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Progress Report

Research and Development Related to the Nevada Nuclear Waste Storage Investigations

July 1—September 30, 1979

University of California

LOS ALAMOS SCIENTIFIC LABORATORY
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This report was prepared by the Los Alamos Scientific Laboratory as part of the Nevada Waste Storage Investigations managed by the Nevada Operations Office of the US Department of Energy. Based upon their applicability to the investigations, some results from the Radionuclide Migration Project, managed by the Nevada Operations Office of the US Department of Energy, are included in this report.

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RESEARCH AND DEVELOPMENT RELATED TO THE NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS

July 1 - September 30, 1979

Compiled by

Bruce M. Crowe

ABSTRACT

Sorption under anoxic conditions is reported for core samples of tuff from exploratory drill hole UE25a-1. Sorption for Sr, Cs, Ba, Ce, and Eu is somewhat lower in an atmosphere of pure nitrogen than in the ambient atmosphere, but generally by less than a factor of two. Uranium and technetium sorb poorly in the nitrogen environment; however, an increase over atmospheric conditions is noted for Tc. Final results for sorption of Pu and Am on core samples from drill hole J-13 are presented, and special problems with Am are discussed. The effect of ground water composition is being investigated with two artificial ground waters, and this variable is found to be a major factor in sorption. Autoradiographic studies indicate that Pu sorbs indiscriminately on rock thin sections and that Np deposits in aggregate form. Zeolite minerals are present within two distinct horizons of tuff in the stratigraphic section penetrated by exploratory drill hole UE25a-1. The horizons occur in low density tuff (partially to nonwelded and bedded tuff) within the lower part of and stratigraphically below Paintbrush Tuff. Zeolite minerals include clinoptilotite and minor amounts of low silica, high alkali mordenite. The zeolite occurrence and mineralogy is characteristic of low temperature (<100°C) ground water alteration of glass in an open hydrologic system. Prototype containment vessels for the hydrothermal soak tests have been assembled and tested. Regional studies of the occurrence and tectonic setting of Plio-Pleistocene age basaltic volcanic centers of the southern Great Basin are in progress. Revised volcanic disruption probability calculations for a 60-km radius circle centered around Yucca Mountain fall into the range of 10^{-9}/year. Petrographic and geochemical data for the basalts of Crater Flat show a strong control of basalt type with structural setting. Models of crystal-liquid fractionation of the basalts of Crater Flat using observed phenocryst phases cannot account for chemical variations of basalt types. Chemical variability probably reflects deep-seated compositional control due to differences in source region compositions or melting regimes. Quality assurance programs were documented for G-6 and CNC-11. LASL personnel were presented a Quality Assurance indoctrination and training session by Quality Assurance personnel. A Quality Assurance Program was presented to USGS management for approval.

I. MEDIA INVESTIGATIONS: (Subtask 3.2.2)

A. Geochemical Studies (CNC-11)

Sorption-desorption experiments using tuff from core samples YM-22, -38, and -54 from hole UE25a-1 in a nitrogen atmosphere (<0.2 ppm oxygen) are in progress. Solid samples were ground in the nitrogen atmosphere and separated in two fractions, <75 μm and 75 to 500 μm. Ground water from drill hole J-13 was pre-equilibrated with each of the three samples using pulverized material that had not been sieved. Tracer solutions were prepared using these waters. Sorption of ^{85}Sr, ^{133}Ba, ^{137}Cs, ^{141}Ce, and ^{152}Eu was to be determined at 3-, 6-, and 12-week contact times. Three- and 6-week sorption experiments have been completed and calculations of the 3-week sorption determinations are finished. Although the R_d values of ^{85}Sr, ^{133}Ba, ^{137}Cs, ^{141}Ce, and ^{152}Eu are somewhat lower in nitrogen conditions than in air, they generally agree within a factor of about two. The R_d values under anoxic conditions vary with fraction size, the smaller fraction having a larger value.

