shell $\delta^{18}O$ values provide a way to identify changes in source waters during summer, the season of active growth. Our modern snail $\delta^{18}O$ values show a rough inverse correlation with elevation suggesting that snails do record a climate signal. All modern $\delta^{18}O$ values are much higher than those from the late Pleistocene fossil record suggesting that the Pleistocene summers were variously colder and wetter than today or less evaporative (more humid). Cooler and wetter summers would be consistent with other lines of evidence including models of past global circulation.

215 Estimating past precipitation and temperature from fossil ostracodes. Smith, A.J. (Kent State Univ., OH (United States)); Forester, R.M. pp. 2545-2552 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 Grant EAR-9210832. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The fossil records of certain aquatic organisms provide a way of obtaining meaningful estimates of past temperature and precipitation. These estimates of past environmental conditions are derived from multivariate statistical methods that are in turn based on the modern biogeographic distributions and environmental tolerances of the biota of interest. These estimates are helpful in conducting slimate studies as part of the Yucca Mountain site characterization. Ostracodes are microscopic crustaceans that produce bivalved calcite shells which are easily fossilized in the sediments of the lakes and wetlands in which the animals lived. The modern biogeographic distribution and environmental conditions of living ostracodes are the basis for the interpretation of the past environmental conditions of the fossil ostracodes. The major assumption in this method of interpretation is that the environmental tolerances of ostracodes have not changed substantially over thousands of years. Two methods using these modern analogs to determine past environmental conditions are the modern analog method and the range method. The range method also considers the information provided by fossil ostracode assemblages that have no modern analog in today's world.

216 Late glacial climate estimates for southern Nevada the ostracode fossil record. Forester, R.M. (Geological Survey, Denver, CO (United States)); Smith, A.J. pp. 2553-2561 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Climate change plays an important role in determining the possible long term hydrological performance of the potential high level nuclear waste repository within Yucca Mountain, Nevada. Present-day global circulation results in this region having an arid to semi-arid climate characterized by hot and relatively dry summers. Global circulation during the late glacial (about 14 to 20 ka) was very different from the present-day. Preliminary study of late-glacial fossil ostracodes from "marsh deposits" in the upper Las Vegas Valley suggests mean annual precipitation may have been four times higher, while mean annual temperature may have been about 10°C cooler than today. A major difference between present-day and late-glacial climate was likely the existence of cooler, cloudier, and wetter summers in the past.

217 Isotopic studies of Yucca Mountain soil fluids and carbonate pedogenesis. McConnaughey, T.A. (Geological Survey, Denver, CO (United States)); Whelan, J.F.; Wickland, K.P.; Moscati, R.J. pp. 2584-2589 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Secondary carbonates occurring within the soils, faults, and subsurface fractures of Yucca Mountain contain some of the best available records of paleoclimate and paleohydrology for the potential radioactive waste repository site. This article discusses conceptual and analytical advances being made with regard to the interpretation of stable isotope data from pedogenic carbonates, specifically related to the ^{13}C content of soil CO_2, $CaCO_3$ precipitation mechanisms, and isotopic fractionations between parent fluids and precipitating carbonates. The ^{13}C content of soil carbon dioxide from Yucca Mountain and vicinity shows most of the usual patterns expected in such contexts: decreasing ^{13}C content with depth (due mainly to increased importance of respired CO_2), decreasing ^{13}C with altitude (partially due to relatively more C-3 vegetation), and reduced ^{13}C during spring (due again to higher rates of respiration, and reduced gas permeability of wet soils). These patterns exist within the domain of a noisy data set; soil and vegetational heterogeneities, weather, and other factors apparently contribute to isotopic variability in the system. Several soil calcification mechanisms appear to be important, involving characteristic physical and chemical environments and isotopic fractionations. When CO_2 loss from thin soil solutions is an important driving factor, carbonates may contain excess heavy isotopes, compared to equilibrium precipitation with soil fluids. When root calcification serves as a proton generator for plant absorption of soil nutrients, heavy isotope deficiencies are likely. Successive cycles of dissolution and reprecipitation mix and redistribute pedogenic carbonates, and tend to isotopically homogenize and equilibrate pedogenic carbonates with soil fluids.

218 Strontium isotope geochemistry of soil and playa deposits near Yucca Mountain, Nevada. Marshall, B.D. (Geological Survey, Denver, CO (United States)); Mahan, S.A. pp. 2685-2691 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The isotopic composition of strontium contained in the carbonate fractions of soils provides an excellent tracer which can be used to test models for their origin. This paper reports data on surface coatings and cements, eolian sediments, playas and alluvial fan soils which help to constrain a

model for formation of the extensive calcretes and fault infillings in the Yucca Mountain region. The playas contain carbonate with a wide range of strontium compositions; further work will be required to fully understand their possible contributions to the pedogenic carbonate system. Soils from an alluvial fan to the west of Yucca Mountain show that only small amounts of strontium are derived from a fan draining a carbonate terrane have strontium component. Although much evidence points to an eolian source for at least some of the strontium in the pedogenic carbonates near Yucca Mountain, an additional component or past variation of strontium composition in the eolian source is required to model the pedogenic carbonate system.

219 Paleoclimatic and paleohydrologic records from secondary calcite: Yucca Mountain, Nevada. Whelan, J.F. (Geological Survey, Denver, CO (United States)); Stuckless, J.S.; Moscati, R.J.; Vaniman, D.T. pp. 2738-2745 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Stable isotope analyses of calcite and opal, fluid inclusion formation conditions and gas compositions, Sr isotope ratios, and REE compositions all support formation of secondary calcite in the unsaturated zone of Yucca Mountain from infiltration of surface-derived (and soil zone buffered) waters of meteoric origin. Detailed sampling of growth-banding preserved by the secondary calcite should provide a record of past variations in the stable isotope chemistry of these infiltrating waters, and, hence, of precipitation at Yucca Mountain, i.e., a proxy of past climate at Yucca Mountain. The precision of this record depends on how well it can be dated. The distribution and texture of secondary calcite occurrences, if mapped in careful detail from existing bore hole samples and underground workings (as exposures become accessible), could provide a time/space map of fracture and fault unsaturated-zone ground water flowpaths during past wetter climates which might prevail in the future with change in climate.

220 Late glacial to modern climate near Yucca Mountain, Nevada. Forester, R.M. (Geological Survey, Denver, CO (United States)). pp. 2750-2754 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Climate plays an important role in evaluating the suitability of Yucca Mountain, Nevada, as a potential high-level nuclear waste repository. Present-day global atmospheric circulation patterns are responsible for the semi-arid climate in the southwestern USA that result in limited winter precipitation and hot, relatively dry summers. Changes in global circulation may produce dramatic climate change resulting in colder average annual air temperatures and much higher average annual precipitation. Preliminary estimates from fossil plant and animal records suggest that during the last glacial (14 to 25 ka) mean annual precipitation may have been as much as five times modern, while mean annual temperatures were 8-10°C lower than today. Such conditions may have been responsible for past percolation through the mountain recorded by the secondary carbonate and silica fracture mineralization within the unsaturated zone.

221 Characterization of a desert soil sequence at Yucca Mountain, NV. Guertal, W.R. (Foothill Engineering, Inc., Mercury, NV (United States)); Hofmann, L.L.; Hudson, D.B.; Flint, A.L. pp. 2755-2763 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Morphological descriptions, borehole geophysics, hydraulic properties from samples, and a ponding experiment were used to characterize a layered, heterogeneous, desert soil sequence at Yucca Mountain, Nevada. Nine major horizon units were identified using standard morphologic techniques and borehole geophysics. The borehole geophysical logging data correlated well with the observed horizons from the exposure and/or the corresponding washout zones. In addition, the geophysical logs provide a quantitative estimate of porosity for the horizons with porosity ranging from 25 to 55 percent. As part of an infiltration experiment, over 50,000 liters of water were applied to a 3.5 m diameter ring during a 14 day period. The final wetting depth was 5 meters. When water application was stopped, redistribution allowed water to continue downward to a maximum depth of 7.4 meters in the next several months. Water content measurements made over time indicate that the horizons had a major influence on the flow of water in the soil and may have caused over 80 percent of the water applied to move laterally.

222 Results of prototype borehole instrumentation at the Hydrologic Research Facility, area 25, NTS. Rousseau, J.P. (Geological Survey, Denver, CO (United States)); Kurzmack, M.; Greengard, A. pp. 2764-2773 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Two 12+ meter (40 feet) deep, dry-augured boreholes, located adjacent to the Hydrologic Research Facility (HRF) calibration laboratory in Area 25, Nevada Test Site (NTS), were instrumented in October, 1991, and a third in February, 1992. Four instrument stations located at depths of 3.0, 6.1, 9.1, and 12.2 meters (m) were established in each borehole in order to evaluate instrumentation that will be used in the deep unsaturated-zone borehole-instrumentation program at Yucca Mountain, Nye County, Nevada. Yucca Mountain is being evaluated as a potential site for the storage of high-level radioactive waste. The Yucca Mountain borehole-instrumentation program is designed to measure and monitor the unsaturated-zone fluid (liquid and gas) flow potential gradients and flow processes in the unsaturated-zone. To date, results of the HRF prototype borehole instrumentation program indicate that the stability and operational reliability of the sensors selected for use at Yucca Mountain will be adequate to sustain a long-term, in-situ monitoring program; one that is expected to last from three to five years. Data from the HRF borehole instrumentation experiment also indicate that sensor accuracy and precision are sufficient to measure the state variables (pneumatic pressure, temperature, vapor pressure and water potential)

needed to quantify water, water vapor, gas, and heat flux in the unsaturated zone at Yucca Mountain.

223 **Saturation levels and trends in the unsaturated zone, Yucca Mountain, Nevada.** Nelson, P.H. (Geological Survey, Denver, CO (United States)). pp. 2774-2781 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Water content and porosity within the unsaturated zone at Yucca Mountain are computered from the caliper, density, and epithermal neutron logs obtained in 15 WT-boreholes. Separation between the water content and porosity logs clearly demarcate the lithophysal zones within the Topopah Spring Member of the Paintbrush Tuff. Lithophysal and non-lithophysal zones constitute regionally correlatable intervals across the area penetrated by the WT-boreholes. Lithophysal abundance appears to be nearly zero in the lower lithophysal zone in the southernmost borehole. Total porosity increases as lithophysal abundance increases, and water saturation decreases in the zones with high lithophysal abundance. Averages of water content for two lithophysal zones in the Topopah Spring Member of the Paintbrush Tuff show that water content decreases with height above the static water level; the trends in water content versus elevation are a function of geological zone. Thus, the pore size distribution spectrum appears to be preserved in the lithophysal zones.

224 **Results of air-permeability testing in a vertical borehole at Yucca Mountain, Nevada.** LeCain, G.D. (Geological Survey, Denver, CO (United States)); Walker, J.N. pp. 2782-2788 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Air-injection testing to determine air permeabilities was conducted in borehole UE-25 UZ No.16 as part of the Yucca Mountain Surface-Based Borehole Investigations Project. Air permeabilities of the rocks tested are: (1) Tiva Canyon Member; 2.0 E-13 m^2 to 88.0 E-13 m^2; (2) Topopah Spring Member; 1.1 E-13 m^2 to 12.0 E-13 m^2. Based on the moisture observed on the downhole equipment, the borehole wall is dry down to 268.3 meters below surface level and wet below this depth. Testing above 268.3 meters showed no wellbore storage or skin effects. Tests conducted below 268.3 meters showed both wellbore storage and skin effects. Tests that forced water out of the rock exhibited a characteristic pressure drop in the arithmetic pressure plots. The stabilization pressure of the steady-state testing following this pressure drop provides an estimate of the test interval in-situ capillary pressure. Permeabilities calculated from the steady-state period following the pressure drop were less than those calculated from the transient tests, because the steady-state analysis did not account for skin effects.

225 **Applications of multi-mode imaging to multiple offset VSP data.** Balch, A.H. (Colorado School of Mines, Golden, CO (United States)); Erdemir, C.; Rousseau, J.P. pp. 2797-2803 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract AI08-92NV10874. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A multiple offset, "9-component" vertical seismic profile (VSP) has been designed in order to obtain subsurface hydro-geologic information at the Yucca Mountain, Nevada, proposed high level radioactive waste repository site. Approximately 96 closely spaced three-component geophones will be grouted in the UE-25 UZ No.16 borehole. In the vicinity of the borehole several hundred three-component seismic source locations will be occupied, and an attempt will be made to use all four once-reflected seismic modes to produce images of the reflecting horizons. Shear wave anisotropy, if present, will be detected and the parameter correlated to the presence and orientation of the fractures. Physical elastic models were used to demonstrate the viability of the concept and to develop imaging computer software. These models were also used to locate the optimum position of UE-25 UZ No.16 in order to image the Ghost Dance fault in the center of Yucca Mountain yet retain the capability to image the imbricate fault structures along the eastern flank of Yucca Mountain. A preliminary VSP, using a single 3-component wall-locking seismometer, was run in August, 1993, to establish that coherent seismic signals can be obtained at depth, and at large offset distances, in the volcanic rocks present at Yucca Mountain. This survey was run in the UE-25 UZ No.16 borehole.

226 (USGS-OFR–92-458) **Evidence of prehistoric flooding and the potential for future extreme flooding at Coyote Wash, Yucca Mountain, Nye County, Nevada.** Glancy, P.A. USDOE Nevada Operations Office, Las Vegas, NV (United States). 1994. 46p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE94018347. Source: OSTI; NTIS; INIS; GPO; GPO Dep.

Coyote Wash, an approximately 0.3-square-mile drainage on the eastern flank of Yucca Mountain, is the potential location for an exploratory shaft to evaluate the suitability of Yucca Mountain for construction of an underground repository for the storage of high-level radioactive wastes. An ongoing investigation is addressing the potential for hazards to the site and surrounding areas from flooding and related fluvial-debris movement. Unconsolidated sediments in and adjacent to the channel of North Fork Coyote Wash were examined for evidence of past floods. Trenches excavated across and along the valley bottom exposed multiple flood deposits, including debris-flow deposits containing boulders as large as 2 to 3 feet in diameter. Most of the alluvial deposition probably occurred during the late Quaternary. Deposits at the base of the deepest trench overlie bedrock and underlie stream terraces adjacent to the channel; these sediments are moderately indurated and probably were deposited during the late Pleistocene. Overlying nonindurated deposits clearly are younger and may be of Holocene age. This evidence of intense flooding during the past indicates that severe flooding and debris movement are possible in the future. Empirical estimates of large floods of the past range from 900 to 2,600 cubic feet per second from the 0.094-square-mile drainage area of North Fork Coyote Wash drainage at two proposed shaft sites. Current knowledge indicates that mixtures of water and debris are likely to flow from North Fork Coyote Wash at rates up to 2,500 cubic feet per second. South Fork Coyote Wash, which has similar basin area and hydraulic characteristics, probably will

have concurrent floods of similar magnitudes. The peak flow of the two tributaries probably would combine near the potential sites for the exploratory shaft to produce future flow of water and accompanying debris potentially as large as 5,000 cubic feet per second.

227 (USGS-OFR–92-657) **Geohydrologic data collected from shallow neutron-access boreholes and resultant-preliminary geohydrologic evaluations, Yucca Mountain area, Nye County, Nevada.** Blout, D.O. (Raytheon Services Nevada, Las Vegas, NV (United States)); Hammermeister, D.P.; Loskot, C.L.; Chornack, M.P. Geological Survey, Denver, CO (United States). 1994. 147p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95005995. Source: OSTI; NTIS; INIS; U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, MS 517, Denver Federal Center, Denver, CO 80225; GPO Dep.

In cooperation with the US Department of Energy, 74 neutron-access boreholes were drilled in and near the southwestern part of the Nevada Test Site, Nye County, Nevada. Drilling, coring, sample collection and handling, and lithologic and preliminary geohydrologic data are presented in this report. The boreholes were drilled in a combination of alluvium/colluvium, ash-flow tuff, ash-fall tuff, or bedded tuff to depths of 4.6 to 36.6 meters. Air was used as a drilling medium to minimize disturbance of the water content and water potential of drill cuttings, core, and formation rock. Drill cuttings were collected at approximately 0.6-meter intervals. Core was taken at selected intervals from the alluvium/colluvium using drive-coring methods and from tuff using rotary-coring methods. Nonwelded and bedded tuffs were continuously cored using rotary-coring methods. Gravimetric water-content and water-potential values of core generally were greater than those of corresponding drill cuttings. Gravimetric water-content, porosity, and water-potential values of samples generally decreased, and bulk density values increased, as the degree of welding increased. Grain-density values remained fairly constant with changes in the degree of welding. A high degree of spatial variability in water-content and water-potential profiles was noted in closely spaced boreholes that penetrate similar lithologic subunits and was also noted in adjacent boreholes located in different topographic positions. Variability within a thick lithologic unit usually was small. 18 refs., 21 figs., 17 tabs.

228 (USGS-OFR–93-098) **Water levels in continuously monitored wells in the Yucca Mountain Area, Nevada, 1989.** Lobmeyer, D.H.; Luckey, R.R.; O'Brien, G.M.; Burkhardt, D.J. Geological Survey, Denver, CO (United States). 1995. 173p. Sponsored by USDOE, Washington, DC (United States);Geological Survey, Reston, VA (United States). DOE Contract AI08-92NV10874. Order Number DE95007251. Source: OSTI; NTIS; INIS; GPO Dep.

Water levels have been monitored hourly in 16 wells representing 24 intervals in the Yucca Mountain area, Nevada. Water levels were monitored using pressure transducers and were recorded by data loggers. The pressure transducers were periodically calibrated by raising and lowering them in the wells. The water levels were normally measured at approximately the same time that the transducers were calibrated. Where the transducer output appeared reasonable, it was converted to water levels using the calibrations and manual water-level measurements. The amount of transducer output that was converted to water levels ranged from zero for one interval to 100 percent for one interval. Fifteen of the wells were completed in Tertiary volcanic rocks and one well was completed in Paleozoic carbonate rocks. Each well monitored from one to four depth intervals. Water-level fluctuation caused by barometric pressure changes and earth tides were observed. Transducer output is presented in graphic form and, where appropriate, water-level altitude is presented in graphical and tabular form.

