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Yucca Mountain Site Characterization Project

Geotechnical Characterization of the North Ramp of the Exploratory Studies Facility

Volume II of II NRG Corehole Data Appendices

Carl E. Brechtel, Ming Lin, Eric Martin, David S. Kessel

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-84AL85000

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**GEOTECHNICAL CHARACTERIZATION OF
THE NORTH RAMP OF THE EXPLORATORY STUDIES FACILITY**

**Volume II of II
NRG Corehole Data Appendices**

by

Carl E. Brechtel
Ming Lin
Eric Martin
Agapito Associates, Inc.
Grand Junction, CO 81506

and

David S. Kessel
Sandia National Laboratories
Albuquerque, NM 87185

ABSTRACT

Geotechnical characterization data were developed in eleven holes, the North Ramp Geotechnical (NRG) boreholes, drilled along the 2800-m route of the North Ramp. The North Ramp is one of two inclined tunnels being excavated to the potential repository horizon for the Yucca Mountain Site Characterization Project. The primary purpose of the drilling program was to produce rock properties data to support subsurface design. Specific data developed included lithologic and rock structural core logs, cross sections with stratigraphic and thermal-mechanical units, rock mechanics laboratory testing, and rock mass quality indices. These data are summarized in this report to address the major topics of geologic setting, geologic features of engineering and construction significance, anticipated ground conditions, and range of required ground support.

Rock structural data and rock mass quality data have been summarized in 3-m (10-ft) intervals and grouped according to the thermal-mechanical units. The distribution of rock mass quality data in all NRG holes within each thermal-mechanical unit has been proposed to be representative of the variability to be encountered by the North Ramp as it cuts across each unit.

MASTER

Document Review and Comment Sheet

This work was supported by the United States Department of Energy under Contract DE-AC04-94AL85000 and was prepared under the Yucca Mountain Site Characterization Project WBS numbers 1.2.3.2.6.2.1, 1.2.3.2.6.2.2, and 1.2.3.2.6.2.3, QA Grading Report #1.2.3.2.6.2.1, Revision 0. The planning document that guided this work activity was Work Agreement #071, Revision 00. The information and data documented in this report were collected under a fully qualified QA Program, except as noted in the report.

TABLE OF CONTENTS

VOLUME I — DATA SUMMARY

<u>Section</u>	<u>Page</u>
1.0 Introduction	1-1
1.1 Purpose	1-1
1.2 Background	1-1
1.3 Scope	1-5
1.4 Quality Assurance	1-8
1.5 Report Organization	1-9
2.0 Geotechnical Summary	2-1
2.1 Introduction	2-1
2.2 Geology and Major Structural Features along the North Ramp	2-2
2.2.1 Known Geologic Features of Engineering and Construction Significance ..	2-3
2.2.2 Potential Geological Features with Engineering and Construction Significance	2-5
2.3 Thermomechanical Stratigraphy	2-6
2.4 Orientations of Joints and Fractures	2-7
2.5 Hydrology	2-7
2.6 Rock Structure Data from the NRG Core	2-8
2.7 Rock Mechanical Properties Tests	2-12
2.8 Rock Mass Quality Indices	2-13
2.8.1 RMR and Q Data	2-13
2.8.2 Projected Range of Ground Support	2-16
2.9 Rock Mass Mechanical Properties Estimates	2-17
3.0 Geologic and Geotechnical Data Development	3-1
3.1 Introduction	3-1
3.2 Lithologic Logging of the Core	3-5
3.3 Rock Structural Logging	3-6
3.4 Rock Mechanical Properties Tests	3-11
3.5 Rock Mass Quality	3-12
3.6 Rock Mass Mechanical Properties	3-15
4.0 Geology of the North Ramp	4-1
4.1 Introduction	4-1
4.2 Stratigraphy	4-1
4.2.1 Ash-Flow Tuffs	4-8
4.2.2 Bedded Tuffs	4-12
4.3 Geologic Cross Sections	4-13
4.3.1 Drilling and Surface Mapping Data	4-14

<u>Section</u>	<u>Page</u>
4.3.2 Seismic Interpretation in Daylight Valley	4-17
4.3.3 Projected Ramp Station Coordinates Stratigraphic Contacts	4-23
4.4 Thermomechanical Stratigraphy	4-23
4.5 Major Structural Features	4-28
4.5.1 Faults Recognized Along North Ramp Alignment	4-28
4.5.2 Recognized Fracture Patterns	4-31
5.0 Rock Structure Data	5-1
5.1 Introduction	5-1
5.2 Core Recovery	5-2
5.3 RQD Data	5-5
5.4 Rock Weathering and Hardness	5-9
5.5 Lithophysae Content	5-12
5.6 Fracture Data	5-15
5.6.1 Feature Type	5-16
5.6.2 Fracture Inclination	5-18
5.6.3 Calculated Fracture Frequencies	5-18
5.6.4 Fracture Infill Mineralization and Thickness	5-23
5.6.5 Fracture Planarity and Roughness	5-27
5.7 Analysis of Rock Structural Character where Boreholes Intersect Faults	5-27
5.8 Correlation of Core Rock Structural Data with Downhole Video Logs	5-33
6.0 Rock Mechanics Laboratory Test Data	6-1
6.1 Introduction	6-1
6.2 Unconfined Compressive Strength	6-2
6.3 Elastic Modulus and Poisson's Ratios	6-5
6.4 Dry Bulk Density, Porosity, and Average Grain Density	6-5
6.5 Indirect Tensile Strength	6-14
6.6 Confined Compressive Strength	6-14
6.7 Schmidt Hammer Rebound Hardness	6-21
7.0 Rock Mass Quality Data	7-1
7.1 Introduction	7-1
7.2 Rock Mass Quality Indices for the Rock Mass Rating System	7-3
7.2.1 Strength Parameter	7-4
7.2.2 Rock Quality Designation Rating	7-7
7.2.3 Spacing of Discontinuity	7-7
7.2.4 Condition of Joint	7-10
7.2.5 Groundwater	7-11
7.2.6 Distribution of Rock Mass Rating Values for the Thermomechanical Units	7-11

<u>Section</u>	<u>Page</u>
7.3 Rock Mass Quality Indices for the Q System	7-15
7.3.1 Rock Quality Designation	7-15
7.3.2 Joint Set Number	7-16
7.3.3 Joint Roughness Number	7-16
7.3.4 Joint Alteration	7-18
7.3.5 Joint Water Reduction Factor	7-20
7.3.6 Stress Reduction Factor	7-20
7.3.7 Distribution of Q Values for the Thermomechanical Units	7-25
7.4 Evaluation of RMR and Q Results	7-25
7.4.1 Correlation of RMR and Q Results	7-27
7.4.2 Comparison of Q and RMR Determined in the NRST to NRG Core-Based Data	7-33
7.5 Comparison of Lithophysae-Rich and Nonlithophysal Portions of the Welded Units	7-35
7.6 Indicated Ground Conditions	7-36
8.0 Rock Mass Mechanical Properties	8-1
8.1 Introduction	8-1
8.2 Rock Mass Strengths	8-1
8.2.1 Yudhbir Criterion	8-4
8.2.2 Hoek and Brown Criterion	8-6
8.2.3 Design Rock Mass Strengths	8-7
8.2.4 Rock Mass Mohr-Coulomb Strength Parameters and Dilation Angles	8-7
8.3 Rock Mass Elastic Modulus	8-15
8.4 Rock Mass Poisson's Ratios	8-16
9.0 References	9-1
Appendix A. Technical Procedure	
Appendix B. Development of Rock Mass Quality Estimates from Core Data	
Appendix C. Ranked Frequency of Occurrence Tables for Q, RMR, and RQD by Thermomechanical Unit	
Appendix D. Rock Mass Quality Indices for the Lithophysae-Rich and Nonlithophysal Tuff Rock in TCw and TSwl Units	

VOLUME II — NRG COREHOLE DATA APPENDICES

<u>Section</u>	<u>Page</u>
1.0 Introduction	1-1
Appendix A. UE25 NRG-1	
Appendix B. UE25 NRG-2	
Appendix C. UE25 NRG-2A	
Appendix D. UE25 NRG-2B	
Appendix E. UE25 NRG-3	
Appendix F. UE25 NRG-4	
Appendix G. UE25 NRG-5	
Appendix H. USW NRG-6	
Appendix I. USW NRG-7/7A	
Appendix J. RF #8	

1.0 INTRODUCTION

1.1 Purpose

This report presents the results of geological and geotechnical characterization of the Miocene volcanic tuff rocks of the Timber Mountain and Paintbrush groups that the tunnel boring machine (TBM) will encounter during excavation of the Exploratory Studies Facility (ESF) North Ramp. The information in this report was developed to support the design of the ESF North Ramp. The ESF is being constructed by the U.S. Department of Energy (DOE) as part of the Yucca Mountain Project site characterization activities. The purpose of these activities is to evaluate the potential to locate the national high-level nuclear waste repository on lands within and adjacent to the Nevada Test Site (NTS), Nye County, Nevada. This report was prepared as part of the Soil and Rock Properties Studies, W.B.S. 1.2.3.2.6.2 in accordance with Study Plan 8.3.1.14.2, Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities (DOE, 1991).

1.2 Report Organization

This report is presented in two volumes:

- Volume I — Data Summary
- Volume II — NRG Corehole Data Appendices

Volume I presents the collection and analysis of the data for the thermomechanical (thermal-mechanical) units to be penetrated by the North Ramp. Volume II presents the individual data and logs for each of the NRG Holes.

Following this introduction in Volume II, data are presented for each of the coreholes:

- Appendix A — UE25 NRG-1
- Appendix B — UE25 NRG-2
- Appendix C — UE25 NRG-2A
- Appendix D — UE25 NRG-2B
- Appendix E — UE25 NRG-3
- Appendix F — UE25 NRG-4
- Appendix G — UE25 NRG-5
- Appendix H — USW NRG-6
- Appendix I — USW NRG-7/7A
- Appendix J — RF #8

Data contained in the report for each hole includes:

- Geology and Rock Structure Log,
- Corehole Rock Structural Data Summary log,
- Estimated Rock Mass Quality Indices Based on Corelog Data (except RF #8),
- Schmidt Hammer Tests (NRG-1, -2, -2A, -3, -4, -5, -6, -7/7A),
- Comparison of Downhole Video Data with Core Data log (NRG-4, -5, -6, and -7/7A), and
- Summary of Laboratory Testing Data (NRG-4, -5, -6, -7/7A).

APPENDIX A

UE25 NRG-1

Geology and Rock Structure Log

Core Hole Rock Structural Data Summary

Estimated Rock Mass Quality Indices Based on Core Log Data

Schmidt Hammer Tests

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**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
GEOLOGY AND ROCK STRUCTURE LOG
UE25 NRG-1**

Sandia National Laboratories
Print Date: 2/4/95
WBS 1.2.3.2.6.2
QA: QA
Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Small changes in 10-ft RQD in three 10-ft intervals. Revised stratigraphic summary to include USGS nomenclature. Corrected study plan number on cover page.

BOREHOLE ID:	UE25 NRG-1	TOTAL DEPTH:	150.1 ft
STUDY PLAN NO:	8.3.1.14.2	ANGLE FROM VERT:	0°
CORE SIZE:	HQ 2.5"	AZIMUTH:	NA
DRILL DATES:	6/16/92 - 6/23/92		
GROUND ELEV:	3753.43 ft		
COORDINATES:	N: 765,358.60 ft E: 569,803.06 ft		

Field Rock Structure

Logged by:

C. G. Scroggins	Drilling Support Division, Drilling
D. Switzer	Support and Sample Management
D. Hattler	Department, T&MSS

Relogged by:

Carl Brechtel	J. F. T. Agapito & Associates, Inc.
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Lithology and Stratigraphy

Logged by:

Chris Rautman	Sandia National Laboratories
---------------	------------------------------

Checked by:

Carl Brechtel	J. F. T. Agapito & Associates, Inc.
Richard Lippoth	J. F. T. Agapito & Associates, Inc.
Eric Martin	J. F. T. Agapito & Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION GEOLOGY AND ROCK STRUCTURE

NONWELDED

WELDED

BEDDED TUFF

LOST CORE

FRACTURE TYPE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition, not a fracture.

LOST CORE AND RUBBLE

LOST CORE

20 x RUBBLE ZONE
(with average maximum diameter of
rubble pieces to nearest 0.01 ft;
NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

ROUGHNESS

INFILLING THICKNESS AND MINERALIZATION

C Clean, no filling.	C Clean	CA Calcite
S Very thin, surface sheen	WC White, crystalline	SI Silica
T Thin (up to 0.1 inches)	WN White, non-crystalline	MN Manganese
M Moderately thick (0.1 - 0.4 inches)	TD Brown dendritic	CL Clay
V Very thick (0.4 - 1.0 inches)	TC Tan crystalline	BC Black crystalline
E Extremely thick, greater than 1.0 inches)	TN Tan, non-crystalline	BD Black dendritic

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If a piece length ≥ 0.33 ft crosses over the 10-ft interval boundary, the portion of the piece length that occurs in the 10-ft interval is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

Reference: USGS — Graphical Lithologic Log of Borehole UE25 NRG-1, Thomas Moyer and Jeffrey Geslin (DTN: GS931208314211.046).

UE25 NRG-1

Stratigraphic and Thermomechanical Units Summary

Date: 12/9/94

Unresolved contact showing difference between criteria. Solid line shows contact based on Scott & Bonk¹; dashed line is contact based on USGS².

- ¹ U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.
- ² U. S. Geological Survey - Graphical Lithologic Log of Borehole UE25-NRG-1, Thomas Moyer and Jeff Gestlin, DTN:GS931208314211.046.

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD %)					FRACTURES (FEET PER FOOT)			HARDNESS	WEATHERING	ESTIMATED % DISCONTINUOUS SURFACE CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RODS)	LOST CORE & RIBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	TOP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND (INDETERMINATE) (+ INDUCED)		10	20	30	40		
5.0																								D.M. - 14.5 NO CORE RECOVERED. SURFACE ALLOWING TO 6.1 FT.
10.0	4	4	(20)																					
																								TIVA CANYON MEMBER--UPPER (?) LITHOMYAL UNIT HEAVILY WEARED ASH-FLOW TUFF. LIGHT GRAY TO LIGHT TAN, BLENDED POOR, FEW PERCENT SANDSTONE (FRESH, VITREOUS), SPARSE SCOTITE.
15.0	4	4	(20)																					
																								TIVA CANYON MEMBER--UPPER (?) LITHOMYAL UNIT HEAVILY WEARED ASH-FLOW TUFF. LIGHT GRAY TO LIGHT TAN, BLENDED POOR, FEW PERCENT SANDSTONE (FRESH, VITREOUS), SPARSE SCOTITE.
20.0	4	4	(20)																					
																								TIVA CANYON MEMBER--UPPER (?) LITHOMYAL UNIT HEAVILY WEARED ASH-FLOW TUFF. LIGHT GRAY TO LIGHT TAN, BLENDED POOR, FEW PERCENT SANDSTONE (FRESH, VITREOUS), SPARSE SCOTITE.
25.0	4	4	(20)																					

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GEOLOGY AND ROCK STRUCTURE LOG

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6-V

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-ROD (R)					FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	PLANARITY	LOWESS	INFILL	THICKNESS AND	ORIENTALS	DP	INDUCED	FEET LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (PER 10 FT)				
																	10 20 30		10 20 30 40		
55.0																					

Structure file: MMS12V7.STR Lithology file: MMS12V7.LTH Date: 10/01/94

M2log v 4.60

GENERALLY MODERATE VAPOR-PHASE ALTERATION--
WHITE FINE-GRAINED MATERIAL THAT OCCURS
LARGE (2-5 CM+) LITHOPHYSEAL CAVITIES
WITH VAPOR-PHASE ALTERATION RINGS BELOW
17 FT ARE SPARSE BUT PROMINENT FEATURES IN
OTHERWISE COMPACT ROCK.

[illegible]

87.8-106.5 FT GRADATIONAL CONTACT ZONE
OF DIMINISHED LITHOPHASE CAVITY CONTENTS--
ROCK BECOMES "SPOTTED" BY 1/2-2 CM SPOTS
OF INTERNE VAPOR-PHASE ALTERATION, ONLY
SPARSE ACTUAL CAVITIES--IRREGULAR, SLIGHTLY
ELONGATED TO 1-4 CM

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

A-11

[illegible]

Stratigraphy file: M8Q18V7.BTK Lithology file: M8Q18.LTM Date: 10/06/94

HP104 v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % ALTERATION (AS APPLIED TO CORE)	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RQD) (%)	LOST CORE & RUBBLE	TYPE	PLANARITY	REGULARITY	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	WEATHERING			
130.0	100 - 110	62	X	N	N	N	N		70		.65			45%			10	1		XXXXXX	
	110 - 120	62	X	N	N	N	N				.90									XXXXXX	
	120 - 130	50	X	N	N	N	N				.70									XXXXXX	
135.0	130 - 140	50	X	N	N	N	N				.60									XXXXXX	
	140 - 150	74	X	N	N	N	N				.45			2%						XXXXXX	
	150 - 160	96	X	N	N	N	N				.45									XXXXXX	
140.0	160 - 170	63	X	N	N	N	N				.42									XXXXXX	
	170 - 180	52	X	N	N	N	N				.60									XXXXXX	
	180 - 190	52	X	N	N	N	N				.37									XXXXXX	
	190 - 200	52	X	N	N	N	N				.52									XXXXXX	
	200 - 210	52	X	N	N	N	N				.36									XXXXXX	
	210 - 220	52	X	N	N	N	N				.58									XXXXXX	
	220 - 230	52	X	N	N	N	N				.65									XXXXXX	
	230 - 240	52	X	N	N	N	N				.42									XXXXXX	
145.0	240 - 250	72	X	N	N	N	N				.36			41%						XXXXXX	
	250 - 260	72	X	N	N	N	N				.35									XXXXXX	
	260 - 270	72	X	N	N	N	N				.33									XXXXXX	
150.0	270 - 280	72	X	N	N	N	N				.33									XXXXXX	

A-12

GEOLOGY AND ROCK STRUCTURE LOG

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by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % ESTIMATION OF FRACTURES AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ ROCKINESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR 25	POOR 50	FAR 75	GOOD 85	EXCELLENT 90	NATURAL AND INDETERMINATE (+ INDUCED)	10	20			30	0	20	40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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Structure file: HW018V7.STR Lithology file: HW018.LTR Date: 10/04/94

HPlog v 4.60

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Sandia National Laboratories

Print Date: 9/1/94

WBS 1.2.3.2.6.2

QA: QA

Revision 1

CORE HOLE ROCK STRUCTURAL DATA SUMMARY

Hole UE25 NRG-1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Change in 10-ft RQD in three intervals. Uses USGS nomenclature for stratigraphy and thermomechanical units.

CODING EXPLANATION

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member	C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal

THERMOMECHANICAL UNITS

TCw—Tiva Canyon Welded Unit

COLUMN INFORMATION (Page 3)

RQD (%)
$$RQD (\%) = \frac{\sum \text{Piece lengths } \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

CORE RQD Core RQD based on piece lengths defined by all types of fractures (C, I, N and V).

ENHANCED RQD Effect of fractures identified as coring induced (Type C) are filtered from the piece lengths.

LITHOPHYSAL (and other cavities) Percent void due to lithophysae and other cavities, estimated visually by counting the number of cavities, estimating the average diameter, calculating the void volume assuming spherical cavities, and normalizing to the core volume.
NM—Not Measured

WEATHERING Subjective evaluation of rock degradation by mechanical/chemical agents:
F: Fresh M: Moderately weathered D: Decomposed
S: Slightly weathered I: Intensely weathered

HARDNESS Subjective evaluation of resistance to breakage:
1: Extremely hard 4: Moderately hard 7: Very soft
2: Very hard 5: Moderately soft 8: Soil-like, cohesive
3: Hard 6: Soft 9: Soil-like, non-cohesive

COLUMN INFORMATION (Page 4)

FEATURE TYPE Following codes indicate origin of feature:
N: Natural—indicated by mineral coating or evidence of weathering, slickensides, lack of fit between sides.
I: Indeterminate—origin questionable, rotated so that coatings possibly removed.
C: Coring induced—fresh, clean, tightly fitting breaks.
V: Vug or large void.

INCLINATION (degrees) Angle between plane normal to core axis and plane of fracture (Type N and I only).

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MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only):		
	C: Clean	TD: Brown dendritic	CL: Clay
	WC: White crystalline	TC: Tan crystalline	TN: Tan noncrystalline
	WN: White noncrystalline	CA: Calcite	FE: Iron oxide
	BC: Black crystalline	SI: Silica	BN: Brown noncrystalline
	BD: Black dendritic	MN: Manganese	
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only):		
	C: Clean, no filling	M: Moderately thick (0.1-0.4 inches)	
	S: Very thin, surface sheen	V: Very thick (0.4 - 1.0 inches)	
	T: Thin (up to 0.1 inches)	E: Extremely thick, greater than 1.0 inches	
PLANARITY	Describes the overall shape of the feature (Type N and I only):		
	P: Planar	S: Stepped	
	C: Curved	I: Irregular	
ROUGHNESS	Describes the local relief of the surface (Type N and I only):		
	V: Very rough—stepped, near-normal steps and ridges occur.		
	R: Rough—large angular asperities can be seen.		
	M: Moderately rough—asperities clearly visible, surface has abrasive feel.		
	S: Smooth—no asperities, smooth to the touch.		
	P: Polished—slickensided, extremely smooth and shiny.		

Interval—0-150 ft (0-45.7 m)

*** Footage in interval may not equal 30 ft because of lost core, splits, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRG-1

Interval—0-150 ft (0-45.7 m)

NO. OF FRACTURES W/GENERAL INFILLING TYPE												NO. OF FRACTURES W/INFILL THICKNESS CODE							NO. OF FRACTURES W/PLANARITY CODE					NO. OF FRACTURES W/ROUGHNESS CODE				
WN	BC	BD	TD	TC	CA	SE	MN	CL	TN	FE	BN	C	S	T	M	V	E	P	C	S	I	V	R	M	S	F		
					5							18	2					2				2	4	1	2			
					1							13			1			1				1	1		7			
												11						1	1					3	8			
												13	1												1			
												27	1															
												13																
												13									1		1	1				
												3									1			1				
								1				3	1												2			
								3				7	1											1	2			
								3				3																
					1		1	8				5	1												8			
								1				1												1				
0	0	0	0	0	7	0	1	11	0	0	0	130	7	0	1	0	0	4	1	2	0	4	8	7	27	0		
0	0	0	0	0	4.8	0	0.7	7.2	0	0	0	84	5.1	0	0.7	0	0	57	14	29	0	8.1	14	16	81	0		

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA**

Sandia National Laboratories
Print Date: 1/16/95
WBS 1.2.3.2.6.2
QA: L
Revision 2

Hole UE25 NRG-1

REVISION HISTORY

Revision 2 Method for calculating percent lithophysae and other cavities revised. Change in three 10-ft RQD values. Method for determining Jr and Ja revised in zones with extensive lost core and rubble; Jn and SRF values resimulated. Revised stratigraphy and thermomechanical units to USGS nomenclature; Q-core index and histogram plots removed from presentation.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{**}} \cdot \frac{J_r}{J_n} \cdot \frac{J_w}{SRF^{**}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of Jn and SRF.

where RQD** = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

Jn* = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9. Value may change in subsequent revisions due to resimulation.

Jr = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

Ja = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

Jw = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: Cannot be determined from core log data and is generated by Monte-Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel. Value may change in subsequent revisions due to resimulation.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean value for the TCw thermomechanical unit in UE25 NRG-1 is:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
TCw	31.2%	44.3%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$\text{RMR} = \text{C} + \text{RQD-I} + \text{JS} + \text{JC} + \text{JW}$$

where C = Rock Strength Index: Derived from compressive strength data (PTn, TSw1) or estimated by Schmidt Rebound Hardness data (TCw, TSw2) for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data or Schmidt Hammer data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, includes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions.

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member	C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal

THERMOMECHANICAL UNITS

TCw—Tiva Canyon Welded Unit

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole UE25 NRG-1

Interval—10-150 ft (3.0-45.7 m)

END DEPTH	STRATIGRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM ¹ Barton et al. (1974)							RMR CLASSIFICATION SYSTEM ² Bieniawski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRP*	Q*	C	RQD-I	JS	JC	JW	RMR
20	T.C. C.R. Nonliih.	TCw	9	4.00	1.78	1.00	1.00	1.00	4.44	12	3	6	19.2	15	54.2
30	T.C. C.R. Nonliih.	TCw	15	4.00	1.22	1.38	1.00	7.50	0.46	12	3	8	17.8	15	55.6
40	T.C. C.P. U. Lith.	TCw	30	9.00	1.38	1.00	1.00	7.50	0.61	12	8	8	20.8	18	63.8
50	T.C. C.P. U. Lith.	TCw	0	9.00	2.51	1.87	1.00	1.00	1.49	12	3	5	23.7	15	58.7
60	T.C. C.P. U. Lith.	TCw	27	9.00	4.00	1.00	1.00	1.00	12.00	7	8	8	30.0	15	68.0
70	T.C. C.P. U. Lith.	TCw	26	8.00	4.00	1.00	1.00	7.60	2.31	7	8	8	30.0	15	68.0
80	T.C. C.P. U. Lith.	TCw	44	8.00	2.50	1.00	1.00	7.60	2.44	12	8	8	28.5	15	71.5
90	T.C. C.P. U. Lith.	TCw	58	4.00	3.00	1.00	1.00	5.00	8.70	12	13	8	28.5	15	76.5
100	T.C. C.P. U. Lith.	TCw	48	8.00	1.00	1.50	1.00	5.00	0.78	12	8	8	24.3	15	67.3
110	T.C. C.P. U. Lith.	TCw	52	7.00	1.33	1.75	1.00	1.00	5.88	12	13	8	24.2	15	72.2
120	T.C. C.P. M. Nonliih.	TCw	15	9.00	2.51	1.87	1.00	1.00	2.24	12	3	8	23.7	15	61.7
130	T.C. C.P. M. Nonliih.	TCw	45	8.00	1.00	3.00	1.00	5.00	0.50	12	8	8	21.7	15	64.7
140	T.C. C.P. M. Nonliih.	TCw	62	7.00	4.00	1.00	1.00	1.00	35.43	12	13	8	30.0	15	78.0
150	T.C. C.P. M. Nonliih.	TCw	41	8.00	2.00	3.00	1.00	7.50	0.48	12	8	8	22.8	15	65.8

Jn*, SRP* = Interval values generated by Monte Carlo simulation to calculate Q*.

RQD**: If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974).

¹ Barton, N., R. Lien, and J. Lunne, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6:189-236 (Springer Verlag, 1974).² Bieniawski, Z.T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 2:41-48 (A. A. Balkema, 1979).

Q

Jn — Joint Set Number
 Jr — Joint Roughness Number
 Ja — Joint Alteration Number
 Jw — Joint Water Reduction Factor
 SRP — Stress Reduction Factor

$$Q = (RQD/Jn)(Jr/Ja)(Jw/SRP)$$

RMR

C — Strength Index
 RQD-I — RQD Index
 JS — Joint Spacing Index
 JC — Discontinuity Condition Index
 JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

A-22

SCHMIDT HAMMER TESTS

Initial Calibration Individual readings not available.

Average Calibration Reading: 73.2

Correction Factor: 1.01

Test Date: 9/2/89

Final Calibration Individual readings not available.

Anvil Standard Value: 74.0

SMF Staff: Harle
Switzer

Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UE25 NRG-1	11.6 - 11.8	35.0	42.5	44.5	48.0	48.5	48.5	47.0	47.0	47.0	47.5	47.5	47.5	48.0	48.5	48.5	48.5	48.5	49.0	49.0	50.5	48.8	3.259	47.9	1.8
	22.3 - 22.3	43.5	45.5	48.5	45.5	45.5	48.5	47.5	47.5	47.5	48.0	48.0	48.0	48.0	48.5	48.5	48.5	49.0	49.0	50.5	51.0	47.6	1.816	48.3	1.6
	38.1 - 38.1	37.0	38.5	42.5	43.5	44.5	45.5	45.5	48.5	47.5	47.5	47.5	47.5	48.0	48.5	48.5	48.5	49.0	49.5	49.5	49.5	48.2	3.519	47.2	2.8
	53.3 - 53.3	36.5	40.0	43.5	44.0	45.0	45.5	48.0	46.5	47.0	47.5	47.5	47.5	48.0	48.0	48.0	48.5	48.5	48.5	49.5	48.5	46.2	3.180	47.2	2.3
	58.7 - 58.7	27.5	31.0	31.5	32.5	35.5	40.0	41.5	42.5	43.0	43.5	44.5	44.5	45.0	45.5	45.5	46.0	46.0	46.0	46.5	46.5	41.2	6.088	42.4	5.3
	66.2 - 66.2	28.5	31.0	32.5	33.5	33.5	34.5	35.5	36.5	37.5	37.5	38.5	38.5	41.0	41.5	41.5	42.0	42.5	42.5	44.0	45.5	38.0	4.877	38.4	4.6
	76.8 - 76.8	38.5	38.0	42.5	44.5	45.0	45.5	45.5	46.5	46.5	46.5	46.5	46.5	47.0	47.0	47.5	48.0	48.5	48.5	48.5	49.0	45.7	3.280	47.1	1.6
	89.2 - 89.2	38.5	40.0	44.5	44.5	46.5	46.5	46.5	46.5	47.0	47.5	47.5	48.5	48.5	48.5	49.0	50.0	50.5	51.5	51.5	53.5	47.4	3.485	48.3	3.0
	99.7 - 99.7	40.0	42.0	43.5	45.5	48.0	48.0	48.5	47.0	47.5	47.5	48.5	48.5	49.0	49.0	49.0	49.5	50.0	50.5	51.5	51.5	47.4	3.010	49.3	2.5
	117.4 - 117.4	42.5	43.5	44.5	44.5	45.0	45.5	45.5	46.0	46.5	46.5	46.5	46.5	46.5	46.5	47.0	47.5	47.5	47.5	48.0	49.5	46.2	1.815	46.6	1.4
	128.1 - 128.1	43.5	43.5	44.0	44.5	44.5	45.0	45.5	45.5	46.0	46.0	46.5	46.5	46.5	46.5	47.5	47.5	47.5	48.0	48.5	48.5	46.1	1.567	46.6	1.6
	140.3 - 140.3	47.5	48.5	48.5	48.5	49.5	49.5	49.5	50.0	50.0	50.0	50.0	50.5	50.5	50.5	50.5	50.5	51.0	51.5	51.5	52.5	50.0	1.186	50.8	1.2
	148.4 - 148.4	45.5	46.5	46.5	47.0	47.0	47.5	47.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	49.5	49.5	50.0	50.0	50.0	50.5	48.5	1.423	49.0	1.4

 Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

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APPENDIX B

UE25 NRG-2

Geology and Rock Structure Log

Core Hole Rock Structural Data Summary

Estimated Rock Mass Quality Indices Based on Core Log Data

Schmidt Hammer Tests

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
GEOLOGY AND ROCK STRUCTURE LOG
UE25 NRG-2

Sandia National Laboratories
Print Date: 2/4/95
WBS 1.2.3.2.6.2
QA: QA
Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Small change in 10-ft RQD in three intervals. Revised stratigraphy summary to include USGS nomenclature. Corrected study plan number on cover page.

BOREHOLE ID:	UE25 NRG-2	TOTAL DEPTH:	215.1'
STUDY PLAN NO:	8.3.1.14.2	ANGLE FROM VERT:	29° 39'
CORE SIZE:	HQ 2.5"	AZIMUTH:	100° 30'
DRILL DATES:	1/12/93-1/27/93 + 6/1/93-6/7/93		
GROUND ELEV:	3796.32'		
COORDINATES:	N: 765,763.05 E: 569,165.33		

Field Rock Structure

Logged by:

Rodrick Myers
Richard Morris Drilling Support Division, Drilling
Mark Edwards Support and Sample Management
Michael Pitterle Department, T&MSS
Arthur Mendenhall
Chris Scroggins

Relogged by:

Carl Brechtel J. F. T. Agapito & Associates, Inc.
Richard Lippoth

Lithology and Stratigraphy

Logged by:

Chris Rautman Sandia National Laboratories
Carolyn Coolidge

Checked by:

Richard Lippoth J. F. T. Agapito & Associates, Inc.
Eric Martin J. F. T. Agapito & Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION GEOLOGY AND ROCK STRUCTURE

NONWELDED

WELDED

BEDDED TUFF

LOST CORE

FRACTURE TYPE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition, not a fracture.

LOST CORE AND RUBBLE

LOST CORE

20 RUBBLE ZONE

(with average maximum diameter of rubble pieces to nearest 0.01 ft; NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

ROUGHNESS

INFILLING THICKNESS AND MINERALIZATION

C Clean, no filling.	C Clean	CA Calcite
S Very thin, surface sheen	WC White, crystalline	SI Silica
T Thin (up to 0.1 inches)	WN White, non-crystalline	MN Manganese
M Moderately thick (0.1 - 0.4 inches)	TD Brown dendritic	CL Clay
V Very thick (0.4 - 1.0 inches)	TC Tan crystalline	BC Black crystalline
E Extremely thick, greater than 1.0 inches)	TN Tan, non-crystalline	BD Black dendritic

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If a piece length ≥ 0.33 ft crosses over the 10-ft interval boundary, the portion of the piece length that occurs in the 10-ft interval is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

UE25 NRG-2

Stratigraphic and Thermomechanical Units Summary

Date: 11/1/94

- ¹ U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.
- ² U. S. Geological Survey - Graphical Lithologic Log of Borehole NRG-2, Thomas Moyer and Jeff Geslin, DTN:GS931008314211.039.

**Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.**

[illegible]

B-7

GEOLOGY AND ROCK STRUCTURE LOG

**Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.**

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)					HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICALLY IDENTIFIABLE CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-N)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	FILL THICKNESS AND MINERALS	DIP	RQD	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED FRACTURES (+ INDUCED)									
																10	20	30							
	30.0	100	10	H	SV			65		.46						29%	15%	(29)							
	35.0	100	10	H	SV			70		.35															
	40.0	100	10	H	SV			70		.33						19%	1%	(9)							
	45.0	100	10	H	SV			60		.23															
	50.0	100	10	H	SV			60		.20															
	55.0	100	10	H	SV			60		.40															
	60.0	100	10	H	SV			60		.40															
	65.0	100	10	H	SV			60		.40															
	70.0	100	10	H	SV			60		.40															
	75.0	100	10	H	SV			60		.40															
	80.0	100	10	H	SV			60		.40															
	85.0	100	10	H	SV			60		.40															
	90.0	100	10	H	SV			60		.40															
	95.0	100	10	H	SV			60		.40															
	100.0	100	10	H	SV			60		.40															
	105.0	100	10	H	SV			60		.40															
	110.0	100	10	H	SV			60		.40															
	115.0	100	10	H	SV			60		.40															
	120.0	100	10	H	SV			60		.40															
	125.0	100	10	H	SV			60		.40															
	130.0	100	10	H	SV			60		.40															
	135.0	100	10	H	SV			60		.40															
	140.0	100	10	H	SV			60		.40															
	145.0	100	10	H	SV			60		.40															
	150.0	100	10	H	SV			60		.40															
	155.0	100	10	H	SV			60		.40															
	160.0	100	10	H	SV			60		.40															
	165.0	100	10	H	SV			60		.40															
	170.0	100	10	H	SV			60		.40															
	175.0	100	10	H	SV			60																	

SEMGROUP file: HQ229.5TA Lithology file: HQ22-5.LTH Date: 10/10/94

NP209 v 4.60

B-8

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)					HARDNESS	WEATHERING	ESTIMATED % LITHOMYCEAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
	INTERVAL	% RECOVERY (RQD) (%)	LOST CORE & KIBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL THICKNESS AND MINERALS	OP	INDUCED	PECE LENGTH	ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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70.1-84.4 CORING NOT ATTEMPTED, HOLE
SEALED, NO OBVIOUS CHANGE IN LITHOLOGY,
INTER RATHER NEAR HEMLOCK TUFF

Copyright © 1999, The

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD OR					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMYCEAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY				
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUMBLE	FRACTURE TYPE	PLANARITY/IRREGULARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)						10	20	30							
																	10	20	30													
															0%		0	(0)					Not Measured									
80.0																																
85.0	↑	20	(0)												0%		0	(0)					0%						5-10 mm SILEX OF OPALINE SILICA--GREY TO ORANGE, GREEN PLAGIOCLASE IN SHORT-NAVE. FRACTURE FILLING ? POSSIBLE FAULT ?			
90.0	↓	0	(0)																													
95.0	↓	2	(0)												0%		0	(0)					0%						RUMBLE: UNWEATHERED TUFF W/ SPARSE RED-BROWN LITHICS			
100.0	↓	0	(0)																										RUMBLE: UNWEATHERED TUFF W/ CLAST SILICA			

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY ESTIMATION-ROQ (R)					FRACTURES (PER 10 FT)					HARDNESS	WEATHERING	ESTIMATED % LITHOMASS AND OTHER CAVITIES					LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ ROUGHNESS	INFILL THICKNESS AND MINERALS	QP	DISJOINT	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			10	20			30	40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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105.0	RUN 22	0	(D)												0%	0	(D)				0%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

Structure file: NRG189.87W Lithology file: NRG2-5.LTH Date: 10/10/94

WPlot v 4.60

B-11

RUBBLE: NONWELED TUFF

SUNILE CHANGE IN CHARACTER OF CUTTINGS--
DISCRETE ESPAR DRUMS ABOVE, ASBEST BELOWRUBBLE: WHITE PUMICEOUS NONWELED TUFF,
COULD BE A FAIRLY WELL-SORTED PUMICE FALL
DEPOSIT, PUMICE 2-4 MMRUBBLE: WHITE PUMICEOUS NONWELED TUFF,
COULD BE A FAIRLY WELL-SORTED PUMICE FALL
DEPOSIT, PUMICE 2-4 MM

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER FOOT)				HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSE AND OTHER CAVITIES					LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUMBLE	FRACTURE TYPE	PLANARITY	ROUTING	INITIAL STRESS	AND	MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)					10	20	30	40			
130.0	27	0 (0)															0%	0 (0)								0%		PROMINENT CHANGE IN CHARACTER OF CUTTINGS FROM WHITE FINE-GRAINED TO TAN COARSE-GRAINED BELOW, COARSE CUTTINGS 128-134 FT	
135.0	30	0 (0)															3%	4 (5)								0%		BRIDGED TUFF--SEE-ENTER MESA, CONTACT APPROX. BETWEEN 133.6-139.6 FT	
140.0	31	0 (17)		I	GR					20																	0%		REMOVED TUFFACEOUS SEDIMENT(?), TAN WELL-CONSOLIDATED, GENERALLY HIGHLY SEATTERED AND BRIDGEMAN WITH SILICA/CO3-BOTRYOIDAL CRUSTS
145.0	32	0 (1)		I	GR					35																	0%		SILICA/CO3 FRACTURE COATINGS AND BRIDGEMAN FILL
150.0	33	0 (1)		I	GR					30																	0%		BRIDGED/REMOVED TUFF, YELLOW-TAN HERE OR LESS CRUMBLY RUBBLE, HAS TIMES MOUNTAIN "LOOK"--CHALKY WHITE FELDSPARS, ABUNDANT RED-BROWN LITHIC GRATES

Structure file: MRC2RD.STR

Lithology file: MRC2-S.LTH

Date: 10/10/94

MPLog v 4.40

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES					LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
	INTERVAL	% RECOVERY (RUR RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10	20	30	40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)		HAZARDOUS WEATHERING	ESTIMATED % LITHOPHYSEAS AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (MIN ROD-IN)	LOST CORN & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND MINERALS	QIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	NATURAL AND INDETERMINATE (+ INDUCED)					
180.0	RUN 40	100 (78)		N			*MC	40		.35					15 (15)			<1%	*****	ARN-FLOW TUFF, POSSIBLY UPPER PART HEAVILY ZONED, RED BROWN-GREY BROWN MOTTLED ROCK. DENSELY WELOD AND CRISTIFISHED VARIANES LIGHT GRAY SOGGY VAPOR PHASE ALTERATION ASSOCIATED WITH SPARS, POORLY DEVELOPED LITHOPHYSEAS (< 1%). SOMEWHAT FLATTENED. DIFFUSE ALTERATION. PLANE OF FLATTENING APPROXIMATELY 40 DEGREES TO CORE AXIS. REMAINS OF SAMIDINE PROMINENT, FRESH, GLASSY.
				N	FR			70		.98									*****	
				N	FR			20	65										*****	
				N	FR			70		.35									*****	
				N	FR			50	50										*****	
										1-20									*****	

185.0	RUN 41	100 (52)	X .05 X	N	FR			35	40	2.10									*****	ARN-FLOW TUFF, POSSIBLY UPPER PART HEAVILY ZONED, RED BROWN-GREY BROWN MOTTLED ROCK. DENSELY WELOD AND CRISTIFISHED VARIANES LIGHT GRAY SOGGY VAPOR PHASE ALTERATION ASSOCIATED WITH SPARS, POORLY DEVELOPED LITHOPHYSEAS (< 1%). SOMEWHAT FLATTENED. DIFFUSE ALTERATION. PLANE OF FLATTENING APPROXIMATELY 40 DEGREES TO CORE AXIS. REMAINS OF SAMIDINE PROMINENT, FRESH, GLASSY.
				N	FR			50	40	.70									*****	
				N	FR			50	50	.80									*****	
				N	FR			50	50	.40									*****	
				N	FR			50	50										*****	
				N	FR			40	35	.35									*****	
				N	FR			30		.50									*****	
				N	FR			70		.80									*****	
				N	FR			40	45										*****	
				N	FR			50	50	1.80									*****	
190.0	RUN 42	100 (35)	X .35 X	N	FR			70	70	.80									*****	ARN-FLOW TUFF, POSSIBLY UPPER PART HEAVILY ZONED, RED BROWN-GREY BROWN MOTTLED ROCK. DENSELY WELOD AND CRISTIFISHED VARIANES LIGHT GRAY SOGGY VAPOR PHASE ALTERATION ASSOCIATED WITH SPARS, POORLY DEVELOPED LITHOPHYSEAS (< 1%). SOMEWHAT FLATTENED. DIFFUSE ALTERATION. PLANE OF FLATTENING APPROXIMATELY 40 DEGREES TO CORE AXIS. REMAINS OF SAMIDINE PROMINENT, FRESH, GLASSY.
				N	FR			70	50										*****	
				N	FR			70	50										*****	
				N	FR			50	70	.60									*****	
				N	FR			50	50	.50									*****	
				N	FR			60	30	.45									*****	
				N	FR			50	50										*****	
				N	FR			40	35	.80									*****	
				N	FR			30	15	.40									*****	
				N	FR			30		.70									*****	
195.0	RUN 43	94 (64)	X .05 X	N	FR			70	70	.80									*****	ARN-FLOW TUFF, POSSIBLY UPPER PART HEAVILY ZONED, RED BROWN-GREY BROWN MOTTLED ROCK. DENSELY WELOD AND CRISTIFISHED VARIANES LIGHT GRAY SOGGY VAPOR PHASE ALTERATION ASSOCIATED WITH SPARS, POORLY DEVELOPED LITHOPHYSEAS (< 1%). SOMEWHAT FLATTENED. DIFFUSE ALTERATION. PLANE OF FLATTENING APPROXIMATELY 40 DEGREES TO CORE AXIS. REMAINS OF SAMIDINE PROMINENT, FRESH, GLASSY.
				N	FR			70	50										*****	
				N	FR			70	50										*****	
				N	FR			50	70	.60									*****	
				N	FR			50	50	.50									*****	
				N	FR			60	30	.45									*****	
				N	FR			50	50										*****	
				N	FR			40	35	.80									*****	
				N	FR			30	15	.40									*****	
				N	FR			30		.70									*****	
200.0	RUN 44	100 (12)	X .12 X	N	FR			70	45	.90									*****	ARN-FLOW TUFF, POSSIBLY UPPER PART HEAVILY ZONED, RED BROWN-GREY BROWN MOTTLED ROCK. DENSELY WELOD AND CRISTIFISHED VARIANES LIGHT GRAY SOGGY VAPOR PHASE ALTERATION ASSOCIATED WITH SPARS, POORLY DEVELOPED LITHOPHYSEAS (< 1%). SOMEWHAT FLATTENED. DIFFUSE ALTERATION. PLANE OF FLATTENING APPROXIMATELY 40 DEGREES TO CORE AXIS. REMAINS OF SAMIDINE PROMINENT, FRESH, GLASSY.
				N	FR			70	45	.90									*****	
				N	FR			70	45	.90									*****	
				N	FR			70	45	.90									*****	
				N	FR			70	45	.90									*****	
				N	FR			70	45	.90									*****	
				N	FR			70	45	.90									*****	
				N	FR			70	45	.90									*****	
				N	FR			70	45	.90									*****	
				N	FR			70	45	.90									*****	

B-14

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICAL VOLUME FILLING AND OTHER CAVERNS	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY				
	INTERVAL	% RECOVERY (CORRECTIONS)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PEACE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)						5	10	20	40
205.0	RUN 45	100 (37)	.08	I	N	C		+20	45 48 30		1.28														204.-215.2 SLIGHT INCREASE IN AMOUNT OF FRACTURES/JOINTS, HARDLY FRACTURE APPEARS TO DIMINISH DOWNWARD AND IS MINOR FROM 204. TO 215.2 FT	
				I	N	C																				
				I	N	C																				
				I	N	C																				
210.0	RUN 46	100 (20)	.36	I	N	C		+20	40 48 30		.48														215.5-227.5, GRADATIONAL CONTACT	
				I	N	C																				
				I	N	C																				
				I	N	C																				
215.0	RUN 48	54 (0)	.36	I	N	C		+20	40 48 30		.48														215.5-227.5, GRADATIONAL CONTACT	
				I	N	C																				
				I	N	C																				
				I	N	C																				
220.0	RUN 51	79 (0)	.36	I	N	C		+20	40 48 30		.48														215.5-227.5, GRADATIONAL CONTACT	
				I	N	C																				
				I	N	C																				
				I	N	C																				
225.0	RUN 51	100 (1)	.36	I	N	C		+20	40 48 30		.48														215.5-227.5, GRADATIONAL CONTACT	
				I	N	C																				
				I	N	C																				
				I	N	C																				

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

Page 10 of 12

by J.R.T. Algebro & ASSOC., INC.

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)					HARDNESS	WEATHERING	ESTIMATED % LITHOMYCE AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY		
	INTERVAL	% RECOVERY (BLIN ROD-IN)	LOST CORE & RIBBLE	FRACTURE TYPE	PLANARITY/BOUGENESS	INFILL	THICKNESS AND MINERALS	ZIP	INDUCED	PRICE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10	20	30										
230.0	RUN 53	100 (5.1)		I N	PS	PS	C	TWC	C	45 60						16%													
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
235.0	RUN 55	96 (4.7)		I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
240.0	RUN 56	97 (4.8)		I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
245.0	RUN 57	97 (4.8)		I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
250.0	RUN 58	97 (4.8)		I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			
				I N	PS	PS	C	TWC	C	45 60																			

GEOLOGY AND ROCK STRUCTURE LOG

**Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.**

B-17

[illegible]

SECRETURE File: H00209-CTR Lithology File: H002-5.1TH Date: 10/10/94

WDJOG v 4.6B

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

[illegible]

Structure file: HMO309.SIR Lichology file: HMO3-B.LTK Date: 10/10/94

MPlog v 4.60

B-18

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CORE HOLE ROCK STRUCTURAL DATA SUMMARY
Hole UE25 NRG-2

Sandia National Laboratories
Print Date: 10/10/94
WBS 1.2.3.2.6.2
QA: QA
Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Small change in 10-ft RQD in three intervals. Revised stratigraphy and thermomechanical units to USGS nomenclature.

CODING EXPLANATION

STRATIGRAPHIC ABBREVIATIONS

B.T.	Rainier Mesa		
T.C.	Bedded Tuff		
	Tiva Canyon Member	C.F. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		C.F. Vitric	Crystal-Poor Vitric

THERMOMECHANICAL UNITS

UO--Undifferentiated Overburden
TCW--Tiva Canyon Welded Unit
PTn--Upper Paintbrush Nonwelded Unit

COLUMN INFORMATION (Page 3)

RQD (%) $RQD (\%) = \frac{\sum \text{Piece lengths } \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$

CORE RQD Core RQD based on piece lengths defined by all types of fractures (C, I, N and V).

ENHANCED RQD Effect of fractures identified as coring induced (Type C) are filtered from the piece lengths.

LITHOPHYSAL (and other cavities) Percent void due to lithophysae and other cavities, estimated visually by counting the number of cavities, estimating the average diameter, calculating the void volume assuming spherical cavities, and normalizing to the core volume.
NM--Not Measured

WEATHERING Subjective evaluation of rock degradation by mechanical/chemical agents:
F: Fresh M: Moderately weathered D: Decomposed
S: Slightly weathered I: Intensely weathered

HARDNESS Subjective evaluation of resistance to breakage:
1: Extremely hard 4: Moderately hard 7: Very soft
2: Very hard 5: Moderately soft 8: Soil-like, cohesive
3: Hard 6: Soft 9: Soil-like, non-cohesive

COLUMN INFORMATION (Page 4)

FEATURE TYPE Following codes indicate origin of feature:
N: Natural--indicated by mineral coating or evidence of weathering, slickensides, lack of fit between sides.
I: Indeterminate--origin questionable, rotated so that coatings possibly removed.
C: Coring induced--fresh, clean, tightly fitting breaks.
V: Vug or large void.

INCLINATION (degrees) Angle between plane normal to core axis and plane of fracture (Type N and I only).

MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only):		
	C: Clean	TD: Brown dendritic	CL: Clay
	WC: White crystalline	TC: Tan crystalline	TN: Tan noncrystalline
	WN: White noncrystalline	CA: Calcite	FE: Iron oxide
	BC: Black crystalline	SI: Silica	BN: Brown noncrystalline
	BD: Black dendritic	MN: Manganese	
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only):		
	C: Clean, no filling	M: Moderately thick (0.1-0.4 inches)	
	S: Very thin, surface sheen	V: Very thick (0.4 - 1.0 inches)	
	T: Thin (up to 0.1 inches)	E: Extremely thick, greater than 1.0 inches	
PLANARITY	Describes the overall shape of the feature (Type N and I only):		
	P: Planar	S: Stepped	
	C: Curved	I: Irregular	
ROUGHNESS	Describes the local relief of the surface (Type N and I only):		
	V: Very rough—stepped, near-normal steps and ridges occur.		
	R: Rough—large angular asperities can be seen.		
	M: Moderately rough—asperities clearly visible, surface has abrasive feel.		
	S: Smooth—no asperities, smooth to the touch.		
	P: Polished—slickensided, extremely smooth and shiny.		

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRG-2

Interval—0-290 ft (0-88.4 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD** %	ENHANCED RQD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	WEATHERING (ft in 10-ft interval)***					HARDNESS (ft in 10-ft interval) ROCK					
								F	S	M	I	D	1	2	3	4	5	6
10	Reiner Mass	UD	20	71	0	1.5	0.8	8.4									9.4	
20	Reiner Mass	UD	29	72	0	0.9	0.8											
30	Reiner Mass	UD	29	65	0	0.4	2.8	4.1									4.1	
40	Reiner Mass	UD	18	42	0	2.6	1.7	4.8									4.8	
50	Reiner Mass	UD	4	18	0	7.3	0.8											
60	Reiner Mass	UD	0	0	0	9.7	0.3											
70	Reiner Mass	UD	0	0	MM	10.0												
80	Reiner Mass	UD	0	0	MM	10.0												
90	Reiner Mass	UD	0	0	0	9.5	1.4											
100	Reiner Mass	UD	0	0	0	9.8	0.2											
110	Reiner Mass	UD	0	0	0	9.8	0.1											
120	Reiner Mass	UD	0	0	0	9.3	0.7											
130	Reiner Mass	UD	0	0	0	9.8	0.2											
140	Reiner Mass	UD	3	0	0	8.6	0.4	1.4								1.4		
150	B.T.	UD	7	22	0	0.8	2.5	5.1								4.9	0.4	1.2
160	B.T.	UD	7	18	0	1.4	1.3	5.0								4.8	0.4	
170	B.T.	UD	13	18	0	4.1	1.3	9.9								5.9		4.8
180	T.C. C.P. L. North.	TDw	75	87	<1	0.0	0.5	9.0								9.0		
190	T.C. C.P. L. North.	TDw	60	87	<1	0.0	0.9	9.8								5.8		
200	T.C. C.P. L. North.	TDw	62	87	<1	0.3	0.7	5.1								5.1		
210	T.C. C.P. L. North.	TDw	29	52	<1	0.0	1.0	4.9						0.4	4.5			
220	T.C. C.P. L. North.	TDw	4	29	<1	1.8	1.2	8.5						6.5				
230	T.C. C.P. L. North.	TDw	15	37	<1	1.4	0.7	9.3						7.9	0.8			
240	T.C. C.P. L. North.	TDw	39	60	<1	0.2	0.5	4.0						0.5	3.5			
250	T.C. C.P. L. North.	TDw	23	47	<1	1.2	0.3	8.7						8.4	0.3			
260	T.C. C.P. L. North.	TDw	32	67	1	0.8	0.5	10.0						7.2		2.8		
270	T.C. C.P. L. North.	TDw	37	80	<1	0.5	0.4	5.8						9.5	1.5	0.8		
280	T.C. C.P. L. North.	TDw	28	95	<1	0.5	0.9	10.0						7.1	2.9			
290	T.C. C.P. Vario	PTw	2	33	<1	0.8	1.2	4.0			6.0			4.0		0.0		

* CORE RQD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as caving induced (Type C) from the piece lengths.

*** Footage in interval may not equal 10 ft because of lost core, rubble, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE23 NRQ-2

Interval—0-290 ft (0-88.4 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (per interval)	NO. OF FRACTURES W/INCLINATION (degrees)										
			N	I	C	V		10	20	30	40	50	60	70	80	90	C	
10	Rainier Mesa	UC	9	5	17													
20	Rainier Mesa	UC	17	3	14													
30	Rainier Mesa	UC	11	1	17													
40	Rainier Mesa	UC	5	0	8													
50	Rainier Mesa	UC	1		9													
60	Rainier Mesa	UC																
70	Rainier Mesa	UC																
80	Rainier Mesa	UC																
90	Rainier Mesa	UC																
100	Rainier Mesa	UC																
110	Rainier Mesa	UC																
120	Rainier Mesa	UC																
130	Rainier Mesa	UC																
140	Rainier Mesa	UC	1	3	1													
150	B.T.	UC	15	5	11													
160	B.T.	UC	8	9	13													
170	B.T.	UC	28	4	3													
180	T.C. C.P. L. Nonlith.	TCw	12	3	3													
190	T.C. C.P. L. Nonlith.	TCw	10	8	4													
200	T.C. C.P. L. Nonlith.	TCw	16	5	7													
210	T.C. C.P. L. Nonlith.	TCw	22	5	8													
220	T.C. C.P. L. Nonlith.	TCw	34	3	10													
230	T.C. C.P. L. Nonlith.	TCw	27	7	9													
240	T.C. C.P. L. Nonlith.	TCw	28	6	13													
250	T.C. C.P. L. Nonlith.	TCw	27	7	11													
260	T.C. C.P. L. Nonlith.	TCw	13	8	21													
270	T.C. C.P. L. Nonlith.	TCw	23	8	13													
280	T.C. C.P. L. Nonlith.	TCw	16	8	18													
290	T.C. C.P. Vitric	PTs	5	1	43													
TOTAL			323	108	249	0												
PERCENT OF OCCURRENCE			48	15	37	0												

Associates, Inc.

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA
Hole UE25 NRG-2**

Sandia National Laboratories
Print Date: 2/13/95
WBS 1.2.3.2.6.2
QA-L
Revision 3

REVISION HISTORY

- Revision 2 Change in method for calculating % lithophysae. Change in 10-ft RQD in some intervals; does not significantly impact quality estimates. Revised stratigraphy and thermomechanical units; Q-core index and histogram plots removed from presentation.
- Revision 3 Revised SRF parameter using NRG rock testing data for PTn unit.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{*}} \cdot \frac{J_r}{J_a} \cdot \frac{J_w}{SRF^{*}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of J_n and SRF.

where RQD** = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

J_n^{*} = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9.

J_r = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

J_a = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

Jw = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: For nonwelded units, SRF is determined from the ratio of UCS/ σ_1 (UCS = unconfined compressive strength, σ_1 = overburden stress). If unconfined compressive strength data is not available for the 10-ft interval, a compressive strength is generated by Monte Carlo simulation using laboratory test data for the thermomechanical units. For welded tuff units, SRF cannot be determined from core log data and is generated by Monte Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean values for thermomechanical units in USW NRG-7/7A are:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
TCw	18.5%	33.9%
PTn	2.0%	33.0%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$\text{RMR} = \text{C} + \text{RQD-I} + \text{JS} + \text{JC} + \text{JW}$$

where C = Rock Strength Index: Derived from compressive strength estimated by Schmidt Rebound Hardness data for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, excludes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

	Rainier Mesa		
T.C.	Tiva Canyon Member	C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysae
		C.P. Vitric	Crystal-Poor Vitric
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain		
	Member		
P.C.	Pah Canyon Member		
T.S.	Topopah Spring		
	Member		

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
 TCw—Tiva Canyon Welded Unit
 PTn—Upper Paintbrush Nonwelded Unit
 TSw1—Topopah Spring Welded Unit—Lithophysae Rich
 TSw2—Topopah Spring Welded Unit—Lithophysae Poor
 TSw3—Topopah Spring Welded Unit—Vitrophyre
 CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole UE25 NRG-2

Interval—170-290 ft (51.8-88.4 m)

END DEPTH	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM ¹ Barton et al. (1974)							RMR CLASSIFICATION SYSTEM ² Bieniawski (1979)					
			RQD** (%)	J _n *	J _r	J _a	J _w	SRF*	Q*	C	RQD-I	JS	IC	JW	RMR
180	T.C. C.P. Nonliih.	TCw	75	6.00	2.00	1.36	1.00	5.00	3.68	7	17	8	20.5	15	67.6
190	T.C. C.P. Nonliih.	TCw	80	7.00	2.00	1.00	1.00	1.00	17.14	12	13	8	20.3	15	68.3
200	T.C. C.P. Nonliih.	TCw	82	7.00	2.14	1.00	1.00	1.00	18.98	12	13	8	22.3	15	70.3
210	T.C. C.P. Nonliih.	TCw	29	7.00	2.05	2.00	1.00	1.00	4.26	12	8	8	18.0	15	61.0
220	T.C. C.P. Nonliih.	TCw	4	8.00	1.93	1.27	1.00	5.00	0.61	12	3	5	18.6	16	53.6
230	T.C. C.P. Nonliih.	TCw	16	7.00	1.33	1.06	1.00	6.00	0.68	7	3	8	18.7	15	51.7
240	T.C. C.P. Nonliih.	TCw	39	7.00	1.21	1.06	1.00	1.00	6.32	12	8	6	18.3	15	61.3
250	T.C. C.P. Nonliih.	TCw	23	8.00	1.12	1.12	1.00	1.00	2.88	12	3	8	18.2	15	56.2
260	T.C. C.P. Nonliih.	TCw	32	7.00	2.00	1.00	1.00	1.00	9.14	12	8	8	21.6	16	64.6
270	T.C. C.P. Nonliih.	TCw	37	9.00	1.37	1.16	1.00	1.00	4.84	7	8	8	18.7	16	56.7
280	T.C. C.P. Nonliih.	TCw	28	8.00	2.55	1.90	1.00	5.00	1.25	7	8	8	23.3	15	61.3
290	T.C. C.P. Vicro	PTn	2	7.00	2.17	1.83	1.00	16.00	0.11	1	3	6	19.8	16	43.8

J_n*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

¹ Barton, N., R. Lien, and J. Lund, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6:189-236 (Springer Verlag, 1974)² Bieniawski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 2:41-48 (A. A. Balkema, 1979)

Q

J_n — Joint Set Number
 J_r — Joint Roughness Number
 J_a — Joint Alteration Number
 J_w — Joint Water Reduction Factor
 SRF — Stress Reduction Factor

$$Q = (RQD/J_n)(J_r/J_a)(J_w/SRF)$$

RMR

C — Strength Index
 RQD-I — RQD Index
 JS — Joint Spacing Index
 IC — Discontinuity Condition Index
 JW — Groundwater Index

$$RMR = C + RQD-I + JS + IC + JW$$

SCHMIDT HAMMER TESTS																									
Initial Calibration 68.0 69.5 70.5 70.6 70.6 71.0 71.5 71.5 71.5 71.5												Average Calibration Reading: 70.6				Correction Factor: 1.05		Test Date: 9/2/93							
Final Calibration 68.0 68.5 69.5 69.5 70.5 71.5 71.5 72.0 72.5 73.0												Anvil Standard Value: 74.0				SMP Staff: Harle		Switzer							
Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UE25 NRG-2	7.4 - 7.9	11.5	12.0	12.5	13.5	13.5	14.5	15.5	15.5	15.5	16.0	16.5	16.5	17.0	18.0	18.5	18.5	19.0	20.0	21.0	21.0	16.3	2.658	17.1	2.9
	17.0 - 17.5	12.5	13.0	13.5	15.5	16.0	16.0	16.0	16.5	16.5	16.5	19.0	19.0	19.5	21.5	21.5	22.0	22.0	22.0	22.5	23.5	18.6	3.324	19.5	3.3
	171.5 - 172.0	40.0	40.5	41.0	41.0	41.5	41.5	42.0	42.0	42.0	42.0	42.5	42.5	43.0	43.0	43.0	44.5	44.5	45.0	45.5	46.5	42.7	1.734	44.7	1.7
	181.4 - 182.0	42.0	43.5	43.5	43.5	44.0	44.0	44.5	44.5	44.5	44.5	44.5	44.5	45.0	45.5	45.5	45.5	46.0	46.0	46.5	46.5	44.7	1.140	47.0	1.0
	192.2 - 192.8	43.5	44.0	44.0	44.5	45.0	45.0	45.0	45.5	45.5	45.5	45.5	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.5	45.4	0.825	47.6	0.7
	208.3 - 208.8	43.5	44.5	46.0	46.0	45.0	46.5	47.0	47.0	47.5	47.5	48.0	48.0	48.5	48.5	48.5	48.5	49.0	49.0	49.5	49.5	47.4	1.624	49.9	1.4
	218.1 - 218.4	41.0	41.0	42.5	42.5	43.5	44.5	44.5	44.5	44.5	45.0	45.0	45.5	45.5	45.5	46.0	46.0	46.5	46.5	46.5	47.5	44.7	1.802	46.8	1.8
	232.3 - 232.7	42.0	42.0	42.5	43.5	43.5	44.0	44.0	44.0	44.5	44.5	45.0	45.5	45.5	45.5	46.0	46.0	46.0	46.5	46.5	46.5	44.7	1.462	46.8	1.6
	241.4 - 242.0	44.5	45.0	45.5	45.5	46.0	46.0	46.0	46.0	46.5	46.5	47.0	47.0	47.5	47.5	48.0	48.0	48.5	48.5	48.5	49.0	46.8	1.299	49.1	1.3

Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

B-28

SCHMIDT HAMMER TESTS

Initial Calibration 68.0 68.0 68.5 70.5 71.0 71.0 71.0 71.0 71.5 73.0
 Final Calibration 70.0 70.0 72.0 72.0 72.0 72.0 74.0 74.0 74.0 74.0

Average Calibration Reading: 71.4
 Anvil Standard Value: 74.0

Correction Factor: 1.04

Test Date: 9/7/93
 SMP Staff: R. Morris
 T. Warburton

Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UE25 NRQ-2	251.4 - 252.0	38.0	40.5	42.5	42.5	44.0	44.0	44.0	44.0	44.5	45.0	46.0	46.0	46.0	46.0	46.0	46.0	46.5	46.5	48.0	48.0	44.6	2.746	46.7	1.9
	262.6 - 263.3	29.0	36.0	36.0	38.0	39.0	39.0	40.0	40.0	40.0	40.0	42.0	43.0	43.0	44.0	44.0	44.0	44.0	46.0	46.0	48.0	41.1	4.261	43.2	3.3
	273.6 - 274.0	30.0	32.0	33.0	34.0	34.0	36.0	36.0	36.0	38.0	39.0	40.0	40.0	40.0	40.0	42.0	44.0	44.0	46.0	46.0	46.0	38.8	4.884	40.2	4.9
	282.3 - 282.7	25.0	26.0	28.0	28.0	28.0	30.0	34.0	34.0	38.0	38.0	38.0	38.0	38.0	39.0	39.0	40.0	40.0	40.0	40.0	40.0	36.1	5.414	36.3	5.4

☐ Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

APPENDIX C

UE25 NRG-2A

Geology and Rock Structure Log

Core Hole Rock Structural Data Summary

Estimated Rock Mass Quality Indices Based on Core Log Data

Schmidt Hammer Tests

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

GEOLOGY AND ROCK STRUCTURE LOG

Hole UE25 NRG-2A

Sandia National Laboratories

Print Date: 2/4/95

WBS 1.2.3.2.6.2

QA: QA

Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Used USGS nomenclature for stratigraphic and thermomechanical unit summary. Corrected study plan number on cover page.

BOREHOLE ID: UE25 NRG-2A

STUDY PLAN NO: 8.3.1.14.2

CORE SIZE: HQ 2.5"

DRILL DATES: 5/13/93 - 5/21/93

GROUND ELEV: 3780.55 ft

COORDINATES: N: 765,699.94 ft
E: 569,001.08 ft

TOTAL DEPTH: 265.7 ft

ANGLE FROM VERT: 0°

AZIMUTH: NA

Field Rock Structure

Logged by:

M. Pitterlee

J. Kirkwood

M. Wagner

S. Weber

R. Meyer

Relogged by:

Richard Lippoth

Drilling Support Division, Drilling
Support and Sample Management
Department, T&MSS

J. F. T. Agapito & Associates, Inc.

Lithology and Stratigraphy

Logged by:

Chris Rautman

Jeffrey Geslin

Thomas Moyer

Sandia National Laboratories

USGS/SAIC

USGS/SAIC

Checked by:

Carl Brechtel

Eric Martin

J. F. T. Agapito & Associates, Inc.

J. F. T. Agapito & Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION GEOLOGY AND ROCK STRUCTURE

ALLUVIUM

ASH-FLOW TUFF

NONWELDED TUFF

WELDED TUFF

BEDDED TUFF

FRACTURE TYPE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition, not a fracture.

LOST CORE AND RUBBLE

LOST CORE

RUBBLE ZONE
(with average maximum diameter of
rubble pieces to nearest 0.01 ft;
NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

ROUGHNESS

INFILLING THICKNESS AND MINERALIZATION

C Clean, no filling.	C Clean	CA Calcite
S Very thin, surface sheen	WC White, crystalline	SI Silica
T Thin (up to 0.1 inches)	WN White, non-crystalline	MN Manganese
M Moderately thick (0.1 - 0.4 inches)	TD Brown dendritic	CL Clay
V Very thick (0.4 - 1.0 inches)	TC Tan crystalline	BC Black crystalline
E Extremely thick, greater than 1.0 inches)	TN Tan, non-crystalline	BD Black dendritic

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If a piece length ≥ 0.33 ft crosses over the 10-ft interval boundary, the portion of the piece length that occurs in the 10-ft interval is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

Reference

Carr, W. J. (1992). "Structural Model for Western Midway Valley Based Upon RF Drillhole Data and Bedrock Outcrops." In Gibson, J. D., Swan, F. H., Wesling, F. R., Bullard, T. F., Perman, R. C., Angell, N. M. and DiSilvestro, L. A., Summary and Evaluation of Existing Geological and Geophysical Data Near Prospective Surface Facilities in Midway Valley, Yucca Mountain Project, Nye County, NV, SAND90-2191, Appendix A, p. A1-A24, Sandia National Laboratories, Albuquerque, NM.

Geslin, J. and Moyer, T. (1993), "Graphical Lithologic Log of Borehole UE25 NRG #2A," USGS DTN: GS931008314211.038.

UE25 NRG-2A

Stratigraphic and Thermomechanical Units Summary

Stratigraphy

Thermomechanical Units

Scott and Bonk ¹
Nomenclature

USGS ²
Nomenclature

Note:

Tuff unit "X" (Carr, 1992) is an informal name for numerous pyroclastic flow and fallout tuffs and tuffaceous sedimentary rocks that occur between the Tiva Canyon and Rainer Mesa Tuffs.

Date: 11/1/94

- ¹ U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.
- ² U. S. Geological Survey - Graphical Lithologic Log of Borehole NRG-2a, Thomas Moyer and Jeff Geslin, DTN:GS931008314211.038.