Core samples YM-22, YM-38, and YM-54 from exploratory drill hole UE25a-1 were ground in the nitrogen environment, penetrated with the appropriate ground water which had been sparged with high purity N_2 and contacted with ground water containing $\sim 10^{-12}$ M ^{95m}Tc. The phases were separated after 3- and 6-week contact times, and an aliquot of each phase was removed for counting. The average R_d value was $\sim$2.5 mℓ/g (with values ranging up to 4.7 mℓ/g) at 3 weeks and 5.8 mℓ/g (with values ranging up to 16.5 mℓ/g) at 6 weeks. We previously reported results with tuff samples and ^{95m}Tc under atmospheric conditions, where the average sorption R_d was 0.22 mℓ/g for a contact time of 6 weeks. Thus, the average sorpton ratio of ^{95m}Tc on the tuffs studied was approximately thirty times larger under nitrogen. Measurements with contact times of 12 weeks are in progress and will give additional information on the apparent trend of increasing the technetium R_d with time in the nitrogen environment.

Sorption of uranium, starting with U(VI), was also measured for tuff samples from hole UE25a-1 under nitrogen. Uranium sorbs poorly and all sorption ratios are <20 mℓ/g. A small increase with time and decreasing particle size (<75 μm vs. 75 to 500 μm) was noted, but errors are too large to quantify these observatons. Material from core sample YM-38 sorbs better than material from samples YM-54 or YM-22 by factors of ten and thirty, respectively. Comparison

with sorption under atmospheric conditions will be made when the latter data are available.

The final results for the batch measurements of the sorption of Pu and Am tuff core samples from drill hole J-13 are summarized in Table I. Data have been revised and updated from those presented in the last quarterly report. Sorption ratios were averaged over available data (4 experiments); contact times ranged from 1 to 8 weeks, particle sizes from 106 to 150 and 355 to 500 μm, with Pu concentrations of $\sim 10^{-6}$ M and $\sim 10^{-13}$ M. The quoted R_d values were calculated from direct counts of the solids and aliquots of the aqueous phases after they were centrifuged but without being filtered.

Batch measurements of the sorption of ^{237}Pu on three Yucca Mountain tuff samples under a nitrogen atmosphere are in progress. One set of samples was contacted with traced feed solutions for 3 weeks. Phases were separated and counted; data analysis is in progress. Untraced ground water was added to the spiked solid phases and desorptions were started. Two sets of the original

TABLE I

AVERAGE SORPTION RATIOS (mℓ/g) FOR Am AND Pu[a]

Element	Core	Temp. (°C)	Dried Feed Preparation		pH Adjusted Feed Preparation	
			Sorption	Description	Sorption	Description
Am	JA-18	22	180(30) 70	1 100(260) 230(30)	435(6) 3 400(300)	960(15)
	JA-32	22	130(30) 70	2 200(650) 110(30)	1 100(120)	2 300(310)
	JA-37	22	670(210) 70	17 000(3 500) 970(240)	8 800(1 100) 34 000(6 000)	12 000(2 000) 5 300(720)
Pu	JA-18	22	140(30)	350(140)		
	JA-32	22	~110		1 200(210)[b]	750(170)
	JA-37	22	280(100)		3 300(1 200)[b]	3 800(950)

[a]Values in parentheses are the standard deviations of the means (absolute values).

[b]Value appeared in wrong column in April 1-June 30, 1979 quarterly report (NVO-196-11 and LA-7974-PR).

samples are being contacted for 6 and 12 weeks for determination of sorption values.

Several samples of tuff from test well J-13 have been contacted with ground water traced with ^{241}Am for 6 months to observe "long term" effects. The experiment is complete except for data analysis. Desorptions have been started.

As mentioned in the previous quarterly report, crushed-rock, and ground water mixtures are separated after contact in Pu and Am batch sorption experiments by centrifuging the aqueous phase three times for at least one hour at $\geq$12,000 rpm followed by careful transfer of the water following each centrifuging. This process produces Pu solutions which generally can be passed through a polycarbonate filter membrane with pores as small as 0.05 µm without removal of activity. Americium activity is normally removed by filtering such centrifuged solutions. A microautoradiographic technique has been used to examine the filter membranes. For solutions from sorption experiments, alpha particle "stars" or large activity clusters are observed, indicating the presence of large agglomerates containing many Am atoms even after the rigorous centrifuging. For solution from desorption experiments, the filter membranes show Am only as single alpha tracks, suggesting sorption of Am on the membrane.