229 (USGS-OFR–93-477) **Lithology, fault displacement, and origin of secondary calcium carbonate and opaline silica at Trenches 14 and 14D on the Bow Ridge Fault at Exile Hill, Nye County, Nevada.** Taylor, E.M.; Huckins, H.E. Colorado Geological Survey, Denver, CO (United States). 1995. 64p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-78ET44802. Order Number DE95006158. Source: OSTI; NTIS; INIS; GPO Dep.

Yucca Mountain, a proposed site for a high-level nuclear-waste repository, is located in southern Nevada, 20 km east of Beatty, and adjacent to the southwest comer of the Nevada Test Site (NTS) (fig. 1). Yucca Mountain is located within the Basin and Range province of the western United States. The climate is semiarid, and the flora is transitional between that of the Mojave Desert to the south and the Great Basin Desert to the north. As part of the evaluation, hydrologic conditions, especially water levels, of Yucca Mountain and vicinity during the Quaternary, and especially the past 20,000 years, are being characterized. In 1982, the US Geological Survey, in cooperation with the US Department of Energy (under interagency agreement DE-A104-78ET44802), excavated twenty-six bulldozer and backhoe trenches in the Yucca Mountain region to evaluate the nature and frequency of Quaternary faulting (Swadley and others, 1984). The trenches were oriented perpendicular to traces of suspected Quaternary faults and across projections of known bedrock faults into Quaternary deposits. Trench 14 exposes the Bow Ridge Fault on the west side of Exile Hill. Although the original purpose of the excavation of trench 14 was to evaluate the nature and frequency of Quaternary faulting on the Bow Ridge Fault, concern arose as to whether or not the nearly vertical calcium carbonate (the term "carbonate" in this study refers to calcium carbonate) and opaline silica veins in the fault zone were deposited by ascending waters (ground water). These veins resemble in gross morphology veins commonly formed by hydrothermal processes.

230 (USGS-OFR–93-540-A) **Gravity and magnetic data of Midway Valley, southwest Nevada.** Ponce, D.A. (Geological Survey, Menlo Park, CA (United States)); Langenheim, V.E.; Sikora, R.F. Geological Survey, Denver, CO (United States). 1993. 22p. Sponsored by USDOE, Washington, DC (United States);Department of the Interior, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95004229. Source: OSTI; NTIS; INIS; US Geological Survey, Open-File Reports - ESIC, Box 25425, Federal Center, Denver, CO 80225; GPO Dep.

Detailed gravity and ground magnetic data collected along five traverses across Midway Valley on the eastern flank of Yucca Mountain in southwest Nevada are described. These data were collected as part of an effort to evaluate faulting in the vicinity of proposed surface facilities for a potential nuclear waste repository at Yucca Mountain. Geophysical data show that Midway Valley is bounded by large gravity and magnetic anomalies associated with the Bow Ridge and Paintbrush Canyon faults, on the west side of Exile Hill and

on the west flank of Fran Ridge, respectively. In addition, Midway Valley itself is characterized by a number of small-amplitude anomalies that probably reflect small-scale faulting beneath Midway Valley.

231 (USGS-OFR–93-586-A) **Gravity and magnetic study of Yucca Wash, southwest Nevada.** Langenheim, V.E. (Geological Survey, Menlo Park, CA (United States)); Ponce, D.A.; Oliver, H.W.; Sikora, R.F. Geological Survey, Denver, CO (United States). 1993. 41p. Sponsored by US-DOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95004228. Source: OSTI; NTIS; INIS; US Geological Survey, Open-File Reports - ESIC, Box 25425, Federal Center, Denver, CO 80225; GPO Dep.

Gravity and ground magnetic data were collected along five traverses across and one traverse along Yucca Wash in the southwest quadrant of the Nevada Test Site. Two additional ground magnetic profiles were collected approximately 100 m to either side of the longitudinal profile. These data do not indicate major vertical offsets greater than 100 m using a density contrast of 0.2 to 0.3 g/cm^3 along the proposed Yucca Wash fault. A broad magnetic high coincides with the location of the hydrologic gradient. Density profiling, a technique used to determine the average density of small topographic features, suggests that the density of near-surface material in the vicinity of Yucca Wash is about 2.0 g/cm^3.

232 (USGS/OFR–94-303) **Water levels in wells J-11 and J-12, 1989-91, Yucca Mountain Area, Nevada.** Boucher, M.S. Geological Survey, Denver, CO (United States). 1994. 9p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95004831. Source: OSTI; NTIS; INIS; U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, MS 517, Denver Federal Center, Denver, CO 80225; GPO Dep.

Water levels have been measured in the Yucca Mountain area, Nevada, since 1981 in order to gain a better understanding of the ground-water flow system in the area. Water levels in wells J-11 and J-12 have been periodically measured using calibrated reeled steel tapes since 1989, however, calculation of water-level altitude was not possible prior to 1993 due to missing reference elevations. These elevations were determined in 1993 by the U.S. Geological Survey. During 1989-91, water-level altitudes for well J-11 ranged from 732.09 to 732.40 meters and the mean water-level altitude was 732.19 meters. During 1989-91, water-level altitudes for well J-12 ranged from 727.84 to 728.03 meters, and the mean water-level altitude was 727.95 meters.

233 (USGS-OFR–94-305) **Hydrochemical data base for the Death Valley Region, California and Nevada.** Perfect, D.L.; Faunt, C.C.; Steinkampf, W.C.; Turner, A.K. Geological Survey, Denver, CO (United States). 1995. 10p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95006175. Source: OSTI; NTIS; INIS; U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, MS 517, Denver Federal Center, Denver, CO 80225 (United States); GPO Dep.

Report includes 2 diskettes designed to run on IBM PC or compatible equipment.

Ground-water chemistry data derived from samples collected within an approximately 100,000-square-kilometer area in the Southern Great Basin have been compiled into a digital data base. The data were compiled from published reports, the U.S. Geological Survey (USGS) National Water Information System (NWIS), and previously unpublished USGS files. The data are contained in two compressed files which self-expand into Lotus (.WK1) files. The first file contains 4,738 records (4.84 megabytes) and represents the basic compilation of all identified analyses. The second file is an edited version of the first and contains 3,733 records (3.84 megabytes). Editing included the removal of duplicate records and the combining of records, when appropriate. The analyses presented are of variable quality and comprehensiveness and include no isotopic data. Of the 3,733 analyses in the edited data base, 58 percent of the major ion concentrations balance to within ±10 percent. Most of the remaining records are not sufficiently complete for a balance to be calculated.

234 (USGS-OFR–94-311) **Water levels in the Yucca Mountain Area, Nevada, 1992.** O'Brien, G.M. (Geological Survey, Denver, CO (United States)); Tucci, P.; Burkhardt, D.J. USDOE Nevada Operations Office, Las Vegas, NV (United States); Geological Survey, Denver, CO (United States). 1995. 74p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95011249. Source: OSTI; NTIS; INIS; GPO Dep.

Water levels were monitored in 27 wells in the Yucca Mountain area, Nevada, during 1992. Fourteen wells were monitored periodically, generally on a monthly basis, and 13 wells representing 21 intervals were monitored hourly. All wells monitor levels in Tertiary volcanic rocks, except one which monitors levels in Paleozoic carbonate rocks. Water levels were measured using calibrated steel tapes and pressure transducers; steel-tape measurements were corrected for mechanical stretch, thermal expansion, and borehole deviation to obtain precise water-level altitudes. Water-level altitudes in the Tertiary volcanic rocks ranged from about 728 meters above sea level east of Yucca Mountain to about 1,035 meters above sea level north of Yucca Mountain. Water-level altitudes in the well monitoring the Paleozoic carbonate rocks varied between 751 and 753 meters above sea level during 1992. Water-level fluctuations were observed at 11 wells in response to the Landers, California earthquake on June 28, 1992. All data were acquired in accordance with a quality-assurance program to support the reliability of the data.

235 (USGS/OFR–94-317) **Selected hydrologic data from Fortymile Wash in the Yucca Mountain area, Nevada, water year 1992.** Savard, C.S. Geological Survey, Denver, CO (United States). 1995. 38p. Sponsored by US-DOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95007192. Source: OSTI; NTIS; INIS; GPO Dep.

Precipitation totals of 245 and 210 mm were measured at UE-29 UZN #91 and UE-29 UZN #92 respectively, during the 1992 water year, October 1, 1991 to September 30, 1992. Approximately ninety percent of the precipitation fell during the period December 27 to April 2. Localized streamflow was generated in the Fortymile Wash drainage basin during the February 12-15, 1992 and March 31, 1992 precipitation, and infiltrated into the streambed materials. The streamflow went across the UE-29 UZN #91 neutron-access borehole location and within several meters of the UE-29 UZN #92 location. Neutron logging in these boreholes showed increases in the volumetric water content of the unsaturated alluvium and indicated streamflow infiltrated to a

depth of approximately 5 meters. The volumetric water content in the upper 5 meters then gradually decreased during the remaining part of the water year. Ground-water levels rose over one meter in wells UE-29 a#1 and UE-29 a#2, and one-half meter in neutron-access borehole LJE-29 UZN #91 following the streamflows. Water level declines of 0.5 meter in UE-29 a#1 and rises of 0.2 meter in UE-29 a#2 and 0.1 meter in UE-29 UZN #91 coincided with a June 29, 1992 earthquake at the Little Skull Mountain, located approximately 27 kilometers southeast of the wells.

236 (USGS-OFR-94-451) **Summary of lithologic logging of new and existing boreholes at Yucca Mountain, Nevada, March 1994 to June 1994.** Geslin, J.K.; Moyer, T.C. Geological Survey, Denver, CO (United States). 1995. 16p. Sponsored by Geological Survey, Reston, VA (United States);USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95009443. Source: OSTI; NTIS; INIS; GPO Dep.

This report summarizes lithologic logging of core from boreholes at Yucca Mountain, Nevada, conducted from March 1994 to June 1994. Units encountered during logging include Quaternary-Tertiary alluvium and colluvium, Tertiary Rainier Mesa Tuff, all units in the Tertiary Paintbrush Group, and Tertiary Calico Hills Formation. Logging results are presented in a table of contact depths for core from unsaturated zone neutron (UZN) boreholes and graphic lithologic logs for core from north ramp geology (NRG) boreholes.

237 (USGS/WRI-92-4016) **Preliminary hydrogeologic assessment of boreholes UE-25c No. 1, UE-25c No. 2, and UE-25c No. 3, Yucca Mountain, Nye County, Nevada.** Geldon, A.L. Geological Survey, Denver, CO (United States). 1993. 92p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95003785. Source: OSTI; NTIS; INIS; U.S. Geological Survey, Earth Science Information Center, Open File Reports Section, Box 25286, MS 517, Federal Center, Denver, CO 80225; GPO Dep.

The purpose of this report is to characterize-the hydrogeology of saturated tuffaceous rocks penetrated by boreholes UE-25c #1, UE-25c #2, and UE-25c #3. These boreholes are referred to collectively in this report as the C-holes. The C-holes were drilled to perform multiwell aquifer tests and tracer tests; they comprise the only complex of closely spaced boreholes completed in the saturated zone at Yucca Mountain. Results of lithologic and geophysical logging, fracture analyses, water-level monitoring, temperature and tracejector surveys aquifer tests, and hydrochemical sampling completed at the C-hole complex as of 1986 are assessed with respect to the regional geologic and hydrologic setting. A conceptual hydrogeological model of the Yucca Mountain area is presented to provide a context for quantitatively evaluating hydrologic tests performed at the C-hole complex as of 1985, for planning and interpreting additional hydrologic tests at the C-hole complex, and for possibly re-evaluating hydrologic tests in boreholes other than the C-holes.

238 (USGS/WRI-93-4000) **Revised potentiometric-surface map, Yucca Mountain and vicinity, Nevada.** Ervin, E.M.; Luckey, R.R.; Burkhardt, D.J. Geological Survey, Denver, CO (United States). 1994. 30p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95003786. Source: OSTI; NTIS; INIS; U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, MS 517, Denver Federal Center, Denver, CO 80225; GPO Dep.

The revised potentiometric-surface map presented in this report updates earlier maps of the Yucca Mountain area using mainly 1988 average water levels. Because of refinements in the corrections to the water-level measurements, these water levels have increased accuracy and precision over older values. The small-gradient area to the southeast of Yucca Mountain is contoured with a 0.25-meter interval and ranges in water-level altitude from 728.5 to 73 1.0 meters. Other areas with different water levels, to the north and west of Yucca Mountain, are illustrated with shaded patterns. The potentiometric surface can be divided into three regions: (1) A small-gradient area to the southeast of Yucca Mountain, which may be explained by flow through high-transmissivity rocks or low ground-water flux through the area; (2) A moderate-gradient area, on the western side of Yucca Mountain, where the water-level altitude ranges from 775 to 780 meters, and appears to be impeded by the Solitario Canyon Fault and a splay of that fault; and (3) A large-gradient area, to the north-northeast of Yucca Mountain, where water level altitude ranges from 738 to 1,035 meters, possibly as a result of a semi-perched groundwater system. Water levels from wells at Yucca Mountain were examined for yearly trends using linear least-squares regression. Data from five wells exhibited trends which were statistically significant, but some of those may be a result of slow equilibration of the water level from drilling in less permeable rocks. Adjustments for temperature and density changes in the deep wells with long fluid columns were attempted, but some of the adjusted data did not fit the surrounding data and, thus, were not used.

239 (USGS/WRI-93-4025) **Precision and accuracy of manual water-level measurements taken in the Yucca Mountain Area, Nye County, Nevada, 1988-90.** Boucher, M.S. Geological Survey, Denver, CO (United States). 1994. 18p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-92NV10874. Order Number DE95003787. Source: OSTI; NTIS; U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, MS 517, Denver Federal Center, Denver, CO 80225 (United States); GPO Dep.

Water-level measurements have been made in deep boreholes in the Yucca Mountain area, Nye County, Nevada, since 1983 in support of the US Department of Energy's Yucca Mountain Project, which is an evaluation of the area to determine its suitability as a potential storage area for high-level nuclear waste. Water-level measurements were taken either manually, using various water-level measuring equipment such as steel tapes, or they were taken continuously, using automated data recorders and pressure transducers. This report presents precision range and accuracy data established for manual water-level measurements taken in the Yucca Mountain area, 1988-1990. Precision and accuracy ranges were determined for all phases of the water-level measuring process, and overall accuracy ranges are presented.

240 **Multimode reverse time VSP imaging over complex structures at Yucca Mountain, Nye County, Nevada.** Jaramillo, H.H. (Colorado School of Mines, Golden, CO (United States)); Balch, A.H.; Erdemir, C.; Rousseau, J.P. pp. 129-132 of 1993 Technical program: Expanded abstracts with biographies. Society of Exploration Geophysicists, Tulsa, OK (United States) (1993). pp. 1448

(CONF-930901--: 63. annual meeting and international exhibition of the Society of Exploration Geophysicists (SEG), Washington, DC (United States), 26-30 Sep 1993).

With VSP (Vertical Seismic Profiling) data, variable density plots of its observed, recorded wavefield reveal little about the nearby geologic structure. Considerable structural information is contained in the reflected events, but migration or some similar procedure is needed to image the reflectors and create an interpretable display of the structure. The authors have succeeded in imaging reflectors by reverse time wave equation migration in a physical elastic model of a simple fault, and in a complex physical 2-D scale model of Yucca Mountain, Nye County, Nevada. All four modes: P-P, P-S, S-P, and S-S can be imaged. Images are generated by forward scattered as well as back scattered events. The images compare favorably with the models can demonstrate the efficacy of the technique in VSP processing and interpretation.

RELATED INFORMATION

241 **Scientific basis for nuclear waste management XVI.** Materials Research Society symposium proceedings, Volume 294. Interrante, C.G. (ed.) (Nuclear Regulatory Commission, Washington, DC (United States)); Pabalan, R.T. (ed.). 959p. Materials Research Society, Pittsburgh, PA (United States) (1993). Sponsored by USDOE, Washington, DC (United States);Nuclear Regulatory Commission, Washington, DC (United States). From 16. Materials Research Society (MRS) fall meeting; Boston, MA (United States); 30 Nov - 5 dec 1992.

One most significant aspect of this particular symposium is the focus on the scientific basis for management of nuclear waste. Engineering principles and practices are important, but this symposium focuses on the science. The extension and application of engineering "know how" to waste management problems sometimes requires a degree of understanding not normally needed to solve other engineering problems. In materials science, for example, scientific understandings important to long-term behavior may be obtained from (1) characterizations and analyses of the structure and properties of materials, (2) the recognition of advancements needed to ensure performance, and (3) improvements in methods of fabrication and processing. In addition to the materials science topics addressed here (on waste forms, engineered barrier systems, and the near-field environment), the symposium addressed various far-field topics. The proceedings are divided into the following sections: spent fuel; glass and crystalline waste forms; glass performance--mechanisms and models; cementitious materials; container alteration; microbiologically influenced corrosion; near-field interactions; natural analogues; long-term prediction for engineered barriers; performance assessment of engineered barrier systems; radionuclide chemistry and transport; and performance assessment of geological systems. Selected papers are indexed separately for inclusion in the Energy Science and Technology Database.

242 **Demonstration of a risk-based approach to high-level repository evaluation "Phase II".** Shaw, R.A.; McGuire, R.K. pp. 1-5 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

This paper describes modifications to an integrated performance assessment model which is applicable to Yucca Mountain. The areas of modification were selected based on discussions with technical experts to identify the particular technical areas where this model would benefit from strengthening. Our discussions with the experts resulted in four broad classifications in which further exploration looked particularly fruitful and promising. These four areas were waste containment, source term, thermal aspects and hydrological aspects. The basis for these modifications and the process of incorporating these modifications in the models are described.

243 **Preliminary assessment of fault rupture hazard at the Yucca Mountain Site based on expert judgement.** Coppersmith, K.J. (Geomatrix Consultants Inc., San Francisco, CA (United States)); Youngs, R.R.; Perman, R.C.; Shaw, R.A. pp. 6-13 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The judgements of seven earth science experts were elicited to quantify the uncertainties associated with the likelihood of fault displacement through the proposed repository at Yucca Mountain during the 10,000 year post-closure period. Each expert identified one or more approaches to modeling fault rupture hazard, regional tectonic models, locations of sources of fault displacement, maximum earthquake magnitudes or maximum coseismic displacement for each source, the likelihood of fault rupture through the repository, and the amount of displacement. The experts generally identified two basic approaches to assessing the hazard: first estimating the location and probability of earthquake occurrence and then the associated fault displacements; and considering only the location and probability of fault displacement directly. A wide variety of tectonic models were some level of credibility, ranging from high-angle planar faults to detachments separating strike-slip faults at depth from normal faults in the shallow crust. Recently acquired geologic data were relied on heavily to estimate the size of past displacements and their recurrence rates. Uncertainties were estimated for each component of the experts' models and the aggregated results are expressed as a probability distribution on the annual frequency of canister failure.

