Aamodt/Newsom
1-15-88
SUBJECT: UPDATE OF INFORMATION FOR A DEEP ODEX EXPLORATORY HOLE

OVERVIEW

A dry drilled hole can be successfully drilled to 1500' depth using the telescoping ODEX method.

It would take approximately 12 weeks after plans, permits, and approvals to procure, prepare site, mobilize, and drill the hole.

The cost would be approximately $800,000 for primary materials and drilling

HYDROLOGY DOCUMENT NUMBER 497

ROUGH DRAFT

To: Paul L. Aamodt
Chairman, ESTP Committee
Los Alamos National Laboratory

From: Jon Newsom
Newsom Industries/Los Alamos

January 14, 1988

SUBJECT: UPDATE OF INFORMATION FOR A DEEP ODEX EXPLORATORY HOLE

This document is in response to your request for information regarding a deep exploratory ODEX hole drilled vertically on Yucca Mtn.. It briefly addresses ODEX system parameters and system air requirements, previous ODEX experience on Yucca Mtn., the potential problems that may be encountered and possible solutions, anticipated range for hole deviation, likelihood for successfully completing the hole, other concerns and comments, estimated time and costs, and two scenarios for the technical drilling approach.

My first look into this matter was in June of 1984. Dale Hammermeister (USGS) wanted to ODEX approximately 1500' vertically. Upon learning that the ODEX 215 was being built, the idea of telescoping succeedingly smaller casing sizes to achieve his desired depth was developed. He proposed to telescope UZ-6A and UZ-8.

ODEX SYSTEMS

Atlas Copco currently has at least 11 different sizes for use with down-the-hole hammers. Mr. Kjell-Ove L. Jansson, an engineer and product designer from Sandvik in Sweden, has discussed with me their willingness to develop a system as large as 32" or 36" for the very large Ingersoll Rand DHD 124 or DHD 130 hammers.

For down-the-hole hammers, there are 6 commercial on-the-shelf ODEX sizes and one very large semi-commercial size that could be used on Yucca Mtn. We can use several combinations of these depending on the minimum hole or core size needed at total depth.

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Below in Table I is a list of commonly available sizes and how they might telescope together.

TABLE I

ODEX Model	Casing Size (inches) O.D.	I.D.	Shoe ID (inches)	Pilot Bit (inches)	Diameter of Reamed Hole(inches)	COST($)	AVAILABLE
90	4 1/2	4	3 1/2	3 11/32	4 13/16	* 6,500	(On shelf)
115	5 1/2	5 1/16	4 9/16	*4 1/2	6	9,000	At NTS
140	6 5/8	6 1/8	5 9/16	5	7 3/8	11,000	(On shelf)
165	7 5/8	7 1/8	6 9/16	6	8 11/32	13,000	At NTS
190	8 5/8	8	7 9/16	6 1/2	*9 3/8	15,000	(On shelf)
215	10	9 1/2	8 9/16	8 1/4	10 15/16	17,000	At NTS
240	10 3/4	N/A	*9 9/16	*9 3/8	N/A	13,247+ plus dth	(2-3 Months)
310	14	N/A	12 3/16	*12	N/A	35,435+ plus dth	(2-3 Months)
365	16	15 1/4	*14 3/4	*14 3/8	N/A	70,000	(On shelf)
610	26	N/A	*24	*23	N/A	106,000+ plus dth	(2-3 Months)
700	30	N/A	27 9/16	*27	N/A	*139,700+ plus dth	(2-3 Months)
Possible	32	N/A	N/A	N/A	N/A	N/A	(Several Months)
Possible	36	N/A	N/A	N/A	N/A	N/A	(Several Months)

* Approximate + dth = down-the-hole hammer

NOTE: N/A in Table I indicates measurements that are unavailable due to systems so new that engineering specifications have not yet been released.

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If the inside lip of the casing shoe is milled out, we double the possible number of telescoping sizes.

TABLE II

EXAMPLE WEIGHTS OF CASING STRINGS:

Length	O.D.	Weight Per Foot	Total Weight
500'	10"	27# CASING	13,500#
1000'	7 5/8"	21# CASING	21,000#
1500'	5 1/2"	13# CASING	19,500#

- -

1000' of 4 1/2" OD DRILL ROD = approximately 17,500#

Rig would need to be able to handle at least 38,500#

- -

AIR VOLUME REQUIREMENTS

Air requirements depend on the diameter of the drill rods used, but REECo has sufficient compressors on the site. The minimum air velocity for effective cuttings removal is about 3000 feet per minute, and 7,000 feet per minute is ideal.

However, the extremely fractured formations of Yucca Mtn. use up much of this air. For example, UZ-6s seemed to have taken about half the injected air into the fractures.

The doubling of air volume cleaned the hole when necessary. The use of larger drill rod would have given us more efficient use of compressors, and also would have streamlined the air flow path.

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NEEDED CFM TO ACHIEVE 7,000' PER MINUTE

			Normal	Double
ODEX 215	9 1/2" ID w/ 5 1/2" OD Drill Rod	=	2,100 CFM	4,200 CFM
	9 1/2" ID w/ 6 1/4" OD Drill Rod	=	1,900 CFM	3,800 CFM
ODEX 165	7" ID w/ 3 1/2" OD Drill Rod	=	1,400 CFM	2,800 CFM
	7" ID w/ 4 1/2" OD Drill Rod	=	1,100 CFM	2,200 CFM
	7" ID w/ 5 1/2" OD Drill Rod	=	600 CFM	1,200 CFM
ODEX 115	5" ID w/ 3 1/2" OD Drill Rod	=	490 CFM	980 CFM
ODEX 365	15" ID w/ 12 3/4 " OD Drill Rod	=	2400 CFM	

(I am not sure if this pipe exists at NTS.)

With the use of the larger sizes of drill rods, 2400 CFM will do the job adequately for the ODEX 115, 165, and 215 systems. In addition to compressed air, the vacuum system used on UZ-6 can be used as an assist on this hole and would help greatly.

TABLE III

DRILL RODS RECOMMENDED FOR EACH SYSTEM AND THE CORE BBLS AND RODS

System	Drill Rods	Suggested Core bbl
ODEX 90	3" +	NQ
ODEX 115	3", 3 1/4"	NQ or HQ
ODEX 140	4 1/2"	HQ
ODEX 165	4 1/2", 5 1/2"	HQ or larger
ODEX 190	4 1/2", 5 1/2"	HQ or larger
ODEX 215	4 1/2", 5 1/2", 6 5/8"	HQ or larger
ODEX 365	12 3/4" if available	HQ or larger

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DRY DRILLING ODEX EXPERIENCE ON YUCCA MTN.

UZ-6s, 4/23/85

The largest diameter ODEX hole drilled on Yucca Mtn. is USW UZ-6s. The hole was started 4/23/85 using an ODEX 165 and intermittently cored with an oversized HQ core bit.

The hole (8 11/32" diameter) was drilled and cased with 7 5/8" O.D. casing to 494.5' and a 3.990" hole was then drilled on to 519'.

Total main-hole construction time was 18.34 days, however, several problems were encountered. Equipment modifications have greatly increased reliability and they should not be a problem on future drilling programs.

The average time to ODEX 20' was about 20 minutes and the average time to core was about 20' per day. Core was not continous from the top to the bottom-of-hole.

It was apparent that this hole could not have been dry drilled without advancing casing or some dual wall system. Both UZ-6 and UZ-6s are very highly fractured and normal circulation could not be maintained without large losses of fluid.

USW UZ13, 1/24/85

A 6" diameter hole (410') deep was ODEXed using the ODEX 115 system. 5 1/2" O.D. casing was run to 410' and 3.937" core was cut to 430'. Total main-hole construction time = 13.19 days. There were numerous problems with bits and casings. Several types and sizes of core bits were tried. Most of the problems encountered have been either eliminated by equipment modification or by changes in drilling programs.

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POTENTIAL PROBLEMS

The ODEX systems are marketed to drill 350' to 400' each. The limitations of the system come about by accumulated friction on the casing as the hole is lengthened. The effective high-impact percussion energy needed to drill the hole and drive the casing is progressively reduced. This combination of high impact energy and drag on the casing can increase failure rates.

Other problems that have been encountered with ODEX drilling are the unscrewing of the pilot bit, wear and fatigue on bits, and the destruction of the internal driving lip of the casing shoe. Redesign of the pilot bit and guide device on the ODEX 115, ODEX 140, and ODEX 165 have remedied these problems and demonstrated that it is possible to successfully drill 400' to 500' holes on a routine basis.

The biggest problem currently facing deep ODEXing is casing breakage. This normally occurs either at the shoe joint or on a joint somewhere below a tight spot in the hole.

There are two methods of adding casings:

1) To weld each joint on to the next one, or
2) To use flush inside and outside left hand threaded joints.

On most small and medium ODEX systems the approach generally taken is to use threaded casings because it goes together easily, comes apart easily, and allows the casing to be used on other jobs, if desired. If a crooked hole is encountered the long straight-sided thread area does not hold up well where it is stressed as the casing rotates. Fatigue starts and this decreases its strength considerably. Threaded joints must also be pre-torqued properly to hold up to predicted stresses. A weld would have to be done to very high quality standards, and if the casing were removed it would have to be cut and reworked to get a straight edge for the next job. The yield strength of a 6 5/8" threaded joint grade is 73,000# while the welded joint has a yield of 195,000#.