In related work B. M. Allard (Chalmers University, Goteburg, Sweden, personal communication) observed sorption ratios for Millipore filter paper comparable to those for rock-forming minerals during batch sorption experiments with Am in simulated ground water.

Considering the above results, we have decided to take the conservative approach in calculating Am sorption ratios and use the results from the solutions after they have been centrifuged but not filtered.

In order to determine the dependence of ground water composition on the sorption ratio of many radionuclides, two synthetic ground waters were prepared for these experiments. The compositions of the two waters (Table II) were selected to represent extremes. The same sieve fracton was used in all experiments. All measurements were made under aerobic conditions at room temperature.

Three different tuff samples, JA-18, -32, and -37 from test well J-13 were selected for the experiments. Two rock-equilibrated waters were prepared by shaking each of the two waters with sample JA-37. The 250 to 355 µm fraction was used for the solid samples. The Sr, Cs, Ba, Ce and Eu tracers were added to these rock treated waters using the technique described earlier. The traced solutions were shaken with the solid samples at the ratio of 20 mℓ/g. Contact

TABLE II

APPROXIMATE INITIAL GROUND WATER COMPOSITION (mg/ℓ)

Constituent	Water I	Water II
Na	10	50
K	5	5
Ca	10	50
Mg	2	20
SO_4	5	70
Cl	4.5	15

times were 4 and 8 weeks. Results of the 4- and 8-week sorption determinations have been completed, and calculations of the 8-week desorption determinations are in progress. Results seem to indicate that the composition of the water is a major factor in determining the R_d value of a particular element. R_d values for Cs, Sr, and Ba are higher in the less concentrated water, probably due to less ion-exchange competition. R_d values for Ce and Eu are the opposite and are much higher in the more concentrated water. This may be explained by a greater tendency of Ce and Eu to form radiocolloids at higher sulfate concentration. It seems that the sorption mechanism for Ce and Eu is quite different from that of Sr, Cs, and Ba.

Water from test well J-13 was pretreated with each of the tuff core samples studied for all batch and column work. Samples of these waters were sent to the USGS (U. S. Geological Survey) for analysis. The results have not yet been received. Included are waters from YM-22, -38, -48, -45, -49, -54, and from YM-3, -5, -42, and -46. The latter waters were prepared for experiments which are planned. YM-30 contains zeolites. YM-5 contains unaltered glass and no zeolites. YM-46 is a densely welded vitric tuff without zeolites, but with significant iron staining. YM-42 is an immature sandstone with clay matrix.

Techniques have been developed previously for preparing autoradiograms of ^{233}U and ^{241}Am on thin sections of rocks from the NTS (Nevada Test Site) (alluvium, tuff, granite, and argillite). In general, the same techniques were employed with ^{239}Pu solutions of ground waters for activity levels which would

remain constant with time. All water used for these solutions was filtered through 0.4- and 0.5-μm filters, and the solutions were stored in capped teflon tubes. The original Pu stock solution (in $HClO_4$) was evaporated to dryness, the Pu dissolved in distilled water, taken to dryness, and redissolved in the ground water. It was found that Pu disappears from these solutions in a period of several days, but could be reintroduced (probably in a colloidal form) by placing the teflon tubes in an ultrasonic bath for a minute. It was suggested that this "colloidal Pu" settles out on the thin section under the force of gravity. However, experiments conducted with droplets of Pu solution suspended from the thin section did not produce less activity on the rock surface than when the droplets were sitting on top of the thin section.

Microautoradiograms were prepared of ^{239}Pu on JA-25 and -26 tuff. Only in one thin section (JA-25) did there seem to be strong sorption by a particular mineral. Generally the alpha track distributon was fairly uniform, with a number of stars present (indicating aggregated species). It appears that Pu sorbs indiscriminately on rock thin sections, and even on glass.