244 **Rainfall and net infiltration probabilities for future climate conditions at Yucca Mountain.** Long, A. (Univ. of Arizona, Tucson, AZ (United States)); Childs, S.W. pp. 112-121 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Performance assessment of repository integrity is a task rendered difficult because it requires predicting the future. This challenge has occupied many scientists who realize that the best assessments are required to maximize the probability of successful repository sitting and design. As part of a performance assessment effort directed by the EPRI, the authors have used probabilistic methods to assess the magnitude and timing of net infiltration at Yucca

Mountain. A mathematical model for net infiltration previously published incorporated a probabilistic treatment of climate, surface hydrologic processes and a mathematical model of the infiltration process. In this paper, we present the details of the climatological analysis. The precipitation model is event-based, simulating characteristics of modern rainfall near Yucca Mountain, then extending the model to most likely values for different degrees of pluvial climates. Next the precipitation event model is fed into a process-based infiltration model that considers spatial variability in parameters relevant to net infiltration of Yucca Mountain. The model predicts that average annual net infiltration at Yucca Mountain will range from a mean of about 1 mm under present climatic conditions to a mean of at least 2.4 mm under full glacial (pluvial) conditions. Considerable variations about these means are expected to occur from year-to-year.

245 **Assessment of volcanic and tectonic hazards to high level radioactive waste repositories.** Wallmann, P.C. (Golder Associates Inc., Redmond, WA (United States)); Miller, I.; Kossik, R. pp. 188-195 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Golder Associates Inc. (GAI) has developed a computer program (RIP) for performing probabilistic total system performance assessment and site characterization strategy evaluation which can be applied in an iterative manner to evaluate repository site suitability and to guide characterization activities. The performance assessment model incorporated in RIP has three basic component models: (1) waste package behavior, (2) radionuclide transport pathways, and (3) disruptive events. Classes of disruptive events are specified in RIP by (1) a disruption rate (events/yr.), (2) "event descriptors" which describe event characteristics and magnitude, and (3) the consequences associated with an event. One of the strengths of RIP is its flexibility, which allows it to evaluate different sites and conceptual models. Examples of seismic and volcanic disruptive event models constructed by GAI for Yucca Mountain are presented. Analysis of the results of these models indicates that for the simulated models, neither of these event classes significantly impacts the performance of the proposed repository over a 10,000 year time span.

246 **Groundwater impacts of foreseeable human activities on a HLW repository.** Coleman, N.M. (Nuclear Regulatory Commission, Washington, DC (United States)). pp. 261-264 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The Nuclear Regulatory Commission (NRC) staff has begun a program of Systematic Regulatory Analysis (SRA) to help ensure that all important technical issues related to the disposal of civilian, high-level nuclear wastes will be identified prior to the receipt of a license application. Large-scale groundwater withdrawals near a repository could have significant impacts on the groundwater flow system. Future large-scale withdrawals of groundwater could occur to support irrigation to growing population centers, such as Las Vegas. Various scenarios of groundwater withdrawals, along with other scenarios of future human activity, will need to be tested before evaluation of the Yucca Mountain site is complete.

247 **Diffusion of carbon dioxide through layers of the unsaturated zone at Yucca Mountain.** Ali, M.S. (North Carolina A&T State Univ., Greensboro, NC (United States)); Bardakci, T.; Ilias, S.; King, F.G. pp. 412-417 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 Contract C-66611. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The estimation of diffusive transport of gases through tuffs is important in order to assess the Yucca Mountain as an environmentally safe and acceptable repository for spent fuel and high-level radioactive waste. The purpose of this study is to provide effective diffusivity data which may be used to calculate the amount of diffusion of carbon dioxide through Yucca Mountain tuff layers to the environment. The effective diffusivity of carbon dioxide was measured for five tuff samples from different layers of the USW-G4 drillhole, which is located in the central part of the proposed repository horizon. The total depth of the USW-G4 is about 905 m. The tuff samples studied are from the following layers and depths: Vapor Phase (83.6 m), Upper Lithophysal (130.1 m), Middle Nonlithophysal (210.1 m), Lower Lithophysal (297.3 m), and Lower Nonlithophysal (356.3 m). A steady state counter-diffusion method, using gas chromatographic analysis, was used to determine the effective diffusivity of carbon dioxide through tuff samples. The effective diffusivity increases linearly with temperature between 25°C and 125°C. The effective diffusivity also increases with increasing porosity of the tuffs for all the samples studied except the Vapor Phase tuff. To provide an explanation for low diffusion coefficient of carbon dioxide of Vapor Phase tuff, further study on pore structures and pore inner-connectivity is required. From the limited data of USW-G4 drillhole, it appears that the diffusion takes place primarily in the combined Knudsen and bulk diffusion regimes.

248 **Containment barrier system performance assessment modeling.** Bullen, D.B. (Iowa State Univ., Ames, IA (United States)). pp. 470-477 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

A mathematical model to predict the cumulative failure distribution for the containment barrier system (CBS) employed in a deep geologic disposal facility is presented as a function of near-field environmental conditions. The effects of container design, areal power density, and dominant heat transfer mode on the cumulative container failure distribution are studied. This model has been employed to describe the performance of the CBS as one part of a risk-based performance assessment of the Yucca Mountain site. The model employs Weibull and exponential distributions to describe container failures. Parameter values employed in the model are based upon simple, time-dependent, mechanistic models and relevant corrosion data, which describe failure of individual components of the CBS as a function of environmental conditions. The relative importance of container design, areal power density, and dominant heat transfer mode on predicted container performance is demonstrated through comparison of the results for each container design exposed to each set of environmental conditions.

249 **Mission analysis of the Exploratory Studies Facility.** Duffy, M.A. (Battelle Memorial Institute, Columbus, OH (United States)); Mele, R.; Mozhi, T.A.; Lemeshewsky, W.A.; Truong, T. pp. 515-520 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The mission of the Exploratory Studies Facility (ESF), as interpreted from the Nuclear Waste Policy Act, can be stated succinctly as, ...to conduct subsurface exploration and testing, in support of site suitability determination and license application, in a manner that protects the environment and nuclear waste isolation capabilities of the site. The objective of the ESF mission analysis effort was to expand this general mission statement to the explicit program needs that must be fulfilled by an ESF during the site characterization program. The scope of the ESF mission analysis was limited to the specification of test requirements that must be satisfied by an ESF in support of site characterization and, if the site is determined to be suitable, license application for construction of a geologic repository. The time period covers from initiation of ESF testing through either Presidential recommendation a a geologic repository or Secretarial determination of unsuitability as a geologic repository, whichever comes first. The analysis stems from the requirements contained in the Physical System Requirements (PSR)-Dispose of Waste document and draws upon the extensive technical knowledge behind preparation of the Site Characterization Program Baseline (SCPB).

250 **Using QA classification to guide design and manage risk.** Lathrop, J. (Strategic Insights, Los Altos, CA (United States)); DeKlever, R.; Petrie, E.H. pp. 530-537 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Raytheon Services Nevada has developed a classification process based on probabilistic risk assessment, using accident/impact scenarios for each system classified. Initial classification analyses were performed for the 20 systems of Package 1A of the Exploratory Studies Facility (ESF). The analyses demonstrated a solid, defensible methodological basis for classification which minimizes the use of direct engineering judgment. They provide guidance for ESF design and risk management through the identification of: the critical characteristics of each system that need to be controlled; and the parts of the information base that most need to be further developed through performance assessment or other efforts.

251 **An assessment of coupled thermal-hydrologic-mechanical-chemical processes.** Manteufel, R.D. (Center for Nuclear Waste Regulatory Analyses, San Antonio, TX (United States)); Ahola, M.P.; Turner, D.R.; Chowdhury, A.H. pp. 576-583 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 Contract NRC-02-88-005. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

A literature review was conducted to determine the state of knowledge available in the modeling of coupled thermal (T), hydrologic (H), mechanical (M), and chemical (C) processes relevant to the design and/or performance of the proposed high-level waste (HLW) repository at Yucca Mountain, Nevada. The review focuses on identifying coupling mechanisms between individual processes, and assessing their relative importance (i.e., if the coupling is either important, potentially important or negligible). The significance of considering THMC coupled processes lies in whether or not the processes impact the design and/or performance of the repository. While some of the coupled processes are relatively well characterized, many warrant further investigation. The subjective assessment provided here is based on the current understanding of the processes and data uncertainties, and may have to be modified as new data and information emerge. A review of the state of knowledge, such as reported herein, is considered useful in identifying potential coupling mechanisms and assessing their importance.

252 **Modeling of the ventilation for emplacement drift re-entry and rock drying.** Danko, G. (Univ. of Nevada, Reno, NV (United States)); Mousset-Jones, P. pp. 590-599 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Different ventilation scenarios were analyzed for a hot repository with a 114 Kw/Acre heat load, to determine the time required to cool a drift to the point where the temperature of the air leaving the drift is at or below 51.66°C (125°F). The results show that it is possible to cool a drift for re-entry within less than three months using a high air flow rate of 94.37 m^3/s (200,000 cfm) at an inlet dry bulb temperature of 26.11°C (79°F), assuming worst-case scenarios. The continuous precooling of the drift with an air flow of 1.415 m^3/s (3,000 cfm) at the same inlet temperature has negligible effect upon drift and air temperatures, assuming dry wall conditions. However, the same precooling results in a significant reduction in the cooling time, to around one week, if a partially wet surface condition is assumed. If the moisture from the partially saturated rock around the drift is removed at a high rate by the ventilating air, assuming 10 percent equivalent wetness and using a continuous precooling air flow rate of 7.08 m^3/s (15,000 cfm) at an inlet temperature of 26.11°C (79°F), the drift will remain accessible. It is also found that cooling the air prior to entering the drift to 18.33°C (65°F) only marginally improves the required cooling time period.

253 **Discontinuities, rock deformation and fluid flow around emplacement rooms.** Yang, G. (Univ. of California, Berkeley, CA (United States)); Cook, N.G.W.; Myer, L.R. pp. 682-688 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

One of the major concerns for the design of the potential nuclear waste repository at Yucca Mountain is how to identify the fast flow paths and how to minimize the flow of the fast paths. To analyze the problem, we take two steps. First, the displacements and deformations of discontinuous rock masses around an underground excavation (emplacement room) must be determined so that increments of fracture width caused by the relaxation process can be estimated.

Second, we must identify the fast paths so that proper measures can be taken to minimize or prevent the flow. In this study, a numerical model for rock deformation, Discontinuous Deformation Analysis developed by Shi, is used to accomplish the first task. To meet the second goal, the authors utilized techniques of graph theory to search through all the possible flow paths after rock deformation and highlighted the fast ones. The identification of fast paths may also provide the information needed to minimize the flow, which could lead to potential methods to secure the repository. The simulation results of Travis et al. and some further assumptions have been based to accomplish the analysis. However, the major interest of this study is the methodology to find the fast path, not the fundamentals of vadose zone flow.

254 **Analyses of natural resources in 10 CFR Part 60 as related to inadvertent human intrusion.** Miklas, M.P. (Center for Nuclear Waste Regulatory Analyses, San Antonio, TX (United States)); Lefevre, H.E. pp. 717-723 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The purpose of this paper is to examine the intent of the regulatory language of the portions of 10 CFR Part 60 which deal with considerations of the natural resources of a proposed geologic repository for high-level radioactive wastes as they relate to inadvertent human intrusion. Four Potentially Adverse Conditions (PAC) the requirements of 10 CFR 60.21(c)(13) are shown to be related to natural resources. Groundwater is identified as a natural resource known to be present at Yucca Mountain, Nevada. For economic considerations of natural resources, the "foreseeable future" is thought to be no more than 50 years. Two of the topics addressed by the PACs, subsurface mining and drilling at a proposed repository site, are pre-site-characterization activities which must be evaluated in the context of repository performance criteria set by the US EPA standard, 40 CFR Part 191. An alternative US DOE compliance demonstration to another PAC, 10 CFR 60.122(c)(17), might be to use an "explorationist perspective" of natural resource assessment. The Commission intends for DOE to evaluate the likelihood and consequence of inadvertent human intrusion into a geologic repository as a result of exploration or exploitation of natural resources within or near a proposed high-level radioactive waste geologic repository.

255 **New directions for EPA's high-level waste standards.** Galpin, F.L. (EPA, Washington, DC (United States)); Weinstock, L.G.; Gruhlke, J.M. pp. 724-729 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

Recently enacted legislation passed by the 102nd Congress directs a significant change in the EPA's development of standards for spent fuel, high-level and transuranic wastes. The Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act (PL 102-579) reinstates the major part of EPA's 40 CFR 191 radiation standards as promulgated in 1985. It further requires that EPA promulgate a final complete standard in six months and gives the EPA a major role in overseeing the WIPP's testing, design, and operation. The Energy Policy Act (PL 102-486) prescribes a procedure for EPA to follow in setting radiation standards for the Yucca Mountain site. This process requires contracting with the National Academy of Sciences and developing standards consistent with their findings and recommendations.

256 **EEI/UWASTE oversight of the DOE Repository Program by the Repository Information Exchange Team.** Henkel, C.J. (Edison Electric Institute, Washington, DC (United States)); Supko, E.M.; Schwartz, M.H. pp. 741-746 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The Utility Nuclear Waste and Transportation Program of the Edison Electric Institute (EEI/UWASTE) has conducted reviews of the US DOE's repository program through its Repository Information Exchange Team (RIET or Team). Eight such reviews have been conducted since 1985 covering topics that include repository program management and control; repository schedule; repository budget; quality assurance; site characterization; repository licensing; environmental issues; and institutional and public information activities. The utility industry has used these repository program reviews as a forum for providing DOE's Office of Civilian Radioactive Waste Management (OCRWM) with comments on the direction of the repository program, advice for future actions regarding quality assurance activities and repository licensing, and suggestions for management and control of the Repository Program. The most significant recommendations made by the utility industry through the RIET are discussed along with any subsequent action by OCRWM in response to or subsequent to utility industry recommendations. The process used by the RIET to develop its recommendations to OCRWM regarding the repository program is also discussed.

257 **Evaluating soil moisture and hydraulic conductivity in semi-arid rangeland soils.** Whitaker, M.P.L. (Univ. of Arizona, Tucson, AZ (United States)). pp. 930-936 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 Grant I-1486-88. From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

The US DOE's Office of Civilian Radioactive Waste Management (DOE-OCRWM) Fellowship Program supports various disciplines of academic research related to the isolation of radionuclides from the biosphere. The purpose of this paper is to provide an example of a university research application in the specific discipline of hydrology and water resources (a multi-disciplinary field encompassing engineering and the earth sciences), and to discuss how this research pertains to the objectives of the DOE-OCRWM Fellowship Program. The university research application is twofold: One portion focuses on the spatial variability of soil moisture (θ) and the other section compares point measurements with small watershed estimates of hydraulic conductivity (K) in a semi-arid rangeland soil in Arizona. For soil moisture measurements collected over a range of horizontal sampling intervals, no spatial correlation was evident. This outcome is reassuring to computer modelers who have assumed no spatial correlation for soil moisture over smaller scales. In regard to hydraulic conductivity, point measurements differed significantly from small watershed estimates of hydraulic conductivity which were derived from a calibrated and verified rainfall-runoff computer model. The

estimates of saturated hydraulic conductivity (Ks) were obtained from previous computer simulations in which measured data was collected in the same research location as the present study.

258 **A formal communication process: Pathway to improved policy making.** Benson, A. (DOE, Washington, DC (United States)); Robison, A.C.; Seidler, P.E. pp. 986-994 of High Level Radioactive Waste Management: Proceedings. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1993). pp. 1115 From 10. international high-level radioactive waste management conference; Las Vegas, NV (United States); 25-29 Apr 1993.

This paper will examine the efforts made and the steps taken by the US DOE's Office of Civilian Radioactive Waste Management (DOE/OCRWM) to establish and keep open lines of communication with officials in Nye County, Nevada, the location of Yucca Mountain, the site of a proposed high-level nuclear waste repository. These efforts include creating policies and procedures for conducting oversight of the Yucca Mountain Site Characterization Project (YMP), as well as developing programs for engaging in technical studies, requests for impact assistance and financial assistance, and ensuring there's a continuous flow of information to the residents of Nevada.

259 **Scientific basis for nuclear waste management XVII.** Materials Research Society symposium proceedings, Volume 333. Barkatt, A. (ed.) (Catholic Univ. of America, Washington, DC (United States)); Van Konynenburg, R.A. (ed.). 964p. Materials Research Society, Pittsburgh, PA (United States) (1994). Sponsored by USDOE, Washington, DC (United States);Nuclear Regulatory Commission, Washington, DC (United States). From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

The 17th Materials Research Society Symposium on the Scientific Basis for Nuclear Waste Management included 17 sessions, during which 120 papers were presented by scientists from 16 countries. The nuclear waste glass overview surveyed achievements to date and identified issues requiring further research. The objectives and limitations session noted the progress that has been made in developing a scientific basis for nuclear waste management, but questioned whether regulations calling for detailed predictions over a period of 10,000 years are either necessary or capable of being satisfied. The other papers presented at the Symposium described the progress of studies in a broad array of areas of nuclear waste science and technology. These areas included radiation effects and gas generation, ceramic materials, cementitious materials, actinides spent fuel, glass processing and properties, glass leaching, dissolution and alteration, natural and ancient analogues, transuranic wastes and special topics, sorption mechanisms, repository studies, geochemistry and hydrology, containers, and backfill materials. Several novel experimental techniques were described, as well as advances in modeling. An encouraging feature of the progress in modeling is that the agreement between calculated results based on models developed, refined and tested in the US and in other countries on one hand, and experimental data on the other, shows considerable improvement. This reflects greater understanding of the mechanisms involved in the release of radionuclides from the various components of the waste repository system, including the wasteforms themselves. Selected papers are indexed separately for inclusion in the Energy Science and Technology Database.

