*Quantitative X-Ray Diffraction Analyses of
Samples Used for Sorption Studies by the
Isotope and Nuclear Chemistry Division,
Los Alamos National Laboratory*

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QUANTITATIVE X-RAY DIFFRACTION ANALYSES OF SAMPLES USED
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LOS ALAMOS NATIONAL LABORATORY

by

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ABSTRACT

Yucca Mountain, Nevada, is currently being investigated to determine its suitability to host our nation's first geologic high-level nuclear waste repository. As part of an effort to determine how radionuclides will interact with rocks at Yucca Mountain, the Isotope and Nuclear Chemistry (INC) Division of Los Alamos National Laboratory has conducted numerous batch sorption experiments using core samples from Yucca Mountain. In order to understand better the interaction between the rocks and radionuclides, we have analyzed the samples used by INC with quantitative x-ray diffraction methods. Our analytical methods accurately determine the presence or absence of major phases, but we have not identified phases present below ~1 wt%. These results should aid in understanding and predicting the potential interactions between radionuclides and the rocks at Yucca Mountain, although the mineralogic complexity of the samples and the lack of information on trace phases suggest that pure mineral studies may be necessary for a more complete understanding.

I. INTRODUCTION

The Isotope and Nuclear Chemistry (INC) Division of Los Alamos National Laboratory has conducted batch sorption experiments on Yucca Mountain core samples to determine how the natural samples interact with radionuclides. The radionuclides chosen for study were americium, cesium, neptunium, plutonium, thorium, uranium, strontium, technetium, tin, barium, radium,

cerium, europium, and selenium (Thomas 1987). To provide a basis for understanding the relationship between sorption of radionuclides and mineralogy, we have conducted quantitative x-ray diffraction (QXRD) analysis to determine the mineralogy of the INC samples.

The studies of Yucca Mountain and the surrounding area are part of the Yucca Mountain Project (YMP), directed by the Yucca Mountain Project Office of the U.S. Department of Energy, Nevada Operations Office.

II. EXPERIMENTAL TECHNIQUES

The volcanic rocks at Yucca Mountain commonly have a fine-grained groundmass that is not amenable to quantitative mineral analysis by optical petrographic techniques. Therefore, the quantitative mineralogic data presented in this report were obtained solely by x-ray powder diffractometer techniques.

The samples examined here, from drill holes J-13, UE-25a#1, USW G-1, G-2, G-3, GU-3, and G-4, (Fig. 1) are splits of the materials used in the INC batch sorption experiments. They were received from INC in bottles labeled with the sample number, the size fraction of the sample, and any additional information on its preparation. INC obtained the samples as drill core and ground them in an automated agate ball mill. Size fractions were produced by dry sieving the ground powder through ASTM sieves. The few samples that were wet sieved are labeled as such in Appendix I. Several samples were washed after sieving using de-ionized or J-13 water to remove any fine material that did not sieve out. Daniels et al. (1982) found that the fine material had an effect on sorption results for some radionuclides, possibly due to the high cation exchange capacity of fine-grained smectite.

Typically, we mixed a small portion of each sample (~0.8 g) with 1.0- μm corundum (Al_2O_3) internal standard in the ratio 80% sample to 20% corundum. Each sample was then ground under acetone in an automatic Brinkmann Micro-Rapid mill (fitted with an agate mortar and pestle) for a time greater than 10 minutes. This produced a sample with an average particle size of less than 5 μm and ensured thorough mixing of sample and internal standard. The fine particle size is necessary to ensure adequate particle statistics and to reduce primary extinction and other sample-related effects (Klug and Alexander 1974). To confirm the adequacy of our grinding times and techniques, the particle size distributions of several samples were measured using a Horiba CAPA-500 automatic particle size distribution analyzer.

Fig. 1.

Location map of Yucca Mountain, Nevada, showing the outline of the exploration block for the Yucca Mountain Project and the locations of drill holes mentioned in the text and Appendix I.

All diffraction patterns were obtained on an automated Siemens D-500 diffractometer using copper-K α radiation, a diffracted-beam monochromator, and pulse-height analysis. Data were collected automatically in the step-scan mode with a step size of 0.02° 2 θ and count times of at least 2.0 s per step. Data were normally collected from 2.0 to 50.0° 2 θ . Mineral identification was accomplished by comparing observed patterns with patterns of pure standards, published patterns from the Joint Committee on Powder Diffraction Standards (JCPDS 1986), or calculated mineral patterns obtained from the program POWD10 (Smith et al. 1982).

III. QUANTITATIVE ANALYSIS

All quantitative analyses for this report employed the internal standard or "matrix-flushing" method of Chung (1974) using synthetic 1.0- μ m corundum as the internal standard. This method requires that reference intensity ratios (RIRs) be determined before sample analysis. It is important to note that the methods of data collection and analysis used for these samples are not conducive to identifying phases present below ~1 wt%, and potentially important trace phases may be present in the Yucca Mountain rocks. Analysis for such trace phases requires either special data collection techniques or concentration by magnetic or heavy-liquid methods.

Table I lists the phases that we currently analyze for, along with the standards we use, their RIRs, and their source. We have found that RIRs remain relatively constant from sample to sample for the silica phases and are either constant or can be compensated for in most other phases such as feldspars and zeolites. Interstratified illite/smectites (I/S), however, exhibit a wide variation in RIRs. Chipera and Bish (1988) compensated for the variable RIR in drill hole UE-25p#1 by separating the clays at intervals down the drill hole and measuring RIRs on each of the separates to determine the appropriate RIR for the I/S at a certain interval. In this report, we compensated for the variable RIR of I/S in the deeper I/S-containing samples (JA-37, G1-3658, and G2-3933) by using the measured RIR from an I/S separated from USW G-1 at a depth of 3490 feet.

Our methods of quantitative analysis are identical to the methods outlined in Bish and Chipera (1986), and Bish and Chipera (1988), and the errors presented are 2-sigma. The quantitative x-ray diffraction analysis computer program QUANT5.01 was used to reduce the data. This is a developmental code currently undergoing verification/validation in accordance with the YMP regulations applicable to computer software.