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Because of the ease of using threaded casing vs. welded casing, sometimes more chances are taken than necessary.

As an example, please see the drilling reports on UZ-6s, and UZ-13. For this reason I recommend that a deep hole at Yucca Mtn. use welded casings on a strings.

HOLE DEVIATION

Anticipated deviation of a deep ODEX hole is not expected to be significant and should be within 12' of the starting center-line of the hole. This would be <1° of deviation. However, if the hole alignment starts to vary too much, it can be realigned by directional drilling of the diamond core holes. This would be done with a gradual curve of adjustment to prevent stress or binding on the casing. Periodic surveys can be run to determine hole-direction.

A decision will need to be made regarding how much of the total depth needs to be cored. Continuous ODEX drilling of the hole would be much quicker than alternating the ODEX and coring operations. However, since the objective is to get as much information as possible, it may be best to try to core a full 20 feet or 40 feet ahead of the casing in areas of low fractures. This long core could, in itself, present a problem of hole deviation.

LIKELIHOOD OF SUCCESS

The probability of successfully completing this hole increases with the number of telescoping systems used in succession. By taking the position that each system has limitations, that a shoe joint or casing joint might break near the bottom, or that one size might bind up prematurely, the availability of several sizes to fall back on should get us to T.D.

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CONCERNS

There are other concerns of project participants which merit study and attention.

1. That hole cleaning problems may result in failure to reach T. D.
2. That a failed attempt at drilling this hole might jeopardize this immediate area of the ESF Site.
3. That the final hole size may be too small for practical use or for stemming.
4. That bridging could occur when casings are removed.

ANSWER TO CONCERNS

1. Cleaning hole can be very difficult, but the use of air injector subs spaced in the drill string could assist up-hole velocity. The addition of a vacuum drilling system would help greatly. This was used to drill USW UZ-6 and should be used as an assist on deep ODEX.
2. The hole would be drilled dry and sealed as needed.
3. No stemming will be needed. Start with the largest hole possible and determine what, if any, stemming needs to be placed.
4. Although casing removal from this hole is not anticipated, bridging could be eliminated by stemming while removing casing.

SPACE REQUIREMENT

Drill pad size, rig, compressors, and pipe storage space could best be determined when the ODEX sizes are decided on.

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ESTIMATED TIME AND COST

Hole Sizes and Primary Materials Costs for Two Possible Drilling Scenarios

Using the larger size scenario #2 provides greater size redundancy (i.e. safeguards) however, this would double the cost of materials. An estimated cost of $8,000 per shift for the rig, some rig support, and compressors was previously given during an ESF meeting when deep ODEX drilling was discussed.

Scenario #1			Scenario #2		
10" - ODEX 215	APX. $ 17,000		16" - ODEX 365	$ 70,000	
7 5/8" - ODEX 165	15,000				
5 1/2" - ODEX 115	9,000				
	41,000.....	41,000...	Plus 3 other sizes	41,000	
					111,000.....111,000

Casing for above sizes:

500' of 10"	= 5,500		16" Casing	= 10,000	
1000' of 7 5/8"	= 9,000				
1500' of 5 1/2"	= 5,500				
	20,000.....	20,000...	Plus Smaller Casing	20,000	
					30,000.....30,000

Scenario #1 Subtotal for ODEX systems with casing.....	61,000	Scenario #2 Subtotal for ODEX systems with casing.....	141,000
Time to alternate ODEX and Core 1500' is 90 shifts @ $ 8,000 ea...	720,000	.....	720,000
30 Core bits @ $ 450 ea.....	13,500	.....	13,500
1 Core bbl. and accessories	3,000	.....	3,000

Scenario #1		Scenario #2	
Approximate hole cost. Total	$ 797,500	Approximate hole cost. Total	$ 877,000

Scenario #1 is recommended.

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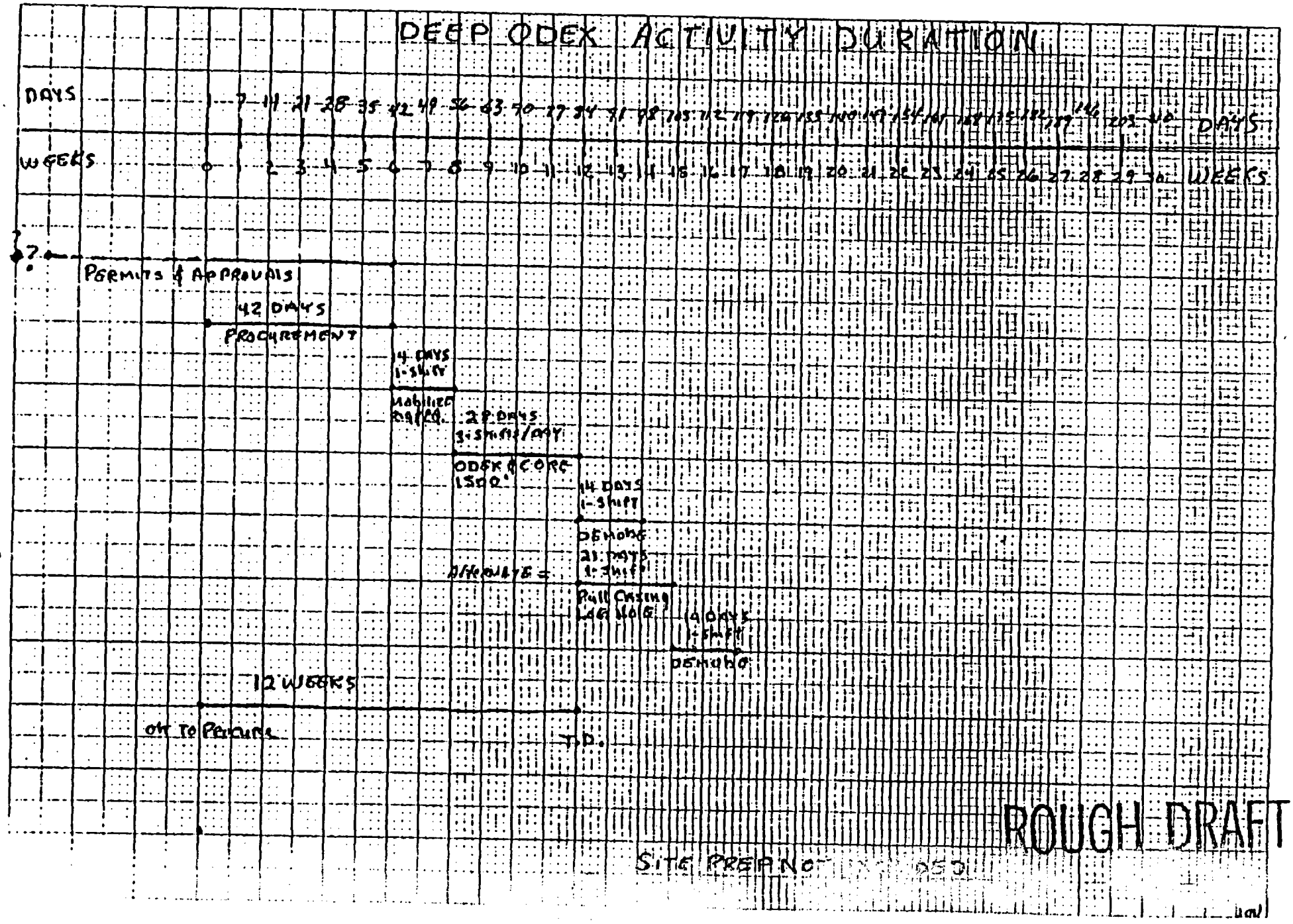
DEEP ODEX ACTIVITY DURATION



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CLASS XIII RIG SPECIFICATIONS

RIG: JOY 1 REECO NO. 85172

PRIMARY USE: DRILLING SMALL DIAMETER EXPLORATORY HOLES

DATE ACQUIRED: FEBRUARY, 1980 New ___ Used X

A. MAST:

1. Mast JOY, 58' HEIGHT
2. Height from Derrick Floor to Pipe Racking Platform 27'
3. Crown Block JOY 4 SHEAVE - 1 LARGE FOR SINGLE LINE
4. API Static Hook Load, lbs. 45,000 MAST / 33,900 REECo Safe Load Rating, lbs. 39,700 4-PART LINE / 26,000 2-PART LINE
5. REECo Safe Load Rating Limited by 2-PART, WIRELINE / 4-PART, 80% STATIC HOOK LOAD

B. DRAW WORKS AND ROTARY TABLE:

1. Draw Works JOY MODEL 225 AS
2. Traveling Block & Hook JOY 4 SHEAVE - 1 LARGE FOR SINGLE LINE
3. Hoisting Power CUMMINS MODEL 855 R, 235 HP
4. Type & Size Drilling Line 5/8", 6 X 19 SEALE, IWRC
5. Rotary Table HYDRAULIC CHUCK
6. Rotary Table Power CUMMINS MODEL 855. R, 235 HP

