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at Yucca Mountain, Nye County, Nevada

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Secondary Mineral Evidence of Large-Scale Water Table Fluctuations at Yucca Mountain, Nye County, Nevada

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At Yucca Mountain, which is currently under consideration as a potential permanent underground repository for high-level radioactive wastes, the present-day water table is 500 to 700 m deep (Luckey et al., 1996). This thick unsaturated zone (UZ) is part of the natural barrier system and is regarded as a positive attribute of the potential site.

The USGS has studied the stable isotopes and petrography of secondary calcite and silica minerals that coat open spaces in the UZ and form irregular veins and masses in the saturated zone (SZ) (Szabo and Kyser, 1990; Whelan et al., 1994). These studies have revealed a thick barren zone in which secondary mineral occurrences are rare. This barren zone extends from about 100 m above to more than 300 m below the present water table (fig. 1). Shallow ground waters beneath Yucca Mountain are undersaturated with respect to calcite (Benson and McKinley, 1985) and have the potential to dissolve calcite along active flowpaths in this interval. The rare occurrences of secondary calcite in this barren interval appear to have formed at times when the water table was much lower than at present.

Strontium isotope studies of secondary calcite within Yucca Mountain (Marshall et al., 1993), and regional analysis of ground water discharge deposits indicate that water table elevations were higher in the past (Quade et al., 1995). Discharge deposits at paleospring sites in southern Crater Flat, 15 to 20 km southwest of Yucca Mountain, indicate at least a 100 m rise in the water table during the late Pleistocene (Paces et al., 1997). Past water table rises beneath Yucca Mountain of ~100 m are likely and a possible explanation for the paucity of secondary minerals within the lower UZ, although Ca depletion in the zeolitic tuffs through cation exchange may produce calcite undersaturation of percolating waters. Only drillhole USW G-2 contains significant amounts of calcite within the lower 100 m of the UZ.

Drusy coatings of free-growing calcite and silica phases formed in the UZ from surface percolation fluxes moving down fracture footwalls and, locally, collecting on the floors of lithophysal cavities. Most UZ calcite $\delta^{13}\text{C}$ values, which are generally between -9 and +2‰, indicate derivation of solutes from the overlying soils during infiltration (fig. 1). Local occurrences of early calcite from UZ exposures in drill core and the Exploratory Studies Facility have anomalously heavy $\delta^{13}\text{C}$ values (as high as 9‰) that are inconsistent with soil organic matter as the sole carbon source.

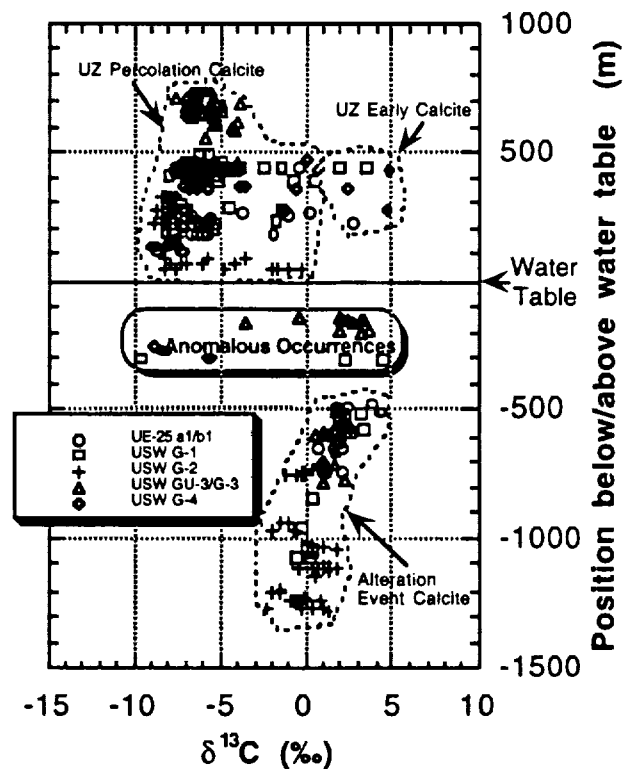


Figure 1. Stable C and O isotopic compositions of calcite, plotted with respect to the water table, from boreholes collared on the crest or eastern flank of Yucca Mountain. Fields discussed in text are outlined and labeled.