[illegible]

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

[illegible]

6-8

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION (RQD-%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % ESTIMATED % LITHOMYKAS AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
	INTERVAL	% RECOVERY (RUN IN/OUT-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	TOP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMYCE AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RQD-N)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	REGULARITY	INT. SPALL	THICKNESS AND	MINERALS	DIP	NOTED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (* INDUCED)			
80.0	80.0 - 81.0	71	(0)															0 (0)	Not Measured		
85.0	85.0 - 86.0	71	(0)															0 (0)			
90.0	90.0 - 91.0	100	(31)															0 (0)			
95.0	95.0 - 96.0	100	(31)															0 (0)			
100.0	100.0 - 101.0	100	(31)															0 (0)			

Structure File: NRG2ARV7.STR Lithology File: NRG2ARV6.LEN Date: 10/11/94

HPlog v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			TEARINESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
	INTERVAL	% RECOVERY (RUN ROD-IN)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	BUTTL THICKNESS AND	MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10			20	30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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Structure file: NRQ2ARV7.STR Lithology file: NRQ2ARV6.LTH Date: 10/11/94

UPING v 4.00

GEOLOGY AND ROCK STRUCTURE LOG

**Sandja National Labs
by J.F.T. Agapito & Assoc., Inc.**

[illegible]

Structure file: MONTARV7.STR Lithology file: MONTARV6.LTH Date: 10/11/94

NPlog v 4.6b

C-12

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSES AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY FROM RQD-N	LOST CORE & RUBBLE	FRAC. TYPE	PLANARITY	ROUGHNESS	ORIF. THICKNESS AND MINERALS	ROP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (+ INDUCED)			10	20	30	40		
		100 (0)	.02																				NH NH NH NH NH NH	151.0 - 155.4 PRE-TUFF UNIT "X" BEDDED TUFF
		75 (0)	.01																				NH NH NH NH NH NH	151.0 - 151.4 HOWLITIFIED ORANGE BROWN MODERATELY TO POORLY SORTED FINE-GRAINED SANDSTONE (PALISADE?)
155.0		2 (0)												0%		0 (3)					0%		NH NH NH NH NH NH	155.4 - 155.7 HOWLITIFIED BEDDED TUFF
		72 (0)	.02																				NH NH NH NH NH NH	155.8 - 157.6 POORLY LITHIFIED, DISSEMINATED LIGHT YELLOWISH-TAN GRAY FINE-GRAINED TUFF
160.0		14 (0)	.02																				NH NH NH NH NH NH	158.3 - 160.3 POORLY LITHIFIED LITHIC-RICH TUFF
		180 (28)	.02																				NH NH NH NH NH NH	158.8 - 162.2 LIGHT GRAY, MODERATELY LITHIFIED, MODERATELY SORTED, FINE-GRAINED LITHIC MUDIC TUFF [SLIGHTLY ORANGE NEAR BOTTOM OF INTERVAL]
		160 (0)	.02																				NH NH NH NH NH NH	161.2 - 161.3 ORANGE YELLOW MODERATELY TO POORLY SORTED TUFF
		160 (0)	.02																				NH NH NH NH NH NH	161.3 - 165.7 HOWLITIFIED MODERATE TO POORLY SORTED TUFF [PYROCLASTIC FLUX DEPOSIT?]
165.0		160 (0)	.02																				NH NH NH NH NH NH	165.7 - 165.8 5 TO 15 mm-THICK MODERATE TO WELL SORTED SAND
		100 (26)	.02																				NH NH NH NH NH NH	165.8 - 165.9 MODERATE TO WELL SORTED, MEDIUM-GRAINED VITRIC BEDDED(?) TUFF (FALLOUT THING?)
		99 (18)	.02																				NH NH NH NH NH NH	165.9 - 166.7 TIVA CANYON TUFF
170.0		90 (31)	.02																				NH NH NH NH NH NH	166.3 - 176.5 MUDIC-RICH INTERVAL [TOTAL MUDIC IS 20 TO 100 OF ROCK] WITH MIXED COLORS OF MUDIC, MUDIC GLASTS ARE UP TO 10X15 mm, WITH MOST 5X10 mm
		90 (31)	.02																				NH NH NH NH NH NH	166.3 - 166.6 TAN PARTIALLY WELDED TUFF WITH DEWITRIFIED GROUNDMASS
		90 (31)	.02																				NH NH NH NH NH NH	166.6 - 169.1 DEWITRIFIED RED BROWN DENSELY WELDED TUFF
		90 (31)	.02																				NH NH NH NH NH NH	169.1 - 172.0 BLACK VITROPHANE
175.0		90 (31)	.02																				NH NH NH NH NH NH	172.0 - 173.0 TIVA CANYON UPPER HOWLITIFIED TUFF, GRAY RED DEWITRIFIED, CAVITIES IN MUDIC AND GROUNDMASS (FORMED DURING COAGULATION BY VAPOR-PHASE ALTERATION?)

Structure file: PPOJARV7.STR Lithology file: HAZJARV6.LTH Date: 10/13/94

RPL09 v 4.00

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-ROD (%)					FRACTURES (PER 10 FT)		SANDNESS	WEATHERING	ESTIMATED % LITHOPHYSIC AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	INTERVAL	% RECOVERY (BLIN ROD-%)	LOST CORE & RUMBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PECK LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
		100 (22)	X	I	3H 2H	C	C	35	90	25					21%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RQD) (RQD-5)	LOST CORE & RUBBLE	FRACTURING TYPE	PLANARITY	IRREGULARITY	THICKNESS AND MINERALS	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10	20	30	40	50	60		
2050	43	92 (84)	X 18							1.70														
	44	100 (87)								1.50														
2100	45	100 (84)	X 18							1.25														
	46	98 (84)	X 18							1.45														
2150	47	100 (84)	X 18							1.60														
	48	100 (84)	X 18							1.70														
2200	49	100 (84)	X 18							1.80														
	50	100 (84)	X 18							1.90														
2250	51	100 (84)	X 18							2.00														

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Structure file: NW02ARV7.STR Lithology file: NW02ARV6.UTM Date: 10/11/04

MPLog V 4.60

C-16

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

Page 11 of 11

by J. L. H. Ruppel & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % LITHOPHYLLS AND OTHER LAYERS	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
	INTERVAL	% RECOVERY (RUR/ROD-W)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	REGULAR	IRREG	THICKNESS AND MINERALS	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	HARDNESS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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Structure file: NRG2ARV7.SYS Lithology file: NRG2ARV6.LTH Date: 10/11/94

NRlog v 4.60

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Sandia National Laboratories

Print Date: 10/11/94

WBS 1.2.3.2.6.2

QA: QA

Revision 1

CORE HOLE ROCK STRUCTURAL DATA SUMMARY

Hole UE25 NRG-2A

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Small change in 10-ft RQD in three intervals. Revised stratigraphy and thermomechanical units to USGS nomenclature.

CODING EXPLANATION

STRATIGRAPHIC ABBREVIATIONS

	Tuff Unit "X"		
	Pre-Tuff Unit "X"		
T.C.	Tiva Canyon Member	C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. Lith.	Crystal-Rich Lithophysal

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
TCw—Tiva Canyon Welded Unit

COLUMN INFORMATION (Page 3)

RQD (%)
$$RQD (\%) = \frac{\sum \text{Piece lengths } \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

CORE RQD Core RQD based on piece lengths defined by all types of fractures (C, I, N and V).

ENHANCED RQD Effect of fractures identified as coring induced (Type C) are filtered from the piece lengths.

LITHOPHYSAL (and other cavities) Percent void due to lithophysae and other cavities, estimated visually by counting the number of cavities, estimating the average diameter, calculating the void volume assuming spherical cavities, and normalizing to the core volume.
NM—Not Measured

WEATHERING Subjective evaluation of rock degradation by mechanical/chemical agents:
F: Fresh M: Moderately weathered D: Decomposed
S: Slightly weathered I: Intensely weathered

HARDNESS Subjective evaluation of resistance to breakage:
1: Extremely hard 4: Moderately hard 7: Very soft
2: Very hard 5: Moderately soft 8: Soil-like, cohesive
3: Hard 6: Soft 9: Soil-like, non-cohesive

COLUMN INFORMATION (Page 4)

FEATURE TYPE Following codes indicate origin of feature:
N: Natural—indicated by mineral coating or evidence of weathering, slickensides, lack of fit between sides.
I: Indeterminate—origin questionable, rotated so that coatings possibly removed.
C: Coring induced—fresh, clean, tightly fitting breaks.
V: Vug or large void.

INCLINATION (degrees) Angle between plane normal to core axis and plane of fracture (Type N and I only).

J.F.T. Agapito & Associates, Inc.

MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only):		
	C: Clean	TD: Brown dendritic	CL: Clay
	WC: White crystalline	TC: Tan crystalline	TN: Tan noncrystalline
	WN: White noncrystalline	CA: Calcite	FE: Iron oxide
	BC: Black crystalline	SI: Silica	BN: Brown noncrystalline
	BD: Black dendritic	MN: Manganese	
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only):		
	C: Clean, no filling	M: Moderately thick (0.1-0.4 inches)	
	S: Very thin, surface sheen	V: Very thick (0.4 - 1.0 inches)	
	T: Thin (up to 0.1 inches)	E: Extremely thick, greater than 1.0 inches	
PLANARITY	Describes the overall shape of the feature (Type N and I only):		
	P: Planar	S: Stepped	
	C: Curved	I: Irregular	
ROUGHNESS	Describes the local relief of the surface (Type N and I only):		
	V: Very rough—stepped, near-normal steps and ridges occur.		
	R: Rough—large angular asperities can be seen.		
	M: Moderately rough—asperities clearly visible, surface has abrasive feel.		
	S: Smooth—no asperities, smooth to the touch.		
	P: Polished—slickensided, extremely smooth and shiny.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UB25 NRG-2A

Interval—80-260 ft (24.4-79.2 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (ft ⁻¹ interval)	NO. OF FRACTURES WITH INCLINATION (degrees)										
			N	I	C	V		10	20	30	40	50	60	70	80	90	C	
80	Tuff Unit "X"	UO	7	13			80	6			1							7
90	Tuff Unit "X"	UO	6	20			90	2		3	1	1						8
100	Tuff Unit "X"	UO	7	24			100	1		3	1	1			1			7
110	Tuff Unit "X"	UO	8	28			110	7		1								8
120	Tuff Unit "X"	UO	3	12	16		120	4		1	6	1			3			14
130	Tuff Unit "X"	UO	1	10	22		130	8				1		1	1			11
140	Tuff Unit "X"	UO	1	4	8		140	1			1	1		1	1			4
150	Pre-Tuff Unit "X"	UO			3		150	1										
160	T.C. C.R. Nonlith.	TCw	7	2	28		160	1		1	2	1	2	1		1		7
170	T.C. C.R. Nonlith.	TCw	8	11	23		170	7	8	1		2			1	8		11
180	T.C. C.R. Nonlith.	TCw	2	16	25		180	2		1		8		2	2	2		15
190	T.C. C.R. Nonlith.	TCw		22	19		190	18			4							22
200	T.C. C.R. Nonlith.	TCw	4	5	12		200	3		1		1	1	1		2		4
210	T.C. C.R. Nonlith.	TCw	14	14	11		210	18	8	2		1		1				9
220	T.C. C.R. Nonlith.	TCw	1	5	19		220	4	1							1		4
230	T.C. C.R. Nonlith.	TCw		9	16		230	1										9
240	T.C. C.R. Lith.	TCw	6	8	20	1	240	6	1		1		1	2	2	3		13
250	T.C. C.R. Lith.	TCw	3	1	17		250			3					1			4
260	T.C. C.R. Lith.	TCw					260	87	14	17	17	18	4	9	12	20		156
TOTAL			51	147	330	1		44	7.1	8.8	8.6	8.1	2	4.5	6.1	10		78
PERCENT OF OCCURRENCE			9.8	28	62	0.2												

NO. OF FRACTURES W/MINERAL INFILLING TYPE												NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE				NO. OF FRACTURES W/ROUGHNESS CODE				
WV	BC	BD	TD	TC	CA	SI	MN	CL	TN	FE	BN	C	S	T	M	V	R	P	C	S	I	V	R	M	S	P
												7										7				
												6										6	1	2	3	
												7						1				6		4	2	
												8										7		7		
												14	1					3				10		10	3	
												11						2				9		9	2	
1												4		1				1				3		2	2	
												7		1	1			6	1			2			7	1
2			1						1			11	6	3				7		1		12		3	17	
					1							16		1		1		2				14			16	
												22								1		21		17	5	
6												4	6					6	1			2			6	
18												9	17	2				21				6		6	22	
2												4	1	1				4	1			1			2	4
												9										9		4	5	
1												13	2					3	6	1		4	3	2	8	
												3		1				2				2		1	3	
35	0	0	1	0	1	0	0	0	1	0	0	154	32	10	1	1	0	68	8	3	120	4	68	112	5	0
6	18	0	0	0.5	0	0.5	0	0	0.5	0	0	78	16	6.1	0.5	0.5	0	30	4.3	1.8	84	2.1	35	60	2.7	0

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA
Hole UE25 NRG-2A

Sandia National Laboratories
Print Date: 1/16/95
WBS 1.2.3.2.6.2
QA: L
Revision 2

REVISION HISTORY

Revision 2 Change in method for calculating % lithophysae. Revisions to stratigraphy and thermomechanical units; Q-core index and histogram plots removed from presentation.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{*}} \cdot \frac{J_r}{J_a} \cdot \frac{J_w}{SRF^{*}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of J_n and SRF.

where RQD^{**} = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

J_n^{*} = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9.

J_r = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

J_a = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

J_w = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: Cannot be determined from core log data and is generated by Monte-Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean values for the thermomechanical unit in UE25 NRG-2A is:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
UO and TCw	23.9%	43.3%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$RMR = C + RQD-I + JS + JC + JW$$

where C = Rock Strength Index: Derived from compressive strength estimated by Schmidt Rebound Hardness data for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, excludes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

	Tuff Unit "X"		
	Pre-Tuff Unit "X"		
T.C.	Tiva Canyon Member	C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. Lith.	Crystal-Rich Lithophysal
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain Member		
P.C.	Pah Canyon Member		
T.S.	Topopah Spring Member		

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
TCw—Tiva Canyon Welded Unit
PTn—Upper Paintbrush Nonwelded Unit
TSw1—Topopah Spring Welded Unit—Lithophysae Rich
TSw2—Topopah Spring Welded Unit—Lithophysae Poor
TSw3—Topopah Spring Welded Unit—Vitrophyre
CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole UE25 NRG-2A

Interval—80-260 ft (24 4-79 2 m)

END DEPTH	STRATIGRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM ¹ Barton et al. (1974)							RMR CLASSIFICATION SYSTEM ² Bieniawski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
90	Tuff Unit "X"	UO	5	5.00	3.00	1.00	1.00	1.00	6.00	1	3	5	28.5	15	62.5
100	Tuff Unit "X"	UO	49	5.00	3.00	1.00	1.00	1.00	29.40	2	8	8	28.5	15	61.5
110	Tuff Unit "X"	UO	30	9.00	2.83	1.00	1.00	1.00	9.44	2	8	8	27.0	15	60.0
120	Tuff Unit "X"	UO	4	4.00	3.00	1.00	1.00	1.00	7.50	2	3	5	28.5	15	53.5
130	Tuff Unit "X"	UO	33	8.00	2.77	1.00	1.00	1.00	11.42	2	8	8	26.4	15	59.4
140	Tuff Unit "X"	UO	36	7.00	2.82	1.00	1.00	1.00	14.49	2	8	8	26.9	15	59.9
150	Tuff Unit "X"	UO	29	4.00	2.75	1.40	1.00	1.00	14.24	2	8	8	24.2	15	57.2
160	Pre-Tuff Unit "X"	UO	0	9.00	2.77	1.38	1.00	1.00	2.23	2	3	5	25.4	15	50.4
170	T C CR Nonkth	TCw	14	8.00	2.13	1.58	1.00	1.00	2.39	4	3	8	20.8	15	50.8
180	T C CR Nonkth	TCw	21	8.00	2.65	1.70	1.00	7.50	0.55	4	3	8	21.5	15	51.5
190	T C CR Nonkth	TCw	0	8.00	2.88	1.41	1.00	5.00	0.45	2	3	5	26.3	15	51.3
200	T C CR Nonkth	TCw	10	8.00	3.00	1.00	1.00	1.00	3.75	2	3	5	28.5	15	53.5
210	T C CR Nonkth	TCw	36	5.00	2.25	2.11	1.00	1.00	6.10	7	8	8	17.4	15	55.4
220	T C CR Nonkth	TCw	38	4.00	2.22	2.36	1.00	5.00	1.84	4	8	8	15.7	15	50.7
230	T C CR Nonkth	TCw	61	7.00	1.50	1.67	1.00	1.00	7.84	4	13	8	18.0	15	58.0
240	T C CR Nonkth	TCw	44	6.00	3.00	1.00	1.00	5.00	4.40	7	8	8	28.5	15	68.5
250	T C CR Lth	TCw	10	9.00	2.38	1.13	1.00	7.50	0.31	4	3	8	24.0	15	54.0
260	T C CR Lth	TCw	8	8.00	2.50	1.00	1.00	1.00	3.13	7	3	5	24.0	15	54.0

Jn*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*

RQD** IF RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

¹ Barton, N., R. Lien, and J. Lunde, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6: 189-236 (Springer Verlag, 1974)

² Bieniawski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 9th International Congress on Rock Mechanics, Montreux, Switzerland, 2-4-18 (A. A. Balkema, 1979)

Q				RMR			
Jn	—	Joint Set Number		C	—	Strength Index	
Jr	—	Joint Roughness Number		RQD-I	—	RQD Index	
Ja	—	Joint Alteration Number		JS	—	Joint Spacing Index	
Jw	—	Joint Water Reduction Factor		JC	—	Discontinuity Condition Index	
SRF	—	Stress Reduction Factor		JW	—	Groundwater Index	

$$Q = (RQD/I_n)(J_r/J_a)(J_w/SRF)$$

$$RMR = C + RQD-I + JS + JC + JW$$

SCHMIDT HAMMER TESTS

Initial Calibration 73.0 73.0 73.5 73.5 73.5 73.5 73.5 73.5 73.5 74.0
 Final Calibration 71.0 71.0 71.0 71.5 71.5 72.0 72.5 73.0 73.5 74.0

Average Calibration Reading: 72.8
 Anvil Standard Value: 74.0

Correction Factor: 1.017

Test Date: 7/28/93

SMF Staff: D. Harle D. Merritt
 L. Linden

Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UE25-NRG2A	90.6 - 90.6	<10	<10	N/A	NO DETECTABLE READING																---	---	---	---	
	92.2 - 92.4	<10	<10	N/A	NO DETECTABLE READING																---	---	---	---	
	107.5 - 107.7	10.5	11.0	11.5	11.5	<10	<10	<10	<10	<10	SAMPLE CRACKED										---	---	---	---	
	134.9 - 135.1	11.5	11.5	11.5	13.0	13.5	13.5	15.5	<10	<10	<10	<10	<10	SAMPLE CRACKED							---	---	---	---	
	166.5 - 166.7	17.0	17.5	19.5	19.5	20.0	21.0	21.5	22.0	22.5	22.5	24.5	24.5	24.5	25.5	25.5	26.0	26.5	27.0	28.0	30.5	23.3	3.582	23.7	3.6
	171.4 - 171.6	42.0	42.0	42.0	42.5	42.5	42.5	42.5	43.0	43.0	43.0	43.5	43.5	43.5	43.5	43.5	44.0	44.0	44.5	44.5	43.2	0.780	43.9	0.8	
	174.2 - 174.4	24.5	25.5	27.0	30.0	31.0	31.0	31.5	SAMPLE CRACKED												---	---	---	---	
	177.2 - 177.4	10.5	12.0	12.5	13.0	13.5	14.5	15.0	15.5	16.5	17.0	17.5	18.5	19.0	19.5	19.5	19.5	20.0	20.0	20.5	21.5	16.8	3.271	17.1	3.3
	188.0 - 188.3	10.0	10.0	10.0	10.0	10.5	10.5	10.5	11.5	11.5	11.5	12.5	12.5	12.5	13.5	13.5	13.5	15.0	15.5	17.0	17.5	12.5	2.933	12.7	2.3
	193.0 - 193.2	10.0	10.0	10.0	10.0	10.0	10.0	10.5	10.5	10.5	11.0	11.0	11.0	11.5	11.5	12.0	12.5	13.0	13.5	15.5	15.5	11.5	1.728	11.2	1.1
	204.1 - 204.4	22.5	25.5	25.5	27.0	27.5	29.5	30.5	31.0	31.5	32.0	32.0	33.5	33.5	33.5	34.0	35.0	35.0	37.0	39.0	42.5	31.9	4.826	32.4	4.8
	214.8 - 215.2	10.0	14.0	14.5	15.0	15.0	17.0	17.5	17.5	19.0	19.5	20.0	20.5	20.5	21.0	21.0	21.0	21.5	24.5	30.0	31.5	18.5	5.092	19.2	4.4
	224.0 - 224.4	23.5	23.5	24.5	24.5	25.0	26.0	28.4	28.5	29.5	29.5	31.5	33.5	33.5	34.0	35.5	36.5	35.5	36.5	36.5	30.4	4.691	30.9	4.7	
	233.6 - 234.0	SAMPLE CRACKED																				---	---	---	---
	233.6 - 233.8	21.5	22.5	27.5	27.5	29.0	29.5	30.5	SAMPLE CRACKED												---	---	---	---	
	237.1 - 237.3	14.5	21.0	21.5	22.0	28.5	26.0	28.0	33.5	34.5	34.5	37.0	37.0	37.5	37.5	38.0	38.5	39.0	41.0	41.5	41.5	32.5	8.057	33.1	8.1
	255.2 - 255.4	39.5	39.5	39.5	40.5	40.5	41.5	41.5	41.5	42.0	42.0	42.0	42.0	42.5	42.5	42.5	42.5	43.0	43.5	43.5	44.5	41.8	1.379	42.5	1.4

Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

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APPENDIX D

UE25 NRG-2B

**Geology and Rock Structure Log
Core Hole Rock Structural Data Summary
Estimated Rock Mass Quality Indices Based on Core Log Data**

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

GEOLOGY AND ROCK STRUCTURE LOG

Hole UE25 NRG-2B

Sandia National Laboratories

Print Date: 2/4/95

WBS 1.2.3.2.6.2

QA: QA

Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Revised stratigraphic and thermomechanical unit summary to use USGS nomenclature. Corrected study plan number on cover page.

BOREHOLE ID: UE25 NRG-2B

STUDY PLAN NO: 8.3.1.14.2

CORE SIZE: HQ

DRILL DATES: 7/30/93 - 9/14/93

GROUND ELEV: 3801.4 ft

COORDINATES: N: 765,765.24

E: 569,214.54

TOTAL DEPTH: 329.5 ft

ANGLE FROM VERT: 0°

AZIMUTH: NA

Field Rock Structure

Logged by:

S. Weber

R. Henson

R. Wilcoxon

R. Myers

M. Wagner

C. Hermes

D. Switzer

Hattler

Drilling Support Division, Drilling

Support and Sample Management

Department, T&MSS

Relogged by:

Richard Lippoth

J. F. T. Agapito & Associates, Inc.

Lithology and Stratigraphy

Logged by:

T. Moyer and

J. Geslin

USGS/SAIC

Checked by:

Carl Brechtel

J. F. T. Agapito & Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION

UNLITHIFIED TUFF

GEOLOGY AND ROCK STRUCTURE

FAULT GOUGE

NONWELDED TUFF

WELDED TUFF

BEDDED TUFF

ASH-FLOW TUFF

FRACTURE TYPE OR FEATURE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition, not a fracture.

LOST CORE AND RUBBLE

LOST CORE

× 20 × RUBBLE ZONE

(with average maximum diameter of rubble pieces to nearest 0.01 ft;
NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.
- 8 Soil Like—Cohesive
- 9 Soil Like—Non-cohesive

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

ROUGHNESS

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

INFILLING THICKNESS AND MINERALIZATION

C Clean, no filling.	C Clean	CA Calcite
S Very thin, surface sheen	WC White, crystalline	SI Silica
T Thin (up to 0.1 inches)	WN White, non-crystalline	MN Manganese
M Moderately thick (0.1 - 0.4 inches)	TD Brown dendritic	CL Clay
V Very thick (0.4 - 1.0 inches)	TC Tan crystalline	BC Black crystalline
E Extremely thick, greater than 1.0 inches)	TN Tan, non-crystalline	BD Black dendritic

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If a piece length ≥ 0.33 ft crosses over a 10-ft interval boundary, the portion of the piece length that occurs in the 10-ft interval is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

Reference

Geslin, J. and Moyer, T. (1993), "Graphical Lithologic Log of Borehole NRG-2B," USGS DTN: GS931108314211.041.

TABLE 1 Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^a				Soil Classification	
				Group Symbol	Group Name ^b
COARSE-GRAINED SOILS More than 50 % retained on No. 200 sieve	Gravels More than 50 % of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5 % fines ^c	$Cu \geq 4$ and $1 \leq Cc \leq 3^e$	GW	Well-graded gravel ^f
			$Cu < 4$ and/or $1 > Cc > 3^e$	GP	Poorly graded gravel ^f
		Gravels with Fines More than 12 % fines ^c	Fines classify as ML or MH	GM	Silty gravel ^{f, g, h}
			Fines classify as CL or CH	GC	Clayey gravel ^{f, g, h}
	Sands 50 % or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines ^c	$Cu \geq 6$ and $1 \leq Cc \leq 3^e$	SW	Well-graded sand ⁱ
			$Cu < 6$ and/or $1 > Cc > 3^e$	SP	Poorly graded sand ⁱ
		Sands with Fines More than 12 % fines ^c	Fines classify as ML or MH	SM	Silty sand ^{g, h, j}
			Fines classify as CL or CH	SC	Clayey sand ^{g, h, j}
FINE-GRAINED SOILS 50 % or more passes the No. 200 sieve	Silt and Clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line ^k	CL	Lean clay ^{k, l, m}
			$PI < 4$ or plots below "A" line ^k	ML	Silt ^{k, l, m}
		Organic	Liquid limit - oven dried < 0.75	OL	Organic clay ^{k, l, m, n}
			Liquid limit - not dried		Organic silt ^{k, l, m, n}
	Silt and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay ^{k, l, m}
			PI plots below "A" line	MH	Elastic silt ^{k, l, m}
		Organic	Liquid limit - oven dried < 0.75	OH	Organic clay ^{k, l, m, n}
			Liquid limit - not dried		Organic silt ^{k, l, m, n}
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

^a Based on the material passing the 3-in. (75-mm) sieve.

^b If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^c Gravels with 5 to 12 % fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

^d Sands with 5 to 12 % fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

$$C_u = D_{60}/D_{10} \quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^e If soil contains ≥ 15 % sand, add "with sand" to group name.

^f If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^g If fines are organic, add "with organic fines" to group name.

^h If soil contains ≥ 15 % gravel, add "with gravel" to group name.

ⁱ If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

^j If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.

^k If soil contains ≥ 30 % plus No. 200, predominantly sand, add "sandy" to group name.

^l If soil contains ≥ 30 % plus No. 200, predominantly gravel, add "gravelly" to group name.

^m $PI \geq 4$ and plots on or above "A" line.

ⁿ $PI < 4$ or plots below "A" line.

^o PI plots on or above "A" line.

^p PI plots below "A" line.

Table 1 (above) reproduced from:

American Society for Testing and Materials (1993), 1993 Annual Book of ASTM Standards, Section 4, Construction, Volume 04.08, Soil and Rock, Dimension Stone, Geosynthetics; Standard D2487-92, "Classification of Soils for Engineering Purposes (Unified Soil Classification System)", p. 327, ASTM, Philadelphia, PA.

UE25 NRG-2b

Stratigraphic and Thermomechanical Units Summary

Stratigraphy

Thermomechanical Units

- Date: 11/1/94
- 1 U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.
 - 2 U. S. Geological Survey - Graphical Lithologic Log of Borehole NRG-2a, Thomas Moyer and Jeff Geslin, DTN:GS931108314211.041.

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YUCCA MOUNTAIN, UE25 NRG-2B GEOLOGY AND ROCK STRUCTURE LOG

Page 1 of 14

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DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION (RQD %)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGIC WEATHERING AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
	INTERVAL	% RECOVERY (UNIT 100%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	POOR	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	10	20			30	40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

Structure file: NRG2BRSV.STR Lithology file: NRG2BRSV.LTH Date: 10/11/94

NLog v 4.40

YUCCA MOUNTAIN, UE25 NRG-2B GEOLOGY AND ROCK STRUCTURE LOG

Page 2 of 14

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DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)				HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICAL VOLUME OF CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (BLN RQD-%)	LOST CORE & BUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	ROCK QUALITY				NATURAL AND INDUCED (+ INDUCED)				30	20	10			5						
											VERY POOR	POOR	FAIR	GOOD	EXCELLENT	10	20	30												
		75	(0)													0%	13%	15%											LITHIFIED, RAISER MBR CONTINUED.	
		0	(0)																											
30.0		20	(0)																											
		50	(0)																											
35.0		20	(0)													5%														
		100	(1.7)																											
40.0		94	(37)																											
		15																												
45.0		88	(31)													36%														
		10																												
50.0		10																												

Structure file: M0228R06.STR Lithology file: M0228R06.LTR Date: 10/11/94

MLog v 4.60

Page 3 of 14

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[illegible]

Structure file: HQ28RVE.STR Ethology file: HQGZBRY1.LTH Date: 10/11/94

RPlog v 4.40

D-11

GEOLOGY AND ROCK STRUCTURE LOG

Page 4 of 14

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[illegible]

Signature file: WRO2HRV6.5TH Lithology file: WRO2HRV6.LTM Date: 20/11/94

NP10M \$ 4.65

D-12

YUCCA MOUNTAIN, UE25 NRG-2B GEOLOGY AND ROCK STRUCTURE LOG

Page 5 of 14

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMYCELIAR AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
	INTERVAL	% RECOVERY (RUN/RED-4)	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	LOG	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			10	20	30	10			20	30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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Structure file: NRG2BUE25.BTR Lithology file: NRG2BUE25.LTR Date: 10/11/94

NPlog v 4.60

Page 6 of 14

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Stucco File: MINZERV6.STR Lithology File: MINZERV6.LTH Date: 10/12/99

MP109 v 4.00

D-14

Page 7 of 14

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[illegible]

Structure file: MR02BHV6.STR Lithology file: MR02BHV6.LTH Date: 10/31/94

MPLOY \$.50

GEOLOGY AND ROCK STRUCTURE LOG

Page 8 of 14

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Structure File: 38Q23EV4.5TR Lithology File: 38Q23EV4.LTH Date: 10/11/2014

WFO: 4.50

D-16

YUCCA MOUNTAIN, UE25 NRG-2B GEOLOGY AND ROCK STRUCTURE LOG

Page 9 of 14

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
	INTERVAL	% RECOVERY (RUN 200-250)	LOST CORE & RUBBLE	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DR	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			10	20	30	40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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Structure file: NRG2B.RV6 87K Lithology file: NRG2B.RV6.LTH Date: 10/11/94

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Page 10 of 14

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Page 10 of 10

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)					HARDNESS	WEATHERING	ESTIMATED % LITHOMYCELES AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (MIN-RQD-M)	LAST CORE A. RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DP	DOUGD	PIECE LENGTH	VERY POOR	POOR	FAR	GOOD	EXCELLENT	NATURAL AND UNDESIRABLE (+ INDUCED)	10	20			30	40				
	RUN 82	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	TUFF ONLY "X" CONTINUED. 129.7 - 230.7 FT. MAY BE FALLOUT. BASAL 1.5 FT. IS A SEPARATE UNIT THAT IS ALTERED. 5-7% WHITE DUNCE IN GRAYISH PINK MATRIX [V.STR7/3]. LOW RIDGE FAULT ZONE 232.3 - 240.0 SLIGHTLY TO EXTREMELY ALTERED, BROKEN TO INTACT CORE, WITH WORKCOVERED INTERVALS. IDENTIFIABLE LITHOLOGIC UNITS INCLUDE: FINEGRAINED FLOW, TIVA CANYON CRYSTAL-RICH NONLITHOMYCELES, TIVA CANYON CRYSTAL-POOR NONLITHOMYCELES.
230.0	RUN 83	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	
235.0	RUN 84	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	
240.0	RUN 85	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	
245.0	RUN 86	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	
250.0	RUN 87	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	
255.0	RUN 88	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	
260.0	RUN 89	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	
265.0	RUN 90	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	
270.0	RUN 91	300 (10)	XXXX	1	IN	C	78	10		1.15	40%						5)					7				0%	

Structure file: PRQZNRV6.SYS Lithology file: PRQZNRV6.LTH Date: 10/11/94

NPlog v 4.40

YUCCA MOUNTAIN, UE25 NRG-2B GEOLOGY AND ROCK STRUCTURE LOG

Page 11 of 14

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % LITHOMYCELE AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN NOD-4)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	STILL	POORNESS AND	MINERALS	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			
255.0	RUN 89	100 (0)	0.00															2 (5)			
260.0	RUN 91	78 (0)	0.10																		
265.0	RUN 94	200 (0)	0.12																		
270.0	RUN 95	96 (1.0)	0.10																		
275.0	RUN 95	100 (0)	0.10																		

260.0 - 265.0 MEDIUM TYPE

268.0 - 274.4 FT. NONWEATHERED, FINE-GRAINED, PORPHYROUS STROCLASTIC FLOW.

274.5 - 277.2 FT. CRUDELY STRATIFIED, POORLY-SORTED, LITHIC AND PUMICE-RICH FALLOUT. DIPS APPROX. 3 DEGREES.

Structure file: NRG25NRG.57R Lithology file: NRG25NRG.17M Date: 10/11/94

4Plog v 4.60

YUCCA MOUNTAIN, UE25 NRG-2B GEOLOGY AND ROCK STRUCTURE LOG

Page 12 of 14

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DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)				FACIES	WEATHERING	ESTIMATED % LITHOPHYSE AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
	INTERVAL	% RECOVERY (WET ROD-N)	LOST CORE & RUBBLE	FRAC TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	REDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10	20	30	40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
280.0	RUN 96	80	(1.2)	1	IR	2H	C	C	C	5 10						9%	23 (21)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

Structure file: MR228WV8.STR Lithology file: MR228WV8.LTH Date: 10/11/94

NPlog v 4.60

YUCCA MOUNTAIN, UE25 NRG-2B GEOLOGY AND ROCK STRUCTURE LOG

Page 13 of 14

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	PLANARITY	PLANARITY / JOINTNESS	JOINTNESS / INFILL	STRENGTH AND MINERALS	Q _p	Q _t	Q _n	Q _u	Q _h	Q _e	NATURAL AND INDUCED (+ INDUCED)	10	20	30				
305.0	101	100	X 1.3	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	DISTINCTIVE CRYSTAL CLOTS FROM 305.2 TO 322.8 FT.
310.0	102	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
315.0	103	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
320.0	104	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
325.0	105	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
330.0	106	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
335.0	107	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
340.0	108	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
345.0	109	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
350.0	110	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
355.0	111	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	LIGHT GRAY ONLY FROM 323.8 - 324.8 FT. IN FINEER GRAY (500/1) MATRIX. CRYSTALS OF FELD, ST, CP2.
360.0	112	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
365.0	113	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
370.0	114	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
375.0	115	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
380.0	116	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
385.0	117	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
390.0	118	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
395.0	119	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
400.0	120	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
405.0	121	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	326.0 - 329.5 BEDDED TUFFS
410.0	122	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
415.0	123	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
420.0	124	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
425.0	125	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
430.0	126	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
435.0	127	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
440.0	128	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
445.0	129	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	
450.0	130	100	X 1.0	I	IN	C	85	85	85	85	85	85	85	16%	10	20	30	1	M	0%	

Structure file: HQ25NRG.STR Lithology file: HQ25NRG.LTH Date: 10/11/94

MPlog v 4.60

D-21

YUCCA MOUNTAIN, UE25 NRG-2B GEOLOGY AND ROCK STRUCTURE LOG

Page 14 of 14

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % IMPROVEMENT IN STRENGTH AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RQD-4)	LOST CORE & RUMBLE	FRACTURE TYPE	PLANARITY/ ROUGHNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR 25	POOR 35	FAIR 45	GOOD 55	EXCELLENT 65	NATURAL AND INDETERMINATE (+ INDUCED)	10	20	30	10	20	30	40		
	106			1	IN	C	05																V---V---V	<p>124.0 - 329.4 FT. ALTERED PUMICEOUS TUFF, VERY PALE ORANGE (10YR6/2) PYROCLASTIC FLOW WITH SHALE (<10 MM), PUMICE, CRYSTALS OF FELD AND BIO; MAY BE 2 UNITS.</p> <p>329.4 - 329.5 FT. PINK CLAY-RICH PUMICE (LAPILLI FALLOUT ?)</p> <p>TOTAL CORED DEPTH = 329.50</p>
	106			1	IN	C	05																V---V---V	
	106			1	IN	C	05																V---V---V	
	106			1	IN	C	05																V---V---V	
	106			1	IN	C	05																V---V---V	
	106			1	IN	C	05																V---V---V	
	106			1	IN	C	05																V---V---V	
	106			1	IN	C	05																V---V---V	
	106			1	IN	C	05																V---V---V	
	106			1	IN	C	05																V---V---V	
330.0																							V---V---V	

Structure file: NRG2BHV6.SYS Lithology file: NRG2BHV6.LTW Date: 10/11/94

MPlog v 4.60

Sandia National Laboratories
Print Date: 10/13/94
WBS 1.2.3.2.6.2
QA: QA
Revision 1

Revision 1 Change in method for calculating percent lithophysae. Stratigraphy and thermomechanical units revised to USGS nomenclature.

		Lithified	Nonlithified
	Rainier Mesa		
	Tuff Unit "X"		
	Bow Ridge Fault		
B.T.	Bedded Tuff		
P.C.	Pah Canyon Member		Tuff

UC—Undifferentiated Overburden
PTn—Upper Paintbrush Nonwelded Unit

$$RQD (\%) = \frac{\sum \text{Piece lengths } \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

HARDNESS Subjective evaluation of resistance to breakage:

1: Extremely hard	4: Moderately hard	7: Very soft
2: Very hard	5: Moderately soft	8: Soil-like, cohesive
3: Hard	6: Soft	9: Soil-like, non-cohesive

FEATURE TYPE Following codes indicate origin of feature:

- N: Natural—indicated by mineral coating or evidence of weathering, slickensides, lack of fit between sides.
- I: Indeterminate—origin questionable, rotated so that coatings possibly removed.
- C: Coring induced—fresh, clean, tightly fitting breaks.
- V: Vug or large void.

INCLINATION (degrees)	Angle between plane normal to core axis and plane of fracture (Type N and I only).		
MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only):		
	C: Clean	TD: Brown dendritic	CL: Clay
	WC: White crystalline	TC: Tan crystalline	TN: Tan noncrystalline
	WN: White noncrystalline	CA: Calcite	FE: Iron oxide
	BC: Black crystalline	St: Silica	BN: Brown noncrystalline
	BD: Black dendritic	MN: Manganese	
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only):		
	C: Clean, no filling	M: Moderately thick (0.1-0.4 inches)	
	S: Very thin, surface sheen	V: Very thick (0.4 - 1.0 inches)	
	T: Thin (up to 0.1 inches)	E: Extremely thick, greater than 1.0 inches	
PLANARITY	Describes the overall shape of the feature (Type N and I only):		
	P: Planar	S: Stepped	
	C: Curved	I: Irregular	
ROUGHNESS	Describes the local relief of the surface (Type N and I only):		
	V: Very rough—stepped, near-normal steps and ridges occur.		
	R: Rough—large angular asperities can be seen.		
	M: Moderately rough—asperities clearly visible, surface has abrasive feel.		
	S: Smooth—no asperities, smooth to the touch.		
	P: Polished—slickensided, extremely smooth and shiny.		

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
Core Hole Structural Data Summary
Hole UE25 NRG-2B
Interval—0-320 ft (0-97.5 m)

BASE OF 10-FT INTERVAL	LITHO- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE ROD*	ENHANCED ROD**	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	WEATHERING (ft in 10-ft interval)***						HARDNESS (ft in 10-ft interval)					
								F	S	M	I	P	1	2	3	4	5	6	
10	Reiner Mass Limited	UO	24	28	0	0.2	1.7	7.7											
20	Reiner Mass Limited	UO	8	17	0	1.7	3.2	2.9	4.1										
30	Reiner Mass Limited	UO	0	18	0	3.1	4.5		2.7										
40	Reiner Mass Limited	UO	5	35	0	2.8	2.1		10.0										
50	Reiner Mass Limited	UO	26	57	0	0.8	0.9	2.6	7.4										2.6
60	Reiner Mass Nonch.	UO	0	0	0	0.8	2.1	2.0	2.3										2.6
70	Reiner Mass Nonch.	UO	0	0	0	3.8	6.2	7.5											
80	Reiner Mass Nonch.	UO	9	9	0	3.8	4.6	10.0											
90	Reiner Mass Nonch.	UO	26	40	0	0.7	3.6	6.0											
100	Reiner Mass Nonch.	UO	11	11	0	1.0	6.0		2.5										
110	Reiner Mass Nonch.	UO	0	0	0	7.5		2.5											
120	B.T.	UO	0	0	NM	0.5													
130	B.T.	UO	0	0	NM	0.0													
140	B.T.	UO	0	7	NM	3.2													
150	A.T.	UO	7	7	0	0.6	1.1	7.7											
160	B.T.	UO	36	64	0	0.0	2.7	6.6	0.2										5.2
170	Tuff Unit "K"	UO	58	87	0	0.0	1.1		8.8	0.2								9.2	6.8
180	Tuff Unit "K"	UO	28	48	0	0.2	1.8		4.8									4.8	
190	Tuff Unit "K"	UO	60	78	0	0.0	0.1		6.2									4.8	0.3
200	Tuff Unit "K"	UO	36	76	0	0.0	2.0		10.0									9.7	
210	Tuff Unit "K"	UO	37	64	0	0.2	2.8		6.0	6.0								5.3	
220	Tuff Unit "K"	UO	21	71	0	0.0	1.7		4.7									4.7	
230	Tuff Unit "K"	UO	40	87	0	0.0	2.9	0.3										9.9	
240	Bow Ridge Fault		9	77	0	0.1	2.8	4.9		2.4								7.3	
250	Bow Ridge Fault		13	20	0	6.1	1.7		4.6									4.6	
260	Bow Ridge Fault		0	0	0	6.0	1.6		2.5							2.5			
270	B.T.	PTa	0	12	0	0.8	4.1	3.7	1.7	6.1						3.7	1.2	6.1	
280	B.T.	PTa	9	17	0	0.2	3.7	6.9	9.1								4.8		5.2
290	B.T.	PTa	6	35	0	1.8	2.7	4.2		1.3						1.3	4.2		
300	P.C. Tuff	PTa	12	48	0	0.6	2.4		10.0								10.0		
310	P.C. Tuff	PTa	18	89	0	0.0	0.8		0.8	9.1							10.0		
320	P.C. Tuff	PTa	20	97	0	0.6	0.2		4.3	5.1	0.6						10.0		

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED ROD Determined by allowing the effects of fracture identified as coring induced (Type C) from the piece lengths.

*** Footage in interval may not equal 10 ft because of lost core, rubble, or conclusion during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRG-2B

Interval—0-320 ft (0-97.5 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (ft/ft Interval)	NO. OF FRACTURES W/INCLINATION (degrees)											
			N	I	C	V		10	20	30	40	50	60	70	80	90	C		
10	Rainier Mesa Lithified	UO	4	12	9		10												
20	Rainier Mesa Lithified	UO	8	13	18		20												
30	Rainier Mesa Lithified	UO	1	2	13		30												
40	Rainier Mesa Lithified	UO		14	17		40												
50	Rainier Mesa Lithified	UO	3	14	14		50												
60	Rainier Mesa Nonlith.	UO		2	7		60												
70	Rainier Mesa Nonlith.	UO			8		70												
80	Rainier Mesa Nonlith.	UO		2	11		80												
90	Rainier Mesa Nonlith.	UO	1	13	17		90												
100	Rainier Mesa Nonlith.	UO			18		100												
110	Rainier Mesa Nonlith.	UO					110												
120	B.T.	UO					120												
130	B.T.	UO					130												
140	B.T.	UO					140												
150	B.T.	UO			27		150												
160	B.T.	UO	1	9	24		160												
170	Tuff Unit "X"	UO	3	1	14		170												
180	Tuff Unit "X"	UO	10	13	16		180												
190	Tuff Unit "X"	UO	8	1	21		190												
200	Tuff Unit "X"	UO	2	3	18		200												
210	Tuff Unit "X"	UO	6	2	12		210												
220	Tuff Unit "X"	UO		10	21		220												
230	Tuff Unit "X"	UO		7	12		230												
240	Bow Ridge Fault		2	3	16		240												
250	Bow Ridge Fault		1	2	3		250												
260	Bow Ridge Fault		1	1	4		260												
270	B.T.	PTn	3	15	7		270												
280	B.T.	PTn	3	10	8		280												
290	B.T.	PTn	1	12	16		290												
300	P.C. Tuff	PTn	4	12	13		300												
310	P.C. Tuff	PTn	6	5	31		310												
320	P.C. Tuff	PTn		4	38		320												
TOTAL			58	176	429	0													
PERCENT OF OCCURRENCE			10	28	84	0													

■ N+I
■ N+I+C

NO. OF FRACTURES W/MINERAL INFILLING TYPE													NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE				NO. OF FRACTURES W/ROUGHNESS CODE				
WC	WN	BC	BD	TD	TC	CA	SI	LN	CL	TN	FE	EN	C	S	T	M	V	B	P	C	S	I	V	R	M	S	P
1													15		1				11			5			11	5	
3													18	2	1				9			11			11	9	
													3							1		2			3		
													14						1		1	12			14		
	1												18	1					8	1		8		1	14	2	
													2						1			1			1	1	
													2									2		2			
													14						14							14	
													4						1	1		1			2	1	
							1						3	1					2			1			1	2	
													23						14	3		6		11	7		
													9						6	2		1		1	8		
													5						3			2		3	2		
													6						5			3		6	2		
													10						3	2		5			10		
													7						3	1		3			7		
													6						2			1			1	2	
													3						2			1			1	2	
	1												1	1					1						1		
	3												16	3					2	3		7		10		2	
													13						3			10		2	11		
													12	1					2	5		8		3	5	4	
													18						1		1	12		1	11	2	
													11						1	2		8			9	2	
													4									4			4		
4	5	0	0	0	0	0	1	0	0	0	0	0	233	9	2	0	0	0	86	21	2	111	0	40	137	48	0
1.6	2.	0	0	0	0	0	0.4	0	0	0	0	0	95	3.7	0.8	0	0	0	41	9.2	0.9	48	0	18	51	21	0

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA
Hole UE25 NRG-2B**

Sandia National Laboratories
Print Date: 2/13/95
WBS 1.2.3.2.6.2
QA-1
Revision 3

REVISION HISTORY

- Revision 2 Change in method for calculating % lithophysae and other cavities. Stratigraphy and thermomechanical units revised; Q-core index and histogram plots removed from presentation.
- Revision 3 Revised SRF parameter using NRG rock testing data for PTn unit.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{*}} \cdot \frac{J_r}{J_a} \cdot \frac{I_w}{SRF^{*}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of J_n and SRF.

where RQD^{**} = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

J_n^{*} = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9.

J_r = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

J_a = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

Jw = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: For nonwelded units, SRF is determined from the ratio of UCS/ σ_1 (UCS = unconfined compressive strength, σ_1 = overburden stress). If unconfined compressive strength data is not available for the 10-ft interval, a compressive strength is generated by Monte Carlo simulation using laboratory test data for the thermomechanical units. For welded tuff units, SRF cannot be determined from core log data and is generated by Monte Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean values for thermomechanical units in UE25 NRG-2B are:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
UO and PTn	16.8%	49.0%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$RMR = C + RQD-I + JS + JC + JW$$

where C = Rock Strength Index: Derived from compressive strength estimated by Schmidt Rebound Hardness data for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, excludes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

	Rainier Mesa		Lithified
		Nonlith.	Nonlithophysae
	Tuff Unit "X"		
	Bow Ridge Fault		
T.C.	Tiva Canyon Member		
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain		
	Member		
P.C.	Pah Canyon Member		Tuff
T.S.	Topopah Spring		
	Member		

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
 TCw—Tiva Canyon Welded Unit
 PTn—Upper Paintbrush Nonwelded Unit
 TSw1—Topopah Spring Welded Unit—Lithophysae Rich
 TSw2—Topopah Spring Welded Unit—Lithophysae Poor
 TSw3—Topopah Spring Welded Unit—Vitrophyre
 CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole UE25 NRG-2B

Interval—0-320 ft (0-97.5 m)

END DEPTH	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al. (1974)							RMR CLASSIFICATION SYSTEM Bieniawski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
10	Rainier Mesa Lathified	UO													
20	Rainier Mesa Lathified	UO													
30	Rainier Mesa Lathified	UO													
40	Rainier Mesa Lathified	UO													
50	Rainier Mesa Lathified	UO													
60	Rainier Mesa Nowlith	UO													
70	Rainier Mesa Nowlith	UO													
80	Rainier Mesa Nowlith	UO													
90	Rainier Mesa Nowlith	UO													
100	Rainier Mesa Nowlith	UO													
110	Rainier Mesa Nowlith	UO													
120	B T	UO													
130	B T	UO													
140	B T	UO													
150	B T	UO													
160	B T	UO													
170	Tuff Unit "X"	UO	88	6.00	1.67	1.00	1.00	1.00	22.67	2	13	8	20.7	15	58.7
180	Tuff Unit "X"	UO	29	6.00	2.28	1.00	1.00	1.00	13.21	2	8	8	22.2	15	56.2
190	Tuff Unit "X"	UO	80	9.00	2.11	1.00	1.00	1.00	14.07	2	13	8	21.5	15	58.5
200	Tuff Unit "X"	UO	36	4.00	2.40	1.00	1.00	1.00	21.60	2	8	8	23.1	15	56.1
210	Tuff Unit "X"	UO	37	6.00	2.38	1.00	1.00	1.00	10.98	2	8	8	22.9	15	55.9
220	Tuff Unit "X"	UO	21	7.00	2.50	1.00	1.00	1.00	7.50	2	3	8	24.9	15	52.9
230	Tuff Unit "X"	UO	40	4.00	2.43	1.00	1.00	1.00	24.29	2	8	8	24.0	15	57.0
240	Bow Ridge Fault		9	20.00	1.00	12.00	1.00	10.00	0.00	0	3	5	0.0	15	23.0
250	Bow Ridge Fault		13	20.00	1.00	12.00	1.00	10.00	0.01	0	3	5	0.0	15	23.0
260	Bow Ridge Fault		0	20.00	1.00	12.00	1.00	10.00	0.00	0	3	5	0.0	15	23.0
270	B T	PTn	0	6.00	2.42	1.33	1.00	7.02	0.43	2	3	8	23.9	15	51.9
280	B T	PTn	9	6.00	2.77	1.00	1.00	16.00	0.31	2	3	8	26.4	15	54.4
290	B T	PTn	6	7.00	2.18	1.00	1.00	16.00	0.21	1	3	8	24.9	15	51.9
300	P.C. Tuff	PTn	12	6.00	2.79	1.00	1.00	16.00	0.37	1	3	8	27.6	15	54.6
310	P.C. Tuff	PTn	16	5.00	2.55	1.00	1.00	15.00	0.54	2	3	8	26.6	15	54.6
320	P.C. Tuff	PTn	20	9.00	3.00	1.00	1.00	8.36	0.80	2	3	5	28.5	15	56.5

Jn*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

Barton, N., R. Lien, and J. Lunde, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics 4:189-216 (Springer Verlag, 1974)

Bieniawski, Z.T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 241-46 (A. A. Balkema, 1979)

Q

Jn — Joint Set Number
 Jr — Joint Roughness Number
 Ja — Joint Alteration Number
 Jw — Joint Water Reduction Factor
 SRF — Stress Reduction Factor

$$Q = (RQD/n)(Jr/Ja)(Jw/SRF)$$

RMR

C — Strength Index
 RQD I — RQD Index
 JS — Joint Spacing Index
 JC — Discontinuity Condition Index
 JW — Groundwater Index

$$RMR = C + RQD I + JS + JC + JW$$

APPENDIX E

UE25 NRG-3

Geology and Rock Structure Log

Core Hole Rock Structural Data Summary

Estimated Rock Mass Quality Indices Based on Core Log Data

Schmidt Hammer Tests

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
GEOLOGY AND ROCK STRUCTURE LOG
Hole UE25 NRG-3

Sandia National Laboratories
Print Date: 2/4/95
WBS 1.2.3.2.6.2
QA: QA
Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Revised stratigraphic summary to include USGS nomenclature. Corrected study plan number on cover page.

BOREHOLE ID: UE25 NRG-3
STUDY PLAN NO: 8.3.1.14.2
CORE SIZE: HQ 2.5"
DRILL DATES: 3/2/93 - 3/30/93
GROUND ELEV: 3823.33 ft
COORDINATES: N: 766,250.60 ft
 E: 568,316.10 ft

TOTAL DEPTH: 330.0 ft
ANGLE FROM VERT: 30.2°
AZIMUTH: 98.7°

Field Rock Structure

Logged by:

R. Myers
M. Edwards Drilling Support Division, Drilling
M. Wagner Support and Sample Management
J. Kirkwood Department, T&MSS
R. Henson
R. Wilcox

Relogged by:

Richard Lippoth J. F. T. Agapito & Associates, Inc.

Lithology and Stratigraphy

Logged by:

Chris Rautman Sandia National Laboratories

Checked by:

Carl Brechtel J.F.T. Agapito & Associates, Inc.
Eric Martin J.F.T. Agapito & Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION GEOLOGY AND ROCK STRUCTURE

NONWELDED TUFF

WELDED TUFF

BEDDED TUFF

ASH-FLOW TUFF

FRACTURE TYPE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition, not a fracture.

LOST CORE AND RUBBLE

LOST CORE

RUBBLE ZONE

(with average maximum diameter of rubble pieces to nearest 0.01 ft;
NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

ROUGHNESS

INFILLING THICKNESS AND MINERALIZATION

C Clean, no filling.	C Clean	CA Calcite
S Very thin, surface sheen	WC White, crystalline	SI Silica
T Thin (up to 0.1 inches)	WN White, non-crystalline	MN Manganese
M Moderately thick (0.1 - 0.4 inches)	TD Brown dendritic	CL Clay
V Very thick (0.4 - 1.0 inches)	TC Tan crystalline	BC Black crystalline
E Extremely thick, greater than 1.0 inches)	TN Tan, non-crystalline	BD Black dendritic

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If a piece length ≥ 0.33 ft crosses over the 10-ft interval boundary, the portion of the piece length that occurs in the 10-ft interval is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

Reference

Geslin, J. and Moyer, T. (1993), "Graphical Lithologic Log of Borehole NRG-3," USGS DTN: GS931008314211.037.

UE25 NRG-3

Stratigraphic and Thermomechanical Units Summary

Stratigraphy

Thermomechanical Units

Date: 11/1/94

Unresolved contact showing difference between criteria. Solid line shows contact based on Scott & Bonk¹, dashed line is contact based on USGS².

¹ U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.

² U. S. Geological Survey - Graphical Lithologic Log of Borehole NRG-3, Thomas Moyer and Jeff Geslin, DTN:GS931008314211.037. E-6

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES					ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMASS AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RQD) (IN)	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DP	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND (DETERMINATE) (+ INDUCED)					
5.0	RUN 1	75 (10)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0.8-08.0. TIVA CLINCH MEMBER, CARBON SCORCH? PARTIALLY WELED ARE-FLOW TOP, LIGHT BROWN TO GREY-BROWN, 2 TO 10% FINE-GRAINED (2-3 MICRONS) VITREOUS SANIDINE PHENOCRYSTS, TRACE OF ALYSED BIOTITE(?), DEVITRIFIED BUT ORIGINALLY PORPHYRIC MATURE OF EIGHT TO EIGHTY PLACATED PORPHYRIC CLASTS QUITE OBVIOUS. SELECT BUBBLE WALL FORMS ALSO OBVIOUS IN GROUNDWATER, ROCK IS POROUS AND VOOY. VAPOR-PHASE ALTERATION MODERATE AND VARIABLE. PORPHYRIC CLASTS LOCALLY SHOW BUBBY COATINGS ON SURFACES.
10.0	RUN 2	89 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	IF THIS IS TIVA CARBON, IT IS SIGNIFI- CANTLY LESS WELED THAN IN JAGGY WASH. ASBEST CHARGE TO WELED UNIT BELOW IS ALSO PUZZLING.
15.0	RUN 3	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	PUMICE-RICH SUBSOL (12.0-02.0): PALE GRAYISH RED TO PALE PINK. PUMICES ARE BROWNISH GRAY AND LIGHT GRAY, REPLACED WITH VAPOR-PHASE MINERALS-DESS DEN. 08911008314211.037.
20.0	RUN 4	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
25.0	RUN 5	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
30.0	RUN 6	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
35.0	RUN 7	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
40.0	RUN 8	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
45.0	RUN 9	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
50.0	RUN 10	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
55.0	RUN 11	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
60.0	RUN 12	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
65.0	RUN 13	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
70.0	RUN 14	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
75.0	RUN 15	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
80.0	RUN 16	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
85.0	RUN 17	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
90.0	RUN 18	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
95.0	RUN 19	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
100.0	RUN 20	100 (0)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION: RQD (%)					FRACTURES (PER 10 FT)				FACIES	WEATHERING	ESTIMATED % LITHOMATERIAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-IN)	LOST CODE & RUBBLE	FRACTURE TYPE	PLANARITY	ROCKPRESS	SWELL	THICKNESS AND	MINERALS	DP	INDUCED	PIES LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			10	20	30	40		
30.0	RUN 9	86 (0)										.50				22%		20% (40%)								
35.0	RUN 10	80 (1.4)										.70				23%										
40.0	RUN 11	100 (1.6)										.05														
45.0	RUN 12	90 (1.7)										.50				50%										
50.0	RUN 13	100 (7.9)										.70														

Structure file: NRG3RV8.STR Lithology file: NRG3RV3.LTH Date: 10/11/94

vlog v 4.60

MUSCLE CLASTS 1-2 CM WITH SPARSE LARGE (5-10 CM) CLASTS. MOST CLASTS GREY, SOME DISTINCTLY MORE BROWN, DIFFERENT ALTERATION?

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

GEOLOGY AND ROCK STRUCTURE LOG

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by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSE AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN/REQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	ENTRILL	THICKNESS AND	MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)				
80.0	RUN 21	41 (10)	.10													0%	0 (5)			<1%		PARTIALLY WELDED ASH-FLUX TUFF AS ABOVE
85.0		43 (10)	.10																	<1%		INTERM. FINE-GRAINED VAPOR-PHASE ALTERATION AT CONTACT. ABRUPT CHANGE IN CHARACTER OF ROCK.
90.0	RUN 26	96 (13)	.10																	<1%		85.0-120.0. TEVA CANYON MEMBER, UPPER CLIFF FORM? DENSELY WELDED, LIGHT GRAY ASH-FLUX TUFF. SAND STRUCTURE LARGELY OCCUPIED BY COMBINATION, DEVITRIFIED, MODERATELY PERVASIVE VAPOR-PHASE ALTERATION, ELONGATION RATIO >1.1. ELONGATED PORCISE CLASTS 1-125 MM, SPARSE LARGE LESS ELONGATED CLASTS WITH EXTENSIVE VAPOR-PHASE ALTERATION.
95.0	RUN 27	85 (10)	.10																	<1%		
100.0		43 (10)	.10																			

Structure Site: MRC3RVS.UTM Lithology Site: MRC3RVS.LTM Date: 08/11/94

HPlog v 4.40

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)						FRACTURES (PER 14 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMYCELES AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-NS)	LAST CORE & RUBBLE	FRAC TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND	MINORALS	DR	REDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED					
1050	42	(0)	.15	1	2H												5	7	<1%			
1100	31	(0)	.10	1	1	TH	2H		25	90												
1150	33	(0)	.03	1	1	TH	2H		60	40												
1200	74	(0)	.03	1	1	TH	2H		60	40												
1250	78	(0)	.04	1	1	TH	2H		50	40												

Structure file: H021RVS.07H Lithology file: H021RVS.07H Date: 10/11/94

HPIlog v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Structure file: HRO10WV1.STR Lithology file: HRO10WV1.LTH Date: 10/11/94

NPLog v 4.50

E-12

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION RQD (%)					FRACTURES (PER 10 FT)					FRACTURE	WEATHERING	ESTIMATED % LITHOPHYSICAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (REINFORCED)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROMBERG	INFILL	THICKNESS AND MATERIALS	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAR	GOOD	EXCELLENT	NATURAL AND INTERMEDIATE (+ INDUCED)											
1550	45	100 (250)	.15	1	IS	SM	30									10 20 30	5	F	4%	XXXXX XXXXX							

STEWART File: MRODREV STR Lithology file: MRODREV.LTH Date: 10/11/94

MPJoa v 4.40

E-13

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[illegible]

Structure file: MO01GV4.STR Technology file: HMK3RV3.LSTR Date: 10/11/96

WD 104 Y 1.60

E-14

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION (RQD %)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (RUN ROD-3)	LOST CORE & RUMBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	FILL	THICKNESS AND MINERALS	DIP	INCLUDED	PEACE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10			20	30	40				
2050	RUN 55	78 (0)	.30	I	2M	2M			45															XXXX			
				I	2M	2M			68															XXXX			
				I	2M	2M			48																	XXXX	
				I	2M	2M			20																	XXXX	
2100	RUN 56	100 (33)	.18	I	2M	2M			40															XXXX	[206.7 IDENTIFIED AS BASE OF UPPER LITHOPHYSEAL ZONE BY GAGE - DTH: 68933008334211.037]		
				I	2M	2M			30																	XXXX	
				I	2M	2M			45																		XXXX
				I	2M	2M			60																		XXXX
2150	RUN 57	59 (0)	.22	I	2M	2M			45															XXXX			
				I	2M	2M			30																		XXXX
				I	2M	2M			50																		XXXX
				I	2M	2M			20																		XXXX
2200	RUN 58	100 (15)	.18	I	2M	2M			45															XXXX			
				I	2M	2M			50																		XXXX
				I	2M	2M			70																		XXXX
				I	2M	2M			40																		XXXX
2250	RUN 59	100 (11)	.10	I	2M	2M			70															XXXX	NON-LITHOPHYSEAL ZONE AS ABOVE. VAPOR-PHASE ALTERATION LESS PERVASIVE AND ROCK MORE REDDISH BROWN IN COLOR. WHITE VAPOR-PHASE ALTERATION CONFINED TO DIFFUSE VEINLETS AND SPARSE LITHOPHYSEAL CAVITIES. DENSE, VIRTUALLY APHYRIC ROCK. SPARSE FINE-GRAINED GRANITIC PHENOCRYSTS.		
				I	2M	2M			48																		XXXX
				I	2M	2M			40																		XXXX
				I	2M	2M			40																		XXXX

GEOLOGY AND ROCK STRUCTURE LOG

**Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.**

[illegible]

B-16

DEPTH (FT)	CORE		FRACTURES					ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHASES AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-78)	LOST CORE & RIBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND MINERALS	DP	INDUCED	PECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT					
		100 (33)																		
		100 (29)																		
255.0		100 (29)																		
	RUN 67																			
		98 (36)																		
260.0		98 (36)																		
	RUN 68																			
		100 (75)																		
265.0		100 (75)																		
	RUN 69																			
		36 (0)																		
270.0		36 (0)																		
	RUN 70																			
		34 (0)																		
275.0		34 (0)																		

Structure file: MND3RV6.67M Lithology file: MND3RV3.LTR Date: 10/31/94

MLog v 4.60

E-17

GRADATIONAL CONTACT. 265.0-275.0 TRANSITIONAL FROM PRECERRING UNIT WITH FINEST OPEN CAVITIES AND MORE PATCHY VAPOR-PHASE ALTERATION.

268.0-270.0. TIVA CANYON MEMBER, LOWER LITHOMYRAL ZONE, DENSELY WELDED, DEHYDRIFIED ASH-FLOW TUFF. REDDISH-BROWN IN COLOR WITH LIGHT GRAY VAPOR-PHASE ALTERATION AS PATCHES AND LITHOMYRAL CAVITIES.

GEOLOGY AND ROCK STRUCTURE LOG

**Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.**

DEPTH (FT)	CORE	FRACTURES								ROCK QUALITY DESIGNATION-RQD (%)						FRACTURES (PER 10 FT)				HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
		INTERVAL	% RECOVERY (RUN RQD-N)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND DIRECTION	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)						
	RUN 70	54 (U)	X .09 X	I	M	IN		30	45								15%							
280.0	RUN 72	56 (18)	X .09 X	I	L	CH		70	58															
285.0	RUN 73	56 (64)	X .08 X	I	L	IN		5	90				12%				2%							
290.0	RUN 74	86 (51)	X .15 X	I	L	IN		35	68	.68														
295.0	RUN 75	100 (51)	X .15 X	I	L	IN		40	70	.45														
300.0	RUN 75	110	X .08 X	I	L	IN		40	45	.50			50%				2%							

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			BLANKNESS	WEATHERING	ESTIMATED % LITHOMASS AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	INTERVAL	% RECOVERY (MIN ROD-14)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	FORCE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	RUN 76			I	2H				50																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					</

Structure file: NRG3R0.UTM Lithology file: NRG3R03.UTM Date: 10/11/94

WPlot v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMASS LOSS DUE TO FRACTURING AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (% DEDUCED)			10	20	30	40		
	RUN 81																								
330.0	21.10																								

Structure file: H003RVS.STR Lithology file: H003RVS.LTH Date: 10/11/94

TOTAL CORE DEPTH = 330.00

MPlog v 4.60

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

CORE HOLE ROCK STRUCTURAL DATA SUMMARY Hole UE25 NRG-3

Sandia National Laboratories
Print Date: 10/13/94
WBS 1.2.3.2.6.2
QA: QA
Revision 1

REVISION HISTORY

Revision 1 Method for calculating percent lithophysae and other cavities revised. Used USGS nomenclature for stratigraphy and thermomechanical units.

CODING EXPLANATION

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member	C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal

THERMOMECHANICAL UNITS

TCw—Tiva Canyon Welded Unit

COLUMN INFORMATION (Page 3)

RQD (%)
$$RQD (\%) = \frac{\sum \text{Piece lengths } \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

CORE RQD Core RQD based on piece lengths defined by all types of fractures (C, I, N and V).

ENHANCED RQD Effect of fractures identified as coring induced (Type C) are filtered from the piece lengths.

LITHOPHYSAL (and other cavities) Percent void due to lithophysae and other cavities, estimated visually by counting the number of cavities, estimating the average diameter, calculating the void volume assuming spherical cavities, and normalizing to the core volume.
NM—Not Measured

WEATHERING Subjective evaluation of rock degradation by mechanical/chemical agents:
F: Fresh M: Moderately weathered D: Decomposed
S: Slightly weathered I: Intensely weathered

HARDNESS Subjective evaluation of resistance to breakage:
1: Extremely hard 4: Moderately hard 7: Very soft
2: Very hard 5: Moderately soft 8: Soil-like, cohesive
3: Hard 6: Soft 9: Soil-like, non-cohesive

COLUMN INFORMATION (Page 4)

FEATURE TYPE Following codes indicate origin of feature:
N: Natural—indicated by mineral coating or evidence of weathering, slickensides, lack of fit between sides.
I: Indeterminate—origin questionable, rotated so that coatings possibly removed.
C: Coring induced—fresh, clean, tightly fitting breaks.
V: Vug or large void.

INCLINATION (degrees) Angle between plane normal to core axis and plane of fracture (Type N and I only).

MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only):		
	C: Clean	TD: Brown dendritic	CL: Clay
	WC: White crystalline	TC: Tan crystalline	TN: Tan noncrystalline
	WN: White noncrystalline	CA: Calcite	FE: Iron oxide
	BC: Black crystalline	SI: Silica	BN: Brown noncrystalline
	BD: Black dendritic	MN: Manganese	
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only):		
	C: Clean, no filling	M: Moderately thick (0.1-0.4 inches)	
	S: Very thin, surface sheen	V: Very thick (0.4 - 1.0 inches)	
	T: Thin (up to 0.1 inches)	E: Extremely thick, greater than 1.0 inches	
PLANARITY	Describes the overall shape of the feature (Type N and I only):		
	P: Planar	S: Stepped	
	C: Curved	I: Irregular	
ROUGHNESS	Describes the local relief of the surface (Type N and I only):		
	V: Very rough—stepped, near-normal steps and ridges occur.		
	R: Rough—large angular asperities can be seen.		
	M: Moderately rough—asperities clearly visible, surface has abrasive feel.		
	S: Smooth—no asperities, smooth to the touch.		
	P: Polished—slickensided, extremely smooth and shiny.		

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRG-3

Interval—0-330 ft (0-100.6 m)

BASE OF 10-Ft INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE ROD* %	ENHANCED ROD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	WEATHERING (ft in 10-ft interval)					HARDNESS (ft in 10-ft interval)					
								F	B	M	E	D	ROCK					
10	T.C. C.R. Northh.	TCv	0	8	<1	1.7	3.0	6.9									1.1	5.2
20	T.C. C.R. Northh.	TCw	14	37	<1	0.0	1.5	8.8								7.8	1.9	
30	T.C. C.R. Northh.	TCw	22	45	<1	0.5	1.2											
40	T.C. C.R. Northh.	TCw	23	53	<1	1.3	2.1											
50	T.C. C.R. Northh.	TCv	58	62	<1	0.5	0.1	8.2									3.2	5.0
60	T.C. C.R. Northh.	TCw	59	69	<1	0.0	1.4	4.4									4.4	
70	T.C. C.R. Northh.	TCv	0	0	<1	4.9	3.1											
80	T.C. C.R. Northh.	TCv	0	0	<1	5.9	3.5	4.2									4.2	
90	T.C. C.R. Northh.	TCw	15	23	<1	4.2	2.5	6.6						3.8	2.9			
100	T.C. C.R. Northh.	TCw	20	39	<1	1.3	1.8	4.6						0.9	3.7			
110	T.C. C.P. U. Lth.	TCw	0	4	<1	4.0	4.5	5.6										
120	T.C. C.P. U. Lth.	TCw	2	12	1	3.0	3.6	2.7										
130	T.C. C.P. U. Lth.	TCw	16	41	2	2.4	1.8											
140	T.C. C.P. U. Lth.	TCw	23	56	4	2.0	1.0	8.8							0.8			
150	T.C. C.P. U. Lth.	TCw	50	87	7	0.9	1.0	10.0							0.6	8.2		
160	T.C. C.P. U. Lth.	TCw	19	39	4	0.0	1.1	10.0							6.1	3.9		
170	T.C. C.P. U. Lth.	TCw	4	10	2	8.5	2.4	3.9							2.9			
180	T.C. C.P. U. Lth.	TCw	0	25	2	1.2	1.4	6.1									6.1	
190	T.C. C.P. U. Lth.	TCv	15	50	5	0.7	1.1	10.0									10.0	
200	T.C. C.P. U. Lth.	TCw	24	51	1	0.7	0.8	10.0									10.0	
210	T.C. C.P. M. Northh.	TCw	8	37	1	1.1	1.3	10.0									10.0	
220	T.C. C.P. M. Northh.	TCw	26	46	1	1.3	2.4	10.0						2.9			7.1	
230	T.C. C.P. M. Northh.	TCw	14	48	1	0.4	3.1	10.0						10.0				
240	T.C. C.P. M. Northh.	TCw	0	12	2	3.0	2.5	10.0						10.0				
250	T.C. C.P. M. Northh.	TCw	0	42	<1	1.0	1.8	2.7			4.9			8.8				
260	T.C. C.P. M. Northh.	TCw	26	50	<1	0.0	1.6	1.1			3.0			4.1				
270	T.C. C.P. M. Northh.	TCw	52	58	1	0.1	2.0	10.0						3.9			6.1	
280	T.C. C.P. L. Lth.	TCv	0	19	<1	5.9	1.7	10.0									10.0	
290	T.C. C.P. L. Lth.	TCw	12	39	2	4.5	1.0	10.0									10.0	
300	T.C. C.P. L. Lth.	TCw	50	60	2	0.7	0.8	10.0									10.0	
310	T.C. C.P. L. Lth.	TCw	5	38	1	1.7	2.1	5.0			5.0						10.0	
320	T.C. C.P. L. Lth.	TCw	5	5	2	5.1	2.4	3.8			6.1					6.1	2.9	
330	T.C. C.P. L. Lth.	TCw	4	25	1	5.1	1.1	5.0			3.9					8.9		

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED ROD Determined by fringing the effects of fractures identified as coring induced (Type C) from the piece lengths.