C. SUBBASE:

1. Maximum Hole Size that can be Drilled, in. 6-1/4"

CLASS XIII RIG SPECIFICATIONS

RIG: JOY 2 REECO NO. 85173

PRIMARY USE: DRILLING SMALL DIAMETER EXPLORATORY HOLES

DATE ACQUIRED: FEBRUARY, 1980 New ___ Used X

A. MAST:

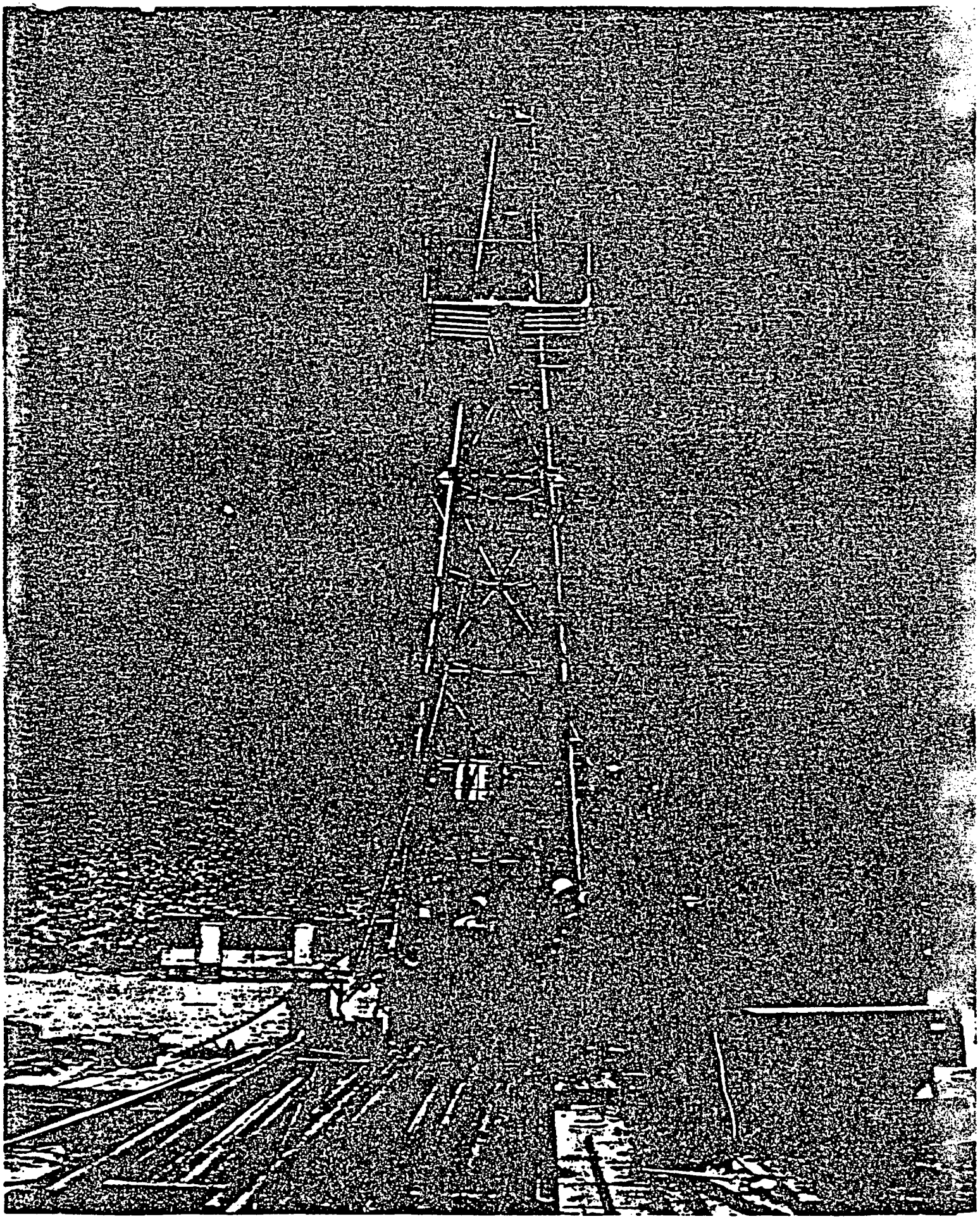
1. Mast JOY, 38' HEIGHT
2. Height from Derrick Floor to Pipe Racking Platform 27'
3. Crown Block JOY 4 SHEAVE - 1 LARGE FOR SINGLE LINE
4. API Static Hook Load, lbs. 50,800 MAST 38,200 REECo Safe Load Rating, lbs. 43,800 4-PART LINE 26,000 2-PART LINE
5. REECo Safe Load Rating Limited by 2-PART, WIRELINE 4-PART, 80% STATIC HOOK LOAD

B. DRAW WORKS AND ROTARY TABLE:

1. Draw Works JOY 225 AT
2. Traveling Block & Hook FAILING 25 TON 4 - SHEAVE
3. Hoisting Power MACK TRUCK R-600
4. Type & Size Drilling Line 5/8", 6 X 19 SEALE, IWRC
5. Rotary Table HYDRAULIC CHUCK
6. Rotary Table Power MACK TRUCK R-600

C. SUBBASE:

1. Maximum Hole Size that can be Drilled, in. 6-1/4"



AUXILIARY RIG SPECIFICATIONS

RIG: CME-550 REECO NO. 85136

PRIMARY USE: DRILLING AND CORING SMALL DIAMETER EXPLORATORY HOLES

DATE ACQUIRED: APRIL, 1983 New ___ Used X

A. MAST:

1. Mast CME-550, 23' HEIGHT
2. Crown Block 1 - SHEAVE
3. API Static Hook Load, lbs. 6000 LBS REECo Safe Load Rating, lbs. ___
4. REECo Safe Load Rating Limited by ___

B. DRAW WORKS AND ROTARY TABLE:

1. Draw Works N/A
2. Hoisting Power FORD 192 CU.IN., 4-CYLINDER, 78 HP, 6000 LBS.
3. Type & Size Drilling Line 5/8", 6 X 19 SEALE, IWRC
4. Rotary Table HYDRAULIC CHUCK
5. Rotary Table Power FORD 192 CU.IN., 4-CYLINDER, 78 HP, 5-SPEED TRANSMISSION, 650 RPM

   Maximum Hole Size that can be Drilled, in. 14"

CLASS III RIG SPECIFICATIONS

RIG: IDECO 37 REECO NO. 85116

PRIMARY USE: DRILLING SMALL DIAMETER EXPLORATORY HOLES

DATE ACQUIRED: JUNE, 1965 New X Used ____

A. MAST:

1. Mast IDECO GUYED TELESCOPING, 103' (MODEL NO. KM103-212G)
2. Height from Derrick Floor to Pipe Racking Platform 54'
3. Crown Block IDECO 5 SHEAVE
4. API Static Hook Load, lbs. 212K# WITH 8 LINES REECo Safe Load Rating, lbs. 170K#
5. REECo Safe Load Rating Limited by 80% STATIC HOOK LOAD

B. DRAW WORKS AND ROTARY TABLE:

1. Draw Works IDECO H-37ED, 400 HP
2. Brake NOT APPLICABLE
3. Traveling Block & Hook McKISSICK, 150 TON - 4 SHEAVE
4. Hoisting Power 2 GM 6-71, 350 HP
5. Type & Size Drilling Line 1", 6 x 19 SEALE, IWRC
6. Rotary Table IDECO 275, 27-1/2"
7. Rotary Table Power 2 GM 6-71, 350 HP

C. SUBBASE:

1. Subbase IDECO, SPLIT TRAILER MOUNT Elev. G.L. 11.30'
2. Outside Dimensions (LXW) ft. 16.8' x 20' Between Boxes, ft. 7.95' x 7.54'
3. Vertical Distance from G.L. to Bottom of Rotary Beams, ft. 8.65'
4. Maximum Hole Size that can be Drilled, in. 20"

Sub Base 45,000 #

Rig 110,000

12 x 60'. 15' high

CLASS V RIG SPECIFICATIONS

RIG: HYCALOG II REECO NO. 85119

PRIMARY USE: DRILLING ANGLE POST SHOT HOLES

DATE ACQUIRED: SEPTEMBER, 1965 New ___ Used ___

A. MAST:

1. Mast HYCALOG TILTING 0 - 30°
2. Crown Block HYCALOG 4 SHEAVE
3. API Static Hook Load, lbs. 180,000 REECo Safe Load Rating, lbs. 144,000
4. REECo Safe Load Rating Limited by 80% STATIC HOOK LOAD

B. DRAW WORKS AND ROTARY TABLE:

1. Draw Works HYCALOG HH 6000
2. Traveling Block & Hook HYCALOG 3 SHEAVE
3. Hoisting Power CUMMINS NT 380 DIESEL, 380 HP @ 2300 RPM
4. Type & Size Drilling Line 1", 6 X 19 SEALE, IWRC
5. Rotary Table POWER SWIVEL, 10-3/4"
6. Rotary Table Power POWER SWIVEL
7. Brake