Attempts to sorb ^{237}Np on rock thin sections were hampered by the low tendency of the Np to sorb (lower than Pu by at least a factor of 10), and by the presence of large amounts of the ^{233}Pa daughter in the radioactive source solution. The ^{233}Pa sorbed strongly on the thin sections, and the beta radiation from this nuclide exposed the emulsions to the point of obscuring the alpha tracks generated by the ^{237}Np. Two procedures were employed to purify the Np: a TTA extraction, and a fluoride precipitation followed by extraction on an ion exchange column. Neither of these procedures gave a very complete separation. Autoradiograms were prepared with JA-26 tuff thin sections using a high specific activity solution (about 7×10^6 disintegrations/sec/mℓ) with the ^{233}Pa in secular equilibrium with the ^{237}Np. In general the Np seemed to deposit in some aggregated form, as dense clumps of tracks were present on all the thin sections. There is possibly some association of the tracks with specific minerals; however, analyses of the minerals sorbing ^{237}Np or ^{239}Pu have not yet been made.

A number of autoradiograms were prepared using ^{85}Sr, ^{63}Ni, ^{233}Pa, and ^{90}Sr. Kodak AR.10 strippable emulsion, Kodak liquid emulsions NTB-2 and NTB-3, and a film-backed emulsion "Ultrafilm ^{3}H" manufactured by LKB, Rockville, MD, were utilized. Beta tracks (generally spots) were readily visible at moderate surface densities against a clear background, but were difficult or impossible to identify except at very high densities against the mottled backgrounds typical

of rock thin sections. Thus it appears that beta autoradiography may be limited in geological applicatons to situations in which high resolution is not required and in which rather large track density can be tolerated.

B. Mineralogical-Petrological Studies (G-6)

Data analysis and petrological studies of core samples of tuff from exploratory drill hole UE25a-1 are complete. A LASL publication entitled "Mineralogy and Petrology of Tuff Units from the UE25a-1 Drill Hole, Yucca Mountain, Nevada," is being processed for final publication. Results of the core studies show that there are two major zeolitized horizons at drill hole depths below 380 m (stratigraphic units include the Topopah Springs Member of the Paintbrush Tuff, Tuffaceous Beds of Calico Hills and the Prow Pass Member of the Crater Flat Tuff). Zeolitized horizons are restricted to low density tuff (air-fall and nonwelded ash-flow tuff) below the basal vitrophyre of the Topopah Springs Member approximately 70 m above the current water table. In general zeolite minerals are most common within partially welded to nonwelded sections of ash-flow cooling units and bedded tuff. The zeolites occur primarily as replacements of original glass pyroclasts, and as vug and fracture fillings.

Zeolite mineralogy is characteristic of low temperature (<100°C) ground water alteration of glass in an open hydrologic system. The principal zeolite phase is high-Si clinoptilolite with Si/Al ratios of 4.7 to 6.0. Ca tends to be the dominant large-radius cation, but grains with dominant K or Na are not uncommon, particularly with increasing depth. Compositional variations in clinoptilolite may be due to ground water composition or original pyroclast composition.

Minor amounts of mordenite, characterized by lower silica content (<55 wt%) and high alkali content (>10 wt% $Na_2O + K_2O$), occur as vug fillings at depths below 500 m. Presence of mordenite may indicate slightly elevated alteration temperatures, but more likely reflects alkali enrichment of ground water with depth.

Mineralogical, compositional, and textural similarities of the zeolitized tuffs from UE25a-1 and J-13 are compatible with a single episode of zeolite crystallization.

Three specimens of Bandelier Tuff have been studied petrographically and submitted to CNC-11 for sorptive studies. Results of the Bandelier Tuff geochemical studies will be compared with the existing data for tuff from the NTS.