TABLE I
REFERENCE INTENSITY RATIOS (RIRs) FOR MINERALS ANALYSED BY QUANT5.01

MINERAL	SOURCE	REFLECTION HKL or 2θ RANGE		RIR
Analcime	Wikieup, AZ	211	(15.8)	1.27
		400	(26.0)	1.80
Calcite	Lab Reagent	104	(29.4)	2.96
		116	(48.5)	0.58
Chabazite	Calculated RIR	100	(9.5)	1.00
Chlorite	Flagstaff Hill, CA, Ripidolite	001	(6.1)	1.53
		002	(12.4)	3.14
		004	(25.1)	1.74
Clinoptilolite	25525 Castle Creek, ID	020	(9.8)	0.97
	27032 Castle Creek, ID		(22.4-22.7)	1.06
	27073 Sheaville, OR		(30.0)	0.49
	27083 Buckhorn, NM UE4P-1660 Nevada Test Site, NV			
Cristobalite	Synthetic Cristobalite	101	(21.9)	4.91
		200	(36.1)	0.84
Dolomite	UE-25p#1-4313/4318, Yucca Mountain, NV	104	(30.9)	2.69
		113	(41.1)	0.48
Ericnite	25216 Needle Peak, NV	100	(7.6)	1.20
	25214 Pine Valley, NV	110	(13.3)	0.45
Feldspar				
Albite	Amelia, VA		(13.4-14.0)	0.24
Albite	Amelia, VA	111	(23.6)	0.27
Sanidine	Eifel, Germany		(13.4-14.0)	0.13
Sanidine	Eifel, Germany	130	(23.6)	0.55
Fluorite	Lab Reagent	111	(28.3)	3.24
		220	(47.0)	3.70
Gypsum	Wyoming Selenite	020	(11.5)	4.25
Hematite	Cleator Moor, England	104	(33.2)	2.38
		110	(35.7)	1.20

TABLE I Continued

<u>MINERAL</u>	<u>SOURCE</u>	<u>REFLECTION HKL or 2θ RANGE</u>		<u>RIR</u>
Hornblende	Yucca Mountain, NV	110	(10.4)	2.34
Illite	Silver Hill, MT	001	(8.8)	0.57
Ilmenite	Koidu, Sierra Leone	104	(32.8)	1.91
		024	(49.0)	0.62
Kaolinite	Average of Wards Kaolin, Washington County, GA and Mesa Alta, NM	001	(12.3)	1.37
Laumontite	Collected by D. Bish in Oregon, 1984	110	(9.3)	1.15
		200	(12.9)	0.47
		130	(21.3)	0.59
Magnetite	Espanola, Ontario, Canada	220	(30.1)	0.78
		311	(35.4)	2.54
Mica	Average of calculated and Bancroft, Ontario	00	(8.8)	3.8
Mordenite	Union Pass, AZ	200	(9.8)	0.44
	Lovelock, NV	330	(19.6)	0.20
	USW G1-2314, Yucca Mt, NV	202	(25.7)	0.36
Opal-CT	28501 Kliwikerthal, Czech. 92509 Owyhee County, ID		(21.0-22.1)	1.80
Quartz	Hot Springs, AR	100	(20.8)	0.86
		101	(26.6)	4.19
Smectite	USW G-1 1415	001		3.85
	USW G-1 3490	001		2.82
Tridymite	Nevada Test Site, NV		(20.5)	1.18
			(21.6)	1.10

IV. RESULTS

Results of the QXRD analyses for the INC sorption samples are given in Appendix I. Samples from drill holes J-13, UE-25a#1, USW G-1, G-2, G-3, GU-3, and G-4 are labeled with the drill hole designator and the footage (e.g., G4-1608 came from drill hole USW G-4 at a depth of 1608 ft). The samples labeled JA are from drill hole J-13 and those labeled YM are from drill hole UE-25a#1. The following is a list of the JA and YM samples giving their depth (footage for JA samples is from Heiken and Bevier 1979, footage for YM samples is from Sykes et al. 1979).

JA-8	607 ft	YM-22	848 ft
JA-18	1421 ft	YM-30	1264 ft
JA-26	1995 ft	YM-38	1505 ft
JA-28	2005 ft	YM-42	1824 ft
JA-32	2533 ft	YM-45	1930 ft
JA-37	3497 ft	YM-46	2002 ft
		YM-48	2114 ft
		YM-49	2220 ft
		YM-54	2491 ft

The QXRD results for each size fraction for a given sample are in excellent agreement with each other. In several cases, INC submitted the same sample and size fraction twice, shown in Appendix I as a dual entry for a sample (e.g., samples GU3-1937 75-500 μm and G3-4868 75-500 μm wet sieved). Results for these samples are also in excellent agreement with each other, demonstrating the reproducibility of our methods.

In general, sieving the samples into several size fractions did not have a significant effect on the relative amounts of individual minerals. Smectite abundance is slightly greater in the finer size fractions, as is zeolite abundance. This is expected since clays are very fine grained and zeolites are soft minerals susceptible to mechanical disintegration. Removal of fine-grained material from a sample by washing was readily apparent in samples that had abundant clay or zeolite.

V. DISCUSSION

The effects of mineralogy on the batch sorption experiments have been discussed by Daniels et al. (1982), Bish et al. (1984), and Thomas (1987). Minerals such as zeolites and clays have high cation-exchange capacities and interact strongly with simple cations such as cesium, strontium, and barium. Thus, zeolitic and clay-rich tuffs generally have high sorption ratios for

these cations. In addition, sorption of cerium and europium was greater in zeolitized and clay-rich samples. Selenium, neptunium, uranium, and plutonium showed slightly higher sorption in zeolitized samples although there are no trends with the degree of zeolitization. Technetium, americium, and thorium showed no correlation with mineralogy. Surface sorption can be important for minerals with high surface areas and depends on a mineral's zero-point-of-charge and the pH of the system. Redox conditions can greatly affect sorption of some radionuclides, especially the actinides, and can significantly alter the solubility of some elements. In particular, phases such as iron and manganese oxides can interact strongly with redox-sensitive species. Daniels et al. (1982) found that technetium in a nitrogen atmosphere was sorbed significantly more than in an air (oxidizing) atmosphere. There is also some evidence to suggest that migration of some radionuclides may be retarded in rocks containing carbonate minerals, perhaps due to precipitation.