C. SUBBASE:

1. Subbase HYCALOG Elev. G.L. 4'
2. Maximum Hole Size that can be Drilled, in. 17-1/2"

DRY DRILLING AND CORING TECHNOLOGY WORKSHOP

AGENDA: Tuesday, July 26, 1988

Activity	Time
Introduction	
Welcome - W. Hughes, WMPO	8:00-8:05
Scope and Objectives - R. Long, SAIC	8:05-8:10
Introductions	8:10-8:20
Agenda - H. Perry, SAIC	8:20-8:30
Scientific Needs	
Unsaturated Zone Hydrology - J. Rousseau, USGS	8:30-9:00
Saturated Zone Hydrology - J. Czarnecki, USGS	9:00-9:30
Geology - R. Spengler, USGS, or representative	9:30-10:00
Geochemistry - A. Norris, LANL	10:00-10:30
Performance Assessment - C. Rautman, SNL/ E. Hardin, SAIC	10:30-11:00
Discussion	11:00-11:30
Lunch	11:30-12:30
NTS Experience and Capabilities	
Description of NTS Drilling Equipment - J. C. McDaniel, REECo	12:30-1:00
Overview of Drilling Systems Used at NTS - B. Garms, F&S	1:00-1:30
Reverse Vacuum Drilling Experience - M. Whitfield, USGS	1:30-2:00
ODEX Drilling Experience - J. Newsome, LANL, Consultant	2:00-2:30
G-Tunnel Prototype Drilling and Coring - J. Newsome, LANL, Consultant	2:30-3:00
Panel Discussion	3:00-4:30

VACUUM DRILLING OF UNSATURATED TUFFS AT A POTENTIAL RADIOACTIVE-WASTE REPOSITORY, YUCCA MOUNTAIN, NEVADA

Merrick S. Whitfield

U.S. Geological Survey
Denver, Colorado

Abstract

A vacuum reverse-air circulation drilling method was used to drill two 17½-inch (44.5-centimeter) diameter test holes to depths of 1,269 feet (387 meters) and 1,887 feet (575 meters) at Yucca Mountain near the Nevada Test Site. The site is being considered by the U.S. Department of Energy for construction of a high-level radioactive-waste repository. One of these two test holes (USW UZ-1) has been equipped with instrumentation to obtain a long-term record of pressure and moisture potential data; the other test hole (USW UZ-6) will be similarly instrumented in the near future. These investigations are being conducted as part of the Nevada Nuclear Waste Storage Investigations Project of the U.S. Department of Energy.

The test holes were drilled using a 5½-inch (14-centimeter) by 8 5/8-inch (22-centimeter) dual-string reverse-vacuum assembly. A vacuum, induced at the land surface, removed the drill cuttings through the inner string. Compressed air was injected into the dual-string annulus to cool the bit and to keep the bit and inner string clean. A tracer gas, sulfur hexafluoride (SF_6), was added to the compressed air for a later determination of atmospheric contamination that might have occurred during the drilling. After reaching the surface, the drill cuttings were routed to a dry separator for sample collection. Then return air and dust from the cuttings were routed to a wet separator where the dust was removed by a water spray, and the remaining air was exhausted through the vacuum unit (blower) to the atmosphere.

Advantages of using vacuum reverse-air circulation for drilling are: (1) Capability of obtaining continuous uncontaminated and representative rock samples, thus permitting a moisture profile to be made of the unsaturated volcanic rocks drilled, and (2) positive

identification of any perched-water zones. Disadvantages of using this drilling method are: (1) Need for more equipment and a larger drill site than for other drilling methods, (2) vacuuming action creates unstable hole conditions and causes frequent caving, and (3) methods need to be developed to obtain satisfactory cores.

Introduction

Vacuum drilling, or more specifically, vacuum reverse-air circulation, was first used in 1967 at the Nevada Test Site to drill an emplacement hole for underground nuclear testing. Since then, 10 emplacement holes and 2 test holes have been drilled using this method. Two years ago, the U.S. Geological Survey started using vacuum drilling in their hydrologic studies of unsaturated tuff at Yucca Mountain near the Nevada Test Site, one of the potential sites being considered as a repository for storage of high-level radioactive wastes. This investigation is part of the Nevada Nuclear Waste Storage Investigations (NNWSI) Project and is conducted in cooperation with the U.S. Department of Energy, Nevada Operations Office, under Interagency Agreement DE-AI08-78ET44802.

The primary objectives in drilling these large diameter test holes were to: (1) Obtain a vertical moisture-content profile of the rocks drilled, (2) check for the presence of perched-water zones, and (3) emplace hydrologic instruments at selected depths so that a long-term record of pressure and moisture-potential data could be collected. The unsaturated section in the Yucca Mountain area consists of nonwelded to densely welded tuff ranging in thickness from 1,500 to 2,500 feet (460 to 760 meters). The two test holes drilled in these unsaturated rocks are the major topic of this paper; location of these test holes is shown in Figure 1.

This unique method of drilling unsaturated rocks permits the detection of perched water or moist zones as soon as they are penetrated and prevents contamination of the unsaturated rocks with drilling liquids. In waste storage, knowledge of the chemistry of native pore water is important in designing canisters to contain radioactive wastes for long periods. Another essential reason for collecting hydrologic data from boreholes drilled in unsaturated rocks is determining whether in situ borehole conditions still exist after completion of a test hole. One way of doing this is to determine the presence or absence of atmospheric gas in the rocks adjacent to the borehole. Any atmospheric gas induced during the drilling process can later be detected if a tracer gas, such as sulfur hexafluoride (SF_6), is injected into the borehole during drilling. In order to obtain an accurate age determination of water from rocks, it is essential that they not be contaminated by present-day atmospheric gases such as carbon dioxide. Prior to instrumenting, the air in the test hole is vacuumed until all the tracer gas has been removed, assuring that only in situ gases are filling the rock pores.

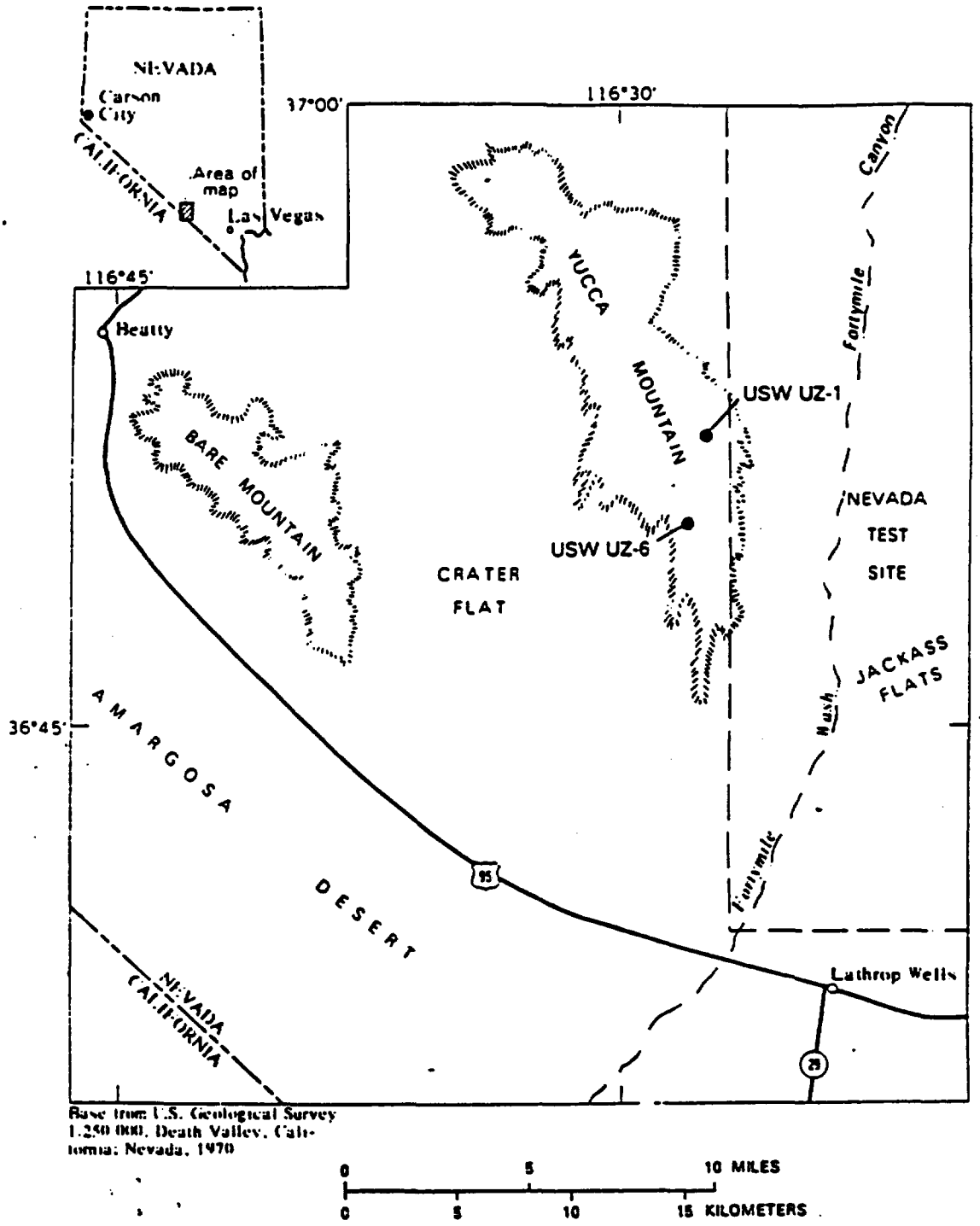


Figure 1. Location of test holes USW UZ-1 and USW UZ-6.