- Quade, J., Mifflin, M.D., Pratt, W.L., McCoy, W., and Burckle, L., 1995, Spring deposits and water table levels in the southern Great Basin during the Quaternary: *Geol. Soc. Amer. Bulletin*, v. 107, p. 213-230.
- Roedder, Edwin, J.F. Whelan, and Vaniman, D.T., 1994, Fluid inclusion homogenization and crushing studies of calcite veins from Yucca Mountain, Nevada, Tuffs: Environment of formation: in *Int'l High-Level Radioact. Waste Man. Proc., ASCE and ANS, 5th Internat. Conf., Las Vegas, Nevada*, p. 1854-1860.
- Szabo, B.J., and Kyser, T.K., 1990, Ages and stable-isotope compositions of secondary calcite and opal in drill cores from Tertiary volcanic rocks of the Yucca Mountain area, Nevada; *Geol. Soc. Amer. Bulletin*, v. 102, p. 1714-1719.
- Whelan, J.F., Vaniman, D.T., Stuckless, J.S., and Moscati, R.J., 1994, Paleoclimatic and paleohydrologic records from secondary calcite: Yucca Mountain, Nevada: in *Int'l High-Level Radioact. Waste Man. Proc., ASCE and ANS, 5th Internat. Conf., Las Vegas, Nevada*, p. 2738-2745.

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7	Session VII: Yucca Mountain Modeling B Session Chair: Russell Patterson, DOE/YMSCO G.S.Bodvarsson, Y-S.Wu, H.G.Wilshire, T.Buscheck
8	Round Table Discussion Moderator: Paul Witherspoon



FTAM workshop

Field Testing and Associated Modeling of Potential High-Level Nuclear Waste Geologic Disposal Sites
December 15 and 16, 1997, Nuclear Waste Department, Lawrence Berkeley National Laboratory, Berkeley California

Underground Testing and Modeling At Yucca Mountain

- **Monday, December 15, 1997, 8:00am-5:00pm, Building 66, Auditorium, LBNL**

Session I: Yucca Mountain Field Testing

Session Chair: William Boyle, DOE/YMSCO

8:00am-8:20am: Welcome Bo Bodvarsson / Maryann Villavert, LBNL

8:20am-8:50am: Invited speaker

Progress in Field Testing and Modeling Activities at the Yucca Mountain Site,

J. R. Dyer DOE/YMSCP, 1180 Town Center Drive, Las Vegas, NV 89134, USA MS 523/HL-523

8:50am-10:30am

Flow Tests to Quantify Seepage into Drifts,

J. S. Y. Wang, P.J. Cook, R.C. Trautz, and G. S. Bodvarsson, Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 90-1116, Berkeley, CA 94720, USA

A Sensitivity Study on the Probability of Seepage Into Drifts at Yucca Mountain,

J. Birkholzer, G. Li, C-F. Tsang, Y. Tsang, Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 90-1116, Berkeley, CA 94720, USA

Analysis of Uncertainty for 2-D Fracture Flow and Seepage Into an Excavated Drift,

A. L. James, C. Oldenberg, and S. Finsterle, Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 90-1116, Berkeley, CA 94720, USA

The Drift Scale Heater Test at Yucca Mountain, Nevada,

M. Peters, R. Datta, and R. Wagner, M&O; *W. Boyle and R. Yasck*, DOE/YMSCP, 1180 Town Center Drive, Las Vegas, NV 89134, USA, and *N. Elkins and D. Weaver*, Los Alamos National Laboratory, Los Alamos, NM 87545, USA.

Predicting Changes in Rock Mass Permeability Due to Thermal-Mechanical Effects,

S. C. Blair, P. A. Bergel, Lawrence Livermore National Laboratory, Livermore, CA 94551, and *H. F. Wang*, University of Wisconsin-Madison, Madison, WI 53706-1692

Measurement and Modeling of Two-Dimensional Unsaturated Zone Water Fluxes Near Buried Radioactive Waste at the Idaho National Engineering and Environmental Laboratory.

J. R. Nimmo, K. S. Perkins, M. A. Denton, S. M. Shakofsky, and J. F. Kaminsky, USGS, MS-421, 345 Middlefield Road, Menlo Park, CA 94025, USA

Time-Dependent Changes in the In Situ Hydrologic Properties of a Shear Zone.