260 **XPS and XRD studies of samples from the natural fission reactors in the Oklo uranium deposits.** Sunder, S. (Whiteshell Research Labs., Manitoba (Canada)); Miller, N.H.; Duclos, A.M. pp. 631-638 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

Mineral samples from the natural fission reactors 10 and 13 in the Oklo uranium deposits were studied using X-ray photoelectron spectroscopy (XPS) and X-ray diffraction (XRD) to gain information about the long-term behaviour of UO_2 fuel in a geological disposal vault. Two samples from reactor zone 10 (samples No. D81N-190292 and D73-88) and one sample from reactor zone 13 (sample No. SD37-S2/CD) were analysed. Low-resolution XPS spectra were recorded to determine the major elements present in the ore. High-resolution spectra were recorded to gain information about the chemical state of the elements present in the mineral samples. The samples show low values for the U^{6+}/U^{4+} ratio. The oxidation state of uranium in these samples is even lower than that in U_4O_9.The binding energies of the Pb 4f bands indicate most of the Pb is in the +2 oxidation state in these samples. The C Is band indicates the presence of organic carbon. XRD analysis shows that the main uranium-bearing phase is uraninite and lead is present mainly as galena. The significance of the results for nuclear fuel waste management is discussed.

261 **Preliminary analysis of potential chemical environments inside failed waste containers at the proposed Yucca Mountain repository.** Colten-Bradley, V. (Nuclear Regulatory Commission, Rockville, MD (United States)); Walton, J.C. pp. 755-760 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

Prediction of radionuclide release rates for high-level waste requires estimates of the rates of waste form alteration and formation of secondary minerals inside the failed canister. Unsaturated repository sites may promote development of a variety of chemical environments related to two phase (liquid/vapor) transport and temperature gradients caused by radiogenic decay. A mass balance (shell balance) approach is used to estimate the effects of dripping water, evaporation, and condensation on the waste canister and the presence of saline water inside the failed waste canister. The simplified calculations predict large variability of water chemistry over spatial scales of a few centimeters. The effects of the predicted aqueous chemistry on waste form alteration, secondary mineral formation, and radionuclide solubility are examined.

262 **Diffusive transport of carbon dioxide through USW-G4 Topopah Spring Tuffs.** Ali, M.S. (North Carolina AT&T State Univ., Greensboro, NC (United States)); King, F.G.; Ilias, S. pp. 827-834 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 Contract C-66611. From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

The estimation of diffusive transport of gases through tuffs is important in order to assess whether Yucca Mountain is

an environmentally safe and acceptable repository for high-level radioactive waste. The purpose of this study is to provide effective diffusivity data which may be used to calculate the amount of diffusion of carbon dioxide through Yucca Mountain tuff layers to the environment. The effective diffusivity of carbon dioxide was measured for tuff samples from five different layers of the USW-G4 drillhole, which is located in the central part of the proposed repository horizon. The tuff samples studied are from the following layers and depths: Vapor Phase (83.6 m), Upper Lithophysal (130.1 m), Middle Nonlithophysal (224.5 m), Lower Lithophysal (243.9 m, 266.9 m, 297.3 m and 335.2 m), and Lower Nonlithophysal (356.3 m and 371.0 m). A steady-state, counter-diffusion method, using gas chromatographic analysis, was used to determine the effective diffusivity of carbon dioxide through tuff samples. Effective diffusivity increased with temperature between 25°C and 125°C for all layers. The effect of temperature on diffusivity correlated well using second-order polynomials. The porosity, specific surface area and mean pore radius were also determined. In general, diffusivity increased with porosity, specific surface area and mean pore radius, but did not correlate well. From the measured data, it appears that the diffusion takes place primarily in the combined Knudsen and bulk diffusion regimes.

263 **Probabilistic calculations of groundwater travel time in heterogeneous three-dimensional porous media.** Bagtzoglou, A.C. (Southwest Research Institute, San Antonio, TX (United States)); Baca, R.G. pp. 849-854 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 Contract NRC-02-88-005. From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

Groundwater travel time (GWTT) estimation at a potential high-level waste (HLW) repository is subject to various technical uncertainties. These uncertainties stem from model and data uncertainties and cannot be resolved with field tests because of the long time (>1,000 yr) and large space (>5,000 m) scales involved. Therefore, computational methods for demonstrating and determining compliance with the GWTT rule will be used. Stochastic theory based approaches constitute a natural framework for performing GWTT estimations under conditions of uncertain and/or limited data. This study employs the generation of spatially correlated hydraulic conductivity fields by the Nearest Neighbor Model (NNM). Repeated (Monte Carlo) realizations of the statistically equivalent random fields are obtained, and the saturated steady-state groundwater flow equation is solved. These results are then used to estimate GWTT along particular paths by releasing a large number of water particles at various starting points. By doing so, path variability is sampled through the realization ensemble space and also through the independent particle "flights" within a specific flow field realization. The uncertainty in predicted GWTT due to parameter variability is assessed for a data set characteristic of the saturated zone at Yucca Mountain at three levels of parameter heterogeneity. However, since several parameters and the boundary conditions of the problem have been arbitrarily assumed, direct conclusions regarding the proposed Yucca Mountain site cannot be drawn from this study.

264 **Performance assessment modeling of a multi-purpose container.** Bullen, D.B. (Iowa State Univ., Ames, IA (United States)). pp. 869-880 of Scientific basis for nuclear waste management XVII. Barkatt, A. (ed.); Van Konynenburg, R.A. (ed.). Materials Research Society, Pittsburgh, PA (United States) (1994). pp. 964 From Fall meeting of the Materials Research Society (MRS); Boston, MA (United States); 29 Nov - 3 dec 1993.

A mathematical model to predict the cumulative failure distribution for the engineered barrier system employed in a deep geologic disposal facility as a function of container design and near-field environmental conditions has been developed. The model employs Weibull and exponential distributions to describe cumulative container failures as a function of time. Parameter values employed in the model are based upon simple, time-dependent, mechanistic models and relevant corrosion data, which describe failure of individual components of the container as a function of environmental conditions. Recent developments in container design for the Yucca Mountain site center on the possible deployment of Multi-Purpose Containers (MPC). These containers will be designed and constructed to serve as transport casks, interim storage containers, and disposal containers. The current container performance assessment model is applied to evaluate the long-term performance of various MPC designs under the areal power density and heat transfer regimes expected in the Yucca Mountain environment. This model has previously been employed to describe the performance of the container as one part of a risk-based performance assessment of the Yucca Mountain site. The relative importance of container design, areal power density, and dominant heat transfer mode on predicted MPC performance is demonstrated through comparison of the cumulative container failure distributions for each MPC design when exposed to expected Yucca Mountain environmental conditions.

265 **The long term radioactive storage alternative.** Draffin, C.W. Jr. (BDM Federal, Inc., Germantown, MD (United States)); Little, R.G.; Blauvelt, R. pp. 13-17 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

With uncertainty regarding the Yucca Mountain geologic repository being just one manifestation of the controversy over where, how, and whether radioactive waste can be safely treated and disposed in a publicly acceptable manner, the authors suggest that a new approach regarding the storage of spent nuclear fuel (SNF) and radioactive waste is needed and, fortunately, available. Safely storing wastes in an environmentally-acceptable, monitored manner while a national political and technical consensus is reached on how to properly treat it prior to its ultimate disposal may be the most cost-effective and rational method of addressing these issues in the interim. Because of the limitations imposed on treatment and disposal options by state governments, legislative and regulatory requirements, and legal challenges, spent fuel, other reactor irradiated nuclear material (RINM), and radioactive waste are remaining where they were produced, usually in facilities neither sited nor designed with long-term storage in mind. The inertia associated with difficult choices based on imperfect information has resulted in a decision-making gridlock where an unpopular status quo continues and promising solutions remain untried. However, well-planned and locally accepted centralization of wastes (especially medical) within states and/or acceptance of dry

spent fuel storage at each nuclear generating station can break the current gridlock of disposal and storage actions and inactions and can result in a more desirable outcome both in the intermediate and long term.

266 **1993 recreational vehicle (RV) park census in Beatty and Pahrump, Nevada.** Levy, L.E. (Planning Information Corp., Denver, CO (United States)); Housel, M.D. pp. 48-55 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper reports on the second annual study of seasonal nonpermanent residents in the towns of Beatty and Pahrump in southern Nye County, Nevada, situs county of the Yucca Mountain Site Characterization Project. The study used a census of recreational vehicle (RV) park managers to enumerate and characterize in demographic terms nonpermanent residents staying in RV parks. The questionnaire sought information from RV park managers which ordinarily would come from a household survey. The main objective was to study "snowbirds", the households of older couples who stay for a month or more each winter. The findings suggest that snowbirds are a majority of the seasonal influx of nonpermanent residents to RV parks in Pahrump. In contrast, a group called "seasonal travelers", similar demographically but who stay less than a month, dominate the seasonal nonpermanent population in Beatty's RV parks. The study also tentatively identified the seasonality of nonpermanent resident occupancy. Because only RV parks were contacted, the study left unanswered the question of how many snowbirds live in other types of accommodations in Beatty and Pahrump.

267 **Public opinion polling and the Yucca Mountain controversy: A seven year inventory December 1986–August 1993.** Himmelberger, J.J. (Clark Univ., Worcester, MA (United States)); Baughman, M.L. pp. 142-149 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 1. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 373 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper presents an inventory of recent (12/87-6/93) public opinion polling activities related to the proposed Yucca Mountain repository. The inventory of polls is discussed in terms of sponsor intentions/objectives, populations polled, survey design/implementation characteristics, and media attention to key findings. We close with some observations on "like" questions as asked over time to Nevadans to shed light on the state of public opinion related to the proposed repository.

268 **A tunnel boring system for the Yucca Mountain Project.** Short, S.N. (Construction & Tunneling Services, Inc., Kent, WA (United States)). pp. 381-385 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Design of the Yucca Mountain Project (YMP) tunnel boring machine (TBM) and backup began in June of 1993, with fabrication, machining and light assembly proceeding through to the end of the year. The original specifications for the project were contained in the request for quote for the YMP TBM and in Construction & Tunneling Services proposal document. As with all complex custom assignments, much of the finer details of the definition of the final scope of delivery was concurrent with the design effort itself. The summation of this effort is described in this paper. The major technical scope of the machine delivery is defined by the parameters listed in TABLE 1. Within the confines of the installed power and design excavation rates, the final product has been tailored to suit the particular needs of the project.

269 **Application of heavy duty roadheaders for underground development of the Yucca Mountain Exploratory Study Facility.** Rostami, J. (Colorado School of Mines, Golden, CO (United States)); Ozdemir, L.; Neil, D.M. pp. 395-402 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 Contract SC-YM-93-159. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Heavy duty roadheaders of 100 ton weight class are being considered for the excavation of the test rooms and alcoves along the main ramp and in the main repository level at the Yucca Mountain site. The current design of the candidate machines was studied and appropriate modifications are proposed. Computer programs for design optimization and performance prediction of roadheaders were developed. Results of computer modeling and operational parameters of the proposed machines are presented in this paper.

270 **Development of a mechanical alcove excavator for the Yucca Mountain Exploratory Study Facility.** Roennkvist, E. (Colorado School of Mines, Golden, CO (United States)); Ozdemir, L.; Friant, J.E. pp. 411-416 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A 25 ft (7.6 m) diameter tunnel, bored nearly 26,000 ft (8 km) long, is planned as the initial opening into a rather thick strata of welded tuff rock, known as Topopah Springs (TSw2). The near term purpose of the tunnel is to examine the geology to determine if the selected formation is suitable to be used as a nuclear waste repository. In addition to the tunnel, some 30 to 40 alcoves are envisioned along the tunnel which will serve as rooms in and from which the various scientists can conduct their analytical experiments. In addition, a series of rooms and hallways are planned in an area set aside as "the main test facility". The overall site is known as The Exploratory Studies Facilities (ESF). The mission of this study program was to determine if a mechanical means of constructing the alcoves, rooms and hallways was feasible. Of particular interest were the alcoves which exit directly off of the main tunnel. The work for this study included determining a somewhat standard size for the initial alcove, determining whether existing equipment and/or technology was available, and determining if such equipment could be transported and launched from the main tunnel with minimum to no interruption to the main TBM operation. The study determined that no off the shelf equipment was both capable of effectively cutting welded tuff, and sufficiently

mobile to meet the minimum interruption requirements. The study did determine that suitable technology was available, and that a special purpose machine was feasible. This paper describes the trade off studies conducted on various excavation methods, the system selected for conceptual design and the potential performance of a mobile alcove excavator.

271 **Novel, low-vibration excavation techniques for underground radioactive waste storage.** Kogelmann, W.J. (Advanced Excavation & Cutting Technologies, State College, PA (United States)). pp. 417-429 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

In order to meet the construction specifications of the challenging Yucca Mountain nuclear waste repository, novel, low-vibration tunneling and shaft sinking techniques must be applied. Conventional roadheaders, even with reduced cutting speed, cannot be employed due to the high strength and widely varying physical properties of the rock formations. The Multi Tool Miner (MTM) concept utilizes both an impact hammer, for efficient hard rock mining, and a cutter head, tooled with drag-bits (picks), to profile tunnel walls down to the sound, undisturbed rock, in order to meet the 10,000-year stability requirement for underground structures. As the operational requirements and rock conditions at the Yucca Mountain site are not suitable for wide, transverse "ripper" cutting drums, a small diameter, in-line, "milling auger" cutter head was developed. The synergetic combination of high-production hammer excavation and precise milling will facilitate the construction of stable, long-life underground structures within the budget limitations mandated by Congress.

272 **Further development of a source term model for a repository in unsaturated tuff.** Codell, R. (Nuclear Regulatory Commission, Washington, DC (United States)); Weller, R. pp. 477-484 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Performance assessments for a potential HLW site at Yucca Mountain should consider the unique characteristics of burying nuclear waste in unsaturated rock. Source term models have been a key part of NRC's first two performance assessments, but have relied on simplified concepts with large uncertainties. NRC is improving its preliminary models for the source term in several important areas, including: (1) incorporation of the latest designs for waste packages; (2) heat transfer near the waste; (3) contact of waste by liquid water, especially thermally induced flows; (4) mechanisms for waste package corrosion; (5) incorporation of spatial and temporal variability at several scales; (6) release of gaseous ^{14}C from the waste; (7) modes of waste package failure other than corrosion; (8) dissolution of radionuclides from the waste form; (9) waste forms other than spent nuclear fuel; (10) abstraction of complex models for use in total system performance assessments; and (11) identification of anticipated and unanticipated events and processes for subsystem performance assessment of the engineered barriers.

273 **An auxiliary ventilation design approach for the ESF development at Yucca Mountain.** Mousset-Jones, P. (Mackay School of Mines, Reno, NV (United States)); Calizaya, F. pp. 508-514 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 2. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 862 DOE Contract FC08-90NV10891. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper summarizes the current status of a research project directed at ventilation design for the construction of long and complex development headings and describes an approach developed to determine the ventilation design parameters. The approach is based on the principle of partitioning a long ductwork into segments of finite length and solving separately the resulting networks. It has been incorporated into a computer program, written in Turbo Pascal for IBM PC micro-computers and compatible machines. An application of the program is illustrated by the detailed solution of two auxiliary ventilation systems for the Exploratory Studies Facilities (ESF) at Yucca Mountain.

274 **Implications of theories of asteroid and comet impact for policy options for management of spent nuclear fuel and high-level radioactive wastes.** Trask, N.J. (Geological Survey, Reston, VA (United States)). pp. 1324-1328 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Concern with the threat posed by terrestrial asteroid and comet impacts has heightened as the catastrophic consequences of such events have become better appreciated. Although the probabilities of such impacts are very small, a reasonable question for debate is whether such phenomena should be taken into account in deciding policy for the management of spent fuel and high-level radioactive waste. The rate at which asteroid or comet impacts would affect areas of surface storage of radioactive waste is about the same as the estimated rate at which volcanic activity would affect the Yucca Mountain area. The Underground Retrievable Storage (URS) concept could satisfactorily reduce the risk from cosmic impact with its associated uncertainties in addition to providing other benefits described by previous authors.

275 **Systems approach for design control at Monitored Retrievable Storage Project.** Kumar, P.N. (Department of Energy, Washington, DC (United States)); Williams, J.R. pp. 1365-1371 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper describes the systems approach in establishing design control for the Monitored Retrievable Storage Project design development. Key elements in design control are enumerated and systems engineering aspects are detailed. Application of lessons learned from the Yucca Mountain Project experience is addressed. An integrated approach combining quality assurance and systems engineering requirements is suggested to practice effective design control.

276 **Treatment of uncertainty in the NRC regulatory process.** McGarry, J.M. III (Winston & Strawn, Washington, DC (United States)); Echols, F.S. pp. 1404-1416 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The information gained during the one to two decades of initial site characterization of Yucca Mountain, Nevada by the Department of Energy (DOE) will be used to make preliminary predictions about the suitability of the site to be developed as a geologic repository. If Yucca Mountain is designated as suitable for application for a construction authorization pursuant to the terms and conditions of the Nuclear Waste Policy Act (NWPA), as amended, then DOE will submit to the Nuclear Regulatory Commission (NRC) an application for a construction authorization. Much of the information supporting site recommendation and a construction authorization will be subject to significant uncertainty. However, both the NWPA and applicable NRC regulations are structured to accommodate this uncertainty in the administrative decisionmaking process such that appropriate determinations can be made at each stage of repository development, operation and permanent closure.

277 **U.S. NRC staff views on the technical bases for Yucca Mountain standards.** Federline, M.V. (Nuclear Regulatory Commission, Washington, DC (United States)); Kotra, J.P.; Firth, J.R. pp. 1422-1428 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The National Academy of Sciences (NAS) has established a committee to examine the scientific and technical issues that underlie the health and safety standards for high-level waste (HLW) disposal. The NAS Committee is developing recommendations for the Environmental Protection Agency (EPA) concerning an appropriate standard for evaluating a potential HLW repository at Yucca Mountain. Because of its regulatory role for the protection of public health and safety, the US Nuclear Regulatory Commission (NRC) has a significant interest in the progress and outcome of the NAS study as well as in the form and content of any standards EPA ultimately promulgates. The NRC will be required to revise its regulations for consistency with EPA's environmental standards and, subsequently, to evaluate compliance of any proposed repository with NRC's regulations. This paper discusses those issues which, in the NRC staff's view, are critical to the formulation of disposal standards for high-level waste and spent fuel, and which the NAS and, eventually, EPA and NRC will need to address.