Drilling Procedures

The two test holes completed at Yucca Mountain for hydrologic studies of unsaturated tuff were drilled using a dual-string pipe with a 17½-inch (44.5-centimeter) modified rock bit. The inner string was 5½ inches (14 centimeters), and the outer string was 8 5/8 inches (22 centimeters) in diameter. A vacuum unit or blower located on the land surface created a suction in the inner string of the drill pipe that moved the drill cuttings from the bottom of the drill hole to the surface. From the inner string, the drill cuttings were routed via the kelly hose to a dry separator for sample collection. The dry separator contains two chambers that could be separated by a hydraulic slide gate, which prevents vacuum loss in the system. Drilling and sample collection can then be done simultaneously. When closed, the slide gate allows drill cuttings to accumulate in the upper compartment of the dry separator while drill cuttings are being collected from the lower compartment of the dry separator. A schematic diagram showing the arrangement of the separators and vacuum unit is given in Figure 2. After collecting samples for lithologic and hydrologic analysis, the remaining drill cuttings were vibrated out of the lower chamber of the dry separator and removed from this collecting point by a conveyor belt.

The dust particles that did not settle out in the dry separator were vacuumed to a wet separator where the dust was removed by a water spray, and the remaining clean vacuumed air was exhausted to the atmosphere through the vacuum unit and exhaust muffler. The water spray removed almost all the dust before it passed through the vacuum unit and exhaust muffler to the atmosphere.

One of the major advantages of using this method in drilling unsaturated rocks is that moist zones can be determined immediately from the returned drill cuttings during drilling. Another advantage of using vacuum drilling is that it requires no drilling liquids, so the natural state of rock liquids is minimally disturbed. In addition, natural hydrologic properties of the rock are not altered significantly by invasion of drilling liquids and can be determined more accurately in the laboratory.

Vacuum drilling has proven to be effective when used with 13 3/8-inch (34-centimeter) diameter drill pipe for drilling boreholes varying in diameter from 17½ to 104 inches (44.5 to 366 centimeters). Coring was attempted in the first test hole (USW UZ-1) but was unsuccessful because of the use of an inappropriate coring bit. In addition, the cores were heated to a high temperature by the dry coring; therefore, the moisture contents determined by laboratory analysis were considered erroneous. One problem in vacuum drilling is the slower drilling rate when rock moisture is greater than 5 percent by weight. In moist zones, plugging of the drill bit and encrustation of the inner string and kelly hose with a mud cake eventually restricts the flow of drill cuttings to the surface. When plugging occurs, drilling needs to stop or the drill bit will be buried in drill cuttings, and eventually it will become stuck. Drilling can be resumed only after the bit, inner string, and kelly hose are cleaned and dried by blowing dry compressed air through them.

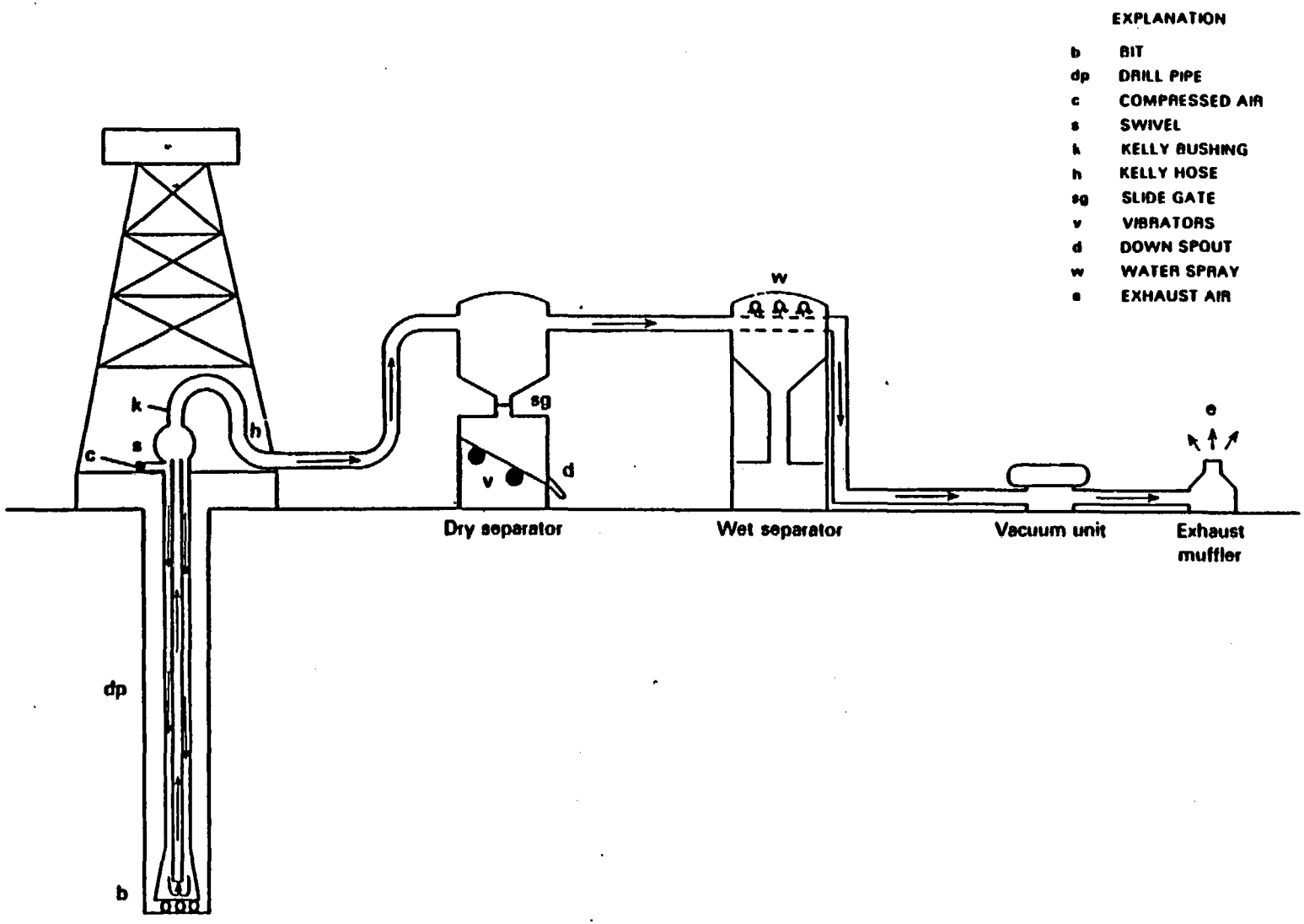


Figure 2. Schematic diagram of separators, vacuum unit, and exhaust muffler.

One solution to the plugging problem can be made if maintaining drilling rate is more important than collecting representative moisture samples. In this case, a measured quantity, less than 2 gallons (7.6 liters) per minute, of clean water can be injected through the outer string of drill pipe while drilling. A tracer of known concentration, such as lithium bromide or lithium chloride, when added to this drilling water will help determine approximately how much formation water has been encountered by periodically checking the concentration of this drilling water as it returns from the borehole. However, by using even this small quantity of drilling water, the ability to detect moist and perched-water zones will be limited. Two critical factors when adding water while drilling are: (1) Water needs to be shut off when drilling is not actually being done, and (2) quantity of water being added needs to be decreased when rock is very hard and the penetration rate is slow. If a head of water occurs above the drill bit, the bit will become submerged, and drill cuttings cannot be removed from the borehole by the vacuum. When this occurs, water in the borehole needs to be pumped out before drilling can be resumed.

Drilling of Test Hole USW UZ-1

The first large diameter test hole using vacuum drilling to collect hydrologic data from the unsaturated zone in the Yucca Mountain area was USW UZ-1. This test hole was drilled to a total depth of 1,269 feet (387 meters). Drilling was discontinued at this depth, because a large volume of water was encountered, and the water level could not be lowered significantly. Thus, the entire unsaturated section, which is about 1,540 feet (470 meters) thick at this location, was not penetrated. There are two possible explanations for the presence of this water:

1. All of this water may be contamination from a geologic test hole (USW G-1) located 1,000 feet (305 meters) to the southeast of test hole USW UZ-1. Approximately 2,300,000 gallons (8,700,000 liters) of polymer drilling fluid were lost in the drilling and coring of USW G-1. A chemical analysis of the water from USW UZ-1 indicated that the polymer was identical to that found in USW G-1. A major fracture zone probably exists between these two test holes that may have provided hydrologic connection between the two holes;

2. A naturally occurring perched-water zone also may have been encountered at this depth; this zone definitely is contaminated with drilling polymer that was used to drill USW G-1.