*** Footage in interval may not equal 10 ft because of lost core, rubble, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRG-3

Interval—0-330 ft (0-100.6 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (per interval)	NO. OF FRACTURES W/INCLINATION (degrees)										
			N	I	C	V		10	20	30	40	50	60	70	80	90	C	
10	T.C. C.R. Nonilh.	TCw	6	28	18		10											
20	T.C. C.R. Nonilh.	TCw	1	28	21		20											
30	T.C. C.R. Nonilh.	TCw		20	20		30											
40	T.C. C.R. Nonilh.	TCw	4	10	9		40											
50	T.C. C.R. Nonilh.	TCw		11	10		50											
60	T.C. C.R. Nonilh.	TCw	4	10	13		60											
70	T.C. C.R. Nonilh.	TCw	11	4	9		70											
80	T.C. C.R. Nonilh.	TCw			5		80											
90	T.C. C.R. Nonilh.	TCw	1	4	15		90											
100	T.C. C.R. Nonilh.	TCw	5	18	17		100											
110	T.C. C.P. U. Lith.	TCw		5	12		110											
120	T.C. C.P. U. Lith.	TCw	5	7	16		120											
130	T.C. C.P. U. Lith.	TCw	6	7	13		130											
140	T.C. C.P. U. Lith.	TCw	7	9	19		140											
150	T.C. C.P. U. Lith.	TCw		10	17		150											
160	T.C. C.P. U. Lith.	TCw	2	10	20		160											
170	T.C. C.P. U. Lith.	TCw	4	7	17		170											
180	T.C. C.P. U. Lith.	TCw	15	14	19		180											
190	T.C. C.P. U. Lith.	TCw	18	12	16		190											
200	T.C. C.P. U. Lith.	TCw	14	17	10		200											
210	T.C. C.P. M. Nonilh.	TCw	7	22	14		210											
220	T.C. C.P. M. Nonilh.	TCw	3	15	5		220											
230	T.C. C.P. M. Nonilh.	TCw	8	10	18		230											
240	T.C. C.P. M. Nonilh.	TCw	19	4	10		240											
250	T.C. C.P. M. Nonilh.	TCw	23	4	10		250											
260	T.C. C.P. M. Nonilh.	TCw	14	8	10		260											
270	T.C. C.P. M. Nonilh.	TCw		13	5		270											
280	T.C. C.P. L. Lith.	TCw	2	3	10		280											
290	T.C. C.P. L. Lith.	TCw		14	12		290											
300	T.C. C.P. L. Lith.	TCw	4	12	12		300											
310	T.C. C.P. L. Lith.	TCw	7	19	11		310											
320	T.C. C.P. L. Lith.	TCw		19	8		320											
330	T.C. C.P. L. Lith.	TCw	1	6	18		330											
TOTAL			177	395	430	0												
PERCENT OF OCCURRENCE			18	39	43	0												

NO. OF FRACTURES W/GENERAL INFILLING TYPE													NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE				NO. OF FRACTURES W/ROUGHNESS CODE						
WC	WN	BC	BD	TD	TC	CA	SI	MN	CL	TN	FE	BN	C	S	I	M	V	E	P	C	S	I	V	R	M	S	P		
			12										20	12								27			27				
													30									28			28				
1													19									20			20				
5	1												8	1			3					8			8	1			
													11									11			11				
													20							1		17			18				
7													9				7					14			14				
1													4	1							1	3			4				
	8		1										14	5		4				2	1	19		4	18				
													5									4			4				
3				1									8	3		1						7			9				
4			2										7	8								2	11			13			
			1										8	1								8			7	1			
													10								1	8			8				
1	3												8	3	1							11			10	1			
2	3												6	8								9			9				
15	3		1										10	15	2	2					1	26		4	22				
6	2												21	8	1						2	25		2	20	6			
7													24	1	5	1						24			24				
													29									27			27				
	5												13	8								17			17				
	1		3										14	4								18		2	11	3			
12			8										8	18	1					1		20		1	15	6			
1	2		7										23	3	1					1		24			24	1			
15													7	14	1					1		2	18		3	18	1		
													13									12			12				
	1		1										3	2								5		1	4				
													14								1	12		7	5				
			4										12	4								15		1	13	1			
1													19		1							20		1	19				
													18									19			19				
1													8		1							4			5				
81	28	0	31	1	0	0	0	0	0	0	0	0	420	107	14	8	10	0	5	8	4	487	0	26	401	19	0		
14	5.2	0	5.5	0.2	0	0	0	0	0	0	0	0	75	19	2.5	1.4	1.8	0	1	1.8	0.8	87	0	5.1	81	3.8	0		

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA
Hole UE25 NRG-3**

Sandia National Laboratories
Print Date: 1/16/95
WBS 1.2.3.2.6.2
QA: L
Revision 2

REVISION HISTORY

Revision 2 Method for calculating percent lithophysae and other cavities revised. Changes in stratigraphy; Q-core index and histogram plots removed from presentation.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{*}} \cdot \frac{J_r}{J_a} \cdot \frac{J_w}{SRF^{*}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of J_n and SRF.

where RQD^{**} = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

J_n^{*} = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9.

J_r = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

J_a = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

J_w = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: Cannot be determined from core log data and is generated by Monte-Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean values for thermomechanical units in UE25 NRG-3 are:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
TCw	16.9%	36.2%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$\text{RMR} = \text{C} + \text{RQD-I} + \text{JS} + \text{JC} + \text{JW}$$

where C = Rock Strength Index: Derived from compressive strength estimated by Schmidt Rebound Hardness data for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, excludes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member	C.R. Nonlith.	Crystal-Rich Nonlithophysae
		C.R. U. Lith.	Crystal-Rich Upper Lithophysae
		C.P. U. Lith.	Crystal-Poor Upper Lithophysae
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysae
		C.P. L. Lith.	Crystal-Poor Lower Lithophysae
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain		
	Member		
P.C.	Pah Canyon Member		
T.S.	Topopah Spring		
	Member		

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
TCw—Tiva Canyon Welded Unit
PTn—Upper Paintbrush Nonwelded Unit
TSw1—Topopah Spring Welded Unit—Lithophysae Rich
TSw2—Topopah Spring Welded Unit—Lithophysae Poor
TSw3—Topopah Spring Welded Unit—Vitrophyre
CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole UE25 NRG-3

Interval—0-330 ft (0-100.6 m)

END DEPTH	STRATI-GRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al. (1974)							RMR CLASSIFICATION SYSTEM Bislawski (1979)				
			RQD** (%)	J _n *	J _r	J _a	J _w	SRF*	Q*	C	RQD-I	JS	JC	JW
10	T.C. CR. Nonliq.	TCw	0	4.00	3.00	1.00	1.00	5.00	1.50	7	3	5	28.5	16
20	T.C. CR. Nonliq.	TCw	14	6.00	3.00	1.00	1.00	7.50	0.93	4	2	5	28.5	15
30	T.C. CR. Nonliq.	TCw	22	6.00	3.00	1.00	1.00	5.00	2.20	4	3	8	28.5	16
40	T.C. CR. Nonliq.	TCw	23	8.00	2.89	2.92	1.00	7.50	0.38	4	3	8	22.7	15
50	T.C. CR. Nonliq.	TCw	58	8.00	3.00	1.00	1.00	7.50	2.30	7	13	8	28.5	15
60	T.C. CR. Nonliq.	TCw	53	7.00	2.94	1.00	1.00	5.00	4.48	12	13	8	28.3	16
70	T.C. CR. Nonliq.	TCw	0	9.00	2.51	1.87	1.00	7.50	0.20	12	3	5	23.7	15
80	T.C. CR. Nonliq.	TCw	0	9.00	2.51	1.87	1.00	1.00	1.49	4	2	6	23.7	15
90	T.C. CR. Nonliq.	TCw	15	4.00	2.75	1.00	1.00	7.50	1.38	12	3	5	27.4	15
100	T.C. CR. Nonliq.	TCw	20	9.00	2.86	2.57	1.00	5.00	0.80	12	3	8	21.4	15
110	T.C. CR. U. Lih.	TCw	0	9.00	2.51	1.87	1.00	1.00	1.49	12	3	5	23.7	15
120	T.C. CR. U. Lih.	TCw	2	8.00	2.88	1.42	1.00	5.00	0.68	12	3	6	27.2	15
130	T.C. CP. U. Lih.	TCw	18	9.00	3.00	1.00	1.00	1.00	5.33	12	3	8	28.5	16
140	T.C. CP. U. Lih.	TCw	23	9.00	2.08	1.00	1.00	1.00	7.35	12	3	8	28.3	16
150	T.C. CP. U. Lih.	TCw	50	8.00	2.89	1.00	1.00	1.00	18.08	7	13	8	28.0	15
160	T.C. CP. U. Lih.	TCw	19	5.00	2.81	1.50	1.00	1.00	7.37	12	3	8	25.5	15
170	T.C. CP. U. Lih.	TCw	4	7.00	3.00	1.55	1.00	5.00	0.55	7	2	5	25.4	15
180	T.C. CP. U. Lih.	TCw	0	5.00	2.86	1.55	1.00	1.00	3.82	12	3	5	28.1	15
190	T.C. CP. U. Lih.	TCw	15	7.00	2.74	1.14	1.00	7.50	0.69	12	3	8	27.1	15
200	T.C. CP. U. Lih.	TCw	24	6.00	3.00	1.18	1.00	1.00	10.33	12	3	8	28.0	15
210	T.C. CP. M. Nonliq.	TCw	8	4.00	3.00	1.00	1.00	7.50	1.00	12	3	8	28.5	15
220	T.C. CP. M. Nonliq.	TCw	24	8.00	3.00	1.55	1.00	1.00	5.79	12	3	8	25.3	15
230	T.C. CP. M. Nonliq.	TCw	14	4.00	2.81	1.11	1.00	1.00	8.66	12	3	8	27.6	15
240	T.C. CP. M. Nonliq.	TCw	0	7.00	2.71	1.00	1.00	1.00	3.89	7	3	5	27.7	15
250	T.C. CP. M. Nonliq.	TCw	0	7.00	2.92	1.15	1.00	7.50	0.48	7	3	8	27.3	15
260	T.C. CP. M. Nonliq.	TCw	26	4.00	2.91	1.00	1.00	5.00	3.78	12	6	8	28.0	15
270	T.C. CP. M. Nonliq.	TCw	52	5.00	3.00	1.00	1.00	1.00	31.20	7	13	8	28.5	15
280	T.C. CP. L. Lih.	TCw	0	9.00	2.51	1.87	1.00	1.00	1.49	12	3	5	23.7	15
290	T.C. CP. L. Lih.	TCw	12	6.00	2.92	1.00	1.00	7.50	0.78	12	3	8	28.2	15
300	T.C. CP. L. Lih.	TCw	50	8.00	2.93	1.00	1.00	1.00	18.30	12	13	8	28.4	15
310	T.C. CP. L. Lih.	TCw	5	5.00	3.00	1.00	1.00	1.00	6.00	12	3	8	28.5	15
320	T.C. CP. L. Lih.	TCw	5	9.00	2.51	1.87	1.00	1.00	1.49	12	3	5	23.7	15
330	T.C. CP. L. Lih.	TCw	4	9.00	2.80	1.00	1.00	1.00	3.11	12	3	5	28.5	15

In*, SRF* = Interval values generated by Monte Carlo simulation; to calculate Q*.

RQD** - If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

Barton, N., R. Lick, and J. Lewis, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6: 189-236 (Springer-Verlag, 1974)

Bislawski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 2-41-43 (A. A. Balkema, 1979).

Q

J_n — Joint Set Number

J_r — Joint Roughness Number

J_a — Joint Alteration Number

J_w — Joint Water Reduction Factor

SRF — Stress Reduction Factor

$$Q = (RQD/J_n)(J_r/J_a)(J_w/SRF)$$

RMR

C — Strength Index

RQD-I — RQD Index

JS — Joint Spacing Index

JC — Discontinuity Condition Index

JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

SCHMIDT HAMMER TESTS

Initial Calibration 66.5 66.5 67.0 67.5 68.5 70.0 70.8 71.0 72.0 73.5

Average Calibration Reading: 69.1

Correction Factor: 1.07

Test Date: 8/24/93

Final Calibration 65.0 68.0 69.0 68.0 68.5 68.5 68.5 70.5 70.5 72.0

Anvil Standard Value: 74.0

SMF Staff: R. Henson

T. Warburton

		Hammer Readings (28)																			I. Warburton						
Borehole	Depth Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.		
UE35 NRG-3	18.1 - 18.2	12.0	13.5	13.5	15.0	17.0	17.0	17.5	17.5	18.0	18.5	18.5	19.0	20.0	20.0	20.0	20.5	20.5	20.5	22.0	24.0	18.2	3.002	19.5	3.0		
	28.3 - 28.4	12.0	14.5	15.5	16.0	17.0	18.0	20.0	20.5	21.0	22.0	22.0	22.0	22.5	23.0	23.0	24.0	24.5	24.5	26.0	26.5	20.8	3.978	22.3	4.0		
	38.0 - 38.1	10.0	10.0	10.0	12.0	13.0	14.0	14.0	15.5	16.0	16.5	17.0	17.0	18.0	18.0	18.0	18.0	20.0	20.0	20.5	22.5	16.0	3.656	17.1	3.7		
	48.7 - 48.8	24.0	25.0	26.5	27.0	30.0	32.5	33.0	33.0	33.5	33.5	36.0	36.5	37.0	38.5	39.0	39.0	39.0	39.0	40.0	40.5	34.7	6.254	36.6	5.3		
	90.6 - 90.7	33.0	33.0	34.0	35.0	43.0	44.5	45.0	46.5	46.5	46.5	46.5	47.0	47.5	47.5	50.0	50.0	50.5	51.0	53.0	54.0	45.3	6.488	48.5	8.5		
	141.35 - 141.45	29.5	32.5	33.0	37.0	38.5	38.5	38.5	38.0	40.0	40.0	41.0	41.0	43.0	43.0	44.0	44.0	44.5	46.0	47.0	47.0	40.4	4.791	43.8	4.2		
	152.0 - 154.1	32.0	44.5	44.5	44.5	45.0	45.0	45.0	46.0	46.5	46.5	46.5	46.5	47.0	47.0	47.5	47.5	47.5	48.0	48.5	49.0	45.7	3.504	49.8	1.4		
	172.6 - 172.7	36.0	38.0	39.0	39.5	41.0	41.5	42.0	42.0	42.5	43.0	43.5	43.5	44.0	44.0	44.0	44.0	44.0	44.5	45.5	47.0	42.4	2.657	45.8	2.2		
	185.6 - 185.7	30.5	31.0	33.5	CORE BROKEN																	---	---	---	---		
	195.3 - 195.7	36.5	37.0	41.5	44.0	44.5	49.0	50.0	50.0	51.0	51.0	51.0	51.0	51.5	51.5	52.0	52.0	52.0	52.5	52.5	57.5	48.9	6.409	53.1	4.7		
	211.4 - 211.5	36.5	39.0	39.0	39.0	40.0	40.5	42.0	45.0	45.0	45.0	46.0	46.0	46.5	47.5	48.0	48.0	48.0	49.0	50.0	50.5	44.5	4.222	47.7	4.2		
	221.2 - 221.4	SAMPLE DOES NOT EXIST AS A RECOVERABLE UNIT																									
	221.16 - 222.25	36.0	37.5	41.5	44.0	44.0	44.5	44.5	45.0	45.0	46.0	46.0	46.5	46.5	46.5	48.5	48.5	46.5	47.0	47.0	50.0	50.0	51.0	45.3	3.669	49.0	3.0
	245.2 - 245.3	32.0	33.5	34.0	34.5	34.5	35.0	35.5	36.0	36.0	36.5	36.5	37.0	37.0	37.5	37.5	38.0	38.0	38.0	38.5	38.5	39.0	36.3	1.921	39.2	1.7	
	258.7 - 258.8	43.5	44.0	44.0	44.5	45.0	45.5	45.5	45.5	45.5	46.0	46.0	46.0	46.0	46.5	46.5	46.5	46.5	46.5	46.5	46.5	45.6	0.958	48.9	1.0		
	268.0 - 268.1	38.5	38.5	39.0	39.0	39.0	39.5	40.0	40.0	40.0	40.5	40.5	41.0	41.0	41.5	42.0	42.0	42.0	42.0	42.5	42.5	40.6	1.356	43.4	1.4		
	284.4 - 286.3	42.5	44.0	44.5	44.5	44.5	45.0	45.0	45.0	45.0	45.0	45.0	45.5	45.5	45.5	46.0	46.0	46.0	46.5	46.5	47.0	47.0	45.3	1.081	48.7	0.9	
	286.3 - 286.5	SAMPLE DOES NOT EXIST AS A RECOVERABLE UNIT																									
	291.86 - 291.95	40.0	40.0	40.5	40.5	40.5	43.0	43.0	43.0	43.5	44.0	45.0	45.0	45.5	46.0	46.0	46.0	46.5	47.0	47.5	48.0	45.0	2.721	47.2	2.7		
302.4 - 302.5	45.0	46.0	46.5	47.0	47.0	47.0	47.5	47.5	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.5	48.5	48.5	48.5	49.0	47.7	1.001	51.2	0.8			

Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

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APPENDIX F

UE25 NRG-4

Geology and Rock Structure Log

Core Hole Rock Structural Data Summary

Estimated Rock Mass Quality Indices Based on Core Log Data

Comparison of Downhole Video with Core Data

Schmidt Hammer Tests

Summary of Laboratory Testing Data

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

GEOLOGY AND ROCK STRUCTURE LOG

UE25 NRG-4

Sandia National Laboratories

Print Date: 2/5/94

WBS 1.2.3.2.6.2

QA: QA

Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Revise stratigraphic summary to include USGS nomenclature. Corrected study plan number on cover page.

BOREHOLE ID: UE25 NRG-4
STUDY PLAN NO: 8.3.1.14.2
CORE SIZE: PQ
DRILL DATES: 6/25/93 - 7/21/93 (core)
GROUND ELEV: 4099.48 ft
COORDINATES: N: 767,080.21 ft
 E: 566,819.99 ft

TOTAL DEPTH: 726.0 ft
ANGLE FROM VERT: 0°
AZIMUTH: NA

Field Rock Structure

Logged by:

R. Wilcoxon
M. Pitterlee
J. Moyer
M. Wagner
M. Edwards
R. Henson
R. Myers

Drilling Support Division, Drilling
Support and Sample Management
Department, T&MSS

Relogged by:

Richard Lippoth J. F. T. Agapito & Associates, Inc.

Lithology and Stratigraphy

Logged by:

Caroline Coolidge Sandia National Laboratories

Checked by:

Carl Brechtel J. F. T. Agapito & Associates, Inc.
Eric Martin J. F. T. Agapito & Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION GEOLOGY AND ROCK STRUCTURE

NONWELDED

WELDED

BEDDED TUFF

ASH-FLOW TUFF

FRACTURE TYPE OR FEATURE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition, not a fracture.

LOST CORE AND RUBBLE

LOST CORE

$\times 20 \times$ RUBBLE ZONE
(with average maximum diameter of
rubble pieces to nearest 0.01 ft;
NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

ROUGHNESS

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

INFILLING THICKNESS AND MINERALIZATION

C Clean, no filling.	C Clean	CA Calcite
S Very thin, surface sheen	WC White, crystalline	SI Silica
T Thin (up to 0.1 inches)	WN White, non-crystalline	MN Manganese
M Moderately thick (0.1 - 0.4 inches)	TD Brown dendritic	CL Clay
V Very thick (0.4 - 1.0 inches)	TC Tan crystalline	BC Black crystalline
E Extremely thick, greater than 1.0 inches)	TN Tan, non-crystalline	BD Black dendritic

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If a piece length ≥ 0.33 ft crosses over a 10-ft interval boundary, the portion of the piece length that occurs in the 10-ft interval is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

Reference: Graphical lithologic log of Borehole NRG-4, Thomas Moyer and Jeffrey Geslin, USGS (DTN: GS931108314211.042).

UE25 NRG-4

Stratigraphic and Thermomechanical Units Summary

Stratigraphy

Thermomechanical Units

Date: 11/1/94

Note: Stratigraphic Identifications between 0-375' are based on examination of drilling cuttings.

Unresolved contact showing difference between criteria. Solid line shows contact based on Scott & Bonk¹; dashed line is contact based on USGS².

¹ U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.

² U. S. Geological Survey - Graphical Lithologic Log of Borehole NRG-4, Thomas Moyer and Jeff Geslin, DTN:GS931108314211.042.

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMATRIX AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY				
	INTERVAL	% RECOVERY (RECOVERED)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DISP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)										
375.0	72 (15)																10%	(9)									0.0 - 375.0 FT. ROTARY PERCUSSION
380.0	RUN 1																										ROBIN TAKING CORE (375.0 FT.).
385.0	43 (0)																										381.0-444.0 P&M CANYON MEMBER OF THE PAINT BRUSH TUFF. L&M FLOW TUFF, UNWEATHERED TO PARTIALLY WEATHERED. VITRIFIC WITH TYPICALLY VAPOR-PHASE DEVITRIFIED GROUNDMASS, GRAYISH ORANGE FINE GROUNDMASS WITH LARGE 1-10 CM PUMICE CLASTS.
390.0	RUN 2																										PUMICE NEAR TOP IS LIGHT GRAY ONLY, BULKY SECTION CONTAINS TYPICAL LARGE YELLOWISH ORANGE/BROWN AND SMALLER VERY PALE ORANGE PUMICE CLASTS. OCCASIONAL BLACK GLASS CLASTS ALSO.
395.0																											CORE IS FAIRLY COHESIVE WITH NUMEROUS 1' BLOCKS, MOST BREAKS ARE INDUCED AT 70-80 DEGREES TO CORE AXIS AND UNCOATED. SPARSE HIGH ANGLE FRACTURES (10-40 DEGREES TO CORE AXIS) OCCUR AS MARKED AND MAY BE HEALED OR CONTAIN CONTENTS.

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (ROD %)					FRACTURES (PER 30 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSICAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (CALC ROD-IN)	LOST CORE & NUMBER	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (> INDUCED)	10			30	50	80			
400.0	RUN 3													0%		0 (0)					0%				PAN CANYON MEMBER CONTINUES.
405.0	←	0	(0)											0%		0 (0)					Not Measured				
410.0	RUN 4																								
415.0	←	71	(42)											21%		(3)					0%				
420.0	←																								

Structure file: NRG4V5.STR Lithology file: NRG4V5.LTH Date: 10/23/94

402log v 4.60

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444.9 WINDOWED OR REMOVED SECTION

GEOLOGY AND ROCK STRUCTURE LOG

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by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES		ROCK QUALITY DESIGNATION-RQD (%)		FRACTURES (PER 10 FT)		HARDNESS	WEATHERING	ESTIMATED % LITHOPHASE AND OTHER CAVITIES		LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (KIN RQD-%)	LAST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL THICKNESS AND MINERALS	DP	ROCKED			10	20	30		
450.0	449.0 - 450.0	100 (64)		I	IR	C	64							0%	445.5-450.0 ASH-FLOW TUFF(1). DIFFERENT TEAM RAN CANYON SITE DOES NOT APPEAR SURE. VERY LIGHT PINKISH-GRAY BRADIES TO WHITE ASH-RICH GROUNDMASS WITH INHERENT TO SLIGHTLY DARKER FINE CLASTS. LOWER PORTION CONTAINS DARK, 1-MM GLASS SHARDS, GRAINS AND BIOTITE. (AGT? MGT?)
455.0	454.0 - 455.0	89 (77)					70							0%	NOTE: USGS LOGGING SHOWS THE BASE OF THE 3RD CANYON MEMBER AT 458.0 FT. (USGS DTH: 02931186314711.042)
460.0	459.0 - 460.0													0%	458.5-459.5 TONGUE SPRING MEMBER, UPPER NON-WELDED ZONE. ASH FLOW TUFFS, FINE RICH, NON-WELDED, MOSTLY DEHYDRATED WITH A "WEATHERED" LOOK. [REACTIVITY?] PATCHY/STREAKY COLOR VARIATIONS [BIOTITE?] FROM VERY PALLY ORANGE TO LIGHT BROWN (YES/8) WITH A ZONE OF FINE RICH GROUNDMASS AND TO BRACKISH AND MURKIN.
465.0	464.0 - 465.0						10							0%	NOTE: USGS LOGGING SHOWS SHODD TUFF INTERVAL 458.0 - 458.3 FT. AND 458.1 - 458.3 AS THE CRYSTAL-RICH VITRIC ZONE OF THE TONGUE SPRING MEMBER. (USGS DTH: 02931186314711.042)
470.0	469.0 - 470.0													0%	SEVERAL FINING UPWARD BOUNDARIES OCCUR WITHIN THIS UNIT, PUMICE RICH AT THE BASE ASH RICH AT THE TOP; MAY HAVE THEM CLAY SUPPORTED "REWORKED" LAYER APPROX. 3-4 CM AT TOP.

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE INTERVAL	IN RECOVERY (RUN ROD-4)	LOST CORE & RUBBLE	FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSE AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
				FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	EXP	INDICED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED				
												.75										
												.35										
475.0		53 (30)	X .10	I																		
				I	IR																	
				I	IR																	
				I	IR																	
480.0	RUN 15		X .04	I	IR							1.18										
												1.00										
485.0	RUN 16	52 (25)		I								1.20										
				I	IR																	
				I	IR																	
				I	IR																	
				I	IR																	
490.0	RUN 17	28 (0)		I	IR																	
				I	IR																	
				I	IR																	
495.0			X .10																			

Structure file: MROEVS.STR Lithology file: MROEVS.LTH Date: 10/15/94

MPLeg v 4.60

F-11

GEOLOGY AND ROCK STRUCTURE LOG

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E7-1

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION RQD (%)					FRACTURES (PER 10 FT)			FIRMNESS	WEATHERING	ESTIMATED % LITHOPHYLLITE AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-H)	LOST CORE & NOBLE	FRAC. TYPE	PLANARITY	ROUGHNESS	TOOTH THICKNESS AND MINERALS	DO	ROUTED	PIECE LENGTH	VERY POOR 10	POOR 25	FAIR 40	GOOD 65	EXCELLENT 80	NATURAL AND INDETERMINATE (% INDUCED)	M	20	30	40	50	60	70		
325.0	RUN 22	100 (69)		H	PS			70																	321.2-325.0 TOSOVAN SPRING MEMBER, MCH- LITHOPHYLLITE (BROWNED) RQD. NONLITHOPHYLLITE ARE FROM TUFF, GRANITE BEDDING BROWN GROUNDMASS, MODERATE TO DENSELY WEATHERED, DEHYDRATED, MID. VAPOR-PHASE ALTERATION INCREASING WITH DEPTH. APPROX. 1/2 TOSOVITZ FORMED BY SMALL (1MM) VUGS IN GROUNDMASS AND LARGER CORRODED TUMBLE. NUMEROUS LARGE (5CM-10CM DIA.) FLATTERED GRAY PUMICE OR/AND COGNATE LITHICS DESTROYED LOWER SECTION.
				H	IR			85																	
				H	IR			85																	
				H	IR			85																	
330.0	RUN 23	95 (46)		H	PS			70																	321.2-327.6 LIGHT BROWNISH GRAY (HYDRO) GROUNDMASS, MODERATE VAPOR-PHASE ALTERATION MODERATE BROWN PUMICE CLASTS UP TO 3 CM (AND 1 CM). APPROX. 5% DISCREPANCY PUMICE MOSTLY SAGDING (GRAY VAPOR-PHASE ALTERATION MAY HAVE SMALLER FLATGLOUSE PUMICE). RARE BIOTITE.
				H	IR			85																	
				H	IR			85																	
				H	IR			85																	
335.0	RUN 24	95 (46)		H	PS			70																	327.6-344.0 TALL REDDISH BROWN TO TALL RED, NEAR-MODERATE VAPOR-PHASE ALTERATION. NUMEROUS LARGE (1 CM-10 CM DIA.) GRAY FLATTERED PUMICE AND/OR COGNATE LITHICS. OCCASIONAL WHITE PUMICE AND ACCIDENTAL LITHICS. APPROX. 1% PUMICE SAGDING AND PLAGIOCLASE.
				H	IR			85																	
				H	IR			85																	
				H	IR			85																	
340.0	RUN 25	93 (69)		H	PS			70																	339.0 SUDDEN BUT SUBTLE LITHOLOGY CHANGE AND IN PERVASIVE VAPOR-PHASE ALTERATION, FIRST APPEARANCE OF LARGE FLATTERED GRAY PUMICE CLASTS AND FOR COGNATE LITHICS
				H	IR			85																	
				H	IR			85																	
				H	IR			85																	
345.0	RUN 26	91 (63)		H	PS			70																	344.0-345.0 TALL REDDISH BROWN TO TALL RED, NEAR-MODERATE VAPOR-PHASE ALTERATION. NUMEROUS LARGE (1 CM-10 CM DIA.) GRAY FLATTERED PUMICE AND/OR COGNATE LITHICS. OCCASIONAL WHITE PUMICE AND ACCIDENTAL LITHICS. APPROX. 1% PUMICE SAGDING AND PLAGIOCLASE.
				H	IR			85																	
				H	IR			85																	
				H	IR			85																	

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES PER 10 FT			HARDNESS	WEATHERING	ESTIMATED % LITHOCLASTIC AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (* INDICED)					
550.0	RUN 26		XX .18 XX	N	PH			C	46		1.20						15 (17)			A1 1/4	XXXXXX	TOPOPAH SPRINGS NONLITHOMORPHIC UNIT CONTINUED.
				N	PH			C	72		.75										XXXXXX	
				P					25		.45										XXXXXX	
				N	PH			C	72		.20										XXXXXX	
				F	PH			C	72		1.15										XXXXXX	
			XX .20 XX	I	IR			C	76												XXXXXX	
			XX .13 XX																		XXXXXX	
555.0		16	(10)						76					98			15			A1 1/4	XXXXXX	
	RUN 27																				XXXXXX	
560.0		0	(10)																		XXXXXX	
	RUN 28																				XXXXXX	TOPOPAH SPRINGS NONLITHOMORPHIC UNIT CONTINUED.
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
565.0			(10)																		XXXXXX	TOPOPAH SPRINGS NONLITHOMORPHIC UNIT CONTINUED.
	RUN 29		XX .10 XX	I	IR			C	10 90 75					08			12			A1 1/4	XXXXXX	
			XX .12 XX						20												XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
																					XXXXXX	
570.0																					XXXXXX	

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)					HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
	INTERVAL	% RECOVERY (RUN ROD-IN)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	FILL	THICKNESS AND MINERALS	CLF	REDUCED	FREE LENGTH	ROCK QUALITY					NATURAL AND INTERMEDIATE (+ INDUCED)	10	20	30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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GEOLOGY AND ROCK STRUCTURE LOG

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F-16

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSIC AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	N. RECOVERY (N. RECOVERY)	FRAC. TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND	MATERIAL	EXP.	INDUCED	PRICE	LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT					
625.0	36	2 (0)																			625.0-629.0 ASH FLOW TUFF AS ABOVE BUT WITH SEVER <3% SANIDINES AND WHITE PUMICE) LESS POROUS.
630.0	38	2 (0)																			629.0-640.0 NUMEROUS BROAD FLAT (1.10 UP TO 3 CM LONG) CAVITIES LINED WITH VAPOR-PHASE MINERALS - ALTERED PUMICE INDUCED LITHOPHYSIC?
635.0	39	2 (0)																			ASH FLOW TUFF CONTINUES AS GRAYISH REDDISH BROWN, GRAY PUMICE AND COARSE LITHICS DECREASE IN SIZE AND NUMBER.
640.0	40	2 (0)																			
645.0	41	2 (0)																			

Structure File: NRG005.STR Lithology File: NRG005.LTH Date: 10/13/94

NPlog v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSICAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
	INTERVAL	% RECOVERY (RUN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	ORIF	REDUCED	PECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)						FRACTURES (FRA IN FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (MIN RQD-30)	LOST CORE & RUBBLE	TYPE	PLANARITY	ACQUINNESS	INFILL	THICKNESS AND MINERALS	ROP	INDUCED	PECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)								
	RUN 43																								TUCOPAN SPRINGS UPPER LITHOMYSAL ZONE CONTINUED.
675.0	RUN 44	10																							TUCOPAN SPRINGS UPPER LITHOMYSAL ZONE CONTINUED.
680.0	RUN 45	16																							TUCOPAN SPRINGS UPPER LITHOMYSAL ZONE CONTINUED.
685.0	RUN 46	28																							TUCOPAN SPRINGS UPPER LITHOMYSAL ZONE CONTINUED.
690.0	RUN 47	84																							TUCOPAN SPRINGS UPPER LITHOMYSAL ZONE CONTINUED.
695.0	RUN 48	10																							TUCOPAN SPRINGS UPPER LITHOMYSAL ZONE CONTINUED.

Structure file: NRG4RVS.STR Lithology file: NRG4RVS.LTH Date: 10/17/94

NLog v 4.40

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Structure file: NRQ4RVE.STR Lithology file: NRQ4RVE.LTW Date: 10/13/94

WPlog v 4.60

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICALLY AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUM ROD %)	LOST CORE & RUBBLES	PLANE	PLANARITY	ROUGHNESS	DEPTH	THICKNESS AND	MINERALS	DO	INDUCED	POOR	VERY POOR	POOR	FAIR	GOOD	EXCELLENT			10	20	30	40		
	50	(0)																							
	53			N	N	CS	CS	C	MIN	40	25														
725.0	RON														0%										
730.0																									

Structure file: NRGRYS.STR Lithology file: NRGRYS.LTH Date: 10/13/94

NPlog v 4.44

TOTAL CORED DEPTH = 726.00

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CORE HOLE ROCK STRUCTURAL DATA SUMMARY
Hole UE25 NRG-4

Sandia National Laboratories
 Print Date: 10/13/94
 WBS 1.2.3.2.6.2
 QA: QA
 Revision 1

REVISION HISTORY

Revision 1 Method for calculating percent lithophysae and other cavities revised. Used USGS nomenclature for stratigraphy and thermomechanical units.

CODING EXPLANATION

STRATIGRAPHIC ABBREVIATIONS

P.C.	Pah Canyon Member	Tuff	
B.T.	Bedded Tuff		
T.S.	Topopah Spring Member	C.R. Vitric	Crystal-Rich Vitric
		C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. Lith.	Crystal-Rich Lithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal

THERMOMECHANICAL UNITS

PTn—Upper Paintbrush Nonwelded Unit
 TSwf—Topopah Spring Welded Unit—Lithophysae Rich

COLUMN INFORMATION (Page 3)

RQD (%) $RQD (\%) = \frac{\sum \text{Piece lengths } \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$

CORE RQD Core RQD based on piece lengths defined by all types of fractures (C, I, N and V).

ENHANCED RQD Effect of fractures identified as coring induced (Type C) are filtered from the piece lengths.

LITHOPHYSAL (and other cavities) Percent void due to lithophysae and other cavities, estimated visually by counting the number of cavities, estimating the average diameter, calculating the void volume assuming spherical cavities, and normalizing to the core volume.

NM—Not Measured

WEATHERING Subjective evaluation of rock degradation by mechanical/chemical agents:

F: Fresh	M: Moderately weathered	D: Decomposed
S: Slightly weathered	I: Intensely weathered	

HARDNESS Subjective evaluation of resistance to breakage:

1: Extremely hard	4: Moderately hard	7: Very soft
2: Very hard	5: Moderately soft	8: Soil-like, cohesive
3: Hard	6: Soft	9: Soil-like, non-cohesive

COLUMN INFORMATION (Page 4)

FEATURE TYPE Following codes indicate origin of feature:

N: Natural—indicated by mineral coating or evidence of weathering, slickensides, lack of fit between sides.

I: Indeterminate—origin questionable, rotated so that coatings possibly removed.

C: Coring induced—fresh, clean, tightly fitting breaks.

V: Vug or large void.

INCLINATION (degrees) Angle between plane normal to core axis and plane of fracture (Type N and I only).

MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only):		
	C: Clean	TD: Brown dendritic	CL: Clay
	WC: White crystalline	TC: Tan crystalline	TN: Tan noncrystalline
	WN: White noncrystalline	CA: Calcite	FE: Iron oxide
	BC: Black crystalline	SI: Silica	BN: Brown noncrystalline
	BD: Black dendritic	MN: Manganese	
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only):		
	C: Clean, no filling	M: Moderately thick (0.1-0.4 inches)	
	S: Very thin, surface sheen	V: Very thick (0.4 - 1.0 inches)	
	T: Thin (up to 0.1 inches)	E: Extremely thick, greater than 1.0 inches	
PLANARITY	Describes the overall shape of the feature (Type N and I only):		
	P: Planar	S: Stepped	
	C: Curved	I: Irregular	
ROUGHNESS	Describes the local relief of the surface (Type N and I only):		
	V: Very rough—stepped, near-normal steps and ridges occur.		
	R: Rough—large angular asperities can be seen.		
	M: Moderately rough—asperities clearly visible, surface has abrasive feel.		
	S: Smooth—no asperities, smooth to the touch.		
	P: Polished—slickensided, extremely smooth and shiny.		

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRG-4

Interval—380-720 ft (118.1-219.5 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD** %	ENHANCED RQD*** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	WEATHERING (ft in 10-ft interval)***					HARDNESS (ft in 10-ft interval)***						
								F	S	M	I	D	ROCK						
													1	2	3	4	5	6	7
380	P.C. Tuff	PTa	4	38	0	1.4	1.8	4.2											4.2
400	P.C. Tuff	PTa	0	0	0	10.0													
410	P.C. Tuff	PTa	0	0	MM	10.0													
420	P.C. Tuff	PTa	21	26	0	8.3	1.1	6.1											5.1
430	P.C. Tuff	PTa	84	85	0	0.0	0.5	8.2										5.2	
440	P.C. Tuff	PTa	80	100	0	0.0		10.0									2.4	7.6	
460	P.C. Tuff	PTa	24	80	0	0.5	1.1	10.0								1.0			8.0
480	P.C. Tuff	PTa	88	100	0	0.0		10.0								10.0			
470	S.T.	PTa	56	78	0	0.2	0.7	2.4		7.8						2.4			7.4
490	T.S. C.R. Vario	PTa	30	46	0	4.1	0.7		8.0	2.0							8.0		2.4
490	T.S. C.R. Vario	TSw1	18	44	<1	3.9	1.8	5.5	2.7								5.6	2.7	
500	T.S. C.R. North	TSw1	0	0	<1	4.4	2.6	8.1							6.1				
510	T.S. C.R. North	TSw1	24	24	<1	0.3	1.0	4.3							4.3				
520	T.S. C.R. North	TSw1	12	28	<1	3.4	0.2	5.8							5.8				
530	T.S. C.R. North	TSw1	45	85	<1	0.8		4.3	5.7						10.0				
540	T.S. C.R. North	TSw1	48	85	<1	0.2	0.6		10.0						7.1	2.9			
550	T.S. C.R. North	TSw1	80	90	<1	0.5	0.5		10.0							10.0			
560	T.S. C.R. North	TSw1	8	18	<1	5.8	1.8	4.4								4.4			
570	T.S. C.R. North	TSw1	0	5	<1	5.8	3.4	5.8								5.8			
580	T.S. C.R. North	TSw1	0	0	<1	10.0		1.4								1.4			
590	T.S. C.R. North	TSw1	57	81	<1	0.4	0.8		8.6						8.6				
600	T.S. C.R. North	TSw1	83	90	1	0.0	0.4		10.1						4.2	5.9			
610	T.S. C.R. North	TSw1	74	100	<1	0.0		8.4	2.4							10.0			
620	T.S. C.R. North	TSw1	47	84	<1	0.0	0.4	8.5								1.8	6.8		
630	T.S. C.R. North	TSw1	32	71	<1	0.9	0.1	5.6									5.5		
640	T.S. C.R. North	TSw1	0	44	<1	1.9	0.5	10.0									10.0		
650	T.S. C.R. North	TSw1	0	0	<1	6.3	0.3	9.4		0.6						5.8	4.8		
660	T.S. C.R. North	TSw1	21	73	<1	0.7	0.2		10.0							10.0			
670	T.S. C.R. Lith.	TSw1	28	84	1	3.1	0.2		5.7	4.2						4.3	5.7		
680	T.S. C.R. Lith.	TSw1	0	31	1	4.0	2.1		3.5	4.2						3.5			
690	T.S. C.R. Lith.	TSw1	0	0	<1	7.9	1.9	5.4										5.4	
700	T.S. C.R. Lith.	TSw1	24	53	2	1.8	2.8	10.0										10.0	
710	T.S. C.R. Lith.	TSw1	0	10	1	3.8	4.8	10.0										10.0	
720	T.S. C.P. V. Lith.	TSw1	8	6	4	8.7	2.7	10.0									7.5	2.8	

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

*** Footage in interval may not equal 10 ft because of lost core, rubble, or deterioration during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRG-4

Interval—380-720 ft (118.-219.5 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (per 100 in.)	NO. OF FRACTURES W/INCLINATION (degrees)													
			N	I	C	V		10	20	30	40	50	60	70	80	90	C				
390	P.C. Tuff	PTn		3	44		380														
400	P.C. Tuff	PTn					410														
410	P.C. Tuff	PTn					430														
420	P.C. Tuff	PTn			8		450														
430	P.C. Tuff	PTn		2	18		470														
440	P.C. Tuff	PTn			11		490														
450	P.C. Tuff	PTn	2	3	22		510														
460	P.C. Tuff	PTn			15		530														
470	P.C. Tuff	PTn	5	1	14		550														
480	B.T.	PTn	1	0	10		570														
490	T.S. C.R. Vitr.	PTn	6	7	7		590														
500	T.S. C.R. Vitr.	TSw1	6		2		610														
510	T.S. C.R. Nonvitr.	TSw1	18	2	2		630														
520	T.S. C.R. Nonvitr.	TSw1	17				650														
530	T.S. C.R. Nonvitr.	TSw1	8	4	3		670														
540	T.S. C.R. Nonvitr.	TSw1	10	3	14		690														
550	T.S. C.R. Nonvitr.	TSw1	2	4	11		710														
560	T.S. C.R. Nonvitr.	TSw1	1	3	11																
570	T.S. C.R. Nonvitr.	TSw1		6	9																
580	T.S. C.R. Nonvitr.	TSw1																			
590	T.S. C.R. Nonvitr.	TSw1	4		14																
600	T.S. C.R. Nonvitr.	TSw1	1	7	6																
610	T.S. C.R. Nonvitr.	TSw1	1	1	20																
620	T.S. C.R. Nonvitr.	TSw1		1	28																
630	T.S. C.R. Nonvitr.	TSw1		6	26																
640	T.S. C.R. Nonvitr.	TSw1		6	36																
650	T.S. C.R. Nonvitr.	TSw1	2	1	18																
660	T.S. C.R. Nonvitr.	TSw1		8	31																
670	T.S. C.R. Nonvitr.	TSw1		1	28																
680	T.S. C.R. Lith.	TSw1		1	18																
690	T.S. C.R. Lith.	TSw1			2																
700	T.S. C.R. Lith.	TSw1			26																
710	T.S. C.R. Lith.	TSw1		1	13																
720	T.S. C.R. Lith.	TSw1			7																
TOTAL	T.S. C.P. U. Unh.	TSw1	85	61	468	0															
PERCENT OF OCCURRENCE			19	13	74	0															

NO. OF FRACTURES W/ MINERAL INFILLING TYPE												NO. OF FRACTURES W/ INFILL THICKNESS CODE						NO. OF FRACTURES W/ PLANARITY CODE				NO. OF FRACTURES W/ ROUGHNESS CODE					
C	WN	BC	BD	TD	TC	CA	SE	MN	CL	TN	FE	BN	C	S	T	M	V	E	P	C	S	I	V	R	M	S	P
													3									3		2	1		
													2									2		2			
													6						2			3		5			
										1					1		5		6						6		
													7									6		1	5		
													7		6				9		2	2		2		10	
						4							2	4					4	1					1	4	
						1	1						18		2				15	1		3		4	7	8	
1													14	3					14	1		1		1	3	12	
							1		2				10	2	1				6	1		6		3	4	4	
1							4						9	1	4				3	2		6		3	8	1	1
													6						2	1		2		2	2	1	
							1						3		1				1			3	1	2			1
													6						4		1	1		1		5	
													4						2			2		1	1	2	
													6									6		5			
									1				2						1			1		1		1	
													1													1	
															1						1	7				1	
									2				6	2					2			6			2	6	
									3					1	2				1			2		1		2	
									6				2		4				2	2		4			4	4	
													1									1			1		
													1							1							
																				1					1		
													1														
																						1			1		
													1														
3	2	0	0	0	0	1	11	0	15	1	0	0	124	14	21	0	5	0	74	10	4	71	1	39	55	01	2
8	1.2	0	0	0	0	0.5	5.5	0	8	0.5	0	0	78	8.5	13	0	2	0	47	0.3	2.5	46	0.6	25	35	39	1.3

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA
Hole UE25 NRG-4**

Sandia National Laboratories
Print Date: 2/13/95
WBS 1.2.3.2.6.2
QA:L
Revision 3

REVISION HISTORY

- Revision 2 Change in method for calculating % lithophysae. Minor revisions to stratigraphy; Q-core index and histogram plots removed from presentation.
- Revision 3 Revised SRF parameter using NRG rock testing data for PTn unit.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{*}} \cdot \frac{J_r}{J_a} \cdot \frac{J_w}{SRF^{*}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of J_n and SRF.

where RQD^{**} = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

J_n^{*} = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9.

J_r = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

J_a = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

J_w = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: For nonwelded units, SRF is determined from the ratio of UCS/ σ_1 (UCS = unconfined compressive strength, σ_1 = overburden stress). If unconfined compressive strength data is not available for the 10-ft interval, a compressive strength is generated by Monte Carlo simulation using laboratory test data for the thermomechanical units. For welded tuff units, SRF cannot be determined from core log data and is generated by Monte Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean values for thermomechanical units in USW NRG-7/7A are:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
PTn and TSw1	30.2%	49.3%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$RMR = C + RQD-I + JS + JC + JW$$

where C = Rock Strength Index: Derived from compressive strength estimated by Schmidt Rebound Hardness data for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, excludes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member		
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain Member		
P.C.	Pah Canyon Member	Tuff	
T.S.	Topopah Spring Member	C.R. Vitric	Crystal-Rich Vitric
		C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. U. Lith.	Crystal-Rich Upper Lithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		Crystal-Poor V. Tran.	Crystal-Poor Vitric Transition
		C.P. Vitric	Crystal-Poor Vitric
		C.P. Vitric MW	Crystal-Poor Vitric Moderately Welded
		C.P. Vitric Basal NW	Crystal-Poor Vitric Basal Nonwelded

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
 TCw—Tiva Canyon Welded Unit
 PTn—Upper Paintbrush Nonwelded Unit
 TSw1—Topopah Spring Welded Unit—Lithophysae Rich
 TSw2—Topopah Spring Welded Unit—Lithophysae Poor
 TSw3—Topopah Spring Welded Unit—Vitrophyre
 CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole UE25 NRG-4

Interval—380-720 ft (115.8-219.5 m)

END DEPTH	STRATIGRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM ¹							RMR CLASSIFICATION SYSTEM ²					
			RQD** (%)	J _a ^a	J _r	J _s	J _w	SRF ^a	Q ^a	C	RQD-I	JS	JC	JW	RMR
380	PC Tuff	PTn	4	6.00	3.00	1.00	1.00	15.00	0.33	1	3	5	28.6	15	52.5
400	PC Tuff	PTn	0	9.00	2.77	1.38	1.00	8.36	0.27	2	3	5	25.4	18	50.4
410	PC Tuff	PTn	0	9.00	2.77	1.38	1.00	0.60	3.74	4	3	5	25.4	15	52.4
420	PC Tuff	PTn	21	9.00	2.77	1.38	1.00	16.00	0.31	1	3	8	25.4	15	52.4
430	PC Tuff	PTn	84	6.00	3.00	1.00	1.00	15.00	2.80	1	17	8	28.6	15	69.5
440	PC Tuff	PTn	90	5.00	4.00	1.00	1.00	15.00	4.80	1	20	10	30.0	15	76.0
450	PC Tuff	PTn	24	5.00	2.60	1.00	1.00	15.00	0.83	1	3	8	24.9	16	61.9
460	PC Tuff	PTn	88	5.00	4.00	1.00	1.00	9.84	7.15	2	17	8	30.0	16	72.0
470	BT	PTn	58	5.00	2.00	6.83	1.00	15.00	0.23	1	13	8	8.1	15	48.1
480	TS CR Verde	PTn	38	5.00	3.00	1.00	1.00	15.00	1.44	1	8	8	28.6	15	60.6
480	TS CR Verde	TSwl	18	4.00	1.50	1.00	1.00	1.00	6.00	2	3	8	21.3	15	49.3
500	TS CR Nonish	TSwl	0	6.00	1.20	1.00	1.00	5.00	0.40	12	3	8	17.3	15	55.3
510	TS CR Nonish	TSwl	34	7.00	1.74	1.00	1.00	1.00	8.44	12	8	8	20.4	15	63.4
520	TS CR Nonish	TSwl	12	7.00	1.31	1.12	1.00	1.00	2.01	7	3	8	18.8	15	51.8
530	TS CR Nonish	TSwl	45	6.00	2.09	1.31	1.00	1.00	14.39	7	8	8	21.4	16	69.4
540	TS CR Nonish	TSwl	49	4.00	2.42	1.15	1.00	5.00	5.14	7	8	8	23.4	15	61.4
550	TS CR Nonish	TSwl	80	6.00	2.20	1.00	1.00	1.00	29.33	7	17	8	23.7	16	70.7
560	TS CR Nonish	TSwl	9	9.00	2.60	1.73	1.00	1.00	1.81	7	3	8	23.7	15	66.7
570	TS CR Nonish	TSwl	0	9.00	2.50	1.73	1.00	7.50	0.21	7	3	5	23.7	16	63.7
580	TS CR Nonish	TSwl	0	9.00	2.50	1.73	1.00	7.50	0.21	7	3	5	23.7	18	53.7
590	TS CR Nonish	TSwl	57	6.00	2.00	1.00	1.00	5.00	3.80	4	13	8	23.3	15	63.3
600	TS CR Nonish	TSwl	83	6.00	3.00	1.00	1.00	1.00	31.13	4	17	8	28.6	15	72.5
610	TS CR Nonish	TSwl	74	4.00	2.00	2.00	1.00	7.50	2.47	4	13	8	18.8	16	68.8
620	TS CR Nonish	TSwl	47	9.00	1.00	1.00	1.00	1.00	5.22	4	8	8	18.0	16	63.0
630	TS CR Nonish	TSwl	37	6.00	3.00	1.25	1.00	5.00	2.22	4	8	8	27.1	15	62.1
640	TS CR Nonish	TSwl	0	9.00	2.00	1.50	1.00	1.00	1.48	7	3	8	22.6	15	55.6
650	TS CR Nonish	TSwl	0	4.00	2.00	3.00	1.00	1.00	1.67	4	3	5	14.7	15	41.7
660	TS CR Nonish	TSwl	21	6.00	2.00	3.00	1.00	1.00	2.33	4	3	8	17.1	15	47.1
670	TS CR Lsh	TSwl	28	9.00	3.00	1.00	1.00	6.00	1.87	2	8	8	28.6	15	61.5
680	TS CR Lsh	TSwl	0	6.00	2.00	1.00	1.00	1.00	3.33	7	3	8	24.0	15	67.0
690	TS CR Lsh	TSwl	0	9.00	2.50	1.73	1.00	1.00	1.61	4	3	5	23.7	15	60.7
700	TS CR Lsh	TSwl	24	4.00	4.00	1.00	1.00	7.50	3.20	4	3	8	30.0	15	60.0
710	TS CR Lsh	TSwl	0	9.00	2.50	1.73	1.00	1.00	1.61	12	3	5	23.7	15	68.7
720	TS C F U Lsh	TSwl	5	9.00	2.50	1.73	1.00	1.00	1.61	4	3	5	23.7	15	60.7

J_a^a, SRF^a = interval values generated by Monte Carlo simulation, to calculate Q^aRQD** (If RQD is less than 10, the value 10 is used in the calculation of Q^a as per Barton et al. (1974))¹ Barton, N., R. Loe, and J. Lund, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6 (1973) (Springer Verlag, 1974)² Bieniawski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 2:41-48 (A. A. Balkema, 1979)

Q

J_a — Joint Set Number

J_r — Joint Roughness Number

J_s — Joint Alteration Number

J_w — Joint Water Reduction Factor

SRF — Stress Reduction Factor

RMR

C — Strength Index

RQD-I — RQD Index

JS — Joint Spacing Index

JC — Discontinuity Condition Index

JW — Groundwater Index

$$Q = (RQD/J_a)(J_r/J_s)(J_w/1+SRF)$$

$$RMR = C + RQD-I + JS + JC + JW$$

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
COMPARISON OF DOWNHOLE VIDEO DATA
WITH CORE DATA
Hole UE25 NRG-4**

Sandia National Laboratories
Print Date: 3/6/95
WBS 1.2.3.2.6.2
QA:L
Revision 0

EXPLANATION OF BOREHOLE WALL CATEGORY

- C1 Excellent, typically symmetrical hole with a smooth surface; no hole enlargement; no to few lithophysae; no pronounced fractures; minor "pluckouts."
- C2 Good, typically symmetrical hole with a smooth surface; hole enlargement small or intermediate but infrequent; no to few fractures; uniform lithophysae can be present.
- C3 Poor — typically a rough surface; hole enlargement is intermediate and frequent, but it is possible for hole to be symmetrical; lithophysae can be prevalent, large, and nonuniformly distributed; fractures are frequent.
- C4 Extremely poor, typically a nonsymmetrical hole having an extremely irregular surface; hole enlargement is large; large lithophysae can be present; fractures are frequent and pronounced.

STRATIGRAPHIC ABBREVIATIONS

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		C.P. Vitric	Crystal-Poor Vitric
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TSw3—Topopah Spring Welded Unit—Vitrophyre
CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Comparison of Downhole Video Data with Core Data

Hole UE25 NRG-4

Interval—380-720 ft (112.8-219.5 m)

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE ROD* %	ENHANCED ROD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	BOREHOLE WALL CATEGORY	DOWN HOLE VIDEO PARAMETERS			
									LITHOPHYSICS			BOREHOLE
									Frequency	Size	Shape	Symmetry
380	P.C. Tuff	PTn	4	39	0	1.4	1.5	C1	N			8
400	P.C. Tuff	PTn	0	0	0	10.0		C1	N			8
410	P.C. Tuff	PTn	0	0	NM	10.0		C1	N			8
420	P.C. Tuff	PTn	21	28	0	6.2	1.1	C1	N			8
430	P.C. Tuff	PTn	84	96	0	0.0	0.8	C1	N			8
440	P.C. Tuff	PTn	80	100	0	0.0		C1	N			8
450	P.C. Tuff	PTn	24	80	0	0.8	1.1	C1	N			8
460	P.C. Tuff	PTn	88	100	0	0.0		C1	N			8
470	B.T.	PTn	68	78	0	0.8	0.7	C1	N			8
480	T.S. C.R. Vitls	PTn	38	48	0	4.1	0.7	C1	N			6
490	T.S. C.R. Vitls	TSw1	18	44	<1	3.9	1.8	C2	N			1
500	T.S. C.R. Nonlth.	TSw1	0	0	<1	4.4	2.8	C2	N			8
510	T.S. C.R. Nonlth.	TSw1	34	74	<1	0.3	1.0	C2	N			6
520	T.S. C.R. Nonlth.	TSw1	12	28	<1	3.4	0.2	C3	N			1
530	T.S. C.R. Nonlth.	TSw1	48	88	<1	0.8		C3	N			1
540	T.S. C.R. Nonlth.	TSw1	49	88	<1	0.2	0.8	C1	N			6
550	T.S. C.R. Nonlth.	TSw1	60	90	<1	0.8	0.8	C2	N			8
560	T.S. C.R. Nonlth.	TSw1	9	18	<1	5.8	1.8	C3	N			1
570	T.S. C.R. Nonlth.	TSw1	0	8	<1	8.2	3.4	C3	N			1
580	T.S. C.R. Nonlth.	TSw1	0	0	<1	10.0		C2	N			8
590	T.S. C.R. Nonlth.	TSw1	67	81	<1	0.4	0.8	C1	N			8
600	T.S. C.R. Nonlth.	TSw1	63	80	1	0.0	0.4	C1	N			8
610	T.S. C.R. Nonlth.	TSw1	74	100	<1	0.0		C1	N			8
620	T.S. C.R. Nonlth.	TSw1	47	84	<1	0.0	0.4	C1	N			8
630	T.S. C.R. Nonlth.	TSw1	37	71	<1	0.8	0.1	C1	N			8
640	T.S. C.R. Nonlth.	TSw1	0	44	<1	1.8	0.8	C1	N			8
650	T.S. C.R. Nonlth.	TSw1	0	0	<1	8.1	0.3	C1	O	S	O	8
660	T.S. C.R. Nonlth.	TSw1	21	78	<1	0.7	0.2	C2	M	M	O	8
670	T.S. C.R. Lith.	TSw1	28	64	1	3.1	0.2	C3	F	S	S	8
680	T.S. C.R. Lith.	TSw1	0	31	1	4.0	2.1	C3	F	S	S	8
690	T.S. C.R. Lith.	TSw1	0	0	<1	7.9	1.8	C3	F	S	S	8
700	T.S. C.R. Lith.	TSw1	24	63	3	1.8	2.8	C2	F	S	S	8
710	T.S. C.R. Lith.	TSw1	0	10	1	3.9	4.8	C3	F	M	O	1
720	T.S. C.P. U. Lith.	TSw1	8	8	4	6.7	2.7	C3	F	M	O	1

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and VI).

** ENHANCED ROD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

DOWNHOLE VIDEO PARAMETERS:

Frequency- No, Rare, Occasional, Moderate, Frequent.

Size- Small, Medium, Large, Cavernous.

Shape- Oblate, Spheroid.

Symmetry- Symmetric, Intermediate, Asymmetric.

Enlargement- No, Small, Intermediate, Large.

Frequency- None, Occasional, Intermediate, Continuous.

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P-35

SCHMIDT HAMMER TESTS																									
Initial Calibration 70.0 70.5 72.0 73.0 73.5 73.5 74.0 74.0 74.5 75.0												Average Calibration Reading: 72.8				Correction Factor: 1.02				Test Date: 8/2/93					
Final Calibration 70.5 71.0 72.5 72.5 73.0 73.0 73.0 73.0 73.5 73.5												Anvil Standard Value: 74.0				SMP Staff: D. Harle D. Merritt									
Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UE25 NRG-4	378.2 - 378.5	<10	NO DETECTABLE READINGS																		---	---	---	---	
	383.1 - 383.4	<10	NO DETECTABLE READINGS																		---	---	---	---	
	415.8 - 416.2	11.0	12.0	15.5	<10	<10	<10	<10	<10	FRACTURED, NO USABLE READINGS											---	---	---	---	
	425.1 - 426.3	<10	SAMPLE CRACKED, NO USABLE READINGS																		---	---	---	---	
	445.3 - 445.6	<10	SAMPLE CRACKED, NO USABLE READINGS																		---	---	---	---	
	456.0 - 456.5	10.0	10.5	13.5	14.0	15.0	16.5	17.5	17.5	18.5	18.5	18.5	21.5	22.0	23.5	24.0	24.0	24.0	25.5	28.5	34.0	19.9	6.017	19.5	6.2
	467.0 - 467.4	10.0	10.0	10.5	11.5	13.0	13.5	13.5	14.0	15.0	15.5	16.0	16.5	17.0	17.0	18.0	18.5	20.5	21.5	22.5	23.0	15.9	3.994	16.1	4.0

Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

SCHEIDT HAMMER TESTS

Initial Calibration: 70.5 71.0 72.5 72.6 73.0 73.0 73.0 73.0 73.5 73.8
 Final Calibration: NO FINAL CALIBRATION TAKEN

Average Calibration Reading: 72.6
 Anvil Standard Value: 74.0

Correction Factor: 1.02

Test Date: 8/2/93
 SMP Staff: D. Merritt
 D. Harle

Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UB25 NRG-4	483.1 - 483.4	25.5	29.5	30.0	31.0	31.5	31.5	33.5	34.0	34.0	34.0	34.5	36.0	36.0	38.5	40.0	42.5	42.5	43.5	43.5	43.5	36.8	5.374	36.6	6.4
	486.1 - 486.3	PIECE CRACKED, NO USABLE READINGS																				---	---	---	---
	504.4 - 504.8	38.5	41.0	43.5	43.5	44.0	45.0	45.5	45.5	48.5	48.5	48.0	50.0	50.0	51.0	52.5	52.5	53.5	54.5	54.5	55.5	48.3	4.840	49.3	4.8
	518.5 - 518.9	42.5	47.5	48.0	48.0	50.0	51.0	51.5	52.5	53.5	54.0	55.0	55.0	55.5	56.5	57.0	57.5	57.5	58.5	58.5	59.5	53.4	4.508	55.1	3.8
	527.0 - 527.4	48.5	48.5	48.0	50.0	50.0	50.0	52.0	52.5	53.5	54.0	56.0	56.5	57.0	57.5	58.0	58.5	58.5	59.0	59.0	59.5	54.0	4.378	55.1	4.4
	535.4 - 535.8	47.5	48.0	48.0	48.5	48.5	50.0	50.0	51.0	51.5	51.5	54.0	54.5	54.5	55.0	55.5	55.5	57.5	58.5	59.0	60.0	52.9	4.004	54.0	4.0

 Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

F-36

SCHMIDT HAMMER TESTS

Initial Calibration 69.5 70.0 72.0 72.0 72.0 72.0 72.0 72.5 72.5 73.0
 Final Calibration 69.0 72.5 72.5 73.0 73.0 73.5 73.5 73.5 74.0 74.0

Average Calibration Reading: 72.3
 Anvil Standard Value: 74.0

Correction Factor: 1.02

Test Date: 8/10/93

SMF Staff: D. Harle

A. Mendenhall

Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UE25 NRG-4	545.0 - 545.4	36.0	40.5	41.5	42.0	42.5	43.0	43.5	44.0	44.0	44.5	45.0	45.0	45.5	45.5	47.0	47.5	48.0	48.5	48.5	49.0	44.7	3.250	46.2	2.6
	550.0 - 550.4	23.5	35.0	40.0	42.0	43.5	44.5	44.5	45.5	46.0	46.0	46.5	46.5	49.0	49.0	49.0	50.5	50.5	51.5	54.0	45.2	6.641	47.4	4.4	
	582.6 - 583.0	29.5	29.5	31.5	36.0	37.0	42.0	43.0	43.5	44.0	44.5	45.0	45.0	45.5	46.5	47.0	48.0	50.0	51.0	51.5	52.5	43.1	6.992	44.1	7.0
	591.8 - 592.2	32.0	35.0	35.0	35.5	36.0	36.5	36.5	38.0	39.5	42.0	42.5	44.0	44.5	44.5	46.0	46.0	46.5	47.0	48.0	41.0	5.016	42.0	6.0	
	602.9 - 603.4	37.0	42.0	42.0	43.5	44.0	45.0	46.0	46.5	47.5	48.0	48.0	48.0	48.5	49.0	49.5	50.0	50.0	51.0	51.5	53.5	47.0	3.899	46.7	3.2
	612.6 - 613.0	32.5	43.5	43.5	44.5	44.5	45.5	46.0	46.0	46.0	46.5	47.0	48.0	49.0	49.5	50.0	50.5	51.5	52.0	52.0	53.5	47.1	4.576	49.0	3.1
	620.0 - 620.4	45.0	47.5	47.5	48.0	48.5	48.5	48.5	49.0	49.0	49.5	50.0	50.0	50.0	50.0	51.0	51.5	52.0	54.0	55.0	55.0	50.0	2.562	51.2	2.8
	627.8 - 628.2	32.5	39.5	40.0	40.0	41.0	42.5	43.5	44.0	44.0	44.5	45.5	46.0	47.0	47.0	48.0	48.5	50.5	51.5	52.5	54.0	45.1	5.147	46.8	4.3
	654.5 - 654.8	38.0	40.0	41.0	41.0	42.5	42.5	42.5	43.5	43.5	44.0	44.0	45.0	46.0	46.5	46.5	46.5	46.5	46.5	46.5	46.5	43.9	2.472	45.2	2.1
	666.3 - 666.7	21.5	25.5	27.5	31.5	34.0	34.5	35.0	39.5	43.5	46.5	47.0	48.0	48.5	48.5	48.5	49.0	49.5	50.0	50.0	51.0	41.5	9.478	42.4	9.5
	692.0 - 692.3	37.5	38.5	39.0	39.5	41.5	43.5	43.5	44.0	47.5	47.5	47.5	49.0	49.5	50.0	50.0	50.0	52.0	53.0	53.5	54.0	46.5	5.293	47.6	5.3

Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

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Summary of Laboratory Testing Data for Hole UE25 NRG-4—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
115.25	378.1-A	Bedded Tuffs	Upper Palatubrush Nonwelded Unit PTn									2.44
116.71	382.9-A	Pah Canyon			50.1						0.10	
116.71	382.9-B											2.27
126.98	416.6-A			4.9	53.1	1.9	0.28	1.18				
126.98	416.6-B											2.35
128.72	422.3-A			1.8	54.1	0.7	0.53	1.07				
128.72	422.3-C											2.32
130.58	428.4-A			3.5	52.7	1.2	0.18	1.11				
130.58	428.4-B				55.2			1.18			0.20	
130.58	428.4-C											2.35
132.04	433.2-A			3.3	50.0	0.8	0.36					
132.04	433.2-B				51.0						0.20	
132.04	433.2-C											2.36
133.93	439.4-B				54.0						0.20	
133.93	439.4-C											2.36
137.53	451.2-A											2.41
138.99	456.0-A			9.4	42.6	2.1	0.09	1.39				
138.99	456.0-B				45.4						0.70	
138.99	456.0-C											2.42
139.81	458.7-A	Bedded Tuffs		5.2	39.8	0.8	0.15	1.49				
139.81	458.7-B				37.0						0.80	
141.15	463.1-A											2.65
142.28	466.8-A			6.4	39.0	1.7	0.14	1.49				
142.28	466.8-B											2.43
142.95	469.0-A	Topopah Spring Crystal-Rich Vitric Zone	Topopah Spring Welded Unit Lithophysal Rich TSwI	2.0	49.4	0.2	0.19	1.28				
142.95	469.0-B				46.1						0.10	
142.95	469.0-C											2.53
145.54	477.5-D											2.44
147.22	483.0-A											2.40
149.17	489.4-A	Topopah Spring Crystal-Rich Nonlithophysal Zone			6.8						7.70	
149.17	489.4-B											2.58
153.77	504.5-A				14.2						9.00	
153.77	504.5-B				13.4						9.30	
153.77	504.5-C											2.57
154.96	508.4-A			102.6	11.7	32.3	0.22	2.27				
154.96	508.4-B											2.57
157.13	515.5-A			98.5	11.7	31.6	0.22	2.26				
157.13	515.5-B				12.8						6.70	

Summary of Laboratory Testing Data for Hole UE25 NRG-4—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
157.13	515.5-C	Topopah Spring Crystal-Rich Nonlithophysal Zone (continued)	Topopah Spring Welded Unit Lithophysal Rich TSw1 (continued)									2.56
160.02	525.0-A			97.9	15.2	27.3	0.21					
160.02	525.0-B				14.9						8.60	
160.02	525.0-C											2.54
160.63	527.0-A				17.8			2.08	5.00	76.50		
160.63	527.0-B				16.5			2.11	5.00	108.90		
160.63	527.0-D				16.8			2.10	5.00	113.60		
160.63	527.0-E				17.8			2.08	5.00	90.00		
160.63	527.0-G				19.2			2.04	5.00	67.50		
160.63	527.0-C				15.2			2.14	10.00	160.80		
160.63	527.0-F				16.1			2.12	10.00	142.10		
160.63	527.0-H				16.1			2.12	10.00	131.40		
160.63	527.0-I				16.4			2.11	10.00	133.00		
160.63	527.0-J											2.53
161.67	530.4-A			67.1	18.0	21.6	0.20					
161.67	530.4-B				16.8						8.20	
161.67	530.4-C											2.54
163.16	535.3-A			55.4	18.5	22.3	0.22					
163.16	535.3-B				18.2						7.50	
163.16	535.3-C											2.54
164.90	541.0-A			33.2	22.1	14.6	0.34					
164.90	541.0-B				22.8						2.80	
164.90	541.0-C											2.59
166.42	546.0-A			56.8	18.6	19.2	0.26					
166.42	546.0-B				19.0						4.80	
166.42	546.0-C											2.59
167.64	550.0-A			61.9	18.5	20.8	0.22					
167.64	550.0-B				19.6						5.80	
167.64	550.0-C											2.60
177.52	582.4-A			26.2	16.7	13.2	0.28					
177.52	582.4-B											2.58
179.04	587.4-A				17.7						3.00	
179.04	587.4-B				16.7						4.20	
179.04	587.4-C											2.59
180.35	591.7-A			31.8	18.1	9.2	0.26					
180.35	591.7-B				19.6						2.30	
180.35	591.7-C											2.58
181.97	597.0-A			33.3	17.2	15.6	0.29				2.70	

Summary of Laboratory Testing Data for Hole UE25 NRG-4—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)	
(m)	(ft)								Confined Pressure	Axial Stress			
181.97	597.0-B	Topopah Spring Crystal-Rich Nonlithophysal Zone (continued)	Topopah Spring Welded Unit Lithophysal Rich TSw1 (continued)		16.6								
181.97	597.0-C											2.58	
183.77	602.9-A				34.1	16.3	13.6	0.27					
183.77	602.9-B					15.6						3.40	
183.77	602.9-C												2.57
185.14	607.4-A					17.9							
185.20	607.6-A				43.7		11.4	0.27					
185.20	607.6-B					18.1						2.80	
185.20	607.6-C												2.57
186.69	612.5-A				47.9	16.0	17.2	0.32					
186.69	612.5-B					15.1						4.30	
186.69	612.5-C												2.57
188.19	617.4-A					15.2						3.60	
188.19	617.4-B					14.9						4.00	
188.19	617.4-C					13.4						3.60	
188.19	617.4-D												2.57
190.14	623.8-A				43.4	14.3	14.9	0.27					
190.14	623.8-B												2.57
191.33	627.7-A				32.0	13.9	11.2	0.20					
191.33	627.7-B												2.55
199.89	655.8-A				31.1	14.7	14.5	0.41					
199.89	655.8-B												2.56
202.51	664.4-A	Topopah Spring Crystal-Poor Upper Lithophysal Zone	26.9	17.2	10.7	0.60							
202.51	664.4-B										2.54		
203.55	667.8-A		17.4	18.7	6.4	0.31							
203.55	667.8-B										2.54		
210.86	691.8-A				20.1						3.70		
210.86	691.8-B				22.2						3.70		
210.86	691.8-C										2.54		
212.08	695.8-A			35.9	21.1	10.3	0.28						
212.08	695.8-B										2.54		

No Tests Conducted

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APPENDIX G

UE25 NRG-5

Geology and Rock Structure Log

Core Hole Rock Structural Data Summary

Estimated Rock Mass Quality Indices Based on Core Log Data

Comparison of Downhole Video with Core Data

Schmidt Hammer Tests

Summary of Laboratory Testing Data

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
GEOLOGY AND ROCK STRUCTURE LOG
Hole UE25 NRG-5

Sandia National Laboratories
Print Date: 2/4/95
WBS 1.2.3.2.6.2
QA: QA
Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Used USGS nomenclature for stratigraphic and thermomechanical unit summary. Corrected study plan number on cover page.