To approximate the effects that individual minerals in the Yucca Mountain tuff samples have on sorption of the various radionuclides, a comprehensive statistical analysis of the mineralogic and sorption data will have to be conducted. It is also possible that sorption of many radionuclides is controlled by trace phases such as iron or manganese oxides, phases which we usually do not detect. Therefore, to determine unequivocally the effects of an individual mineral on sorption, sorption experiments should be conducted on purified mineral separates of the phases found in the Yucca Mountain tuffs. Even with purified samples, the possibility exists for sorption of some radionuclides to be controlled by trace phases that have not been completely removed in the purification process.

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QUALITY ASSURANCE

The quality assurance level of this document is QA Level III.

The YMP notebooks and logbooks containing data presented in this report are listed in Appendix II.

REFERENCES

- Bish, D. L., and S. J. Chipera, "Problems and Solutions in Quantitative Analysis of Complex Mixtures by X-Ray Powder Diffraction," in Advances in X-Ray Analysis, C. S. Barrett, J. V. Gilfrich, R. Jenkins, J. C. Russ, J. W. Richardson, Jr., and P. K. Predecki, Eds. (Plenum Press, New York, 1988) Vol.31, 295-308. NNA.890405.0178
- Bish, D. L., and S. J. Chipera, "Mineralogy of Drill Holes J-13, UE-25A#1, and USW G-1 at Yucca Mountain, Nevada," Los Alamos National Laboratory report LA-10764-MS (September 1986). HQS.880517.1957
- Bish, D. L., D. T. Vaniman, R. S. Rundberg, K. Wolfsberg, W. R. Daniels, and D. E. Broxton, "Natural Sorptive Barriers in Yucca Mountain, Nevada, for Long-Term Isolation of High-Level Waste," *Radioactive Waste Management*, Vol. 3, 415-432, International Atomic Energy Agency, Vienna (1984). NNA.890602.0025
- Chipera, S. J., and D. L. Bish, "Mineralogy of Drill Hole UE-25p#1 at Yucca Mountain, Nevada," Los Alamos National Laboratory report LA-11292-MS (May 1988). NNA.880607.0036
- Chung, F. H., "Quantitative Interpretation of X-Ray Diffraction Patterns of Mixtures. I. Matrix-Flushing Method for Quantitative Multicomponent Analysis," *Journal of Applied Crystallography* 7, 519-525 (1974). NNA.890405.0179
- Daniels, W. R., K. Wolfsberg, R. S. Rundberg, A. E. Ogard, J. F. Kerrisk, C. J. Duffy, T. W. Newton, J. L. Thompson, B. P. Bayhurst, D. L. Bish, J. D. Blacic, B. M. Crowe, B. R. Erdal, J. F. Griffith, S. D. Knight, F. O. Lawrence, V. L. Rundberg, M. L. Sykes, G. M. Thompson, B. J. Travis, E. N. Treher, R. J. Vidale, G. R. Walter, R. D. Aguilar, M. R. Cisneros, S. Maestas, A. J. Mitchell, P. Q. Oliver, N. A. Raybold, and P. L. Wanek, "Summary Report on the Geochemistry of Yucca Mountain and Environs," Los Alamos National Laboratory report LA-9328-MS (December 1982). HQS.880517.1974
- Heiken, G. H., and M. L. Bevier, "Petrology of Tuff Units from the J-13 Drill Site, Jackass Flats, Nevada," Los Alamos Scientific Laboratory report LA-7563-MS (February 1979). NNA.870519.0045
- JCPDS, Mineral Powder Diffraction File Data Book (International Centre for Diffraction Data, Swarthmore, Pennsylvania, 1986).
- Klug, H. P., and L. E. Alexander, X-ray Diffraction Procedures for Polycrystalline and Amorphous Materials (John Wiley & Sons, Inc., New York, 1974).
- Smith, D. K., M. C. Nichols, and M. E. Zolensky, "POWD10, A FORTRAN IV Program for Calculating X-Ray Powder Diffraction Patterns - Version 10," Pennsylvania State University, College of Earth and Mineral Sciences report (March 1983). NNA.890602.0030

Sykes, M. L., 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 (November 1979). HQS.880517.1516

Thomas, K. W., "Summary of Sorption Measurements Performed with Yucca Mountain, Nevada, Tuff Samples and Water from Well J-13," Los Alamos National Laboratory report LA-10960-MS (December 1987). NNA.890602.0026

