State of Nevada Briefing to the Nuclear Waste Technical Review Board (NWTRB)

Subject: Geochemical Concerns of the Proposed Nuclear Waste Repository, Yucca Mountain, Nevada

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Problem

To determine the Ability of the Surface Volcanic Tuffs to Isolate Radionuclides from the Accessible Environment.

Retardation Credit

- Retardation credit is needed for radionuclides that require isolation in the host rock in order for the Repository to meet Regulatory critera. These radionuclides that require isolation are considered *Key Radionuclides*.
- Isolation can be accomplished by: Sorption, Precipitation, Ion Exclusion, and Diffusion mechanisms.

Key Radionuclides

Key Radionuclides	Mechanism of Possible Release
Actinides*: • Plutonium • Americium • Neptunium	Ground Water Travel
Technetium*	Ground Water Travel
Carbon-14	Gas Transport

* After A.D. Kelmers, ORNL-WS 41476.

Mineralogy-Related Parameters Necessary for a Retardation Barrier

Parameter	Comments
Suitable Mineralogy	Zeolites*, Clays, Fe & Mn Oxyhydroxides
Mineral Stability	Ambient Temperatures, low Na water, high Silica activity
Mineral Accessibility	**Open pores lined with suitable minerals in likely path of travel combine with:** • A significant volume of sorbing minerals • Mineral crystals oriented so that sorbing crystal faces are exposed to passing liquids. **This is a function of:** • Crystal orientation • No nonsorbing mineral overgrowths

* Sorbing zeolites such as clinoptilolite, mordenite, and heulandite.

Zeolite Stability

- As the concentration of sodium in water that contacts clinoptilolite increases, the stability of clinoptilolite as a function of temperature decreases. Clinoptilolite converts to the nonsorbing zeolite analcime. Silica activity also affects clinoptilolite stability.

- If the sodium concentration is held constant and at the level of J-13 water at Yucca Mountain, then the clinoptilolite conversion to analcime will probably take place at a temperature of about 90 degrees Centigrade. At temperatures between 60 and 90 degrees Centigrade, there would be a reduction of the clinoptilolite unit cell volume and therefore a partial loss of sorption capabilities, therefore retardation would be affected.

- Heulandite is not stable in the present day Yucca Mountain saturated zone as indicated by recent studies by Los Alamos on J-13. Repository induced changes to Yucca Mountain will affect minerals that are presently stable.

Other Parameters Affecting A Retardation Barrier

Parameter	Comments
Mass Action Competition	Clinoptilolite Exchange Preferences: Cs > K > Sr = Ba > Ca >> Na > Li Mordenite Exchange Preferences: Cs > K > NH4 > Na > Ba > Li NOTE: Cation exchange and thermal stability are both affected by cations present in the structures.
Colloid Formation	Example: Actinide transport
Multiple Speciation	Example: Actinides of various oxidation states.
Fracture Flow Predominant	Insignificant exposure to sorbing minerals. Low unit per unit residence time.
Nonsorbing Radionuclides	Most probably the actinides and Technetium.
Soil Gas Circulation	Known pressure differential in vadose zone create blowing wells - Radionuclide gas transport through open fractures and faults.

If

- Sorption credit is to be taken

The Most Likely Path of Travel

Must Be:

- Geochemically Stable
- Composed of actively sorbing minerals
- A slow path of travel

If the Most Likely Path of Travel is:

IF	THEN
Fracture Flow	No sorption is expected because there are not enough sorbing minerals present along fracture pathways. Sorption credit is needed for site licensing.
Matrix Flow	Sorption is expected for non-key radionuclides. Transport is generally so slow that sorption credit for these radionuclides are not needed for licensing.
Selective Matrix Flow (preferential pathways)	Limited sorption is expected for non-key radionuclides. Transport may be rapid and sorption credit is needed for licensing.

A TENTATIVE CONCLUSION might be that when sorption/ retardation is really needed, it is not available and when it is not needed it is available on a limited basis.