BOREHOLE ID: UE25 NRG-5

STUDY PLAN NO: 8.3.1.14.2

CORE SIZE: HQ

DRILL DATES: 4/20/93 - 6/9/93

GROUND ELEV: 4106.66 ft

COORDINATES: N: 767,889.61 ft
E: 564,769.87 ft

TOTAL DEPTH: 1350.0 ft

ANGLE FROM VERT: 0°

AZIMUTH: NA

Field Rock Structure

Field Log by:

M. Pitterlee

M. Edwards

R. Wilcoxon

D. Hattler

R. Myers

D. Henson

Relogged by:

Richard Lippoth J. F. T. Agapito & Associates, Inc.

Drilling Support Division, Drilling
Support and Sample Management
Department, T&MSS

Lithology and Stratigraphy

Logged by:

Chris Rautman

Sandia National Laboratories

Checked by:

Carl Brechtel

Eric Martin

J. F. T. Agapito & Associates, Inc.

J.F.T. Agapito & Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION GEOLOGY AND ROCK STRUCTURE

NONWELDED

WELDED

BEDDED TUFF

ASH-FLOW TUFF

FRACTURE TYPE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition.

LOST CORE AND RUBBLE

LOST CORE

RUBBLE ZONE

(with average maximum diameter of rubble pieces to nearest 0.01 ft;
NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

ROUGHNESS

INFILLING THICKNESS AND MINERALIZATION

C Clean, no filling.	C Clean	CA Calcite
S Very thin, surface sheen	WC White, crystalline	SI Silica
T Thin (up to 0.1 inches)	WN White, non-crystalline	MN Manganese
M Moderately thick (0.1 - 0.4 inches)	TD Brown dendritic	CL Clay
V Very thick (0.4 - 1.0 inches)	TC Tan crystalline	BC Black crystalline
E Extremely thick, greater than 1.0 inches)	TN Tan, non-crystalline	BD Black dendritic

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE ROD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If a piece length ≥ 0.33 ft crosses over the 10-ft interval boundary, the portion of the piece length that occurs in the 10-ft interval is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

Reference: USGS—Graphical Lithologic Log of Borehole NRG-5, Thomas Moyer and Jeffrey Geslin (DTN: GS931108314211.043).

UE25 NRG-5

Stratigraphic and Thermomechanical Units Summary

Stratigraphy

Thermomechanical Units

Unresolved contact showing difference between criteria. Solid line shows contact based on Scott & Bonk¹, dashed line is contact based on USGS².

Date: 12/9/94

¹ U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.

² U. S. Geological Survey - Graphical lithologic log of Borehole NRG-5, Thomas Moyer and Jeff Geslin, DTN G5931108314211.043.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (FROM 100%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	BOUGNESS	INFILL	THICKNESS AND	MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)				
																		10 20 30		20 25 30 35 40		
685.0																0%		0 (0)		Not Measured		0.2 - 689.7 HOLE DRILLED WITH CH-THE-HOLE
690.0																						DEPTH TAKING CORE AT 689.7 FT
691.0	RUN 1															0%		0 (1)		Not Measured		689.3-803.3 TOPUPAN SPRING, LITHOPHYSEAL UNIT. ASH FLOW TUFF, DENSELY BLENDED, DEHYDRIFIED, 1-1 1/2 FINE SANDS AND 1-2 MM. TUFF COLOR TAN-BROWN WITH EXTENSIVE GREY TO WHITE VAPOR-PHASE ALTERATION. ALTERATION OF LITHOPHYSEAL PRESENT IN PATCHY, HORIZONTAL VAPOR-PHASE ALTERATION 1-2 CM ACROSS WITH MUCH SMALLER CAVITIES WITH DENSE VAPOR-PHASE BLENDED, [CAVITIES MOSTLY FLATTENED APPROX. 90 DEGREES TO CORE AXIS].
700.0	RUN 2																					
705.0																0%		1 (5)		Not Measured		

Structure file: NRGSRV6.STR Lithology file: NRGSRV6.LTH Date: 10/30/94

MRlog v 4.40

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMYCELE AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ BOUNDEDNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND OR DETERMINATE (+ INDUCED)	10	20	30				
	RUN 2													0%	1 (5)					Not Measured		TOPOPAH SPRING LITHOMYCELE UNIT CONTINUED
710.0		28 (0)	.08																			
	RUN 3																					
715.0		75 (9)	.08	1									4%		(10)				3%			
	RUN 4								.60													
		20 (0)	.08																			
720.0																						
	RUN 5																					
725.0													0%		0 (2)					Not Measured		
	RUN 6																					
		37 (0)	.20																			
730.0																						

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD, Q)					FRACTURES (PER 10 FT)			HAZINESS	WEATHERING	ESTIMATED % LITHOPHASE AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (RUN ROD-20)	LOST CORE & RUBBLE	TYPE	PLANARITY	ROUGHNESS	WALL THICKNESS AND SURFACES	DIP	INDUCED	PECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10	20	30			10	20	30		
	735.0 - 740.0	64 (10)																							STRUCTURE: CORE IS MOSTLY RUBBLE, ORIGINAL VIDEO RECORD SHOWS SEVERAL VARIETIES: 1) 0.5-1.0 CM ANG. CLASTS CEMENTED BY CLEAR CRYSTALLINE GCS(?) 2) MIXED 0.5-2.0 CM CRUSHED CLASTS WITH 2-5 CM UNBROKEN CLASTS(?). 3) SHATTERED ZONES THAT MAINTAIN SOME INTEGRITY	
735.0	RUN 8														0%	0 (2)					Not Measured					
740.0																										
745.0	RUN 9														0%	0 (3)					Not Measured				[REDOXIA MAY REPRESENT DRILL, HOLE WASH FAULT ZONE]	
750.0																										
755.0	RUN 10														0%	0 (16)					3%					

Structure file: WMSKVS.07X Lithology file: WMSKVS.07X Date: 10/20/94

WBlog v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSICAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (MIN-RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	SPALL	THICKNESS AND	MINERALS	IMP	INDUCED	ROCK LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT			10	20	30	40		
760.0	30 (10)																0%	15 (15)				3%			TOROAN SPRING LITHOPHYSICAL UNIT CONTINUED.
765.0	RUN 10																0%	1 (3)				Not Measured			
770.0	RUN 12																								
775.0	69 (32)																12%	(7)				1%			LITHOPHYSICAL UNIT - AS ABOVE, MARKED CHANGE IN QUALITY OF CORE AT APPROX. 775 FT. SANDOZA SEEMS TO BE MOSTLY OF SHAFTER TYPE BELOW THIS DEPTH.
780.0	RUN 13																								

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[illegible]

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Structure file: MROSRV6.STR Psychology file: MROSRV6.LTH Date: 10/20/94

WP109 v 4.60

G-13

GEOLOGY AND ROCK STRUCTURE LOG

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G-15

[illegible]

SECRET//NOFORN FILE: NMICRVS-878 L1603099 CALL: DM75876-174 PAGE: 10/10/94

42100 Y 4.60

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NOTE: USSS LOG IDENTIFIER 901.5 FT. AS TOP
OF THE CRYSTAL-POOR LOWER LITHOPHYREAN ZONE.
THE DESCRIPTION OF THIS ZONE IS SIMILAR TO
THE MOTTLED SUBUNIT ABOVE. ± 50 VISIBLE
LITHOPHYREAN, HOWEVER, CORE LOSS AND RUBBLE
ARE ATTRIBUTED TO LITHOPHYREAN.
(DTN: 08931105334211.043)

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMYSEL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	INTERVAL	% RECOVERY (RUN RQD-%)	LOST CORE & NUBBLE	STRUCTURE	TYPE	PLANARITY	SPHERICITY	INTILL THICKNESS AND MINERALS	CD	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED FRACTURES (+ INDUCED)	10						20	30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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Structure file: HDSRV6.BTR Lithology file: HDSRV6.LTH Date: 10/20/94

46log v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

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6-18

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61-19

[illegible]

Structure file: W0615V6.STR Lithology file: W0615V6.LTH Date: 10/20/98

HPLOY v 4.40

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

CORE HOLE ROCK STRUCTURAL DATA SUMMARY Hole UE25 NRG-5

Sandia National Laboratories
Print Date: 10/20/94
WBS 1.2.3.2.6.2
QA: QA
Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Stratigraphy and thermomechanical units revised to USGS nomenclature.

CODING EXPLANATION

STRATIGRAPHIC ABBREVIATIONS

T.S.	Topopah Spring Member	C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal

THERMOMECHANICAL UNITS

TSw1—Topopah Spring Welded Unit—Lithophysae Rich
TSw2—Topopah Spring Welded Unit—Lithophysae Poor

COLUMN INFORMATION (Page 3)

RQD (%) $RQD (\%) = \frac{\sum \text{Piece lengths } \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$

CORE RQD Core RQD based on piece lengths defined by all types of fractures (C, I, N and V).

ENHANCED RQD Effect of fractures identified as coring induced (Type C) are filtered from the piece lengths.

LITHOPHYSAL (and other cavities) Percent void due to lithophysae and other cavities, estimated visually by counting the number of cavities, estimating the average diameter, calculating the void volume assuming spherical cavities, and normalizing to the core volume.
NM—Not Measured

WEATHERING Subjective evaluation of rock degradation by mechanical/chemical agents:
F: Fresh M: Moderately weathered D: Decomposed
S: Slightly weathered I: Intensely weathered

HARDNESS Subjective evaluation of resistance to breakage:
1: Extremely hard 4: Moderately hard 7: Very soft
2: Very hard 5: Moderately soft 8: Soil-like, cohesive
3: Hard 6: Soft 9: Soil-like, non-cohesive

COLUMN INFORMATION (Page 4)

FEATURE TYPE Following codes indicate origin of feature:
N: Natural—indicated by mineral coating or evidence of weathering, slickensides, tack of fit between sides.
I: Indeterminate—origin questionable, rotated so that coatings possibly removed.
C: Coring induced—fresh, clean, tightly fitting breaks.
V: Vug or large void.

INCLINATION (degrees) Angle between plane normal to core axis and plane of fracture (Type N and I only).

MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only):		
	C: Clean	TD: Brown dendritic	CL: Clay
	WC: White crystalline	TC: Tan crystalline	TN: Tan noncrystalline
	WN: White noncrystalline	CA: Calcite	FE: Iron oxide
	BC: Black crystalline	SI: Silica	BN: Brown noncrystalline
	BD: Black dendritic	MN: Manganese	
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only):		
	C: Clean, no filling	M: Moderately thick (0.1-0.4 inches)	
	S: Very thin, surface sheen	V: Very thick (0.4 - 1.0 inches)	
	T: Thin (up to 0.1 inches)	E: Extremely thick, greater than 1.0 inches	
PLANARITY	Describes the overall shape of the feature (Type N and I only):		
	P: Planar	S: Stepped	
	C: Curved	I: Irregular	
ROUGHNESS	Describes the local relief of the surface (Type N and I only):		
	V: Very rough—stepped, near-normal steps and ridges occur.		
	R: Rough—large angular asperities can be seen.		
	M: Moderately rough—asperities clearly visible, surface has abrasive feel.		
	S: Smooth—no asperities, smooth to the touch.		
	P: Polished—slickensided, extremely smooth and shiny.		

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRG-5

Interval—690-990 ft (210.3-301.8 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE ROD** %	ENHANCED ROD*** %	ESTIMATED % CAVITIES	LOST CORE (%)	RUBBLE ZONE	WEATHERING (ft to 10-ft interval)***					HARDNESS (ft to 10-ft interval)					
								F	S	M	L	D	1	2	3	4	5	6
700	T.S. C.P. U. Lth.	T5w1	0	0	NM	9.8	0.1											
710	T.S. C.P. U. Lth.	T5w1	0	0	NM	8.1	1.3		0.2							0.2		
720	T.S. C.P. U. Lth.	T5w1	4	4	2	4.1	4.6		10.0							10.0		
730	T.S. C.P. U. Lth.	T5w1	0	0	NM	8.6	1.5		10.0							10.0		
740	T.S. C.P. U. Lth.	T5w1	0	0	NM	8.2	1.8		3.5							3.5		
750	T.S. C.P. U. Lth.	T5w1	0	0	NM	8.7	1.0											
760	T.S. C.P. U. Lth.	T5w1	0	5	3	4.8	4.7		3.3							3.3		
770	T.S. C.P. U. Lth.	T5w1	0	0	NM	8.2	1.8		10.0							10.0		
780	T.S. C.P. U. Lth.	T5w2	12	11	1	7.8	0.8		10.0							10.0		
790	T.S. C.P. U. Lth.	T5w1	48	70	<1	0.0	0.8		10.0							10.0		
800	T.S. C.P. U. Lth.	T5w1	38	40	<1	2.0	0.8	5.4	4.6						5.4	4.6		
810	T.S. C.P. M. North.	T5w2	22	29	1	0.2	0.8	10.0							10.0			
820	T.S. C.P. M. North.	T5w2	41	69	<1	0.2	0.8	10.0							4.7	5.8		
830	T.S. C.P. M. North.	T5w2	10	44	<1	0.0	0.1	6.8							0.0			
840	T.S. C.P. M. North.	T5w2	15	28	<1	0.0	1.1											
850	T.S. C.P. M. North.	T5w2	46	59	<1	0.4	0.5	8.8							9.8			
860	T.S. C.P. M. North.	T5w2	27	55	<1	0.1	1.5	6.7							0.7			
870	T.S. C.P. M. North.	T5w2	38	77	4	1.4	0.2	8.0								8.0		
880	T.S. C.P. M. North.	T5w2	21	77	1	0.0	0.1	10.0								10.0		
890	T.S. C.P. M. North.	T5w2	33	67	<1	0.2		10.0								8.7	1.3	
900	T.S. C.P. M. North.	T5w2	42	55	<1	0.0	1.5	10.0								1.3	8.7	
910	C.P. L. Lth.	T5w2	0	25	<1	2.1	1.2	5.1								5.1		
920	C.P. L. Lth.	T5w2	5	18	<1	2.7	1.2	5.5	2.9							8.4		
930	C.P. L. Lth.	T5w2	10	18	<1	4.1	2.8	10.0								10.0		
940	C.P. L. Lth.	T5w2	9	20	<1	3.8	1.2	10.0								10.0		
950	C.P. L. Lth.	T5w2	8	9	<1	4.1	1.2	0.8	9.4							10.0		
960	C.P. L. Lth.	T5w2	0	18	<1	2.8	3.9	10.0								10.0		
970	C.P. L. Lth.	T5w2	0	0	<1	6.2	2.1	10.0								1.8	6.4	
980	C.P. L. Lth.	T5w2	0	28	<1	1.1	2.6	10.0								7.7	2.9	
990	C.P. L. Lth.	T5w2	20	23	<1	2.0	1.0	5.5								5.5		

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED ROD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

*** Footage in interval may not equal 10 ft because of lost core, rubble, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole UE25 NRO-5

Interval—690-990 ft (210.3-301.3 m)

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (per 10-FT interval)	NO. OF FRACTURES WITH INCLINATION (degrees)									
			N	I	C	V		10	20	30	40	50	60	70	80	90	C
700	T.S. C.P. U. Lith.	TSw1			1		700										
710	T.S. C.P. U. Lith.	TSw1		1	6		710				1						1
720	T.S. C.P. U. Lith.	TSw1		3	7		720	3									3
730	T.S. C.P. U. Lith.	TSw1			2		730										
740	T.S. C.P. U. Lith.	TSw1			2		740										
750	T.S. C.P. U. Lith.	TSw1			3		750										
760	T.S. C.P. U. Lith.	TSw1		3	13		760										
770	T.S. C.P. U. Lith.	TSw1		1	2		770							2		1	3
780	T.S. C.P. U. Lith.	TSw1	2	1	4		780					1					1
790	T.S. C.P. U. Lith.	TSw1	3	11	14		790	6		2		1	2	1	2		11
800	T.S. C.P. U. Lith.	TSw1	31	3	8		800	4								17	33
810	T.S. C.P. M. Nonlith.	TSw2	68	6	21		810	6	4	1	4	5	5	5	9	36	57
820	T.S. C.P. M. Nonlith.	TSw2	5	12	17		820	5		2	1	2	1	1	1	4	9
830	T.S. C.P. M. Nonlith.	TSw2	33	10	12		830	9	3	10	2	4	7	2	3	3	12
840	T.S. C.P. M. Nonlith.	TSw2	28	2	18		840	6	1	2	2	2	5		8	2	15
850	T.S. C.P. M. Nonlith.	TSw2	21	14	19		850	12	9	5	2	1	2	6	2	2	16
860	T.S. C.P. M. Nonlith.	TSw2	3	14	17		860	5		1	1		3	2	2	3	11
870	T.S. C.P. M. Nonlith.	TSw2	4	1	28		870	2			2					1	2
880	T.S. C.P. M. Nonlith.	TSw2	19		29		880	5	1	4	2	1			1	5	8
890	T.S. C.P. M. Nonlith.	TSw2	20	2	22		890	7	7			1	1	1	2	3	1
900	T.S. C.P. M. Nonlith.	TSw2	18	9	12		900	13	3	2	2	2		1	4	2	4
910	C.P. L. Lith.	TSw2	7	5	25		910	2			1	1	1			7	2
920	C.P. L. Lith.	TSw2	14	5	11		920	5	1			2	7		1	3	17
930	C.P. L. Lith.	TSw2	3	4	4		930	4					1	1		1	7
940	C.P. L. Lith.	TSw2	4	2	18		940	2		1						3	5
950	C.P. L. Lith.	TSw2	13	6	19		950	6	1	3			5			1	19
960	C.P. L. Lith.	TSw2	18	8	6		960	1		1	9	1	1	2	4	5	22
970	C.P. L. Lith.	TSw2	7	2	5		970	5							4		9
980	C.P. L. Lith.	TSw2	10	3	21		980	1	1	1	1	2			1	6	4
990	C.P. L. Lith.	TSw2	10	2	17	2	990	1		1						10	1
TOTAL			360	128	371	2		111	25	38	30	28	44	24	61	131	278
PERCENT OF OCCURRENCE			42	15	48	0.2		23	5.1	7.4	6.1	5.3	9	4.9	13	27	57

NO. OF FRACTURES W/MINERAL INFILLING TYPE													NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE					NO. OF FRACTURES W/ROUGHNESS CODE					
WC	WN	BC	BD	TD	TC	CA	SI	LN	CL	TN	FR	BN	C	S	T	M	V	E	P	C	S	I	L	V	R	M	S	P	
													1									1					1		
													3																
													3									3					3		
													1																
2													1	1		1							2				2		
3													11	2	1					1	2	1	8				11		
17													37		17					1			50		33	17	1		
18			1									1	57	2	16					30	3		61		13	48	5	1	
3			5										9	2	6					5	1	3	5		1	8	8		
28		1	2										12	20	11					23	2	6	11		1	15	22	1	
11			2										15	11	1					24	2		1			17	10		
17			2										18	7	12					11	8		18			20	14		
5			1										11	6						11			5			8	10		
1			2										2	3						2			2			2	2		
9			3					1					8	11	2					10	1		8			18	3		
12	2		8				1						1	20	1					15			7			16	8		
14	4		6										4	22	1					17	3		7		1	21	3		
3		2	5										2	10						5	2		3			7	3		
	2												17	2						2	3	2	7	1	10	2	1		
													7								1		2		2	1			
													6							2	1		1			4			
													19								1	7	5		5	8			
	1		1										22	2						4	2		19	3	15	6			
1													8		1						4		3		1	6			
8	4												6	2	5					5			7		3	2	6		
4	7												2	1	9					1	3		7		7	1	3		
53	22	1	35	0	0	0	1	1	0	0	0	1	278	124	83	1	0	1	159	87	18	230	4	92	243	84	2		
11	4.8	0.2	7.2	0	0	0	0.2	0.2	0	0	0	0.2	57	25	17	0.2	0	0.2	38	8.3	4.1	52	0.9	21	56	22	0.6		

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA
Hole UE25 NRG-5**

Sandia National Laboratories
Print Date: 1/16/95
WBS 1.2.3.2.6.2
QA: L
Revision 2

REVISION HISTORY

Revision 2 Change in method for calculating % lithophysae. Interval RQD at 840 ft changes from 15 to 27%. Stratigraphy and thermomechanical units revised; Q-core index and histogram plots removed from presentation.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{*}} \cdot \frac{J_r}{J_a} \cdot \frac{J_w}{SRF^{*}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of J_n and SRF .

where RQD^{**} = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

J_n^{*} = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9.

J_r = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

J_a = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

J_w = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: Cannot be determined from core log data and is generated by Monte-Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean values for thermomechanical units in USW NRG-7/7A are:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
Tsw1 and Tsw2	14.8%	29.9%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$\text{RMR} = \text{C} + \text{RQD-I} + \text{JS} + \text{JC} + \text{JW}$$

where C = Rock Strength Index: Derived from compressive strength estimated by Schmidt Rebound Hardness data for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, excludes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member		
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain		
	Member		
P.C.	Pah Canyon Member		
T.S.	Topopah Spring	C.R. Vitric	Crystal-Rich Vitric
	Member		
		C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. U. Lith.	Crystal-Rich Upper Lithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		Crystal-Poor V. Tran.	Crystal-Poor Vitric Transition
		C.P. Vitric	Crystal-Poor Vitric
		C.P. Vitric MW	Crystal-Poor Vitric Moderately Welded
		C.P. Vitric Basal NW	Crystal-Poor Vitric Basal Nonwelded

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
 TCw—Tiva Canyon Welded Unit
 PTn—Upper Paintbrush Nonwelded Unit
 TSw1—Topopah Spring Welded Unit—Lithophysae Rich
 TSw2—Topopah Spring Welded Unit—Lithophysae Poor
 TSw3—Topopah Spring Welded Unit—Vitrophyre
 CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole UE25 NRG-5

Interval—690-990 ft (210.3-301.8 m)

END DEPTH	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al. (1974)							RMR CLASSIFICATION SYSTEM Bremerski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
700	TS CP U Lnh	TSw1	0	9.00	2.50	1.73	1.00	7.50	0.21	7	3	5	23.7	15	53.7
710	TS CP U Lnh	TSw1	0	9.00	2.50	1.73	1.00	1.00	1.61	2	3	5	23.7	15	48.7
720	TS CP U Lnh	TSw1	4	9.00	2.50	1.73	1.00	5.00	0.32	7	3	5	23.7	15	53.7
730	TS CP U Lnh	TSw1	0	9.00	2.50	1.73	1.00	1.00	1.61	2	3	5	23.7	15	48.7
740	TS CP U Lnh	TSw1	0	9.00	2.50	1.73	1.00	7.50	0.21	4	3	5	23.7	15	50.7
760	TS CP U Lnh	TSw1	0	9.00	2.50	1.73	1.00	1.00	1.61	7	3	5	23.7	15	53.7
780	TS CP U Lnh	TSw1	0	9.00	2.50	1.73	1.00	1.00	1.61	4	3	5	23.7	15	50.7
770	TS CP U Lnh	TSw1	0	9.00	2.50	1.73	1.00	1.00	1.61	7	3	5	23.7	15	53.7
780	TS CP U Lnh	TSw1	12	9.00	2.50	1.73	1.00	5.00	0.39	4	3	8	23.7	15	53.7
790	TS CP U Lnh	TSw1	45	4.00	2.82	1.00	1.00	5.00	6.34	12	8	8	27.0	15	70.0
800	TS CP U Lnh	TSw1	33	5.00	2.86	1.00	1.00	1.00	19.54	4	8	5	28.3	15	60.3
810	TS CP M Nonlth	TSw2	22	8.00	2.56	1.00	1.00	5.00	1.95	7	3	5	25.7	15	55.7
820	TS CP M Nonlth	TSw2	41	7.00	2.21	1.00	1.00	1.00	12.97	12	8	8	24.4	15	67.4
830	TS CP M Nonlth	TSw2	10	8.00	1.81	1.00	1.00	7.50	0.40	12	3	8	22.3	15	60.3
840	TS CP M Nonlth	TSw2	27	7.00	1.87	1.25	1.00	7.50	0.38	4	3	8	19.1	15	49.1
850	TS CP M Nonlth	TSw2	48	8.00	2.08	1.00	1.00	5.00	2.37	12	8	8	24.0	15	67.0
860	TS CP M Nonlth	TSw2	27	8.00	1.69	1.00	1.00	1.00	7.59	12	8	8	21.4	15	64.4
870	TS CP M Nonlth	TSw2	36	4.00	2.00	1.00	1.00	7.50	2.40	12	8	8	23.3	15	66.3
880	TS CP M Nonlth	TSw2	21	7.00	2.26	1.00	1.00	1.00	6.79	12	3	8	23.1	15	61.1
890	TS CP M Nonlth	TSw2	33	8.00	2.05	1.18	1.00	1.00	7.14	7	8	8	21.0	15	59.0
900	TS CP M Nonlth	TSw2	42	5.00	2.16	1.30	1.00	1.00	14.00	12	8	8	20.7	15	63.7
910	TS C P L Lnh	TSw2	0	7.00	2.00	1.33	1.00	1.00	2.14	7	3	5	21.1	15	61.1
920	TS C P L Lnh	TSw2	5	9.00	2.57	1.21	1.00	1.00	2.38	12	3	8	25.0	15	63.0
930	TS C P L Lnh	TSw2	10	7.00	2.67	1.00	1.00	1.00	3.81	12	3	8	27.0	15	65.0
940	TS C P L Lnh	TSw2	8	6.00	2.25	1.00	1.00	7.50	0.50	12	3	8	22.9	15	60.9
950	TS C P L Lnh	TSw2	8	5.00	2.92	1.00	1.00	1.00	5.85	12	3	5	28.2	15	63.2
960	TS C P L Lnh	TSw2	0	5.00	2.75	1.08	1.00	1.00	5.08	12	3	5	26.2	15	61.2
970	TS C P L Lnh	TSw2	0	9.00	2.10	1.22	1.00	5.00	0.38	12	3	5	23.1	15	58.1
980	TS C P L Lnh	TSw2	6	4.00	2.09	1.82	1.00	1.00	3.24	12	3	8	21.0	15	59.0
990	TS C P L Lnh	TSw2	20	7.00	2.36	2.17	1.00	1.00	3.12	12	3	8	20.0	15	58.0

Jn*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

¹ Barton, N. R. Lee, and J. J. L. "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6:189-236 (Springer Verlag, 1974)² Bremerski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 2:41-48 (A. A. Balkema, 1979)

Q

Jn — Joint Set Number

Jr — Joint Roughness Number

Ja — Joint Alteration Number

Jw — Joint Water Reduction Factor

SRF — Stress Reduction Factor

$$Q = (RQD)(J_n/J_r/J_a/J_w/SRF)$$

RMR

C — Strength Index

RQD-I — RQD Index

JS — Joint Spacing Index

JC — Discontinuity Condition Index

JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
COMPARISON OF DOWNHOLE VIDEO DATA
WITH CORE DATA
Hole UE25 NRG-5**

Sandia National Laboratories
Print Date: 3/6/95
WBS 1.2.3.2.6.2
QA:L
Revision 0

EXPLANATION OF BOREHOLE WALL CATEGORY

- C1 Excellent, typically symmetrical hole with a smooth surface; no hole enlargement; no to few lithophysae; no pronounced fractures; minor "pluckouts."
- C2 Good, typically symmetrical hole with a smooth surface; hole enlargement small or intermediate but infrequent; no to few fractures; uniform lithophysae can be present.
- C3 Poor — typically a rough surface; hole enlargement is intermediate and frequent, but it is possible for hole to be symmetrical; lithophysae can be prevalent, large, and nonuniformly distributed; fractures are frequent.
- C4 Extremely poor, typically a nonsymmetrical hole having an extremely irregular surface; hole enlargement is large; large lithophysae can be present; fractures are frequent and pronounced.

STRATIGRAPHIC ABBREVIATIONS

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		C.R. U. Lith.	Crystal-Rich Upper Lithophysal
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		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		Crystal-Poor V. Tran.	Crystal-Poor Vitric Transition
		C.P. Vitric	Crystal-Poor Vitric
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THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
TCw—Tiva Canyon Welded Unit
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TSw1—Topopah Spring Welded Unit—Lithophysae Rich
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TSw3—Topopah Spring Welded Unit—Vitrophyre
CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Comparison of Downhole Video Data with Core Data

Hole UE25 NRG-5

Interval—690-990 ft

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD* %	ENHANCED RQD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	BOREHOLE WALL CATEGORY	DOWN HOLE VIDEO PARAMS			
									LITHOPHYSAE			BOH
									Frequency	Size	Shape	Symmetry
700	T.S. C.P. U. Uth.	T8w1	0	0	NM	8.9	0.1	C2	N			S
710	T.S. C.P. U. Uth.	T8w1	0	8	NM	8.1	1.8	C1	N			S
720	T.S. C.P. U. Uth.	T8w1	4	4	3	4.1	4.8	C1	N			S
730	T.S. C.P. U. Uth.	T8w1	0	0	NM	8.6	1.5	C2	N			S
740	T.S. C.P. U. Uth.	T8w1	0	0	NM	8.2	1.8	C2	N			S
750	T.S. C.P. U. Uth.	T8w1	0	0	NM	8.7	1.0	C2	N			S
760	T.S. C.P. U. Uth.	T8w1	0	8	3	4.6	4.7	C3	N			S
770	T.S. C.P. U. Uth.	T8w1	0	0	NM	8.3	1.8	C2	N			S
780	T.S. C.P. U. Uth.	T8w1	12	11	1	7.5	0.5	C2	N			S
790	T.S. C.P. U. Uth.	T8w1	46	70	<1	0.0	0.9	C1	N			S
800	T.S. C.P. U. Uth.	T8w1	33	40	<1	2.0	0.9	C1	N			S
810	T.S. C.P. M. Nonlith.	T8w2	22	29	1	0.2	0.5	C1	N			S
820	T.S. C.P. M. Nonlith.	T8w2	41	69	<1	0.2	0.9	C1	N			S
830	T.S. C.P. M. Nonlith.	T8w2	10	44	<1	0.0	0.1	C2	N			S
840	T.S. C.P. M. Nonlith.	T8w2	15	68	<1	0.0	1.1	C2	N			S
850	T.S. C.P. M. Nonlith.	T8w2	45	58	<1	0.4	0.5	C2	N			S
860	T.S. C.P. M. Nonlith.	T8w2	27	55	<1	0.1	1.5	C2	N			S
870	T.S. C.P. M. Nonlith.	T8w2	35	77	4	1.4	0.2	C2	M	L?	O	S
880	T.S. C.P. M. Nonlith.	T8w2	21	77	1	0.0	0.1	C2	O	L?	O	S
890	T.S. C.P. M. Nonlith.	T8w2	33	57	<1	0.2		C1	N			S
900	T.S. C.P. M. Nonlith.	T8w2	42	55	<1	0.0	1.5	C2	R	L	O	S
910	C.P. L. Lith.	T8w2	0	25	<1	3.1	1.2	C3	O	L	O	I
920	C.P. L. Lith.	T8w2	5	16	<1	2.7	1.3	C3	N			I
930	C.P. L. Lith.	T8w2	10	18	<1	4.1	2.2	C3	N			I
940	C.P. L. Lith.	T8w2	9	26	<1	3.9	1.2	C3	N			I
950	C.P. L. Lith.	T8w2	8	8	<1	4.1	1.8	C4	N			A
960	C.P. L. Lith.	T8w2	0	19	<1	3.8	3.9	C4	N			A
970	C.P. L. Lith.	T8w2	0	0	<1	3.3	2.1	C3	M?	L	O	A
980	C.P. L. Lith.	T8w2	8	25	<1	1.1	2.5	C3	M?	L	O	I
990	C.P. L. Lith.	T8w2	20	23	<1	2.0	1.0	C3	M?	L	O	I

* CORE RQD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as casing induced (Type C) from the piece lengths.

DOWNHOLE VIDEO PARAMETERS:

Frequency: No, Rare, Occasional, Moderate, Frequent.

Size: Small, Medium, Large, Cavernous.

Shape: Oblate, Spherical.

Symmetry: Symmetric, Intermediate, Asymmetric.

Enlargement: No, Small, Intermediate, Large.

Frequency: None, Occasional, Intermediate, Continuous.

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G-33

SCHMIDT HAMMER TESTS																									
Initial Calibration		71.0	71.0	71.0	73.0	73.5	74.0	74.0	74.5	74.5	74.5	Average Calibration Reading: 72.6					Correction Factor: 1.02					Test Date: 7/29/93			
Final Calibration		69.0	71.0	71.8	72.0	72.0	72.0	72.5	73.0	73.5	74.0	Anvil Standard Value: 74.0										SMF Staff: L. Linde J. Hanley D. Sanchez			
Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UE25 NRG-5	779.4 - 779.7	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	11.0	12.0	12.6	13.0	13.8	15.0	15.0	16.5	18.0	11.8	2.536	11.7	2.1
	791.3 - 791.6	17.0	19.5	21.0	22.5	25.5	26.0	27.5	29.0	33.5	33.8	SAMPLE CRACKED										--	--	--	--
	789.8 - 800.0	10.0	14.0	14.5	24.0	<10	SAMPLE CRACKED										SAMPLE CRACKED					--	--	--	--
	811.5 - 811.8	15.0	15.5	16.8	17.8	20.0	21.0	22.5	23.5	24.0	29.0	29.5	30.0	31.0	31.5	32.5	SAMPLE CRACKED					--	--	--	--
	822.7 - 823.1	13.0	18.0	24.5	25.5	29.0	SAMPLE FRACTURING										SAMPLE CRACKED					--	--	--	--
	828.1 - 828.4	48.0	47.0	47.0	48.0	48.0	48.5	48.5	48.5	48.5	49.0	49.0	49.0	49.0	49.5	50.0	50.0	50.0	50.0	53.0	48.8	1.450	48.6	1.1	
	837.4 - 837.7	18.0	18.5	21.5	22.0	23.0	24.0	24.5	25.0	25.5	26.0	27.0	27.5	27.5	29.0	30.0	30.0	31.0	31.5	32.0	34.0	28.4	4.336	26.9	4.3

indicates outlying values excluded in calculating the final Schmidt Hardness Value.

C-34

SCHMIDT HAMMER TESTS																									
Initial Calibration		74.0	73.0	74.0	74.0	73.0	74.0	74.0	76.0	74.0	74.0	Average Calibration Reading: 73.3					Correction Factor: 1.01		Test Date: 7/30/93						
Final Calibration		74.0	72.0	72.0	72.0	74.0	74.0	74.0	70.0	72.0	72.0	Anvil Standard Value: 74.0					SMF Staff: L. Linden		J. L. Homme						
Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
UE25 NRG-5	848.4 - 848.7	40.0	42.0	42.0	42.0	44.0	46.0	46.0	46.0	46.0	46.0	46.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	50.0	46.0	2.675	46.8	2.3
	856.7 - 857.0	16.0	32.0	SAMPLE CRACKED																		---	---	---	---
	872.4 - 872.7	32.0	36.0	SAMPLE CRACKED																		---	---	---	---
U.L.-Mid-N L.	890.8 - 891.1	40.0	40.0	42.0	42.0	42.0	42.0	44.0	44.0	44.0	44.0	44.0	46.0	46.0	46.0	46.0	46.0	48.0	48.0	48.0	50.0	44.5	2.666	45.0	2.7
	891.5 - 891.8	44.0	46.0	46.0	46.0	46.0	46.0	46.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	50.0	50.0	50.0	50.0	50.0	47.7	1.750	48.2	1.8
	968.2 - 968.3	38.0	38.0	ABANDON SAMPLE, CORE DIAMETER INCONSISTENT																		---	---	---	---

☐ indicates outlying values excluded in calculating the final Schmidt Hardness Value.

Summary of Laboratory Testing Data for Hole UE25 NRG-5—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
238.05	781.0-B	Topopah Spring Crystal-Poor Upper Lithophysal Zone	Topopah Spring Welded Unit Lithophysal-Rich TSw1									2.53
240.37	788.6-A				19.2			2.04			4.30	
240.37	788.6-C											2.53
240.89	790.3-C											2.54
243.23	798.0-B	Topopah Spring Crystal-Poor Middle Nontolithophysal Zone	Topopah Spring Welded Unit Lithophysal- Poor TSw2									2.55
243.90	800.2-B											2.55
244.67	802.7-B											2.53
245.98	807.0-B											2.54
247.62	812.4-A				9.8							
247.62	812.4-B											2.54
249.24	817.7-A											2.51
249.24	817.7-C				9.4							
250.94	823.3-A				10.4							
250.94	823.3-B											2.55
253.87	832.9-A				11.5			2.25			7.70	
253.87	832.9-B											2.55
255.58	838.5-A											2.55
255.58	838.5-B				9.1							
258.23	847.2-A				9.9			2.29			5.70	
258.23	847.2-B				13.2			2.21				
258.23	847.2-C											2.55
258.90	849.4-A				8.9			2.31				
258.90	849.4-B											2.54
261.25	857.1-A											2.56
261.25	857.1-C				16.4							
262.50	861.2-A				15.2			2.18				
262.50	861.2-B											2.57
264.94	869.2-A				12.6							
264.94	869.2-B											2.56
266.22	873.4-A				15.0			2.18				
266.22	873.4-B											2.57
267.50	877.6-A											2.54
267.50	877.6-B				10.3							
270.42	887.2-A				10.1			2.28			16.80	
270.42	887.2-B				9.9			2.29				

to be continued

Summary of Laboratory Testing Data for Hole UE25 NRG-5—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
270.42	887.2-C	Topopah Spring Crystal-Poor Middle Nonlithophysal Zone (continued)	Topopah Spring Welded Unit Lithophysal- Poor TSw2 (continued)									2.54
270.91	888.8-A				9.3			2.29			15.90	
270.91	888.8-B				9.0			2.29				
270.91	888.8-C											2.52
271.85	891.9-A				9.9			2.28				
271.85	891.9-B				10.5			2.27			12.90	
271.85	891.9-C											2.53
273.26	896.5-A				9.6			2.28				
273.26	896.5-B											2.53
281.91	924.9-A				11.4							
281.91	924.9-B	Topopah Spring Crystal-Poor Lower Lithophysal Zone										2.61
296.36	972.3-A											2.57
296.36	972.3-B				8.7							
297.70	976.7-A											2.58
297.70	976.7-D				13.3							
302.33	991.9-A											2.59
302.33	991.9-B		10.6									

 No Tests Conducted

APPENDIX H

USW NRG-6

Geology and Rock Structure Log

Core Hole Rock Structural Data Summary

Estimated Rock Mass Quality Indices Based on Core Log Data

Comparison of Downhole Video with Core Data

Schmidt Hammer Tests

Summary of Laboratory Testing Data

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

GEOLOGY AND ROCK STRUCTURE LOG

Hole USW NRG-6

Sandia National Laboratories

Print Date: 2/4/95

WBS 1.2.3.2.6.2

QA: QA

Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Corrected study plan number on cover page.

BOREHOLE ID: USW NRG-6

STUDY PLAN NO: 8.3.1.14.2

CORE SIZE: HQ and PQ

DRILL DATES: 11/23/92 - 3/3/93

GROUND ELEV: 4092.20 ft

COORDINATES: N: 766,726.28 ft

E: 564,187.17 ft

TOTAL DEPTH: 1100 ft

ANGLE FROM VERT: 0°

AZIMUTH: NA

Field Rock Structure

Logged by:

C. Scroggins D. Switzer

D. Hattler M. Pitterlee

R. Henson C. Hermes Drilling Support Division, Drilling

J. Kirkwood M. Wagner Support and Sample Management

A. Mendenhall S. Weber Department, T&MSS

M. Edwards R. Meyer

R. Morris

Relogged by:

Richard Lippoth

J.F.T. Agapito & Associates, Inc.

Lithology and Stratigraphy

Logged by:

Chris Rautman Sandia National Laboratories

Checked by:

Carl Brechtel

Eric Martin

J.F.T. Agapito & Associates, Inc.

J.F.T. Agapito & Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION GEOLOGY AND ROCK STRUCTURE

NONWELDED

WELDED

BEDDED TUFF

ASH-FLOW TUFF

FRACTURE TYPE OR FEATURE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition, not a fracture.

LOST CORE AND RUBBLE

LOST CORE

20 RUBBLE ZONE

(with average maximum diameter of rubble pieces to nearest 0.01 ft;

NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

ROUGHNESS

INFILLING THICKNESS AND MINERALIZATION

- C Clean, no filling.
- S Very thin, surface sheen
- T Thin (up to 0.1 inches)
- M Moderately thick (0.1 - 0.4 inches)
- V Very thick (0.4 - 1.0 inches)
- E Extremely thick, greater than 1.0 inches)
- C Clean
- WC White, crystalline
- WN White, non-crystalline
- TD Brown dendritic
- TC Tan crystalline
- TN Tan, non-crystalline
- CA Calcite
- SI Silica
- MN Manganese
- CL Clay
- BC Black crystalline
- BD Black dendritic

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \cdot$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If piece lengths ≥ 0.33 ft cross over 10-ft interval boundaries, the portion of the piece length that occurs in the 10 ft is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

Reference: Table depicting depths to lithologic contacts in core samples from boreholes NRG-2 and NRG-6, Yucca Mountain, Nevada (DTN: GS930308314211.009), David C. Buesch, U.S. Geological Survey, Las Vegas, NV.

UE25 NRG-6

Stratigraphic and Thermomechanical Units Summary

Stratigraphy

Thermomechanical Units

Unresolved contact showing difference between criteria. Solid line shows contact based on Scott & Bonk¹; dashed line is contact based on USGS².

Date: 12/9/94

¹ U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.

² U. S. Geological Survey - Graphical Lithologic Log of Borehole NRG-6, Thomas Moyer and Jeff Geslin, DTN:GS931008314211.045.

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)				WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (MIN ROD-NG)	LOST CODE & NUMBER	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL THICKNESS AND MINERALS	DP	INDICED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (PER 10 FT)	10	20	30				
30.0	29.0 - 30.0	100 (40)	1A-BLY	1	2	THC	30								18% (24)				2	2%	MINERAL	FRACTURES GENERALLY COATED BY YELLOWISH CO ₃ (?) + PHOS DENDRITES. THIS MATERIAL ALSO LINES SOME LARGER LITHOPHYSAL CAVITIES, ESPECIALLY ABOVE 33-35 FEET.
	30.0 - 31.0	100 (40)	1A-BLY	1	2	THC	30								18% (24)				2	2%	MINERAL	
	31.0 - 32.0	100 (40)	1A-BLY	1	2	THC	30								18% (24)				2	2%	MINERAL	
	32.0 - 33.0	100 (40)	1A-BLY	1	2	THC	30								18% (24)				2	2%	MINERAL	
35.0	34.0 - 35.0	100 (87)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	NONLITHOPHYSAL INTERVALS ARE QUITE DISTINCT AND LACK VAPOR-PHASE MINERALIZATION. FRACTURES POOR TO SPARSE--BAKING EVIDENT.
	35.0 - 36.0	100 (87)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	36.0 - 37.0	100 (87)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	37.0 - 38.0	100 (87)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
40.0	38.0 - 39.0	100 (24)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	LITHOPHYSAL 1-2 CM. SQUARE. MOSTLY FILLED BY VAPOR-PHASE MINERALS.
	39.0 - 40.0	100 (24)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	40.0 - 41.0	100 (24)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	41.0 - 42.0	100 (24)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
45.0	42.0 - 43.0	100 (91)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	43.0 - 44.0	100 (91)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	44.0 - 45.0	100 (91)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	45.0 - 46.0	100 (91)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
50.0	46.0 - 47.0	100 (91)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	47.0 - 48.0	100 (91)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	48.0 - 49.0	100 (91)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	
	49.0 - 50.0	100 (91)	1A-BLY	1	2	THC	30		2.10						18% (24)				2	2%	MINERAL	

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMASS AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (BLM RQD-N)	LOST CORE & RUBBLE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DP	RECEIVED	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED	10	20	30			
55.0	RUN 16	1.00																			
		1.00																			
		1.00																			
		1.00																			
		1.00																			
		1.00																			
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		1.00																			
		1.00																			
		1.00																			
60.0	RUN 21	1.00																			
		1.00																			
		1.00																			
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		1.00																			
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		1.00																			
65.0	RUN 21	1.00																			
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		1.00																			
		1.00																			
		1.00																			
		1.00																			
		1.00																			
70.0	RUN 21	1.00																			
		1.00																			
		1.00																			
		1.00																			
		1.00																			
		1.00																			
		1.00																			
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		1.00																			
		1.00																			
75.0	RUN 21	1.00																			
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DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION (RQD) %					FRACTURES (FEET 10 FT)					HARDNESS	WEATHERING	ESTIMATED % LIPOPHILIC AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
	INTERVAL	% RECOVERY (GAIN/LOSS)	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	ADHERENCE	DIP	REDUCED	PEGS LENGTH	NATURAL AND INDUCED (+ INDUCED)					10	20	30	40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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105.0	RUN 37	100 (73)	1	1	DN	2H				30		1.70																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

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H-12

GEOLOGY AND ROCK STRUCTURE LOG

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by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION RQD (%)					FRACTURES (PER 10 FT)					HARDNESS	WEATHERING	ESTIMATED % LITHOMYCELE AND OTHER CAVITIES					LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-N)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND MODERATELY (+ INDICES)	10	20	30	10			20	30	40	50	60		
155.0	RUN 50	94 (44)		1	1M					10																		DISTINCTLY HOMOGENEOUS ASH FLOW WITH ABUNDANT BLACK STREARS AND 5-10 MM PINK PUMICE CLASTS 150 0-150 S			
160.0	RUN 51	96 (101)	.15	1	1M																							WHITE, WELL SORTED PUMICE BED AT BASE OF LOWE.			
165.0	RUN 52	96 (56)		1	1M																							160.0-165.0 "BEDDED TUFF" COARSE REMOVED INTERFACIAL MATERIAL WITH LARGE 5 MM PUMICE AND BLACK GLASS.			
170.0	RUN 53	92 (32)	.18	1	1M																							INDISTINCT, GRADATIONAL CONTACT			
175.0	RUN 54	95 (58)		1	1M																							165.0-175.0 ASH-BLOW TUFF(?) POSSIBLY EQUIVALENT TO YUCCA MOUNTAIN MEMBER(75). PUMICE-RICH BASE, ORANGE, WEATHERED AND REMOVED IN PART.			

Structure File: HRCARU11.DAT Lithology File: HRCARU11.DAT Date: 10/20/94

MPL09 v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)				SOUNDNESS	WEATHERING	ESTIMATED % LITHOMYCE AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD %)	LOST CORE & RUBBLE	FRAC TYPE	PLANARITY	ROUGHNESS	ENTRIL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			10	20	30	40			
180.0	RUN 54	95 (66)		N	3H	2H			15		1.00			50%		15	15							0%	ASH-FLY-ASH TUFF WITH CHARACTERISTIC VERY LARGE YELLOWISH-BROWN FUSION GLASS TO 5 CM. PINK LIGHT BROWN MASS, QUITE VITRIFIC.	
185.0	RUN 55	X 36 X		N	3H	2H			60		1.20						15	15						0%		ZONE APPEARS TO LOSE CHARACTERISTIC PINK COLOR BELOW 206'. BECOMING NEAR PINKISH GREY--STILL ASH-FLY TUFF WITH LARGE BOUNT FUSION GLASS, VITRIFIC WITH GOOD GRAIN STRUCTURES.
190.0	RUN 55	(0)		N	3H	2H			10		1.10						15	15						0%		
195.0	RUN 56	(0)		N	3H	2H			55		1.20						15	15						0%		
200.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
205.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
210.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
215.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
220.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
225.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
230.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
235.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
240.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
245.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
250.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
255.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
260.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
265.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
270.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
275.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
280.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
285.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
290.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
295.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		
300.0	RUN 56	(0)		N	3H	2H			10		1.10						15	15						0%		

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

H-15

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION RQD (%)					FRACTURES (PER 10 FT)			HAZARDNESS	WEATHERING	ESTIMATED % LITHOLOGICALLY AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-74)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROCKINESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PECE LENGTH	VERY POOR 25	POOR 50	FAIR 75	GOOD 90	EXCELLENT	NATURAL AND DETERMINATE (+ INDUCED)			10	20	30	40		
205.0	RUN 58			I	IR											16% (5)						0%		
210.0	RUN 59	96 (148)		I	IR																	0%		
215.0	RUN 60	76 (27)		I	IR					2.30						49% (3)						0%		
220.0	RUN 61	96 (86)		I	IR					1.10												0%		
225.0	RUN 61			I						1.80												0%		
										1.40												0%		
										3.40												0%		
										.40												0%		

Structure file: HNGR613.DAT Lithology file: HNGR613.DAT Date: 10/10/94

WPlot v 4.60

221.8-225.8 "BEDDED TUFF" COARSE GRAINED,
FINE-SIZED, REDDISH MATERIAL. WHITE SILICEOUS
CLASTS IN LIGHT GRAY SANDY GROUNDMASS.
CLASTS OF RED-BROWN TO BLACK AND GLASSY
LITHICS, SOME MAY BE LAVAS (?)

ABRUPT CONTACT.

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)		FRACTURES (PER 10 FT)		WEATHERING	ESTIMATED % LITHOMYCELE AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIFICATION
	INTERVAL	% RECOVERY (BIN MID-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ ROUGHNESS	DEPTH, THICKNESS AND MINERALS	DISP	INDUCED	VERY POOR	POOR	FAIR	GOOD EXCELLENT				
230.0	RUN 62 97 (96)	100 (47)		1	1H		35									239.5-239.8 YONOGAH SPRING MEMBER. UPPER NON- WELDED ZONE. ARE-FLOW TUFF. SCORRELL, PUMICE RICH, HEAVILY WEATHERED AND ALTERED, YELLOWISH TO PINK-AND PE-02. RELATIVELY UNWEATHERED EXCEPT IN "BENTONITE" ZONE AT BASE. SOME PUMICE CLASTS SPALL VITRIC W/SPITE ALTERATION. CLAST SIZE TO 2.5 CM.
235.0	RUN 63 105 (97)				1R		75									239.5-239.8 YONOGAH SPRING MEMBER. UPPER NON- WELDED ZONE. ARE-FLOW TUFF. SCORRELL, PUMICE RICH, HEAVILY WEATHERED AND ALTERED, YELLOWISH TO PINK-AND PE-02. RELATIVELY UNWEATHERED EXCEPT IN "BENTONITE" ZONE AT BASE. SOME PUMICE CLASTS SPALL VITRIC W/SPITE ALTERATION. CLAST SIZE TO 2.5 CM.
240.0	RUN 64 92 (87)				1H											239.5-239.8 YONOGAH SPRING MEMBER. UPPER NON- WELDED ZONE. ARE-FLOW TUFF. SCORRELL, PUMICE RICH, HEAVILY WEATHERED AND ALTERED, YELLOWISH TO PINK-AND PE-02. RELATIVELY UNWEATHERED EXCEPT IN "BENTONITE" ZONE AT BASE. SOME PUMICE CLASTS SPALL VITRIC W/SPITE ALTERATION. CLAST SIZE TO 2.5 CM.
245.0	RUN 64 71 (44)				1H		35									239.5-239.8 YONOGAH SPRING MEMBER. UPPER NON- WELDED ZONE. ARE-FLOW TUFF. SCORRELL, PUMICE RICH, HEAVILY WEATHERED AND ALTERED, YELLOWISH TO PINK-AND PE-02. RELATIVELY UNWEATHERED EXCEPT IN "BENTONITE" ZONE AT BASE. SOME PUMICE CLASTS SPALL VITRIC W/SPITE ALTERATION. CLAST SIZE TO 2.5 CM.
250.0																239.5-239.8 YONOGAH SPRING MEMBER. UPPER NON- WELDED ZONE. ARE-FLOW TUFF. SCORRELL, PUMICE RICH, HEAVILY WEATHERED AND ALTERED, YELLOWISH TO PINK-AND PE-02. RELATIVELY UNWEATHERED EXCEPT IN "BENTONITE" ZONE AT BASE. SOME PUMICE CLASTS SPALL VITRIC W/SPITE ALTERATION. CLAST SIZE TO 2.5 CM.

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H-17

[illegible]

SEARCHED File: HQ66W13.5TA lithology film: WRIGERT6.LTH Date: 10/20/94

WP249 v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

H-18

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H-19

[illegible]

Structure file: HQ08RV13.STR Ideology file: HQ08RV6.LTH Date: 10/20/94

NDL 4 4 60

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.P.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN HQD-N)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	DISCONTINUITY	INFILL	THICKNESS AND MINERALS	TOP	NOVED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10			20	30	40			
330.0	18 RUN			1	TH						1.00															
335.0	24 RUN			1	TH						.40			19%												
340.0	28 RUN			1	TH						.20															
345.0	45 RUN			1	TH						.15			5%												
350.0	53 RUN			1	TH						.45															

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Structure file: MRCR013.STR Pathology file: MRCR016.LTH Date: 10/20/94

MPLog v 4.60

H-21

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOCLASTIC AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
	INTERVAL	% RECOVERY (RUN LOG-6)	LOST CORE & JUMBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PRICE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
				N	3M 2M			30		.95					42	15 (24)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															</

VAPOUR-PHASE ALTERATION THROUGHOUT AFFECTS MOSTLY FINE-GRAINED LITHIC FRAGMENTS; ALSO ALONG FRACTURE PLANES; MOSTLY WHITE, LIGHT GREY "FINE-GRAINED" MATERIAL; ENHANCES POROSITY.

LOCAL VUGS (LEACHED POKERS) CONTAIN 1-5 MM CLEAR BARRER CRYSTALS OF CaCO₃ (?) OR CaSO₄ (?) .

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Scanned file: MUGOV19 STR Lichology file: MUGOV4.LTR Date: 10/20/94

HPLog v 4.60

H-23

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORRE & NUGGLES	FRACTURE TYPE	PLANARITY/ROUGHNESS	ORIENT	THICKNESS AND	MINERALS	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)					
430.0	RUN 92			I	IR	IR	40	75			1.50						1-17			5%	<p>VAPOR-PHASE ALTERATION INCREASING DOWNWARD.</p> <p>439.0-466.0 UPPER LITHOPHYSAL ZONE. AIR-FLOW TUFF, HEAVILY WEARED FOR ELONGATION OF PORE. INTENSELY VAPOR-PHASE ALTERED WITH ABUNDANT LARGE OPEN LITHOPHYSAL CAVITIES, 2-3 CM AND LARGER. CORE BEARS THROUGH CAVITIES. SOME LARGER THAN TO CORE. GROUNDWATER IS GENERALLY PROGRESSIVELY VAPOR-PHASE ALTERED, PRODUCING A GASTLY-WHITE SPONGE-ORIGINATED MASS. UNALTERED AIR-SHOWN TUFF IS EXCEPTIONAL. SPARSE COGNATE(?) LITHIC CLASTS 1-3 CM ARE GENERALLY ELONGATED AND DISTORTED WITH LESS VAPOR-PHASE ALTERATION. (439.0-715.0, IDENTIFIED AS UPPER LITHOPHYSAL ZONE BY USGS, DTH:G831050421211, 089)</p>	
435.0				I	IR	IR	20	20			1.50									4%		
440.0	RUN 93			I	IR	IR	20	20			1.50											
445.0	RUN 94			I	IR	IR	20	20			1.50									10%		
450.0				I	IR	IR	20	20			1.50											

GEOLOGY AND ROCK STRUCTURE LOG

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by J.F.T. Agapito & Assoc., Inc.

[illegible]

STANDARD film: MMS511 STR Lithology film: MMS615E LTK Date: 10/20/94

MP205 v 4.10

H-25

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD %)						FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHASES AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	TYPE	PLANARITY	SPACINGS	INFILL	THICKNESS AND	MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	Fair	GOOD	EXCELLENT	NATURAL AND INDUCED (PER 10 FT)		10	20	30	40			
480.0	480.0 - 485.0	75	(D)							45								2 (4)						0%		
485.0	485.0 - 490.0	100	(D)							75								(10)						0%		
490.0	490.0 - 495.0	100	(D)							75														0%		
495.0	495.0 - 500.0	100	(D)							75														0%		
500.0	500.0 - 505.0	100	(D)							75														0%		

RELATIVELY ABRUPT CONTACT.

491.0-491.0 LITHOPHASEAL ZONE. DENSELY WELOD
TUFF WITH VERY ABUNDANT LITHOPHASEAL, GENERALLY
1-3 CM BUT LOCALLY MUCH LARGER, 5-15 CM.
SMALLER LITHOPHASEAL GENERALLY PARTLY FILLED BY
WHITE, "SPIN-GLASS" VAPOR-PHASE MINERALS.
TOTAL ALTHOUGH MORE OR LESS SPHERICAL. LARGER
CAVITIES TYPICALLY LARGELY FILLED AND MORE
FERROUS IN SHAPE.

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY	LOSS CORE & NOBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	DEPTH	THICKNESS AND MINERALS	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	NATURAL AND PROTERMINATE (+ INDUCED)	M	20	30						
505.0	401 NDR	53	(10)								1.90					31%						10%		XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	TUFF GROUNDMASS IS ONLY PARTLY VAPOR-PHASE ALTERED- NOTED GRAY-BROWN TO RED-BROWN DEVITRIFIED TUFF. ROCK LOCALLY INCLUDES LARGE (3-18 CM) COGNATE(?) LITHICS, SIGNIFIED BY WEEDING AND GENERALLY LESS VAPOR-PHASE ALTERED.
510.0	801 NDR																							XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	
515.0	601 NDR	53	(10)													0%						9%		XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	
520.0	501 NDR	53	(10)																					XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	
525.0	401 NDR	53	(10)																					XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	
																								XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	
																								XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	
																								XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	
																								XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	
																								XXXX XXXX XXXX XXXX XXXX XXXX XXXX XXXX	

Structure file: HNGSRV13.STR Lithology file: HNGSRV6.LTH Date: 10/20/94

HNGSRV v 4.50

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % SANDSTONE AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN IN QD-N)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ TENDENCIES	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (% INDUCED)	10	20	30				
330.0	RUN 111.1	90 (34)							.65				17%		9)					9%	XXXX	
331.0	RUN 112	78 (35)							.90											6%	XXXX	
340.0	RUN 113	58 (74)							1.60											10%	XXXX	
345.0		100 (78)							1.70												XXXX	
350.0									1.10												XXXX	

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

SEFUCRUK File: H006RV13.BTR Lithology File: H006RV4.LTM Date: 10/20/94

HPLog v 4.6M

H-29

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD %)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYLITES AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIFICATION				
	INTERVAL	% RECOVERY (RQD (RQD-64))	LOST CORE & RUBBLE	FRAC. TYPE	PLANARITY/ ROUGHNESS	INFILL THICKNESS AND MINERALS	TOP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)											
580.0																										
585.0																										
590.0																										
595.0																										
600.0																										

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % LITHOPHYSICAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (MIN RQD-%)	LAST CODE & NUMBER	FRACTURE TYPE	PLANARITY	ROUGHNESS	OUTLET	THICKNESS AND MINERALS	DP	INDUCED	PRICE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (* INDUCED)			
605.0	RUN 121	41	(D)	1	1	1H	1H		60	98	.45									
610.0	RUN 122	59	(24)	1	1	1H	1H		70	70	.58									
615.0	RUN 122	59	(24)	1	1	1H	1H		90	90	.45									
620.0	RUN 125	65	(15)	1	1	1H	1H		60	55	.58									
625.0				1	1	1H	1H	ENC	40		.78									

Structure File: MRG6N712.STR Lithology File: MRG6N712.LTH Date: 06/20/94

NPlog v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAS AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	INTERVAL	% RECOVERY (RUN ROD-M)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	QD	INDUCED	PIECE LENGTH					NATURAL AND INDETERMINATE (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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DEEPLY WEARDED TUFF WITH PROMINENT LITHOLOGY AS ABOVE. BELOW 640'-645'. SMALLER LITHOLOGY ARE RARELY OPEN, GENERALLY SPHERICAL TO OVOID PATCHES OF INTENSE WHITE PEARL-SHINE ALTERATION. LARGER CAVITIES SHOW GREATER FILLING, BUT TYPICALLY MAINTAIN SIGNIFICANT VOID SPACE.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITOMORPHIC AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (RUN ROD-S)	LOST CORE & RIBBLE	STRUCTURE	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	SUBSTRATE	TOP	INDUCED	INCL. LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT					
655.0	132	100	(10)			SH							1.15										
660.0	133	100	(42)			SH							1.00										
665.0	134	62	(25)			SH							1.00										
670.0	135	58	(11)			SH							1.00										
675.0						SH							1.00										

A DISTINCTIVE FEATURE IS LOCAL PARTIAL FILLING OF LITOMORPHIC CAVITIES BY A VERY CLEAR, STAINED MINERAL, CDS(?)

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

[illegible]

H-34

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LIQUID, VAPOR AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
	INTERVAL	% RECOVERY (RUN ROD-NO)	LOST CORE & PIECE	FRACTURE TYPE	PLANARITY/ROUGHNESS	DIPL. THICKNESS AND MINERALS	DP	ROUDED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (- INDUCED)	10	20			30	10	20	30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
709.0	RUN 141	95 (131)	1.10	I	IM	STM	45	20	90						5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						</

GENERALLY WELODED TYPE AS ABOVE. VERY SPARGE SMALL FRAMOCYSTS OF VITROUS SIALIDINE. CHALTRIED ROCK IS LIGHT TAN IN COLOR. LOCALLY PERVASIVE BUT NEAR VAPOR-PHASE ALTERATION PRODUCES LIGHT-MEDIUM GRAY ROCK. VARIABLE ALTERATION PRODUCES PATCHY COLOR LOCALLY. LOCALIZED MORE INTENSE VAPOR-PHASE ALTERATION ON FRACTURES PRODUCES VERY THIN WHITE CONTIGUS AND 2-3 MM LIGHTER BELLAGES INTO GROUNDMASS.

[711.0-916.1, IDENTIFIED AS MIDDLE NON-LITHOMYRAL ZONE BY USGS, DTH:G5936108. 114111,809]

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION: RQD (%)					FRACTURES (#/BS. 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & KIBBLE	PLANE	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	IMP	INDUCED	POOR	VERY POOR	GOOD	EXCELLENT	NATURAL AND INDUCED (#/BS. 10 FT)	10	20	30	10	20	30				
730.0	51.1 RUN	98	.11	N	PS	SSC	90							11%												
735.0	51.1 RUN	97	.15	N	PS	SSC	90							5%												
740.0	51.1 RUN	95	.15	N	PS	SSC	90																			
745.0	51.1 RUN	95	.15	N	PS	SSC	90							16%												
750.0	51.1 RUN	95	.15	N	PS	SSC	90																			

ROCK TYPICALLY EXHIBITS POORLY DEFINED SPOTS OF OBSCURE ORIGIN, MAY BE SELECT MINOR CLASTS AND/OR INCIPENT VAPOR-PHASE ALTERATION.

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD, %)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMYCE AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	INTERVAL	% RECOVERY (RUN ROD-N)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PERCENT LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10	20			30	40	50	60			70	80	90	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
755.0	RUN 157	100 (C)			IR		90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
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[illegible]

Structure file: NND6RW13.SFB Lithology file: NND6RW6.LTH Date: 20/20/94

MPLOY 4.60

H-38

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-ROD (R)						FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGIC CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	IN RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND MINERALS	DP	REDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	10	20	30		10	20	30	40			
805.0	168	100 (15)	1.00	1	TH			90											1	Y					XXXXXX	VAPOR-PHASE ALTERATION SEEMS SOMEWHAT MORE ERRATIC AND PATCHY. SPARKS, SMALL (<1 CM) CRACKS PROBABLY ORIGINALLY ALTERED PUMICE CLASTS(?)
				2	TH			50		.45															XXXXXX	
					TH			90																	XXXXXX	
				3	TH			70	40	.80			14%										0%		XXXXXX	
				4	TH			75	90																XXXXXX	
				5	TH		STD	85	90																XXXXXX	
810.0	170	100 (17)	1.00	1	TH		DMC	10		.45															XXXXXX	
				2	TH		DMC	10	75																XXXXXX	
				3	TH			30	75																XXXXXX	
815.0	172	100 (12)	1.00	1	TH			30		.40													0%		XXXXXX	
				2	TH			30																	XXXXXX	
				3	TH			30																	XXXXXX	
820.0	174	100 (10)	1.00	1	TH			30																	XXXXXX	VAPOR-PHASE ALTERATION SEEMS SOMEWHAT MORE ERRATIC AND PATCHY. SPARKS, SMALL (<1 CM) CRACKS PROBABLY ORIGINALLY ALTERED PUMICE CLASTS(?)
				2	TH			30																	XXXXXX	
				3	TH			30																	XXXXXX	
				4	TH			30																	XXXXXX	
				5	TH			30																	XXXXXX	
				6	TH			30																	XXXXXX	
				7	TH			30																	XXXXXX	
				8	TH			30																	XXXXXX	
				9	TH			30																	XXXXXX	
				10	TH			30																	XXXXXX	
825.0	176	100 (15)	1.00	1	TH			30																	XXXXXX	

GEOLOGY AND ROCK STRUCTURE LOG

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Page 54 of 44

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)						FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY		
	INTERVAL	% RECOVERY (MIN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INTELL THICKNESS AND MINERALS	DP	INDUCED	PRICE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10	20						30	
	9-1/2	69	(0)	.15	I	I	IN		80						0%	15					3	4	Not Measured		
830.0	RUN 173			.07			IN		90																
				.04	I		IN		90																
835.0				.17											0%	10									
	RUN 174			.20	H	H	IN	IN	90	50															
					H	H	IN	IN	50	50															
840.0					H		IN		60																
					H		IN	IN	45																
				.20	H		IN	IN	45																
				.07	H		IN	IN	55																
845.0	RUN 175			.13	I	H	IN	IN	90						5%										
					H		IN	IN	90																
				.17	I		IN		80		.60														
850.0					I		IN	IN	90																

INDISTINCT CONTACT.

WPI 09 4 6.60

H-42

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 18 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMINERAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (R/RQD-4)	LOST CORE & RUBBLE	FRACTURE	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	QDP	SAFETY	PIECE LENGTH	VERY POOR 25	POOR 35	FAIR 45	GOOD 55	EXCELLENT 65	NATURAL AND INDISTINGUISHABLE (+ INDUCED)	18	20	30	10	20	30			
905.0	RUN 184																											
910.0		56 (7)																										
915.0	RUN 185																											
920.0		43 (10)																										
925.0	RUN 186																											

GEOLOGY AND ROCK STRUCTURE LOG

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by J.F.T. Agapito & Assoc., Inc.