APPENDIX I

QUANTITATIVE XRD RESULTS

APPENDIX I

J-13

Sample ^a	Smectite	Mica	Clino- ptilolite	Morden- ite	Anal- cime	Quartz	Cristo- balite	Opal- CT	Alkali Feldspar	Glass	Hema- tite	Other
JA-8 <75 μ m	25 $\pm$ 8	-	-	-	-	Tr.	-	4 $\pm$ 1	-	70 $\pm$ 8	-	1 $\pm$ 1 ^b
JA-8 75-500 μ m	31 $\pm$ 9	-	-	-	-	1 $\pm$ 1	-	6 $\pm$ 1	Tr.	62 $\pm$ 9	-	Tr. ^b
JA-8 75-500 μ m Washed	30 $\pm$ 9	-	-	-	-	Tr.	-	8 $\pm$ 2	1 $\pm$ 1	61 $\pm$ 9	-	Tr. ^b
JA-8 >500 μ m	24 $\pm$ 7	-	-	-	-	4 $\pm$ 1	-	12 $\pm$ 2	1 $\pm$ 1	59 $\pm$ 7	-	Tr. ^b
JA-18 <106 μ m	2 $\pm$ 1	Tr.	15 $\pm$ 1	-	-	Tr.	-	13 $\pm$ 3	11 $\pm$ 1	59 $\pm$ 3	-	-
JA-18 106-150 μ m	1 $\pm$ 1	Tr.	14 $\pm$ 1	-	-	Tr.	-	15 $\pm$ 4	13 $\pm$ 2	57 $\pm$ 5	-	-
JA-18 150-180 μ m	1 $\pm$ 1	Tr.	14 $\pm$ 1	-	-	Tr.	-	17 $\pm$ 5	13 $\pm$ 2	55 $\pm$ 6	-	-
JA-18 180-250 μ m	1 $\pm$ 1	Tr.	15 $\pm$ 1	-	-	1 $\pm$ 1	-	16 $\pm$ 4	12 $\pm$ 2	55 $\pm$ 5	-	-
JA-18 250-355 μ m	1 $\pm$ 1	-	14 $\pm$ 1	-	-	1 $\pm$ 1	-	15 $\pm$ 4	16 $\pm$ 2	53 $\pm$ 5	-	-
JA-18 355-500 μ m	1 $\pm$ 1	-	14 $\pm$ 1	-	-	1 $\pm$ 1	-	17 $\pm$ 5	15 $\pm$ 2	52 $\pm$ 6	-	-
JA-18 355-500 μ m Washed	1 $\pm$ 1	Tr.	15 $\pm$ 1	-	-	Tr.	-	17 $\pm$ 4	11 $\pm$ 1	56 $\pm$ 4	-	-
JA-18 >500 μ m	1 $\pm$ 1	Tr.	15 $\pm$ 1	-	-	Tr.	-	17 $\pm$ 5	14 $\pm$ 2	53 $\pm$ 6	-	-
JA-26 <75 μ m	3 $\pm$ 1	-	Tr.	-	42 $\pm$ 2	33 $\pm$ 2	-	-	24 $\pm$ 3	-	-	-
JA-26 75-500 μ m	1 $\pm$ 1	-	Tr.	-	57 $\pm$ 3	21 $\pm$ 2	-	-	22 $\pm$ 3	-	-	-
JA-28 <75 μ m	1 $\pm$ 1	Tr.	-	-	28 $\pm$ 2	41 $\pm$ 2	-	-	27 $\pm$ 3	-	-	-
JA-28 75-500 μ m	1 $\pm$ 1	1 $\pm$ 1	Tr.	-	47 $\pm$ 2	22 $\pm$ 2	-	-	33 $\pm$ 4	-	-	-
JA-32 <106 μ m	2 $\pm$ 1	1 $\pm$ 1	-	-	-	44 $\pm$ 2	-	-	55 $\pm$ 6	-	1 $\pm$ 1	-
JA-32 106-150 μ m	1 $\pm$ 1	4 $\pm$ 1	-	-	-	40 $\pm$ 2	-	-	59 $\pm$ 7	-	1 $\pm$ 1	-
JA-32 150-180 μ m	1 $\pm$ 1	3 $\pm$ 1	-	-	-	38 $\pm$ 2	-	-	57 $\pm$ 7	-	1 $\pm$ 1	-
JA-32 180-250 μ m	1 $\pm$ 1	2 $\pm$ 1	-	-	-	40 $\pm$ 2	-	-	57 $\pm$ 7	-	1 $\pm$ 1	-
JA-32 250-355 μ m	1 $\pm$ 1	2 $\pm$ 1	-	-	-	39 $\pm$ 2	-	-	55 $\pm$ 6	-	1 $\pm$ 1	-
JA-32 355-500 μ m	1 $\pm$ 1	2 $\pm$ 1	-	-	-	39 $\pm$ 2	-	-	58 $\pm$ 7	-	1 $\pm$ 1	-
JA-32 355-500 μ m Washed	1 $\pm$ 1	3 $\pm$ 1	-	-	-	43 $\pm$ 2	-	-	57 $\pm$ 7	-	1 $\pm$ 1	-
JA-37 <106 μ m	28 $\pm$ 8	1 $\pm$ 1	4 $\pm$ 1	-	-	33 $\pm$ 2	-	-	32 $\pm$ 4	-	Tr.	-
JA-37 106-250 μ m Washed	15 $\pm$ 5	2 $\pm$ 1	3 $\pm$ 1	-	-	37 $\pm$ 2	-	-	37 $\pm$ 4	-	Tr.	-
JA-37 150-180 μ m	26 $\pm$ 8	1 $\pm$ 1	2 $\pm$ 1	-	-	33 $\pm$ 2	-	-	33 $\pm$ 4	-	Tr.	-
JA-37 355-500 μ m Washed	22 $\pm$ 7	Tr.	2 $\pm$ 1	-	-	36 $\pm$ 2	-	-	38 $\pm$ 5	-	Tr.	-

^a Sample designation JA refers to a sample from drill hole J-13.

Sample JA-8 came from a depth of 607 ft, JA-18 - 1421 ft, JA-26 - 1995 ft, JA-28 - 2005 ft, JA-32 - 2533 ft, and JA-37 - 3497 ft.

^b Calcite.