278 **A health risk based approach for HLW repository environmental protection criteria.** Williams, R.F. (Electric Power Research Institute, Palo Alto, CA (United States)); Yang, R.L.; McGuire, R.; Wilems, R.E. pp. 1435-1450 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper illustrates a health risk based criteria for the potential HLW repository at Yucca Mountain. The criteria is expressed as an overall health risk goal. Compliance with the standard is proposed to be demonstrated by meeting specific design requirements and design objectives. It is proposed that different degrees of proof apply to design objectives and design requirements. The approach also proposes a combination of more conventional code-like requirements and probabilistic requirements for protection of public health and safety and the environment. The strawman criteria are similar in many respects to ICRP 46, and European repository criteria. However, we propose that the probability distribution of dose to an average individual in a critical population group be used as the measure of health risk. Implementation is illustrated through a probabilistic analysis of a future site specific biosphere.

279 **Models for source term, flow, transport and dose assessment in NRC's Iterative Performance Assessment, Phase 2.** McCartin, T. (Nuclear Regulatory Commission, Washington, DC (United States)); Codell, R.; Neel, R.; Ford, W.; Wescott, R.; Bradbury, J.; Sagar, B.; Walton, J. pp. 1469-1479 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The core consequence modules for the recently completed Phase 2 Iterative Performance Assessment (IPA) of the Yucca Mountain repository for high-level nuclear waste depend on models for releases from the engineered barrier system (source term), flow of liquid and gas, transport of radionuclides in the geosphere and assessment of dose to target populations. The source term model includes temperature and moisture phenomena in the near-field environment, general, pitting and crevice corrosion, contact of the waste form by water, dissolution and oxidation of the waste form, and transport of dissolved and gaseous radionuclides from the waste package by advection and diffusion. The liquid flow and transport models describe water flow through fractures and matrix in both the unsaturated and saturated zones. Models for flow of gas and transport of $^{14}CO_2$ released from the engineered barrier system to the atmosphere take into account repository heat and the geothermal gradient. The dose assessment model calculates doses to a regional population and a farm family for an assumed reference biosphere in the vicinity of the repository. The Phase 2 IPA led to a number of suggestions for model improvement: (1) improve the ability of the models to include spatial and temporal variability in the parameters; (2) improve the coupling among processes, especially the effects of changing environments in the waste packages; (3) develop more mechanistic models, but abstracted for use in total system performance assessment; and (4) use more site specific parameters, especially for the dose assessments.

280 **IPA Phase 2 sensitivity and uncertainty analysis.** Colten-Bradley, V. (Nuclear Regulatory Commission, Washington, DC (United States)); Codell, R.; Byrne, M.R. pp. 1480-1491 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The NRC's Phase 2 Iterative Performance Assessment (IPA) used Monte Carlo techniques to propagate uncertainty for up to 297 independent variables and nine scenarios through computer models representing the performance of the Yucca Mountain repository. The NRC staff explored the use of a number of parametric and non-parametric tests and graphical methods to display the probabilistic results. Parametric tests included regression and differential analysis. Non-parametric tests included the Kolmogorov-Smirnov test and Sign test. Graphical methods included the Complementary Cumulative Distribution Function (CCDF), hair diagram, scatter plots, histograms and box plots. Multiple linear regression of raw, ranked, standardized and other transformed variables determined the gross sensitivity over the parameter space. CCDF's were also generated from subsets of the 400 vector sets formed by screening the vectors according to values of derived variables related to the behavior of the engineered and natural systems. While no single statistical or graphical technique proved to be useful in all cases, diverse methods of sensitivity and uncertainty analysis identified the same important input parameters.

281 **The use of expert judgment elicitation to predict future climate for the Yucca Mountain Nevada vicinity.** DeWispelare, A. (Center for Nuclear Waste Regulatory Analyses, San Antonio, TX (United States)); Miklas, M.P. Jr.; Clemen, R.T.; Herren, L.T.; Park, J.R. pp. 1614-1621 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 Contract NRC-02-88-005. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Expert judgment elicitations are expected to supplement other data used to assess the long-term safety of a high-level waste (HLW) geologic repository. The US Nuclear Regulatory Commission (NRC) is examining the applicability of expert judgment elicitation to the licensing process. This paper describes the basis and conduct of an expert judgment elicitation project focused on the future climate around Yucca Mountain, Nevada (YMNV). Results in terms of climate predictions over the next 10,000 years are presented.

282 **Using performance assessment for radioactive waste disposal decision making - implementation of the methodology into the third performance assessment iteration of the greater confinement disposal site.** Gallegos, D.P. (Sandia National Labs., Albuquerque, NM (United States)); Conrad, S.H.; Baer, T.A. pp. 1671-1681 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 DOE Contract AC04-76DP00789. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The US Department of Energy is responsible for the disposal of a variety of radioactive wastes. Some of these wastes are prohibited from shallow land burial and also do not meet the waste acceptance criteria for proposed waste repositories at the Waste Isolation Pilot Plant (WIPP) and Yucca Mountain. These wastes have been termed "special-case" waste and require an alternative disposal method. From 1984 to 1989, the Department of Energy disposed of a small quantity of special-case transuranic wastes at the Greater Confinement Disposal (GCD) site at the Nevada Test Site. In this paper, an iterative performance assessment is demonstrated as a useful decision making tool in the overall compliance assessment process for waste disposal. The GCD site has been used as the real-site implementation and test of the performance assessment approach. Through the first two performance assessment iterations for the GCD site, and the transition into the third, we demonstrate how the performance assessment methodology uses probabilistic risk assessment concepts to guide effective decisions about site characterization activities and how it can be used as a powerful tool in bringing compliance assessment decisions to closure.

283 **Role of U.S. Nuclear Regulatory Commission's On-Site Representatives in pre-licensing activities for a high-level radioactive waste repository.** Justus, P.S. (Nuclear Regulatory Commission, Las Vegas, NV (United States)); Gilray, J. pp. 1712-1715 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Under the Nuclear Waste Policy Act, the US Department of Energy and the US Nuclear Regulatory Commission are required to consult with each other prior to DOE's submittal of a license application to construct a high-level radioactive waste repository. DOE entered into an agreement which, in part, enabled NRC On-Site Representatives to be stationed at a high-level waste candidate site "principally to serve as a point of prompt informational exchange and consultation and to preliminary identify concerns about such investigations relating to potential licensing issues." On-Site Representatives' direct observation of site characterization activities including construction of an underground studies facility (at Yucca Mountain, NV candidate site) provides NRC staff opportunities to help ensure that DOE will develop data which are appropriate to determine if the site will safely isolate waste and which will be defensible in a License Application. The On-Site Representatives, through supervision and input from the Division of High-Level Waste Management, may consult with the DOE site project office and its contractor staff on items pertaining to management and program controls necessary to satisfy NRC licensing needs, such as demonstrated application of procedural controls and technical data that will support a License Application. The On-Site Representatives interact with DOE through consultations with project staff, quality assurance workshops, observations of reviews of computer software and Q-List considerations, responses to audit and surveillance observations and day-to-day contact with DOE site management, QA staff, and technical investigators.

284 **The case for retrievable high-level nuclear waste disposal.** Roseboom, E.H. Jr. (Geological Survey MS-106, Reston, VA (United States)). pp. 1774-1781 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 3. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 699 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Plans for the nation's first high-level nuclear waste repository have called for permanently closing and sealing the repository soon after it is filled. However, the hydrologic environment of the proposed site at Yucca Mountain, Nevada, should allow the repository to be kept open and the waste retrievable indefinitely. This would allow direct monitoring of

the repository and maintain the options for future generations to improve upon the disposal methods or use the uranium in the spent fuel as an energy resource.

285 **The role of fracture coatings on water imbibition into unsaturated tuff.** Chekuri, V.S. (Univ. and Community College System of Nevada, Reno, NV (United States)); Tyler, S.W.; Fordham, J.W. pp. 1891-1896 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A thin lining of low permeability material on fracture walls may significantly impede imbibition into the matrix of unsaturated fractured tuff. Capillary forces from the matrix acting on the mobile liquid water in the fractures start the process of imbibition. A convenient measure of the property of imbibition is the sorptivity. To investigate the role of fracture coatings on sorptivity in the laboratory we modified a simple sorptivity cell. This sorptivity cell was used to measure imbibition across the fracture surfaces and to investigate the role of fracture coatings. Results of Tiva Canyon tuff samples collected from surface outcrops near Yucca Mountain were contrary to the hypothesis that the fracture coating may impede imbibition.

286 **Statistical considerations on large-scale geomechanics test design for nuclear waste repository characterization.** Kim, Kunsoo (Columbia Univ., New York, NY (United States)); Gao, Hang. pp. 1922-1929 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 Grant 1124136FY93. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A statistical method based on a Monte Carlo simulation and the statistics of extremes is employed to characterize the natural variability of the rock mass properties for siting a high level nuclear waste repository. The method is applied to the well documented NNWSI and BWIP data to assess its validity. The results of the analysis suggest that the large-scale tests should be designed to provide information to describe the rock mass properties in analytical forms, not just to produce discrete data points. Ancillary tests including the constituent material properties for the analytical relationships should be planned as an integral part of the large-scale tests. Then, via Monte Carlo simulation one can estimate the distribution functions of rock mass properties which permit to assess the variability of the rock mass behavior in repository conditions.

287 **Yucca Mountain: A potential trade-off in radiological hazards.** Spiegler, P. (Nuclear Waste Project Office, Carson City, NV (United States)). pp. 1959-1963 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Simple and preliminary calculations show that the excess emanation of radon and radon daughter products resulting from the heating of the rock could produce effective dose equivalent rates comparable to or greater than those of background radiation over large areas surrounding the Yucca Mountain site. This important issue is not being properly addressed in the licensing and characterization strategy of the Yucca Mountain site. The excess emanation of radon and radon daughter product could be an important constraint on the aereal power density, which is a repository design parameter that is under review at the writing of this paper. The review became necessary because the DOE is considering the disposal of spent fuel in multi-purpose canisters and because the DOE has indicated the intention of storing more than 70,000 MTU of spent fuel at Yucca Mountain. Also very important, excess radon emanation could stimulate a debate that the Yucca Mountain site is a trade-off of one radiological hazard for another.

288 **Testing conceptual unsaturated zone flow models for Yucca Mountain.** Brown, T.P. (L. Lehman & Associates, Inc., Burnsville, MN (United States)); Lehman, L.L.; Nieber, J.L. pp. 1999-2006 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

An important component of site characterization and suitability assessment of the proposed nuclear waste repository at Yucca Mountain, Nevada is determination of the most appropriate conceptual model of the hydrologic mechanisms governing saturated and unsaturated flow for the site. As observers in the ITNRAVAL Unsaturated Zone Working Group, L. Lehman & Associates conducted a modeling exercise which numerically examined alternative conceptual flow models. Information was provided to the Working Group by the U.S. Geological Survey. Additional published data were utilized to fill in data gaps and to provide additional confidence in results. Data were modeled utilizing one and two dimensional matrix and fracture numerical models. Good agreement was obtained using a 2-dimensional dual porosity fracture flow model. Additional measures are needed to constrain the field conditions enough to validate conceptual models using numerical models. Geochemical data on tritium, chlorine-36, or carbon-14 concentrations or temperature profiles which can give estimates of time since recharge for water in the unsaturated zone, are needed to eliminate the non-uniqueness of various model solutions.

289 **Above and below boiling thermal loading strategies for large waste packages.** Smith, M.L. (Virginia Power, Glen Allen, VA (United States)). pp. 2146-2151 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A simplified repository thermal model was developed with the Mathcad computer code which indicates that large waste packages may be compatible with both above and below boiling repository thermal loading strategies. Minimum spent fuel decay time of at least 20 to 30 years was shown to be important for both thermal loading strategies. Constant isothermal boundary conditions are assumed at the ground surface (296 K) and 305 meters below the water table (309.7 K) with a uniform temperature change of 1.55 10^{-2} K/meter. Homogeneous tuff properties are assumed: conductivity (2.1 watt/m-k); density (2.22 gm/cm^3); and thermal

capacitance (2.17 joule/cm^3 K). Based on these properties, the tuff thermal diffusion coefficient is 9.68 $\times$ 10^{-7} m^2/sec.

290 Liquid infiltration through the boiling-point isotherm in a desiccating fractured rock matrix. Phillips, O.M. (John Hopkins Univ., Baltimore, MD (United States)). pp. 2189-2196 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 Contract NRC-02-88-005. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Over a long time interval, the integrity of the radioactive waste repository proposed at Yucca Mountain may be compromised by corrosion accelerated by intermittent wetting which could occur by episodic infiltration of meteoric water from above through the fracture network. A simple two-dimensional model is constructed for the infiltration of liquid water down a fracture in a permeable rock matrix, beyond the boiling-point isotherm. The water may derive from episodic infiltration or from the condensation of steam above a desiccating region. Boiling of the water in the fracture is maintained by heat transfer from a surrounding superheated matrix blocks. There are two intrinsic length scales in this situation, (1): $l_s = \rho q_o L/(k_m \beta)$ which is such that the total heat flow over this lateral distance balances that needed for evaporation of the liquid water infiltration, and (2): The thermal diffusion distance $l_\theta = (k_m t)^{\frac{1}{2}}$ which increases with time after the onset of infiltration. The primary results are: (a) for two-dimensional infiltration down an isolated fracture or fault, the depth of penetration below the (undisturbed) boiling point isotherm is given by $\frac{1}{2}\pi^{\frac{1}{2}}(l_s l_\theta)^{\frac{1}{2}}$, and so increases as $t^{\frac{1}{4}}$. Immediately following the onset of infiltration, penetration is rapid, but quickly slows. This behavior continues until l_θ (and D) become comparable with l_s. (b) With continuing infiltration down an isolated fracture or cluster of fractures, when $l_\theta >> l_s$ the temperature distribution becomes steady and the penetration distance stabilizes at a value proportional to l_s. (c) Effects such as three-dimensionality of the liquid flow paths and flow rates, matrix infiltration, etc., appear to reduce the penetration distance.

291 Thermosyphon analysis of a repository: A simplified model for vapor flow and heat transfer. Manteufel, R.D. (Center for Nuclear Waste Regulatory Analyses, San Antonio, TX (United States)); Powell, M.W. pp. 2207-2216 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 Contract NRC-02-88-005. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A simplified model is developed for thermally-driven buoyant gas flow in an unsaturated repository such as that anticipated at Yucca Mountain. Based on a simplified thermosyphon model, the strength of buoyant gas flow is related to key thermal-hydraulic parameters (e.g., bulk permeability and maximum repository temperature). The effects of buoyant gas flow on vapor flow and heat transport near the repository horizon are assessed, namely: (i) the strength of buoyant flow through the repository, (ii) the effect of buoyant flow on vapor transfer, and (iii) the effect of buoyant flow on heat transfer.

292 Pressure-driven gas flow in heated, partially-saturated porous media. Dodge, F.T. (Southwest Research Institute, San Antonio, TX (United States)); Green, R.T. pp. 2217-2227 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 Contract NRC-02-93-005. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Calculations have been made at the Center for Nuclear Waste Regulatory Analyses (CNWRA) to assess the importance of the various driving mechanisms of heat and mass transport at a high-level nuclear waste (HLW) repository located in the unsaturated zone. Scoping measurements of the relative importance of vapor movement by buoyancy forces and by advective forces have been made for a proposed laboratory-scale experiment to be conducted at CNWRA and for a proposed field-scale heater experiment by U.S. Department of Energy (DOE) at Fran Ridge. These scoping measurements are made using a set of dimensionless terms assembled for this analysis. Numerical simulations of the same laboratory- and field-scale experiments are made using VTOUGH. These calculations will be used to predict (and design in the case of the laboratory-scale experiment) the redistribution of moisture in response to the imposition of heat on the two experiments.

293 The Cigar Lake analog study: An international R&D project. Cramer, J.J. (Whiteshell Lab., Pinawa, Manitoba (Canada)); Sargent, F.P. pp. 2237-2242 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

This paper provides background information and summarizes the results of AECL's analog study on the Cigar Lake uranium deposit. This R&D project includes national and international cooperation with many organizations directly or indirectly involved in nuclear waste management research. The emphasis is on the analog aspects of this deposit and the implications of modelling activities related to the environmental and safety assessment of the Canadian disposal concept for nuclear fuel waste.

294 A-TOUGH: A multimedia fluid-flow/energy-transport model for fully-coupled atmospheric-subsurface interactions. Montazer, P. (Multimedia Environmental Technology, Inc., Newport Beach, CA (United States)); Hammermeister, D.; Ginanni, J. pp. 2333-2340 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Modeling the extreme thermodynamic conditions encountered in the near-ground surface atmosphere-soil boundary in desert environments requires a robust code that is capable of simulating fully-coupled flow and transports of water liquid, water vapor, and heat in porous and fractured media - where flow is usually laminar, and the atmosphere - where flow is usually turbulent. A-TOUGh (Atmospheric TOUGH) is developed to simulate the transport of air, vapor, and heat through an atmospheric boundary layer coupled with the

transport of moisture, an air-vapor mixture, and heat through porous or fractured media. The three-dimensional nature of the code allows simulation of rough terrain and heterogeneous subsurface conditions encountered at site such as Yucca Mountain. The allowable range of temperatures (-50°C to 200°C) and relative humidities (0 to 100 percent) for this new code permits the simulation of complex processes such as condensation in fractures during the winter season. A-TOUGH can also be used to predict the effect that ventilation shafts and tunnels in underground facilities have on moisture conditions in the host fractured rocks over extended periods of time. A-TOUGH has been tested with several simple and complicated problem sets, including a two-dimensional low-level radioactive waste trench with a layered cap. This paper: (1) summarizes the physical and mathematical approach used by previous investigators and the current study to simulate near-surface unsaturated flow processes, (2) briefly describes the numerical procedures incorporated in A-TOUGH, and (3) presents the results of a calibration simulation based on published field data.