Page 78 of 81

of J.P.T. Aguirre & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHASES AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN-RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/BACKFILL	INFILL TECHNIQUES AND MODERALS	DOF	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)								
		75 (9)		R 1R								0%			(13)	1	Y	1%				ARE GENERALLY SPHERICAL TO SLIGHTLY OVOID, GREY AND "FISH-SEALED". CAVITIES TYPICALLY ELONGATED WITH TROMPOCHED WHITE LINES. CAVITIES ONLY ASSOCIATED WITH LARGER ALTERED AREAS. GRAINBODIES OF ROCK MINIMALLY AFFECTED BY VAPOR-PHASE ALTERATION (LIGHT TAN-BROWN, DEHYDRIFIED).	
930.0	RUN 1.87			R 1R			60																
		74 (10)		I			30																
935.0	RUN 1.88			I								0%			(2)	2	Y	1%					
		70 (5)		I																			
940.0				I																			
				I																			
945.0	RUN 1.89			I			30																
				I																			
				I																			
950.0				I								5%											
				I																			
955.0				I			60																

GEOLOGY AND ROCK STRUCTURE LOG

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H-45

[illegible]

EEVStructure file: HMO6AV13.STR Lithology file: HMO6AV6.LTW Date: 10/20/24

HP109 v 1.60

**Sandia National Labs
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[illegible]

Structure File: NRGSRV13.STB Lithology File: NRGSRV13.LTH Date: 10/20/94

uplog v 4.60

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GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Structure file: MAGSERV1.STR Lithology file: MAGSERV6.LTH Date: 10/10/94

MP100 v 4.50

H-47

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAE AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (MINIMUM)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	IMP	INDUCED	PERCENT LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	10	20	30	10			20	30	40				
			X .85	1	1	1M	EX	2M			28	85	85			0%			15	(12)				0%					
1030.0	RUN 202																												
1035.0		60 (6)	.07													0%				(10)				0%					
	RUN 203		.08																										
		57 (10)				2M					98																		
1040.0			.15																										
	RUN 204		.05			2M					90																		
1045.0			X .65													0%				15				0%					
1050.0		65 (10)	.70																										

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[illegible]

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % UNFRACTURED AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-6)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/IRREGULARITY	SPACING/THICKNESS AND MINERALS	DIP	INDUCED	PRICE	LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			5	25	10	40		
	97	(13)	.15										9%		10 (20)						1%			
1080.0	RUN 209		.04	I	2M		20		.40															
				I	2M	1M	50 14		.45															
				I	M	2M 2M	50 35																	
				M	1M	2M	72																	
			.01	M	1M	2M	90 80		.45															
1085.0				I	M		76		1.00				30%								1%			
	93	(9)	.12	M	2M	2M	80		.90															
			.12	M	2M	2M	82		.40															
1090.0	RUN 210		.16		2M		90																	
			.20	M																				
			.05	I	2M		75 55		.50															
1095.0													5%								0%			
	89	(0)		I			40																	
				I																				
			.15	I		2M	90																	
1100.0																								

Structure file: HNG68V13.DTW Lithology file: HNG68V6.DTW Date: 10/30/94

TOTAL CORED DEPTH = 1104.04

WPIlog v 4.48

Sandia National Laboratories
Print Date: 10/20/94
WBS 1.2.3.2.6.2
QA: QA
Revision 1

COLUMN INFORMATION (Page 4)

FEATURE TYPE	Following codes indicate origin of feature:		
	N: Natural—indicated by mineral coating or evidence of weathering, slickensides, lack of fit between slides.		
	I: Indeterminate—origin questionable, rotated so that coatings possibly removed.		
	C: Coring induced—fresh, clean, tightly fitting breaks.		
	V: Vug or large void.		
INCLINATION (degrees)	Angle between plane normal to core axis and plane of fracture (Type N and I only).		
MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only):		
	C: Clean	TD: Brown dendritic	CL: Clay
	WC: White crystalline	TC: Tan crystalline	TN: Tan noncrystalline
	WN: White noncrystalline	CA: Calcite	FE: Iron oxide
	BC: Black crystalline	SI: Silica	BN: Brown noncrystalline
	BD: Black dendritic	MN: Manganese	
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only):		
	C: Clean, no filling	M: Moderately thick (0.1-0.4 inches)	
	S: Very thin, surface sheen	V: Very thick (0.4 - 1.0 inches)	
	T: Thin (up to 0.1 inches)	E: Extremely thick, greater than 1.0 inches	
PLANARITY	Describes the overall shape of the feature (Type N and I only):		
	P: Planar	S: Stepped	
	C: Curved	I: Irregular	
ROUGHNESS	Describes the local relief of the surface (Type N and I only):		
	V: Very rough—stepped, near-normal steps and ridges occur.		
	R: Rough—large angular asperities can be seen.		
	M: Moderately rough—asperities clearly visible, surface has abrasive feel.		
	S: Smooth—no asperities, smooth to the touch.		
	P: Polished—slickensided, extremely smooth and shiny.		

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-6

Interval—0-150 ft (0-45.7 m), TCw Unit

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE ROD*	ENHANCED ROD**	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	WEATHERING (ft in 10-ft interval)***					HARDNESS (ft in 10-ft interval) ROCK					
								F	S	M	T	D	1	2	3	4	5	6
10	T.C. C.P. L. Lth.	TCw	82	71	2	2.2	0.3											
20	T.C. C.P. L. Lth.	TCw	82	69	2	1.8	0.1		5.1						5.1			
30	T.C. C.P. L. Lth.	TCw	44	70	2	0.0	0.3	4.2	3.7		0.9			4.2	3.7			0.9
40	T.C. C.P. L. Lth.	TCw	63	71	1	0.0	0.4	4.8						4.8				
50	T.C. C.P. L. Lth.	TCw	74	82	2	0.0		4.5	2.2					4.5	2.4			
60	T.C. C.P. L. Northh.	TCw	22	81	1	0.5	0.8	0.5						4.8	0.7			
70	T.C. C.P. L. Northh.	TCw	24	59	1	0.9	0.8	7.8						4.0	3.8			
80	T.C. C.P. L. Northh.	TCw	22	38	0	0.2	0.5	9.0						9.0				
90	T.C. C.P. L. Northh.	TCw	34	34	0	0.1	0.8	5.8						5.8				
100	T.C. C.P. L. Northh.	TCw	36	86	0	0.0	0.2	3.4						2.4	2.6			
110	T.C. C.P. L. Northh.	TCw	72	88	0	0.0												
120	T.C. C.P. L. Northh.	TCw	48	87	0	0.0	0.3											
130	T.C. C.P. L. Northh.	TCw	16	32	0	0.0	1.2	2.7								2.7		
140	T.C. C.P. L. Northh.	TCw	32	38	0	0.6	1.2	1.3								1.2		
150	T.C. C.P. Vane	TCw	79	72	0	0.0		4.9								4.9		

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED ROD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

*** Footage in interval may not equal 10 ft because of lost core, rubble, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-6

Interval—0-150 ft (0-45.7 m), TCw Unit

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (24-ft interval)	NO. OF FRACTURES W/INCLINATION (degrees)										
			N	I	C	V		10	20	30	40	50	60	70	80	90	C	
10	T.C. C.P.L. Lsh.	TCw	6	6	11	1	10		6	3		1		1				8
20	T.C. C.P.L. Lsh.	TCw	3	4	12		20		4		2					1	3	
30	T.C. C.P.L. Lsh.	TCw	14	4	6		30		11				2			5	5	
40	T.C. C.P.L. Lsh.	TCw	16	1	3		40		6	2			2	2	5		2	
50	T.C. C.P.L. Lsh.	TCw	10		6		50		2		1	1	1	2	2			
60	T.C. C.P.L. Nonlith.	TCw	12	6	12		60		5	1	1		1	1	4		1	1
70	T.C. C.P.L. Nonlith.	TCw	11	12	23		70		6	2	3	2	2	5		1	2	1
80	T.C. C.P.L. Nonlith.	TCw	18	6	26		80		18	2					1		5	2
90	T.C. C.P.L. Nonlith.	TCw	17	13	11		90		8	1			1	1	2	1	14	3
100	T.C. C.P.L. Nonlith.	TCw	13	8	15		100		3		2	1		1	1	1	5	1
110	T.C. C.P.L. Nonlith.	TCw	4	6	6		110		2	2	4		2		2			8
120	T.C. C.P.L. Nonlith.	TCw	6	3	10		120		2	1			2		2	2	2	2
130	T.C. C.P.L. Nonlith.	TCw	27	11	1		130		16	1	5	2	4	1		2	8	9
140	T.C. C.P.L. Nonlith.	TCw	23	13	6		140		16	3	4	2	1	2	2	3	4	8
150	T.C. C.P. Vtelo	TCw	3	10	8		150		6		1	1			4	1		8
TOTAL			181	88	159	1	160		110	18	21	12	10	21	18	20	47	57
PERCENT OF OCCURRENCE			42	22	38	0.2			40	6.5	7.6	4.3	3.6	7.6	8.5	7.2	17	21

NO. OF FRACTURES W/MINERAL INFILLING TYPE												NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE				NO. OF FRACTURES W/ROUGHNESS CODE				
WN	BC	BD	TD	TC	CA	SI	MN	CL	IN	FE	BN	C	S	T	M	V	S	P	C	S	I	V	R	M	S	P
		2		3								6	5					1	1		5	2	6			
				4								3	4					1			5	3	3			
												3	10	1	4			13	3		1				17	
				16								2	14					8			8		3	12		
				6					1			6			3			2			8		1	9		
2		1		9					2			1	12		6			5			12		7	10		
11		7							3			1	16		6			3			20		1	22		
12		8											20		3			14			9		1	14	8	
4		15										3	22		2			7		1	18		1	20		
1		9										1	13								13		1	12		
2		2							2			8	8								12		1	11		
		1							6			2	7								7		1	9		
		6							23			9	20		9			1	1		34	1	8	27		
		10							18			6	25		6			3			29		2	28	6	
1		3							1			8	8					1			11		1	10	1	
33	0	85	0	37	0	0	0	0	58	0	0	61	185	1	37	0	0	60	5	1	190	6	38	202	14	0
12	0	23	0	13	0	0	0	0	20	0	0	19	98	0.4	14	0	0	23	2	0.4	74	2.8	14	78	8.4	0

Interval—150-250 ft (45.7-76.2 m), PTn Unit

* * * Footage in interval may not equal 10 ft because of lost core, rubble, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-6

Interval---150-250 ft (45.7-76.2 m), PTn Unit

BASE OF 10-Ft INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (ft/ft interval)	NO. OF FRACTURES W/INCLINATION (degrees)									
			N	I	C	V		10	20	30	40	50	60	70	80	90	C
160	T.G. G.P. Vado	PTn	1	25	2		160		3	1							12
170	B.T.	PTn		2	11		170										2
180	P.C.	PTn	10	6			180		2								15
190	P.C.	PTn	4	9	2		190			1		1					13
200	P.C.	PTn					200										5
210	P.C.	PTn	2	3	1		210										4
220	P.C.	PTn	1	4	3		220		1								5
230	T.S. B.T.	PTn		5	13		230				1						3
240	T.S. B.T.	PTn	1	3	4		240								1		4
250	T.S. B.T.	PTn		3	6		250		1								3
TOTAL			18	60	41	0		67	6	2	2	0	1	0	1	0	84
PERCENT OF OCCURRENCE			18	60	34	0		85	7.6	2.5	2.5	0	1.3	0	1.3	0	81

NO. OF FRACTURES W/GENERAL INFILLING TYPE												NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE				NO. OF FRACTURES W/ROUGHNESS CODE				
WN	EC	ED	TD	TC	CA	SI	MN	CL	TN	FE	BN	C	S	T	M	V	E	P	C	S	I	V	R	M	S	P
									15			12	14		1			1			22			23		
												2									2		1	1		
												16									16		1	14		
												13						1			8			9		
												6									4		2	2		
												6									4		4			
												6									1			1		
												4									3		2	1		
												3									2		1	1		
0	0	0	0	0	0	0	0	0	15	0	0	64	14	0	1	0	0	2	0	0	91	0	11	52	0	0
0	0	0	0	0	0	0	0	0	19	0	0	81	18	0	1.3	0	0	3.2	0	0	97	0	17	83	0	0

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-6

Interval—250-710 ft (76.2-216.4 m), TSw1 Unit

BASE OF INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE ROD** %	ENHANCED ROD** %	ESTIMATED % CAVITIES	LOST CORE (%)	SUSPENSE ZONE (%)	WEATHERING (ft in 10-ft interval)**					HARDNESS (ft in 10-ft interval)**				
								F	S	M	I	D	1	2	3	4	5
250	T.S. C.R. Vtble	TSw1	32	50	0	2.6	1.0	0.2		9.6					0.2		9.6
270	T.S. C.R. Northh.	TSw1	13	33	0	1.7	0.6	2.8							2.8		
280	T.S. C.R. Northh.	TSw1	27	58	1	0.8		0.2							0.2		
290	T.S. C.R. Northh.	TSw1	4	13	3	0.8	0.7	10.0							10.0		
300	T.S. C.R. Northh.	TSw1	38	62	1	0.2	0.7	10.0							10.0		
310	T.S. C.R. Northh.	TSw1	28	67	1	0.0	0.2	10.0							10.0		
320	T.S. C.R. Northh.	TSw1	31	44	0	0.4	0.9	1.7		6.3					10.0		
330	T.S. C.R. Northh.	TSw1	63	80	0	0.0		9.2		1.8					10.0		
340	T.S. C.R. Northh.	TSw1	18	37	0	0.7		10.0							7.0	8.0	
350	T.S. C.R. Northh.	TSw1	5	20	0	0.6		10.0							10.0		
360	T.S. C.R. Northh.	TSw1	22	51	1	0.5	0.4	10.0							10.0		
370	T.S. C.R. Northh.	TSw1	38	61	1	2.4		2.4							7.4		
380	T.S. C.R. Northh.	TSw1	42	78	1	0.7		7.7							7.7		
390	T.S. C.R. Northh.	TSw1	55	80	0	0.0		5.7							6.7		
400	T.S. C.R. Northh.	TSw1	73	94	0	0.0		3.1							3.1		
410	T.S. C.R. Northh.	TSw1	70	73	0	0.0		6.8							6.8		
420	T.S. C.R. Northh.	TSw1	79	84	1	0.0	0.1	3.8							3.8		
430	T.S. C.R. Northh.	TSw1	71	84	8	0.0		7.0							7.0		
440	T.S. C.R. Lth.	TSw1	18	38	4	0.7	1.6	3.1							2.1		
450	T.S. C.R. Lth.	TSw1	27	66	10	3.7	0.6	8.5							6.5		
460	T.S. C.R. Lth.	TSw1	28	49	8	2.8	1.4	10.0							10.0		
470	T.S. C.R. Lth.	TSw1	15	41	6	0.7	2.1	8.4							9.4		
480	T.S. C.P. U. Lth.	TSw1	0	0	0	3.8	5.4										
490	T.S. C.P. U. Lth.	TSw1	0	21	0	3.0	4.2	4.8							2.5	2.3	
500	T.S. C.P. U. Lth.	TSw1	20	63	8	0.5	2.5	0.5							0.5		
510	T.S. C.P. U. Lth.	TSw1	31	31	10	4.7	2.0										
520	T.S. C.P. U. Lth.	TSw1	0	59	8	1.4	1.8	1.4							1.4		
530	T.S. C.P. U. Lth.	TSw1	17	67	8	1.8	1.1	5.8							5.8		
540	T.S. C.P. U. Lth.	TSw1	29	57	6	1.5	0.7	8.1							6.7	2.4	
550	T.S. C.P. U. Lth.	TSw1	60	89	10	0.2	0.3	7.8							7.8		
560	T.S. C.P. U. Lth.	TSw1	66	82	11	0.0	0.1	2.3							2.3		
570	T.S. C.P. U. Lth.	TSw1	68	82	8	0.0	1.4	2.4							2.4		
580	T.S. C.P. U. Lth.	TSw1	15	13	5	0.8	1.4	7.7							7.7		
590	T.S. C.P. U. Lth.	TSw1	4	18	10	8.4	2.0										
600	T.S. C.P. U. Lth.	TSw1	69	65	11	0.0	0.4	2.3							2.3		
610	T.S. C.P. U. Lth.	TSw1	14	43	11	4.1	0.6	7.7							7.7		
620	T.S. C.P. U. Lth.	TSw1	11	11	3	5.8	1.6										
630	T.S. C.P. U. Lth.	TSw1	13	50	4	3.1	1.5										
640	T.S. C.P. U. Lth.	TSw1	25	61	5	2.1	1.1	8.8							8.8		
650	T.S. C.P. U. Lth.	TSw1	21	58	5	1.0	2.0	10.0							10.0		
660	T.S. C.P. U. Lth.	TSw1	30	33	7	1.2	1.6	9.4							8.4		
670	T.S. C.P. U. Lth.	TSw1	30	54	4	1.7	1.8										
680	T.S. C.P. U. Lth.	TSw1	7	23	3	3.8	1.8										
690	T.S. C.P. U. Lth.	TSw1	11	42	3	2.8	1.5	4.0							4.0		
700	T.S. C.P. U. Lth.	TSw1	9	28	2	2.5	1.4	8.6							8.6		
710	T.S. C.P. U. Lth.	TSw1	9	35	2	1.3	2.8	3.7							3.7		

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED ROD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

*** Footage in interval may not equal 30 ft because of lost core, rubble, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-6

Interval—250-710 ft (76.2-216.4 m), T8w1 Unit

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (10-ft interval)	NO. OF FRACTURES WINCLINATION (degrees)										
			N	I	C	V		10	20	30	40	50	60	70	80	90	C	
260	T.S. C.R. Vitro	T8w1	3	5	9		260			1					5	1	6	
270	T.S. C.R. Nonilh.	T8w1	55	7	12		270	53	1		2			1	2	3	11	
280	T.S. C.R. Nonilh.	T8w1	26	10	11		280	20	5	3		2			2	4	10	
290	T.S. C.R. Nonilh.	T8w1	42	6	8		290	27	8	1	1	1	2	2		6	23	
300	T.S. C.R. Nonilh.	T8w1	7	12	13		300	8						6	4	1	16	
310	T.S. C.R. Nonilh.	T8w1	6	31	13		310	33				1			2		35	
320	T.S. C.R. Nonilh.	T8w1	10	19			320	27	2								28	
330	T.S. C.R. Nonilh.	T8w1	2	18	5		330	17		1		1		1			18	
340	T.S. C.R. Nonilh.	T8w1		38			340	35								1	36	
350	T.S. C.R. Nonilh.	T8w1		44			350	42	2								44	
360	T.S. C.R. Nonilh.	T8w1	1	27			360	20	3	2	1	1			1		27	
370	T.S. C.R. Nonilh.	T8w1		17	2		370	14	2							1	17	
380	T.S. C.R. Nonilh.	T8w1	8	9	7		380	13	3	1							15	
390	T.S. C.R. Nonilh.	T8w1	5	7	9		390	8	2	1						1	12	
400	T.S. C.R. Nonilh.	T8w1	3	2	11		400	2	1	1				1			1	
410	T.S. C.R. Nonilh.	T8w1	6	11	10		410	7	4	1	1	1	1		2		7	
420	T.S. C.R. Nonilh.	T8w1		15	8		420	11	4								10	
430	T.S. C.R. Nonilh.	T8w1	4	10	9		430	8		2	3				1		9	
440	T.S. C.R. Uth.	T8w1	3	10	7	1	440	8	5	1	1			1	2		18	
450	T.S. C.R. Uth.	T8w1		6	11		450	8									8	
460	T.S. C.R. Uth.	T8w1	1	12	8		460	4		2	1		3			3	12	
470	T.S. C.R. Uth.	T8w1	4	10	12		470	8							1	1	12	
480	T.S. C.P. U. Uth.	T8w1	1	1	2		480					1		1			2	
490	T.S. C.P. U. Uth.	T8w1	4		8		490	1						1	1	1	4	
500	T.S. C.P. U. Uth.	T8w1	1	5	15		500	4							1	1	6	
510	T.S. C.P. U. Uth.	T8w1		2	1		510	1								1	2	
520	T.S. C.P. U. Uth.	T8w1		5	23		520					1			1	3	5	
530	T.S. C.P. U. Uth.	T8w1		3	10		530	3								1	2	
540	T.S. C.P. U. Uth.	T8w1	3	8	12		540	7		1					1	2	5	
550	T.S. C.P. U. Uth.	T8w1		5	10		550	1			1					1	2	4
560	T.S. C.P. U. Uth.	T8w1		6	11		560	2	1	1	1		1				8	
570	T.S. C.P. U. Uth.	T8w1			15		570											
580	T.S. C.P. U. Uth.	T8w1		1	5		580		1								1	
590	T.S. C.P. U. Uth.	T8w1		2	9		590	1								1	1	
600	T.S. C.P. U. Uth.	T8w1		3	14		600	1						1		1	3	
610	T.S. C.P. U. Uth.	T8w1		6	14		610						1	2		3	6	
620	T.S. C.P. U. Uth.	T8w1		7	6		620					1	2	1		3	7	
630	T.S. C.P. U. Uth.	T8w1	5	1	15		630	1			2		1	1	1		4	
640	T.S. C.P. U. Uth.	T8w1	4	8	15		640	3		2		1		1	1	2	8	
650	T.S. C.P. U. Uth.	T8w1	7	1	13		650	2			1	1		2		2	6	
660	T.S. C.P. U. Uth.	T8w1	2	7	14		660	2	1		2		1			3	7	
670	T.S. C.P. U. Uth.	T8w1	4	5	15		670				5		2			2	4	
680	T.S. C.P. U. Uth.	T8w1		5	14		680	1			1			2	1		4	
690	T.S. C.P. U. Uth.	T8w1	4	4	19		690	2		1		1			3	1	8	
700	T.S. C.P. U. Uth.	T8w1	7	5	19		700	2	2	2						8	9	
710	T.S. C.P. U. Uth.	T8w1	6	10	38		710	6	1	1		2			2	4	14	
TOTAL			233	427	477	1		411	48	25	23	15	14	26	34	65	490	
PERCENT OF OCCURRENCE			20	38	42	0.1		62	7.3	3.9	3.5	2.3	2.1	3.6	5.2	9.8	74	

■ N+I
■ N+I+O

NO. OF FRACTURES W/ MINERAL INFILLING TYPE												NO. OF FRACTURES W/ INFILL THICKNESS CODE						NO. OF FRACTURES W/ PLANARITY CODE				NO. OF FRACTURES W/ ROUGHNESS CODE					
WN	BC	BD	TD	TC	CA	SI	MN	CL	TN	FE	BN	C	S	T	M	V	E	P	C	S	I	V	R	M	S	P	
									3			5	3								9			9			
1									60			11	23		18			1	1	2	59		1	42	18		
3		2							20			9	24		3			11			29		4	30			
3		7							14			21	24		2			21			23		6	41	1		
3												15	2		2			2			13		2	13	1		
								1				38	1								32		1	24	8		
1												28	1					1			24		1	24	1		
1												19	1								18		2	18			
												38									33			33			
												44									36		1	35			
									1			27			1						23		2	21			
												17									16		3	12			
2												15	2								13		2	11			
												12						2			9			11			
3									1			1	3	1				1			4		1	9	1		
6												7	8	1	1					1	11		2	11			
4												10	5								6			6			
5												9	5								11		4	7			
1												17	2								12		4	8			
												6									1			1			
1												12	1								2		2	9			
												11	2	1							1			6	3		
												1	1						1					2			
												4									3			1	2		
												6									2			2			
												2									1		1				
												5									6		2	3			
												2				1					3		1	2			
6												6	9		3						9		7	2			
1												4	1								6		2	3			
												6									5		5				
												1									1		1				
												1			1						1			2			
												3									2		2				
												6									6			6			
												7									7			7			
												3	3								5	1	2	2			
												8	1		1						9		1	8			
												6	1		1						7		2	5			
												7	2								7			7			
												3	1		5			4			5			5	4		
												4				1					4			4			
												7	1								4			5		1	
1	1	1										7	2		9			5			7			4	8	2	
									2			19	9								13			12	1		
40	1	11	0	0	0	0	0	0	92	0	0	478	138	3	43	2	0	48	2	8	488	1	63	455	48	3	
6.1	0.2	1.7	0	0	0	0	0	0	14	0	0	72	21	0.5	6.2	0.3	0	8.7	0.4	1.1	80	0.2	11	80	8.1	0.5	

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-6

Interval—710-1100 ft (216.4-335.3 m), TSw2 Unit

BASE OF 10-FT INTERVAL	STRATIGRAPHIC ZONE	THERMO- MECHANICAL UNIT	CORE ROD* %	ENHANCED ROD** %	ESTIMATED N CAVITIES	LOST CORE (ft)	RUMBLE ZONE (ft)	WEATHERING (ft in 10-ft interval)***					MASS LOSS (ft in 10-ft interval)***					
								F	S	M	I	D	1	2	3	4	5	6
720	T.S. C.P. M. North.	TSw2	0	31	1	1.7	3.2											
730	T.S. C.P. M. North.	TSw2	11	18	0	0.5	1.5											
740	T.S. C.P. M. North.	TSw2	8	8	0	1.7	3.5	0.7							0.7			
750	T.S. C.P. M. North.	TSw2	14	39	0	2.2	0.9	3.1							3.1			
760	T.S. C.P. M. North.	TSw2	0	0	0	0.1	1.8	7.6							7.6			
770	T.S. C.P. M. North.	TSw2	0	27	0	0.5	1.8											
780	T.S. C.P. M. North.	TSw2	30	40	1	2.1	1.2	0.9							0.9			
790	T.S. C.P. M. North.	TSw2	22	43	0	0.2	0.7	4.4							4.4			
800	T.S. C.P. M. North.	TSw2	0	16	0	0.0	4.4	4.6							4.6			
810	T.S. C.P. M. North.	TSw2	14	60	0	0.0	1.0	6.3							6.3			
820	T.S. C.P. L. Unit	TSw2	4	8	0	3.0	3.9	3.3							3.3			
830	T.S. C.P. L. Unit	TSw2	0	18	NAE	2.5	4.5	3.8							3.8			
840	T.S. C.P. L. Unit	TSw2	0	27	0	3.2	2.1	5.4							5.4			
850	T.S. C.P. L. Unit	TSw2	6	28	0	2.5	2.2											
860	T.S. C.P. L. Unit	TSw2	0	36	0	0.0	2.4											
870	T.S. C.P. L. Unit	TSw2	0	18	0	2.1	2.8	2.3							2.3			
880	T.S. C.P. L. Unit	TSw2	0	8	0	1.0	1.8	1.9							1.9			
890	T.S. C.P. L. Unit	TSw2	0	16	0	2.4	0.7											
900	T.S. C.P. L. Unit	TSw2	6	33	0	3.3	2.1											
910	T.S. C.P. L. Unit	TSw2	27	47	0	1.5	0.2											
920	T.S. C.P. L. Unit	TSw2	8	14	0	3.8	3.0											
930	T.S. C.P. L. Unit	TSw2	0	33	1	3.2	1.3	3.8							3.8			
940	T.S. C.P. L. Unit	TSw2	0	57	1	3.1	0.5	6.2							6.2			
950	T.S. C.P. L. Unit	TSw2	5	44	2	2.8	1.7											
960	T.S. C.P. L. Unit	TSw2	38	74	1	0.9	0.9	1.8							1.8			
970	T.S. C.P. L. Unit	TSw2	12	32	1	3.7	0.8	9.2							9.2			
980	T.S. C.P. L. Unit	TSw2	24	37	2	0.5	0.5											
990	T.S. C.P. L. Unit	TSw2	28	46	2	2.4	1.2											
1000	T.S. C.P. L. Unit	TSw2	5	41	1	3.0	2.8	4.7					4.7					
1010	T.S. C.P. L. Unit	TSw2	20	36	0	2.0	2.8	10.0					10.0					
1020	T.S. C.P. L. Unit	TSw2	23	45	0	3.5	1.5	4.9					4.9					
1030	T.S. C.P. L. Unit	TSw2	0	5	0	7.3	1.4											
1040	T.S. C.P. L. Unit	TSw2	0	0	0	5.4	2.8											
1050	T.S. C.P. L. Unit	TSw2	0	21	0	3.9	3.4											
1060	T.S. C.P. L. Unit	TSw2	4	35	0	4.4	1.2	1.7									1.7	
1070	T.S. C.P. L. Unit	TSw2	5	37	0	1.0	2.5	6.1									6.1	
1080	T.S. C.P. L. Unit	TSw2	0	27	1	3.7	1.7											
1090	T.S. C.P. L. Unit	TSw2	20	48	1	0.7	0.9											
1100	T.S. C.P. L. Unit	TSw2	5	22	0	4.0	1.1	3.9							3.9			

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED ROD Determined by sharing the effects of fractures identified as coring induced (Type C) from the piece lengths.

*** Footage in interval may not equal 10 ft because of lost core, rubble, or compression during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-6

Interval—710-1100 ft (216.4-335.3 m), TSw2 Unit

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (ft-d. interval)	NO. OF FRACTURES W/INCLINATION (degree)										
			N	I	C	V		10	20	30	40	50	60	70	80	90	C	
720	T.S. C.P. M. North.	TSw2	11	4	33		720				4		1	1	4	1	12	
730	T.S. C.P. M. North.	TSw2	11	6	25		730			2	1	1			4	5	9	
740	T.S. C.P. M. North.	TSw2	17	3	19		740					1				16	10	
750	T.S. C.P. M. North.	TSw2	7	2	20		750			1				1	1	5	1	
760	T.S. C.P. M. North.	TSw2	3		3		760									3	1	
770	T.S. C.P. M. North.	TSw2	12	5	27		770								3	9	5	
780	T.S. C.P. M. North.	TSw2	5	1	21		780		1						1	2	2	
790	T.S. C.P. M. North.	TSw2	9	2	19		790		2	1			1	2	1	4	5	
800	T.S. C.P. M. North.	TSw2	7	9	7		800		5	1		1	2	1	3	2	1	12
810	T.S. C.P. M. North.	TSw2	9	3	30		810		3			1	1		1	5	5	
820	T.S. C.P. L. Lith.	TSw2		3	18		820									1	3	3
830	T.S. C.P. L. Lith.	TSw2		3	12		830		1							1	1	3
840	T.S. C.P. L. Lith.	TSw2	9	2	9		840		1				2	2		1	4	10
850	T.S. C.P. L. Lith.	TSw2	8	7	12		850		5	1			2		1		7	18
860	T.S. C.P. L. Lith.	TSw2	8	1	11		860		1			1		1	1	6	8	
870	T.S. C.P. L. Lith.	TSw2	9	1	11		870		2	1	1			2	1	2	1	4
880	T.S. C.P. L. Lith.	TSw2	3	1	65		880		1							3	3	
890	T.S. C.P. L. Lith.	TSw2	1	1	20		890									2	2	
900	T.S. C.P. L. Lith.	TSw2		1	25		900										1	1
910	T.S. C.P. L. Lith.	TSw2	5	5	20		910		5					1	1	3	6	
920	T.S. C.P. L. Lith.	TSw2	3		7		920										3	3
930	T.S. C.P. L. Lith.	TSw2	3	2	8		930		3				1			1	5	
940	T.S. C.P. L. Lith.	TSw2	1	3	17		940		3							1	4	
950	T.S. C.P. L. Lith.	TSw2		4	20		950		2				1			1	4	
960	T.S. C.P. L. Lith.	TSw2	1	6	19		960		3			1		1		2	7	
970	T.S. C.P. L. Lith.	TSw2		4	10		970		4								4	
980	T.S. C.P. L. Lith.	TSw2	1	8	28		980		1	3					2	3	9	
990	T.S. C.P. L. Lith.	TSw2	2	18	8		990		16							2	17	
1000	T.S. C.P. L. Lith.	TSw2	1		12		1000								1		1	
1010	T.S. C.P. L. Lith.	TSw2	2	2	18		1010		1							3	4	
1020	T.S. C.P. L. Lith.	TSw2	1	1	17		1020		1					1			2	
1030	T.S. C.P. L. Lith.	TSw2		5	7		1030				1					4	5	
1040	T.S. C.P. L. Lith.	TSw2	1	1	8		1040		1							1	2	
1050	T.S. C.P. L. Lith.	TSw2	4		11		1050		3							1	4	
1060	T.S. C.P. L. Lith.	TSw2		9	18		1060		6				1			2	9	
1070	T.S. C.P. L. Lith.	TSw2	7	4	23		1070		9							2	9	
1080	T.S. C.P. L. Lith.	TSw2		10	10		1080		2							8	10	
1090	T.S. C.P. L. Lith.	TSw2	13	5	24		1090		2		1		1		3	11	10	
1100	T.S. C.P. L. Lith.	TSw2	1	8	18		1100		5		1		2		1	1	8	
TOTAL			173	148	685	0			108	7	4	11	11	12	14	31	126	241
PERCENT OF OCCURRENCE			17	15	68	0			33	2.2	1.2	3.4	3.4	3.2	4.3	9.8	39	75

NO. OF FRACTURES W/MINERAL INFILLING TYPE													NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE				NO. OF FRACTURES W/ROUGHNESS CODE				
WM	BC	ED	TD	TC	CA	SI	MN	CL	TN	FE	BN	EN	C	S	T	M	V	E	P	G	S	I	V	R	M	S	P
													11	4					1	2		9			10	2	
													7	8		1			8	1		8			7	7	
1													10	8		1			3		1	9			13	6	
		3												8	1				2	1		6			8	4	
		1	1										1	2								3			1	2	
		3	2											17					1			16			13	4	
2													2	3		1						6			6		
													8	3					1			9			9	1	
		1											12	4								11			11		
			1										6	4								12			12		
													3									3		1	2		
													3									3			3		
													10									10			10		
													16									16			16		
1													8	1								9		3	6		
6													4	6								8		1	7		
		1											3	1								4			4		
													2									2			2		
													1									1			1		
													6	4		1						9		1	8	1	
													3									3		2	1		
													8									8		2	1		
													4									1			1		
													4									2			2		
													7									8			8		
													4									4		1	3		
													9									8			8		
													17		1							18		3	18		
													1									1			1		
													4									3			3		
													2									1			1		
													5									6			6		
													2									1			1		
													4									1			4		
													9									3			3		
													8	2								8		3	8		
7													10									9			9		
													10	8								7			8	8	
													8	1								1			1	1	
17	0	9	4	0	0	0	0	0	3	0	0	0	231	85	2	4	0	0	13	4	8	238	0	16	224	38	0
5.3	0	2.8	1.2	0	0	0	0	0	0.9	0	0	0	72	26	0.8	1.2	0	0	4.9	1.5	3	90	0	5.6	81	13	0

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA**

**Hole USW NRG-6
TCw, PTn, TSw1 and TSw2**

Sandia National Laboratories
Print Date: 2/13/95
WBS 1.2.3.2.6.2
QA:L
Revision 3

REVISION HISTORY

- Revision 2 Change in method for calculating % lithophysae. Stratigraphy and thermomechanical units revised to USGS nomenclature. Method for determining Jr and Ja revised in zones with extensive lost core and rubble; Jn and SRF resimulated; Q-core index and histogram plots removed from presentation.
- Revision 3 Revised SRF parameter using NRG rock testing data for PTn unit.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{**}} \cdot \frac{J_r}{J_a} \cdot \frac{J_w}{SRF^{**}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of Jn and SRF.

where RQD** = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

Jn* = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9. Values may change in subsequent revisions due to resimulation.

Jr = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

Ja = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

Jw = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: For nonwelded units, SRF is determined from the ratio of UCS/ σ_1 (UCS = unconfined compressive strength, σ_1 = overburden stress). If unconfined compressive strength data is not available for the 10-ft interval, a compressive strength is generated by Monte Carlo simulation using laboratory test data for the thermomechanical units. For welded tuff units, SRF cannot be determined from core log data and is generated by Monte Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean values for thermomechanical units in USW NRG-6 are:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
TCw	44.7%	62.7%
PTn	50.5%	63.4%
TSw1	29.3%	51.9%
TSw2	9.3%	30.6%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$\text{RMR} = C + \text{RQD-I} + \text{JS} + \text{JC} + \text{JW}$$

where C = Rock Strength Index: Derived from compressive strength data (PTn, TSw1) or estimated by Schmidt Rebound Hardness data (TCw, TSw2) for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data or Schmidt Hammer data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, includes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions.

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member	C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		C.P. Vitric	Crystal-Poor Vitric
B.T.	Bedded Tuff		
P.C.	Pah Canyon Member		
B.T.	Bedded Tuff		
T.S.	Topopah Spring Member	C.R. Vitric	Crystal-Rich Vitric
		C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. Lith.	Crystal-Rich Lithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal

THERMOMECHANICAL UNITS

TCw—Tiva Canyon Welded Unit

PTn—Upper Paintbrush Nonwelded Unit

TSw1—Topopah Spring Welded Unit—Lithophysae Rich

TSw2—Topopah Spring Welded Unit—Lithophysae Poor

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRG-6

Interval—0-150 ft (0-45.7 m), TCw Unit

END DEPTH	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al. (1974)							RMR CLASSIFICATION SYSTEM Bisniawski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
10	T.C. C.P. L. Lith.	TCw	52	4.00	2.71	1.00	1.00	1.00	35.29	12	13	8	26.6	15	74.6
20	T.C. C.P. L. Lith.	TCw	62	7.00	2.83	1.00	1.00	5.00	5.02	12	13	8	26.6	15	74.6
30	T.C. C.P. L. Lith.	TCw	44	5.00	2.06	2.11	1.00	1.00	8.58	12	13	8	27.0	15	75.0
40	T.C. C.P. L. Lith.	TCw	63	5.00	2.40	1.00	1.00	5.00	6.05	12	8	8	18.3	15	61.3
50	T.C. C.P. L. Lith.	TCw	74	6.00	2.80	2.67	1.00	7.50	1.73	12	13	8	23.1	15	71.1
60	T.C. C.P. L. Nonlith.	TCw	22	9.00	2.71	2.61	1.00	7.50	0.34	12	13	8	21.6	16	69.8
70	T.C. C.P. L. Nonlith.	TCw	24	6.00	2.87	3.26	1.00	1.00	3.52	12	3	8	20.8	15	58.8
80	T.C. C.P. L. Nonlith.	TCw	22	5.00	2.04	2.70	1.00	1.00	3.34	12	3	8	18.3	16	56.3
90	T.C. C.P. L. Nonlith.	TCw	34	8.00	2.70	1.87	1.00	1.00	6.89	12	3	8	18.5	16	54.5
100	T.C. C.P. L. Nonlith.	TCw	36	8.00	3.00	1.14	1.00	5.00	2.30	7	8	8	23.6	15	61.6
110	T.C. C.P. L. Nonlith.	TCw	72	7.00	3.00	1.33	1.00	1.00	23.14	12	8	8	27.7	15	70.7
120	T.C. C.P. L. Nonlith.	TCw	48	5.00	3.00	1.00	1.00	5.00	5.76	12	13	8	26.2	16	74.2
130	T.C. C.P. L. Nonlith.	TCw	18	8.00	2.94	2.18	1.00	5.00	0.54	12	8	8	28.5	16	71.5
140	T.C. C.P. L. Nonlith.	TCw	32	4.00	2.73	1.69	1.00	7.50	1.72	7	3	8	24.5	16	57.5
150	T.C. C.P. Vitrific	TCw	70	6.00	2.83	1.15	1.00	7.50	3.82	7	8	8	25.3	16	63.3

Jn*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*.

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

Barton, N., R. Lien, and J. Lunde, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6:189-236 (Springer Verlag, 1974)

Bisniawski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 2:41-48 (A. A. Balkema, 1979)

Q				RMR			
Jn	—	Joint Set Number		C	—	Strength Index	
Jr	—	Joint Roughness Number		RQD-I	—	RQD Index	
Ja	—	Joint Alteration Number		JS	—	Joint Spacing Index	
Jw	—	Joint Water Reduction Factor		JC	—	Discontinuity Condition Index	
SRF	—	Stress Reduction Factor		JW	—	Groundwater Index	
$Q = (RQD/Jn)(Jr/Ja)(Jw/SRF)$				$RMR = C + RQD-I + JS + JC + JW$			

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRG-6

Interval—150-250 ft (45.7-76.2 m), PTn Unit

END DEPTH	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM 1 Barton et al. (1974)							RMR CLASSIFICATION SYSTEM 2 Bieniawski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
160	T.C. C.F. Vitric	PTn	27	9.00	2.86	1.19	1.00	7.02	1.07	2	8	8	27.5	15	60.6
170	B.E.	PTn	51	5.00	3.00	1.00	1.00	15.00	2.04	1	13	8	28.5	15	65.6
180	P.C.	PTn	50	7.00	3.00	1.00	1.00	15.00	1.43	1	13	8	28.5	15	65.6
190	P.C.	PTn	67	9.00	2.89	1.00	1.00	15.00	1.43	1	13	8	27.5	15	64.5
200	P.C.	PTn	0	9.00	2.77	1.38	1.00	15.00	0.15	1	3	6	25.4	15	49.4
210	P.C.	PTn	16	6.00	3.00	1.00	1.00	15.00	0.53	1	3	10	28.5	15	57.5
220	P.C.	PTn	49	8.00	3.00	1.00	1.00	15.00	1.23	1	8	10	28.5	15	62.5
230	T.S. B.T.	PTn	72	9.00	3.00	1.00	1.00	15.00	1.60	1	13	8	28.5	15	65.5
240	T.S. B.T.	PTn	87	6.00	3.00	1.00	1.00	6.38	5.18	2	17	10	28.5	15	72.5
250	T.S. B.T.	PTn	86	5.00	3.00	1.00	1.00	15.00	3.44	1	17	10	28.5	15	71.5

Jn*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*.

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

1 Barton, N., R. Lunn, and J. Lunde, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6 199-236 (Springer Verlag, 1974)

2 Bieniawski, Z.T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 2 41-48 (A. A. Balkema, 1979)

Q

Jn — Joint Set Number
 Jr — Joint Roughness Number
 Ja — Joint Alteration Number
 Jw — Joint Water Reduction Factor
 SRF — Stress Reduction Factor

$$Q = (RQD/Jn)(Jr/Ja)(Jw/SRF)$$

RMR

C — Strength Index
 RQD-I — RQD Index
 JS — Joint Spacing Index
 JC — Discontinuity Condition Index
 JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

R-65

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRJ-6

Interval---250-710 ft (76.2-216.4 m), TSwt Unit

END DEPTH	STRATIGRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al. (1974)							RMR CLASSIFICATION SYSTEM Bieniawski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRT*	Q*	C	RQD-I	JS	JC	JW	RMR
260	TS CR Vene	TSwt	32	4.00	3.00	1.00	1.00	1.00	24.00	2	8	8	28.5	15	61.5
270	TS CR Nonlith	TSwt	13	4.00	2.65	2.48	1.00	7.50	0.45	4	3	5	22.8	15	49.6
280	TS CR Nonlith	TSwt	27	4.00	2.68	1.58	1.00	5.00	2.28	12	8	8	22.8	15	65.6
290	TS CR Nonlith	TSwt	4	6.00	2.47	1.34	1.00	1.00	3.07	7	3	5	22.8	15	52.0
300	TS CR Nonlith	TSwt	38	5.00	2.75	1.84	1.00	7.50	0.95	7	8	8	24.0	15	62.0
310	TS CR Nonlith	TSwt	29	7.00	2.73	1.00	1.00	1.00	11.30	12	8	8	28.1	15	71.1
320	TS CR Nonlith	TSwt	31	6.00	2.88	1.07	1.00	7.50	1.86	7	8	8	27.7	15	65.7
330	TS CR Nonlith	TSwt	63	6.00	3.00	1.10	1.00	7.50	2.86	7	13	8	27.9	15	70.9
340	TS CR Nonlith	TSwt	19	9.00	3.00	1.00	1.00	1.00	6.33	7	3	8	28.5	15	61.5
350	TS CR Nonlith	TSwt	5	6.00	3.00	1.00	1.00	7.50	0.67	7	3	8	28.5	15	61.5
360	TS CR Nonlith	TSwt	22	8.00	3.00	1.18	1.00	1.00	7.00	4	3	8	27.9	15	57.9
370	TS CR Nonlith	TSwt	23	9.00	3.00	1.00	1.00	1.00	11.00	4	8	8	28.6	15	63.6
380	TS CR Nonlith	TSwt	42	5.00	3.00	1.24	1.00	1.00	20.40	7	8	8	27.2	15	65.2
390	TS CR Nonlith	TSwt	55	7.00	2.82	1.00	1.00	1.00	22.14	7	13	8	28.9	15	69.9
400	TS CR Nonlith	TSwt	73	6.00	2.60	2.20	1.00	1.00	14.38	7	13	8	18.5	15	61.5
410	TS CR Nonlith	TSwt	70	6.00	2.92	1.88	1.00	1.00	18.12	7	13	8	24.3	15	67.3
420	TS CR Nonlith	TSwt	78	4.00	3.00	1.53	1.00	7.50	5.09	4	17	8	25.5	15	69.6
430	TS CR Nonlith	TSwt	71	4.00	3.00	1.71	1.00	1.00	31.06	4	13	8	24.4	15	64.4
440	TS CR Lith	TSwt	16	6.00	2.92	1.11	1.00	1.00	7.05	7	3	8	27.9	15	60.9
450	TS CR Lith	TSwt	27	7.00	3.00	1.00	1.00	1.00	11.57	4	8	8	28.5	15	63.6
460	TS CR Lith	TSwt	26	6.00	2.91	1.15	1.00	1.00	10.93	12	8	8	27.6	15	70.6
470	TS CR Lith	TSwt	16	4.00	2.67	1.00	1.00	7.50	1.33	7	3	8	28.0	15	61.0
480	TS CP U Lith	TSwt	0	9.00	2.50	1.73	1.00	5.00	0.32	4	3	5	23.7	15	60.7
490	TS CP U Lith	TSwt	0	9.00	2.50	1.73	1.00	1.00	1.61	12	3	8	23.7	15	61.7
500	TS CP U Lith	TSwt	20	7.00	3.00	1.00	1.00	6.00	1.71	7	3	8	28.5	15	61.5
510	TS CP U Lith	TSwt	31	8.00	3.00	1.00	1.00	1.00	11.63	4	8	10	28.5	15	65.5
520	TS CP U Lith	TSwt	0	8.00	3.00	1.00	1.00	1.00	3.75	7	3	8	28.6	15	61.6
530	TS CP U Lith	TSwt	17	4.00	3.00	3.33	1.00	7.50	0.53	4	3	8	21.9	15	51.9
540	TS CP U Lith	TSwt	38	7.00	3.00	3.27	1.00	1.00	4.98	7	8	8	19.8	15	57.8
550	TS CP U Lith	TSwt	80	6.00	3.00	1.40	1.00	6.00	6.71	4	17	8	26.2	15	70.2
560	TS CP U Lith	TSwt	58	6.00	3.00	1.00	1.00	1.00	29.00	4	13	8	28.5	15	68.5
570	TS CP U Lith	TSwt	69	7.00	4.00	1.00	1.00	6.00	7.89	4	13	8	30.0	15	70.0
580	TS CP U Lith	TSwt	15	9.00	2.50	1.73	1.00	1.00	2.41	7	3	8	23.7	15	56.7
590	TS CP U Lith	TSwt	4	9.00	2.50	1.73	1.00	7.50	0.21	4	3	5	23.7	15	60.7
600	TS CP U Lith	TSwt	59	6.00	3.00	1.00	1.00	7.50	3.33	7	13	8	28.5	15	71.5
610	TS CP U Lith	TSwt	14	7.00	3.00	1.00	1.00	1.00	6.00	7	3	8	28.5	15	61.5
620	TS CP U Lith	TSwt	11	9.00	2.50	1.73	1.00	7.50	0.24	4	3	8	23.7	15	53.7
630	TS CP U Lith	TSwt	13	5.00	3.00	1.00	1.00	5.00	1.56	7	3	8	28.5	15	61.5
640	TS CP U Lith	TSwt	25	8.00	3.00	1.50	1.00	1.00	6.25	12	8	8	28.9	15	69.9

B-55

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
Estimated Rock Mass Quality Indices Based on Core Log Data
Hole USW NRG-6
Interval—250-710 ft (76.2-216.4 m), TSw1 Unit

END DEPTH	STRATI-GRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM 1 Barton et al. (1974)							RMR CLASSIFICATION SYSTEM 2 Bieniawski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
850	T.S. C.P. U. Lith.	TSw1	21	7.00	3.00	1.63	1.00	1.00	5.54	4	3	8	26.5	15	56.5
860	T.S. C.P. U. Lith.	TSw1	20	6.00	3.00	1.00	1.00	1.00	12.00	7	3	8	28.5	15	61.5
870	T.S. C.P. U. Lith.	TSw1	30	6.00	2.11	3.78	1.00	1.00	3.36	7	8	8	16.6	15	54.6
580	T.S. C.P. U. Lith.	TSw1	7	7.00	3.00	2.40	1.00	1.00	1.78	7	3	8	24.6	15	57.6
690	T.S. C.P. U. Lith.	TSw1	11	7.00	2.42	1.00	1.00	1.00	3.80	7	3	8	26.0	15	61.0
700	T.S. C.P. U. Lith.	TSw1	8	7.00	1.83	2.42	1.00	1.00	1.08	4	3	8	18.6	15	49.6
710	T.S. C.P. U. Lith.	TSw1	9	5.00	2.92	1.00	1.00	5.00	1.17	7	3	5	28.4	15	58.4

Jn*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*.

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

Barton, N., R. Lien, and J. Lunde, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6:199-236 (Springer Verlag, 1974)

Bieniawski, Z.T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 2:41-48 (A. A. Balkema, 1979)

Q
 Jn — Joint Set Number
 Jr — Joint Roughness Number
 Ja — Joint Alteration Number
 Jw — Joint Water Reduction Factor
 SRF — Stress Reduction Factor

$$Q = (RQD/Jn)(Jr/Ja)(Jw/SRF)$$

RMR
 C — Strength Index
 RQD-I — RQD Index
 JS — Joint Spacing Index
 JC — Discontinuity Condition Index
 JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

H-67

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRG-6

Interval—710-1100 ft (216.4-335.3 m), TSw2 Unit

LMD DEPTH	STRATIGRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al (1974)							RMR CLASSIFICATION SYSTEM Diederichs (1979)						
			RQD** (%)	J _w *	J _r	J _a	J _s	SRF*	Q*	C	RQD-I	J _S	J _C	J _W	RMR	
720	TS CP M Noshub	TSw2	0	5.00	2.58	1.00	1.00	1.00	5.17	7	3	5	26.8	15	56.8	
730	TS CP M Noshub	TSw2	11	5.00	2.07	1.29	1.00	1.00	2.20	7	3	5	23.4	15	56.4	
740	TS CP M Noshub	TSw2	5	5.00	2.21	1.35	1.00	5.00	0.55	12	3	5	24.7	15	59.7	
750	TS CP M Noshub	TSw2	16	5.00	2.22	1.00	1.00	1.00	7.11	7	3	5	25.3	15	58.3	
760	TS CP M Noshub	TSw2	0	5.00	2.33	1.00	1.00	1.00	3.99	4	3	10	27.5	15	62.5	
770	TS CP M Noshub	TSw2	0	5.00	2.71	1.00	1.00	1.00	6.41	12	3	5	27.6	15	65.6	
780	TS CP M Noshub	TSw2	30	5.00	3.00	2.50	1.00	1.00	7.20	12	3	5	22.4	15	55.4	
790	TS CP M Noshub	TSw2	32	7.00	2.80	1.00	1.00	1.00	12.80	12	3	5	27.5	15	70.5	
800	TS CP M Noshub	TSw2	0	5.00	3.00	1.00	1.00	5.00	1.00	12	3	5	26.5	15	66.5	
810	TS CP M Noshub	TSw2	14	5.00	3.00	1.00	1.00	1.00	5.25	12	3	5	26.5	15	66.5	
820	TS CP L Lsh	TSw2	4	5.00	2.10	1.22	1.00	1.00	1.91	12	3	5	23.1	15	59.1	
830	TS CP L Lsh	TSw2	0	5.00	3.00	1.00	1.00	7.50	0.87	7	3	5	28.5	15	61.5	
840	TS CP L Lsh	TSw2	0	5.00	3.00	1.00	1.00	1.00	5.00	12	3	5	28.5	15	66.5	
850	TS CP L Lsh	TSw2	6	5.00	3.00	1.00	1.00	1.00	3.75	12	3	5	28.5	15	66.5	
860	TS CP L Lsh	TSw2	0	5.00	3.00	1.22	1.00	5.00	0.88	12	3	5	27.2	15	55.2	
870	TS CP L Lsh	TSw2	0	5.00	3.00	2.33	1.00	1.00	2.14	12	3	5	21.7	15	59.7	
880	TS CP L Lsh	TSw2	0	4.00	3.00	1.00	1.00	5.00	1.50	12	3	5	28.5	15	63.5	
890	TS CP L Lsh	TSw2	0	5.00	3.00	1.00	1.00	1.00	5.00	12	3	5	28.5	15	66.5	
900	TS CP L Lsh	TSw2	5	5.00	3.00	1.00	1.00	1.00	3.75	12	3	5	28.5	15	66.5	
910	TS CP L Lsh	TSw2	27	4.00	2.80	1.50	1.00	1.00	12.80	12	3	5	26.8	15	69.8	
920	TS CP L Lsh	TSw2	6	5.00	3.00	1.00	1.00	1.00	5.00	12	3	5	28.5	15	66.5	
930	TS CP L Lsh	TSw2	0	5.00	3.00	1.00	1.00	5.00	0.75	12	3	5	28.5	15	66.5	
940	TS CP L Lsh	TSw2	0	7.00	3.00	1.00	1.00	5.00	0.88	12	3	5	29.5	15	66.5	
950	TS CP L Lsh	TSw2	5	5.00	3.00	1.00	1.00	5.00	1.20	12	3	5	28.5	15	66.5	
960	TS CP L Lsh	TSw2	39	5.00	3.00	1.00	1.00	7.50	1.88	12	3	5	28.5	15	71.5	
970	TS CP L Lsh	TSw2	13	5.00	3.00	1.00	1.00	5.00	1.20	12	3	5	28.5	15	66.5	
980	TS CP L Lsh	TSw2	24	7.00	3.00	1.00	1.00	7.50	1.37	12	3	5	28.5	15	66.5	
990	TS CP L Lsh	TSw2	26	4.00	2.84	1.00	1.00	7.50	2.55	12	3	5	28.5	15	71.5	
1000	TS CP L Lsh	TSw2	5	5.00	3.00	1.00	1.00	5.00	1.20	12	3	5	28.5	15	66.5	
1010	TS CP L Lsh	TSw2	20	5.00	3.00	1.00	1.00	1.00	10.00	12	3	5	28.5	15	66.5	
1020	TS CP L Lsh	TSw2	23	5.00	3.00	1.00	1.00	1.00	13.80	12	3	5	28.5	15	69.5	
1030	TS CP L Lsh	TSw2	0	9.00	2.10	1.22	1.00	1.00	1.91	12	3	5	23.1	15	59.1	
1040	TS CP L Lsh	TSw2	0	9.00	2.10	1.22	1.00	5.00	0.38	7	3	5	23.1	15	59.1	
1050	TS CP L Lsh	TSw2	0	9.00	2.10	1.22	1.00	7.50	0.28	12	3	5	23.1	15	61.1	
1060	TS CP L Lsh	TSw2	4	5.00	3.00	1.00	1.00	7.50	0.80	4	3	5	29.5	15	59.5	
1070	TS CP L Lsh	TSw2	5	7.00	3.00	1.00	1.00	1.00	4.29	7	3	5	28.5	15	61.5	
1080	TS CP L Lsh	TSw2	9	5.00	3.00	1.00	1.00	5.00	1.00	4	3	5	28.5	15	59.5	
1090	TS CP L Lsh	TSw2	30	5.00	2.50	1.78	1.00	1.00	8.44	4	3	5	23.4	15	59.4	
1100	TS CP L Lsh	TSw2	5	5.00	2.00	1.00	1.00	7.50	0.53	12	3	5	27.6	15	55.6	

J_w, SRF* = numerical values generated by Moore Code simulation, to calculate Q*

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al (1974)

Barton, N., R. Lien, and J. Lund, "Engineering Classification of Rock Masses for the Design of Tunnel Support,"

Rock Mechanics, 6 (19-24) Springer Verlag, 1974

Diederichs, E. T., "The Geomechanical Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Amsterdam, Switzerland, 2-11-88 (A. A. Brillman, 1989)

Q

J_w — Joint Set Number

J_r — Joint Roughness Number

J_a — Joint Alteration Number

J_s — Joint Water Reduction Factor

SRF — Stress Reduction Factor

$$Q = (RQD)(J_r)(J_a)(J_s)(J_w)(SRF)$$

RMR

C — Strength Index

RQD-I — RQD Index

JS — Joint Spacing Index

JC — Discontinuity Condition Index

JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
COMPARISON OF DOWNHOLE VIDEO DATA
WITH CORE DATA
Hole USW NRG-6**

Sandia National Laboratories
Print Date: 3/6/95
WBS 1.2.3.2.6.2
QA:L
Revision 0

EXPLANATION OF BOREHOLE WALL CATEGORY

- C1 Excellent, typically symmetrical hole with a smooth surface; no hole enlargement; no to few lithophysae; no pronounced fractures; minor "pluckouts."
- C2 Good, typically symmetrical hole with a smooth surface; hole enlargement small or intermediate but infrequent; no to few fractures; uniform lithophysae can be present.
- C3 Poor — typically a rough surface; hole enlargement is intermediate and frequent, but it is possible for hole to be symmetrical; lithophysae can be prevalent, large, and nonuniformly distributed; fractures are frequent.
- C4 Extremely poor, typically a nonsymmetrical hole having an extremely irregular surface; hole enlargement is large; large lithophysae can be present; fractures are frequent and pronounced.

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member	C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		C.P. Vitric	Crystal-Poor Vitric
B.T.	Bedded Tuff		
P.C.	Pah Canyon Member		
B.T.	Bedded Tuff		
T.S.	Topopah Spring Member	C.R. Vitric	Crystal-Rich Vitric
		C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. Lith.	Crystal-Rich Lithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
TCw—Tiva Canyon Welded Unit
PTn—Upper Paintbrush Nonwelded Unit
TSw1—Topopah Spring Welded Unit—Lithophysae Rich
TSw2—Topopah Spring Welded Unit—Lithophysae Poor
TSw3—Topopah Spring Welded Unit—Vitrophyre
CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Comparison of Downhole Video Data with Core Data

Hole USW NRG-6

Interval—0-150 ft (0.0-45.7 m), TCw Unit

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE ROD* %	ENHANCED ROD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	SCREEBLE WALL CATEGORY	DOWNHOLE		
									LITHOPHYSAR		
									Frequency	Size	Shape
10	T.C. C.P. L. Lith.	TCw	62	71	2	2.2	0.3	Hole Cased			
20	T.C. C.P. L. Lith.	TCw	62	69	7	1.5	0.1	Hole Cased			
30	T.C. C.P. L. Lith.	TCw	44	76	2	0.0	0.3	Hole Cased			
40	T.C. C.P. L. Lith.	TCw	63	71	1	0.0	0.4	Hole Cased			
50	T.C. C.P. L. Lith.	TCw	74	83	2	0.0		Hole Cased			
60	T.C. C.P. L. Nonlith.	TCw	22	61	1	0.5	0.6	Hole Cased			
70	T.C. C.P. L. Nonlith.	TCw	24	59	1	0.9	0.9	Hole Cased			
80	T.C. C.P. L. Nonlith.	TCw	22	36	0	0.2	0.5	Hole Cased			
90	T.C. C.P. L. Nonlith.	TCw	34	34	0	0.1	0.9	Hole Cased			
100	T.C. C.P. L. Nonlith.	TCw	35	66	0	0.0	0.2	Hole Cased			
110	T.C. C.P. L. Nonlith.	TCw	72	66	0	0.0		Hole Cased			
120	T.C. C.P. L. Nonlith.	TCw	48	67	0	0.0	0.3	Hole Cased			
130	T.C. C.P. L. Nonlith.	TCw	16	32	0	0.0	1.2	Hole Cased			
140	T.C. C.P. L. Nonlith.	TCw	32	39	0	0.6	1.2	Hole Cased			
150	T.C. C.P. Vitric	TCw	70	70	0	0.0		Hole Cased			

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED ROD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

DOWNHOLE VIDEO PARAMETERS:

Frequency- No, Rare, Occasional, Moderate, Frequent.

Size- Small, Medium, Large Cavities.

Shape- Oblate, Spherical.

Symmetry- Symmetric, Intermediate, Asymmetric.

Enlargement- No, Small, Intermediate, Large.

Frequency- None, Occasional, Intermediate, Continuous.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Comparison of Downhole Video Data with Core Data

Hole USW NRG-6

Interval—150-250 ft (45.7-76.2 m), PTn Unit

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD* %	ENHANCED RQD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	BOREHOLE WALL CATEGORY	DOWN HOLE VID		
									LITHOPHYSAE		
									Frequency	Size	Shape
160	T.C. C.P. Vitric	PTn	27	36	0	0.5	0.9	Hole Cased			
170	B.T.	PTn	31	68	0	2.7	0.5	Hole Cased			
180	P.C.	PTn	50	80	0	0.5		Hole Cased			
190	P.C.	PTn	67	73	0	1.1	0.4	Hole Cased			
200	P.C.	PTn	0	0	0	9.7	0.3	Hole Cased			
210	P.C.	PTn	16	44	0	4.0	1.1	Hole Cased			
220	P.C.	PTn	49	60	0	2.0	1.5	Hole Cased			
230	T.S. B.T.	PTn	72	80	0	0.4	0.3	Hole Cased			
240	T.S. B.T.	PTn	87	80	0	0.3	0.5	Hole Cased			
250	T.S. B.T.	PTn	85	81	0	0.8	0.1	Hole Cased			

* CORE RQD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

DOWNHOLE VIDEO PARAMETERS:

Frequency- No, Rare, Occasional, Moderate, Frequent.

Size- Small, Medium, Large, Coarse.

Shape- Oblate, Spherical.

Symmetry- Symmetric, Intermediate, Asymmetric.

Enlargement- No, Small, Intermediate, Large.

Frequency- None, Occasional, Intermediate, Continuous.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Comparison of Downhole Video Data with Core Data

Hole USW NRG-6

Interval—250-710 ft (76.2-216.4 m), TSw1 Unit

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD* %	ENHANCED RQD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	BOREHOLE WALL CATEGORY	DOWN HOLE VIDEO PARAMETERS			
									LITHOPHYSAE		BOREHOLE	
									Frequency	Size	Shape	Symmetry
260	T.S. C.R. Vitr.	TSw1	32	50	0	2.8	1.0	Hole Cased				
270	T.S. C.R. Nonlith.	TSw1	13	23	0	1.2	0.6	Hole Cased				
280	T.S. C.R. Nonlith.	TSw1	27	58	1	0.8		Hole Cased				
280	T.S. C.R. Nonlith.	TSw1	4	18	2	0.5	0.7	Hole Cased				
300	T.S. C.R. Nonlith.	TSw1	38	80	1	0.3	0.7	Hole Cased				
310	T.S. C.R. Nonlith.	TSw1	28	57	1	0.0	0.2	Hole Cased				
320	T.S. C.R. Nonlith.	TSw1	31	44	0	0.4	0.8	C2	M	S	O	S
330	T.S. C.R. Nonlith.	TSw1	33	50	0	0.0		C1	M	S	O	S
340	T.S. C.R. Nonlith.	TSw1	18	37	0	0.7		C1	O	L	O	S
350	T.S. C.R. Nonlith.	TSw1	5	20	0	0.6		C2	M	M	O	S
360	T.S. C.R. Nonlith.	TSw1	22	61	1	0.5	0.4	C2	M	M	O	S
370	T.S. C.R. Nonlith.	TSw1	33	61	1	2.6		C2	M	S	O	S
380	T.S. C.R. Nonlith.	TSw1	42	78	1	0.7		C1	N			S
390	T.S. C.R. Nonlith.	TSw1	68	90	0	0.0		C1	N			S
400	T.S. C.R. Nonlith.	TSw1	73	94	0	0.0		C1	N			S
410	T.S. C.R. Nonlith.	TSw1	70	73	0	0.0		C1	N			S
420	T.S. C.R. Nonlith.	TSw1	78	94	1	0.0	0.1	C1	R			S
430	T.S. C.R. Nonlith.	TSw1	71	84	1	0.0		C1	O	M	O	S
440	T.S. C.R. Lith.	TSw1	16	38	4	0.7	1.8	C2	O	M	O	S
450	T.S. C.R. Lith.	TSw1	27	55	10	3.7	0.6	C2	M	S	O	S
460	T.S. C.R. Lith.	TSw1	28	48	8	2.8	1.4	C2	O	M	O	S
470	T.S. C.R. Lith.	TSw1	18	41	8	0.7	3.1	C3	O	M	O	S
480	T.S. C.P. U. Lith.	TSw1	0	0	0	3.8	5.4	C3	O	M	O	S
490	T.S. C.P. U. Lith.	TSw1	0	11	0	3.0	4.2	C3	O	M	O	S
500	T.S. C.P. U. Lith.	TSw1	20	69	8	0.5	2.8	C2	M	S	O	S
510	T.S. C.P. U. Lith.	TSw1	31	81	10	4.7	2.0	C2	O	M	O	S
520	T.S. C.P. U. Lith.	TSw1	0	59	8	1.4	1.8	C2	M	M	O	S
530	T.S. C.P. U. Lith.	TSw1	12	67	8	1.8	1.1	C2	M	M	O	S
540	T.S. C.P. U. Lith.	TSw1	38	67	4	1.5	0.7	C2	M	M	O	S
550	T.S. C.P. U. Lith.	TSw1	80	88	10	0.2	0.3	C2	M	M	O	S
560	T.S. C.P. U. Lith.	TSw1	58	82	11	0.0	0.1	C2	F	M	O	S
570	T.S. C.P. U. Lith.	TSw1	48	82	8	0.3	1.4	C2	F	M	O	S
580	T.S. C.P. U. Lith.	TSw1	16	13	6	6.8	1.4	C3	O	M	O	S
590	T.S. C.P. U. Lith.	TSw1	4	16	10	6.4	2.0	C3	M	M	O	S
600	T.S. C.P. U. Lith.	TSw1	69	95	11	0.0	0.4	C2	F	M	O	S
610	T.S. C.P. U. Lith.	TSw1	14	43	11	4.1	0.5	C3	M	M	O	S
620	T.S. C.P. U. Lith.	TSw1	11	11	3	6.8	1.6	C3	M	M	O	S
630	T.S. C.P. U. Lith.	TSw1	13	50	4	3.1	1.5	C2	P	M	O	S
640	T.S. C.P. U. Lith.	TSw1	25	61	5	2.1	1.3	C2	M	M	O	S
650	T.S. C.P. U. Lith.	TSw1	21	50	5	1.0	2.0	C3	M	M	O	S
660	T.S. C.P. U. Lith.	TSw1	20	33	7	1.2	1.6	C2	M	M	O	S
670	T.S. C.P. U. Lith.	TSw1	30	54	4	1.7	1.8	C3	O	M	O	S
680	T.S. C.P. U. Lith.	TSw1	7	20	3	2.8	1.8	C2	O	M	O	S
690	T.S. C.P. U. Lith.	TSw1	11	42	3	2.8	1.5	C2	O	M	O	S
700	T.S. C.P. U. Lith.	TSw1	8	38	2	2.5	1.4	C2	O	L	O	S
710	T.S. C.P. U. Lith.	TSw1	9	35	2	1.9	2.2	C2	O	M	O	S

* CORE RQD Determined from piece lengths formed by all types of fractures (C, L, N and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

DOWNHOLE VIDEO PARAMETERS:

Frequency- No, Rare, Occasional, Moderate, Frequent.

Size- Small, Medium, Large, Cavemous.

Shape- Oblate, Spherical.

Symmetry- Symmetric, Intermediate, Asymmetric.

Enlargement- No, Small, Intermediate, Large.

Frequency- None, Occasional, Intermediate, Continuous.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Comparison of Downhole Video Data with Core Data

Hole USW NRG-6

Interval—710-1100 ft 216.4-335.3 m), TS2 Unit

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD*	ENHANCED RQD**	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	BOREHOLE WALL CATEGORY	DOWN HOLE VIDEO PARAMETERS				
									LITHOPHYSAB		BOREHOLE W		
									Frequency	Size	Shape	Symmetry	Scale
720	T.S. C.P. M. Nonlith.	TSw2	0	31	1	1.7	3.2	C2	O	M	O	S	
730	T.S. C.P. M. Nonlith.	TSw2	11	18	0	0.5	1.6	C2	R	M	O	S	
740	T.S. C.P. M. Nonlith.	TSw2	6	8	0	1.7	3.6	C2	R	M	O	S	
750	T.S. C.P. M. Nonlith.	TSw2	16	38	0	2.2	0.8	C2	R	L	O	S	
760	T.S. C.P. M. Nonlith.	TSw2	0	0	0	0.1	1.8	C2	O	M	O	S	
770	T.S. C.P. M. Nonlith.	TSw2	0	27	0	0.5	1.8	C2	O	M	O	I	
780	T.S. C.P. M. Nonlith.	TSw2	30	60	1	2.1	1.2	C3	N			I	
790	T.S. C.P. M. Nonlith.	TSw2	32	43	0	0.2	0.7	C2	N			I	
800	T.S. C.P. M. Nonlith.	TSw2	0	18	0	0.0	4.4	C3	N			I	
810	T.S. C.P. M. Nonlith.	TSw2	14	80	0	0.0	1.0	C3	O	M	O	A	
820	T.S. C.P. L. Lith.	TSw2	4	5	0	3.6	3.9	C4	O	L	O	A	
830	T.S. C.P. L. Lith.	TSw2	0	13	NM	2.6	4.6	C3	O	L	O	A	
840	T.S. C.P. L. Lith.	TSw2	0	27	0	3.2	2.1	C3	M	L	O	I	
850	T.S. C.P. L. Lith.	TSw2	0	29	0	2.6	2.2	C2	O	L	O	S	
860	T.S. C.P. L. Lith.	TSw2	0	39	0	0.0	2.4	C2	O	L	O	I	
870	T.S. C.P. L. Lith.	TSw2	0	18	0	2.1	2.8	C3	O	L	O	S	
880	T.S. C.P. L. Lith.	TSw2	0	8	0	1.0	1.8	C2	O	M	O	I	
890	T.S. C.P. L. Lith.	TSw2	0	35	0	2.4	0.7	C3	O	L	O	I	
900	T.S. C.P. L. Lith.	TSw2	6	33	0	3.3	2.1	C3	O	L	O	I	
910	T.S. C.P. L. Lith.	TSw2	27	47	0	1.8	0.2	C2	M	L	O	I	
920	T.S. C.P. L. Lith.	TSw2	6	14	0	3.9	3.0	C2	O	L	O	S	
930	T.S. C.P. L. Lith.	TSw2	0	33	1	6.2	1.3	C3	O	L	O	I	
940	T.S. C.P. L. Lith.	TSw2	0	67	1	3.1	0.5	C3	O	L	O	I	
950	T.S. C.P. L. Lith.	TSw2	6	44	2	2.8	1.7	C3	O	L	O	S	
960	T.S. C.P. L. Lith.	TSw2	39	74	1	0.8	0.8	C3	M	M	O	I	
970	T.S. C.P. L. Lith.	TSw2	12	63	1	3.7	0.8	C3	M	L	O	I	
980	T.S. C.P. L. Lith.	TSw2	24	67	2	0.5	0.6	C3	O	C	O	I	
990	T.S. C.P. L. Lith.	TSw2	26	40	2	2.4	1.3	C3	M	L	O	I	
1000	T.S. C.P. L. Lith.	TSw2	5	41	1	3.0	2.6	C4	M	L	O	A	
1010	T.S. C.P. L. Lith.	TSw2	20	38	0	2.0	2.9	C4	M	L	O	A	
1020	T.S. C.P. L. Lith.	TSw2	22	46	0	3.6	1.5	C3	O	L	O	A	
1030	T.S. C.P. L. Lith.	TSw2	0	5	0	2.3	1.4	C4	O	L	O	A	
1040	T.S. C.P. L. Lith.	TSw2	0	0	0	5.8	2.8	C4	O	L	O	A	
1050	T.S. C.P. L. Lith.	TSw2	0	21	0	3.9	3.4	C4	M	L	O	I	
1060	T.S. C.P. L. Lith.	TSw2	4	28	0	4.4	1.3	C3	M	L	O	I	
1070	T.S. C.P. L. Lith.	TSw2	5	37	0	1.0	2.5	C3	M	C	O	S	
1080	T.S. C.P. L. Lith.	TSw2	8	27	1	3.7	1.7	C3	M	C	O	S	
1090	T.S. C.P. L. Lith.	TSw2	30	48	1	0.3	0.5	C3	M	C	O	S	
1100	T.S. C.P. L. Lith.	TSw2	5	22	0	4.0	1.1	C3	M	L	O	S	

* CORE RQD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

DOWNHOLE VIDEO PARAMETERS:

Frequency- No, Rare, Occasional, Moderate, Frequent.