APPENDIX I Continued

UE-25a#1

Sample ^a	Smectite	Mica	Clino- ptilolite	Morden- ite	Anal- cime	Quartz	Cristo- balite	Opal- CT	Alkali Feldspar	Glass	Hema- tite	Other
YM-22 <75 μ m	2 $\pm$ 1	Tr.	Tr.	-	-	32 $\pm$ 2	5 $\pm$ 2	-	57 $\pm$ 7	-	Tr.	-
YM-22 75-106 μ m	1 $\pm$ 1	Tr.	-	-	-	34 $\pm$ 2	5 $\pm$ 2	-	60 $\pm$ 7	-	Tr.	-
YM-22 106-500 μ m	1 $\pm$ 1	Tr.	-	-	-	34 $\pm$ 2	4 $\pm$ 1	-	58 $\pm$ 7	-	Tr.	-
YM-30 75-500 μ m	4 $\pm$ 1	Tr.	14 $\pm$ 1	-	-	16 $\pm$ 1	17 $\pm$ 1	-	55 $\pm$ 7	-	-	-
YM-38 <75 μ m	3 $\pm$ 1	-	70 $\pm$ 7	6 $\pm$ 2	-	2 $\pm$ 1	-	9 $\pm$ 2	4 $\pm$ 1	-	-	-
YM-38 75-500 μ m	5 $\pm$ 2	-	64 $\pm$ 6	5 $\pm$ 2	-	5 $\pm$ 1	-	12 $\pm$ 3	6 $\pm$ 1	-	-	-
YM-38 106-500 μ m	8 $\pm$ 2	-	70 $\pm$ 5	-	-	5 $\pm$ 1	-	16 $\pm$ 4	5 $\pm$ 1	-	-	-
YM-38 >500 μ m	5 $\pm$ 2	-	67 $\pm$ 5	-	-	5 $\pm$ 1	-	12 $\pm$ 3	9 $\pm$ 2	-	-	-
YM-42 <75 μ m	2 $\pm$ 1	1 $\pm$ 1	24 $\pm$ 2	-	-	19 $\pm$ 1	1 $\pm$ 1	-	49 $\pm$ 7	-	-	-
YM-42 75-500 μ m	2 $\pm$ 1	2 $\pm$ 1	25 $\pm$ 2	-	-	21 $\pm$ 2	1 $\pm$ 1	-	51 $\pm$ 7	-	-	-
YM-45 <106 μ m	8 $\pm$ 2	Tr.	-	-	-	35 $\pm$ 2	-	-	61 $\pm$ 7	-	-	-
YM-45 106-500 μ m	7 $\pm$ 2	Tr.	-	-	-	36 $\pm$ 2	-	-	58 $\pm$ 7	-	-	-
YM-46 <75 μ m	2 $\pm$ 1	Tr.	-	-	-	37 $\pm$ 2	-	-	59 $\pm$ 7	-	Tr.	-
YM-46 75-500 μ m	1 $\pm$ 1	Tr.	-	-	-	41 $\pm$ 2	-	-	54 $\pm$ 6	-	Tr.	-
YM-48 <106 μ m	1 $\pm$ 1	Tr.	10 $\pm$ 1	-	-	1 $\pm$ 1	-	-	17 $\pm$ 2	71 $\pm$ 3	-	-
YM-48 106-500	1 $\pm$ 1	-	15 $\pm$ 1	-	-	2 $\pm$ 1	-	3 $\pm$ 1	22 $\pm$ 3	57 $\pm$ 4	-	-
YM-49 <75 μ m	Tr.	-	52 $\pm$ 9	21 $\pm$ 6	-	Tr.	-	12 $\pm$ 3	10 $\pm$ 3	-	-	-
YM-49 75-500 μ m	Tr.	-	54 $\pm$ 8	14 $\pm$ 4	-	1 $\pm$ 1	-	13 $\pm$ 3	13 $\pm$ 3	-	-	-
YM-49 <106 μ m	Tr.	-	54 $\pm$ 10	21 $\pm$ 6	-	1 $\pm$ 1	-	11 $\pm$ 3	16 $\pm$ 4	-	-	-
YM-49 106-250 μ m Washed	Tr.	-	52 $\pm$ 9	19 $\pm$ 5	-	2 $\pm$ 1	-	12 $\pm$ 3	15 $\pm$ 4	-	-	-
YM-49 106-500 μ m	Tr.	-	48 $\pm$ 9	22 $\pm$ 6	-	1 $\pm$ 1	-	13 $\pm$ 4	17 $\pm$ 5	-	-	-
YM-54 <75 μ m	6 $\pm$ 2	1 $\pm$ 1	-	-	-	37 $\pm$ 2	-	-	59 $\pm$ 7	-	1 $\pm$ 1	-
YM-54 75-500 μ m	4 $\pm$ 1	1 $\pm$ 1	-	-	-	46 $\pm$ 2	-	-	46 $\pm$ 5	-	1 $\pm$ 1	-
YM-54 106-500 μ m	5 $\pm$ 2	1 $\pm$ 1	-	-	-	39 $\pm$ 2	-	-	49 $\pm$ 6	-	1 $\pm$ 1	-

^a Sample designation YM refers to a sample from drill hole UE-25a#1.

Sample YM-22 came from a depth of 848 ft, YM-30 - 1264 ft, YM-38 - 1505 ft, YM-42 - 1824 ft, YM-45 - 1930 ft, YM-46 - 2002 ft, YM-48 - 2114 ft, YM-49 - 2220 ft, and YM-54 - 2491 ft.