295 **Published attenuation functions compared to 6/29/1992 Little Skull Mountain earthquake motion.** Hofmann, R.B. (Center for Nuclear Waste Regulatory Analysis, San Antonio, TX (United States)); Ibrahim, A.K. pp. 2402-2408 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Several western U.S. strong motion acceleration earthquake attenuation functions are compared to peak accelerations recorded during the 6/29/1992 Little Skull Mountain, Nevada earthquake. The comparison revealed that there are several definitions of site-to-source distance and at least two definitions of peak acceleration in use. Probabilistic seismic hazard analysis (PSHA) codes typically estimate accelerations assuming point sources. The computer code, SEISM 1, was developed for the eastern U.S. where ground acceleration is usually defined in terms of epicentral distance. Formulae whose distance definitions require knowledge of the earthquake fault slip zone dimensions may predict very different near-field accelerations when epicentral distance is used. Approximations to achieve more consistent PSHA results are derived.

296 **A characterization study of fractured rock.** Karasaki, K. (Lawrence Berkeley Lab., CA (United States)); Freifeld, B.; Davison, C. pp. 2423-2428 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A suite of experiments are being conducted at a dedicated field study site in the Sierra Nevada foothills, near the town of Raymond, California to develop and test a multidisciplinary approach to the characterization of ground-water flow and transport in fractured rocks. A cluster of nine approximately 90m deep boreholes have been drilled at the site in a reverse V pattern with an angle of 60 degrees and with increasing spacing of 7.5, 15, 30, and 60 meters from the central well. A newly developed data acquisition system uses a 486 PC and centrally controls many of the test parameters. Intra- and cross-borehole geophysical surveys indicated that the flow is mainly confined to a few subhorizontal fracture zones. Various kinds of hydraulic tests were conducted with and without packers. A radial convergent tracer test was then conducted by injecting a three tracer mixture of deuterium, fluorescein, and micro-spheres followed by a mixture of bromide and fluoride in a well 30 m away from the pumping well. Preliminary results show some differences between the breakthrough curves, which may have been strongly influenced by the borehole hydrodynamics.

297 **In situ stress determination research study.** Austin, W.G. (Bureau of Reclamation, Denver, CO (United States)); Thompson, P.M. pp. 2429-2436 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The objectives of this study are to evaluate and implement rock stress determination instruments and techniques developed by Atomic Energy of Canada Limited (AECL) at its Underground Research Laboratory (URL) for use in jointed rock and to continue the development of analytical and interpretation methods for stress determination results including effects of scale, structure and anisotropy. Testing and evaluation of the instruments and methods developed at URL need to be done in a similar rock type prior to underground access at the Yucca Mountain Site Characterization Project.

298 **Spring deposits and late pleistocene groundwater levels in southern Nevada.** Quade, J. (Univ. of Arizona, Tucson, AZ (United States)). pp. 2530-2537 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Ground-water discharge deposits dating to the last glacial cycle and to several earlier cycles crop out in at least ten valleys in the southern Great Basin. The elevation and distribution of these deposits allow us to reconstruct the elevation of the water table during periods of wetter climate over much of the region, including the area around Yucca Mountain, site of the proposed high-level nuclear waste repository. Results from areas undisturbed by recent ground-water pumpage reveal that water levels have varied by < 115 m, and in most cases much less, in the latter half of the Quaternary. The extent of ground-water discharge during older wet cycles is similar in scale to discharge during the last full-glacial period. This places most of the proposed repository horizon at least 85 to 285 m above the maximum levels attained by the water table under full-glacial climates. During the late-glacial period (~11,500 to 8000 B.P.), a pulse of renewed discharge, perhaps corresponding to the Younger Dryas event well-documented elsewhere, produced organic-rich mats and flowing streams in many localities.

299 **Potential of vertebrate studies for assessing past climate variations.** Livingston, S.D. (Desert Research Institute, Reno, NV (United States)). pp. 2562-2568 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive

waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Vertebrate remains are commonly recovered in the course of archaeological and paleontological investigations. They are routinely used as a source of data from which to reconstruct subsistence practices and environmental factors perceived as important to past people. But this source of information has not been recognized as relevant to estimation of late Quaternary climate changes in the Great Basin until recently. In this paper I summarize three ways that environmental information is encoded in prehistoric vertebrate assemblages and provide examples of evidence that vertebrates do reflect changes of interest for climatic studies.

300 **Tree-rings and climate: Implications for Great Basin paleoenvironmental studies.** Graybill, D.A. (Univ. of Arizona, Tucson, AZ (United States)); Rose, M.R.; Nials, F.L. pp. 2569-2573 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

The Quaternary Sciences Center of the Desert Research Institute is currently conducting a multi-phased study of floral, faunal, and geomorphic response to long- and short-term climate change and extremes in assessing Yucca Mountain's suitability as a high-level nuclear waste repository. Preliminary results of these studies indicate synchronous responses in late Holocene tree-ring, palynology and geomorphic records. A tree-ring chronology for paleoclimatic reconstruction is developed by collection of multiple cores from 20-60 living trees and a similar number of dead trees in a climate-sensitive location. Samples are cross-dated and every growth layer in each specimen is measured to the nearest .001 mm. The measured ring width series potentially contain a variety of climatic, biological, and anthropogenic signals. Each ring width series is subjected to a numerical standarization procedure that removes an age-related biological growth trend, reduces endogeneous and exogenous stand disturbance factors, and maximizes any climatic signal that is present. Each of these empirically defined components can be graphically portrayed and subjected to further analyses. The geophysical signal analysis techniques involved in the standarized protocol are well-documented and established. The final result is a tree-ring chronology that represents regional paleoclimatic variability over the time represented by the sample population.

301 **Late holocene climate derived from vegetation history and plant cellulose stable isotope records from the Great Basin of western North America.** Wigand, P.E. (Desert Research Institute, Reno, NV (United States)); Hemphill, M.L.; Patra, S.M. pp. 2574-2583 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 DOE Contract FC08-93NV11417. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Integration of pollen records, and fossil woodrat midden data recovered from multiple strata of fossil woodrat (Neotoma spp.) dens (middens) in both northern and southern Nevada reveal a detailed paleoclimatic proxy record for the Great Basin during the last 45,000 years in growing detail. Clear, late Holocene climate-linked elevational depressions of plant species' distributions have occurred throughout the Great Basin of up to 200 m below today's and by as much as 1000 m below what they were during the middle Holocene. Horizontal plant range extentions during the Holocene reflecting the final northern most adjustments to Holocene climates range up to several hundred kilometers in the Great Basin. Well documented lags evidenced in the late Holocene response of vegetation communities to increased precipitation indicate reduced effectiveness in the ability of plant communities to assimilate excess precipitation. This resulted in significant runoff that was available for recharge. These responses, although indicating both rapid and dramatic fluctuations of climate for the Holocene, fall far short of the scale of such changes during the late Pleistocene. Extension of these results to Pleistocene woodrat den and pollen data evidence spans lasting several hundred to a thousand or more years during which significantly greater amounts of precipitation would have been available for runnoff or recharge.

302 **Effective unsaturated hydraulic property determination with the renormalization group approach: Methodology.** Mohanty, S. (Southwest Research Institute, San Antonio, TX (United States)); Bagtzoglou, C. pp. 2660-2668 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 Contract NRC-02-88-005. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

Assessing the performance of the potential high-level waste repository at Yucca Mountain, Nevada, requires the determination of the rate of radionuclide transport via groundwater through the fractured zone to the accessible environment. An efficient methodology for the calculation of effective hydraulic properties is presented in this paper. The Real Space Renormalization Group (RSRG) approach is adapted and modified for application to fractured rock under unsaturated conditions. The conceptual models associated with this approach are discussed briefly and the implementation of the algorithm is presented in diagrammatic form. Some verification comparisons with direct numerical simulations are presented. The estimates of effective unsaturated hydraulic conductivity, as obtained with the RSRG method, compare very well with direct numerical simulation results for the fracture configurations considered in this work. The RSRG method also proves to be highly efficient in terms of computational requirements.

303 **Stochastic analysis of unsaturated flow and transport with the SUFLAT executive numerical code.** Bagtzoglou, A.C. (Southwest Research Institute, San Antonio, TX (United States)); Islam, M.R.; Muller, M. pp. 2669-2677 of High Level Radioactive Waste Management: Proceedings of the fifth annual international conference. Volume 4. American Nuclear Society, Inc., La Grange Park, IL (United States) (1994). pp. 1048 Contract NRC-02-88-005. From International high-level radioactive waste management conference; Las Vegas, NV (United States); 22-26 May 1994.

A description of the executive numerical code SUFLAT, for stochastic analysis of unsaturated flow and transport, is presented in this paper. A brief introduction to the theory of cross-correlated random fields is given together with a verification test case, using data from the Las Cruces Trench. Finally, the SUFLAT methodology is applied to a hypothetical flow system analogous, in some respects, to the Yucca

Mountain site. Flow and transport simulations are conducted for a two-layered system with stochastically generated hydraulic properties, similar to the Topopah Spring welded (TSw) and Calico Hills nonwelded-vitric (CHnv) interface. Various qualitative observations serve to build confidence in the results of these simulations. The high saturation values in the low part of the upper layer and extensive lateral flow along the interface are indeed consistent with numerous other simulation results and conceptual models. However, and in stark contrast with these conceptual models, highly focused preferential flow channels are developed and break the continuity of the "hypothesized" capillary barrier. These results serve to strongly emphasize the notion that analyses neglecting the effects of the inherent heterogeneity in the flow system are bound to underestimate the mass flux crossing a prescribed compliance boundary.

304 (DOE–95007796) **1993 Annual progress report for subsidiary agreement No. 2 (1991–1996) between AECL and US/DOE for a radioactive waste management technical co-operative program.** Atomic Energy of Canada Ltd., Pinawa, MB (Canada). Whiteshell Labs.; US-DOE Yucca Mountain Site Characterization Project Office, Las Vegas, NV (United States). [1993]. 55p. Sponsored by USDOE, Washington, DC (United States);Atomic Energy of Canada Ltd., Ottawa, ON (Canada). Order Number DE95007796. Source: OSTI; NTIS; INIS; GPO Dep.

A coordinated research program on radioactive waste disposal is being carried out by the Atomic Energy of Canada Limited and the US Department of Energy. This annual report describes progress in the following eight studies: Fundamental materials investigations; In-situ stress determination; Development of a spent fuel dissolution model; Large block tracer test–Experimental testing of retardation models; Laboratory and field tests of in-situ hydrochemical tools; Cigar Lake–Analogue study, actinide and fission product geochemistry; Performance assessment technology exchange; and Development of multiple-well hydraulic test and field tracer test methods.

305 (DOE-HMIP-RR–94.031) **Natural analogue studies in the geological disposal of radioactive wastes.** Miller, W. (Intera Information Technologies (United Kingdom)); Chapman, N.; Alexander, R.; McKinley, I.; Smellie, J. Department of the Environment, London (United Kingdom). Her Majesty's Inspectorate of Pollution. 1994. 395p. Contract PECD-7/9/631; PECD-7/9/553. Source: Available from the British Library Document Supply Centre, Boston Spa, Wetherby, West Yorks. LS23 7BQ.

Published by Elsevier as no. 57 in the series Studies in Environmental Science.

In this volume the concept of the geological disposal of radioactive wastes is discussed and repositories in Sweden, Switzerland and Britain described. The selection, status and relevance of studying natural analogues is discussed. Information on the performance of near-field materials in a repository gained from natural analogue studies is evaluated. Detailed descriptions of natural analogue sites such as Pocos de Caldas, Cigar Lake, Needle's Eye and Loch Lomond are given and their importance in advancing the understanding of processes such as radionuclide release and transport are discussed. Finally the application of the information gained from natural analogue studies to the performance assessment for the geological disposal of radioactive wastes is considered. Recommendations are made for future natural analogue studies. (UK).

306 (DOE/IG–0366) **Audit of management of the site characterization program at Yucca Mountain.** Layton, J.C. USDOE Office of Inspector General, Albuquerque, NM (United States). Western Regional Audit Office. 15 Feb 1995. 14p. Sponsored by USDOE, Washington, DC (United States). Source: OSTI (Free of Charge).

Report to The Secretary.

The Department of Energy (Department) is responsible for establishing an underground repository to store high-level nuclear waste. In accordance with the amended Nuclear Waste Policy Act of 1982, the Department began characterization of the Yucca Mountain site to assess the feasibility of safely storing spent fuel and high-level waste for 10,000 years. Site characterization was originally scheduled to be completed in 1995. Subsequently, your predecessor, Admiral Watkins, changed the plan completion date to 2001. The purpose of our audit was to determine if the Department is making adequate progress in characterizing the Yucca Mountain project.

307 (DOE/NV/10845–49) **Identification of potential groundwater flow paths using geological and geophysical data.** Pohlmann, K.; Andricevic, R. USDOE Economic Regulatory Administration, Washington, DC (United States). Office of Utility Systems. Sep 1994. 26p. Sponsored by US-DOE, Washington, DC (United States). DOE Contract AC08-90NV10845. Order Number DE95006253. Source: OSTI; NTIS; INIS; GPO Dep.

This project represents the first phase in the development of a methodology for generating three-dimensional equiprobable maps of hydraulic conductivity for the Nevada Test Site (NTS). In this study, potential groundwater flow paths were investigated for subsurface tuffs at Yucca Flat by studying how these units are connected. The virtual absence of site-specific hydraulic conductivity data dictates that as a first step a surrogate attribute (geophysical logs) be utilized. In this first phase, the connectivity patterns of densely welded ash-flow tuffs were studied because these tuffs are the most likely to form zones of high hydraulic conductivity. Densely welded tuffs were identified based on the response shown on resistivity logs and this information was transformed into binary indicator values. The spatial correlation of the indicator data was estimated through geostatistical methods. Equiprobable three-dimensional maps of the distribution of the densely-welded and nonwelded tuffs (i.e., subsurface heterogeneity) were then produced using a multiple indicator simulation formalism. The simulations demonstrate that resistivity logs are effective as soft data for indicating densely welded tuffs. The simulated welded tuffs reproduce the stratigraphic relationships of the welded tuffs observed in hydrogeologic cross sections, while incorporating the heterogeneity and anisotropy that is expected in this subsurface setting. Three-dimensional connectivity of the densely welded tuffs suggests potential groundwater flow paths with lengths easily over 1 km. The next phase of this investigation should incorporate other geophysical logs (e.g., gamma-gamma logs) and then calibrate the resulting soft data maps with available hard hydraulic conductivity data. The soft data maps can then augment the hard data to produce the final maps of the spatial distribution of hydraulic conductivity that can be used as input for numerical solution of groundwater flow and transport.

308 (DOE/RW–0449) **FY1993 annual report to Congress.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (United States). Sep 1994. 130p. Sponsored by USDOE, Washington, DC (United

States). Order Number DE95003292. Source: OSTI; NTIS; INIS; GPO Dep.

As established by the Nuclear Waste Policy Act of 1982, as amended, the United States Department of Energy's Office of Civilian Radioactive Waste Management is responsible for managing and disposing of the Nation's spent nuclear fuel from civilian nuclear power reactors and high-level radioactive waste from defense activities. The program will provide leadership in developing and implementing strategies that assure the health and safety of the public and workers, protect the environment, and merit public confidence, in an economically viable manner. To accomplish the program's mission, we are developing a waste management system culminating in a geologic repository for permanent disposal deep beneath the surface of the earth. Our goals include: (1) determining whether Yucca Mountain, Nevada, designated by the Nuclear Waste Policy Amendments Act of 1987 as the only site currently to be evaluated, is suitable for a geologic repository; (2) resolving the issue of acceptance of spent fuel from nuclear utilities in 1998; (3) developing more effective working relationships with external parties who have an interest in the waste disposal mission; and (4) establishing a new funding mechanism that will permit efficient and effective execution of our mission and achievement of our goals. This report contains details of the program's accomplishments and activities over the past fiscal year and the audited financial statements for the Nuclear Waste Fund.

309 (DOE/RW–0460) **OCRWM Bulletin, Winter 1995.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (United States). [1995]. 24p. Sponsored by USDOE, Washington, DC (United States). Order Number DE95008452. Source: OSTI; NTIS; INIS; GPO Dep.

This publication describes activities associated with the United States Department of Energy's Office of Civilian Radioactive Waste Program. Activities at the Yucca Mountain Site Characterization Project are described.

310 (EPRI-TR–104012) **A proposed public health and safety standard for Yucca Mountain: Presentation and supporting analysis. Final report.** Kessler, J.H. (Electric Power Research Inst., Palo Alto, CA (United States)); Yang, R.L. Electric Power Research Inst., Palo Alto, CA (United States); Risk Engineering, Inc., Boulder, CO (United States); Del Mar Consulting, Corpus Christi, TX (United States); Polestar Applied Technology, Inc., Los Altos, CA (United States). ©Dec 1994. 148p. Sponsored by Electric Power Research Inst., Palo Alto, CA (United States). Source: EPRI Distribution Center, 207 Coggins Drive, PO Box 23205, Pleasant Hill, CA 94523 (United States).

The National Academy of Science Subcommittee on the Technical Bases for Yucca Mountain Standards (TYMS Committee) requested public input on the technical bases for a performance standard for a potential geologic repository to dispose irradiated fuel and high-level radioactive waste at Yucca Mountain, Nevada. This report proposes a standard for Yucca Mountain and provides the technical bases for the proposed Standard. EPRI's analysis of the earlier EPA standard found it inappropriate from both a practical and public health protection standpoint. The public health and safety standard that EPRI proposes for Yucca Mountain has two parts. The first part proposes essentially complete containment for 1000 years; the second part is regulatory guidance based on limiting health risk in the long term. This second part requires probabilistic analysis of dose estimates to future populations living in the Yucca Mountain vicinity. This two-part Standard recognizes the difficulties of model prediction in the long term while maintaining a focus on what is most important in any regulatory standard-minimization of long-term human health risk.

311 (MIC–95-00953/XAB) **Final report of the AECL/SKB Cigar Lake analog study. AECL research No. AECL-10851.** Atomic Energy of Canada Ltd., Pinawa, MB (Canada). Whiteshell Labs. ©1994. 403p. Source: NTIS Prices: PC E19/MF E01.