Size- Small, Medium, Large Cavernous.

Shape- Oblate, Spherical.

Symmetry- Symmetric, Intermediate, Asymmetric.

Enlargement- No, Small, Intermediate, Large.

Frequency- None, Occasional, Intermediate, Continuous.

☐ Indicates outlying points excluded in calculating the final Schmidt Hardness Value.

Summary of Laboratory Testing Data for Hole USW NRG-6—NRG Holes

Depth (m)	(ft)	Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
									Confined Pressure	Axial Stress		
6.77	22.2-A	Tiva Canyon Crystall-Poor Lower Lithophysae Zone	Tiva Canyon Welded Unit TCW	313.6	5.7	36.7	0.22	2.35				
6.77	22.2-B				5.6	36.9	0.23	2.36	10.00	439.70		
6.77	22.2-C				5.8	38.1	0.20	2.35	10.00	434.60		
6.77	22.2-D				6.7	35.6	0.21	2.33	10.00	343.40		
6.77	22.2-E				5.3	38.3	0.21	2.36	10.00	417.30		
6.77	22.2-F				5.1	36.4	0.22	2.37	5.00	395.50		
6.77	22.2-G				5.2	37.4	0.22	2.37	5.00	391.20		
6.77	22.2-H				5.7	36.8	0.21	2.35	5.00	396.80		
6.77	22.2-I				5.5	36.3	0.20	2.36	5.00	307.10		
6.77	22.2-J			315.8	5.5	37.2	0.21	2.36	0.00	315.80		
6.77	22.2-K			284.2	5.3	37.4	0.20	2.36	0.00	284.20		
6.77	22.2-L			313.8	5.2	36.4	0.22	2.37	0.00	313.80		
6.77	22.2-M							2.36	0.00	332.40		
6.77	22.2-N											2.50
7.13	23.4-A			303.7	4.8	39.0	0.22	2.36				
7.13	23.4-B				5.6			2.35			16.00	
7.13	23.4-C				5.5			2.36			13.20	
7.13	23.4-D											2.49
8.78	28.8-A											2.51
29.90	98.1-A	Tiva Canyon Crystall-Poor Lower Nonlithophysal Zone		245.6	7.4	30.0	0.24	2.31				
29.90	98.1-B			242.2	7.5	29.2	0.25	2.31				
29.90	98.1-C				7.3			2.31			10.60	
29.90	98.1-D				7.4			2.31			11.30	
29.90	98.1-E											2.49
33.83	111.0-A			78.2	11.1	23.1	0.21	2.22				
33.83	111.0-B			114.1	10.5	26.5	0.21	2.24				
33.83	111.0-C				10.4			2.24			8.20	
33.83	111.0-D				11.1			2.22			12.10	
33.83	111.0-E											2.50
43.74	143.5-A	Tiva Canyon Crystall-Poor Vitic Zone		61.8	22.2	14.8	0.13	1.90				
43.74	143.5-B											2.44
44.41	145.7-A				29.7			1.72			4.50	
44.41	145.7-B											2.44
46.09	151.2-A			11.3	40.8	5.9	0.13	1.43				
46.09	151.2-B		Upper Paintbrush Nonwelded Unit		40.8			1.43			1.90	

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-6--NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)	
(m)	(ft)								Confined Pressure	Axial Stress			
46.09	151.2-C	Crystal-Poor Virric (continued) Bedded Tufts	Upper Paintbrush Nonwelded Unit PTn (continued)									2.42	
46.60	152.9-A											2.40	
49.20	161.4-A			3.5	38.5	2.9	0.16	1.49					
49.20	161.4-B												
51.66	169.5-A			5.9	39.9	2.4	0.12	1.50				2.42	
51.66	169.5-B												
53.04	174.0-A			4.3	54.4	1.2	0.21	1.10				2.50	
53.04	174.0-B				55.7			1.07					
53.04	174.0-C											0.30	
55.54	182.2-A	Pah Canyon										2.41	
55.54	182.2-B			3.3	56.6	0.8	0.23	1.04					
55.54	182.2-C				55.6			1.06			0.40		
57.00	187.0-A				4.1	53.3	1.3	0.34	1.11			2.39	
57.00	187.0-B											2.38	
67.67	222.0-A	Bedded Tufts		4.8	43.9	1.5	0.23	1.40					
67.67	222.0-B			46.3			1.33			0.30			
67.67	222.0-C											2.49	
69.46	227.9-A		2.7	56.6	0.7	0.23	1.03					2.36	
69.46	227.9-B												
73.61	241.5-A		2.1	58.2	0.5	0.29	1.03						
73.61	241.5-B			59.4			1.00			0.20			
73.61	241.5-C											2.46	
84.19	276.2-A	Topopah Spring Crystal-Rich Nonlithophysal Zone	Topopah Spring Welded Unit Lithophysal-Rich TSW1	118.6	10.2	31.2	0.21	2.30					
84.19	276.2-B				10.1			2.31			8.40		
84.19	276.2-C											2.57	
84.58	277.5-A											2.57	
92.78	304.4-A			102.2	11.3	28.1	0.21	2.27					
92.78	304.4-B				10.6			2.29			9.30		
92.78	304.4-C											2.56	
96.41	316.3-A			79.2	15.5	22.0	0.26	2.19					
96.41	316.3-B											2.59	
96.99	318.2-A			77.2	15.1	22.4	0.27	2.19					
96.99	318.2-B		14.1			2.22			7.60				
96.99	318.2-C									2.59			
97.87	321.1-A									2.59			

Summary of Laboratory Testing Data for Hole USW NRG-6—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
100.19	328.7-A	Topopah Spring Crystal-Rich Nonlithophysal Zone (continued)	Topopah Spring Welded Unit Lithophysal- Rich TSw1 (continued)	73.2	16.5	21.5	0.29	2.17				
100.19	328.7-B			72.8	15.9	23.8	0.24	2.18				
100.19	328.7-C											2.59
108.02	354.4-A			32.4	16.4	17.0	0.15	2.16				
108.02	354.4-B											2.59
108.17	354.9-A											2.59
108.33	355.4-A				15.9			2.17				
108.33	355.4-B										5.30	2.58
113.57	372.6-A			33.3	15.4	15.1	0.16	2.17				
113.57	372.6-B											2.57
113.72	373.1-A			68.8	16.6	21.2	0.25	2.15				
113.72	373.1-B											2.57
113.87	373.6-A											2.57
113.87	373.6-B				14.5			2.20			6.60	
119.36	391.6-A			58.3	13.3	20.6	0.22	2.22				
119.36	391.6-B											2.56
119.51	392.1-A											2.56
119.67	392.6-A											2.55
119.67	392.6-B				12.4			2.23			6.50	
120.40	395.0-A											2.55
120.40	395.0-B				11.4			2.26			6.80	
120.46	395.2-A			48.4	12.4	21.8	0.21	2.23				
120.46	395.2-B											2.54
121.01	397.0-A			60.4	12.2	20.6	0.29	2.25				
121.01	397.0-B											2.56
121.16	397.5-A											2.55
121.16	397.5-B				11.8			2.25			4.70	
124.06	407.0-A											2.55
124.06	407.0-B				12.2			2.24			5.10	
124.12	407.2-A			56.8	12.5	20.1	0.27	2.23				
124.12	407.2-B											2.55
126.80	416.0-A											2.55
126.80	416.0-B				11.2			2.26	10.00	119.90		
126.80	416.0-C				11.0			2.27	10.00	147.90		
126.80	416.0-D				11.0			2.27	10.00	61.10		

Summary of Laboratory Testing Data for Hole USW NRG-6—NRG Holes

Depth (m)	Depth (ft)	Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
									Confined Pressure	Axial Stress		
126.80	416.0-F	Topopah Spring Crystal-Rich Nonlithophysal Zone (continued)	Topopah Spring Welded Unit Lithophysal- Rich TSW1 (continued)		12.1			2.24	5.00	77.10		
126.80	416.0-G				13.7			2.20	5.00	39.60		
126.80	416.0-H				12.2			2.24	5.00	84.70		
126.80	416.0-I				12.4			2.23	5.00	58.80		
128.26	420.8-A			36.2	13.2	12.2	0.33	2.20				
128.26	420.8-B											2.54
128.47	421.5-A											2.53
128.47	421.5-B				14.2			2.17			4.10	
130.15	427.0-A			43.4	14.1	14.2	0.19	2.17				
130.15	427.0-B				12.6			2.21			4.00	
130.15	427.0-C											2.53
140.91	462.3-A	Topopah Spring Crystal-Rich Lith. Topopah Spring Crystal-Poor Upper Lithophysal Zone			13.8			2.17			5.20	
140.91	462.3-B			149.4	11.4	33.3	0.21	2.22				2.52
148.74	488.0-A											2.50
148.74	488.0-B											2.53
150.88	495.0-A				29.8							
150.88	495.0-B											2.52
153.26	502.8-A				20.2							
153.26	502.8-B											2.51
164.35	539.2-A				24.4							
164.35	539.2-B											2.50
164.53	539.8-A											2.53
164.53	539.8-B				22.5							
168.86	554.0-A				21.1							2.51
168.86	554.0-B											
172.18	564.9-A				32.1							
172.18	564.9-B				13.6			2.19			5.10	
195.07	640.0-A											2.53
195.07	640.0-B											2.54
198.00	649.6-A				21.8							
198.00	649.6-B			50.4	15.3	29.2	0.38	2.15				
201.84	662.2-A											2.53
201.84	662.2-B											2.54
205.25	673.4-A											
205.25	673.4-B				18.3							2.54

Summary of Laboratory Testing Data for Hole USW NRG-6—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
209.55	687.5-A	Crystal-Poor Upper Lithophysal (continued)	TSw1 Unit (continued)	95.8	12.4	24.6	0.12	2.22			8.70	
209.55	687.5-B				11.9			2.23				
209.55	687.5-C											2.54
219.67	720.7-A	Topopah Spring Crystal-Poor Middle Nontolithophysal Zone	Topopah Spring Welded Unit Lithophysal-Poor TSw2	235.5	8.5	37.1	0.19	2.29				2.50
219.67	720.7-B											2.50
226.26	742.3-A			162.3	11.0	30.6	0.20	2.25			14.50	
226.26	742.3-B				9.7			2.28				
226.26	742.3-C											2.53
226.44	742.9-A			212.8	10.0	32.4	0.22	2.28			13.00	
226.44	742.9-B				10.3			2.27				
226.44	742.9-C											2.53
232.53	762.9-A			112.1	9.5	29.2	0.18	2.31				
232.53	762.9-B											2.55
235.77	773.5-A			117.4	10.3	36.2	0.23	2.26			7.90	
235.77	773.5-B				11.9			2.22				
235.77	773.5-C											2.52
239.21	784.8-A			223.0	9.6	29.7	0.17	2.27				
239.21	784.8-B				9.6			2.27			12.50	
239.21	784.8-C											2.51
239.45	785.6-A			218.6	9.3	30.1	0.16	2.27				
239.45	785.6-B				9.3			2.27			14.10	
239.45	785.6-C											2.51
245.92	806.8-A			261.9	8.0	31.7	0.16	2.31				
245.92	806.8-B											2.51
258.47	848.0-A	Topopah Spring Crystal-Poor Lower Lithophysal Zone		175.5	10.9	34.6	0.19	2.32				
258.47	848.0-B				10.0			2.34			7.90	
258.47	848.0-C											2.61
276.15	906.0-A											2.60
276.15	906.0-B				10.8							
276.82	908.2-A				10.5						8.80	
276.82	908.2-B							2.31				2.58
284.69	934.0-A				12.6			2.25			10.80	
284.69	934.0-B				12.4			2.26			4.00	
284.69	934.0-C									2.58		
286.67	940.5-A									2.56		

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-6—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
286.67	940.5-B	Topopah Spring Crystal-Poor Lower Lithophysal Zone (continued)	Topopah Spring Welded Unit Lithophysal- Poor TSw2 (continued)		10.4							
290.54	953.2-A			31.6	17.6	16.9	0.11	2.10				
290.54	953.2-B											2.55
291.64	956.8-A				16.4			2.12			5.30	
291.64	956.8-B											2.54
293.62	963.3-A			56.3	14.8	19.3	0.31	2.17				
293.62	963.3-B				14.1			2.18			3.20	
293.62	963.3-C											2.54
295.45	969.3-A				13.5			2.21			7.50	
295.45	969.3-B											2.55
295.45	969.3-C				15.5							
296.09	971.4-A			97.3	12.4	27.4	0.19	2.23				
296.09	971.4-B				10.4			2.28			11.70	
296.09	971.4-C											2.54
296.39	972.4-A											2.55
296.39	972.4-B				11.8							
300.45	985.7-A			177.3	9.9	37.6	0.25	2.30				
300.45	985.7-B											2.55
310.23	1017.8-A			84.9	12.7	27.4	0.23	2.25				
310.23	1017.8-B											2.57
330.71	1085.0-A											2.56
330.71	1085.0-B				17.5							

 No Tests Conducted

APPENDIX I

USW NRG-7/7A

Geology and Rock Structure Log

Core Hole Rock Structural Data Summary

Estimated Rock Mass Quality Indices Based on Core Log Data

Comparison of Downhole Video with Core Data

Schmidt Hammer Tests

Summary of Laboratory Testing Data

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
GEOLOGY AND ROCK STRUCTURE LOG
USW NRG-7/7A

Sandia National Laboratories
Print Date: 2/4/95
WBS 1.2.3.2.6.2
QA: QA
Revision 1

REVISION HISTORY

Revision 1 Change in method for calculating % lithophysae. Survey coordinates and elevation revised. Data from 770-1510 ft included. Corrected study plan number on cover.

BOREHOLE ID: USW NRG-7/7A
STUDY PLAN NO: 8.3.1.14.2
CORE SIZE: HQ
DRILL DATES: 10/21/93-3/4/94
GROUND ELEV: 4207.17 ft
COORDINATES: N: 768,880.11 ft
E: 562,983.99 ft

TOTAL DEPTH: 1513.4 ft
ANGLE FROM VERT: 0°
AZIMUTH: NA

Field Rock Structure

Field Log by:

Linden Kirkwood
Switzer Mendenhall
Henson Myers
Wilcoxon Wagner
Pitterle

Relogged by:

Richard Lippoth and
Eric Martin

Agapito Associates, Inc.

Lithology and Stratigraphy

Logged by:

Dale Engstrom Sandia National Laboratories

Checked by:

Carl Brechtel
Eric Martin

Agapito Associates, Inc.
Agapito Associates, Inc.

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

EXPLANATION GEOLOGY AND ROCK STRUCTURE

FRACTURE TYPE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition, not a fracture.

LOST CORE AND RUBBLE

LOST CORE

20 RUBBLE ZONE

(with average maximum diameter of rubble pieces to nearest 0.01 ft; NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.
- 8 Soil Like—Cohesive
- 9 Soil Like—Non-cohesive

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

ROUGHNESS

INFILLING THICKNESS AND MINERALIZATION

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

- C Clean, no filling
- S Very thin, surface sheen
- T Thin (up to 0.1 inches)
- M Moderately thick (0.1 - 0.4 inches)
- V Very thick (0.4 - 1.0 inches)
- E Extremely thick, greater than 1.0 inches)
- C Clean

- WC White, crystalline
- WN White, non-crystalline
- BC Black crystalline
- BD Black dendritic
- TD Brown dendritic
- TC Tan crystalline
- TN Tan, non-crystalline
- BN Brown, non-crystalline
- CA Calcite
- SI Silica
- MN Manganese
- CL Clay
- FE Iron Oxide

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100 .$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If a piece length ≥ 0.33 ft crosses over the 10-ft interval boundary the portion of the piece length that occurs in the 10-ft interval is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on comparison of the core with charts designed for estimating the proportions of various rock or mineral components. Estimates are then spot checked using a quantitative graphical summation technique to calculate the percent area occupied by lithophysal cavities in core photographs or video tape.

The estimated percent cavities volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured;" zones containing vapor-phase alteration and very small or no lithophysal cavities are labeled as <1%).

Reference: USGS—Graphical Lithologic Log of Borehole NRG-7/7A, Thomas Moyer and Jeffrey Geslin (DTN: GS940408314211.020).

USW NRG-7/7a (1 of 2)

Stratigraphic and Thermomechanical Units Summary

0 - 881 ft

USW NRG-7/7a (2 of 2)
Stratigraphic and Thermomechanical Units Summary
881 - 1513 ft

Stratigraphy

**Thermomechanical
Units**

Unresolved contact showing difference between criteria. Solid line shows contact based on Scott & Bonk¹, dashed line is contact based on USGS².

Date: 12/9/94

¹ U. S. Geological Survey - Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, With Geologic Sections, Robert B. Scott and Jerry Bonk, USGS Open File Report 84-494.

² U. S. Geological Survey - Graphical Lithologic Log of Borehole NRG-7/7a, Thomas Moyer and Jeff Geslin, DTN:GS940408314211.020.

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % FRACTURE FILLING AND OTHER CAVITIES	Argillite	Litholite	Vapor Ph.	Desulfurization	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (O) (CON. BRO-50)	LOST CORE & RIMMERS	TYPE	PLANARITY	ROUGHNESS	IRREG.	THICKNESS AND MINERALS	TOP	INDUCED	PIECES LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND UNDETERMINED (+ INDUCED)									
	1.0	14	11																							
	1.0	14	11																							
5.0	1.0	14	11																							
	1.0	14	11																							
	1.0	14	11																							
10.0	1.0	14	11																							
	1.0	14	11																							
	1.0	14	11																							
15.0	1.0	14	11																							
	1.0	14	11																							
	1.0	14	11																							
20.0	1.0	14	11																							
	1.0	14	11																							
	1.0	14	11																							
25.0	1.0	14	11																							
	1.0	14	11																							
	1.0	14	11																							

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQR (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOMYCE AND OTHER CAVITIES	Argillic Lithomyc.	Vapor Ph.	Dissolution	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY			
	INTERVAL	% RECOVERY (GAIN ROD-RO)	LOST CORE	FLA. BUBBLE	FLA. TYPE	FLA. PLANKET	FLA. RODNESS	FLA. TYP. TYP.	FLA. TYP. TYP.	FLA. TYP. TYP.	FLA. TYP. TYP.	FLA. TYP. TYP.	FLA. TYP. TYP.	FLA. TYP. TYP.	FLA. TYP. TYP.	FLA. TYP. TYP.	FLA. TYP. TYP.	NATURAL AND INDUCED	NATURAL AND INDUCED	NATURAL AND INDUCED										10	20	30
30.0	RUN 14	100 (1.0)	X.07>																													Tiva Canyon—Hackly Zone (continued)
																																SR 6/1
																																— 30.0 ft. Pink clay replacement of pumice pseudomorphs.
35.0	RUN 15	100 (1.0)	X.08>																													33.2-69.7 ft. Tiva Canyon—Calumet Zone (cc): (approx. contact) Medium red-gray, densely welded ash-flow tuff. Black vitric pumice fragments become very fine (5:1) 3%, weak vapor-phase mineralization in halos around pumice, lithics and phenocrysts, some older fractures healed by white vapor-phase mineralization; becomes harder, lighter in color and slightly more argillized downward. Gradually more light gray, more argillic altered.
40.0	RUN 17	100 (1.0)	X.08>																													
45.0	RUN 18	100 (1.0)	X.08>																													
50.0	RUN 19	100 (1.0)	X.08>																													

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[illegible]

STRUCTURE file: 0007056A.FTB Ideology file:

Date: 05/15/14

WFLA-TV \$4.50

DEPTH (FT)	CORE		FRACTURES					ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES PER FOOT					HARDNESS	WEATHERING	ESTIMATED % LITHOCLASTIC AND OTHER CAVITIES	Apatite	Lithol.	Vapor Ph.	Debris/fragm.	Weathering	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED FRACTURES (% INDUCED)												
77.2	77.2-79.0	79 (61)		N	PO	GRY	45		2.40						51%					0%							77.2-102.6 ft, Tiva Canyon--Basal Nonwelded Subzone: Gradational contact to nonwelded pumice-rich ash-flow tuff, distinctive by black glass shard content. Equest pumice up to 35-mm diameter, 20% are vitric, devitrified shards, light orange-tan, weakly crystallized, especially 81.0-85.8 ft.
80.0	79.0-80.5	94 (59)		N	PO	GRY	30		1.19																		78.0 ft, Light brown shards
85.0	80.5-81.0	100 (61)		N	PO	GRY	30		1.10						9%					0%							80.5 ft, Light brown and black shards
85.5	81.0-85.5	100 (61)		N	PO	GRY	30		1.00																		85.5-94.0 ft, Black shard-dominant section, gradually lessening upward and downward to dark orange-gray ash-flow tuff with orange-gray pumice.
90.0	85.5-90.0	94 (61)		N	PO	GRY	30		.70																		5 YR 5/1
95.0	90.0-95.0	61 (21)		N	PO	GRY	30		.60						50%					0%							95.0-102.0 ft, Partial to non-welded, vitric with black shards. Size pumice decreasing to 3-4 mm but occasionally up to 23 mm.
100.0	95.0-100.0			N	PO	GRY	30		.60																		

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGY LOSS DURING CORING				Argillite	Lithopel.	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERNAL	% RECOVERY (PER 10 FT)	LOG CORE & RUBBLE	FRAC. TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	IMP.	INDUCED	SPICE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDENTATION RATE (LBS/INCH)	10	20	30		10	20	30									
105.0	→	100 (51)	XXXXXX									.50				31%																	Ash Fall/Pumice Fall (pumiceol): 102.6-106.4 ft, Bedded Tuff: Light brown-gray, weak limonitic zone at top, all pumice zone at bottom, argillite altered devitrified matrix, devitrified pumice fragments, 15-20% sanidine phenocrysts, 2-3% lithics, reworked 104.1-106.4 ft.	
110.0	→	90 (34)	XXXXXX									.60																						106.4-109.5 ft, Yucca Mountain Tuff: Light medium brown (5 YR 7/2), weak to partially welded, vitric ash-flow tuff; 3-5% cognate lithics, 1/2-1% exotic lithics mostly rhyolite composition, <1% sanidine, biotite and possibly zircon phenocrysts (aphytic); sandy texture 106.4-110.6 ft, possibly reworked, less dense, weakly argillized with depth, ~15-20% rock volume is bubble shards with hollow complete bubbles creating 1-2% porosity.
115.0	→	100 (34)	XXXXXX									.70				39%																		
120.0	→	100 (50)	XXXXXX									.45																						
125.0	→	100 (12)	XXXXXX									.50				14%																		

Structure File: R007806A.DSR Lithology File:

Date: 06/15/94

WPlot v 4.40

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			SOUNDNESS	WEATHERING	ESTIMATED % LITHOMATERIAL AND OTHER CAVITIES	Argill. Lithol.	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-W)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECES LENGTH	VERY POOR	POOR	FAIR	GOOD	NATURAL AND INTERMEDIATE (+ INDUCED)									
					PS		SCL		5					14%											Yucca Mountain—Tuff (continued)
	RUN 39				PS		SCL		75																
					PS		SCL		15																
130.0		100 (60)																							
	RUN 40																								
135.0		100 (66)																							
	RUN 41																								
140.0		46 (10)																							
	RUN 42																								
145.0		25 (0)																							
	RUN 43																								
150.0																									

DEPTH (FT)	CORR	FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HAZARDS	WEATHERING	ESTIMATED % LITHOPHASES AND OTHER CAVITIES					Asphic Lithoph.	Vapor Ph.	Deveification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
		INTERVAL	% RECOVERY (IN RQD-%)	LOST CORE & RUBBLE	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS	MINERALS	DIP	REDUCED	RECS LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)			10	20	30	40	50							
155.0		RUN 44	0																0 (3)						0%								
160.0		RUN 45	100																														
165.0		RUN 46	94																25%							0%							
170.0		RUN 47	96																														
175.0		RUN 48	96																48%							0%							

160.5-165.6 ft. Bedded Tuff: (sharp contact) coarse grained, light orange-gray (10 YR 8/2) moderately well-sorted pumice fall tuff, 2-8 mm pumice clasts (60% vitric) weakly consolidated.

163.3-166.6 ft. Becomes unconsolidated sandy lapilli.

165.6-176.1 ft. Unmatted Ash-Flow Tuff: (sharp contact) Light medium yellow-gray (10 YR 8/3) pumice-rich ash-flow tuff, nonwelded, 15-25% vitric to devitrified, 5-10 mm pumice, 5-7% dark lithic, 10% exotic rhyolitic lithic 2-3 mm. Top 1 ft possibly reworked; white argillized pumice increased downward becoming crowded at bottom, 5% of pumice fragments vitric.

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Statement of [Name] regarding [Topic] and [Topic] Category [Name]

Page 57/159

NT100 4.50

DEPTH (FT)	CORES		FRACTURES							ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (FEET IN FT)			HAZARDOUS	WEATHERING	ESTIMATED % LIQUIDITY LOSS (OTHER CAUSES)	Aqueous Liquor Vapor Ph. Deviation Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
	EXTERNAL	% RECOVERY (RQD) (RQD) (RQD)	LOST CORE & RUBBLES	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MATERIALS	DIP	INDUCED	MEAS. LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT							NATURAL AND INDUCED FRACTURES (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD, %)					FRACTURES (PER 10 FT)			ESTIMATED % ESTIMATED LITHOMYCEAL AND OTHER CAVITIES	Acidic Lithoph.	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-9)	LOST CORE & SUTBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)								
	230.0	95 (52)	X							2.80						7)			0%					Peh Canyon Tuff (continued) 227.5 ft, 8-inch vitric pumice clast
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
	235.0	92 (58)	X							.65						10)			0%					Peh Canyon Tuff (continued) 227.5 ft, 8-inch vitric pumice clast
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
	240.0	100 (64)	X							.65														Peh Canyon Tuff (continued) 227.5 ft, 8-inch vitric pumice clast
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
	245.0	97 (91)	X							.65														Peh Canyon Tuff (continued) 227.5 ft, 8-inch vitric pumice clast
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
										.65														
	250.0									1.15														Peh Canyon Tuff (continued) 227.5 ft, 8-inch vitric pumice clast
										1.15														
										1.15														
										1.15														
										1.15														
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										1.15														
										1.15														
										1.15														
										1.15														

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-ROD (S)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % FRACTURED & DISCONTINUITIES AND OTHER CAVITIES				Angular Lithology	Vapor Pk.	Deviation	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	INTERNAL	% RECOVERY (SEE REGR.)	LAST CORE & YRABLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	SPALL	THICKNESS AND	MINORALS	DP	INDUCED	ROCK LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT			NATURAL AND DISCONTINUITIES (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
	→	100 (85)										1.15							7	8																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

258.7-264.0 ft, Bedded Tuff: Light brown-gray (10 YR 8/1) nonwelded, devitrified, pumice-rich ash-flow tuff, 15-25% blue-gray pumice clasts up to 20 mm, 1-2% sanidine phenocrysts, quartz phenocrysts, biotite phenocrysts, 2-3% lithic rhyolite to dark red-brown exotic, 1% black glass shards.

260.6-261.4 ft, Unconsolidated sand zone

264.8-295.9 ft, Topopah Spring—Upper Crystal-Rich Nonwelded Zone: Medium orange-brown dark red-brown top (10R 3/3), nonwelded, devitrified, pumice-rich ash-fall tuff, 7-8% white devitrified pumice to 20 mm in waddy devitrified matrix, 1-2% sanidine, biotite phenocrysts, lithic less common 1-2%, lumpy texture at 285.0 ft suggests quiet pumice-fall.

GEOLOGY AND ROCK STRUCTURE LOG

**Sandja National Laboratories
by J.F.T. Agapito & Assoc., Inc.**

I-20

[illegible]

SCHUBERT, Sir | MATHIAS A. STEINBOCK | Ethology [Eti.]

Date: 05/16/94

MP 100 + 4.50

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LOSS OF STRENGTH AND OTHER CAVITIES				Appl. Lib. Vapor Ph. Dev. Calc. Wetting	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (XRD RED-6)	LOST CORE & RUMBLE	FRACTURE TYPE	PLANARITY	IRREGULARITY	THICKNESS	AND MINERALS	DP	DP	DP	DP	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	10	20	30			10	20	30	40			
	100	(0)																											
	100	(0)																											
305.0	100	(0)																											
	100	(0)																											
	100	(0)																											
310.0	100	(1B)																											
	100	(1B)																											
	100	(1B)																											
	100	(1B)																											
315.0	100	(1B)																											
	100	(1B)																											
	100	(1B)																											
	100	(1B)																											
320.0	100	(0)																											
	100	(0)																											
	100	(0)																											
	100	(0)																											
325.0	100	(0)																											
	100	(0)																											
	100	(0)																											
	100	(0)																											

Structure file: HSD7706A.STR Lithology file:

Date: 06/16/94

NWlog v 4.60

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Laboratories
by J.P.T. Agapito & Assoc., Inc.

CORE			FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)				HAZINESS	WEATHERING	ESTIMATED % FRACTURE, VESICULARITY AND OTHER CAVITIES				Asphic Lithol.	Vapor Ph.	Deviation	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
DEPTH (FT)	INTERNAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	ROP	REDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)						10	20	30	40						
330.0	RUN B1			N I	PS		0++			5																							Topopah Spring Crystal-Rich Neolithophysal Zone (continued)
				N I	PS		0++			10 30																							
			X.12	N I	PS		0++			15 5																							
				N I	PS		0++			20 10																							
				N I	PS		0++			25 5																							
				N I	PS		0++			30 5																							
				N I	PS		0++			35 5																							
			X.13	N I	PS		0++			40 5																							
			X.05	N I	PS		0++			45																							
			X.04	N I	PS		0++			50																							
				N I	PS		0++			55																							
335.0	RUN B2			N I	PS		0++			5																							328.2 ft, Large pumice-rich xenoliths 329.0 ft, Large pumice-rich xenoliths 331.0 ft, Pervasive vapor-phase mineralization replaces and rims small pumice fragments, - 40% groundmass recrystallized by vapor-phase alteration, becoming more intense, pervasive downward 332.0 ft, Few small weakly developed lithophysas, or small cavities that probably resulted from vapor-phase corrosion of pumice. 330.0-340.0 ft, Core dusty
				N I	PS		0++			10 15																							
				N I	PS		0++			15																							
				N I	PS		0++			25 5																							
				N I	PS		0++			30																							
				N I	PS		0++			35																							
				N I	PS		0++			40																							
				N I	PS		0++			45																							
				N I	PS		0++			50																							
				N I	PS		0++			55																							
340.0	RUN B3			N I	PS		0++			5																							Vapor-phase mineralization increasing Core becoming lighter color due to pervasive vapor-phase alteration, pumice fragments replaced, rimmed by vapor-phase mineralization, 45-55% matrix is vapor-phase replaced, creates 25% void (porosity).
				N I	PS		0++			10 15																							
				N I	PS		0++			20 10																							
				N I	PS		0++			25 5																							
				N I	PS		0++			30																							
				N I	PS		0++			35																							
				N I	PS		0++			40																							
				N I	PS		0++			45																							
				N I	PS		0++			50																							
				N I	PS		0++			55																							
345.0	RUN B4			N I	PS		0++			5																							
				N I	PS		0++			10 15																							
				N I	PS		0++			20 10																							
				N I	PS		0++			25 5																							
				N I	PS		0++			30																							
				N I	PS		0++			35																							
				N I	PS		0++			40																							
				N I	PS		0++			45																							
				N I	PS		0++			50																							
				N I	PS		0++			55																							
350.0	RUN B5			N I	PS		0++			5																							
				N I	PS		0++			10 15																							
				N I	PS		0++			20 10																							
				N I	PS		0++			25 5																							
				N I	PS		0++			30																							
				N I	PS		0++			35																							
				N I	PS		0++			40																							
				N I	PS		0++			45																							
				N I	PS		0++			50																							
				N I	PS		0++			55																							
				N I	PS		0++			60																							

Structure file: PROTHVER.DIR Lithology file:

Date: 06/16/94

WFLog v 4.04

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DETERMINATION-RQR (S)						FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED & LITHOPHYSE AND OTHER CAVITIES	APPLICABLE LITHOLOGY	VAPOR PHASE DETERMINATION	WELDING	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
	INTERVAL	% RECOVERY (RUN ROD-85)	LOST CORES & SPLIT	TYPE	PLANARITY	ROUGHNESS	UNPL. THICKNESS AND MINERALS	DIP	INDUCED	FLYING RQR	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND UNDETERMINED (+ INJECTED)	10	20									30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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DEPTH (FT)		CORE		FRACTURES										ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER M FT)					HAZARD					ESTIMATED % LITHOMYCELE AND OTHER CAVITIES					Argillic Lithoph. Vapor Ph. Devitrification Welding					Geology					LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
INTERVAL		% RECOVERY (RIN BQ-B)		LAST CORRECTION		PLANARITY		ROUGHNESS		INFILL		TECHNIQUES AND MINERALS		DIP		INDUCED		PEACE LENGTH		VERY POOR		POOR		FAIR		GOOD		EXCELLENT		NATURAL AND INDUCED FRACTURES (+ INDUCED)		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10		20		30		10	

Sandia National Laboratories
by J.F.T. Agapito & Assoc., Inc.

HP10g v 4.50

I-25

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Laboratories
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOLOGICAL AND OTHER CAVITIES				Argill. Lith. Vapor Ph. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERNAL	% RECOVERY (SDN ROD-S)	LOST CORE & RUBBLES	FLUCTURE	TYPE	PLANARITY/IRREGULARITY	ROUGHNESS	DEPTH	TRACINGS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	NATURAL AND INDUCED (± INDUCED)		25	50	75	100			
430.0	RUN 93	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
435.0		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
440.0	RUN 94	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
445.0		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
450.0	RUN 95	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Topopah Spring—Crystal-Rich Nonfractured Zone (retained) (tr): (continued) Pumice replaced by weak moderate vapor-phase mineralization; relict frothy text, devitrified ground-mass, small pumice fragments replaced by vapor-phase mineralization, 10-12% phenocrysts, rhyolite filices look more cognate to host in color and texture, saw up to 200-mm long by 60-mm wide with relict frothy pumice zones.

Foliation at 15 degrees to core axis.
432.7 ft. Weak lithophysal development on fractures.

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Laboratories
by J.P.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-POD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	EXTRACTED % LITHOPHYSEAS AND OTHER CAVITIES					Aplite	Lithoph.	Vapor Pl.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERNAL	% RECOVERY (RUN ROD-S)	LOST CORE A RUMBLE	TYPE	PLANARITY	ROCKINESS	SPALL	TRACERS AND MINERALS	DEF	INDUCED	PECK LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND SUBSEQUENT (± INDUCED)			10	20	30	40	50							
455.0	RUN 95	100 (85)																													Topopah Spring—Crystal-Rich Neokithophysal (rounded) (tr): (continued) Pumice replaced by weak moderate vapor-phase mineralization; relict frothy text, devitrified groundmass, small pumice fragments replaced by vapor-phase mineralization, 10-12% phenocrysts, thylitic lithics look more cognate to host in color and texture, now up to 200-mm long by 60-mm wide with relict frothy pumice zones. Weakly developed lithophysae on fractures.
460.0	RUN 96	100																													
465.0		100 (12)																													463.6 ft, Small oval lithophysae not on fractures.
470.0		100 (40)																													
475.0	RUN 98	100																													

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-ROD (R)		FRACTURES (PER 10 FT)		HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSE AND OTHER CAVITIES	Argill. Lithoph. Vapor Ph. Desulfurization Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-S)	LAST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ADHESION	REFILL	THICKNESS AND	MINERALS	DIP	INDUCED	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND REINTERPRETATION (INDUCED)		
		100	(51)																
480.0	RON 99																		
485.0		69	(36)																
490.0	RON 100																		
495.0		67	(34)																
500.0	RUE 101																		

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			ESTIMATED % LITHOPHYSES AND OTHER CAVITIES	Argillic Alteration	Lithoph. Vapor Ph. Devitrification	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY		
	INTERVAL	% RECOVERY (RUN ROD-4)	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	NATURAL AND INDETERMINATE (REDUCED)	HALOZONES						WEATHERING	
505.0	RUN 101	63 (15)	X											4%		0			13%					Topopah Spring—Crystal Transition Subzone: (continued) <

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)				FRACTURES PER FOOT			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES	Argillic Alteration	Vapor Ph. Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-S)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ FOLGATION	INFILL	THICKNESS AND MINERAL	DIP	INDUCED	BLIND	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND UNDETERMINATE (+ INDUCED)								
530.0	RUN 106			I	CH	PH	C	70	70						40				4%					Topopah Spring— Crystal-Poor Upper Lithophysal Zone: (continued) Light mottled red-gray (10R 3/2), densely welded, devitrified, medium-large lithophysae; ~10% flat pumice with vapor-phase replacement, ~8% sanidine, plagioclase and biotite phenocrysts. Medium to very large lithophysae with four levels of vapor-phase mineralization haloed: (1) vapor-phase minerals (0.5-2 mm long) coat the interior of lithophysal cavities and have euhedral terminations that project into the cavity; (2) light gray to light pink vapor-phase alteration rims on lithophysae up to 30-mm diameter; (3) light gray rims typically have a thin 1-2 mm reddish purple border (SRP4-5); (4) very fine-grained blue-tinted vapor-phase recrystallization of the groundmass (SRP6/2), up to 10% is pumice with 8:1 flattening; zones of most intense vapor-phase mineralization contain microcrystals of bladed specularite.
535.0	RUN 109			I	CH	PH	C	50	50						5%				0%					530.0 - 545.0 ft, Non-lithophysal zone but continuing intensity of vapor-phase mineralization.
540.0	RUN 110			I	CH	PH	C	50	50															
545.0	RUN 112			I	CH	PH	C	50	50						11%	(12)			5%					545.0 ft, Lithophysae return - moderately spaced small lithophysae in blue moderate intensity (SRP4-5) vapor-phase altered groundmass. At 550.0 ft becomes crowded with large lithophysae in medium-orange unaltered groundmass.
550.0	RUN 113			I	CH	PH	C	50	50															

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD %)					FRACTURES (PER 30 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES	Argillite	Lithopha	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	RECOVERY (RUN RQD-%)	LOST CORE & RUBBLES	TYPE	PLANARITY	REGULARITY	INFILL	THICKNESS AND	MINERALS	DIP	ROCK LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED FRACTURES (> 1/8 INCH)	10	20	30								
555.0	RUN 113	36 (10)	.08 .11	I	FR					70	.35 .38				7%						3	H	10%					Topopah Spring— Crystal-Poor Upper Lithophysal Zone: (continued) Light mottled red-gray (10R 3/2), densely welded, devitrified, medium- large lithophysae; ~10% flat pumices with vapor-phase replacement, ~8% sanidine, plagioclase and biotite phenocrysts. Medium to very large lithophysae with four levels of vapor-phase mineralization halos: (1) vapor-phase minerals (0.5-2 mm long) coat the interior of lithophysal cavities and have conical terminations that project into the cavity; (2) light gray to light pink vapor-phase alteration rims on lithophysae up to 30-mm diameter; (3) light gray rims typically have a thin 1-2 mm reddish purple border (SRP4-5); (4) very fine-grained blue-lined vapor-phase recrystallization of the groundmass (SRP6/2), up to 10% is pumice with 8:1 flattening; zones of most intense vapor-phase mineralization contain microcrystals of bladed apatite.
560.0	RUN 114																											
565.0		65 (15)	.10 .10	I	IR					90	1.50			15%							3	H	9%					550.0 ft. Slight decrease in vapor-phase intensity, groundmass rapidly changes downward to more coarse microcrystalline and orange-gray.
570.0	RUN 115		.14 .10																									
575.0		70 (10)	.15												0%						3	H	11%					

CORE		FRACTURES								ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES				Asphic Lithic Vapor Ph Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
DEPTH (FT)	INTERVAL	% RECOVERY (RUN RQD-%)	LAST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	FINELY FLINTY	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)			10	25	50	75			
580.0	RUN 116		X .15 X														(9)									<p>Topopah Spring— Crystal-Poor Upper Lithophysal Zone: (continued) Light mottled red-gray (10R 3/2), densely welded, devitrified, medium- large lithophysae; ~10% flat pumice with vapor-phase replacement, ~8% sanidine, plagioclase and biotite phenocrysts. Medium to very large lithophysae with four levels of vapor-phase mineralization haloed: (1) vapor-phase minerals (0.5-2 mm long) coat the interior of lithophysal cavities and have euhedral terminations that project into the cavity; (2) light gray to light pink vapor-phase alteration rims on lithophysae up to 30-mm diameter; (3) light gray rims typically have a thin 1-2 mm reddish purple border (SRP4-5); (4) very fine-grained blue-bued vapor-phase recrystallization of the groundmass (SRP6/2), up to 10% is pumice with 8:1 flattening; zones of most intense vapor-phase mineralization contain microcrystals of bladed specularite.</p>
585.0		37 (4)	X .15 X											4%			1 (5)							16%		
590.0	RUN 117		X .15 X																							
595.0		46 (6)	X .15 X											4%			(17)							12%		
595.4	RUN 118		X .15 X																							595.4 ft, Return to small sized lithophysae
600.0			X .15 X																							

Structure file: NRG77NVA.SVR Lithology file:

Date: 06/14/94

Scale: 1:100

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL ALTERATION				Alteration	Lithoph.	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY		
	INTERVAL	% RECOVERY (GRIN 801-89)	LAST CORE & RUSSEL	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	DIP	INDUCED	PIECES LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED FRACTURES (% INDUCED)			5	10	15	20									
605.0	RUN 118	100	331														17%	(1.0)	3	2			6%									Topopah Spring—Crystal-Poor Upper Lithophysal Zone (continued) Light mottled red-gray (10R 3/2), densely welded, devitrified, medium-large lithophysae; ~10% flat pumice with vapor-phase replacement, ~8% sanidine, plagioclase and biotite phenocrysts. Medium to very large lithophysae with four levels of vapor-phase mineralization haloed: (1) vapor-phase minerals (0.5-2 mm long) coat the interior of lithophysal cavities and have oohedral terminations that project into the cavity; (2) light gray to light pink vapor-phase alteration rims on lithophysae up to 30-mm diameter; (3) light gray rims typically have a thin 1-2 mm reddish purple border (SRP/4-5); (4) very fine-grained blue-bued vapor-phase recrystallization of the groundmass (SRP/6/2), up to 10% is pumice with 3:1 flattening; zones of most intense vapor-phase mineralization contain microcrystals of bladed specularite.
610.0	RUN 119	95	331																3	2												605.5-620.0 ft, Vapor-phase alteration increases; strong white vapor-phase mineralization rims and lines lithophysae interiors to 3-5 mm radius, dark blue-gray halo of vapor-phase alteration to 10-15 mm, coalesces leaving small islands of unaltered, devitrified, red-gray crystal tuff; pervasive blue-gray alteration decreasing downward gradually (white vapor-phase mineralization remains).
615.0	RUN 120	100	331														14%		3	2			8%									620.0 ft, Vapor-phase gradually decreasing
620.0	RUN 121	100	331																3	2												
625.0	RUN 122	100	331														14%	(1.1)	3	2			6%									

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)						FRACTURES (PER 10 FT)			HAZARDS	VEGETATION	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES	Aesthetics	Lithoph.	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY		
	INTERVAL	% RECOVERY (RQD ROD-A)	LOST CORE & NUMBER	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	TACHOSES AND MINERALS	DP	INDUCED	SIZE	LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT											NATURAL AND INDUCED FRACTURES (+ INDUCED)	10
630.0	RUN 123	30	127	X														(11)											<p>Topopah Spring— Crystal-Poor Upper Lithophysal Zone (continued) Light mottled red-gray (10R 3/2), densely welded, devitrified, medium- large lithophysae; ~10% flat pumice with vapor-phase replacement, ~8% sanidine, plagioclase and biotite phenocrysts. Medium to very large lithophysae with four levels of vapor-phase mineralization haloed: (1) vapor-phase minerals (0.5-2 mm long) coat the interior of lithophysal cavities and have cohered terminations that project into the cavity; (2) light gray to light pink vapor-phase alteration rims on lithophysae up to 30-mm diameter; (3) light gray rims typically have a thin 1-2 mm reddish purple border (SRP4-5); (4) very fine-grained blue-hued vapor-phase recrystallization of the groundmass (SRP6/2), up to 10% is pumice with 8:1 flattening; zones of most intense vapor-phase mineralization contain microcrystals of bladed speckelite.</p> <p>Blue-gray vapor-phase alteration decreasing from maximum at 630.0 ft to very narrow 1-2 mm halo at 645.0 ft.</p>
635.0	RUN 126	32	101	X																									
640.0	RUN 128	35	113	X																									
645.0	RUN 129	44	101	X																									
650.0	RUN 130	95	145	X																									

GEOLOGY AND ROCK STRUCTURE LOG

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[illegible]

Background File: HMC2706A.2TH Ideology File:

Date: 05/26/92

HP100 7 1 60

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			RAZINESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES					Argillite Lithology Vapor Ph. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RQD-RQD-9)	LOST CORE & RUBBLE	FRAC. TYPE	PLANARITY	ROUGHNESS	INFILL	TECTONICS AND MINERALS	DIP	INDUCED	PRICE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED FRACTURES (+ INDUCED)		10	20	30	40	50			
680.0	RUN 133	91 (1.4)	X .07 X .08 X .09	I	IR	IR	C	90 90						40%												<p>Topopah Spring-- Crystal-Four Upper Lithophysal Zone: (continued) Light mottled red-gray (10R 3/2), densely welded, devitrified, medium-large lithophysae; ~10% flat pumice with vapor-phase replacement, ~8% sanidine, plagioclase and biotite phenocrysts. Medium to very large lithophysae with four levels of vapor-phase mineralization halos: (1) vapor-phase minerals (0.5-2 mm long) coat the interior of lithophysal cavities and have euhedral terminations that project into the cavity; (2) light gray to light pink vapor-phase alteration rims on lithophysae up to 30-mm diameter; (3) light gray rims typically have a thin 1-2 mm reddish purple border (SRP4-5); (4) very fine-grained blue-hued vapor-phase recrystallization of the groundmass (SRP6/2), up to 10% is pumice with 8:1 flattening; zones of most intense vapor-phase mineralization contain microcrystals of bladed speleothems.</p> <p>695.5-717.0 ft. Increase in larger, closer-spaced lithophysae, light gray 5-7 mm vapor-phase halo around white vapor-phase minerals after flat pumice - very weak blue-gray vapor-phase alteration 2-mm halo.</p>
685.0	RUN 134	79 (0)	X .14	I	IR	IR	C	90 90						40%												
690.0	RUN 135	83 (1.4)	X .15 X .05	I	IR	IR	C	90 90						33%												
695.0	RUN 136	76 (1.2)	X .06	I	IR	IR	C	90 90						33%												
700.0	RUN 137	76 (1.2)	X .06	I	IR	IR	C	90 90						33%												
705.0	RUN 138	76 (1.2)	X .06	I	IR	IR	C	90 90						33%												
710.0	RUN 139	76 (1.2)	X .06	I	IR	IR	C	90 90						33%												
715.0	RUN 140	76 (1.2)	X .06	I	IR	IR	C	90 90						33%												
720.0	RUN 141	76 (1.2)	X .06	I	IR	IR	C	90 90						33%												
725.0	RUN 142	76 (1.2)	X .06	I	IR	IR	C	90 90						33%												

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION: RQD (%)					FRACTURES (PER 10 FT)			BARNESS	WEATHERING	ESTIMATED % LITHOPHYSEAS AND OTHER CAVITIES	Asphib	Lithoph	Vapor Ph	Devitification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN LOG-5)	LOST CORE & RUBBLS	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	TRACKERS AND MINERALS	DEF	INDUCED	SECS LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND SUBTERMINATE (+ INDUCED)									
720.0	RUN 139	71	10	X.15	I				90 30		.55	13%							6%							Topopah Spring— Crystal-Poor Upper Lithophysal Zone: (continued) Light mottled red-gray (10R 3/2), densely welded, devitrified, medium-large lithophysae; ~10% flat pumice with vapor-phase replacement, ~8% sanidine, plagioclase and biotite phenocrysts. Medium to very large lithophysae with four levels of vapor-phase mineralization halos: (1) vapor-phase minerals (0.5-2 mm long) coat the interior of lithophysal cavities and have cohered terminations that project into the cavity; (2) light gray to light pink vapor-phase alteration rims on lithophysae up to 30-mm diameter; (3) light gray rims typically have a thin 1-2 mm reddish purple border (SRP4-5); (4) very fine-grained blue-fused vapor-phase recrystallization of the groundmass (SRP6/2), up to 10% is pumice with 8:1 flattening; zones of most intense vapor-phase mineralization contain microcrystals of bladed specularite. ~30-mm radius around lithophysae, with groundmass texture contorted by lithophysae growth. ~10% very flat pumice and dark lithics that contain texture, ~8% sanidine, plagioclase, biotite phenocrysts, some rimmed by vapor-phase mineralization.
735.0	RUN 140	71	10	X.15	I				90 30		.55	0%							5%							734.0 ft. Light-medium orange-gray porous devitrified groundmass with up to 20-mm diameter lithophysae. Moderately spaced, up to 40-mm diameter halos of white vapor-phase mineralization rimming lithophysae. Cavities lined by vapor-phase crystals. Weak blue vapor-phase alteration pervasive through groundmass, non-lithophysal pumice very flat and also mineralized.
740.0	RUN 141	71	10	X.15	I				90 30		.55	5%							3%							741.0 ft. Beginning of flat pumice
745.0	RUN 142	71	10	X.15	I				90 30		.55	5%							3%							
750.0	RUN 142	71	10	X.15	I				90 30		.55	5%							3%							

DEPTH (FT)	CORE		FRACTURES					ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (FEET/10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES				Argillite Lithoph. Vapor Ph. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (R) (RQD) (RQD-4)	LOST CORE & RUBBLES	TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	DP	INDUCED	FORCE	LENGHT	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (4 INDUCED)	10	20	30		
755.0	RUN 1.43	73 (19)	XX .15																					Topopah Spring—Crystal-Poor Upper Lithophysal Zone (continued)
760.0	RUN 1.44	77 (20)	XX .14																					
765.0	RUN 1.45	65 (21)	XX .12																					762.5-877.6 ft, Topopah Spring—Middle Nonlithophysal Zone
770.0	RUN 1.47	62 (21)	XX .13																					762.5-810.8 ft, Topopah Spring—Crystal-Poor Upper Nonlithophysal Subzone: Lithophyses disappearing - light orange-gray, devitrified porous groundmass, 30-35% vapor-phase mineralization replacement of groundmass, occasionally small (3x10 mm) lithophyses and flat pumice replaced by white vapor-phase mineralization, 20-30 mm diameter light pink-gray halos - intensity of vapor-phase decreasing downward rapidly going to 5-mm light pink-gray vapor-phase mineralization halo, 1-3 mm rim of blue-gray vapor-phase alteration on halo. Fractures follow zones of mineralization.
775.0	RUN 1.48	68 (22)	XX .14																					

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY (ESTIMATION: RQD (%))					FRACTURES (PER FOOT)					HAZINESS	WEATHERING	ESTIMATED % LITHOPHASE AND OTHER CONTENTS					Agalite Lithop. Vapor Ph. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
	INTERVAL	% RECOVERY (RIN RQD-R)	LOST CORE & RUBBLE	FRACTURE	TYPE	PLANARITY/ BOUNDNESS	INFILL	THICKNESS AND MINERAL	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (+ INDUCED)	30	20	10	0%	30			20	10	0%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
780.0	RUN 149	100	X .13 X .14																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																</

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)				HARDNESS	WEATHERING	ESTIMATED LITHOPHYSE CONTENTS	ANGULAR LITHOPHYSE	VAPOR PH.	DEVITRIFIED WELDING	GEOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (24)	TYPE	PLANARITY	IRREGULARITY	SPALL	TRUNCATION	AND	MINERALS	DP	INDICATED	PRECISE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (PER 10 FT)	10	20	30								
		100																											
		100																											
		100																											
805.0	RUN 155	51																											
810.0																													
815.0		60																											
820.0	RUN 157	70																											
825.0	RUN 158	75																											

Topopah Spring—Crystal-Poor
Upper Nondolophyal Subzone:
(continued) Lithophyses disappearing - light orange-gray, devitrified porous groundmass, 30-35% vapor-phase mineralization replacement of groundmass, occasionally small (3x10 mm) lithophyses and flat pumice replaced by white vapor-phase mineralization, 20-30 mm diameter light pink-gray halos - intensity of vapor-phase decreasing downward rapidly going to 5-mm light pink-gray vapor-phase mineralization halo, 1-3 mm rim of blue-gray vapor-phase alteration on halo. Fractures follow zones of mineralization.

810.0-855.0 ft, Topopah Spring—
Crystal-Poor Middle Lithophyal
Subzone: Lithophyses reappear. Light orange-gray, devitrified, densely welded groundmass, lithophyses up to 10 cm, weakly rimmed with 8-10 mm of white vapor-phase mineralization. Light lavender-gray vapor-phase alteration halos and speckles of light gray vapor-phase alteration in zones less crowded by lithophyses.

Increasing development of
lithophyses downward

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY INFORMATION - RQD (%)						FRACTURES (PER 20 FT)			HARDNESS	WEATHERING	ESTIMATED LITHOPHYSE AND VAPOR-PHASE ALTERATION ZONES	Artificial Lithoph. Vapor Ph. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
	INTERVAL	% RECOVERY (RUN ROD-PS)	LOST CORE & RUBBLE	FRAC. TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	POSS. LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND MINERALIZATION (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Laboratories
by J.F.T. Aguirre & Assoc., Inc.

DEPTH (FT)	CORRE	FRACTURES								ROCK QUALITY DESIGNATION RQD (%)					FRACTURES (FEET/100)			HAZARD	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES				Amplio	Lithoph	Vapor Pl.	Deviation	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
		TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	DIP	UNFACED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)	10			20	30	40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	RUN 162																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

Seismicity file: R07004A.B7R Lithology file:

Date: 06/10/94

MP2log v 4.50

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WPZ-09 v 4.60

I-44

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES	Asphic	Lithob.	Vapor Ph.	Dissolution	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN LOG-M)	LOST CORE & KUBELS	FRACTURE TYPES	PLANARITY	REGULARITY	SPALL	THICKNESS AND MINERALS	EXP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)									
	175	53 (0)	10	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1	1	0%						
905.0	RUN 175		04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1	1	0%						
			05	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1	1	0%						
910.0	RUN 176	11 (0)																1	1	0%						
915.0																		1	1	0%						
		10 (0)	15															1	1	0%						
920.0		78 (0)																1	1	0%						
		0 (0)																1	1	0%						
925.0		10 (0)																1	1	0%						

Structure File: NRG07RVA-57R Lithology File:

Date: 06/23/94

WLog v 4.60

912.0 ft, Topopah Spring--Lower Lithophysal (continued): Light to medium orange-gray devitrified groundmass. Small (2x6 mm) streaks of vapor-phase mineralization after purples makes 7-8% groundmass volume. Weak flat vertical joints. 2-3% sandstone phenocrysts, 0.1% black biotite flakes. Large round light pink-gray vapor-phase alteration spots (75-100-mm diameter) each foot. Some fractures (especially thin vapor-phase spots) coated by black metallic mineralization (MnOx?). Very weak 3-5-mm spots of light-green stain (possibly zeolite). Blue vapor-phase alteration absent.

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)						FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % LITHOPHASES AND OTHER CAVITIES				Argill. Lithoph. Vapor Ph. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-BA)	LOST CORE & KIBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DP	REDUCED	POOR	VERY POOR	EXCELLENT	NATURAL AND INDUCED (> INDUCED)	10	20	30		10	20	30	40			
930.0	RUN 180													0 (0)											Topogah Spring—Lower Litho-physical (continued): Light to medium orange-gray devitrified groundmass. Small (2x6 mm) streaks of vapor-phase mineralization after pumice makes 7-8% groundmass volume. Weak flat vertical joints, 2-3% sanidine phenocrysts, 0.1% black biotite flakes. Large round light pink-gray vapor-phase alteration spots (75-100-mm diameter) each foot. Some fractures (especially thru vapor-phase spots) coated by black metallic mineralization (MnOx?). Very weak 3-5-mm spots of light-green stain (possibly zeolite). Blue vapor-phase alteration absent.
935.0														0 (5)											
940.0	RUN 183																								
945.0	RUN 184													1 (1)											945.3 ft. Dark asconaceous pumice nucleates altered spot (partially opened by lithophyses).
950.0																									

[illegible]

Structure ELJ01.HRM7RM6A.BTH Technology file

DocId: 3113120

HP100 7 4 50

I-47

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-ROD (%)						FRACTURES (PER M FT)			HAZARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES	Aquatic Leachability	Vapor Ph. Degradation	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY		
	INTERVAL	% RECOVERY (27) (RUN ROD-S)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUTING	INCL.	THICKNESS AND MINERALS	DIP	BRIDGED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND HYDROTHERMAL (+ INDUCED)	10	20									30	
		65	<.12>												19%								1%					<p>Topopah Spring—Lower Lithophysal (continued): Light to medium orange-gray, devitrified, less strongly welded groundmass streaked by haloes of vapor-phase white mineralization in very flat pumice sites, haloed by 1-2-mm wide light lavender-gray weak to moderately intense vapor-phase alteration (10-15% rock volume). Large (50-70 mm) lithophysae on flat pumice each 6-10 inches. Lithophysae interiors are muddy exfoliated, like onion layers, with remnants of coarse-grained crystalline vapor-phase mineralization replacing flat pumice and appearing to have developed prior to lithophysal formation. 2-3% exotic lithic fragments, 1-2% anhydrous phenocrysts, 0.1% "fresh" biotite flakes.</p> <p>977.0 ft. Scoriaceous pumice-type lithophysae.</p> <p>From 985.4 ft. predominately rubble and unrecovered zones probably due to "cavernous" lithophysae (>50 cm).</p>	
				2	CH					20																			
				2	2M	FW				30																			
				2	2M	FW				30																			
				2	2R					50																			
				2	2R					60																			
980.0	191		<.03>																										
			<.03>	2		FW				90																			
			<.03>	2		FW				60																			
985.0	192	53	(23)							10					28%								2%						
			<.05>	2						30																			
				2						30																			
											1.15																		
990.0	192		<.05>	2		FW				30																			
			<.05>	2						30					0%								1%						
995.0	193	37	(6)																										
			<.05>	2						30																			
			<.05>	2						30																			
1000.0		59	(11)							30																			

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSES AND OTHER CAVITIES				Argillic Lithoph. Vapor Ph. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN 800-5)	LAST CORE & RUMBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	STICKINESS AND MINERALS	Q _P	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)			10	20	30	40			
	194			X	SE	SE	C	C	50 40		.50															<p>Topopah Spring—Lower Lithophysal (continued): Light to medium orange-gray devitrified, less strongly welded groundmass streaked by haloes of vapor-phase white mineralization in very flat pumice sites, haloed by 1-2-mm wide light lavender-gray weak to moderately intense vapor-phase alteration (10-15% rock volume). Large (50-70 mm) lithophysae on flat pumices each 6-10 inches. Lithophysae interiors muddy-exfoliate, like onion layers, remnant of co. gr. vapor-phase mineralization after flat pumice appears to occur prior to lithophysae formation. 2-3% exotic lithic fragments, 1-2% sanidine phenocrysts, 0.1% "fresh" biotite flakes.</p>
1005.0	195		(B)	X	SE	SE	C	C	25		.50			95			21			0%						
	195			X	SE	SE	C	C	40 75		.50															
1010.0				X	SE	SE	C	C	40 45 30																	<p>1008.2 - 1026.6 ft. Unrecovered interval (hammer drilled).</p>
1015.0														0%			0 (0)		Not Measured							
1020.0																										
1025.0														0%			0 (5)			0%						<p>Vapor-phase intensity gradually decreasing downward.</p>

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Laboratories
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)		REASONABLE WEATHERING	ESTIMATED LITHOPHYSAL AND OTHER CAVITIES	ASTILLIC Lithophysal Voids Pl. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-IN)	LOST CORE & REBLE	FRAC TYPE	PLANARITY	ROCKINESS	WELL THICKNESS AND MINERALS	DIP	INDICED	PECK LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND UNDETERMINATE (+ INDUCED)				
1030.0	196	100	0.15	P				5							0 (5)		0%			<p>Topopah Spring—Crystal Poor Lower Lithophysal Zone (continued): Light to medium orange-gray, devitrified, densely welded with thin flat irregular pumice replaced by white vapor-phase mineralization. Circular "spots" of medium-gray vapor-phase around flat pumice and lithophysae, thin 1-2-mm rims of blue alteration, expanding to 3-5-mm rims around other small altered zones. 10-15% pumice are lithophysal, small to medium sized, moderately wide-spaced (6-10 inches). 1-2% white sandstone probably replaced by white vapor-phase mineralization, (lithic not observed).</p> <p>1030.0 ft, Crowded medium-large lithophysae.</p> <p>1034.5 ft, Lithophysae "flattened".</p>
1035.0	197	100	0.15	P				10							0 (7)		0%			
1040.0	199	100	0.15	P				15												
1045.0	200	100	0.15	P				15												
1050.0	201	100	0.15	P				15												
1055.0	202	100	0.15	P				15												
1060.0	203	100	0.15	P				15												
1065.0	204	100	0.15	P				15												
1070.0	205	100	0.15	P				15												
1075.0	206	100	0.15	P				15												

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSE AND OTHER CAVITIES					Asphite	Lithoph	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (RUN ROD-S)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	SCURNESS	INFILL	THICKNESS AND	MINERALS	DOF	INDUCED	PECS	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND UNDETERMINATE (+ INDUCED)	10	20	30		20	30	40	50									
1055.0	RUN 201	52 (0)		1	1													7				X				24								Topopah Spring—Crystal-Poor Lower Lithophysal Zone (continued): Light-medium orange-gray; devitrified, densely welded with thin flat irregular pumice replaced by white vapor-phase mineralization. Circular "spots" of medium-gray vapor-phase alteration around flat pumice and lithophyses, thin 1-2-mm rims of blue alteration, expanding to 3-5-mm rims around other small altered zones. 10-15% pumice are lithophysal, small to medium sized, moderately wide-spaced (6-10 inches). 1-2% white sandstone probably replaced by white vapor-phase mineralization, (lithics not observed).	
1060.0	RUN 202																																		1050.0 ft. Small pumice-cored lithophyses, each 6-10 inches.
1065.0	RUN 203	74 (4)																1				0				14								Vapor-phase intensity decreasing downward.	
1070.0	RUN 204	60 (0)																																	
1075.0	RUN 204																																		

Structure file: NRG7R40.STR Lithology file:

Date: 12/03/94

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GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER FOOT)				HAZARDOUS WEATHERING	ESTIMATED & OBSERVED FRACTURE AND OTHER CAVITIES	Argill. Lithoph. Vapor Ph.	Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RQD) (%)	LOST CORE & RUBBLE	TYPE	PLANARITY	SPACING	INFILL	THICKNESS AND	MINERAL	UTP	INDUCED	POOR	VERY POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ REDUCED)						
1080.0	40	(10)	X.15	H	PS	C				70					0%								<p>Tapach Spring—Crystal-Poor Lower Lithophysal Zone (continued): Light-medium orange-gray; devitrified, densely welded with thin flat irregular pumice replaced by white vapor-phase mineralization. Circular "spots" of medium-gray vapor-phase alteration around flat pumice and lithophysae, then 1-2-mm rims of blue alteration, expanding to 3-5-mm rims around other small altered zones. 10-15% pumice are lithophysal, small to medium sized, moderately wide-spaced (6-10 inches). 1-2% white sanidine probably replaced by white vapor-phase mineralization, (lithics not observed).</p> <p>1080.0 ft, Flat pumice, very weakly lithophysal.</p>
1085.0	205		X.10	H	PS	C				70					0%								
1090.0	54	(13)	X.10	H	PS	C				60					0%								
1095.0	58	(10)	X.10	H	PS	C				90					4%								
1100.0	58	(10)	X.10	H	PS	C				90													
			X.10	H	PS	C				90													
			X.10	H	PS	C				90													
			X.10	H	PS	C				90													
			X.10	H	PS	C				90													
			X.10	H	PS	C				90													

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-RQD (%)						FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES				Argillite	Lithoph.	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN REQ-45)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERAL	DIP	INDUCED	NECS	LOTHO	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDISTINGUISHABLE (+ INDUCED)	10			20	30	10	20							
	RUN 207		X .05																													Topopah Spring—Crystal-Poor Lower Lithophysal Zone (continued): Light-medium orange-gray; devitrified, densely welded with thin flat irregular pumice replaced by white vapor-phase mineralization. Circular "spots" of medium-gray vapor-phase alteration around flat pumice and lithophysae, thin 1-2-mm rims of blue alteration, expanding to 3-5-mm rims around other small altered zones. 10-15% pumice are lithophysal, small to medium sized, moderately wide-spaced (6-10 inches). 1-2% white sanidine probably replaced by white vapor-phase mineralization, (lithics not observed).
1103.0	RUN 208	7B (C)	X .05																													
	RUN 209	7C (C)	X .07 X .04																													
	RUN 210	7D (C)	X .08																													1120.0 ft, Topopah Spring—Crystal-Poor Lower Lithophysal Zone (continued): Light-medium orange-gray, devitrified, grainy texture. Densely welded, small, flat (4 x 15 mm) lithophysae in haloes 10-20-mm in diameter. Pink moderate intensity vapor-phase alteration, white lithophysae, thin streaks of weak pink vapor-phase alteration throughout groundmass. All pink alteration bordered by 0.5 to 1 mm blue alteration. 1-2% white sanidine phenocrysts, 3-4% subangular lithics, mostly rhyolite composition up to 8 mm. Specks of MnOx on very irregular joint surfaces. Most of core below 985.4 ft rubble or unrecovered probably due to "cavernous" lithophysae (>50 cm).
1115.0	RUN 211	11 (C)	X .12																													
	RUN 212	4E (C)	X .09 X .06 X .04																													
1120.0	RUN 213	4F (C)																														
	RUN 214																															
1125.0	RUN 215																															

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Laboratories
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DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)				HAZARD	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES				Auriferous	Lithoph. Vapor Ph.	Deveification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERNAL	% RECOVERY (RDN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	TECHONICS AND MINERALS	DIP	INDUCED	PIECES	LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDICATED)			10	20	30	40						
11300	RDN 213	45 (0)	10	1	PS	PS	C	PS	18 70									0 (7)						0%						Topopah Spring—Crystal-Poor Lower Lithophysal Zone (continued): Light-medium orange-gray, devitrified, granular texture. Densely welded, small, flat (4 x 15 mm) lithophysae in haloes 10-20-mm in diameter. Pink moderate intensity vapor-phase alteration, white lithophysae, thin streaks of weak pink vapor-phase alteration throughout groundmass. All pink alteration bordered by 0.5 to 1 mm blue alteration. 1-2% white sandstone phenocrysts, 3-4% subangular lithes, mostly thymite composition up to 8 mm. Specks of MnOx on very irregular joint surfaces. Most of core below 985.4 ft rubble or unrecovered probably due to "cavernous" lithophysae (>50 cm).
11350	RDN 214	34 (10)	10															0 (5)						1%						
11400	RDN 215	35 (10)	10						10									0 (9)						0%						
11450																														
11500																														

Structure file M067AV50 STR Lithology file

Date: 12/12/94

WPIlog v 4.66

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION (RQD (%))					FRACTURES (PER 10 FT)			ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES	WEATHERING	APPLIC LITHOPH.	VAPOR PH.	DETERMINATION	GEOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (AUN RQD-%)	LAST CORE & RUBBLE	TYPE	PLANARITY	REGULARITY	INFILL	THICKNESS AND	MINERALS	DP	INDUCED	POOR	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND MODIFIED (INDUCED)						
1155.0	RUN 216	40 (0)	.03	1	1											0%		0%						Topopah Spring—Crystal-Poor Lower Lithophysal Zone (continued): Light-medium orange-gray, devitrified, grainy texture. Densely welded, small, flat (4 x 15 mm) lithophysae in haloes 10-20-mm in diameter. Pink moderate intensity vapor-phase alteration, white lithophysae, thin streaks of weak pink vapor-phase alteration throughout groundmass. All pink alteration bordered by 0.5 to 1 mm blue alteration. 1-2% white sanidine phenocrysts, 3-4% subangular feldspar, mostly rhyolite composition up to 8 mm. Specks of MnOx on very irregular joint surfaces. Most of core below 985.4 ft rubble or unrecovered probably due to "cavernous" lithophysae (>50 cm).
1160.0	RUN 217	75 (0)	.10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1160.5 - 1177.9 ft. Zone of small flattened, closely spaced crystalline lithophysae.
1165.0	RUN 218	44 (0)	.10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
1170.0		58 (0)	.10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
1175.0		63 (0)	.10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	

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85-70-0514-4 File: 85G78746-578 Library File:

Date: 12/12/14

MP: 4.60

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURE										ROCK QUALITY DESIGNATION-RQD (%)						FRACTURES (PER 10 FT)			SOUNDNESS	WEATHERING	ESTIMATED % LITHOPHYSES AND OTHER CAVITIES				Argill. Lithoph.	Vapor Ph. Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
	INTERVAL	% RECOVERY (RQD-4)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	SOLIDNESS	FILL	THICKNESS AND MINERALS	DIP	NOTED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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Structure File: HRC76V6B.STR Lithology File:

Date: 12/12/94

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DEPTH (FT)	CORR		FRACTURES										ROCK QUALITY DESIGNATION (RQD %)						FRACTURES (PER M FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES				Argill. Lithom.	Vapor Ph.	Desertification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	INTERNAL	% RECOVERY (RUN ROD-S)	LAST CORR	A RUBELS	TYPE	PLANARITY	ROUGHNESS	DEPTH THICKNESS AND	MINERALS	DP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED FRACTURES (+ INDUCED)	10	20	30			40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Laboratories
by J.F.T. Agapito & Assoc., Inc.