APPENDIX I Continued

USW G-1

Sample ^a		Smectite	Mica	Clino- ptilolite	Morden- ite	Anal- cime	Quartz	Cristo- balite	Opal- CT	Alkali Feldspar	Glass	Hema- tite	Other
G1-1271	75-500 μ m	1 $\pm$ 1	-	-	-	-	22 $\pm$ 2	15 $\pm$ 1	-	60 $\pm$ 7	-	1 $\pm$ 1	-
G1-1271	75-500 μ m Washed	3 $\pm$ 1	Tr.	-	-	-	20 $\pm$ 2	17 $\pm$ 1	-	57 $\pm$ 7	-	1 $\pm$ 1	-
G1-1292	<75 μ m	1 $\pm$ 1	Tr.	-	-	-	1 $\pm$ 1	-	10 $\pm$ 2	7 $\pm$ 1	81 $\pm$ 3	-	Tr. ^b
G1-1292	75-355 μ m	Tr.	Tr.	-	-	-	1 $\pm$ 1	-	9 $\pm$ 2	8 $\pm$ 1	82 $\pm$ 2	-	Tr. ^b
G1-1292-2	75-500 μ m Wet S.	-	-	-	-	-	1 $\pm$ 1	-	11 $\pm$ 3	9 $\pm$ 1	79 $\pm$ 3	-	-
G1-1292	355-500 μ m	-	-	-	-	-	1 $\pm$ 1	-	10 $\pm$ 2	4 $\pm$ 1	85 $\pm$ 2	-	-
G1-1436	<75 μ m	Tr.	-	81 $\pm$ 6	-	-	3 $\pm$ 1	-	12 $\pm$ 3	2 $\pm$ 1	-	-	-
G1-1436	<500 μ m	Tr.	-	73 $\pm$ 5	-	-	3 $\pm$ 1	-	14 $\pm$ 3	6 $\pm$ 1	-	-	-
G1-1854	<75 μ m	4 $\pm$ 1	-	59 $\pm$ 5	-	-	1 $\pm$ 1	-	22 $\pm$ 6	15 $\pm$ 3	-	-	-
G1-1883	<106 μ m	3 $\pm$ 1	Tr.	-	-	-	36 $\pm$ 2	2 $\pm$ 1	-	64 $\pm$ 8	-	1 $\pm$ 1	-
G1-1883	75-106 μ m Washed	Tr.	Tr.	-	-	-	40 $\pm$ 2	1 $\pm$ 1	-	60 $\pm$ 7	-	1 $\pm$ 1	-
G1-1883	106-250 μ m	Tr.	1 $\pm$ 1	-	-	-	34 $\pm$ 2	-	-	68 $\pm$ 8	-	1 $\pm$ 1	-
G1-1941	75-500 μ m	-	Tr.	-	-	-	28 $\pm$ 2	3 $\pm$ 1	-	64 $\pm$ 8	-	-	-
G1-1941	75-500 μ m Washed	Tr.	Tr.	-	-	-	31 $\pm$ 2	5 $\pm$ 2	-	65 $\pm$ 8	-	-	-
G1-1982	<75 μ m	5 $\pm$ 2	-	-	-	-	3 $\pm$ 1	32 $\pm$ 2	-	57 $\pm$ 7	-	-	3 $\pm$ 1 ^c
G1-1982	75-500 μ m	Tr.	Tr.	-	-	-	3 $\pm$ 1	25 $\pm$ 2	-	70 $\pm$ 9	-	-	1 $\pm$ 1 ^c
G1-1982-2	75-500 μ m	1 $\pm$ 1	Tr.	-	-	-	5 $\pm$ 1	17 $\pm$ 1	-	71 $\pm$ 10	-	-	4 $\pm$ 1 ^c
G1-1982	<500 μ m	4 $\pm$ 1	-	-	-	-	3 $\pm$ 1	26 $\pm$ 2	-	63 $\pm$ 8	-	-	1 $\pm$ 1 ^c
G1-2233	<38 μ m	3 $\pm$ 1	Tr.	49 $\pm$ 8	20 $\pm$ 7	-	Tr.	-	12 $\pm$ 4	25 $\pm$ 7	-	-	-
G1-2233	<75 μ m	3 $\pm$ 1	Tr.	44 $\pm$ 6	12 $\pm$ 4	-	1 $\pm$ 1	-	14 $\pm$ 5	32 $\pm$ 7	-	-	-
G1-2233-2	75-500 μ m	1 $\pm$ 1	2 $\pm$ 1	26 $\pm$ 3	10 $\pm$ 3	-	7 $\pm$ 1	-	13 $\pm$ 5	42 $\pm$ 8	-	-	-
G1-2233	<500 μ m	3 $\pm$ 1	1 $\pm$ 1	35 $\pm$ 5	13 $\pm$ 5	-	1 $\pm$ 1	-	14 $\pm$ 6	39 $\pm$ 9	-	-	-
G1-2289	<75 μ m	2 $\pm$ 1	Tr.	15 $\pm$ 5	62 $\pm$ 25	-	1 $\pm$ 1	-	3 $\pm$ 1	17 $\pm$ 5	-	-	-
G1-2289	75-500 μ m Washed	2 $\pm$ 1	Tr.	6 $\pm$ 3	43 $\pm$ 20	-	7 $\pm$ 2	-	7 $\pm$ 3	35 $\pm$ 18	-	-	-
G1-2289-2	75-500 μ m	-	Tr.	-	51 $\pm$ 12	-	6 $\pm$ 1	-	-	39 $\pm$ 15	-	-	-
G1-2289	<500 μ m	2 $\pm$ 1	Tr.	11 $\pm$ 5	44 $\pm$ 20	-	5 $\pm$ 2	-	10 $\pm$ 3	28 $\pm$ 16	-	-	-
G1-2363	<75 μ m	8 $\pm$ 2	1 $\pm$ 1	-	-	-	34 $\pm$ 2	-	-	62 $\pm$ 7	-	Tr.	-
G1-2363	38-106 μ m	2 $\pm$ 1	Tr.	-	-	-	56 $\pm$ 3	-	-	41 $\pm$ 5	-	Tr.	-
G1-2363	75-500 μ m	2 $\pm$ 1	1 $\pm$ 1	-	-	-	49 $\pm$ 2	-	-	49 $\pm$ 6	-	Tr.	-
G1-2363-2	75-500 μ m	1 $\pm$ 1	1 $\pm$ 1	-	-	-	43 $\pm$ 2	-	-	52 $\pm$ 6	-	Tr.	-
G1-2363	75-500 μ m Washed	4 $\pm$ 1	Tr.	-	-	-	45 $\pm$ 2	-	-	52 $\pm$ 6	-	Tr.	-
G1-2363	106-500 μ m	1 $\pm$ 1	1 $\pm$ 1	-	-	-	49 $\pm$ 2	-	-	55 $\pm$ 6	-	Tr.	-
G1-2363	<500 μ m	5 $\pm$ 2	1 $\pm$ 1	-	-	-	42 $\pm$ 2	-	-	51 $\pm$ 6	-	Tr.	Tr. ^d