C. Hydrothermal Soak Tests (G-6)

Prototype containment vessels for the hydrothermal soak tests have been assembled and tested. The systems are satisfactory for 50 and 150°C. A new design for jacket material for temperatures of 250°C is being developed. The hydrothermal soak tests are designed to evaluate the effects of extended exposure of selected types of tuff to simulated repository conditions. Tuff samples from UE25a-1 will be subjected to temperatures of 50, 150, and 250°C, confining pressures of 10 and 20 MPa and pore water pressures of 0.5 and 5 MPa for periods up to six months. Comparative studies of mineralogical and thermomechanical properties will be made before and after exposure.

II. VOLCANIC HAZARD INVESTIGATIONS: Activity 2.5.1 (G-6)

A. Regional Field Investigations

Field investigations of the occurrence of Plio-Pleistocene basaltic volcanism has been extended regionally. Basaltic volcanic centers have been examined at Buckboard Mesa and along the Silent Canyon cauldron ring-fracture zone, NTS, the Lunar Craters volcanic field and the Reveille Range. These centers and the Greenwater volcanic field of southern Death Valley outline a discontinuous northeast-trending belt of basaltic volcanism in the southern Great Basin. The lavas of these centers are somewhat similar petrologically to Late Cenozoic lavas of the San Francisco volcanic field and a north-trending belt of basaltic centers extending from northwestern Arizona into Utah.

B. Probability Calculations

Revised calculations have been made for the yearly probability of both the recurrence of volcanism and the disruption of a repository site at Yucca Mountain by activity for a 60-km radius circle centered at Yucca Mountain. The calculations and supportive data are described in a report by Crowe and Carr (in preparation). The calculated probabilities are dependent upon the details of cone counts and the time period chosen. The significant point, however, is that preliminary calculations using the extreme ranges (minimum and maximum) of cone counts and time periods, fall into the range of volcanic disruption probabilities of 10^{-9}/year.

C. Petrography-Geochemistry

Previous field studies have shown that there is a three-fold structural grouping of basaltic volcanic centers within Crater Flat:

1. Relatively young basalts that occur in a northeast-trending arc.
2. An older series of eroded cones arrayed along a N-S arc.
3. A relatively young cone that may represent reactivation along the N-S arc (Lathrop Wells Cone).

The first two structural groups, the northeast and N-S arcs of volcanic activity, provide recognizable control of the distribution of chemical and petrographic/mineralogic basalt groups. Three major basalt types are defined within Crater Flat by the concurrence of basalt chemistry and geographic distribution.

1. The N-S trending cones and the cone of Lathrop Wells are moderately hypersthene (Hy) normative* (1 to 10% normative Hy) with high TiO_2 content (1.5 to 2% TiO_2) and constrained Fe' ratios of 0.48 to 0.50 (Fe' is the atomic ratio of Fe divided by Fe + Mg).
2. The northeast-trending arc is distinctive; although basalts from one cone in this arc have a normative Hy content within the range described above, the typical olivine-porphyritic basalts in this arc are more Hy-rich (10 to 20% normative Hy), with lower TiO_2 content ($\leq$ 1.5% TiO_2) and higher Fe'(0.50 to 0.52).
3. A unique alkaline basalt type (nepheline rather than hypersthene-normative) occurs in what may be the youngest cone ("Little Cone") of the southwest end of the northeast-trending arc of volcanic centers. In addition to its slightly higher alkali content ($Na_2O + K_2O$ = 5.5% vs. 3-5% in all other Crater Flat basalts), this nepheline-normative basalt has an exceptionally high Fe' value of 0.56.

Models of crystal-liquid fractionation using observed phenocryst phases (clinopyroxene, olivine, plagioclase) cannot account for the chemical variation between these three groups. Extensive crystal fractionation is ruled out by the maintenance of nearly constant Al, Ca (and to a large extent Na, K) contents in samples which otherwise have marked variation in Fe', Ti and Si. This variability in a few elements, superimposed on an otherwise fixed composition, apparently reflects deep-seated compositional control via differences in source regions or melting regimes.

*Normative mineral compositions are calculated as cation weight percent from major-element rock analyses. Oxide percentages are reported as molecular percent.