AECL has conducted natural analog studies on the Cigar Lake uranium deposit in northern Saskatchewan since 1984 as part of the Canadian Nuclear Fuel Waste Management Program. This report provides background information and summarizes the results of the study, emphasizing the analog aspects and the implications of modelling activities related to the performance assessment of disposal concepts for nuclear fuel wastes developed in both Canada and Sweden. The study was undertaken to obtain an understanding of the process involved in, and the effects of, steady-state water-rock interaction and trace-element migration in and around the deposit, including paleo-migration processes since the deposit was formed. To achieve these objectives, databases and models were produced to evaluate the equilibrium thermodynamic codes and databases; the role of colloids, organics, and microbes in transport processes for radionuclides; and the stability of UO2 and the influence of radiolysis on UO2 dissolution and radionuclide migration.

312 (NUREG/CR–6221) **The Valles natural analogue project.** Stockman, H. (Sandia National Labs., Albuquerque, NM (United States)); Krumhansl, J.; Ho, C.; McConnell, V. Nuclear Regulatory Commission, Washington, DC (United States). Div. of Engineering; Sandia National Labs., Albuquerque, NM (United States). Dec 1994. 122p. Sponsored by Nuclear Regulatory Commission, Washington, DC (United States). DOE Contract AC04-94AL85000. (SAND–94-0650). Source: OSTI; NTIS; GPO; INIS.

The contact between an obsidian flow and a steep-walled tuff canyon was examined as an analogue for a highlevel waste repository. The analogue site is located in the Valles Caldera in New Mexico, where a massive obsidian flow filled a paleocanyon in the Battleship Rock tuff. The obsidian flow provided a heat source, analogous to waste panels or an igneous intrusion in a repository, and caused evaporation and migration of water. The tuff and obsidian samples were analyzed for major and trace elements and mineralogy by INAA, XRF, X-ray diffraction; and scanning electron microscopy and electron microprobe. Samples were also analyzed for D/H and $^{39}Ar/^{40}$ isotopic composition. Overall,the effects of the heating event seem to have been slight and limited to the tuff nearest the contact. There is some evidence of devitrification and migration of volatiles in the tuff within 10 meters of the contact, but variations in major and trace element chemistry are small and difficult to distinguish from the natural (pre-heating) variability of the rocks.

313 (NUREG/CR–6288) **Geochemical investigations related to the Yucca Mountain environment and potential nuclear waste repository.** Murphy, W.M. (Southwest Research Institute, San Antonio, TX (United States). Center for Nuclear Waste Regulatory Analyses); Pabalan, R.T. Nuclear Regulatory Commission, Washington, DC (United States). Div. of Regulatory Applications; Southwest Research Inst., San Antonio, TX (United States). Center for

Nuclear Waste Regulatory Analyses. Nov 1994. 192p. Sponsored by Nuclear Regulatory Commission, Washington, DC (United States). Source: OSTI; NTIS; GPO; INIS.

This report presents final results of the Geochemistry Research Project conducted at the Center for Nuclear Waste Regulatory Analyses (CNWRA) for the Nuclear Regulatory Commission (NRC) Office of Nuclear Regulatory Research. The study focused on experimental determinations and theoretical interpretations of fundamental thermodynamic and kinetic properties of minerals and reactions that characterize geochemical processes at the proposed nuclear waste repository site at Yucca Mountain and that could affect the capacity of the site to isolate nuclear waste. Technical results are presented in three major sections covering (i) cation exchange studies on clinoptilolite, (ii) kinetic and solubility studies on analcime and Na-clinoptilolite, and (iii) conceptual and numerical geochemical modeling of natural and repository systems. Experimental studies were designed to advance knowledge of the fundamental properties of the zeolite minerals clinoptilolite and analcime through controlled tests at 25°C, and to interpret the data in the context of the geochemical system at Yucca Mountain. Cation exchange equilibria were determined for clinoptilotite and binary solutions of Na^+ with K^+, Ca^{2+}, and Sr^{2+} at several solution concentrations. Results were interpreted using a Margules solid solution model for clinoptilolite coupled with a Pitzer activity coefficient model for aqueous solutions. Experimental data for analcime and clinoptilolite dissolution rates were interpreted using postulated rate mechanisms, and corresponding rate constants were determined. Dissolution rate data for analcime can be rationalized by alternate mechanisms which invoke either the presence of ultrareactive material or rate dependence on aqueous aluminum. Reversed solubility determinations were interpreted to obtain equilibrium constants for dissolution reactions and standard state Gibbs free energies of formation of the minerals.

314 (RIVM–715206005) **INTRAVAL phase 2, test case 8, Alligator Rivers Natural Analogue: Modelling of uranium transport in the weathered zone at Koongarra (Australia).** Van de Weerd, H.; Leijnse, A.; Hassanizadeh, S.M.; Richardson-van der Poel, M.A. Rijksinstituut voor Volksgezondheid en Milieuhygiene, Bilthoven (Netherlands). Apr 1994. 88p. Source: Available from RIVM, P.O. Box 1, 3720 BA Bilthoven (Netherlands).

The title research is part of the project 'International Model Validation' which is carried out within the framework of the phase 1A program of the Dutch Committee 'Opberging te Land' (OPLA) (Land Storage). Within the OPLA program the title study is part of the program 'Risks of Radioactive Waste Storage'.

The purpose of this study is to test the simulation package METROPOL, developed at RIVM to simulate transport of radionuclides over large time scales. At the Koongarra site secondary uranium mineralization and dispersed uranium is present from the surface down to the base of weathering. Field data are analyzed to choose a modelling approach, to estimate model inputs and to test model results. Field data show that three layers can be distinguished in the Koongarra area: (1) a top layer which is fully weathered, (2) an intermediate layer which is partially weathered (the transition zone) and (3) a lower layer which is unweathered. The groundwater velocities are largest in the transition zone which has been moving downward as the weathering process proceeds. The finite element code METROPOL has been adapted to account for the movement of the transition zone and to describe the dissolution of uranium in the orebody by a non-equilibrium relation. In simulations taking into account the downward movement of the transition zone, the dispersion patterns at all depths are simulated. These simulations result in a pseudo steady state situation. Despite the fact that the model results presented are not fully in agreement with the dispersion patterns, it is expected that the present situation may be obtained by changing some of the model parameters. In this study it was shown that over large timescales geologic processes may have an impact on the transport of radionuclides, and the movement of the transition zone will have an impact on the uranium concentration distribution. The simulation results are influenced by the parameters values, which are difficult to estimate for a period of some million years. The largest uncertainties are associated with the boundary conditions. Continuation of natural analogue studies in the framework of nuclear waste disposal research is highly recommended. 24 figs., 13 tabs., 2 appendices, 39 refs.

315 (RIVM–725206010) **INTRAVAL phase 2, test case 8. Alligator Rivers Natural Analogue. Modelling of uranium transport in the weathered zone at Koongarra, Australia.** Hassanizadeh, S.M. (National Inst. of Public Health and Environmental Protection RIVM, Bilthoven (Netherlands)); Van de Weerd, H.; Richardson-Van der Poel, M.A. Rijksinstituut voor Volksgezondheid en Milieuhygiene, Bilthoven (Netherlands). Jan 1993. 48p. Source: Available from RIVM, P.O. Box 1, 3720 BA Bilthoven (Netherlands).

The title research is part of the project 'International Model Validation' which is carried out within the framework of the phase 1A program of the Dutch Committee 'Opberging te Land' (OPLA) (Land Storage). Within the OPLA program the title study is part of the program 'Risks of Radioactive Waste Storage'.

Preliminary results of modelling of the dispersion of uranium in the weathered and transition zones are given. In the course of the Alligator Rivers Analogue Project (ARAP) more insight was gained about the formation of the dispersion fan and about the hydrology at Koongarra. The here applied transport modelling strategy takes into account those results. First, a general explanation of Natural Analogue is given, next to a brief description of the ARAP test case, carried out within the INTRAVAL phase 2. INTRAVAL is an international project concerned with the use of mathematical models for predicting the potential transport of radioactive solutes in the geosphere. Following is the analysis of chemical data, necessary for the choice of the modelling approach, for estimation of model inputs and for testing model results. Subsequently, the modelling strategy is expounded and a description is given of METROPOL, the transport code, used for modelling. 11 figs., 2 tabs., 1 appendix, 17 refs.

316 (SAND–94-2348C) **Use of a scenario-development procedure to identify potentially disruptive scenarios, Greater Confinement Disposal facility, Area 5, Nevada Test Site.** Guzowski, R.V. (Science Applications International Corp., San Diego, CA (United States)). Sandia National Labs., Albuquerque, NM (United States). [1994]. 9p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. (CONF-950216–59: Waste management '95, Tucson, AZ (United States), 26 Feb - 2 mar 1995). Order Number DE95007730. Source: OSTI; NTIS; INIS; GPO Dep.

The Greater Confinement Disposal (GCD) facility includes four boreholes that contain transuranic (TRLT) waste. Presence of the TRU waste means that this facility must comply

with the US Environmental Protection Agency's Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Waste-Final Rule 40 CFR Part 191. To comply with the Containment Requirements of this rule, all potentially disruptive events and processes, and by implication all potentially disruptive combinations of events and processes (scenarios), must be identified for possible inclusion in performance assessments. Screening of the FEPs identified four events for scenario development: exploratory drilling for natural resources, drilling withdrawal wells, irrigation, and subsidence. Recent environmental-isotope analyses of the vadose zone suggest that radionuclide transport from the boreholes to the water table by infiltration is not a feasible transport mechanism within the time frame of regulatory concern. For this reason, the event of drilling withdrawal wells was merged with exploratory drilling for resources. The descriptions of the remaining three events were modified slightly to aid in estimation of event probabilities and consequence analyses. The three events are: exploratory drilling for resources penetrates a TRU borehole, irrigation occurs at the Radioactive Waste Management Site (RWMS), and subsidence occurs at the RWMS. Use of a logic diagram with these three events resulted in the construction of eight scenarios, including base-case (undisturbed) conditions. Screening these scenarios at this stage of scenario development was beyond the scope of this task. Based on the implementation assumptions, this scenario-development procedure produced a comprehensive set of mutually exclusive scenarios that are reproducible and auditable for use in GCD performance assessments.

317 (SAND–94-2563/3) **Performance assessment of the direct disposal in unsaturated tuff of spent nuclear fuel and high-level waste owned by US Department of Energy. Volume 3, Appendices.** Rechard, R.P. (ed.). Sandia National Labs., Albuquerque, NM (United States). Feb 1995. 714p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. Order Number DE95010452. Source: OSTI; NTIS; INIS; GPO Dep.

This assessment studied the performance of high-level radioactive waste and spent nuclear fuel in a hypothetical repository in unsaturated tuff. The results of this 10-month study are intended to help guide the Office of Environment Management of the US Department of Energy (DOE) on how to prepare its wastes for eventual permanent disposal. The waste forms comprised spent fuel and high-level waste currently stored at the Idaho National Engineering Laboratory (INEL) and the Hanford reservation. About 700 metric tons heavy metal (MTHM) of the waste under study is stored at INEL, including graphite spent nuclear fuel, highly enriched uranium spent fuel, low enriched uranium spent fuel, and calcined high-level waste. About 2100 MTHM of weapons production fuel, currently stored on the Hanford reservation, was also included. The behavior of the waste was analyzed by waste form and also as a group of waste forms in the hypothetical tuff repository. When the waste forms were studied together, the repository was assumed also to contain about 9200 MTHM high-level waste in borosilicate glass from three DOE sites. The addition of the borosilicate glass, which has already been proposed as a final waste form, brought the total to about 12,000 MTHM.

318 (SAND–95-0271C) **A natural analogue for high-level waste in tuff: Chemical analysis and modeling of the Valles site.** Stockman, H.W. (Sandia National Labs., Albuquerque, NM (United States)); Krumhansl, J.L.; Ho, C.K.; Kovach, L.; McConnell, V.S. Sandia National Labs., Albuquerque, NM (United States). [1995]. 9p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AC04-94AL85000. (CONF-950216–76: Waste management '95, Tucson, AZ (United States), 26 Feb - 2 mar 1995). Order Number DE95008533. Source: OSTI; NTIS; INIS; GPO Dep.

The contact between an obsidian flow and a steep-walled tuff canyon was examined as an analogue for a high-level waste repository. The analogue site is located in the Valles Caldera in New Mexico, where a massive obsidian flow filled a paleocanyon in the Battleship Rock Tuff. The obsidian flow provided a heat source, analogous to waste panels or an igneous intrusion in a repository, and caused evaporation and migration of water. The tuff and obsidian samples were analyzed for major and trace elements and mineralogy by INAA, XRF, x-ray diffraction, and scanning electron microscopy and electron microprobe. Samples were also analyzed for D/H and $^{39}Ar/^{40}Ar$ isotopic composition. Overall, the effects of the heating event seem to have been slight and limited to the tuff nearest the contact. There is some evidence of devitrification and migration of volatiles in the tuff within 10 m of the contact, but variations in major and trace element chemistry are small and difficult to distinguish from the natural (pre-heating) variability of the rocks.

319 (SKB-TR–94-04) **Final report of the AECL/SKB Cigar Lake analog study.** Cramer, J. (ed.) (Atomic Energy of Canada Ltd. Research, Pinawa, MB (Canada). Whiteshell Labs.); Smellie, J. (ed.). Swedish Nuclear Fuel and Waste Management Co., Stockholm (Sweden). May 1994. 402p. (AECL–10851; COG–93-147.). Order Number DE95613252. Source: OSTI; NTIS; INIS.

The Cigar Lake uranium deposit is located in northern Saskatchewan, Canada. The 1.3-billion-year-old deposit is located at a depth of about 450 m below surface in a water-saturated sandstone at the unconformity contact with the high-grade metamorphic rocks of the Canadian Shield. The Cigar Lake deposit has many features that parallel those being considered within the Canadian concept for disposal of nuclear fuel waste. The study of these natural structures and processes provides valuable insight toward the eventual design and site selection of a nuclear fuel waste repository. The main feature of this analog is the absence of any indication on the surface of the rich uranium ore 450 m below. This indicates that the combination of natural barriers has been effective in isolating the uranium ore from the surface environment. More specifically, the deposit provides analog information relevant to the stability of UO_2 fuel waste, the performance of clay-based barriers, radionuclide migration, colloid formation, radiolysis, fission-product geochemistry and general aspects of water-rock interaction. The main geochemical studies on this deposit focus on the evolution of groundwater compositions in the deposit and on their redox chemistry with respect to the uranium, iron and sulphide systems. Since 1984, through cooperation from the owners of the Cigar Lake deposit, analog studies have been conducted. AECL, with support from Ontario Hydro under the auspices of the CANDU Owners Group, initiated international participation in 1989 through collaboration with the Swedish Nuclear Fuel and Waste Management Company (SKB) and, more recently, with the Los Alamos National Laboratory (LANL).

320 (USGS/OFR–94-491) **Meteorological data for four sites at surface-disruption features in Yucca Flat,**

Nevada Test Site, Nye County, Nevada, 1985–1986. Carman, R.L. Geological Survey, Carson City, NV (United States). 1994. 46p. Sponsored by USDOE, Washington, DC (United States). DOE Contract AI08-91NV11040. Order Number DE95004391. Source: OSTI; NTIS; INIS; GPO Dep.

Surface-disruption features, or craters, resulting from underground nuclear testing at the Nevada Test Site may increase the potential for ground-water recharge in an area that would normally produce little, if any, recharge. This report presents selected meteorological data resulting from a study of two surface-disruption features during May 1985 through June 1986. The data were collected at four adjacent sites in Yucca Flat, about 56 kilometers north of Mercury, Nevada. Three sites (one in each of two craters and one at an undisturbed site at the original land surface) were instrumented to collect meteorological data for calculating bare-soil evaporation. These data include (1) long-wave radiation, (2) short-wave radiation, (3) net radiation, (4) air temperature, and (5) soil surface temperature. Meteorological data also were collected at a weather station at an undisturbed site near the study craters. Data collected at this site include (1) air temperature, (2) relative humidity, (3) wind velocity, and (4) wind direction.

321 **Nuclear waste disposal: Gambling on Yucca Mountain.** Ginsburg, S. 153p. Aegean Park Press, Laguna Hills, CA (United States) (1995).

This document describes the historical aspects of nuclear energy ,nuclear weapons usage, and development of the nuclear bureaucracy in the United States, and discusses the selection and siting of Yucca Mountain, Nevada for a federal nuclear waste repository. Litigation regarding the site selection and resulting battles in the political arena and in the Nevada State Legislature are also presented. Alternative radioactive waste disposal options, risk assessments of the Yucca Mountain site, and logistics regarding the transportation and storage of nuclear waste are also presented. This document also contains an extensive bibliography.

322 **H.R. 2081: A Bill to prohibit site characterization of the Yucca Mountain site in the State of Nevada during fiscal years 1994 through 1998, and for other purposes. Introduced in the House of Representatives, One Hundred Third Congress, First Session, May 11, 1993.** 4p. Government Printing Office, Washington, DC (United States) (1994).

This bill provides that no amount of money may be expended from the Nuclear Waste Fund during fiscal years 1994-1998 for site characterization of the Yucca Mountain site in Nevada in conjunction with a nuclear waste policy reassessment.

323 **Thermoluminescence dating techniques at the Alligator Rivers Region Research Institute. Technical Memorandum 41.** Roberts, R.G.; Uren, C.J.; Murray, A.S. 56p. Australian Government Publishing Service, Canberra (Australia) (1993).

Techniques for dating Quaternary sediments have been developed, with specific application to fluvial and colluvial sand deposits in tropical northern Australia. In thermoluminescence (TL) dating, the age of the deposit is determined as a function of the 'equivalent dose' (ED), the quantity of ionizing radiation required to produce the observed natural TL intensity and the dose rate. To determine the ED, the 90-125 μm diameter quartz fraction of each deposit was used (following conventional quartz-inclusion pretreatment procedures) and adopted a combined additive-dose and regenerative methodology. For unheated sediments, the TL clock is reset by exposure to sunlight, but an unbleachable (residual) TL signal remains even after prolonged exposure. The residual TL signal at the time of sediment deposition was estimated from ED determinations on modern (surface and near-surface) deposits. By examining the potential of dating water-lain deposits by TL it was possible to obtain ages for a range of deposits that are widespread across northern Australia and are of particular relevance in assessing the long-term geomorphological stability of uranium mining waste sites. Radionuclide concentrations were deduced from high-resolution gamma and alpha spectrometry. which enabled disequilibrium in the uranium decay series to be identified and the time-dependent correction in the dose rate to applied. The latter was preformed using the computer program listed in Appendix A. 66 refs., 3 tab., 3 figs.