APPENDIX I Continued

USW G-1

Sample ^a		Smectite	Mica	Clino- ptilolite	Morden- ite	Anal- cime	Quartz	Cristo- balite	Opal- CT	Alkali Feldspar	Glass	Hema- tite	Other
G1-2410	<38 μ m	8 $\pm$ 2	1 $\pm$ 1	-	-	-	21 $\pm$ 2	Tr.	-	67 $\pm$ 8	-	Tr.	1 $\pm$ 1 ^d
G1-2410	38-106 μ m	5 $\pm$ 2	Tr.	-	-	-	36 $\pm$ 2	Tr.	-	58 $\pm$ 7	-	Tr.	Tr. ^d
G1-2410	38-106 μ m Washed	2 $\pm$ 1	Tr.	-	-	-	46 $\pm$ 2	Tr.	-	51 $\pm$ 6	-	-	-
G1-2410	106-500 μ m	3 $\pm$ 1	1 $\pm$ 1	-	-	-	37 $\pm$ 2	-	-	56 $\pm$ 7	-	Tr.	Tr. ^d
G1-2476	<75 μ m	2 $\pm$ 1	Tr.	-	-	-	37 $\pm$ 2	-	-	58 $\pm$ 7	-	Tr.	-
G1-2476	75-500 μ m	1 $\pm$ 1	1 $\pm$ 1	-	-	-	38 $\pm$ 2	-	-	60 $\pm$ 7	-	Tr.	-
G1-2698	<75 μ m	-	2 $\pm$ 1	44 $\pm$ 5	7 $\pm$ 2	-	5 $\pm$ 1	-	17 $\pm$ 6	26 $\pm$ 5	-	-	-
G1-2698	75-500 μ m Wet S.	1 $\pm$ 1	5 $\pm$ 1	44 $\pm$ 4	2 $\pm$ 1	-	9 $\pm$ 1	-	15 $\pm$ 5	29 $\pm$ 5	-	-	-
G1-2698	75-500 μ m	Tr.	3 $\pm$ 1	45 $\pm$ 5	5 $\pm$ 2	-	7 $\pm$ 1	-	15 $\pm$ 5	27 $\pm$ 5	-	-	-
G1-2698-2	75-500 μ m	Tr.	2 $\pm$ 1	34 $\pm$ 4	6 $\pm$ 2	-	7 $\pm$ 1	-	14 $\pm$ 5	27 $\pm$ 5	-	-	-
G1-2698	<500 μ m	Tr.	3 $\pm$ 1	51 $\pm$ 5	5 $\pm$ 2	-	7 $\pm$ 1	-	14 $\pm$ 5	26 $\pm$ 4	-	-	-
G1-2840	<75 μ m	3 $\pm$ 1	1 $\pm$ 1	-	-	-	39 $\pm$ 2	-	-	59 $\pm$ 7	-	Tr.	-
G1-2840	<106 μ m	Tr.	1 $\pm$ 1	-	-	-	35 $\pm$ 2	-	-	61 $\pm$ 7	-	Tr.	-
G1-2840	150-355 μ m	1 $\pm$ 1	1 $\pm$ 1	-	-	-	38 $\pm$ 2	1 $\pm$ 1	-	60 $\pm$ 7	-	Tr.	-
G1-2840	355-500 μ m	1 $\pm$ 1	1 $\pm$ 1	-	-	-	39 $\pm$ 2	-	-	60 $\pm$ 7	-	Tr.	-
G1-2840	75-500 μ m Washed	Tr.	2 $\pm$ 1	-	-	-	39 $\pm$ 2	-	-	57 $\pm$ 7	-	Tr.	-
G1-2840-2	75-500 μ m	1 $\pm$ 1	2 $\pm$ 1	-	-	-	41 $\pm$ 1	-	-	61 $\pm$ 7	-	Tr.	-
G1-2854	75-500 μ m	Tr.	2 $\pm$ 1	-	-	-	41 $\pm$ 2	-	-	55 $\pm$ 6	-	Tr.	-
G1-2901	75-500 μ m	2 $\pm$ 1	1 $\pm$ 1	-	-	-	36 $\pm$ 2	-	-	57 $\pm$ 7	-	Tr.	1 $\pm$ 1 ^b
G1-2901	<500 μ m	Tr.	2 $\pm$ 1	-	-	-	36 $\pm$ 2	Tr.	-	59 $\pm$ 7	-	Tr.	-
G1-3116	<38 μ m	7 $\pm$ 2	1 $\pm$ 1	20 $\pm$ 2	-	5 $\pm$ 1	37 $\pm$ 3	-	-	32 $\pm$ 4	-	-	-
G1-3116	<75 μ m	7 $\pm$ 2	1 $\pm$ 1	19 $\pm$ 1	-	6 $\pm$ 1	36 $\pm$ 2	-	-	31 $\pm$ 4	-	-	-
G1-3116	106-500 μ m	4 $\pm$ 1	3 $\pm$ 1	6 $\pm$ 1	-	15 $\pm$ 1	30 $\pm$ 2	-	-	41 $\pm$ 5	-	-	-
G1-3116	75-500 μ m	2 $\pm$ 1	2 $\pm$ 1	5 $\pm$ 1	-	17 $\pm$ 1	30 $\pm$ 2	-	-	43 $\pm$ 5	-	-	-
G1-3116-2	75-500 μ m	3 $\pm$ 1	2 $\pm$ 1	4 $\pm$ 1	-	18 $\pm$ 1	30 $\pm$ 2	-	-	43 $\pm$ 5	-	-	-
G1-3116	<500 μ m	5 $\pm$ 2	2 $\pm$ 1	11 $\pm$ 1	-	11 $\pm$ 1	34 $\pm$ 2	-	-	36 $\pm$ 5	-	-	-
G1-3658	<500 μ m	58 $\pm$ 17	-	-	-	-	-	2 $\pm$ 1	-	34 $\pm$ 4	-	Tr.	1 $\pm$ 1 ^e

^a Sample designation G1-3116 refers to a sample from drill hole USW G-1 at 3116 feet depth. Wet S. = Wet Sieved.^b Calcite.^c Tridymite.^d Kaolinite.^e Hornblende.

APPENDIX I Continued

USW G-2

Sample ^a			Smectite	Mica	Clino- ptilolite	Morden- ite	Anal- cime	Quartz	Cristo- balite	Opal- CT	Alkali Feldspar	Glass	Hema- tite	Other
G2-339	<75 μ m	Wet S.	6 $\pm$ 2	-	-	-	-	Tr.	-	-	-	94 $\pm$ 2	-	-
G2-339	75-500 μ m	Wet S.	14 $\pm$ 3	-	-	-	-	1 $\pm$ 1	1 $\pm$ 1	-	Tr.	84 $\pm$ 3	-	-
G2-339	75-500 μ m		23 $\pm$ 5	-	-	-	-	-	-	-	-	77 $\pm$ 5	-	-
G2-547	75-500 μ m		29 $\pm$ 9	2 $\pm$ 1	-	-	-	2 $\pm$ 1	-	7 $\pm$ 2	25 $\pm$ 3	35 $\pm$ 10	-	-
G2-723	75-500 μ m		4 $\pm$ 1	Tr.	-	-	-	Tr.	Tr.	-	13 $\pm$ 2	49 $\pm$ 3	-	34 $\pm$ 2 ^b
G2-1915	75-500 μ m		Tr.	-	5 $\pm$ 5	83 $\pm$ 15	-	7 $\pm$ 1	-	2 $\pm$ 1	11 $\pm$ 6	-	-	-
G2-1951	<75 μ m		1 $\pm$ 1	-	58 $\pm$ 10	18 $\pm$ 5	-	Tr.	-	15 $\pm$ 3	6 $\pm$ 2	-	-	-
G2-1951	75-500 μ m	Wet S.	2 $\pm$ 1	-	56 $\pm$ 9	18 $\pm$ 6	-	5 $\pm$ 1	-	15 $\pm$ 4	8 $\pm$ 2	-	-	Tr. ^b
G2-1952	75-500 μ m	Wet S.	1 $\pm$ 1	-	43 $\pm$ 9	25 $\pm$ 7	-	3 $\pm$ 1	-	15 $\pm$ 4	8 $\pm$ 2	-	-	-
G2-2017	75-500 μ m	Washed	1 $\pm$ 1	-	51 $\pm$ 7	11 $\pm$ 3	-	7 $\pm$ 1	-	17 $\pm$ 5	15 $\pm$ 3	-	-	-
G2-2017	75-500 μ m		1 $\pm$ 1	-	55 $\pm$ 8	17 $\pm$ 5	-	5 $\pm$ 1	-	7 $\pm$ 2	11 $\pm$ 3	-	-	-
G2-3308	75-500 μ m		1 $\pm$ 1	2 $\pm$ 1	-	-	-	37 $\pm$ 2	-	-	61 $\pm$ 7	-	1 $\pm$ 1	-
G2-3933	75-500 μ m		8 $\pm$ 2	-	-	-	15 $\pm$ 1	40 $\pm$ 2	-	-	33 $\pm$ 4	-	-	-

^a Sample designation G2-3933 refers to a sample from drill hole USW G-2 at 3933 feet depth. Wet S. = Wet Sieved.