P. Talwani, Department of Geological Sciences, University of South Carolina, 701 Sumter Street, Columbia, SC 29208, USA

3:30pm-3:45pm Break

Session IV: Yucca Mountain Hydrochemistry

Session Chair: Ned Elkins, M&O/LANL

3:45am-5:30pm

Use of Air-Flow and Rock-Gas Chemistry Data From Boreholes Open in the Unsaturated Zone to Estimate Permeability and Effective Air-Filled Porosity.

E. P. Weeks, G. L. Patterson, and D. C. Thorstenson, USGS, Box 25046, MS 413, Denver Federal Center, Lakewood, CO 80225, USA

Stable Isotope and Carbon-14 Data From Unsaturated-Zone Cores at Yucca Mountain.

I.C. Yang, USGS, Box 25046, Federal Center, MS 421, Lakewood, CO 80225, USA

Evolution of Ground Water Chemistry in a Deep Vadose Zone in Silicic Volcanic Rocks in an Arid Environment.

A Meijer, Los Alamos National Laboratory, Los Alamos, NM 87545, USA

Hydraulic Inferences from Strontium Isotopes in Pore Water From the Unsaturated Zone at Yucca Mountain, Nevada.

B. D. Marshall, K. Fusa, and Z. E. Peterman, USGS MS 963, Denver, CO 80225-0046, USA

Secondary Mineral Evidence of Large-Scale Water Table Fluctuations at Yucca Mountain, Nye County, Nevada.

J. F. Whelan and R. J. Moscati, USGS, PO Box 25046, MS 963, Denver Federal Center, Denver, CO 80225, USA

● **Tuesday, December 16, 1997, 8:00am-5:00pm, Building 66, Auditorium, LBNL**

Session V: International Papers

Session Chair: Paul Witherspoon, LBNL/UCB

8:20am-8:50am Invited Speaker:

From Field Data to the Evaluation of a Potential Site for Deep Geological Disposal: The Role of Groundwater Flow Models.

S. Vomvoris, P. Vinard and P. Maschall, Nagra, Hardstrasse 73, CH-5430, Wettingen, Switzerland

FTAM Program-Lawrence Berkeley National Laboratory, December 15 - 16, 1997

Synthesis of Environmental Tracer Data and Numerical Simulations Test Models of Flow and Transport at Yucca Mountain,

A. Wolfberg, J. Fabryka-Martin, G. Roemer, S. Levy, Los Alamos National Laboratory, Los Alamos, NM 87545, USA, and D. Sweetkind

12:30pm-1:45pm Lunch

Session VII: Yucca Mountain Modeling B

Session Chair: Russell Patterson, DOE/YMSCO

1:45pm-3:30pm

A Site-Scale Model for Modeling Unsaturated Zone Processes at Yucca Mountain Nevada,

G. S. Bodvarsson, Y-S. Wu, E. L. Sonnenthal, M. Bandurraga, C. Ahlers, C. Haukwa, J. Fairley, J. Hinds, and A. Ritscy Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 90-1116, Berkeley, CA 94720, USA

A modeling Study of Perched Water Phenomena in the Vadose Zone,

Y-S. Wu, A. C. Ritscy, G. S. Bodvarsson, Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 90-1116, Berkeley, CA 94720, USA

Integrated Radionuclide Transport Models for the Potential Repository at Yucca Mountain,

B. A. Robinson, K. H. Birdsell, C. W. Gable, A. V. Wolfberg, G. A. Zvoloski, Los Alamos National Laboratory, Los Alamos, NM 87545, USA

Unsaturated Zone and Groundwater and Groundwater Contamination at Two Western US Low-Level Radioactive Waste Disposal Sites: A Review,

H. G. Wilshire, 1348 Isabelle Avenue, Mountain View, CA 94040, USA, and I. Friedman, 2620 Vivian Street, Lakewood, CO 80215, USA

Numerical Simulations of Thermohydrological Process at YM.

T. Buscheck, Lawrence Livermore National Laboratory, Livermore, CA 94551, USA

3:30pm-3:45pm Break

3:45pm-5:30pm Round Table Discussion

Moderator: Paul Witherspoon