324 **Timely topics on spent fuel storage.** Selin, I. pp. 10-12 of 35th Annual meeting proceedings. Volume XXIII. Institute of Nuclear Materials Management, Northbrook, IL (United States) ([1994]). pp. 1360 (CONF-940748–: 35. annual meeting of the Institute of Nuclear Materials Management (INMM), Naples, FL (United States), 17-20 Jul 1994).

The history of spent fuel management in this country has taken several turns, with a final resolution still out of reach. Several repository programs started, stalled ans stopped. The latest effort at Yucca Mountain is progressing but, at best, is years from the early phases of licensing, much less the actual underground disposal of spent fuel. A monitored retrieval storage [MRS] facility was expected to start accepting commercial spent fuel beginning in 1998, but no such facility is clearly on the horizon. All of these recent developments changed the circumstances that we face in spent fuel management. The obvious conclusion is that an increasing number of plants, both operating and permanently shutdown reactors, will have to provide for additional spent fuel storage on-site for a longer period than originally planned, and even after plant decommissioning, prudence requires that provision be made for continual, stand-alone, on-site storage. After pool capacity is reached, most utilities opt for some sort of dry storage. But the dry storage option has triggered an unprecedented amount of local opposition at many sites, further taxing NRC and industry resources.

325 **Domestic and international nuclear waste management.** Jones, J. (Dept. of Energy, Washington, DC (United States)). pp. 36-45 of Global strategies for environmental issues. National Association of Environmental Professionals, Washington, DC (United States) (1994). pp. 749 (CONF-940650–: 19. annual conference and exposition of the National Association of Environmental Professionals (NAEP): global strategies for environmental issues, New Orleans, LA (United States), 12-15 Jun 1994).

Passage of the Nuclear Waste Policy Act in 1982, and subsequent 1987 amendments, allowed Congress to establish the plan to manage the nation's spent nuclear fuel and other high-level radioactive waste. The principal elements in the waste management system include waste acceptance, storage, disposal, and transportation. Interim storage of spent fuel is proposed to be in Monitored Retrievable Storage facility. Studies are being implemented for research and design of multipurpose canisters which will be used for the storage, transport, and disposal of spent nuclear fuel. The potential repository site for permanent disposal is located at Yucca Mountain, Nevada. Site characterization activities are currently being conducted. Underground construction has

started for the Exploratory Studies Facility; surface based activities are currently under way. Factors considered in this phase include environmental concerns, geologic parameters, public safety, local economic impacts and ease and cost of constructing and operating the facility. The United States is involved in cooperative studies with other countries regarding fundamental aspects of radioactive waste storage and disposal systems for high-level waste. Most emphasize assessment of long-term performance of permanent geologic repositories for spent nuclear fuel and high level waste. By participating in international activities, the United States has been involved in transfer of technological developments and information exchange. Most of the countries which produce electricity with nuclear power plants plan to dispose of the spent fuel within their own countries. The permanent disposal of high level waste for most countries will be in deep geological repositories. This paper will provide the status of the U.S. program in the storage and disposal of its nuclear waste. Strategies for addressing nuclear waste management in the domestic program will be compared to those of foreign countries. 6 refs.

326 **Disposition of actinides released from high-level waste glass.** Ebert, W.L. (Argonne National Lab., IL (United States)); Bates, J.K.; Buck, E.C.; Gong, M.; Wolf, S.F. pp. 231-241 of Ceramic transactions: Environmental and waste management issues in the ceramic industry II. Volume 45. Bickford, D.; Bates, S.; Jain, V.; Smith, G. (eds.). American Ceramic Society, Westerville, OH (United States) (1994). pp. 513 DOE Contract W-31109-ENG-38. (CONF-940416–: 96. annual meeting of the American Ceramic Society (ACS), Indianapolis, IN (United States), 25-28 Apr 1994).

The disposition of actinide elements released from high-level waste glasses into a tuff groundwater in laboratory tests at 90°C at various glass surface area/leachant volume ratios (S/V) between dissolved, suspended, and sorbed fractions has been measured. While the maximum release of actinides is controlled by the corrosion rate of the glass matrix, their solubility and sorption behavior affects the amounts present in potentially mobile phases. Actinide solubilities are affected by the solution pH and the presence of complexants released from the glass, such as sulfate, phosphate, and chloride, radiolytic products, such as nitrate and nitrite, and carbonate. Sorption onto inorganic colloids formed during lass corrosion may increase the amounts of actinides in solution, although subsequent sedimentation of these colloids under static conditions leads to a significant reduction in the amount of actinides in solution. The solution chemistry and observed actinide behavior depend on the S/V of the test. Tests at high S/V lead to higher pH values, greater complexant concentrations, and generate colloids more quickly than tests at low S/V. The S/V also affects the rate of glass corrosion.

327 **Fossil spring deposits in the southern Great Basin and their implications for changes in water-table levels near Yucca Mountain, Nevada, during quaternary time.** Quade, J. (Univ. of Arizona, Tucson, AZ (United States)); Mifflin, M.D.; Pratt, W.L.; McCoy, W.; Burckle, L. *Geological Society of America, Bulletin;* 107(2): 213-230 (Feb 1995).

The proposed high-level nuclear waste repository at Yucca Mountain will be located nearly 200-400 m above the modern water table. Water tables will rise in response to a future return to glacial climates, but the magnitude of the change - and the consequences for radionuclide travel times and overall repository integrity - are key uncertainties. Increased recharge during past pluvial periods in the Spring Mountains and Sheep Range caused water tables to rise and ground water to discharge over broad expanses of the Las Vegas Valley system, and in nearby Pahrump, Sandy, and Coyote Springs Valleys. The change in water-table levels since the last full glacial period varies between and within valleys, from as little as 10 m in several areas to 95 m in the Coyote Springs Valley. At Yucca Mountain, the water table has probably changed by $\leq$115 m in response to climate change. The spring deposits and the mollusk faunas found with them, often misinterpreted as lacustrine in origin, share many essential features with active spring systems in northeast Nevada. Deposits associated with discharge mainly consist of pale brown silt and sand that is entrapped by dense stands of phreatophytes covering valley bottoms when water tables are high. 81 refs., 13 figs., 6 tabs.

328 **Selection of slim hole core rods by vibratory analysis.** Eustes, A.W. III (Colorado School of Mines, Golden, CO (United States). Drilling Engineering Research Group); Mitchell, B.J.; Stoner, M.S. *Journal of Energy Resources Technology;* 116(4): 251-257 (Dec 1994).

Presented at the Sixteenth Annual Energy-Sources Technology Conference and Exhibition, Houston, Texas, January 31–February 4, 1993.

The purpose of this research was to determine the nature of the core rod vibrations and characterize their vibratory spectrums in order that an optimal core rod size could be chosen. The research was performed for the Yucca Mountain Site Characterization Project, US Department of Energy, Office of Civilian Radioactive Waste Management, which is directing the coring of boreholes at Yucca Mountain, Nevada. This paper describes the axial, torsional, and transient buckling vibratory models developed for the selection of optimum core rod size. The axial and torsional vibratory core rod simulator (VCRS) models are coupled by way of a transient buckling wave which propagates over the length of the core rod. This paper reports the frequencies and magnitudes of the stresses in the 101 core rod now in use. In addition, four core bit vibratory forcing functions for thrust and torque wee developed. The thrust and torque frequencies and magnitudes for the bit forcing functions were extracted from full-size laboratory core bit tests with fast Fourier transforms. The natural frequencies of the core rod were determined with closed-form solution models and were confirmed with a finite element model. Finally, a selection of core rod sizes were modeled to determine the best size to minimize damaging stress which stems from vibration.

329 **Socioeconomic studies of high-level nuclear waste disposal.** White, G.F. (Univ. of Colorado, Boulder, CO (United States)); Bronzini, M.S.; Colglazier, E.W.; Dohrenwend, B.; Erikson, K.; Hansen, R.; Kneese, A.V. *Proceedings of the National Academy of Sciences of the United States of America;* 91(23): 10786-10789 (8 Nov 1994).

The socioeconomic investigations of possible impacts of the proposed repository for high-level nuclear waste at Yucca Mountain, Nevada, have been unprecedented in several respects. They bear on the public decision that sooner or later will be made as to where and how to dispose permanently of the waste presently at military weapons installations and that continues to accumulate at nuclear power stations. No final decision has yet been made. There is no clear precedent from other countries. The organization of state and federal studies is unique. The state studies involve more disciplines than any previous efforts. They have

been carried out in parallel to federal studies and have pioneered in defining some problems and appropriate research methods. A recent annotated bibliography provides interested scientists with a compact guide to the 178 published reports, as well as to relevant journal articles and related documents.

330 Erosional stability of rehabilitated uranium mine structures incorporating natural landform characteristics, northern tropical Australia. East, T.J. (Bureau of Resource Sciences, Canberra (Australia)); Uren, C.J.; Noller, B.N.; Cull, R.F.; Curley, P.M. *Zeitschrift fuer Geomorphologie;* 38(3): 285-298 (Sep 1994). (In German).

Australian Government guidelines specify that tailings containment structures at rehabilitated uranium mines in the Alligator Rivers Region of tropical northern Australia should have an engineered structural life of 1000 years. As part of the containment structure design process, erosion plots incorporating both regional geomorphological characteristics (concave hillslope profiles and a weathering-resistant rock cover of schist) and more conventional engineering design parameters (straight slopes and mine waste rock) were constructed at the Ranger Uranium Mine. The plots were monitored for storm runoff, and concentrations of solutes, suspended solids and selected ions over successive wet seasons. The concave slopes (the hillslope analogues) had lower peak discharges and lower concentrations of suspended solids than the straight slopes. However, solute concentrations in runoff from the schist covered (hillslope) slopes were higher than from the waste rock covered plots. Solute (mainly magnesium sulfate) concentrations for both rock types decreased by about an order of magnitude over the wet season. High sulfate concentrations are also likely to decrease substantially after several wet seasons, due to settlement of the waste rock and a reduction in rates of weathering. Development of a vegetation cover on the rehabilitated landforms will reduce the high suspended sediment concentrations. These initial results suggest that rehabilitated uranium mine structures which utilise selected features of stable natural landforms in their design may have greater erosional stability than more conventionally engineered structures. (orig.)

331 Underground exploration and testing at Yucca Mountain. *Tunnelling and Underground Space Technology;* 9(3): 353-363 (Jul 1994).

Underground exploration and testing are major components of site-characterization efforts, under the direction of the U.S. Department of Energy (DOE), for an underground repository for high-level nuclear waste at Yucca Mountain, in Nevada. The DOE's current program involves extensive tunneling throughout the geologic block at Yucca Mountain, with the goal of gaining visual access to the complex geology at the site. This report reviews the status of the underground exploration and testing program, and reports the Nuclear Waste Technical Review Board's recommendations concerning future strategies for the exploration and testing program. 27 refs., 3 figs.

332 Impatient states ask court to goad DOE. *ENR;* 232(26): 9 (27 Jun 1994).

On June 20, 27 states asked a federal court in Washington to rule that the U.S. Department of Energy must begin removing spent nuclear fuel from its plants starting in January 1998 despite the current lack of a DOE storage facility for the high-level radioactive wastes. DOE has collected about $10 billion from power customers to cover costs of building storage facilities for waste from U.S. reactors starting in 1998. But it is not expected to open a permanent storage facility at Yucca Mountain, Nevada, until at least 2010, and has not yet sited an interim storage facility.

333 Potential for Oklo-Mounana type uranium deposit hosted by the Rio Fresco group in Brazil. Kobayashi, Takao (Power Reactor and Nuclear Fuel Development Corp., Toki, Gifu (Japan). Chubu Works). *Donen Giho (PNC Technical Review);* (90): 56-68 (Jun 1994). (In Japanese).

High grade uranium mineralization occurs in the Rio Fresco area, Southern Para, Brazil. The geological characteristics of this mineralization are similar to the Oklo-Mounana type uranium deposit in the Franceville basin, Gabon as; 1. Archean granitic rocks form the basement craton; 2. Lower Proterozoic unmetamorphosed sediments host the uranium mineralization; and 3. Uranium minerals occur in deformed/brecciated sandstone along fine fractures which are closely related to fault structures. Although some geological implications are left to be explained, it is believed that Oklo-Mounana type deposit may exist in the Rio Fresco area. (author).

334 The first detection of naturally-occurring ^{236}U with accelerator mass spectrometry. Zhao, X.L. (IsoTrace Laboratory, Department of Physics, University of Toronto, 60 St. George St., Toronto, Ontario (Canada)); Nadeau, M.J.; Kilius, L.R. *Nuclear Instruments and Methods in Physics Research, Section B;* 92(1-4): 249-253 (Jun 1994). (CONF-930960--: 6. international conference on accelerator mass spectrometry, Canberra (Australia), 17 Sep - 1 oct 1993).

The IsoTrace heavy element AMS system has been successfully used to detect naturally-occurring ^{236}U ($^{236}U/^{238}U=(5.6\pm1.5)\times10^{-10}$) in samples of uranium ore from Cigar Lake, Saskatchewan, Canada. This level of ^{236}U agrees with that previously claimed for samples of a processed uranium ore (D.J. Rokop, D.N. Metta and C.M. Stevens, Int. J. Mass Spectrom. Ion Phys. 8 (1972) 259 [1]), and is consistent with the amount of ^{239}Pu found in pitchblende (W.A. Myers and M. Lindner, J. Inorg. Nucl. Chem. 33 (1971) 3233 [2]). This experiment illustrates the general capability of a small tandem-based AMS system for analyzing actinides, in particular ^{236}U. It can be shown that the isotope-ratio detection limit of this system, is at present 5×10^{-8} for detecting a less abundant actinide isotope one mass unit above, and 5×10^{-10} one mass unit below, a major isotope. ((orig.))

335 Nuclear waste's human dimension. Erikson, K. (Yale Univ., New Haven, CT (United States)); Colglazier, E.W.; White, G.F. *Forum for Applied Research and Public Policy;* 9(3): 91-97 (Fal 1994).

The United States has pinned its hopes for a permanent underground repository for its high-level nuclear wastes on Yucca Mountain, Nevada. Nevertheless, the Department of Energy's (DOE) site research efforts have failed "to adequately consider human behavior and emotions," write Kai Erikson of Yale University, E. William Colglazier of the National Academy of Sciences, and Gilbert F. White of the University of Colorado. The authors maintain that it is impossible to predict changes in geology, seismology, and hydrology that may affect the Yucca Mountain area over the next 1,000 years. Predicting human behavior in that time frame remains even more daunting, they insist. They admit that "DOE...has been given the impossible assignment to take tens of thousands of metric tons of the most hazardous materials ever created and, in the face of growing opposition, entomb them so that they will do little harm for

thousands of years." The researchers suggest that the government seek a secure, retrievable storage arrangement while it continues its search for safer long-term options.

336 **Predicted gas-phase movement of carbon-14 from a radioactive waste repository.** Ross, B. (Disposal Safety, Inc., Washington, DC (United States)); Amter, S.; Lu, N. *Radioactive Waste Management and Environmental Restoration;* 19(1-3): 97-106 (1994).

Special issue Yucca Mountain.

The migration of radioactive $^{14}CO_2$ gas to the atmosphere is a potentially important mechanism for the release of radioactivity from the potential nuclear waste repository at Yucca Mountain, Nevada. Finite-difference computer simulations of gas circulation within Yucca Mountain suggest that the travel time of ^{14}C gas from a hot repository to the atmosphere may be less than 10,000 yr. (author) 5 figs., 10 refs.

337 **Outlook remains dim for waste solution.** Parker, F.L. *Forum for Applied Research and Public Policy;* 9(3): 98-102 (Fal 1994).

When Congress selected Yucca Mountain as the proposed site for storing the nation's high-level nuclear waste, this isolated piece of real estate in Nevada became the focus of national debate about the long-term safety and feasibility of underground storage, writes Frank L. Parker, a professor in environmental engineering at Vanderbilt University. "While scientific knowledge will increase in the future, it is unlikely that we will ever achieve full understanding of the long-term movement of radioactive waste that must remain buried for hundreds of thousands of years," says Parker. Parker maintains that the battle over the future of Yucca Mountain has proved that local communities should have a strong voice in the site-selection process, and, once a site is chosen, people who live nearby should be compensated for the burden they bear.

338 **High-level waste: View from Nevada.** Miller, B. *Forum for Applied Research and Public Policy;* 9(3): 103-105 (Fal 1994).

"Instead of acknowledging the serious shortcomings of the current waste program, the Department of Energy (DOE) has sought to tighten the screws on Nevada," says Nevada Governor Bob Miller. Nevada's opposition to the federal government's proposed high-level radioactive waste repository at Yucca Mountain has grown out of fundamental flaws within the siting process, says Miller. "This process has left the nation with one technically flawed site as its sole prospect for nuclear waste disposal," he says. Miller claims that DOE has acknowledged that the site is inadequate. Nevertheless, he says, the agency has insisted on pressing ahead with its plans, attempting to "adjust the standards to fit the site." Miller concludes that dry and/or above-ground waste storage at reactor site represents a more sensible - and less costly - disposal method for high-level wastes, at least in the short term.

339 **Oklo: fossil nuclear reactors.** Naudet, R. *Memoires de La Societe Geologique de France;* (162): 111-118 (1994). (In French). (CONF-9211338--: Colloquium acts on atom and geology, Paris (France), 25-26 Nov 1992).

Nearly two billions years ago, fission chain reactions set up spontaneously in small portions of a uranium deposit in Gabon, and were sustained for sufficiently long periods for the isotopic compositions of many elements to be deeply modified. These natural reactors were found remarkably preserved. Through neutronic analysis, the operating conditions were reconstituted: during reactions, heat release turned out in convection streams, which dissolved quartz and so eliminated large amounts of silica, densifying uranium and deeply modifying geometry and composition of the rocks; reactors were mainly controlled by temperature which modified water density. 3 figs., 1 tab., 5 refs.