Conclusions

The ability to determine whether or not there will be sufficient isolation of radionuclides from the accessible environment rests on the following concerns:

- Actinides do not appear to respond to sorption as a mechanism for retardation. Precipitation on the canisters or repository tuffs will depend upon unknown local conditions. Colloid formation is expected. It is doubtful that actinide retardation can be adequately characterized on a site-specific basis.
- Technetium is expected to stay in solution.
- Sorption of the other radionuclides (except actinides and vapor phase radionuclides) probably can be significant under idealized conditions at the Calico Hill Formation (below the proposed repository horizon) if the following conditions are met: There is no fracture flow, low sodium and high silica concentrations in the pore waters, and temperatures are at or below 60 degrees C. Transport by preferred channeling (selective matrix flow) may reduce sorption capacity by reducing exposure to sorbing minerals.
- Vapor phase radionuclide transport of C-14 is expected. No retardation mechanism has been identified yet.

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VITAE

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EDUCATION:

Ph.D., 1974, University of Hawaii, in Geology and Geophysics.
M.S., 1969, Syracuse University, in Geology.
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New Mexico Institute of Mining and Technology (NMIMT).

PROFESSIONAL EXPERIENCE:

Chairman and Research Scientist, Mifflin & Associates, Inc., Las Vegas Nevada, June 1986 to present.
Consultant, Desert Research Institute, Water Resources Center, University of Nevada System, 1984-June 1986.
Senior Geologist, Geophysicist, Director of Operations, Brim Partnership, placer gold mining operation, Lake Havasu, Arizona, 1982-1984.
President, Hawaii Marine Research, Corporation, Honolulu, Hawaii, 1974-1982.
Consultant, Altman & Vanairsdale, Attorneys-at-Law, Hilo, Hawaii, Economic Geology, 1978 to present.
Affiliate Faculty of the Graduate School of the University of Hawaii, 1976-1979.
Consultant, State of Hawaii, Department of Land and Natural Resources, Division of State Parks, 1977.
Aquatic Biologist, State of Hawaii, Department of Fish and Game, Honolulu, Hawaii, 1976-1977.
Consultant, Energy Resources, Pacific Marine and Supply Co., Honolulu, Hawaii.
Director of Research, Commercial Division, Pacific Analysis Corporation, Honolulu, Hawaii, 1976.
Assistant Oceanographer, University of Hawaii, 1975.
Assistant Researcher, Research Corporation of the University of Hawaii, 1974-1975.
Ferromanganese Program Coordinator, State Program, University of Hawaii, 1973-1975.
Research Assistant, Research Corporation of the University of Hawaii, 1972-1974.
Chief Scientist - R/V Kana Keoke, 1972-1974.
Lecturer - University of Hawaii, 1972.
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Assistant in Geophysics, University of Hawaii, 1969-1972.
Lecturer - Utica College, 1968-1969.
Lecturer - Department of Geology, Rutgers University, NSF Summer Institute, 1967.
Teaching Assistant - Syracuse University, 1967-1969.
Chief Geologist - R/V Conrad, 1965-1969.
Assistant in Research, Lamont-Doherty Geological Observatory of Columbia University, 1964-1969.

PROFESSIONAL AFFILIATIONS:

American Association for the Advancement of Science
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International Association of Sedimentologists
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PUBLICATIONS:

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CONSULTANT PUBLICATIONS:

Morgenstein, Fein, Andrews, Deepsea Ocean Mining for AMAX, Denver, Colorado.

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Morgenstein and HMR archaeologists, various publications Geoarchaeology of Kaho'olawe, Maui County, Hawaii, for State of Hawaii, Department of Parks.

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Morgenstein, Geoarchaeology, Chemical Stratigraphy, Micropaleontology, Hydration-rind Dating, various publications, Society Islands, Hawaiian Islands, Samoa, Easter Island, etc., Bernice Pauahi Bishop Museum, Honolulu, Hawaii.

Morgenstein, Geoarchaeology, Hydration-rind Dating, Micropaleontology with various archaeologists, various publications, Maui, Oahu, Hawaii, Molokai, Kauai, archaeological sites for U.S. Army Corps of Engineers and for State of Hawaii, Department of Parks.

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Morgenstein, Reviews of various DOE and DOE contractors, NRC, USGS, and other publications and reports.

PATENTS:

2 U.S. Patents in Deep-Sea Mining Equipment, concepts:

1) Morgenstein, Elevator Apparatus; and

2) Andrews and Morgenstein, Concept of Full Mining System.