With the possible exception of perched water in the bottom of this test hole, no perched-water zones were encountered in the upper part. A profile of the geologic units penetrated and the moisture content (by weight) of these rocks are shown in Figure 3. The moisture-content profile of this test hole ranged from 1 to 22 percent by weight. The first 58 feet (17.7 meters) of this hole was drilled in the alluvium using 1,208 gallons (4,573 liters) of water tagged with a lithium bromide tracer, added at the rate of 1.5 to 2 gallons (5.7 to 7.6 liters)

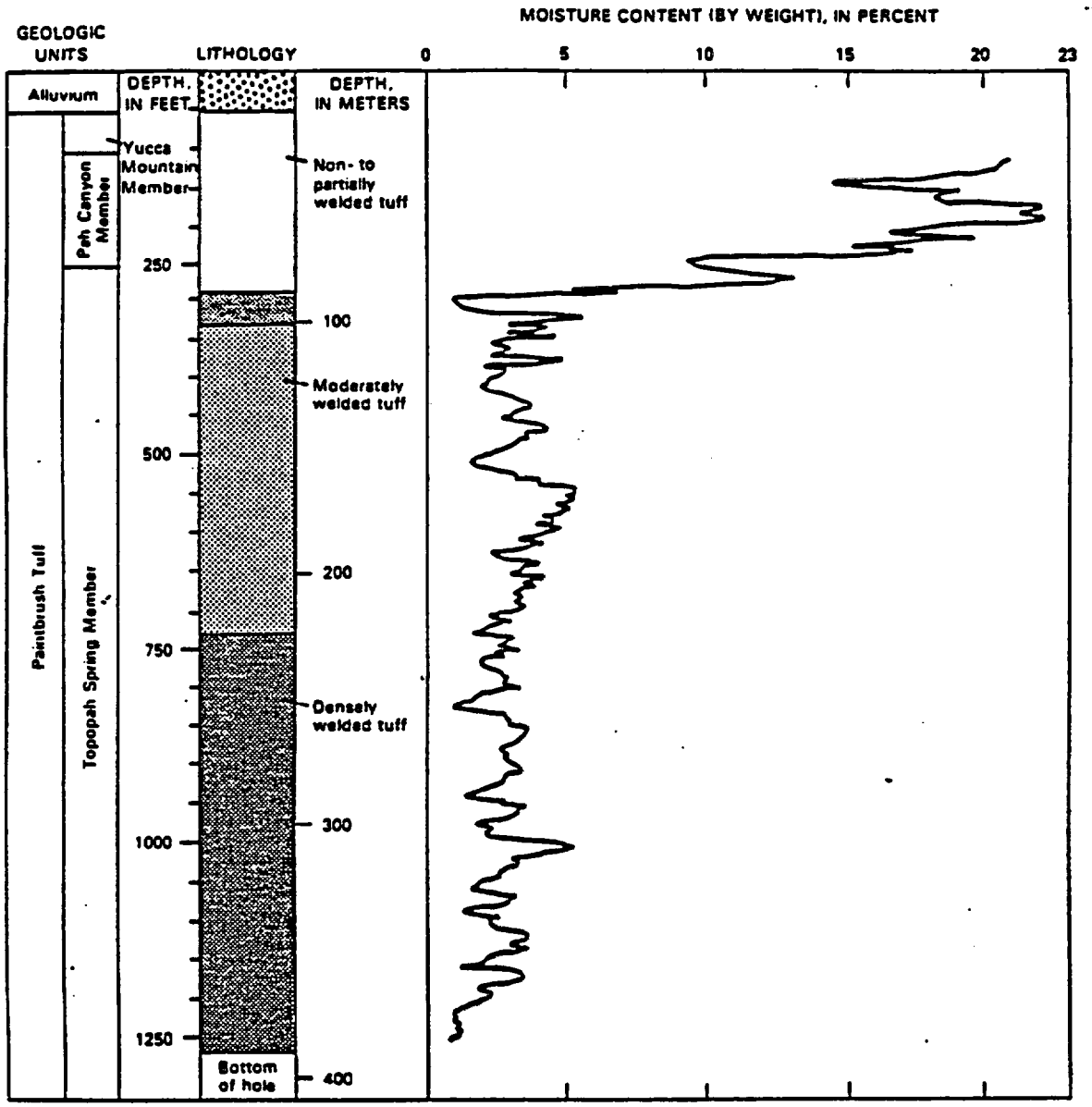


Figure 3. Geologic units, lithology, and moisture content of rocks penetrated in test hole USW UZ-1.

per minute. The addition of water was discontinued below this depth, because a balance could not be maintained between rate of penetration and minimum quantity of water needed to cool the bit. Four hundred gallons (1,514 liters) of water were pumped out of the hole by a diaphragm pump that was lowered downhole; thus, 808 gallons (3,059 liters) of water were left in the borehole. Drill-cutting and instrumentation data indicate that this drilling water probably did not seep below 250 feet (76 meters). Drill cuttings from selected depths were submitted to the laboratory for lithium leaching. Laboratory results indicate that the lithium concentration was 13 micrograms per gram to a depth of 101 feet (31 meters) but showed a background level of lithium less than 10 micrograms per gram below 250 feet (76 meters). Hydrologic-instrumentation data obtained after drilling USW UZ-1 show a relatively low matric potential below a depth of 83 feet (25.3 meters) (Montazer et al. 1985, this proceedings). Below this depth, the rock-moisture content is considered to be representative of rocks underlying a wash that probably receives periodic recharge from surface-water runoff and flooding. This test hole has been instrumented with pressure transducers, psychrometers, and heat-dissipation probes so that a long-term record of atmospheric-pressure and moisture-potential changes can be monitored for selected depths (Montazer et al. 1985, this proceedings; Thamir and McBride, 1985, this proceedings).

Drilling of Test Hole USW UZ-6

The second test hole for collecting hydrologic data from the unsaturated zone was drilled without any drilling water to a total depth of 1,887 feet (575 meters); it will be instrumented next year with pressure transducers, psychrometers, and heat-dissipation probes. The initial plan was to drill through the entire unsaturated section, which is about 2,550 feet (777 meters) thick at this location. However, drilling was stopped because of an overrun of drilling time caused by numerous hole cavings and excessive breakage of the drill-pipe inner string. Continual caving occurred to a depth of 1,000 feet (305 meters) because of the numerous fractures in the densely welded tuffs in the lower part of the Tiva Canyon Member and in the upper one-half of the Topopah Spring Member of the Miocene Paintbrush Tuff. In the drilling of USW UZ-6, the deepest unsaturated-zone test hole, no free water was encountered; however, the kelly hose became plugged and required cleaning several times while drilling through a 60-foot (18-meter) moist, nonwelded to partially welded tuffaceous zone at the geologic contact between the Tiva Canyon Member and the Topopah Spring Member of the Miocene Paintbrush Tuff. Laboratory analysis indicated that this zone had a moisture content ranging from 5 to 18 percent by weight. Similar drilling problems occurred near the bottom of this test hole from 1,400 feet (427 meters) to total depth in nonwelded to partially welded tuff of the tuffaceous beds of Calico Hills and the Prow Pass Member of the Crater Flat Tuff, both of Miocene age. The moisture content in these discontinuous zones generally was less than 5 percent by weight. The geologic units penetrated and the moisture content of these rocks are shown in Figure 4.

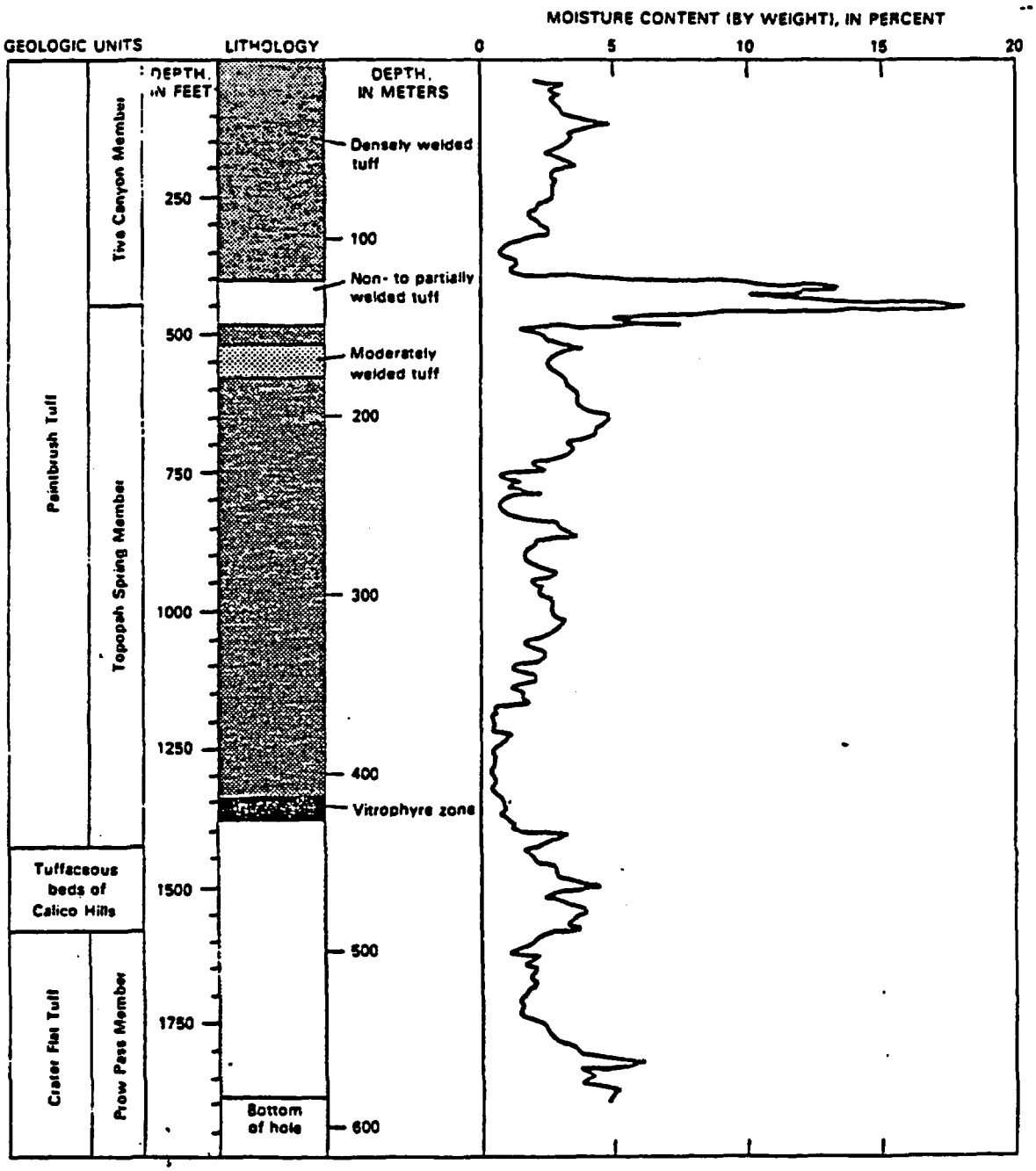


Figure 4. Geologic units, lithology, and moisture content of rocks penetrated in test hole USW UZ-6.