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STRUCTURE FILE: HMC78V6B.DTH Pathology File:

Date: 12/12/20

Deposited at \$.65

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES PER 10 FT			RAIDNESS	WEATHERING	EXTRACTED & LITHOPHYSAL AND OTHER CAVITIES	Asphalic	Lithoph.	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
	INTERVAL	% RECOVERY (RQD-6)	LOST CODE & RUNS	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	POOR	GOOD	EXCELLENT	NATURAL AND UNDETERMINATE (+ INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			SOUNDNESS	WEATHERING	FILLING & LITHOLOGICAL AND OTHER CAVITIES	AGGREGATE	LITHOLOGY	VAPOR PH.	DEVOLATIZATION	WELDING	GEOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN 200-4)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/FLATNESS	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	RODDED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED									
	1305.0		X-10X	I	PK	C			15																	Topopah Spring—Crystal-Poor Neolithophyrid (continued): Pale red-gray (10R 6/2) moderate to densely welded, devitrified pastite very flat 14-16:1, most weak-moderate vapor-phase altered. Some fragments look more devitrified (grainier) than groundmass. Groundmass 30% blue alteration.
	1306.2			I	PK	C			15																	1306.2 - 1307.8 ft, Several large lithic fragments, very densely welded, hard and shiny (more vapor-phase alteration?)
	1310.0			I	PK	C			30																	1308.6 - 1314.3 ft, Uncovered interval.
	1315.0			I	PK	C			15																	1315.0 ft, Vapor-phase streaks and lithic-rich zone, 10-15% white to light-gray subangular rhyolitic lithics up to 30 mm.
	1320.0			I	PK	C			15																	
	1325.0			I	PK	C			15																	

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-ROD (R)					FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % LITHOLOGICAL AND OTHER CAVITIES	Argillic	Lithoph.	Vapor Ph.	Devitrification	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERNAL	% RECOVERY (RIN ROD-S)	LOST CORE & RUBBLE	FRACTURE TYPE	FLAXIVITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	DIS	INDUCED	FREE LENSITE	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (A+INDUCED)								
			.03																							
	RUN 243		.03																							
1330.0		.2	.22																							
			.03																							
	RUN 244																									
1335.0																										
1340.0		.5	.17																							
			.02																							
	RUN 245		.02																							
1345.0																										
1350.0		.75	.14																							

Topopah Spring—Crystal-Poor
Lower Nealthophysalt: Pale red-gray
(10R 6/2) densely welded, devitrified
lithic rich. 10% light gray subangular
rhyolite up to 30 mm decreasing down-
ward. Vapor-phase mineralization
weakly streaked around flat pumice.

1348.9 ft. Light to medium orange,
1-2-mm devitrification halos on
fibers. Very weak pervasive blue
vapor-phase alteration, rare halo
around white vapor-phase viallet.

GEOLOGY AND ROCK STRUCTURE LOG

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Date: 12/12/24

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DEPTH (FT)	CORR		FRACTURES						ROCK QUALITY DEFORMATION-ROD (%)						FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHASE AND OTHER CAVITIES				Argill. Lithol.	Vesic. Ph.	Devirification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RON ROD-9)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	CLAP	INDICES	PIECE LENGTH	VECT	POOR	POOR	FAIR	GOOD	EXCELLENT			10	20	30	40					
1380.0	250	76 (20)		I 1	IR	PS	C	C	30 20							11%			3	P								
1385.0	251	56 (6)							5							8%			3	P								
1390.0	252	81 (0)																	2	P								
1395.0	253	33 (41)														15%			2	P								
1400.0	253																											

1385.2 ft, Topopah Spring—
Crystal-Poor Vitric Zone
Transition: Begin transition to
vitrophyre, weakly vitric, mottled
texture, dark vitric portion and
medium-orange devirification
around lithics, pumices, 7-9% light
orange (5-7:1) flat pumice and
cognate lithics, exotic rhyolitic lithics
up to 8 cm make 4-5%, subangular
exotic quartz into red-brown 2-3%,
devirification strongest in haloes
around lithics and along fractures.
Crystal-poor, 2-3% clear sanidine
phenocrysts.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHASES AND OTHER CAVITIES				Ave. Lithoph. Vapor Ph. Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN REQ-4)	LOST CORE & RUBBLES	FLACATURE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DP	INDUCED	FREE LENGTH	VERY POOR	POOR	Fair	GOOD	EXCELLENT	NATURAL AND UNDETERMINATE (+ INDUCED)			10	20	30	40			
1405.0	RUN 253	82 (39)		1 1/2	1 1/2	20	000	00			2.50															1403.0 ft, Vitrified with black shards, moderately-dense welded.
											.80															
											.40															
											.33															
											.53															
1410.0	RUN 254										.30															
											.40															
											.40															
											.50															
											.40															
											.40															
1415.0		52 (10)									.40															
											.40															
											.40															
											.40															
											.40															
											.40															
1420.0	RUN 255										.40															
											.40															
											.40															
											.40															
1425.0											.40															

DEPTH (FT)	CORE		FRACTURES										ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES PER MFT					ESTIMATED % LITHOPHASES AND OTHER CAVITIES	Argillic Lithobol.	Vapor Fl.	Devitrification	Welding	Oology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
	GENERAL	% RECOVERY (10)	LOST CORE & RUBBLES	TYPE	PLANARITY	ROUGHNESS	TEXTURE	THICKNESS AND MINERALS	DIP	INDUCED	PERCENT	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDUCED (± INDUCED)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
1430.0	RUN 256	36	XX	1	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	</

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-ROD (R)					FRACTURES (PER 10 FT)			WEATHERING	ESTIMATED % LITHOMYCELE AND OTHER CAVITIES	Amplic	Lithoph	Vapor Ph.	Deviatificat	Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-90)	LOST CORE & MOBILE	FRAC TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND	MINERALS	DIP	INDUCED	POOR	POOR	POOR	POOR	NATURAL AND HYDROLYZABLE (+ INDUCED)	10	20	30							
1455.0	RUN 259	38 (10)																								1452.8 ft, Topopah Spring— Crystal-Poor Vitric, Moderately Welded Subzone: Transition from black vitrophyre to moderately-densely welded, slightly devitrified vitrophyres, large orange pumice in matrix of 75% black shards, 20% devitrified.
1460.0	RUN 260	100 (70)																								1459.5 ft, Lighter colored, dusky brown (5YR 2/2), medium size slightly flat subrounded light orange-gray (10YR 7/4) devitrified pumice in matrix of 75% black shards. 25% orange devitrified material between shards.
1465.0		98 (50)																								1469.7 - 1474.6 ft, Transition: Moderately-welded very vitric to partially vitric nonwelded.
1470.0	RUN 261																									1474.6 - 1492.8 ft, Topopah Spring— Crystal-Poor Vitric, Basal Non- to Partially Welded Subzone: Gray-orange-pink (5YR 7/2) partially vitric, mostly orange devitrified, original textures preserved, voids after bubbles with spherulites. 7-8% coagulate pumice, porous with indistinct borders. 15% of wide size-range, light gray fine-grained rhyolite pumice up to 70-80 mm. 2-3% dark angular lithoc (quartz latite) up to 50 mm.
1475.0																										

GEOLOGY AND ROCK STRUCTURE LOG

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DEPTH (FT)	CORE		FRACTURES						ROCK QUALITY DESIGNATION (RQD) (%)					FRACTURES (PER. RQD)			FACIES	WEATHERING	ESTIMATED % LITHICS AND OTHER CAVITIES	Argillic	Lithoph.	Vapor Ph.	Devitrification Welding	Geology	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-S)	LOST CORES & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	REGS LENGTH	VERY POOR 0-25	POOR 25-50	FAIR 50-75	GOOD 75-90	EXCELLENT 90-100	NATURAL AND INDETERMINATE (+ INDUCED)									
1480.0	RUN 262	98 (62)																							1474.6 - 1492.8 ft, Topopah Spring— Crystal-Poor Vitric, Basal Non- to Partially Welded Subzone: Gray-orange-pink (SYR 7/2) partially vitric, mostly orange devitrified, original textures preserved, voids after bubbles with spherulites. 7-8% cognate pumice, porous with indistinct borders. 15% of wide size-range, light gray fine-grained rhyolite pumice up to 70-80 mm. 2-3% dark angular lithics (quartz latite) up to 50 mm.
1485.0		98 (86)																							1487.0 ft, increasing quartz latite lithics to 10%, smaller, up to 8 mm.
1490.0	RUN 263																								1492.8 - 1498.3 ft, Pre-Topopah Bedded Tuff: Medium-grained, pink-gray (SR 8/2) nonwelded fallout. 10-20% pink-gray pumice, <5 mm. 15-20% 2-3-mm dark obsidian lithics, <3 mm and red-gray quartz latite lithics.
1495.0	RUN 264	98 (52)																							1498.3 ft, Calico Hills Formation: Gray-pink (SR 8/2) nonscored, nonwelded ash flow. 8-10% large yellow-green subangular pumice up to 28 mm altered to zeolite, 3-5% subrounded dark quartz-latite lithics up to 12 mm. 1-2% light medium-gray subrounded rhyolite lithics up to 15 mm, most lithics <5 mm. 2-3% sanidine quartz phenocrysts, oxybiotite.
1500.0																									

GEOLOGY AND ROCK STRUCTURE LOG

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DocId: 32714791

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CORE HOLE ROCK STRUCTURAL DATA SUMMARY
Hole USW NRG-7/7A
TCw, PTn, TSw1, and TSw2, TSw3, CHn1

Sandia National Laboratories
 Print Date: 11/11/94
 WBS 1.2.3.2.6.2
 QA: QA
 Revision 1

REVISION HISTORY

Revision 1 Additional stratigraphic data from 770-1510 ft included. Method for calculating percent lithophysae and other cavities revised.

CODING EXPLANATION

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member	C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain Member		
P.C.	Pah Canyon Member		
T.S.	Topopah Spring Member	C.R. Vitric	Crystal-Rich Vitric
		C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. Lith.	Crystal-Rich Lithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		C.P. Vitric	Crystal-Poor Vitric
		C.P. Vitric MW	Crystal-Poor Vitric Moderately Welded
		C.P. Vitric Basal NW	Crystal-Poor Vitric Basal Nonwelded

THERMOMECHANICAL UNITS

UC—Undifferentiated Overburden
 TCw—Tiva Canyon Welded Unit
 PTn—Upper Paintbrush Nonwelded Unit
 TSw1—Topopah Spring Welded Unit—Lithophysae Rich
 TSw2—Topopah Spring Welded Unit—Lithophysae Poor
 TSw3—Topopah Spring Welded Unit—Vitrophyre
 CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

COLUMN INFORMATION (Page 3)

RQD (%)
$$RQD (\%) = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ ft}}{\text{Interval length}} \times 100.$$

CORE RQD Core RQD based on piece lengths defined by all types of fractures (C, I, N and V).

ENHANCED RQD Effect of fractures identified as coring induced (Type C) are filtered from the piece lengths.

LITHOPHYSAL (and other cavities) Percent void due to lithophysae and other cavities, estimated visually by counting the number of cavities, estimating the average diameter, calculating the void volume assuming spherical cavities, and normalizing to the core volume.
 NM—Not Measured

WEATHERING	Subjective evaluation of rock degradation by mechanical/chemical agents:		
	F: Fresh	M: Moderately weathered	D: Decomposed
	S: Slightly weathered	I: Intensely weathered	
HARDNESS	Subjective evaluation of resistance to breakage:		
	1: Extremely hard	4: Moderately hard	7: Very soft
	2: Very hard	5: Moderately soft	8: Soil-like, cohesive
	3: Hard	6: Soft	9: Soil-like, non-cohesive

COLUMN INFORMATION (Page 4)

FEATURE TYPE	Following codes indicate origin of feature: N: Natural—indicated by mineral coating or evidence of weathering, slickensides, lack of fit between sides. I: Indeterminate—origin questionable, rotated so that coatings possibly removed. C: Coring induced—fresh, clean, tightly fitting breaks. V: Vug or large void.		
INCLINATION (degrees)	Angle between plane normal to core axis and plane of fracture (Type N and I only).		
MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only): C: Clean WC: White crystalline WN: White noncrystalline BC: Black crystalline BD: Black dendritic TD: Brown dendritic TC: Tan crystalline CA: Calcite SI: Silica MN: Manganese CL: Clay TN: Tan noncrystalline FE: Iron oxide BN: Brown noncrystalline		
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only): C: Clean, no filling S: Very thin, surface sheen T: Thin (up to 0.1 inches) M: Moderately thick (0.1-0.4 inches) V: Very thick (0.4 - 1.0 inches) E: Extremely thick, greater than 1.0 inches		
PLANARITY	Describes the overall shape of the feature (Type N and I only): P: Planar C: Curved S: Stepped I: Irregular		
ROUGHNESS	Describes the local relief of the surface (Type N and I only): V: Very rough—stepped, near-normal steps and ridges occur. R: Rough—large angular asperities can be seen. M: Moderately rough—asperities clearly visible, surface has abrasive feel. S: Smooth—no asperities, smooth to the touch. P: Polished—slickensided, extremely smooth and shiny.		

Interval — 0-70 ft (0-21.34 m), TCw Unit

*** Footcans in interval may not equal 10 ft because of lost core, tubular, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-7/7A

Interval — 0-70 ft (0-21.34 m), TCw Unit

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (per interval)	NO. OF FRACTURES W/INCLINATION (degrees)									
			N	I	C	V		10	20	30	40	50	60	70	80	90	
10	Alluvium	UD	2		9		10						2				
20	Alluvium	UD	18	2	14		20							1	1	1	
30	T.C. C.P. L. Nonlith	TCw	47	3	12		30						2	3	4	2	
40	T.C. C.P. L. Nonlith	TCw	87	9	10		40					4	5	2	2	8	2
50	T.C. C.P. L. Nonlith	TCw	18	2	15		50					5			2	2	
60	T.C. C.P. L. Nonlith	TCw	2	13	20		60					1	4	2	1		
70	T.C. C.P. L. Nonlith	TCw	17	14	26		70					4	2	3	4	8	
TOTAL			138	41	108	0											
PERCENT OF OCCURRENCE			48	14	37	0											

NO. OF FRACTURES W/ MINERAL INFILLING TYPE													NO. OF FRACTURES W/ INFILL THICKNESS CODE							NO. OF FRACTURES W/ PLANARITY CODE				NO. OF FRACTURES W/ ROUGHNESS CODE				
WC	WN	BC	BD	TD	TC	CA	SI	MN	CL	TN	FE	BN	C	S	T	M	V	E	P	C	S	I	V	R	M	S	P	
10						7					2		3	2	10				1		1				1	1	1	
	23		1			13			4		2		4	5	41				7	1		42	7	32	7	2		
1	7		4			1			1		11		20	8	18				8			38	1	22	9		7	
6	1					1			2		8			13	4				10			1		1	13	3		
									7				6	7					4			5			9			
									20		3		7	23	1				19	6	2	4		2	28	1		
16	31	0	5	0	0	22	0	0	34	0	26	0	40	59	20	0	0	0	64	6	3	101	8	65	85	19	7	
6.9	17	0	2.9	0	0	12	0	0	19	0	15	0	22	39	45	0	0	0	37	3.4	1.7	58	4.9	40	40	12	4.3	

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-77A

Interval -- 70-290 ft (21.3-88.4 m), PTn Unit

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD*	ENHANCED RQD**	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	WEATHERING (Rin 10-ft interval)***					HARDNESS (ft in 10-ft interval)***							
								P	S	M	I	D	ROCK							
80	T.C. C.P. Vmto	PTn	61	90	0	0.7			2.9	5.9							4.1	4.7		
90	T.C. C.P. Vmto	PTn	58	74	0	1.1			1.0	2.2	4.8							1.0	4.2	4.8
100	T.C. C.P. Vmto	PTn	80	79	0	1.8				10.0									5.0	4.0
110	B.T.	PTn	31	61	0	0.8	2.4			5.0									1.8	3.1
120	Y.M.	PTn	38	68	0	0.4	0.7			7.5									7.5	
130	Y.M.	PTn	14	63	0	0.0	1.7			5.0									5.0	
140	Y.M.	PTn	48	91	0	0.0	0.5		0.2	3.9									10.0	
150	Y.M.	PTn	0	0	0	5.4	2.1		10.0									4.8	5.2	
160	Y.M.	PTn	0	8	0	0	9.5		4.9									0.2	4.8	
170	B.T.	PTn	25	70	0	0.4	3.6		5.1										5.1	
180	B.T.	PTn	49	80	0	0.4	1.4		5.0										5.0	
190	P.C.	PTn	61	90	0	0.8	0.1		10.0										10.0	
200	P.C.	PTn	54	87	0	1.0	1.4		10.0										0.1	9.8
210	P.C.	PTn	50	84	0	2.5	0.8		4.9										4.7	0.2
220	P.C.	PTn	53	74	0	0.8	0.8		10.0										10.0	
230	P.C.	PTn	55	89	0	0.5	1.1		10.0									4.3	5.7	
240	P.C.	PTn	81	74	0	1.0	1.8		5.9									0.9	5.1	
250	P.C.	PTn	58	81	0	0.5	0.8		7.2	1.9									9.1	
260	P.C.	PTn	75	81	0	0.1	0.3		8.0	1.0									1.0	9.0
270	B.T.	PTn	58	74	0	0.0	2.3		1.0		3.0									8.1
280	B.T.	PTn	4	20	0	5.9	2.1				0.9									0.1
290	B.T.	PTn	58	78	0	1.2	1.0		4.0	5.2									4.0	5.2

* CORE RQD Determined from piece lengths formed by all types of fractures (C, I, M and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

*** Footage in interval may not equal 10 ft because of lost core, rubble, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Cose Hole Structural Data Summary

Hole USW NRG-77A

Interval — 70-290 ft (21.3-88.4 m), PTn Unit

NO. OF FRACTURES W/GENERAL INFILLING TYPE														NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE					NO. OF FRACTURES W/ROUGHNESS CODE				
C	WC	WN	BC	BD	TD	TC	CA	SI	MM	CL	TN	FE	BN	C	S	T	M	V	B	P	C	S	T	V	R	M	S	P	
2									8	2				2	4	4				6	4	1				2	4	3	1
1									2	2				1	5					4				2		1	1	4	
1														1										1					
4														4						1	2			1			2	1	
2									6					2	6					8							2	6	
4										1				4		1				1				3		1	2	1	
8														6						4				2		2	3	1	
11														11						1				10			10	1	
4														4						2				2		2	2		
9														3										2		2			
2														2						2							1	1	
10														10						6	2			2		1	6		
2														2										2		2			
3														3						1				2		1	2		
1														1										1			1		
1														1										1		1			
	1															1								1			1		
3														3												1	2		
80	1	0	0	0	0	0	0	0	9	11	0	0	0	80	10	5	1	0	0	38	8	1	24	0	18	41	12	1	
74	1.2	0	0	0	0	0	0	0	11	14	0	0	0	74	19	6.2	1.2	0	0	44	11	1.3	43	0	21	54	24	1.3	

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-77A

Interval — 290-770 ft (88.4-234.7 m), TSW1 Unit

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE ROD** %	ENHANCED ROD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	RUBBLE ZONE (ft)	WEATHERING (ft in 10-ft interval)***					HARDNESS (ft in 10-ft interval)***						
													ROCK						
								F	S	M	I	D	1	2	3	4	5	6	7
300	T.S. C.P. Vels	TSw1	26	40	0	1.0	0.0	4.2	1.8						4.2			1.8	
310	T.S. C.P. Nonch.	TSw1	0	24	0	0.0	0.4	0.7	7.0				7.2		1.9				
320	T.S. C.P. Nonch.	TSw1	13	44	0	0.0	0.0		10.0						10.0				
330	T.S. C.P. Nonch.	TSw1	4	61	0	0.0	1.3		4.1						4.1				
340	T.S. C.P. Nonch.	TSw1	33	55	0	0.0	2.2												
350	T.S. C.P. Nonch.	TSw1	21	62	0	0.0	2.0												
360	T.S. C.P. Nonch.	TSw1	12	34	0	0.0	2.3	2.0							2.0				
370	T.S. C.P. Nonch.	TSw1	15	74	0	1.2	0.0	10.0							10.0				
380	T.S. C.P. Nonch.	TSw1	12	67	0	2.3	0.3	10.0							10.0				
390	T.S. C.P. Nonch.	TSw1	20	70	0	1.1	0.0	0.0	1.2						10.0				
400	T.S. C.P. Nonch.	TSw1	5	66	0	0.0	1.4	0.0							0.0				
410	T.S. C.P. Nonch.	TSw1	15	61	0	1.4	0.0	5.0							5.0				
420	T.S. C.P. Nonch.	TSw1	87	89	1	0.0		10.0							10.0				
430	T.S. C.P. Nonch.	TSw1	34	86	0	0.0	0.7	10.0							10.0				
440	T.S. C.P. Nonch.	TSw1	42	89	0	0.0	0.2	4.3	0.7						10.0				
450	T.S. C.P. Nonch.	TSw1	77	97	0	0.0		5.7	4.3						10.0				
460	T.S. C.P. Nonch.	TSw1	73	100	0	0.0		4.6	5.4						10.0				
470	T.S. C.P. Nonch.	TSw1	42	77	0	0.0	0.1	2.7	7.3						10.0				
480	T.S. C.P. Nonch.	TSw1	37	69	0	0.0	0.3	10.0							10.0				
490	T.S. C.P. Uch.	TSw1	58	80	4	0.0	0.0	10.0							10.0				
500	T.S. C.P. Uch.	TSw1	41	65	9	3.2	0.3	10.0							10.0				
510	T.S. C.P. Uch.	TSw1	4	31	13	4.7	1.0	10.0							10.0				
520	T.S. C.P. Uch.	TSw1	36	68	7	1.2	0.0	0.0	0.0						0.0				
530	T.S. C.P. U. Uch.	TSw1	40	66	4	1.0	1.2	10.0							10.0				
540	T.S. C.P. U. Uch.	TSw1	5	25	0	0.4	0.4	10.0							10.0				
550	T.S. C.P. U. Uch.	TSw1	12	22	5	4.0	2.0	5.7	4.7					0.0	0.0				
560	T.S. C.P. U. Uch.	TSw1	7	50	10	3.0	1.1	4.4		0.0					10.0				
570	T.S. C.P. U. Uch.	TSw1	15	41	9	4.4	1.1			10.0					10.0				
580	T.S. C.P. U. Uch.	TSw1	0	19	11	7.4	0.7	5.7	4.3						10.0				
590	T.S. C.P. U. Uch.	TSw1	4	4	16	7.2	2.1	5.5	4.5						10.0				
600	T.S. C.P. U. Uch.	TSw1	4	25	12	5.5	1.5	10.0							10.0				
610	T.S. C.P. U. Uch.	TSw1	17	26	8	4.5	2.0	10.0							10.0				
620	T.S. C.P. U. Uch.	TSw1	14	30	8	3.0	2.5	10.0							10.0				
630	T.S. C.P. U. Uch.	TSw1	14	21	6	0.0	0.0	4.6							4.6				
640	T.S. C.P. U. Uch.	TSw1	2	30	4	4.0	1.0	0.5							0.5				
650	T.S. C.P. U. Uch.	TSw1	7	37	5	2.0	2.3	10.0							10.0				
660	T.S. C.P. U. Uch.	TSw1	48	69	5	0.5	0.2	10.0							10.0				
670	T.S. C.P. U. Uch.	TSw1	25	37	4	0.1	0.1	10.0							10.0				
680	T.S. C.P. U. Uch.	TSw1	40	64	4	0.0	0.7	5.9	4.7						0.0	4.7			
690	T.S. C.P. U. Uch.	TSw1	0	22	2	2.1	1.9	10.0							10.0				
700	T.S. C.P. U. Uch.	TSw1	33	63	3	2.1	1.5	2.7	7.3						2.7	7.3			
710	T.S. C.P. U. Uch.	TSw1	24	40	8	2.2	3.1	10.0							10.0				
720	T.S. C.P. U. Uch.	TSw1	22	52	4	3.0	0.0	10.0							10.0				
730	T.S. C.P. U. Uch.	TSw1	19	39	8	2.0	2.0	10.0							10.0				
740	T.S. C.P. U. Uch.	TSw1	0	25	5	3.0	2.2	10.0							10.0				
750	T.S. C.P. U. Uch.	TSw1	5	29	3	2.0	3.0	10.0							10.0				
760	T.S. C.P. U. Uch.	TSw1	9	47	3	2.2	2.4	2.5							2.5				
770	T.S. M. Nonch.	TSw1	9	14	2	4.1	2.7	10.0							10.0				

* CORE ROD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED ROD Determined by raising the effects of fractures identified as coring induced (Type C) from the piece lengths.

*** Forage in interval may not equal 10 ft because of lost core, rubble, or omission during logging.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole USW NRG-777A

Interval — 290-770 ft (88.4-234.7 m), TSw1 Unit

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (per interval)	NO. OF FRACTURES WINCLINATION (degrees)										
			N	E	C	V		0	10	20	30	40	50	60	70	80	90	C
300	T.S. C.R. Vitic	TSw1	13	9	24													
310	T.S. C.R. Nonlith.	TSw1	8	12	14													
320	T.S. C.R. Nonlith.	TSw1	41	3	6													
330	T.S. C.R. Nonlith.	TSw1	37	5	2													
340	T.S. C.R. Nonlith.	TSw1	9	9	9													
350	T.S. C.R. Nonlith.	TSw1	11	4	14													
360	T.S. C.R. Nonlith.	TSw1	2	9	28													
370	T.S. C.R. Nonlith.	TSw1		9	31													
380	T.S. C.R. Nonlith.	TSw1	1	3	32													
390	T.S. C.R. Nonlith.	TSw1	4	5	23													
400	T.S. C.R. Nonlith.	TSw1	6	8	32													
410	T.S. C.R. Nonlith.	TSw1	10	3	35													
420	T.S. C.R. Nonlith.	TSw1			17													
430	T.S. C.R. Nonlith.	TSw1		6	32													
440	T.S. C.R. Nonlith.	TSw1	1	10	23													
450	T.S. C.R. Nonlith.	TSw1		4	19													
460	T.S. C.R. Nonlith.	TSw1	2	4	16													
470	T.S. C.R. Nonlith.	TSw1	9	3	28													
480	T.S. C.R. Nonlith.	TSw1	2		38													
490	T.S. C.R. Lith.	TSw1			31													
500	T.S. C.R. Lith.	TSw1			17													
510	T.S. C.R. Lith.	TSw1		1	19													
520	T.S. C.R. Lith.	TSw1	1	2	27													
530	T.S. C.P. U. Lith.	TSw1		7	28													
540	T.S. C.P. U. Lith.	TSw1	2	11	15													
550	T.S. C.P. U. Lith.	TSw1		2	10													
560	T.S. C.P. U. Lith.	TSw1		2	24													
570	T.S. C.P. U. Lith.	TSw1		2	18													
580	T.S. C.P. U. Lith.	TSw1			8													
590	T.S. C.P. U. Lith.	TSw1		1	4													
600	T.S. C.P. U. Lith.	TSw1		3	14													
610	T.S. C.P. U. Lith.	TSw1			10													
620	T.S. C.P. U. Lith.	TSw1	2	1	21													
630	T.S. C.P. U. Lith.	TSw1			11													
640	T.S. C.P. U. Lith.	TSw1	1	2	20													
650	T.S. C.P. U. Lith.	TSw1	1	4	20													
660	T.S. C.P. U. Lith.	TSw1	3	1	28													
670	T.S. C.P. U. Lith.	TSw1	1	5	28													
680	T.S. C.P. U. Lith.	TSw1	2	9	28													
690	T.S. C.P. U. Lith.	TSw1	9	7	13													
700	T.S. C.P. U. Lith.	TSw1	2	6	20													
710	T.S. C.P. U. Lith.	TSw1	2	2	22													
720	T.S. C.P. U. Lith.	TSw1		1	17													
730	T.S. C.P. U. Lith.	TSw1		4	23													
740	T.S. C.P. U. Lith.	TSw1		3	23													
750	T.S. C.P. U. Lith.	TSw1		2	18													
760	T.S. C.P. U. Lith.	TSw1		6	22													
770	T.S. M. Nonlith.	TSw1	1	4	11													
TOTAL			153	187	971	0												
PERCENT OF OCCURRENCE			14	14	72	0												

NO. OF FRACTURES W/MINERAL INFILLING TYPE													NO. OF FRACTURES W/INFILL THICKNESS CODE						NO. OF FRACTURES W/PLANARITY CODE				NO. OF FRACTURES W/ROUGHNESS CODE				
WC	WN	BC	BD	TD	TC	CA	SI	MN	CL	TN	FB	BN	C	S	T	M	V	E	P	C	S	I	V.	R	M	S	P
12													10	3	8				18			2			7	13	
													20						9			8		6	4	10	
													44						30			11	5	3	21	8	1
8	3												21	21					33	1		5	1	3	6	29	
	13												5	13					13			1			6	8	
6	2												5	10					11			2			7	8	
1													4	1					5					2		3	
	2												7	2					2			8		8	2		
													4						2			2		2	2		
													8						3			8	1	5	2		
	1												13	1					3	1	1	8		2	6	8	
													13						8	3	1			1		8	
													4				1		4			1		3	2		
	1												10	1					5	3	3			5	6	1	
													4						4					3	1		
													8						2	2	2				6		
	1											1	10		2				8	3	1			2	5	4	1
												2			1	1			2							1	1
													1									1			1		
													3									1	2		2	1	
												1	12	1					3	4				4	3		
													1	1					4	5		3			10	2	
													2						2					2			
													2						1			1		2			
													2									2		2			
													1									1			1		
													3						3						2	1	
													3									1		1			
													3									1			1		
													5						3			2		1	1	3	
													4						4							4	
													8						2		1	3		1	2	3	
2													8		2				2	2		7		1	6	2	
													15	1					5	4	1	2		3	6	2	1
													7		1				4	1	1	1		2	3	2	
1													3		1				2			1		1	1		
													1						1							1	
													4						1		1	1		1		2	
													3									1		1			
													2						1			1			2		
													8									5		2	1	2	
													5						2			3		2	3		
27	23	0	0	0	0	0	0	0	0	0	0	4	297	66	15	0	2	0	194	33	14	80	7	49	132	132	4
7.3	6.2	0	0	0	0	0	0	0	0	0	0	1.1	80	15	4.3	0	0.5	0	59	9.9	4.2	27	2.1	15	42	40	1.2

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
Core Hole Structural Data Summary
Hole USW NRG-377A
Interval — 770-1510 ft (234.7-460.3 m), T3w2, T3w3 and CHn1 Units

BASE OF 10-FT INTERVAL	STRATIGRAPHY ZONE	THERMO- MECHANICAL UNIT	FEATURE TYPE				FRACTURE FREQUENCY (#/ft interval)	NO. OF FRACTURES WITH INCLINATION (deg)						
			N	E	C	V		10	20	30	45	50	60	75
780	T.S. M. North.	T3w2	13	14	11		780							
790	T.S. M. North.	T3w2		4	3		790							
800	T.S. M. North.	T3w2	17	8	12		800							
810	T.S. M. North.	T3w2	8	10	22		810							
820	T.S. M. North.	T3w2	4	2	25		820							
830	T.S. M. North.	T3w2		9	22		830							
840	T.S. M. North.	T3w2	1	4	8		840							
850	T.S. M. North.	T3w2		1	5		850							
860	T.S. M. North.	T3w2	2	5	24		860							
870	T.S. M. North.	T3w2	8	4	24		870							
880	T.S. M. North.	T3w2	5	7	20		880							
890	T.S. C.P. L. Lsh.	T3w2	1	2	12		890							
900	T.S. C.P. L. Lsh.	T3w2	12	2	16		900							
910	T.S. C.P. L. Lsh.	T3w2	10		2		910							
920	T.S. C.P. L. Lsh.	T3w2			1		920							
930	T.S. C.P. L. Lsh.	T3w2					930							
940	T.S. C.P. L. Lsh.	T3w2		1	8		940							
950	T.S. C.P. L. Lsh.	T3w2	5	1	5		950							
960	T.S. C.P. L. Lsh.	T3w2	7	7	24		960							
970	T.S. C.P. L. Lsh.	T3w2	5	7	11		970							
980	T.S. C.P. L. Lsh.	T3w2	2	12	27		980							
990	T.S. C.P. L. Lsh.	T3w2		5	14		990							
1000	T.S. C.P. L. Lsh.	T3w2		2	4		1000							
1010	T.S. C.P. L. Lsh.	T3w2	1	10	10		1010							
1020	T.S. C.P. L. Lsh.	T3w2					1020							
1030	T.S. C.P. L. Lsh.	T3w2			5		1030							
1040	T.S. C.P. L. Lsh.	T3w2		1	15		1040							
1050	T.S. C.P. L. Lsh.	T3w2	2	18	25		1050							
1060	T.S. C.P. L. Lsh.	T3w2	2	4	11		1060							
1070	T.S. C.P. L. Lsh.	T3w2	1		2		1070							
1080	T.S. C.P. L. Lsh.	T3w2	18	2	24		1080							
1090	T.S. C.P. L. Lsh.	T3w2	5	2	15		1090							
1100	T.S. C.P. L. Lsh.	T3w2	3	4	14		1100							
1110	T.S. C.P. L. Lsh.	T3w2	1	8	18		1110							
1120	T.S. C.P. L. Lsh.	T3w2			5		1120							
1130	T.S. C.P. L. Lsh.	T3w2	1	3	18		1130							
1140	T.S. C.P. L. Lsh.	T3w2			5		1140							
1150	T.S. C.P. L. Lsh.	T3w2	1		15		1150							
1160	T.S. C.P. L. Lsh.	T3w2	5	5	17		1160							
1170	T.S. C.P. L. Lsh.	T3w2	4	4	22		1170							
1180	T.S. C.P. L. Lsh.	T3w2	1	2	24		1180							
1190	T.S. C.P. L. Lsh.	T3w2		8	24		1190							
1200	T.S. C.P. L. Lsh.	T3w2		1	7		1200							
1210	T.S. C.P. L. Lsh.	T3w2	7		20		1210							
1220	T.S. C.P. L. Lsh.	T3w2	1	2	5		1220							
1230	T.S. C.P. L. Lsh.	T3w2	2	1	5		1230							
1240	T.S. C.P. L. North.	T3w2	1	4	5		1240							
1250	T.S. C.P. L. North.	T3w2	8	3	24		1250							
1260	T.S. C.P. L. North.	T3w2	2	5	18		1260							
1270	T.S. C.P. L. North.	T3w2	8	4	23		1270							
1280	T.S. C.P. L. North.	T3w2	3	5	27		1280							
1290	T.S. C.P. L. North.	T3w2	2	7	15		1290							
1300	T.S. C.P. L. North.	T3w2	2	5	14		1300							
1310	T.S. C.P. L. North.	T3w2	2	5	10		1310							
1320	T.S. C.P. L. North.	T3w2	1	11	5		1320							
1330	T.S. C.P. L. North.	T3w2	1	7	15		1330							
1340	T.S. C.P. L. North.	T3w2	1	2	5		1340							
1350	T.S. C.P. L. North.	T3w2	1	10	10		1350							
1360	T.S. C.P. L. North.	T3w2	4	7	5		1360							
1370	T.S. C.P. L. North.	T3w2	5	10	22		1370							
1380	T.S. C.P. L. North.	T3w2	5	3	25		1380							
1390	T.S. C.P. L. North.	T3w2	15	5	24		1390							
1400	T.S. C.P. L. North.	T3w2	14	3	15		1400							
1410	T.S. C.P. L. North.	T3w2	9	3	14		1410							
1420	T.S. C.P. Viro	T3w3	21	5	14		1420							
1430	T.S. C.P. Viro	T3w3	5	1	21		1430							
1440	T.S. C.P. Viro	T3w3	13		5		1440							
1450	T.S. C.P. Viro	T3w3	1		22		1450							
1460	T.S. C.P. Viro NW	T3w3	5		21		1460							
1470	T.S. C.P. Viro NW	CHn1	7	2	12		1470							
1480	T.S. C.P. Viro NW	CHn1	4	4	15		1480							
1490	T.S. C.P. Viro NW	CHn1	1	1	27		1490							
1500	T.S.	CHn1		5	11		1500							
1510	Proterozoic Bedrock	CHn1	2	5	14		1510							
TOTAL			288	310	1088	0								
PERCENT OF OCCURRENCE			18	18	64.00	0								

**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
ESTIMATED ROCK MASS QUALITY INDICES
BASED ON CORE LOG DATA
Hole USW NRG-77A**

Sandia National Laboratories
Print Date: 2/13/95
WBS 1.2.3.2.6.2
QA:L
Revision 3

REVISION HISTORY

- Revision 2 Additional stratigraphic data from 770-1510 ft included. Method for calculating percent lithophysae and other cavities revised; Q-core index and histogram plots removed from presentation.
- Revision 3 Revised SRF parameter using NRG rock testing data for PTn unit.

EXPLANATION OF CALCULATION

Rock mass quality indices, Q (Barton et al., 1974) and RMR (Bieniawski, 1979), have been estimated for 10-ft intervals using Rock Structural Data Summaries developed from structural logging of the core, observations of rock conditions in the North Ramp Starter Tunnel, and laboratory testing data.

- Q is developed to evaluate the distribution of rock mass quality as a basis for developing the range of credible rock mass quality to establish the ground support requirements within rock units and to derive rock mass mechanical properties according to the methodology proposed by Hardy and Bauer (1993). Procedures used in the calculation were:

$$Q = \frac{RQD^{**}}{J_n^{*}} \cdot \frac{J_r}{J_a} \cdot \frac{J_w}{SRF^{*}}$$

Note: Any spatial correlation may be masked by Monte Carlo simulation of J_n and SRF.

where RQD^{**} = Core RQD where all fractures types [natural (N), indeterminate (I) and coring induced (C)] have been considered in determination of RQD. If the RQD is less than 10%, the value used is set to 10 as per Barton et al. (1974). By definition, soil-like materials are considered to have zero RQD.

J_n^{*} = Joint Set Numbers: Cannot be determined from the core log data and are generated by Monte-Carlo simulation assuming a uniform distribution of values between 4 to 9.

J_r = Joint Roughness Number: A weighted average value derived based on the N and I type fractures in the 10-ft interval.

J_a = Joint Alteration Number: A weighted average value derived from the description of N and I type fractures in the interval.

Jw = Joint Water Factor: Set equal to 1.0 assuming dry conditions.

SRF* = Stress Reduction Factor: For nonwelded units, SRF is determined from the ratio of UCS/ σ_1 (UCS = unconfined compressive strength, σ_1 = overburden stress). If unconfined compressive strength data is not available for the 10-ft interval, a compressive strength is generated by Monte Carlo simulation using laboratory test data for the thermomechanical units. For welded tuff units, SRF cannot be determined from core log data and is generated by Monte Carlo simulation assuming a distribution derived from mapping of the North Ramp Starter Tunnel.

- The use of the Core RQD is conservative since it includes the effect of coring induced breaks. Filtering the effects of coring induced breaks from the RQD calculation ("Enhanced RQD") produced an increase in the mean RQD. The mean values for thermomechanical units in USW NRG-77A are:

	<u>Core RQD</u>	<u>Enhanced RQD</u>
TCw	24.7%	42.4%
PTn	43.7%	65.8%
TSw1	22.8%	52.6%
TSw2, TSw3 and CHn1	14.3%	29.2%

- RMR is estimated based on the Rock Structural Summary log data, and rock strength data. Procedures used in the calculation were:

$$RMR = C + RQD-I + JS + JC + JW$$

where C = Rock Strength Index: Derived from compressive strength estimated by Schmidt Rebound Hardness data for the 10-ft interval. If data is not available for the 10-ft interval, a compressive strength is generated by Monte-Carlo simulation using laboratory test data for the thermomechanical unit.

RQD-I = RQD Index: Derived using the Core RQD value for the 10-ft interval.

JS = Joint Spacing Index: Derived from the rock structural data for the 10-ft interval, excludes coring induced features.

JC = Discontinuity Condition Index: Derived from the description of fractures in the 10-ft interval.

JW = Groundwater Index: Assumed dry conditions

- Q and RMR data are presented in log format to associate parameters with depth intervals in the core log; however, any spatial correlation may be masked by Monte-Carlo simulation.

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member		
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain Member		
P.C.	Pah Canyon Member		
T.S.	Topopah Spring Member	C.R. Vitric	Crystal-Rich Vitric
		C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. Lith.	Crystal-Rich Lithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		Crystal-Poor V. Tran.	Crystal-Poor Vitric Transition
		C.P. Vitric	Crystal-Poor Vitric
		C.P. Vitric MW	Crystal-Poor Vitric Moderately Welded
		C.P. Vitric Basal NW	Crystal-Poor Vitric Basal Nonwelded

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
 TCw—Tiva Canyon Welded Unit
 PTn—Upper Paintbrush Nonwelded Unit
 TSw1—Topopah Spring Welded Unit—Lithophysae Rich
 TSw2—Topopah Spring Welded Unit—Lithophysae Poor
 TSw3—Topopah Spring Welded Unit—Vitrophyre
 CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRG-77A

Interval — 0-70 ft (0-21.3 m), TCw Unit

END DEPTH	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM ¹ Barton et al. (1974)							RMR CLASSIFICATION SYSTEM ² Bieniawski (1979)					
			RQD** (%)	J _n *	J _r	J _a	J _w	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
10	Alluvium	UO													
20	Alluvium	UO													
30	TC CPL Nonlith	TCw	14	8.00	2.79	2.35	1.00	5.00	0.42	12	3	8	19.1	15	57.1
40	TC CPL Nonlith	TCw	26	9.00	2.86	1.33	1.00	1.00	5.78	12	8	6	23.6	16	63.6
50	TC CPL Nonlith	TCw	48	4.00	1.88	1.43	1.00	7.50	2.08	4	8	8	17.2	15	52.2
60	TC CPL Nonlith	TCw	43	7.00	2.56	2.08	1.00	1.00	7.58	12	8	8	19.2	15	62.2
70	TC CPL Nonlith	TCw	12	6.00	2.17	2.29	1.00	1.00	1.90	7	3	5	15.7	15	45.7

J_n*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

¹ Barton, N., R. Lien, and J. Lund, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6:189-236 (Springer Verlag, 1974)² Bieniawski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland 2:41-46 (A. A. Balkema, 1979)

Q

J_n — Joint Set Number
 J_r — Joint Roughness Number
 J_a — Joint Alteration Number
 J_w — Joint Water Reduction Factor
 SRF — Stress Reduction Factor

$$Q = (RQD/J_n)(J_r/J_a)(J_w/SRF)$$

RMR

C — Strength Index
 RQD-I — RQD Index
 JS — Joint Spacing Index
 JC — Discontinuity Condition Index
 JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRG-77A

Interval — 70-290 ft (21.3-88.4 m), PTn Unit

END DEPTH	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al. (1974)							RMR CLASSIFICATION SYSTEM Bieniawski (1979)					
			RQD** (%)	Jn*	Jr	Ja	Jw	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
80	T.C. C.P. Vitric	PTn	61	8.00	1.55	1.40	1.00	1.40	7.14	2	13	8	17.8	15	55.8
90	T.C. C.P. Vitric	PTn	59	8.00	1.67	1.67	1.00	15.00	0.66	2	13	8	17.0	15	55.0
100	T.C. C.P. Vitric	PTn	50	5.00	4.00	1.00	1.00	15.00	2.67	1	13	8	30.0	15	67.0
110	B.T.	PTn	31	8.00	3.00	1.00	1.00	15.00	0.77	1	8	8	28.5	15	60.5
120	Y.M.	PTn	39	5.00	2.00	1.00	1.00	6.38	2.44	2	8	8	23.6	15	56.6
130	Y.M.	PTn	14	6.00	1.25	2.50	1.00	15.00	0.09	2	3	8	12.9	15	40.9
140	Y.M.	PTn	48	9.00	2.50	1.40	1.00	15.00	0.63	1	8	8	23.8	15	65.8
150	Y.M.	PTn	0	9.00	2.77	1.38	1.00	15.00	0.15	1	3	8	25.4	15	49.4
160	Y.M.	PTn	0	9.00	2.77	1.38	1.00	15.00	0.15	2	3	8	25.4	15	50.4
170	B.T.	PTn	25	6.00	4.00	1.00	1.00	0.60	27.91	4	8	8	30.0	15	65.0
180	B.T.	PTn	48	5.00	2.82	1.00	1.00	0.60	45.31	4	8	8	27.6	15	62.8
190	P.C.	PTn	61	8.00	2.50	1.00	1.00	15.00	1.27	1	13	8	24.0	15	61.0
200	P.C.	PTn	54	9.00	3.00	1.00	1.00	15.00	1.20	2	13	8	28.5	15	66.5
210	P.C.	PTn	50	7.00	1.50	1.00	1.00	15.00	0.71	2	13	8	18.6	15	58.8
220	P.C.	PTn	53	5.00	2.29	1.00	1.00	15.00	1.82	2	13	8	22.2	15	60.2
230	P.C.	PTn	66	7.00	3.00	1.00	1.00	8.38	3.38	2	13	8	28.5	15	66.5
240	P.C.	PTn	61	7.00	2.67	1.00	1.00	15.00	1.55	2	13	8	25.5	15	63.5
250	P.C.	PTn	56	9.00	3.00	1.00	1.00	15.00	1.24	1	13	8	28.5	15	65.5
260	P.C.	PTn	76	8.00	3.00	1.00	1.00	15.00	1.90	1	17	8	28.5	15	69.5
270	B.T.	PTn	58	7.00	3.00	8.00	1.00	15.00	0.28	1	13	8	12.8	15	49.8
280	B.T.	PTn	4	9.00	2.77	1.38	1.00	15.00	0.15	1	3	8	25.4	15	52.4
290	B.T.	PTn	58	6.00	2.67	1.00	1.00	15.00	1.72	2	13	8	27.0	15	65.0

Jn*, SRF* = interval values generated by Monte Carlo simulation, to calculate Q*

In-Core, SRF-Core = average values of assumed distribution, to calculate Q-Core

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974)

If RQD is 0, the value 1 is used in the calculation of Q-Core

¹ Barton, N. R. Lien, and J. Lund, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6:189-213 (Springer Verlag, 1974)

² Bieniawski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 3:41-48 (A. A. Balkema, 1979)

Q

Jn — Joint Set Number

Jr — Joint Roughness Number

Ja — Joint Alteration Number

Jw — Joint Water Reduction Factor

SRF — Stress Reduction Factor

$$Q = (RQD/Jn)(Jr/Ja)(Jw/SRF)$$

RMR

C — Strength Index

RQD-I — RQD Index

JS — Joint Spacing Index

JC — Discontinuity Condition

Index

JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRG-77A

Interval — 290-770 ft (88 4-234 7 m), TSwl Unit

END DEPTH	STRATIGRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM							RMR CLASSIFICATION SYSTEM					
			Barton et al (1974)							Bremowski (1979)					
			ROD** (%)	J _a *	J _r	J _s	J _w	SRI*	Q*	C	ROD-I	JS	JC	JW	RMR
300	TS CR Vitr	TSwl	26	7.00	1.45	1.00	1.00	1.00	5.39	2	8	8	19.4	15	52.4
310	TS CR Nonlth	TSwl	0	9.00	1.89	1.00	1.00	7.60	0.28	7	3	6	23.0	15	63.0
320	TS CR Nonlth	TSwl	13	7.00	2.01	1.00	1.00	5.00	0.75	7	3	8	21.5	15	54.5
330	TS CR Nonlth	TSwl	4	7.00	1.38	1.14	1.00	1.00	1.73	4	3	8	19.1	15	49.1
340	TS CR Nonlth	TSwl	33	7.00	1.50	2.44	1.00	1.00	2.89	7	8	8	13.7	15	51.7
350	TS CR Nonlth	TSwl	21	4.00	1.69	1.27	1.00	7.50	0.94	4	3	8	19.1	15	49.1
360	TS CR Nonlth	TSwl	12	5.00	1.40	1.00	1.00	1.00	3.36	12	3	8	18.6	15	56.6
370	TS CR Nonlth	TSwl	15	5.00	2.50	1.44	1.00	1.00	5.19	4	3	8	23.6	15	53.6
380	TS CR Nonlth	TSwl	12	5.00	2.00	1.00	1.00	7.50	0.64	4	3	8	23.3	15	53.3
390	TS CR Nonlth	TSwl	30	6.00	2.50	1.00	1.00	7.50	1.67	7	8	8	25.1	15	63.1
400	TS CR Nonlth	TSwl	5	5.00	2.13	1.13	1.00	1.00	3.79	4	3	8	24.5	15	54.5
410	TS CR Nonlth	TSwl	15	8.00	1.29	1.00	1.00	1.00	2.41	2	3	8	19.5	15	47.5
420	TS CR Nonlth	TSwl	87	8.00	4.00	1.00	1.00	7.50	5.80	4	17	8	30.0	15	74.0
430	TS CR Nonlth	TSwl	34	5.00	2.20	2.40	1.00	1.00	6.23	7	8	8	18.3	15	56.3
440	TS CR Nonlth	TSwl	43	8.00	2.18	1.18	1.00	1.00	9.92	7	8	8	22.2	15	60.2
450	TS CR Nonlth	TSwl	77	7.00	2.00	1.00	1.00	1.00	22.00	7	17	8	24.0	15	71.0
460	TS CR Nonlth	TSwl	73	8.00	2.33	1.00	1.00	5.00	4.26	4	13	8	24.0	15	64.0
470	TS CR Nonlth	TSwl	42	9.00	1.63	1.17	1.00	5.00	1.30	7	8	8	19.9	15	67.9
480	TS CR Nonlth	TSwl	37	6.00	0.75	4.60	1.00	1.00	1.03	7	8	8	11.2	15	49.2
490	TS CR Lth	TSwl	58	8.00	4.00	1.00	1.00	1.00	29.00	7	13	8	30.0	15	73.0
500	TS CR Lth	TSwl	41	7.00	4.00	1.00	1.00	7.50	3.12	7	8	8	30.0	15	69.0
510	TS CR Lth	TSwl	4	8.00	3.00	1.00	1.00	1.00	5.00	4	3	8	28.5	15	58.5
520	TS CR Lth	TSwl	36	5.00	3.00	1.00	1.00	7.50	2.89	4	8	8	28.5	15	63.5
530	TS CP U Lth	TSwl	40	8.00	2.00	1.00	1.00	1.00	10.00	7	8	8	22.1	15	60.1
540	TS CP U Lth	TSwl	5	8.00	2.08	1.00	1.00	1.00	3.47	4	3	8	23.4	15	60.4
550	TS CP U Lth	TSwl	11	9.00	2.50	1.73	1.00	7.50	0.24	2	3	8	23.7	15	51.7
560	TS CP U Lth	TSwl	7	5.00	2.50	1.00	1.00	1.00	5.00	7	3	8	24.0	15	57.0
570	TS CP U Lth	TSwl	15	9.00	3.00	1.00	1.00	7.50	0.67	4	3	8	28.5	15	58.5
580	TS CP U Lth	TSwl	0	9.00	2.50	1.73	1.00	1.00	1.61	7	3	8	23.7	15	56.7
590	TS CP U Lth	TSwl	4	9.00	2.50	1.73	1.00	1.00	1.61	7	3	5	23.7	15	53.7
600	TS CP U Lth	TSwl	4	5.00	1.67	1.00	1.00	7.50	0.44	7	3	8	19.0	15	52.0
610	TS CP U Lth	TSwl	17	9.00	2.50	1.73	1.00	5.00	0.55	12	3	8	23.7	15	61.7
620	TS CP U Lth	TSwl	14	4.00	3.00	1.00	1.00	7.50	1.40	4	3	8	28.5	15	58.5
630	TS CP U Lth	TSwl	14	8.00	2.50	1.73	1.00	7.50	0.30	12	3	8	23.7	15	61.7
640	TS CP U Lth	TSwl	2	7.00	3.00	1.00	1.00	5.00	0.86	4	3	8	28.5	15	58.5
650	TS CP U Lth	TSwl	7	7.00	1.80	1.00	1.00	1.00	2.57	4	3	8	22.2	15	52.2
660	TS CP U Lth	TSwl	48	7.00	1.00	1.00	1.00	1.00	6.86	7	8	8	18.0	15	56.0
670	TS CP U Lth	TSwl	35	5.00	2.17	1.00	1.00	5.00	3.03	4	8	8	24.8	15	59.8
680	TS CP U Lth	TSwl	40	7.00	2.45	1.00	1.00	1.00	14.03	12	8	8	25.8	15	68.8

T-86

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRG-77A

Interval — 290-770 ft (88.4-234.7 m), TSwt Unit

END DEPTH	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM ¹ Barton et al. (1974)							RMR CLASSIFICATION SYSTEM ² Bieniawski (1979)					
			RQD** (%)	J _n *	J _r	J _a	J _w	SRP*	Q*	C	RQD-I	JS	JC	JW	RMR
690	T.S. C.P. U. Lith.	TSwt	0	5.00	1.98	1.00	1.00	1.00	3.92	7	3	8	22.8	15	55.8
700	T.S. C.P. U. Lith.	TSwt	33	4.00	2.00	1.00	1.00	5.00	3.30	7	8	8	22.3	15	60.3
710	T.S. C.P. U. Lith.	TSwt	24	7.00	2.00	1.00	1.00	1.00	6.86	12	3	8	21.8	15	59.5
720	T.S. C.P. U. Lith.	TSwt	22	5.00	1.00	1.00	1.00	1.00	4.40	7	3	8	18.0	15	51.0
730	T.S. C.P. U. Lith.	TSwt	13	8.00	2.00	1.00	1.00	1.00	3.25	4	3	8	24.5	15	54.5
740	T.S. C.P. U. Lith.	TSwt	0	8.00	3.00	1.00	1.00	7.50	0.60	4	3	5	28.5	15	55.5
750	T.S. C.P. U. Lith.	TSwt	5	6.00	2.50	1.00	1.00	7.50	0.56	4	3	8	24.0	15	54.0
760	T.S. C.P. U. Lith.	TSwt	9	6.00	2.60	1.00	1.00	5.00	0.87	7	3	8	27.9	15	60.9
770	T.S. M. North.	TSwt	8	5.00	2.00	1.00	1.00	1.00	4.00	7	3	8	24.0	15	57.0

J_n*, SRP* = interval values generated by Monte Carlo simulation to calculate Q*.

RQD** If RQD is less than 10, the value 10 is used in the calculation of Q* as per Barton et al. (1974).

¹ Barton, N., R. Lien, and J. Lunde, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6:189-216 (Springer Verlag, 1974).

² Bieniawski, Z. T., "The Geomechanics Classification in Rock Engineering Applications," Proceedings, 4th International Congress on Rock Mechanics, Montreux, Switzerland, 241-48 (A. A. Balkema, 1979).

Q

J_n — Joint Set Number
 J_r — Joint Roughness Number
 J_a — Joint Alteration Number
 J_w — Joint Water Reduction Factor
 SRP — Stress Reduction Factor

$$Q = (RQD/J_n)(J_r/J_a)(J_w/SRP)$$

RMR

C — Strength Index
 RQD-I — RQD Index
 JS — Joint Spacing Index
 JC — Discontinuity Condition Index
 JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
 Estimated Rock Mass Quality Indices Based on Core Log Data
 Hole USW NRG-77A
 Interval — 770-1510 ft (234 7-460 3 m), 1Sw2 Unit

END DEPTH	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al (1974)							RMR CLASSIFICATION SYSTEM Deere and Davis (1979)					
			RQD** (%)	Jn*	J1	J2	Jw	SRF*	Q*	C	RQD*	J5	JC	JW	RMR
780	TS M Nonlab	1Sw2	4	6.00	1.44	1.00	1.00	5.00	0.48	12	3	5	19.7	15	54.7
790	TS M Nonlab	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.91	7	3	5	23.1	15	53.1
800	TS M Nonlab	1Sw2	10	4.00	1.89	1.00	1.00	7.50	0.53	12	3	5	21.2	15	56.2
810	TS M Nonlab	1Sw2	48	7.00	1.65	1.11	1.00	1.00	10.18	12	8	8	19.5	15	52.9
820	TS M Nonlab	1Sw2	18	4.00	1.00	1.00	1.00	6.00	0.80	12	3	5	18.0	15	53.0
830	TS M Nonlab	1Sw2	12	5.00	1.13	1.00	1.00	1.00	2.70	12	3	5	18.2	15	52.2
840	TS M Nonlab	1Sw2	25	8.00	1.87	1.00	1.00	7.50	1.11	12	8	8	21.5	15	54.5
850	TS M Nonlab	1Sw2	2	9.00	2.10	1.22	1.00	1.00	1.91	12	3	5	23.1	15	56.1
860	TS M Nonlab	1Sw2	29	6.00	1.43	1.00	1.00	5.00	1.38	12	8	8	19.7	15	52.7
870	TS M Nonlab	1Sw2	17	4.00	1.20	1.00	1.00	7.50	0.88	12	3	8	18.1	15	58.1
880	TS M Nonlab	1Sw2	10	7.00	1.25	1.00	1.00	1.00	1.79	7	3	5	19.3	15	49.3
890	TS C P L Lih	1Sw2	8	9.00	2.10	1.22	1.00	5.00	0.38	12	3	8	23.1	15	51.1
900	TS C P L Lih	1Sw2	0	7.00	1.60	1.27	1.00	1.00	1.80	12	3	8	18.4	15	53.4
910	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.91	7	3	5	23.1	15	53.1
920	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.91	7	3	8	23.1	15	56.1
930	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.91	12	3	5	23.1	15	58.1
940	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.91	7	3	8	23.1	15	58.1
950	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	5.00	0.38	12	3	5	23.1	15	58.1
960	TS C P L Lih	1Sw2	7	8.00	1.79	1.00	1.00	7.50	0.30	12	3	5	20.6	15	55.6
970	TS C P L Lih	1Sw2	3	8.00	1.92	1.00	1.00	6.00	0.77	12	3	5	22.1	15	57.1
980	TS C P L Lih	1Sw2	19	6.00	2.15	1.00	1.00	1.00	6.82	12	3	8	23.4	15	51.4
990	TS C P L Lih	1Sw2	28	5.00	1.60	1.00	1.00	1.00	8.88	12	8	8	19.8	15	52.8
1000	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	5.00	0.38	12	3	5	23.1	15	58.1
1010	TS C P L Lih	1Sw2	9	8.00	1.73	1.00	1.00	7.50	0.28	12	3	8	20.8	15	58.9
1020	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.81	12	3	5	23.1	15	58.1
1030	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.81	12	3	5	23.1	15	58.1
1040	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.81	12	3	5	23.1	15	58.1
1050	TS C P L Lih	1Sw2	3	9.00	1.68	1.00	1.00	1.00	1.73	12	3	5	20.3	15	55.3
1060	TS C P L Lih	1Sw2	3	9.00	2.10	1.22	1.00	1.00	1.81	4	3	5	23.1	15	50.1
1070	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.81	12	3	5	23.1	15	58.1
1080	TS C P L Lih	1Sw2	0	9.00	1.60	1.00	1.00	7.50	0.24	12	3	5	22.5	15	57.5
1090	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.81	7	3	5	23.1	15	53.1
1100	TS C P L Lih	1Sw2	4	9.00	2.30	1.29	1.00	1.00	1.90	12	3	5	22.4	15	57.4
1110	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	7.50	0.26	12	3	5	23.1	15	58.1
1120	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	6.00	0.38	12	3	5	23.1	15	58.1
1130	TS C P L Lih	1Sw2	3	9.00	2.10	1.22	1.00	1.00	1.91	12	3	8	23.1	15	58.1
1140	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	5.00	0.38	4	3	5	23.1	15	50.1
1150	TS C P L Lih	1Sw2	0	9.00	1.00	1.00	1.00	7.50	0.15	12	3	5	18.0	15	53.0
1160	TS C P L Lih	1Sw2	0	7.00	2.33	1.20	1.00	7.50	0.37	12	3	5	22.3	15	57.3
1170	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	5.00	0.38	12	3	5	23.1	15	58.1
1180	TS C P L Lih	1Sw2	0	7.00	1.00	1.00	1.00	1.00	1.43	12	3	5	18.0	15	53.0
1190	TS C P L Lih	1Sw2	16	9.00	1.33	1.00	1.00	1.00	2.27	7	3	8	20.5	15	53.5
1200	TS C P L Lih	1Sw2	0	8.00	2.10	1.22	1.00	1.00	1.91	12	3	5	23.1	15	58.1
1210	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.81	12	3	5	23.1	15	58.1
1220	TS C P L Lih	1Sw2	0	9.00	2.10	1.22	1.00	1.00	1.91	12	3	8	23.1	15	51.1
1230	TS C P L Lih	1Sw2	19	8.00	2.10	1.22	1.00	1.00	2.87	12	3	8	23.1	15	51.1

188

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Estimated Rock Mass Quality Indices Based on Core Log Data

Hole USW NRG-77A

Interval — 770-1510 ft (234.7-460.3 m), TSw2 Unit

END DEPTH	STRATIGRAPHY ZONE	THERMO-MECHANICAL UNIT	Q CLASSIFICATION SYSTEM Barton et al. (1974)							RMR CLASSIFICATION SYSTEM Barton et al. (1979)					
			RQD** (%)	J _w *	J _r	J _a	J _w	SRF*	Q*	C	RQD-I	JS	JC	JW	RMR
1240	TS C.P.L. Northh	TSw1	18	9.00	2.10	1.22	1.00	1.00	3.44	12	3	8	23.1	16	61.1
1250	TS C.P.L. Northh	TSw1	12	5.00	1.00	1.00	1.00	1.00	2.40	12	3	8	18.6	15	56.6
1260	TS C.P.L. Northh	TSw1	44	7.00	1.57	1.71	1.00	1.00	5.76	12	8	8	18.4	15	61.4
1270	TS C.P.L. Northh	TSw2	38	5.00	1.58	1.22	1.00	1.00	9.87	12	8	8	18.8	15	61.8
1280	TS C.P.L. Northh	TSw2	31	7.00	1.13	1.00	1.00	1.00	4.88	12	8	8	18.2	15	61.2
1290	TS C.P.L. Northh	TSw2	33	6.00	1.20	1.00	1.00	5.00	1.32	7	8	8	18.8	15	56.8
1300	TS C.P.L. Northh	TSw2	13	6.00	1.16	1.00	1.00	1.00	2.60	12	3	8	18.8	15	56.8
1310	TS C.P.L. Northh	TSw1	8	8.00	1.08	1.00	1.00	1.00	1.36	12	3	8	18.1	18	66.1
1320	TS C.P.L. Northh	TSw2	25	7.00	1.33	1.00	1.00	1.00	4.78	12	8	8	19.1	15	62.1
1330	TS C.P.L. Northh	TSw1	8	8.00	1.75	1.00	1.00	1.00	2.18	12	3	8	22.1	18	67.1
1340	TS C.P.L. Northh	TSw1	4	8.00	2.10	1.22	1.00	1.00	1.91	4	3	8	23.1	18	63.1
1350	TS C.P.L. Northh	TSw2	20	7.00	1.64	1.00	1.00	1.00	4.68	12	3	8	20.7	15	56.7
1360	TS C.P.L. Northh	TSw2	11	5.00	1.38	1.00	1.00	1.00	3.00	12	3	8	19.9	18	67.9
1370	TS C.P.L. Northh	TSw2	21	5.00	1.21	1.00	1.00	1.00	5.10	7	3	8	19.1	15	52.1
1380	TS C.P.L. Northh	TSw2	11	5.00	1.44	1.00	1.00	1.00	3.18	12	3	8	21.2	15	59.2
1390	TS C.P.L. Northh	TSw2	8	5.00	1.35	1.00	1.00	1.00	2.70	12	3	8	20.4	15	55.4
1400	TS C.P.L. Northh	TSw2	15	5.00	1.44	1.00	1.00	1.00	2.40	12	3	8	20.5	15	58.5
1410	TS C.P.L. Northh	TSw2	50	8.00	2.08	1.00	1.00	1.00	13.07	12	13	8	22.0	15	70.0
1420	TS CP Vetric	TSw3	13	6.00	1.80	1.18	1.00	5.00	0.88	12	3	8	21.0	15	59.0
1430	TS CP Vetric	TSw3	0	5.00	2.10	1.22	1.00	1.00	1.91	12	3	8	23.1	15	68.1
1440	TS CP Vetric	TSw3	0	5.00	2.10	1.22	1.00	7.50	0.26	4	3	8	23.1	15	50.1
1450	TS CP Vetric	TSw3	8	5.00	1.00	3.00	1.00	1.00	0.56	12	3	8	10.8	15	45.8
1460	TS CP Vetric NW	TSw3	37	6.00	1.00	1.00	1.00	1.00	6.17	12	8	8	18.0	15	61.0
1470	TS CP Vetric NW	TSw3	76	5.00	1.22	1.00	1.00	1.00	18.59	12	17	8	19.7	15	71.7
1480	TS CP Vetric Basal NW	CHal	48	7.00	1.38	1.25	1.00	1.00	7.54	12	8	8	20.3	15	63.3
1490	TS CP Vetric Basal NW	CHal	58	8.00	2.00	1.00	1.00	1.00	23.20	12	13	8	21.8	15	69.8
1500	BT	CHal	83	6.00	1.67	1.00	1.00	7.50	3.07	7	17	8	21.5	15	68.5
1510	Pyroclastic Rocks	CHal	70	6.00	1.00	1.00	1.00	1.00	11.87	4	13	8	19.0	15	66.0

J_w*, SRF* = interval data generated by Monte Carlo simulation, to calculate Q*.

RQD** If RQD is less than 10, the value 0 is used in the calculation of Q* as per Barton et al. (1974)

Barton, N. R. E., and J. Lunn, "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, 6: 189-234 (Springer Verlag, 1974)

Burland, Z. T., "The Geomechanical Classification in Rock Engineering Applications," Proceedings, 9th International Congress on Rock Mechanics, Moscow, U.S.S.R., 2: 41-48 (A. A. Balkema, 1979)

Q

J_w — Joint Set Number
 J_r — Joint Roughness Number
 J_a — Joint Alteration Number
 J_w — Joint Water Reduction Factor
 SRF — Stress Reduction Factor

$$Q = (RQD)(J_r)(J_a)(J_w)(SRF)$$

RMR

C — Strength Index
 RQD-I — RQD Index
 JS — Joint Spacing Index
 JC — Discontinuity Condition Index
 JW — Groundwater Index

$$RMR = C + RQD-I + JS + JC + JW$$

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**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
COMPARISON OF DOWNHOLE VIDEO DATA
WITH CORE DATA
Hole USW NRG-7/7A**

Sandia National Laboratories
Print Date: 3/6/95
WBS 1.2.3.2.6.2
QA-L
Revision 0

EXPLANATION OF BOREHOLE WALL CATEGORY

- C1 Excellent, typically symmetrical hole with a smooth surface; no hole enlargement; no to few lithophysae; no pronounced fractures; minor "pluckouts."
- C2 Good, typically symmetrical hole with a smooth surface; hole enlargement small or intermediate but infrequent; no to few fractures; uniform lithophysae can be present.
- C3 Poor — typically a rough surface; hole enlargement is intermediate and frequent, but it is possible for hole to be symmetrical; lithophysae can be prevalent, large, and nonuniformly distributed; fractures are frequent.
- C4 Extremely poor, typically a nonsymmetrical hole having an extremely irregular surface; hole enlargement is large; large lithophysae can be present; fractures are frequent and pronounced.

STRATIGRAPHIC ABBREVIATIONS

T.C.	Tiva Canyon Member		
B.T.	Bedded Tuff		
Y.M.	Yucca Mountain Member		
P.C.	Pah Canyon Member		
T.S.	Topopah Spring Member	C.R. Vitric	Crystal-Rich Vitric
		C.R. Nonlith.	Crystal-Rich Nonlithophysal
		C.R. Lith.	Crystal-Rich Lithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. U. Lith.	Crystal-Poor Upper Lithophysal
		C.P. M. Nonlith.	Crystal-Poor Middle Nonlithophysal
		C.P. L. Lith.	Crystal-Poor Lower Lithophysal
		C.P. L. Nonlith.	Crystal-Poor Lower Nonlithophysal
		Crystal-Poor V. Tran.	Crystal-Poor Vitric Transition
		C.P. Vitric	Crystal-Poor Vitric
		C.P. Vitric MW	Crystal-Poor Vitric Moderately Welded
		C.P. Vitric Basal NW	Crystal-Poor Vitric Basal Nonwelded

THERMOMECHANICAL UNITS

UO—Undifferentiated Overburden
TCw—Tiva Canyon Welded Unit
PTn—Upper Paintbrush Nonwelded Unit
TSw1—Topopah Spring Welded Unit—Lithophysae Rich
TSw2—Topopah Spring Welded Unit—Lithophysae Poor
TSw3—Topopah Spring Welded Unit—Vitrophyre
CHn1—Calico Hills and Lower Paintbrush Nonwelded Unit

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Interval—0-70 ft (0.0-21.3 m), UO and TCw Unit

Frequency: None, Occasional, Intermediate, Continuous.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Comparison of Downhole Video Data with Core Data

Hole USW NRG-7/7A

Interval—70-290 ft (21.3-88.4 m), PTn Unit

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD* %	ENHANCED RQD** %	ESTIMATED % CAVITIES	LOST CORE (#)	RUBBLE ZONE (#)	BOREHOLE WALL CATEGORY	DOWN HOLE VIDEO PARAMETERS				
									LITHOPHYSES		BOREHOLE WALL		
									Frequency	Size	Shape	Symmetry	Enlargement
80	T.C. C.P. Vene	PTn	81	80	0	0.7		C1	N			3	
90	T.C. C.P. Vene	PTn	88	74	0	1.1		C1	N			3	
100	T.C. C.P. Vene	PTn	60	78	0	1.5		C1	N			6	
110	B.T.	PTn	51	61	0	0.9	2.4	C1	N			8	
120	Y.M.	PTn	38	66	0	0.4	0.7	C1	N			6	
130	Y.M.	PTn	14	65	0	0.0	1.7	C1	N			6	
140	Y.M.	PTn	48	91	0	0.0	0.5	C1	N			6	
150	Y.M.	PTn	0	0	0	6.4	2.3	C1	N			6	
160	Y.M.	PTn	0	5	0	9.5		C1	N			6	
170	B.T.	PTn	26	70	0	0.4	2.8	C1	N			6	
180	B.T.	PTn	48	60	0	0.4	1.4	C1	N			6	
190	P.C.	PTn	61	60	0	0.9	0.1	C1	N			6	
200	P.C.	PTn	84	67	0	1.0	1.4	C1	N			6	
210	P.C.	PTn	80	84	0	2.5	0.6	C1	N			6	
220	P.C.	PTn	83	74	0	0.8	0.9	C1	N			6	
230	P.C.	PTn	88	83	0	0.5	1.1	C1	N			6	
240	P.C.	PTn	61	74	0	1.0	1.8	C1	N			6	
250	P.C.	PTn	88	81	0	0.5	0.8	C1	N			6	
260	P.C.	PTn	79	81	0	0.1	0.9	C1	N			6	
270	B.T.	PTn	88	74	0	0.0	2.9	C1	N			6	
280	B.T.	PTn	4	20	0	5.9	2.1	C1	N			6	
290	B.T.	PTn	68	78	0	1.2	1.0	C1	N			6	

* CORE RQD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

DOWNHOLE VIDEO PARAMETERS:

Frequency- No, Rare, Occasional, Moderate, Frequent.