There is not a direct one-to-one correlation between petrographic and chemical types among the basalts of Crater Flat. The most abundant and widespread petrographic type contains phenocrysts of olivine plus clinopyroxene or plagioclase. Groundmass plagioclase grains (An_{63-69}) are more Na-rich than the plagioclase phenocrysts (An_{70-83}) but show little K enrichment. This petrographic type is found in cones of all structural affinities. Two other petrographic types (described below) are restricted to either the northeast or N-S structural trends.

The volcanic centers of the northeast trend are marked by a characteristic olivine-porphyritic basalt that lacks other phenocrysts. Groundmass minerals in this petrographic type include orthopyroxene as well as clinopyroxene, and plagioclase (An_{60-79}) with little K enrichment.

The older, dissected basaltic centers of the N-S trend contain a petrographic type which is phenocryst-rich (olivine plus clinopyroxene plus plagioclase) with characteristic glomeroporphyritic clusters of clinopyroxene plus plagioclase. The plagioclase phenocrysts are zoned to compositions of considerable K enrichment (range of An_{80} to $An_{61}Or_3$).

III. QUALITY ASSURANCE (CMB-QA)

Implementation of the LASL Quality Assurance Program was continued this quarter. Surveillance of all assigned subtasks was performed and documented.

Quality Assurance personnel presented a QA-indoctrination and training session to LASL personnel involved in NNWSI work this quarter. Documentation is on file to show the attendance and the subject matter covered.

The following documents have been updated and issued this quarter:

TWS-CMB QA-QP-01, R1	QA Program Plan
TWS-CMB QA-QP-02, R1	QA Program Index
TWS-CMB QA-QP-03, R2	Document Control
TWS-CNC11-WP-03, R2	Tuff Experiments-Sorption Coefficients and Migration Measurements
TWS-G6-WP-04, R1	Volcanic-Tectonic Investigations
TWS-G6-WP-05, R1	Tuff Experiments-Mineralogy & Petrology Studies by G-6.

TWS-G6-DP-01, R1	X-Ray Diffraction Analysis
TWS-G6-DP-03, R1	NTS Core Petrography Procedure
TWS-CNC11-DP-03, R0	Procurement Procedure

LASL Quality Assurance personnel met with USGS personnel on several occasions to finalize drafts of the Quality Assurance Program Plan, Unit Task Procedures, and selected Detailed Procedures. This Quality Assurance Program was presented to the USGS management in Reston, VA, for approval on September 25, 1979.

IV. ACKNOWLEDGMENTS

The following people contributed to this report: B. P. Bayhurst, P. L. Bussolini, B. M. Crowe, W. R. Daniels, S. J. DeVilliers, B. R. Erdal, G. H. Heiken, F. O. Lawrence, C. Nelson, R. J. Romero, J. R. Smyth, M. Sykes, J. L. Thompson (Idaho State University), D. Vaniman, E. N. Vine, and K. Wolfsberg.

PUBLICATIONS

1. B. M. Crowe and K. A. Sargent, "Major-Element Geochemistry of the Silent Canyon - Black Mountain Peralkaline Volcanic Centers, Northwestern Nevada Test Site: Applications to an Assessment of Renewed Volcanism," U.S. Geol. Surv. Open File Report 79-926, 25 p. (1979).

2. B. R. Erdal, B. P. Bayhurst, B. M. Crowe, W. R. Daniels, D. C. Hoffman, F. O. Lawrence, J. R. Smyth, J. L. Thompson, and K. Wolfsberg, "Laboratory Studies of Radionuclide Transport in Geologic Media," IAEA/OECD Symposium on the Underground Disposal of Radioactive Wastes, Otaniemi, Finland, July 2-6, 1979 (in press).

3. B. R. Erdal, B. P. Bayhurst, W. R. Daniels, S. J. DeVilliers, F. O. Lawrence, J. L. Thompson, E. N. Vine, and K. Wolfsberg, "Parameters Affecting Radionuclide Migration in Argillaceous Media," Workshop on the Use of Argillaceous Materials for the Isolaton of Radioactive Waste, OECD Nuclear Energy Agency, Paris, France, September 10-12, 1979 (in press).