Conclusions

The reverse-vacuum drilling method is well suited for collecting hydrologic data from unsaturated rocks because it permits the drilling of rocks without appreciably changing their moisture content; the rock pores are not contaminated with any drilling fluids, and laboratory determinations of moisture content and hydrologic properties can be more accurately determined. In addition, this drilling method permits the immediate detection of moist or perched-water zones.

Major disadvantages of using the vacuum-reverse-air drilling method are that it requires more equipment and space than conventional rotary-drilling rigs. Drilling problems, such as caving of the borehole, also are quite common because no liquids are in the borehole to exert hydrostatic pressure on the walls of the hole, and the vacuuming action creates an inward suction of loose rocks. Extensively fractured zones create the largest drilling problems, and considerable time is required to remove caved material from the borehole.

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OVERVIEW OF DRY DRILLING SYSTEMS USED AT NTS

- REVERSE VACUUM ROTARY DRILLING
  - Used to drill USW UZ-1 17-1/2 inch hole to 1270'
  - Used to drill USW UZ-6 17-1/2 inch hole to 1887'

o USW UZ-1	Total Cost-To-Date	Cost/Foot
	$1,852,950	$1,459
o USW UZ-6	Total Cost-To-Date	Cost/Foot
	$1,972, 009	$1,021

- ODEX DRILLING/DRY AIR CORING
  - UE-25 UZ #4 — 6 inch hole to 367 feet
    $131,342 Total Cost — $358/foot
  - UE-25 UZ #5 — 6 inch hole to 365 feet
    $114,931 — $325/foot
  - USW UZ-6s — 8-11/32 inch hole to 494.5 feet
    3.990 inch hole to 519 feet
    $293,854 — $566/foot
  - USW UZ-7 — 6 inch hole to 207 feet
    $71,869 — $347/foot

- USW UZ-8 — 6 inch hole to 55 feet
  4.25 inch hole to 57 feet
  $106,163 — $1863/foot
  Hole not completed due to work stoppage

- USW UZ-13 — 6 inch hole to 417 feet
  3.937 inch hole to 430 feet
  $172,219 — $400/foot

- Neutron Access Holes - 76 Total Drilled
  6 inch hole to 43 feet (average depth)
  $619,203 Total Cost — $189/foot

COMMENTS:

- Reverse vacuum rotary drilling not a good method for cutting cores.

- 15 spot cores were attempted in UZ-1 using a Globe basket. One core was attempted using a Kore-King barrel and conventional air circulation. Globe basket core recovery was 67% and core was extremely hot when recovered.

- UZ-1 hole was terminated when Globe basket became stuck in a cement plug spotted to isolate drilling fluid from the G-1 hole.

- On UZ-6 hole extreme vibration caused drill pipe failures and plugging of the inner string. No cores were attempted.

- ODEX-drilled holes, casing failure and other problems occurred on the following holes:

- UZ #4 5-1/2 in. O.D. 7.3 ft. fish left in the hole at 231 feet.

- UZ #5 5-1/2 in. O.D. casing parted at 99 feet. Recovered fish and drilled to 365 feet. Left 2 feet of parted casing shoe in the hole.

- UZ-6s Bit backed off at 336 feet. Recovered bit. Drill pipe parted at 294 feet. Recovered fish. Lost fish in hole at 490 feet. Recovered fish. 7-5/8 in. casing parted at 253 feet. Recovered fish after fishing for 14 days.

- UZ-7 Hole completed at 207 feet. Hole bridged at 37 feet after pulling casing. Cleaned out bridge and completed hole at 201 feet. Hole bridged at 22 feet now.

- UZ-13 Casing parted at 147 feet. Casing stuck. Recovered casing. Lost bit in hole at 275 feet. Destroyed bit with explosive. Resumed drilling. Drill pipe parted at 276 feet. Recovered fish. Hole completed to 407 feet.

- Neutron Access Holes, 76 holes, average depth 43 feet.

  - These holes were drilled and cored at about one day per hole.
    No serious drilling problems occurred.

For DTH hammers							
ODEX 90 W/T	**COP 32** **A 30–15**	**W: max. O.D. 115** **min. I.D. 102** **min. wall thickness 5 mm** **T: 114.3 × 101.6 L.H. thread**	**4½** **4** **4½ × 4**	**76**	**(3)**	**123**	**(4 13/16)**
ODEX 115 W/T	**COP 42** **DHD 24** **DHD 340 A** **A 34–15**	**W: max. O.D. 142** **min. I.D. 128** **min. wall thickness 5 mm** **T: 140 × 128 L.H. thread**	**5 10/16** **5 1/16** **5½ × 5 1/16**	**76** **or** **89**	**(3)** **(3½)**	**152**	**(6)**
ODEX 140 W	**DHD 15** **DHD 350** **A 43–15**	**max. O.D. 171** **min. I.D. 157** **min. wall thickness 5 mm**	**6⅝** **6⅛**	**89** **or** **114**	**(3½)** **(4½)**	**187**	**(7⅜)**
ODEX 165 W	**COP 62** **DHD 16** **DHD 360** **A 53–15**	**max. O.D. 196** **min. I.D. 183** **min. wall thickness 5.5 mm**	**7⅝** **7⅛**	 **114**	 **(4½)**	 **212**	 **(8 11/32)**
ODEX 215 W	**DHD 380** **A 63–15**	**max. O.D. 257** **min. I.D. 241** **min. wall thickness 6 mm**	**10** **9½**	**114** **or** **140**	**(4½)** **(5½)**	**278**	**(10 15/16)**

***T = threaded casing tubes**
W = welded casing tubes

SATURATED ZONE STUDIES

John B. Czarnecki
U.S. Geological Survey

Dry-hole drilling required for:

1) Potentiometric-levels study (WT Holes)

2) Fortymile Wash Infiltration Study
(FM and FMN holes)

WATER-TABLE (WT) HOLES

Dry hole drilling required "... to eliminate contamination of gas and water samples to be sampled near the water table ..."

Re: dry coring and drilling -- usgs saturated-zone studies.
john czarnecki fts 776-5176
bill steinkampf fts 776-4939

well number	estimated well depth (m)	approx. length of core (m) uz	sz
<activity 8.3.1.2.3.2.2; WBS 1.2.3.3.3.G; steinkampf>			
USW WT-8	640	25	10
USW WT-9	670	--	5
USW WT-19	335	25	10
USW WT-20	305	25	10
USW WT-21	550	25	10
USW WT-22	395	--	5
USW WT-23	670	75 *	10
USW WT-24	670	--	5
<activity 8.3.1.2.1.3.3; WBS 1.2.3.3.4.G; czarnecki>			
UE-25 FM#1	350-370	3/15 **	30
UE-25 FM#2	300-320	3/15 **	30
UE-25 FM#3	260-275	3/15 **	30

* uncertain length of uz core from WT-23 derives from uncertainty as to water-table elevation.

** approximately 20 percent of unsaturated interval.

WATER-TABLE HOLES TO BE DRILLED (DRY?)

HOLE	APPROX. DEPTH (m)
USW WT-8	640
USW WT-9	670
UE-25 WT-19	335
UE-25 WT-20	305
UE-25 WT-21	550
USW WT-22	395
USW WT-23	670
USW WT-24	670

About 25 m of core will be collected at the UZ/SZ interface for gas and water sample extraction. It may be difficult to predict this interface within 10 m accuracy.

FORTYMILE WASH DRILLHOLES

FM SERIES

Three deep holes to water table

* Depths: 275, 320, and 370 m
* Core: 3 m/ 15 m (10 ft/ 50 ft)
* Diameter: 12.7 cm (6 in.)