Size- Small, Medium, Large, Cavernous.

Shape- Chise, Spherical.

Symmetry- Symmetric, Intermediate, Asymmetric.

Enlargement- No, Small, Intermediate, Large.

Frequency- None, Occasional, Intermediate, Continuous.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Comparison of Downhole Video Data with Core Data

Hole USW NRG-77/A

Interval—290-770 ft (88.4-234.7 m), TSw1 Unit

BASE OF 10-FT INTERVAL	STRATI- GRAPHY ZONE	THERMO- MECHANICAL UNIT	CORE RQD** %	ENHANCED RQD*** %	ESTIMATED % CAVITIES	LOST CORE (ft)	BURRICE ZONE (ft)	BOREHOLE WALL CATEGORY	DOWN HOLE VIDEO PARAMETERS			
									LITHOPHYSAE		BOREHOLE	
									Frequency	Size	Shape	Symmetry
290	T.S. C.R. Vltic	TSw1	28	40	0	1.8	0.8	C1	N			S
310	T.S. C.R. Nandih	TSw1	0	34	0	0.0	5.4	C2	N			S
320	T.S. C.R. Nandih	TSw1	13	44	0	0.0	0.8	C2	N			S
330	T.S. C.R. Nandih	TSw1	4	81	0	0.0	1.3	C2	N			S
340	T.S. C.R. Nandih	TSw1	33	66	0	0.0	2.2	C1	N			S
350	T.S. C.R. Nandih	TSw1	21	62	0	0.8	2.0	C2	N			S
360	T.S. C.R. Nandih	TSw1	12	34	0	2.0	2.3	C2	N			S
370	T.S. C.R. Nandih	TSw1	16	74	0	1.2	0.8	C2	N			S
380	T.S. C.R. Nandih	TSw1	12	67	0	2.3	0.3	C1	N			S
380	T.S. C.R. Nandih	TSw1	30	79	0	1.1	0.8	C1	N			S
400	T.S. C.R. Nandih	TSw1	8	66	0	0.0	1.4	C1	N			S
410	T.S. C.R. Nandih	TSw1	16	81	0	1.4	0.8	C1	N			S
420	T.S. C.R. Nandih	TSw1	87	88	0	0.0		C1	N			S
430	T.S. C.R. Nandih	TSw1	34	88	0	0.0	0.7	C1	N			S
440	T.S. C.R. Nandih	TSw1	43	88	0	0.0	0.2	C1	N			S
450	T.S. C.R. Nandih	TSw1	77	87	0	0.0		C1	N			S
460	T.S. C.R. Nandih	TSw1	73	100	0	0.0		C1	N			S
470	T.S. C.R. Nandih	TSw1	42	77	0	0.0	0.1	C1	N			S
480	T.S. C.R. Nandih	TSw1	37	89	0	0.0	0.3	C1	R	S	O	S
490	T.S. C.R. Uth	TSw1	88	90	4	0.0	0.8	C1	R	S	O	S
500	T.S. C.R. Uth	TSw1	41	86	8	3.2	0.3	C1	R	S	O	S
510	T.S. C.R. Uth	TSw1	4	31	13	4.7	1.8	C1	R	S	O	S
520	T.S. C.R. Uth	TSw1	36	88	7	1.2	0.8	C1	R	S	O	S
530	T.S. C.P. U. Uth	TSw1	40	86	4	1.0	1.2	C2	R	S	O	S
540	T.S. C.P. U. Uth	TSw1	6	26	0	3.4	2.4	C4	R	S	O	A
550	T.S. C.P. U. Uth	TSw1	11	22	5	4.5	2.8	C3	R	S	O	I
560	T.S. C.P. U. Uth	TSw1	7	58	10	2.8	1.1	C2	O	S	O	S
570	T.S. C.P. U. Uth	TSw1	16	41	8	4.4	1.1	C2	O	M	O	S
580	T.S. C.P. U. Uth	TSw1	0	19	11	7.4	0.7	C2	O	M	O	S
590	T.S. C.P. U. Uth	TSw1	4	4	16	7.2	2.1	C2	R	M	O	S
600	T.S. C.P. U. Uth	TSw1	4	26	12	6.6	1.8	C2	R	M	O	I
610	T.S. C.P. U. Uth	TSw1	17	28	6	4.5	2.9	C2	R	S	O	S
620	T.S. C.P. U. Uth	TSw1	14	58	5	2.8	2.8	C3	R	M	O	I
630	T.S. C.P. U. Uth	TSw1	14	21	8	8.8	0.8	C3	R	M	O	I
640	T.S. C.P. U. Uth	TSw1	2	30	4	4.9	1.0	C3	R	M	O	I
650	T.S. C.P. U. Uth	TSw1	7	37	6	2.8	2.3	C2	R	M	O	S
660	T.S. C.P. U. Uth	TSw1	48	86	6	0.6	0.2	C2	R	M	O	S
670	T.S. C.P. U. Uth	TSw1	35	87	4	0.1	0.1	C2	R	M	O	S
680	T.S. C.P. U. Uth	TSw1	40	84	4	0.8	0.7	C2	R	M	O	S
690	T.S. C.P. U. Uth	TSw1	0	82	2	2.1	1.9	C2	R	M	O	S
700	T.S. C.P. U. Uth	TSw1	33	52	3	2.1	1.8	C2	R	M	O	S
710	T.S. C.P. U. Uth	TSw1	24	40	6	2.3	3.1	C2	R	M	O	S
720	T.S. C.P. U. Uth	TSw1	22	52	6	3.9	0.8	C2	R	M	O	S
730	T.S. C.P. U. Uth	TSw1	13	38	6	2.9	2.0	C2	R	M	O	S
740	T.S. C.P. U. Uth	TSw1	0	26	6	3.8	2.2	C2	R	M	O	S
750	T.S. C.P. U. Uth	TSw1	6	29	3	2.8	3.3	C2	R	M	O	S
760	T.S. C.P. U. Uth	TSw1	9	47	3	2.2	2.4	C2	R	M	O	S
770	T.S. M. Nandih	TSw1	8	14	2	4.1	2.7	C2	R	M	O	S

* CORE RQD Determined from piece lengths formed by all types of fractures (C, I, N and V).

** ENHANCED RQD Determined by filtering the effects of fractures identified as coring induced (Type C) from the piece lengths.

DOWNHOLE VIDEO PARAMETERS:

Frequency- No, Rare, Occasional, Moderate, Frequent.

Size- Small, Medium, Large, Continuous.

Shape- Oblate, Spherical.

Symmetry- Symmetric, Intermediate, Asymmetric.

Enlargement- No, Small, Intermediate, Large.

Frequency- None, Occasional, Intermediate, Continuous.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
Comparison of Downhole Video Data with Core Data
Hole USW NRG-77A
Interval—770-1510 ft (234.7-460.3 m), TSw2, TSw3 and CHn1 Units

BASE OF INTERVAL	STRATI- GRAPHY ZONE	THEAMO- MECHANICAL UNIT	CORE RQD* %	ENHANCED RQD** %	ESTIMATED % CAVITIES	LOST CORE (ft)	NUMBER CORE (ft)	BOREHOLE WALL CATEGORY	DOWN HOLE VIDEO PARAMETERS				
									LITHOLOGY	Frequency	Size	Shape	Symmetry
780	T.S. M. Nephth.	TSw2	4	14	0	4.4	1.7	C2	N	M	D	E	1
780	T.S. M. Nephth.	TSw2	0	0	0	7.2	2.1	C2	N	M	D	E	1
800	T.S. M. Nephth.	TSw2	10	21	0	2.9	1.8	C2	N	M	D	E	1
810	T.S. M. Nephth.	TSw2	48	72	0	0.7	0.2	C2	N	M	D	E	1
820	T.S. M. Nephth.	TSw2	19	42	0	1.7	3.0	C2	N	M	D	E	1
830	T.S. M. Nephth.	TSw2	12	37	2	3.0	2.3	C2	N	M	D	E	1
840	T.S. M. Nephth.	TSw2	28	31	5	5.2	1.0	C2	N	M	D	E	1
850	T.S. M. Nephth.	TSw2	2	4	1	7.1	2.2	C2	N	M	D	E	1
860	T.S. M. Nephth.	TSw2	23	39	0	1.8	1.7	C2	N	M	D	E	1
870	T.S. M. Nephth.	TSw2	17	48	0	0.5	2.0	C2	N	M	D	E	1
880	T.S. M. Nephth.	TSw2	10	26	0	3.2	1.7	C2	N	M	D	E	1
890	T.S. C.P. L. Lbh.	TSw2	8	25	1	5.8	1.5	C2	N	M	D	E	1
900	T.S. C.P. L. Lbh.	TSw2	0	28	0	3.2	1.8	C2	N	M	D	E	1
910	T.S. C.P. L. Lbh.	TSw2	0	4	0	5.8	2.3	C2	N	M	D	E	1
920	T.S. C.P. L. Lbh.	TSw2	0	5	0	7.2	1.8	C2	N	M	D	E	1
930	T.S. C.P. L. Lbh.	TSw2	0	0	0	8.2	1.2	C2	N	M	D	E	1
940	T.S. C.P. L. Lbh.	TSw2	4	9	3	8.4	0.4	C2	N	M	D	E	1
950	T.S. C.P. L. Lbh.	TSw2	0	35	3	5.0	1.8	C2	N	M	D	E	1
960	T.S. C.P. L. Lbh.	TSw2	7	10	0	3.7	1.4	C2	N	M	D	E	1
970	T.S. C.P. L. Lbh.	TSw2	3	17	0	6.2	0.5	C2	N	M	D	E	1
980	T.S. C.P. L. Lbh.	TSw2	14	68	1	1.4	1.6	C2	N	M	D	E	1
990	T.S. C.P. L. Lbh.	TSw2	29	40	2	3.2	2.3	C2	N	M	D	E	1
1000	T.S. C.P. L. Lbh.	TSw2	0	1	1	7.0	2.2	C2	N	M	D	E	1
1010	T.S. C.P. L. Lbh.	TSw2	9	14	0	4.4	1.7	C2	N	M	D	E	1
1020	T.S. C.P. L. Lbh.	TSw2	0	3	NM	10.0		C2	N	M	D	E	1
1030	T.S. C.P. L. Lbh.	TSw2	0	0	0	8.0	1.8	C2	N	M	D	E	1
1040	T.S. C.P. L. Lbh.	TSw2	0	20	0	4.9	2.7	C2	N	M	D	E	1
1050	T.S. C.P. L. Lbh.	TSw2	3	22	2	2.7	2.0	C2	N	M	D	E	1
1060	T.S. C.P. L. Lbh.	TSw2	2	9	1	4.1	3.3	C2	N	M	D	E	1
1070	T.S. C.P. L. Lbh.	TSw2	0	0	1	5.8	3.8	C2	N	M	D	E	1
1080	T.S. C.P. L. Lbh.	TSw2	0	18	0	2.5	3.5	C2	N	M	D	E	1
1090	T.S. C.P. L. Lbh.	TSw2	0	9	0	5.1	1.4	C2	N	M	D	E	1
1100	T.S. C.P. L. Lbh.	TSw2	4	21	0	4.7	2.2	C2	N	M	D	E	1
1110	T.S. C.P. L. Lbh.	TSw2	0	14	0	4.6	2.6	C2	N	M	D	E	1
1120	T.S. C.P. L. Lbh.	TSw2	0	1	0	8.3	0.4	C2	N	M	D	E	1
1130	T.S. C.P. L. Lbh.	TSw2	3	10	0	4.0	3.8	C2	N	M	D	E	1
1140	T.S. C.P. L. Lbh.	TSw2	0	3	1	8.9	2.4	C2	N	M	D	E	1
1150	T.S. C.P. L. Lbh.	TSw2	0	15	0	5.5	0.5	C2	N	M	D	E	1
1160	T.S. C.P. L. Lbh.	TSw2	0	8	0	5.3	1.9	C2	N	M	D	E	1
1170	T.S. C.P. L. Lbh.	TSw2	0	6	0	4.8	2.9	C2	N	M	D	E	1
1180	T.S. C.P. L. Lbh.	TSw2	0	28	0	2.9	3.4	C2	N	M	D	E	1
1190	T.S. C.P. L. Lbh.	TSw2	18	48	1	1.6	2.5	C2	N	M	D	E	1
1200	T.S. C.P. L. Lbh.	TSw2	0	0	0	7.2	1.9	C2	N	M	D	E	1
1210	T.S. C.P. L. Lbh.	TSw2	0	13	0	4.8	2.5	C2	N	M	D	E	1
1220	T.S. C.P. L. Lbh.	TSw2	0	17	4	3.2	4.8	C2	N	M	D	E	1
1230	T.S. C.P. L. Lbh.	TSw2	15	23	2	4.2	3.2	C2	N	M	D	E	1
1240	T.S. C.P. L. Nephth.	TSw2	19	19	1	5.9	1.8	C2	N	M	D	E	1
1250	T.S. C.P. L. Nephth.	TSw2	12	41	0	2.7	1.8	C2	N	M	D	E	1
1260	T.S. C.P. L. Nephth.	TSw2	44	59	1	1.9	0.8	C2	N	M	D	E	1
1270	T.S. C.P. L. Nephth.	TSw2	22	59	1	1.2	0.6	C2	N	M	D	E	1
1280	T.S. C.P. L. Nephth.	TSw2	31	62	0	1.7	1.3	C2	N	M	D	E	1
1290	T.S. C.P. L. Nephth.	TSw2	33	47	0	3.1	0.8	C2	N	M	D	E	1
1300	T.S. C.P. L. Nephth.	TSw2	13	25	0	2.2	2.0	C2	N	M	D	E	1
1310	T.S. C.P. L. Nephth.	TSw2	8	27	0	4.3	0.5	C2	N	M	D	E	1
1320	T.S. C.P. L. Nephth.	TSw2	26	39	0	4.3	0.8	C2	N	M	D	E	1
1330	T.S. C.P. L. Nephth.	TSw2	8	21	0	3.9	1.4	C2	N	M	D	E	1
1340	T.S. C.P. L. Nephth.	TSw2	4	10	0	8.8	1.5	C2	N	M	D	E	1
1350	T.S. C.P. L. Nephth.	TSw2	20	58	0	2.3	0.8	C2	N	M	D	E	1
1360	T.S. C.P. L. Nephth.	TSw2	11	22	0	4.8	1.7	C2	N	M	D	E	1
1370	T.S. C.P. L. Nephth.	TSw2	21	85	0	0.2	0.2	C2	N	M	D	E	1
1380	T.S. C.P. L. Nephth.	TSw2	11	28	0	4.4	0.2	C2	N	M	D	E	1
1390	T.S. C.P. L. Nephth.	TSw2	8	34	0	2.8	0.8	C2	N	M	D	E	1
1400	T.S. C.P. L. Nephth.	TSw2	15	43	0	1.4	2.2	C2	N	M	D	E	1
1410	T.S. C.P. L. Nephth.	TSw2	82	88	0	1.8	0.3	C2	N	M	D	E	1
1420	T.S. C.P. Vrbz	TSw3	12	30	0	1.4	1.4	C2	N	M	D	E	1
1430	T.S. C.P. Vrbz	TSw3	0	30	0	5.8	1.6	C2	N	M	D	E	1
1440	T.S. C.P. Vrbz	TSw3	0	0	0	5.3	1.8	C2	N	M	D	E	1
1450	T.S. C.P. Vrbz	TSw3	8	44	0	8.8		C2	N	M	D	E	1
1460	T.S. C.P. Vrbz RW	TSw3	37	59	0	2.8		C2	N	M	D	E	1
1470	T.S. C.P. Vrbz RW	TSw3	78	92	0	0.0		C2	N	M	D	E	1
1480	T.S. C.P. Vrbz RW	CHn1	48	80	0	0.2		C2	N	M	D	E	1
1490	T.S. C.P. Vrbz RW	CHn1	58	97	0	0.4	0.5	C2	N	M	D	E	1
1500	G.T.	CHn1	93	98	0	0.0		C2	N	M	D	E	1
1510	Pyroclastic Rocks	CHn1	70	82	0	0.4	0.3	C2	N	M	D	E	1

* CORE RQD Determined from piece lengths sorted by all types of fractures (C, L, N and V).

** ENHANCED RQD Determined by stacking the effects of (nesting identified as early induced (Type C) from the piece lengths).

DOWNHOLE VIDEO PARAMETERS:

Frequency- No, Rare, Occasional, Moderate, Frequent.

Size- Small, Medium, Large, Continuous.

Shape- Oblate, Spherical.

Symmetry- Symmetric, Intermediate, Asymmetric.

Enlargement- No, Small, Intermediate, Large.

Frequency- None, Occasional, Intermediate, Continuous.

SCHMIDT HAMMER TESTS

Initial Calibration 71.5 72.5 72.0 71.5 68.5 67.3 71.0 71.5 70.0 71.0 Average Calibration Reading: 71.2 Correction Factor: 1.039 Test Date: 3/3/94
 Final Calibration 68.5 73.0 70.0 73.0 72.5 72.0 72.5 71.5 72.0 72.0 Anvil Standard Value: 74.0 SME Staff: D. Morris
 T. Warburton

Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
USW NRG-77A	861.7 - 862.1	52.0	52.5	50.0	53.0	50.5	48.5	49.5	49.5	49.0	51.0	54.0	51.5	60.0	62.0	52.5	60.0	50.5	50.5	52.5	50.0	51.00	1.405	53.01	1.405
	958.8 - 959.2	55.0	55.0	56.0	56.0	58.0	54.5	53.5	55.5	56.0	53.5	54.0	54.5	56.5	55.0	59.5	62.5	59.0	54.0	63.5	56.0	54.93	1.360	56.92	1.363
	975.6 - 976.0	42.0	46.0	44.5	46.5	48.0	44.5	47.5	47.0	48.0	47.0	49.0	42.0	48.5	47.5	48.5	45.5	49.0	47.5	48.0	48.0	48.73	2.074	49.11	1.375
	1188.7 - 1189.1	46.0	47.0	42.0	41.0	42.5	44.0	44.0	43.0	42.0	43.5	43.0	43.5	41.0	46.5	43.0	43.0	43.5	42.0	40.5	44.0	43.25	1.738	44.95	1.736
	1230.2 - 1230.7	52.5	52.5	51.5	52.0	54.5	53.0	52.0	52.0	53.0	53.5	52.0	54.5	53.5	54.0	52.0	52.0	52.5	53.0	52.5	53.0	52.78	0.868	54.95	0.866
	1260.9 - 1261.3	42.0	46.5	43.0	42.5	45.0	42.5	42.0	41.5	43.5	41.5	44.5	43.0	42.5	40.5	39.0	41.0	34.0	37.0	42.0	41.0	41.66	2.647	43.73	1.966
	1259.1 - 1259.7	48.0	48.0	47.0	46.5	47.0	48.5	48.5	48.5	46.0	46.0	48.5	47.0	47.0	47.0	48.5	45.5	47.5	48.5	60.0	48.5	47.55	1.202	49.42	1.202
	1270.3 - 1271.0	47.5	46.5	46.5	46.0	48.0	48.0	45.5	47.0	43.5	44.5	49.0	47.0	44.5	47.0	44.0	43.5	48.5	48.5	47.5	48.0	45.78	1.534	47.58	1.634
	1281.3 - 1282.0	42.0	44.0	41.0	41.5	40.0	39.5	43.5	45.0	48.5	45.0	43.5	42.0	38.0	42.0	39.5	38.5	41.0	40.5	40.0	47.5	42.13	2.628	43.43	2.483
	1314.7 - 1315.3	46.5	47.5	46.0	45.5	47.5	47.0	49.0	49.0	47.0	45.5	50.0	48.0	48.0	46.5	47.0	48.0	45.0	45.5	45.5	48.0	47.25	1.352	49.11	1.352
	1364.0 - 1364.5	45.5	44.0	48.0	42.0	35.5	44.0	47.0	43.5	44.0	37.0	43.0	37.0	43.5	46.0	43.5	44.0	42.5	41.0	38.0	33.0	41.95	3.814	44.09	3.267

Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

I-97

SCHEIDT HAMMER TESTS

Initial Calibration 71.5 72.5 72.0 71.5 68.9 67.5 71.0 71.5 70.0 71.0
 Final Calibration 68.5 73.0 70.0 73.0 72.5 72.0 72.5 71.5 72.0 72.0

Average Calibration Reading: 71.2 Correction Factor: 1.039
 Anvil Standard Value: 74.0

Test Date: 3/3/94
 SMF Staff: D. Metrix
 T. Warburton

Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
USW NRG-7/7A	39.5 - 39.8	43.0	43.0	48.0	42.5	46.0	46.5	46.5	46.0	42.0	41.0	42.5	44.5	42.5	48.5	45.0	45.0	48.0	46.0	47.5	46.5	44.73	2.049	46.48	2.048
	53.2 - 53.5	48.0	47.0	47.0	44.0	47.5	48.0	48.0	45.0	42.0	48.0	48.0	48.0	47.0	45.0	48.0	49.0	48.0	47.6	49.5	47.5	47.00	1.792	48.12	1.388
	61.8 - 62.4	40.0	35.0	34.0	34.5	36.5	38.0	34.0	35.5	34.5	28.5	38.0	37.0	35.0	36.0	34.0	33.5	35.0	34.0	32.5	33.0	34.58	2.504	36.38	1.675

Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

1-99

SCHMIDT HAMMER TESTS																									
Initial Calibration												Average Calibration Reading: 71.5						Correction Factor: 1.035				Test Date: 2/22/94			
Final Calibration												Anvil Standard Value: 74.0						SMF Staff: L. Linden							
Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
USW NRG-77A	126.0 - 126.3	42.5	44.0	38.0	40.0	38.0	40.0	52.0	42.0	42.0	46.0	44.0	38.0	44.0	38.0	52.0	42.0	40.0	40.0	44.0	40.0	42.32	4.068	42.68	2.497
	533.5 - 533.8	40.0	54.0	26.0	44.0	50.0	42.0	48.0	28.0	50.0	52.0	42.0	24.0	24.0	54.0	44.0	48.0	50.0	40.0	24.0	50.0	41.60	10.595	43.04	10.595
	613.8 - 614.1	48.0	42.0	50.0	44.0	50.0	48.0	44.0	42.0	52.0	52.0	44.0	50.0	38.0	44.0	54.0	52.0	44.0	38.0	52.0	40.0	46.40	5.008	48.01	5.009
	698.5 - 698.8	52.0	24.0	52.0	50.0	42.0	28.0	48.0	52.0	52.0	50.0	24.0	18.0	16.0	Starting Fracture						---	---	---	---	
	840.5 - 840.7	48.0	48.0	50.0	48.0	48.0	50.0	48.0	48.0	50.0	52.0	50.0	46.0	42.0	50.0	44.0	44.0	52.0	48.0	48.0	44.0	47.70	2.774	49.35	2.774
	479.8 - 480.0	48.0	Specimen was beginning to fracture.																			---	---	---	---

 Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

SCHMIDT HAMMER TESTS

Initial Calibration 68.0 74.0 72.0 69.5 73.0 72.5 72.0 71.0 70.5 72.0
 Final Calibration 74.0 75.5 72.5 72.0 72.0 70.0 68.5 71.5 68.0 68.0

Average Calibration Reading: 71.3
 Anvil Standard Value: 74.0

Correction Factor: 1.038

Test Date: 2/2/94

SME Staff: D. Merritt D. Sanchez
 D. Harle

Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
USW NRG-77A	345.3 - 345.8	68.0	68.5	68.0	68.0	62.0	57.5	66.0	57.0	58.0	58.0	58.5	64.0	54.0	57.0	56.5	54.0	56.0	58.0	57.0	58.5	56.58	1.955	58.95	1.677
	371.2 - 371.4	51.0	49.0	44.0	39.8	58.5	38.5	39.5	25.5	45.5	38.0	55.0	62.0	44.5	52.5	43.5	54.0	42.0	56.0	48.0	40.5	45.50	7.815	48.30	6.409
	379.0 - 379.2	40.0	48.5	36.0	32.5	38.5	40.5	42.5	39.0	45.0	38.5	42.0	36.0	44.0	43.0	44.5	37.0	39.5	44.0	41.0	41.0	40.45	3.806	41.87	3.906
	393.0 - 393.2	39.0	31.0	25.0																		---	---	---	---
	407.8 - 408.0	39.0	42.0	49.0	25.0	48.0	46.5	46.5	43.0	43.5	44.5	30.0	50.5	46.5	42.5	48.0	47.5	52.0	46.0	42.5	45.0	43.78	8.400	48.44	4.756
	412.6 - 412.9	42.0	42.5	38.0	43.5	50.0	52.0	48.5	46.0	53.5	49.0	45.5	45.0	47.0	50.5	51.5	38.0	64.0	58.5	48.0	39.5	47.03	5.322	49.79	5.322
	419.9 - 420.2	42.5	45.0	52.5	52.5	48.5	48.0	48.5	46.0	45.0	52.0	45.0	53.5	50.5	48.0	46.5	52.0	54.5	44.5	44.0	42.0	48.05	3.835	49.85	3.835
	427.7 - 428.0	36.0	58.0	46.0	56.5	49.5	57.0	49.5	39.5	50.5	54.5	68.0	56.5	53.0	52.0	47.0	32.0	48.5	58.0	52.5	49.0	50.03	7.348	52.89	6.161
	438.2 - 438.5	44.0	50.0	48.0	47.0	43.0	47.5	49.0	52.0	49.0	48.0	46.0	47.5	44.5	53.0	41.0	51.0	46.5	47.0	48.0	51.0	47.65	3.022	48.44	3.022
	448.5 - 448.9																					---	---	---	---
	458.3 - 459.8	56.0	54.5	55.0	49.0	56.5	40.0	57.5	57.5	52.5	50.0	49.5	55.5	53.0	54.0	57.0	50.0	58.0	52.0	55.5	53.0	53.20	4.118	55.82	2.777
	470.2 - 470.4	32.0	57.0	52.5	52.5	52.0	58.0	50.0	48.5	51.5	50.5	57.5	55.0	54.0	52.5	43.0	58.0	58.0	55.5	56.5	36.0	51.43	7.029	54.41	5.485
	483.4 - 483.7	48.0	52.0	52.0	48.5	48.0	47.5	47.0	48.0	47.5	50.0	46.0	44.0	45.0	44.5	50.0	46.5	48.0	47.0	49.5	48.5	47.63	2.259	49.41	2.259
	487.1 - 487.3	43.5	43.5	44.0	48.5	42.0	48.0	42.5	48.0	48.0	45.0	44.0	43.0	42.5	41.5	43.0	43.5	48.5	46.0	45.0	41.0	44.40	2.303	46.07	2.303
	495.4 - 496.8	28.0	46.0	45.5	52.0	39.0	45.0	41.0	40.0	50.0	42.5	44.0										---	---	---	---
	551.8 - 552.1	46.0	53.0	44.0	48.5	50.0	49.0	48.0	48.0	48.5	49.0	53.0	47.5	48.0	53.0	57.0	59.5	51.0	48.0	49.0	48.5	48.73	3.782	51.06	3.084
	569.4 - 569.8	42.0	52.0	53.5	58.0	58.0	56.5	56.0	50.0	55.0	54.0	55.5	50.0	54.0	52.5	51.5	51.0	50.0	57.0	55.0	53.0	53.03	3.458	55.62	2.349
	717.8 - 718.0	54.0	52.0	58.0	55.0	54.0	57.0	58.0	56.0	55.5	54.0	52.5	54.5	54.0	58.5	52.0	54.0	51.5	54.5	56.5	53.5	54.70	1.978	56.75	1.978
	760.0 - 760.2	54.0	53.0	37.0	34.0	53.0	52.0	53.0	54.5	51.0	52.5	55.0	52.5	55.0	50.0	46.5	58.0	31.0	51.0	55.0	50.0	49.80	7.219	52.89	5.860
	776.5 - 778.7	57.0	52.0	55.5	58.5	58.0	55.0	53.0	58.5	55.0	55.5	51.5	52.0	54.5	54.5	54.5	53.0	53.5	54.5	54.0	53.5	54.58	1.908	56.62	1.908
	808.3 - 808.6	55.5	55.5	55.0	59.0	58.5	55.0	55.0	58.0	57.5	58.0	59.5	59.5	58.5	59.0	55.0	58.0	58.0	56.5	56.5	56.5	56.45	1.654	58.57	1.654
	817.3 - 817.6	55.0	52.5	52.5	51.5	50.0	51.0	49.5	50.0	49.5	46.0	51.0	51.5	48.5	52.0	46.5	46.5	46.0	48.5	50.5	52.5	50.10	2.447	51.98	2.447

Indicates outlying values excluded in calculating the final Schmidt Hardness Value.

I-100

101-I

SCHMIDT HAMMER TESTS																										
Initial Calibration		73.5	72.5	73.5	73.0	72.5	72.0	72.0	72.0	72.0	Average Calibration Reading:				71.6	Correction Factor:				1.034	Test Date:		2/24/94			
Final Calibration		71.5	71.0	65.5	72.0	70.0	71.5	72.0	70.0	71.5	71.5	Anvil Standard Value:				74.0	SHF Staff:				G.D. Olson T. Warburton					
Borehole	Depth Interval	Hammer Readings (20)																				Mean	Standard Deviation	Schmidt Value	Adjusted Std. Dev.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20					
USW NRG-77A	27.9 - 28.2	41.0	42.0	41.0	46.6	50.0	49.0	47.0	42.0	41.0	46.0	52.0	48.5	47.0	43.5	48.5	60.0	47.0	52.5	62.5	44.5	48.48	3.854	48.05	3.854	
	37.8 - 38.2	43.0	44.5	49.0	48.0	49.0	47.5	46.0	45.5	38.5	35.0	42.0	47.0	49.5	49.5	50.0	47.0	43.0	45.0	49.5	50.5	45.90	4.031	48.05	3.195	
	74.3 - 74.8	20.0	22.5	27.0	22.5	30.0	29.0	29.0	23.5	29.5	30.0	31.0	30.5	27.5	30.5	25.5	24.5	32.5	28.5	30.5	31.0	27.80	3.518	28.74	3.518	
	83.1 - 83.5	22.0	22.0	19.0	19.0	15.5	15.5	18.0	12.5	13.5	15.5	19.5	17.0	22.0	19.0	25.0	26.0	19.0	27.0	21.5	18.5	19.25	3.995	19.80	3.995	
	83.2 - 93.8																					---	---	---	---	
	107.2 - 107.6																						---	---	---	---
	120.9 - 121.4	17.5	18.5	18.5	11.0	18.5	18.5	21.0	10.5	11.0	18.5	13.5	11.0	11.0	17.0	16.5	22.0	25.0	16.5	12.5	13.0	16.88	4.120	16.41	4.120	
	132.6 - 133.2	23.5	24.5	25.5	24.5	27.5	31.5	29.0	32.0	29.0	27.0	22.5	18.5	22.5	27.0	30.5	29.0	25.0	25.0	28.0	36.0	26.85	3.853	27.76	3.853	
	176.6 - 177.2																					---	---	---	---	
248.1 - 248.5																					---	---	---	---		

Indicates readings excluded in calculating the final Schmidt Hardness Value.

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Summary of Laboratory Testing Data for Hole USW NRG-7/7A—NRG Holes

Summary of Laboratory Testing Data for Hole BSW (NAG-11A) - NAG Notes													
Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)	
(m)	(ft)								Confined Pressure	Axial Stress			
5.49	18.0-A	Tiva Canyon Crystal-Poor Lower Nonlithophysal Zone	TCw Unit	84.6	7.5	28.7	0.18	2.32					
5.49	18.0-B				8.8			2.29			10.60		
5.49	18.0-C											2.51	
7.44	24.4-A				6.6			2.35			9.40		
7.44	24.4-B				6.9			2.34			9.90		
7.44	24.4-C											2.51	
10.21	33.5-A				160.4	5.2	35.0	0.21	2.36				2.49
10.21	33.5-B												
12.62	41.4-A				135.0	8.8	31.5	0.18	2.27			13.00	
12.62	41.4-B					8.5			2.27			13.00	
12.62	41.4-C												2.48
14.45	47.4-A				228.1	12.8	28.1	0.20	2.17				
14.45	47.4-B					13.7			2.15			13.40	
14.45	47.4-C												2.49
16.89	55.4-A				143.3	16.4	21.4	0.20	2.09				
16.89	55.4-B					16.6			2.08			11.80	
16.89	55.4-C												2.49
18.26	59.9-A												2.50
18.26	59.9-C					21.7							
22.46	73.7-A	Tiva Canyon Crystal-Poor Vitriz Zone	PTn Unit	27.4	28.8	7.7	0.09	1.76					
22.46	73.7-B				27.9				1.78			5.10	
22.46	73.7-C												2.47
23.68	77.7-A				12.2	35.2	2.1	0.06	1.60				
23.68	77.7-B					37.0			1.56			1.20	
23.68	77.7-C												2.47
25.73	84.4-A				6.9	39.3	3.7	0.10	1.44				
25.85	84.4-B												2.37
27.74	91.0-A				5.4	38.0	3.9	0.06	1.41				
27.74	91.0-B					41.2			1.34			0.50	
27.74	91.0-C												2.28
29.84	97.9-A				3.9	37.8	0.3	0.21	1.44				
29.84	97.9-B												2.32
31.43	103.1-A	Bedded Tuffs		46.5									
31.43	103.1-B											2.35	
32.00	105.0-A			1.2	57.1	0.2	0.17	1.00					
32.00	105.0-B											2.34	

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-7/7A--NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
33.83	111.0-A	Yucca Mountain Tuff	PTn Unit (continued)		41.7							
33.83	111.0-B											2.24
36.39	119.4-A			22.8	37.3	9.2	0.15	1.46				
36.39	119.4-B											2.33
39.62	130.0-A			21.0	31.0	2.3	0.17	1.64				
39.62	130.0-B											2.38
41.24	135.3-A			26.2	30.5	4.9	0.16	1.64				
41.24	135.3-B				31.3			1.62			3.00	
41.24	135.3-C											2.36
49.20	161.4-A	Bedded Tuffs										2.34
49.20	161.4-C				42.6							
51.54	169.1-A			0.8	38.0	0.2	0.28	1.49				
51.54	169.1-C											2.41
53.07	174.1-A			1.8	54.5	0.3	0.19	1.10				
53.07	174.1-B			52.3			1.15			0.10		
53.07	174.1-C										2.41	
55.63	182.5-A	Pah Canyon Tuff			52.2				1.10		0.10	
55.63	182.5-B				54.3			1.06			0.03	
55.63	182.5-C				53.9			1.07			0.02	
55.63	182.5-D											2.31
58.37	191.5-A											2.29
61.75	202.6-A											2.30
65.11	213.6-A			1.5	47.5	0.3	0.25	1.20				
65.11	213.6-B											2.29
68.40	224.4-A				48.7			1.18			0.02	
68.40	224.4-B											2.30
69.80	229.0-A											2.33
73.03	239.6-A											2.31
74.59	244.7-A				54.6			1.08			0.20	
74.59	244.7-B				50.9			1.16			0.10	
74.59	244.7-C											2.37
76.11	249.7-A			2.3	51.2	0.6	0.31	1.15				
76.11	249.7-B											2.35
77.42	254.0-A			2.1	49.3	0.4	0.26	1.17				
77.42	254.0-B										2.31	
81.87	268.6-A	Bedded Tuffs		0.8	54.7	0.1	0.13	1.11				

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-7/7A—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)		
(m)	(ft)								Confined Pressure	Axial Stress				
81.87	268.6-B	Bedded Tuffs (continued)	PTn (continued)		55.2			1.10			0.10			
81.87	268.6-C												2.46	
86.41	283.5-A												2.44	
86.41	283.5-C						58.2							
87.78	288.0-A	Topopah Spring Crystal-Rich Vitric Zone										2.39		
87.78	288.0-C						54.8							
89.12	292.4-A					5.8	39.8	1.9	0.30	1.35				
89.12	292.4-B													
95.01	311.7-A	Topopah Spring Crystal-Rich Nonlithophysal Zone											2.24	
95.01	311.7-C						8.8							2.56
96.53	316.7-A													2.57
96.53	316.7-C						15.4							
98.42	322.9-A						10.1			2.30		9.30		
98.42	322.9-B													2.56
101.96	334.5-A					63.3	19.5	22.4	0.19	2.03				
101.96	334.5-B						21.3			1.98		6.30		
101.96	334.5-C													2.52
104.97	344.4-A						13.8	27.3	0.21	2.15	10.00	185.00		
104.97	344.4-B				14.0	25.2	0.15	2.15	10.00	139.10				
104.97	344.4-D				13.0	29.4	0.15	2.17	10.00	208.30				
104.97	344.4-E				15.4	24.7	0.17	2.11	5.00	56.50				
104.97	344.4-F				13.7	28.7	0.23	2.16	5.00	163.90				
104.97	344.4-G				16.7	22.5	0.20	2.08	5.00	75.90				
104.97	344.4-H				15.4	20.6	0.21	2.11	5.00	110.20				
104.97	344.4-I				13.6	26.3	0.17	2.16	0.00	106.20				
104.97	344.4-J				14.3	19.1	0.15	2.14	0.00	89.50				
104.97	344.4-K				14.5	27.7	0.18	2.14	0.00	97.30				
104.97	344.4-L				14.7	27.2	0.15	2.13	0.00	88.70				
104.97	344.4-M											2.50		
106.77	350.3-A			148.4	8.6	34.3	0.17	2.29						
106.77	350.3-B				10.5			2.24			10.50			
106.77	350.3-C											2.51		
110.58	362.8-A				16.9			2.14			6.80			
110.58	362.8-B											2.57		
112.62	369.5-A			45.2	17.0	22.9	0.19	2.13						
112.62	369.5-B											2.56		

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-77A—NRG Holes

Depth (m)	Depth (ft)	Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
									Confined Pressure	Axial Stress		
116.07	380.8-A	Topopah Spring Crystalline Nonlithophysal Zone (continued)	TSwt Unit (continued)	61.0	16.2	19.9	0.22	2.16				
116.07	380.8-B											2.57
118.45	388.6-A				18.9			2.09			1.60	
118.45	388.6-B				17.0			2.14			2.30	
118.45	388.6-C											
120.89	396.6-A			33.9	18.0	13.1	0.26	2.12				2.58
120.89	396.6-B											
124.15	407.3-A				16.7			2.15			6.10	
124.15	407.3-B				16.5			2.15			4.90	
124.15	407.3-C											2.58
124.94	409.9-A				16.8			2.14			5.90	
124.94	409.9-B				17.1			2.13			6.20	
124.94	409.9-C											
127.38	417.9-A			27.9	17.0	9.8	0.16	2.13				2.57
127.38	417.9-B				14.3			2.20			4.70	
127.38	417.9-C											2.56
128.63	422.0-A			60.8	13.9	19.0	0.18	2.20				
128.63	422.0-B				12.2			2.24			3.90	
128.63	422.0-D											2.56
130.67	428.7-A			55.5	14.1	21.8	0.20	2.20				
130.67	428.7-B				14.4			2.19			7.00	
130.67	428.7-C											2.56
133.02	436.4-A				15.4			2.16			4.90	
133.02	436.4-B				13.6			2.21			5.40	
133.02	436.4-C											2.56
135.09	443.2-A			66.3	13.9	17.9	0.31	2.21				
135.09	443.2-B				15.0			2.18			4.70	
135.09	443.2-C											2.56
137.19	450.1-A			25.7	14.3	17.2	0.28	2.19				
137.19	450.1-B				14.3			2.19			5.30	
137.19	450.1-C											2.56
140.51	461.0-A			52.6	12.9	13.7	0.36	2.22				
140.51	461.0-B				10.5			2.28			4.80	
140.51	461.0-C											2.55
141.95	465.7-A				12.2			2.24			4.00	
141.95	465.7-B				12.2			2.23			5.10	

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-7/7A—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
141.95	465.7-C	Topopah Spring Crystal-Rich Nonlithophysal Zone (continued)	TSWI Unit (continued)									2.55
143.07	469.4-A			53.9	11.0	18.4	0.43	2.26				
143.07	469.4-B				11.2			2.25			4.40	
143.07	469.4-C											2.54
144.14	472.9-A			54.2	11.3	15.5	6.23	2.26				
144.14	472.9-B				12.1			2.24			4.20	
144.14	472.9-C										2.54	
146.12	479.4-A	Topopah Spring Crystal-Rich Lithophysal Zone			12.4			2.22			5.30	
146.12	479.4-B										2.54	
148.87	488.4-A				20.2			2.01			3.40	
148.87	488.4-B										2.52	
149.54	490.6-A				10.6			2.26			5.10	
149.54	490.6-B										2.52	
150.88	495.0-A										2.52	
150.88	495.0-C				14.7							
154.66	507.4-A	Topopah Spring Crystal-Poor Upper Lithophysal			16.4			2.10			7.30	
158.50	520.0-A				18.7			2.05			3.60	
160.30	525.9-A			21.1	23.3	13.0	0.35	1.94				
162.58	533.4-A				21.8			1.97			5.70	
166.48	546.2-A			15.7	16.2	6.0	0.46	2.10				
169.07	554.7-A				27.5							2.52
172.79	566.9-A				16.5			2.11			2.10	
178.43	585.4-A				28.2							2.52
181.42	595.2-A				21.2			2.00			3.90	
184.56	605.5-A				19.2			2.05			3.50	
187.09	613.8-A				25.2							2.52
190.56	625.2-A				21.1			1.97			4.00	
195.20	640.4-A				15.6			2.12			6.40	
198.00	649.6-A			36.1	17.3	13.4	0.20	2.09				
199.19	653.5-A				15.7			2.13			4.30	
199.19	653.5-B				17.7			2.08			4.80	
200.38	657.4-A				18.4							2.53
202.79	665.3-A				13.5			2.19			11.20	
204.43	670.7-A				15.5							2.54
207.30	680.1-A				12.4			2.22			9.00	
207.30	680.1-B				16.6			2.11			2.70	

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-77A—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
211.06	692.5-A	Topopah Spring Crystal-Poor Upper Lithophysal Zone (continued)	TSw1 Unit (continued)	81.8	13.4	19.7	0.09					
212.87	698.4-A				11.3			2.25			12.90	
212.87	698.4-B				15.2			2.15			3.60	
215.92	708.4-A				14.0			2.19			1.90	
218.36	716.4-A				15.1			2.16			8.50	
218.36	716.4-B				18.7			2.07			3.90	
220.71	724.1-A				20.8							2.56
225.13	738.6-A				14.7							2.55
227.48	746.3-A				14.2							2.55
229.82	754.0-A				11.8							2.54
232.29	762.1-A	Topopah Spring Crystal-Poor Middle Nonlithophysal Zone	TSw2 Unit		14.8			2.18			9.30	
236.83	777.0-A			143.8	10.6	32.9	0.22	2.27				
243.90	800.2-A			179.2	10.3			2.27				
245.76	806.3-A			225.4	10.1	36.7	0.19	2.28				
249.48	818.5-A			126.3	10.2	33.1	0.20	2.27				
252.50	828.4-A				15.9			2.16			6.10	
259.05	849.9-A				27.7			1.84				
260.61	855.0-A				11.0			2.25			11.60	
261.89	859.2-A				11.3	38.8	0.20	2.28				
263.78	865.4-A				10.3	32.3	0.19	2.27				
263.78	865.4-B				10.4	34.0	0.21	2.27		10.00	325.20	
263.78	865.4-D				11.7	32.0	0.25	2.23		10.00	354.00	
263.78	865.4-E				10.0	34.1	0.22	2.28		10.00	235.50	
263.78	865.4-C				10.4	35.0	0.20	2.27		5.00	316.70	
263.78	865.4-F				10.4	34.5	0.21	2.27		5.00	259.80	
263.78	865.4-G				11.1	34.0	0.18	2.25		5.00	322.30	
263.78	865.4-H				11.1	36.8	0.21	2.25		5.00	255.10	
263.78	865.4-I				10.7	34.3	0.20	2.26		5.00	231.60	
263.78	865.4-J				10.4	33.5	0.19	2.27		0.00	215.80	
263.78	865.4-K				10.3	34.9	0.22	2.27		0.00	232.00	
263.78	865.4-L				10.6	35.7	0.21	2.26		0.00	239.10	
263.78	865.4-M							0.00	248.50			
267.98	879.2-A	Topopah Spring Crystal-Poor Lower Lithophysal Zone									2.53	
267.98	879.2-B			8.8			2.30			14.30		
267.98	879.2-C			10.9			2.24			11.00		
267.98	879.2-D										2.52	
268.53	881.0-A				8.9			2.29		12.10		

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-7/7A—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
268.53	881.0-B	Topopah Spring Crystal-Poor Lower Lithophysal Zone (continued)	TSw2 Unit									2.52
273.65	897.8-A				7.4			2.36				
273.65	897.8-B											2.56
292.22	958.7-A				12.8			2.23			11.20	
292.22	958.7-B				12.0			2.25			11.50	
292.22	958.7-A											2.56
297.61	976.4-A				11.8			2.28			5.50	
297.61	976.4-B				13.5			2.23			6.30	
297.61	976.4-C											2.58
298.59	979.6-A				11.5			2.28			5.20	
298.59	979.6-B											2.58
300.84	987.0-A				11.1			2.29				
300.84	987.0-B											2.57
305.14	1001.1-A				9.7			2.33				
305.14	1001.1-B											2.58
319.07	1046.8-A				12.6			2.22			6.20	
319.07	1046.8-B											2.54
322.36	1057.6-A				12.5			2.26				
322.36	1057.6-B											2.58
328.27	1077.0-A				11.2			2.29				
328.27	1077.0-B											2.57
330.71	1085.0-B				17.5							
332.33	1090.3-A				9.9			2.31			10.40	
332.33	1090.3-B				10.4			2.29			10.20	
332.33	1090.3-C											2.56
334.77	1098.3-A				15.5			2.20			6.60	
334.77	1098.3-B											2.60
344.21	1129.3-A				10.7			2.27			7.00	
344.21	1129.3-B											2.54
353.54	1159.9-A											2.54
353.54	1159.9-D				14.2			2.17				
359.67	1180.0-A				12.5			2.25			5.30	
359.67	1180.0-B											2.57
362.32	1188.7-A				11.4			2.29			8.60	
362.32	1188.7-B											2.58
374.97	1230.2-A	(see next page)		117.2	11.4	29.8	0.23	2.29				

to be continued

Summary of Laboratory Testlog Data for Hole USW NRG-77A—NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
374.97	1230.2-B	Topopah Spring Crystal-Poor Lower Nonlithophysal Zone	TSw2 Unit (continued)		14.7			2.21			9.20	
374.97	1230.2-C											2.59
385.18	1263.7-A				9.8			2.32			13.70	
385.18	1263.7-B				10.9			2.30			9.90	
385.18	1263.7-C				9.0			2.34			9.00	
376.95	1236.7-B											2.59
376.95	1236.7-A			61.0	11.7	21.8	0.40	2.29				
381.71	1252.3-A			82.9	13.2	30.4	0.14	2.25				
381.71	1252.3-B											2.59
383.38	1257.8-A			169.3	9.7	41.8	0.20	2.33				
383.38	1257.8-B											2.58
383.78	1259.1-A			172.5	9.8	40.6	0.21	2.34				
383.78	1259.1-B											2.59
385.18	1263.7-D											2.58
385.64	1265.2-A			192.9	9.6	40.7	0.21	2.34				
385.64	1265.2-B											2.59
386.83	1269.1-A				11.2			2.30				
386.83	1269.1-B											2.59
387.22	1270.4-A				9.1			2.35				
387.22	1270.4-B											2.59
390.85	1282.3-A				11.2			2.30				
390.85	1282.3-B											2.59
398.38	1307.0-A				9.7			2.34			10.90	
398.38	1307.0-B				9.7			2.33			8.80	
398.38	1307.0-C											2.58
400.76	1314.8-A			173.4	9.9	37.7	0.21	2.33				
400.76	1314.8-B											2.58
402.01	1318.9-A				9.0			2.33				
402.01	1318.9-B											2.56
404.05	1325.6-A				9.3			2.33				
404.05	1325.6-B											2.57
409.29	1342.8-A				10.9			2.30				
409.29	1342.8-B											2.58
409.78	1344.4-A				8.7			2.35				
409.78	1344.4-B											2.58
411.12	1348.8-A				8.3			2.35			4.80	

to be continued

Summary of Laboratory Testing Data for Hole USW NRG-7/7A--NRG Holes

Depth		Stratigraphy	Thermomechanical Unit	UCS (MPa)	Porosity (%)	Young's Modulus (GPa)	Poisson's Ratio	Dry Bulk Density (g/cc)	Confined Compressive Test (MPa)		Indirect Tensile Strength (MPa)	Average Grain Density (g/cc)
(m)	(ft)								Confined Pressure	Axial Stress		
411.12	1348.8-B	Topopah Spring Crystal-Poor Lower Nonlithophysal Zone (continued)	TSw2 Unit (continued)		9.0			2.34			5.90	
411.12	1348.8-C											2.57
412.61	1353.7-A				11.2			2.29			7.60	
412.61	1353.7-B											2.58
415.60	1363.5-A				7.7			2.37			7.60	
415.60	1363.5-B											2.57
418.31	1372.4-A				8.8			2.34				
418.31	1372.4-B											2.57
420.45	1379.4-A											2.55
420.45	1379.4-C				15.0			2.17				
422.15	1385.0-A				7.7			2.35			6.10	
422.15	1385.0-B				7.8			2.35			6.30	
422.15	1385.0-C											2.54
426.15	1398.1-A				13.0			2.18				
426.15	1398.1-B											2.51
427.55	1402.7-A				9.9			2.27			4.80	
427.55	1402.7-B											2.51
429.47	1409.0-A				3.8			2.42			7.60	
429.47	1409.0-B											2.52
430.32	1411.8-A				21.8			1.89			4.10	
430.32	1411.8-B											2.42
438.25	1437.8-A	Topopah Spring Crystal-Poor Vitric Zone	TSw3 Unit		1.3			2.35			4.10	
438.25	1437.8-B											2.38
441.51	1448.5-A				1.2			2.35			4.20	
441.51	1448.5-B				1.4			2.34			3.60	
441.51	1448.5-C											2.37
442.00	1450.1-A				0.7			2.35				
442.00	1450.1-B											2.37

No Tests Conducted

continued

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APPENDIX J

RF #8

Geology and Rock Structure Log Core Hole Rock Structural Data Summary

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**YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
GEOLOGY AND ROCK STRUCTURE LOG**

WBS 1.2.3.2.6.2
QA: NO

BOREHOLE ID: RF #8
STUDY PLAN NO: 8.3.1.2.2.1
CORE SIZE: HQ 2.5"
DRILL DATES: NA
GROUND ELEV: 3787.9 ft
COORDINATES: N: 765,631 ft
E: 568,790 ft

TOTAL DEPTH: 128 ft
ANGLE FROM VERT: 0°
AZIMUTH: NA

Field Rock Structure

Logged by:

C. E. Brechtel J. F. T. Agapito & Associates, Inc.

Lithology and Stratigraphy

Logged by:

D. Buesch U. S. Geological Survey
W. J. Carr SAND90-2491 (1992)

Checked by:

R. E. Lippoth J. F. T. Agapito & Associates, Inc.

NON-QUALITY—CORROBORATING DATA

FINAL LOG PRINTED: 11/1/93

Log prepared by J. F. T. Agapito & Associates, Inc. for Sandia National Laboratories

ALLUVIUM

EXPLANATION GEOLOGY AND ROCK STRUCTURE

SANDSTONE

NONWELDED

WELDED

BEDDED TUFF

FRACTURE TYPE

- N Natural fractures are indicated by mineral coatings, evidence of weathering, slickensides, lack of rematch/fit between sides or by surfaces that form an ellipse in the core.
- C Coring-induced fractures are generally normal to the axis of the core or indicate some torquing of the core. They are typically clean, fresh and fit tightly back together.
- I Indeterminate fractures are those not clearly described as "N" or "C." This includes fracture surfaces that have been shaped by drilling rotation.
- H Handling-induced fractures are formed in the core by removal from the core barrel or placement in the core box. These fractures are witnessed and, according to BTP-SMF-008, are marked by the SMF personnel by lines parallel to the fracture on both sides of the core. "H" fractures are typically not recorded in the log unless there is a specific reason.
- V Vug or large void.
- P Foliation plane due to gravity flattening upon deposition.

LOST CORE AND RUBBLE

LOST CORE

RUBBLE ZONE

(with average maximum diameter of rubble pieces to nearest 0.01 ft; NM = not measured)

HARDNESS (Subjective estimate, YMP procedures do not allow core to be broken or scratched etc.)

- 1 Extremely Hard—Cannot be scratched, chipped only with repeated heavy hammer blows.
- 2 Very Hard—Cannot be scratched, broken only with repeated heavy hammer blows.
- 3 Hard—Scratched with heavy pressure, breaks with heavy hammer blow.
- 4 Moderately Hard—Scratched with light-moderate pressure, breaks with moderate hammer blow.
- 5 Moderately Soft—Grooved (16th in.) with moderate heavy pressure, breaks with light hammer blow.
- 6 Soft—Grooved easily with light pressure, scratched with fingernail, breaks with light-moderate manual pressure.
- 7 Very Soft—Readily gouged with fingernail, breaks with light manual pressure.

WEATHERING

- F Fresh—Rock and fractures not oxidized or discolored, no separation of grains, change of texture or solutioning.
- S Slightly Weathered—Oxidized or discolored fractures and nearby rock, some dull feldspars, no separation of grains, minor leaching.
- M Moderately Weathered—Fractures and most of rock oxidized or discolored, partial separation of grains, crystals rusty or cloudy, moderate leaching of soluble minerals.
- I Intensely Weathered—Fractures and rock totally oxidized or discolored, extensive clay alteration, leaching complete, grain separation extensive, rock is friable.
- D Decomposed—Grain separation and clay alteration complete.

PLANARITY

- P Planar
- C Curved
- S Stepped
- I Irregular
- V Very rough, stepped, near-normal steps and ridges occur.
- R Rough, large angular asperities can be seen.
- M Moderately rough, asperities clearly visible, surface has an abrasive feel; to slightly rough, small asperities are visible and can be felt.
- S Smooth, no asperities, smooth to the touch.
- P Polished, slickensided, extremely smooth and shiny.

ROUGHNESS

INFILLING THICKNESS AND MINERALIZATION

C Clean, no filling.	C Clean	CA Calcite
S Very thin, surface sheen	WC White, crystalline	SI Silica
T Thin (up to 0.1 inches)	WN White, non-crystalline	MN Manganese
M Moderately thick (0.1 - 0.4 inches)	BC Black crystalline	CL Clay
V Very thick (0.4 - 1.0 inches)	BD Black dendritic	
E Extremely thick, greater than 1.0 inches)	TD Brown dendritic	
	TC Tan crystalline	

EXPLANATION (concluded) GEOLOGY AND ROCK STRUCTURE

CORE RQD

Core RQD is calculated using piece lengths that are defined by all fractures (type N, I, and C) that exist in the core when it is removed from the core barrel. Only handling-induced breaks are discounted in piece length determination. RQD is calculated as:

$$RQD = \frac{\sum \text{Piece lengths} \geq 0.33 \text{ feet}}{\text{Interval length}}$$

RQD is calculated for both the core run interval (run RQD) and even 10-ft intervals. If piece lengths ≥ 0.33 ft cross over 10-ft interval boundaries, the portion of the piece length that occurs in the 10 ft is included in the summation.

ESTIMATED PERCENTAGE LITHOPHYSAL VOIDS & OTHER CAVITIES

The percentage of lithophysal voids and other cavities is estimated for each core run interval where sufficient whole core is available. Excessive lost core and rubble zones may prevent the estimate on specific core runs. The estimate is based on the following procedure:

1. Count the number of cavities on the visible half of the core.
2. Estimate the average diameter of the cavities.
3. Assuming spherical voids, calculate the average void volume of individual cavities.
4. Estimate total void volume as the product of average void volume and number of cavities.
5. Estimate percent cavity volume as the total void volume normalized to the volume of core.

The estimated percent cavity volume for core runs is used to calculate a run length, weighted average for even 10-ft intervals. (Runs for which percent cavities cannot be determined are assumed to have the average percentage for the 10-ft interval; intervals for which the percent cavities was not estimated are labeled "Not Measured.")

Reference

Carr, W. J. (1992). "Structural Model for Western Midway Valley Based Upon RF Drillhole Data and Bedrock Outcrops." In Gibson, J. D., Swan, F. H., Wesling, F. R., Bullard, T. F., Perman, R. C., Angell, N. M. and DiSilvestro, L. A., Summary and Evaluation of Existing Geological and Geophysical Data Near Prospective Surface Facilities in Midway Valley, Yucca Mountain Project, Nye County, NV, SAND90-2191, Appendix A, p. A1-A24, Sandia National Laboratories, Albuquerque, NM.

Geslin, J. and Moyer, T. (1993), "Graphical Lithologic Log of Borehole RF#8," USGS DTN: GS931008314211.035.

UE25 RF #8

Stratigraphic and Thermomechanical Units Summary

Date: 11/1/93

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-ROD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES					LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR 25	POOR 50	FAIR 75	GOOD 90	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			10			20	30	40				
5												0%			0	(	0)			Not Measured							0.0-45.0 FT, ALLUVIUM (ref> SAND80-1491)
10																											0.0-28.0 FT, NO CORE TAKEN.
15												0%			0	(	0)			Not Measured							
20																											
25												0%			0	(	6)			Not Measured							

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

7-8

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES								ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSEAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY		
	INTERVAL	% RECOVERY (RUN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR < 25	POOR 25-50	FAIR 50-75	GOOD 75-90	EXCELLENT > 90	NATURAL AND INDETERMINATE (+ INDUCED)	10						20	30
55	RUN 3	100 (51)	XXXXXX	M		SR			50		.40	45%	1	(19)			5	M	Not Measured						58.0-58.5 FT, TUFF UNIT "X" (IMPERIAL MINE, CALIF., 1992, FOR NUMEROUS PYROCLASTIC FLOW AND FALLOUT TUFFS AND TUFFACEOUS SEDIMENTARY ROCKS THAT OCCUR BETWEEN THE CIVA CANYON & RAINIER MESA TUFFS).
											.13														
											.18														
											.45														
											.60														
											.65														
											.61														
											.53														
											.80														
											.37														
											60														
.90																									
.45																									
.70																									
.36																									
.37																									
.40																									
.47																									
.75																									
.76																									
65	RUN 5	100 (19)	X .05	M				30	50	.38		93%	0	(15)			6	H	Not Measured						
										.55															
										.43															
										.60															
										.50															
										.50															
										.50															
										.50															
										.50															
										.50															
										.50															

GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSIC AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY
	INTERVAL	% RECOVERY (RUN RQD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY	ROUGHNESS	INFILL	THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)			10	15	20	30		
80	RUN 5	100 (79)							30		1.00	93%					0 (15)	5	H	Not Measured				LITHOLOGY	
											.98														
											.95														
											1.60														
											1.30														
											.55														
											.42														
											.37														
											.90														
											.62														
85	RUN 6								40		.82						2 (24)	6	H	Not Measured				LITHOLOGY	
											.70														
											.57														
											.36														
											.35														
											.35														
											.68														
											.48														
											.46														
											.50														
90	RUN 7	100 (25)									.48							7	X	Not Measured				LITHOLOGY	
											.46														
											.50														
											.48														
											.46														
											.50														
											.48														
											.46														
											.50														
											.52														
95	RUN 7										.48							7	X	Not Measured				LITHOLOGY	
											.46														
											.50														
											.48														
											.46														
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GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.F.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-RQD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSAL AND OTHER CAVITIES	LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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GEOLOGY AND ROCK STRUCTURE LOG

Sandia National Labs
by J.P.T. Agapito & Assoc., Inc.

DEPTH (FT)	CORE		FRACTURES							ROCK QUALITY DESIGNATION-ROD (%)					FRACTURES (PER 10 FT)			HARDNESS	WEATHERING	ESTIMATED % LITHOPHYSICAL AND OTHER CAVITIES				LITHOLOGY	LITHOLOGIC DESCRIPTION AND STRATIGRAPHY	
	INTERVAL	% RECOVERY (RUN ROD-%)	LOST CORE & RUBBLE	FRACTURE TYPE	PLANARITY/ROUGHNESS	INFILL THICKNESS AND MINERALS	DIP	INDUCED	PIECE LENGTH	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	NATURAL AND INDETERMINATE (+ INDUCED)					10	20	30	40			
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130																										

Structure file: r18e.ctr

Lithology file: r18g.lth

Date: 11/ 1/93

PLLOG v 4.51

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CORE HOLE ROCK STRUCTURAL DATA SUMMARY
Hole RF#8

Sandia National Laboratories
 Print Date: 11/24/93
 WBS 1.2.3.2.6.2
 QA: NO
 FOR CORROBORATING
 INFORMATION

CODING EXPLANATION

STRATIGRAPHIC ABBREVIATIONS

Pre-Rainier T.C.	Pre-Rainier Mesa Member Tiva Canyon Member	B.T. U. Lith. U. Nonlith. Nonlith. L. Lith. & Hackly L. Lith. Crystal-Rich Lith.	Bedded Tuff Upper Lithophysal Upper Nonlithophysal Nonlithophysal Lower Lithophysal and Hackly Lower Lithophysal Crystal-Rich Lithophysal
Air Fall & B.T. P.C. T.S.	Air Fall and Bedded Tuff Pah Canyon Member Topopah Spring Member	U. Nonwelded Nonlith. U. Lith. Lith. L. Lith.	Upper Nonwelded Nonlithophysal Upper Lithophysal Lithophysal Lower Lithophysal

THERMOMECHANICAL UNITS

TCw—Tiva Canyon Welded Unit
 PTn—Upper Paintbrush Nonwelded Unit
 TSw1—Topopah Spring Welded Unit, Lithophysal Rich
 TSw2—Topopah Spring Welded Unit—Lithophysal Poor

COLUMN INFORMATION (Page 3)

RQD
$$RQD = \frac{\sum_{i=1}^n L_{pi}}{INTERVALLENGTH} \times 100$$

CORE RQD	Core RQD based on piece lengths defined by all types of fractures (C, I, N and V)		
ENHANCED RQD	Effect of fractures identified as coring induced (Type C) are filtered from the piece lengths.		
LITHOPHYSAL (and other cavities)	Percent void due to lithophysae and other cavities, estimated visually by counting the number of cavities, estimating the average diameter, calculating the void volume assuming spherical cavities, and normalizing to the core volume. NM—Not Measured		
WEATHERING	Subjective evaluation of rock degradation by mechanical/chemical agents: F: Fresh S: Slightly weathered M: Moderately weathered I: Intensely weathered D: Decomposed		
HARDNESS	Subjective evaluation of resistance to breakage: 1: Extremely hard 2: Very hard 3: Hard 4: Moderately hard 5: Moderately soft 6: Soft 7: Very soft 8: Soil-like, cohesive 9: Soil-like, non-cohesive		

COLUMN INFORMATION (Page 4)

FEATURE TYPE	Following codes indicate origin of feature: N: Natural—indicated by mineral coating or evidence of weathering, slickensides, lack of fit I: Indeterminate—origin questionable, rotated so that coatings possibly removed. C: Coring induced—fresh, clean, tightly fitting breaks. V: Vug or large void.		
INCLINATION (degrees)	Angle between plane normal to core axis and plane of fracture (Type N and I only).		
MINERAL INFILLING	Describes the infilling on fracture surfaces (Type N and I only): C: Clean WC: White crystalline WN: White noncrystalline BC: Black crystalline BD: Black dendritic TD: Brown dendritic TC: Tan crystalline CA: Calcite SI: Silica MN: Manganese CL: Clay TN: Tan noncrystalline		
INFILL THICKNESS	Describes the thickness of mineral infillings on the fracture surface (Type N and I only): C: Clean, no filling S: Very thin, surface sheen T: Thin (up to 0.1 inches) M: Moderately thick (0.1-0.4 inches) V: Very thick (0.4 - 1.0 inches) E: Extremely thick, greater than 1.0		
PLANARITY	Describes the overall shape of the feature (Type N and I only): P: Planar C: Curved S: Stepped I: Irregular		
ROUGHNESS	Describes the local relief of the surface (Type N and I only): V: Very rough—stepped, near-normal steps and ridges occur. R: Rough—large angular asperities can be seen. M: Moderately rough—asperities clearly visible, surface has abrasive feel. S: Smooth—no asperities, smooth to the touch. P: Polished—slickensided, extremely smooth and shiny.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Core Hole Structural Data Summary

Hole RF#8

Interval—50-120 ft

•G INFORMATION

Sandia National Laboratories

Print Date: 11/24/93

WBS 1.2.3.2.6.2

QA: NO

[illegible]

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

UC814 - DISTRIBUTION LIST

1	D. A. Dreyfus (RW-1) Director OCRWM US Department of Energy 1000 Independence Avenue SW Washington, DC 20585	1	R. M. Nelson (RW-20) Office of Geologic Disposal OCRWM US Department of Energy 1000 Independence Avenue SW Washington, DC 20585
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1	S. Rousso (RW-50) Office of Contract Business Management OCRWM US Department of Energy 1000 Independence Avenue SW Washington, DC 20585	1	D. R. Elle, Director Environmental Protection Division DOE Nevada Field Office US Department of Energy P.O. Box 98518 Las Vegas, NV 89193-8518

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4	Victoria F. Reich, Librarian Nuclear Waste Technical Review Board 1100 Wilson Blvd., Suite 910 Arlington, VA 22209	1	Senior Project Manager for Yucca Mountain Repository Project Branch Division of Waste Management US NRC Washington, DC 20555
5	Wesley Barnes, Project Manager Yucca Mountain Site Characterization Office US Department of Energy P.O. Box 98608--MS 523 Las Vegas, NV 89193-8608	1	NRC Document Control Desk Division of Waste Management US NRC Washington, DC 20555
1	C. L. West, Director Office of External Affairs DOE Nevada Field Office US Department of Energy P.O. Box 98518 Las Vegas, NV 89193-8518	1	Chad Glenn NRC Site Representative 301 E Stewart Avenue, Room 203 Las Vegas, NV 89101
8	Technical Information Officer DOE Nevada Field Office US Department of Energy P.O. Box 98518 Las Vegas, NV 89193-8518	1	E. P. Binnall Field Systems Group Leader Building 50B/4235 Lawrence Berkeley Laboratory Berkeley, CA 94720
1	P. K. Fitzsimmons, Technical Advisor Office of Assistant Manager for Environmental Safety and Health DOE Nevada Field Office US Department of Energy P.O. Box 98518 Las Vegas, NV 89193-8518	1	Center for Nuclear Waste Regulatory Analyses 6220 Culebra Road Drawer 28510 San Antonio, TX 78284
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4	J. A. Canepa Technical Project Officer - YMP N-5, Mail Stop J521 Los Alamos National Laboratory P.O. Box 1663 Los Alamos, NM 87545	1	V. R. Schneider Asst. Chief Hydrologist--MS 414 Office of Program Coordination and Technical Support US Geological Survey 12201 Sunrise Valley Drive Reston, VA 22092
1	H. N. Kalia Exploratory Shaft Test Manager Los Alamos National Laboratory Mail Stop 527 101 Convention Center Dr., #820 Las Vegas, NV 89109	1	J. S. Stuckless Geologic Division Coordinator MS 913 Yucca Mountain Project US Geological Survey P.O. Box 25046 Denver, CO 80225

1	N. Z. Elkins Deputy Technical Project Officer Los Alamos National Laboratory Mail Stop 527 101 Convention Center Drive, #820 Las Vegas, NV 89109	1	D. H. Appel, Chief Hydrologic Investigations Program MS 421 US Geological Survey P.O. Box 25046 Denver, CO 80225
5	L. S. Costin, Acting Technical Project Officer - YMP Sandia National Laboratories Organization 6313, MS 1325 P.O. Box 5800 Albuquerque, NM 87185	1	E. J. Helley Branch of Western Regional Geology MS 427 US Geological Survey 345 Middlefield Road Menlo Park, CA 94025
1	J. F. Devine Asst Director of Engineering Geology US Geological Survey 106 National Center 12201 Sunrise Valley Drive Reston, VA 22092	1	R. W. Craig, Chief Nevada Operations Office US Geological Survey 101 Convention Center Drive Suite 860, MS 509 Las Vegas, NV 89109
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1	D. A. Beck Water Resources Division, USGS 6770 S. Paradise Road Las Vegas, NV 89119	2	L. D. Foust Nevada Site Manager TRW Environmental Safety Systems 101 Convention Center Drive Suite 540, MS 423 Las Vegas, NV 89109
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1	Carlos G. Bell, Jr. Professor of Civil Engineering Civil and Mechanical Engineering Dept. University of Nevada, Las Vegas 4505 S. Maryland Parkway Las Vegas, NV 89154	1	David Rhode Desert Research Institute P.O. Box 60220 Reno, NV 89506
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1	Florindo Mariani White Pine County Nuclear Waste Project Office 457 Fifth Street Ely, NV 89301	1	Commission of European Communities 200 Rue de la Loi B-1049 Brussels BELGIUM
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		1	Steve Bradhurst P.O. Box 1510 Reno, NV 89505

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1	Ray Williams, Jr. P.O. Box 18 Austin, NV 89310	1	J. T. Sullivan U. S. Department of Energy YMSCO MS 423 P. O. Box 98608 Las Vegas, NV 89193-8608
1	Nye County District Attorney P.O. Box 593 Tonopah, NV 89049	1	D. R. Williams U. S. Department of Energy YMSCO MS 423 P. O. Box 98608 Las Vegas, NV 89193-8608
1	William Offutt Nye County Manager Tonopah, NV 89049	1	W. H. Hansmire Kewitt/PB 4460 S. Arville Street, Suite 6 Las Vegas, NV 89103
1	Charles Thistlethwaite, AICP Associate Planner Inyo County Planning Department Drawer L Independence, CA 93526	1	MS
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