4. B. R. Erdal, W. R. Daniels, D. C. Hoffman, F. O. Lawrence, and K. Wolfsberg, "Sorption and Migration of Radionuclides in Geologic Media," in Scientific Basis for Nuclear Waste Management, G. J. McCarthy, Ed. (Plenum Press, NY, 1979), p. 423.

5. J. R. Smyth, B. M. Crowe, P. M. Halleck, and A. W. Reed, "A Preliminary Evaluation of Radioactive Waste Isolation Potential of the Alluvium-Filled Valleys of the Great Basin," Los Alamos Scientific Laboratory report LA-7962-MS, 22 p (1979).

6. J. R. Smyth, J. Thompson, and K. Wolfsberg, "Microautoradiographic Studies of the Sorption of U and Am on Natural Rock Samples," submitted to Radioactive Waste Management Journal (1979).

7. M. L. Sykes, G. H. Heiken, and J. R. Smyth, "Mineralogy and Petrology of Tuff Units from the UE25a-1 Drill Site, Yucca Mountain, Nevada," Los Alamos Scientific Laboratory report LA-8139-MS, 76 p. (1979).

ORAL PRESENTATIONS

1. B. R. Erdal, B. P. Bayhurst, B. M. Crowe, W. R. Daniels, D. C. Hoffman, F. O. Lawrence, J. R. Smyth, J. L. Thompson, and K. Wolfsberg, "Laboratory Studies of Radionuclide Transport in Geologic Media," IAEA/OECD Symposium on the Underground Disposal of Radioactive Wastes, Otaniemi, Finland, July 2-6, 1979 (in press).

2. B. R. Erdal, B. P. Bayhurst, W. R. Daniels, S. J. DeVilliers, F. O. Lawrence, J. L. Thompson, E. N. Vine, and K. Wolfsberg, "Parameters Affecting Radionuclide Migration in Argillaceous Media," Workshop on the Use of Argillaceous Materials for the Isolation of Radioactive Waste, OECD Nuclear Energy Agency, Paris, France, September 10-12, 1979 (in press).

3. B. R. Erdal, J. K. Johnstone, and A. Friedman, "Field Tests of Nuclide Migration in Geologic Media," Office of Nuclear Waste Isolation (ONWI) Columbus, OH, September 24, 1979.

4. B. R. Erdal, "Studies of the Behavior of Radionuclides in Geologic Media," University of Oslo, Oslo, Norway, June 21, 1979.

5. B. R. Erdal, "Radionuclide-Geologic Media Interactions," Chalmers University of Technology, Goteborg, Sweden, June 25, 1979.

6. B. R. Erdal, "A Field Study of Radionuclide Migration," Studsvik Energiteknik AB, Studsvik, Sweden, June 27, 1979.

7. B. M. Crowe, K. Wolfsberg, A. R. Lappin and L. D. Tyler, "Evaluation of Disposal in Desert Tuff," presented at AICME meeting, Boston, August, 1979; Paper No. 33e.

8. K. Wolfsberg, "Media Investigations - Geochemical Properties," Department of Energy/Office of Nuclear Waste Management Review of Nevada Nuclear Waste Storage Investigations, NVOO, Las Vegas, NV, July 30, 1979.

9. B. M. Crowe, "Geologic Investigations - Geochemical Properties," Department of Energy/Office of Nuclear Waste Management Review of Nevada Nuclear Waste Storage Investigations, NVOO, Las Vegas, NV, July 30, 1979.

ABSTRACT ACCEPTED FOR PRESENTATION

1. B. R. Erdal, B. P. Bayhurst, W. R. Daniels, S. J. DeVilliers, F. O. Lawrence, E. N. Vine, and K. Wolfsberg, "Parameters Affecting Radionuclide Migration in Geologic Media," Symposium on the Scientific Basis for Nuclear Waste Management, Materials Research Society, Boston, MA, November 26-29, 1979.

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