^b Calcite.

APPENDIX I Continued

USW GU-3 and USW G-3

Sample ^a		Smectite	Mica	Clino- ptilolite	Morden- ite	Anal- cise	Quartz	Cristo- balite	Opal- CT	Alkali Feldspar	Glass	Hema- tite	Other
GU3-433	75-500 μ m	Tr.	2 $\pm$ 1	-	-	-	-	15 $\pm$ 1	-	76 $\pm$ 10	-	1 $\pm$ 1	2 $\pm$ 1 ^b
GU3-688	150-500 μ m Washed	1 $\pm$ 1	Tr.	-	-	-	4 $\pm$ 1	27 $\pm$ 2	-	68 $\pm$ 8	-	-	Tr. ^b
GU3-916	75-500 μ m Washed	Tr.	Tr.	-	-	-	18 $\pm$ 1	19 $\pm$ 2	-	59 $\pm$ 8	-	-	2 $\pm$ 1 ^b
GU3-1203	75-500 μ m Washed	Tr.	Tr.	-	-	-	1 $\pm$ 1	-	16 $\pm$ 4	13 $\pm$ 2	70 $\pm$ 5	-	-
GU3-1301	75-500 μ m Washed	Tr.	Tr.	-	-	-	2 $\pm$ 1	-	5 $\pm$ 1	7 $\pm$ 1	86 $\pm$ 2	-	-
GU3-1436	75-500 μ m	Tr.	Tr.	-	-	-	4 $\pm$ 1	-	3 $\pm$ 1	18 $\pm$ 2	75 $\pm$ 2	-	-
GU3-1437	75-500 μ m	-	1 $\pm$ 1	-	-	-	6 $\pm$ 1	-	-	14 $\pm$ 2	79 $\pm$ 2	-	-
GU3-1437	75-500 μ m Washed	Tr.	-	-	-	-	2 $\pm$ 1	-	2 $\pm$ 1	10 $\pm$ 1	86 $\pm$ 2	-	-
GU3-1531	75-500 μ m Washed	Tr.	1 $\pm$ 1	-	-	-	17 $\pm$ 1	-	-	26 $\pm$ 3	56 $\pm$ 3	-	-
GU3-1937	75-500 μ m	1 $\pm$ 1	Tr.	69 $\pm$ 5	-	-	3 $\pm$ 1	-	10 $\pm$ 3	18 $\pm$ 3	-	-	-
GU3-1937	75-500 μ m	2 $\pm$ 1	Tr.	63 $\pm$ 4	-	-	3 $\pm$ 1	-	9 $\pm$ 3	23 $\pm$ 4	-	-	-
GU3-1937-2	75-500 μ m	3 $\pm$ 1	-	60 $\pm$ 4	1 $\pm$ 1	-	2 $\pm$ 1	-	8 $\pm$ 2	20 $\pm$ 4	-	-	-
G3-4868	75-500 μ m Wet S.	3 $\pm$ 1	2 $\pm$ 1	-	-	33 $\pm$ 2	30 $\pm$ 2	-	-	36 $\pm$ 4	-	-	-
G3-4868	75-500 μ m Wet S.	2 $\pm$ 1	1 $\pm$ 1	-	-	33 $\pm$ 2	30 $\pm$ 2	-	-	31 $\pm$ 4	-	-	-

^a Sample designation GU3-1937 refers to a sample from drill hole USW GU-3 at 1937 feet depth. Wet S. = Wet Sieved.

^b Tridymite.

APPENDIX I Continued

USW G-4

Sample ^a	Smectite	Mica	Clino- ptilolite	Morden- ite	Anal- cime	Quartz	Cristo- balite	Opal- CT	Alkali Feldspar	Glass	Hema- tite	Other
G4-1395 75-500 μ m	3 $\pm$ 1	-	22 $\pm$ 2	-	-	1 $\pm$ 1	-	-	7 $\pm$ 1	67 $\pm$ 3	-	-
G4-1395 75-500 μ m Washed	3 $\pm$ 1	-	22 $\pm$ 2	-	-	2 $\pm$ 1	-	5 $\pm$ 1	9 $\pm$ 1	59 $\pm$ 3	-	-
G4-1502 75-500 μ m Washed	2 $\pm$ 1	-	71 $\pm$ 5	-	-	4 $\pm$ 1	-	15 $\pm$ 3	3 $\pm$ 1	-	-	-
G4-1608 75-500 μ m	6 $\pm$ 2	-	63 $\pm$ 5	Tr.	-	1 $\pm$ 1	-	18 $\pm$ 4	7 $\pm$ 1	-	-	-
G4-1608 75-500 μ m	5 $\pm$ 2	Tr.	64 $\pm$ 6	3 $\pm$ 1	-	5 $\pm$ 1	-	18 $\pm$ 4	7 $\pm$ 1	-	-	-
G4-1608 75-500 μ m Washed	5 $\pm$ 2	Tr.	54 $\pm$ 4	-	-	6 $\pm$ 1	-	20 $\pm$ 5	11 $\pm$ 2	-	-	-
G4-1608 <500 μ m	6 $\pm$ 2	Tr.	68 $\pm$ 6	3 $\pm$ 1	-	3 $\pm$ 1	-	15 $\pm$ 3	5 $\pm$ 1	-	-	-

^a Sample designation G4-1608 refers to a sample from drill hole USW G-4 at 1608 feet depth.

APPENDIX II

QUALITY ASSURANCE

The following is a list of YMP logbooks and notebooks containing data presented in this report.

TWS-ESS-1-4/85-17
TWS-ESS-1-9/85-10
TWS-ESS-1-7/86-3
TWS-ESS-1-7/86-35
TWS-ESS-1-7/86-36
TWS-ESS-1-8/86-57

A list of the raw data computer files has been placed in the resident file with the other documentation for this report.

The following number is for Office of Civilian Radioactive Waste Management purposes only and should not be used when ordering this document:

Accession Number: NNA.890414.0062