FMN SERIES

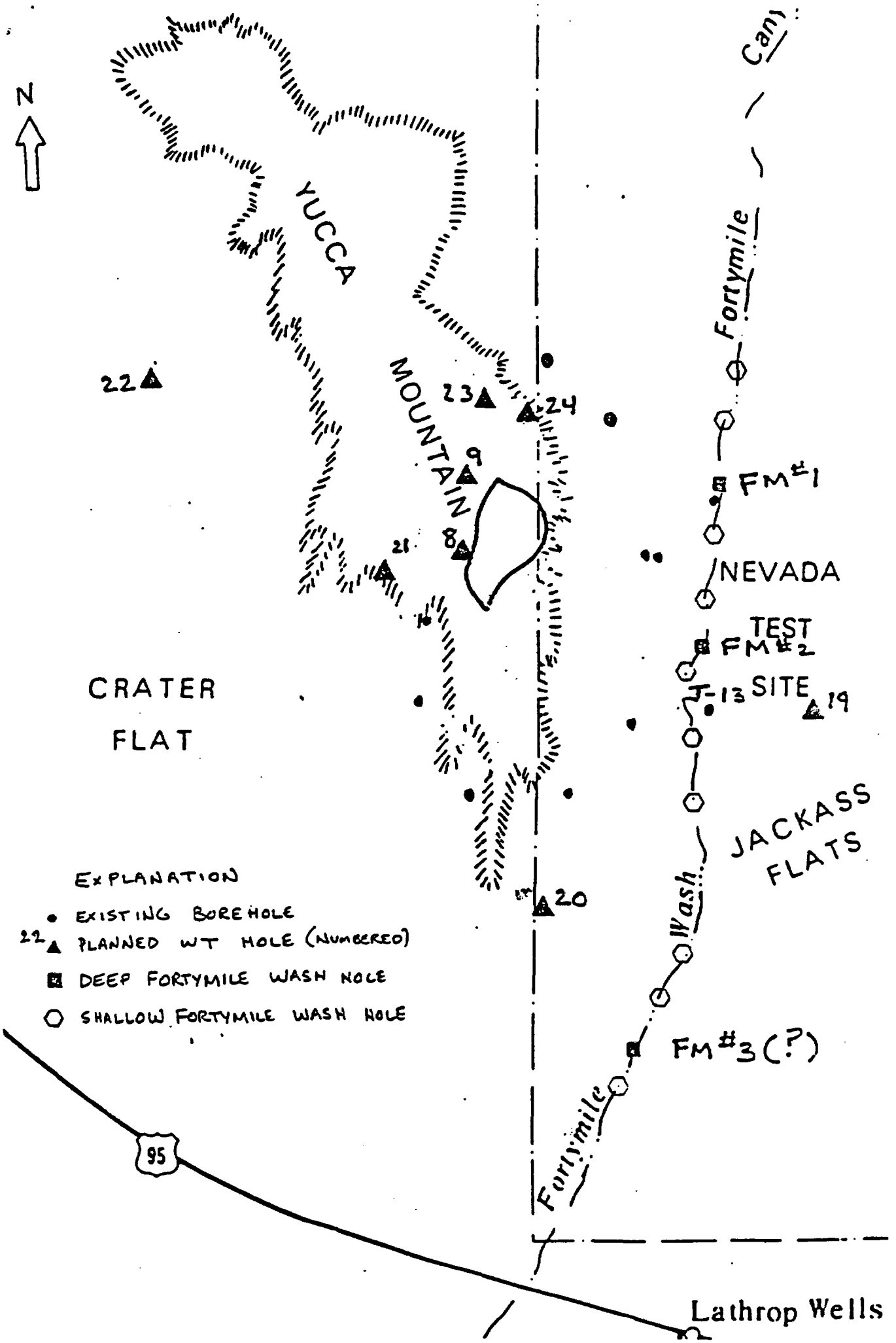
Neutron-access holes

* Ten holes up to 50 m deep
* Continuous core for bulk soil properties and hydrochemical samples

INFILTRATION TESTS

Flooding with LiBr tagged water from well J-13

Ponding/Infiltration tests at each FM hole and selected FMN holes


N
YUCCA
MOUNTAIN
CRATER
FLAT
22
23
24
9
8
21
20
19
J-13
Fortymile
Canyon
FM#1
NEVADA
TEST
SITE
FM#2
JACKASS
FLATS
Wash
FM#3(?)
Fortymile
95
Lathrop Wells
EXPLANATION
EXISTING BOREHOLE
22 PLANNED WT HOLE (NUMBERED)
DEEP FORTYMILE WASH HOLE
SHALLOW FORTYMILE WASH HOLE

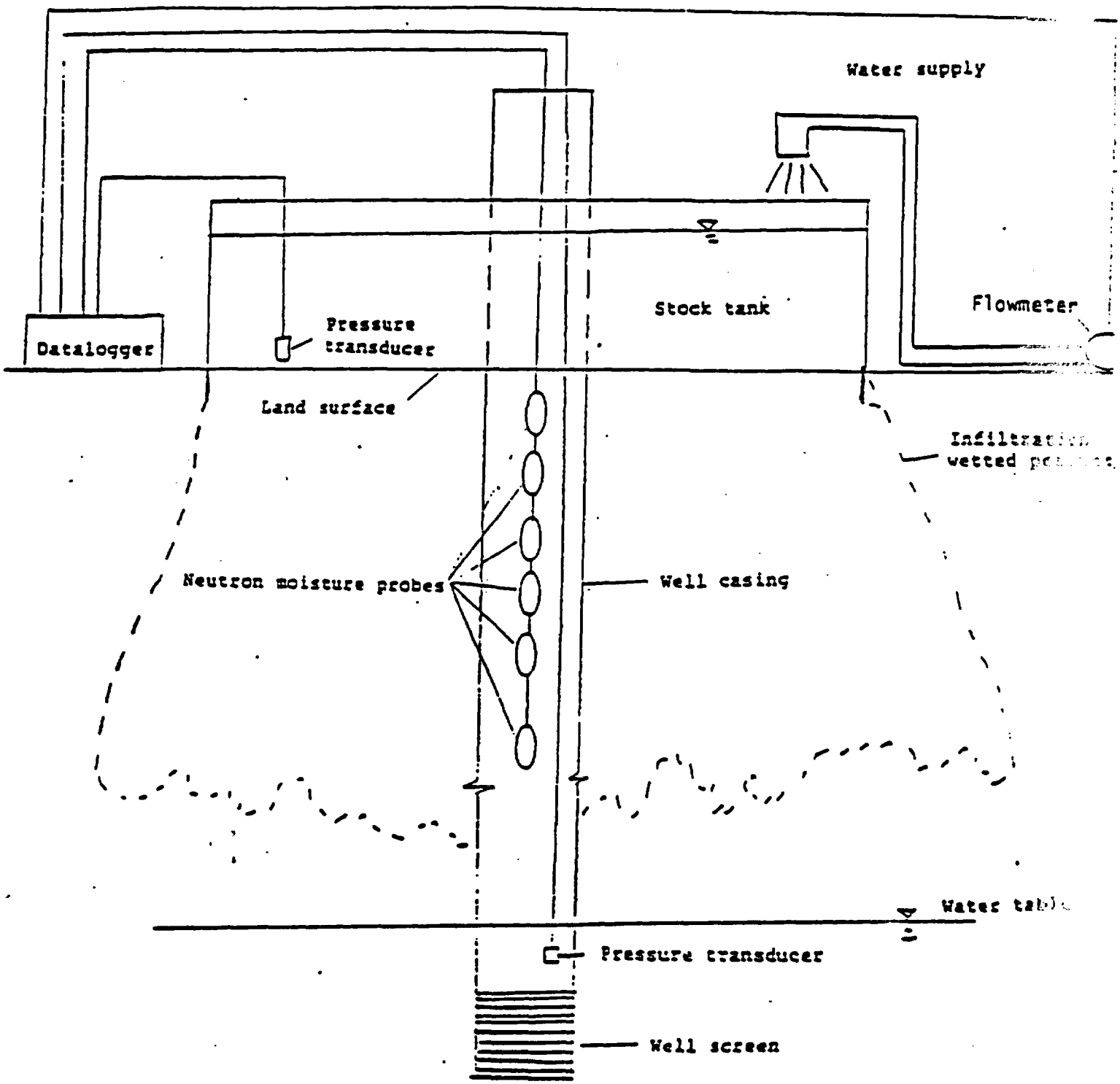


Figure 3-4 Ponding and infiltration experimental setup.

Los Alamos/NNWSI

Prototype Testing

Prototype Air Coring and Evaluation of Potential Dust-Related Hazards

Principal Investigators

J. M. Ray - ESS-1
J. Newsom - Drilling Consultant
B. Skaggs - HSE-5

PREVIOUS EXPERIENCE

FRAN RIDGE AIR CORING (1982-83)

Goals:

1) Air core two parallel horizontal holes 400 ft into Topopah Spring welded tuff at Fran Ridge

2) Conduct radionuclide transport tests between the two holes

Accomplishments:

1) Air cored 165 ft of hole before problems required air-mist and, finally, air, soap and water to be used to reach a final depth of 400 ft

Problems:

1) High bit wear

2) Drill string vibration

3) Core retrieval problems

4) Loss of circulation air

5) Sloughing of hole

6) Low core recovery rate (73%) and mechanical breakage

7) Occasionally stuck in hole

G-TUNNEL AIR CORING TEST OBJECTIVES

1. Validate air coring technology in fractured welded tuff.

2. Select, modify, and test dust collection system.

3. Evaluate health hazard potential from fugitive dust emissions.

4. Develop procedures for underground air coring.

5. Develop procedures for fugitive dust control underground.

6. Train drilling personnel in air coring/dust control operations.

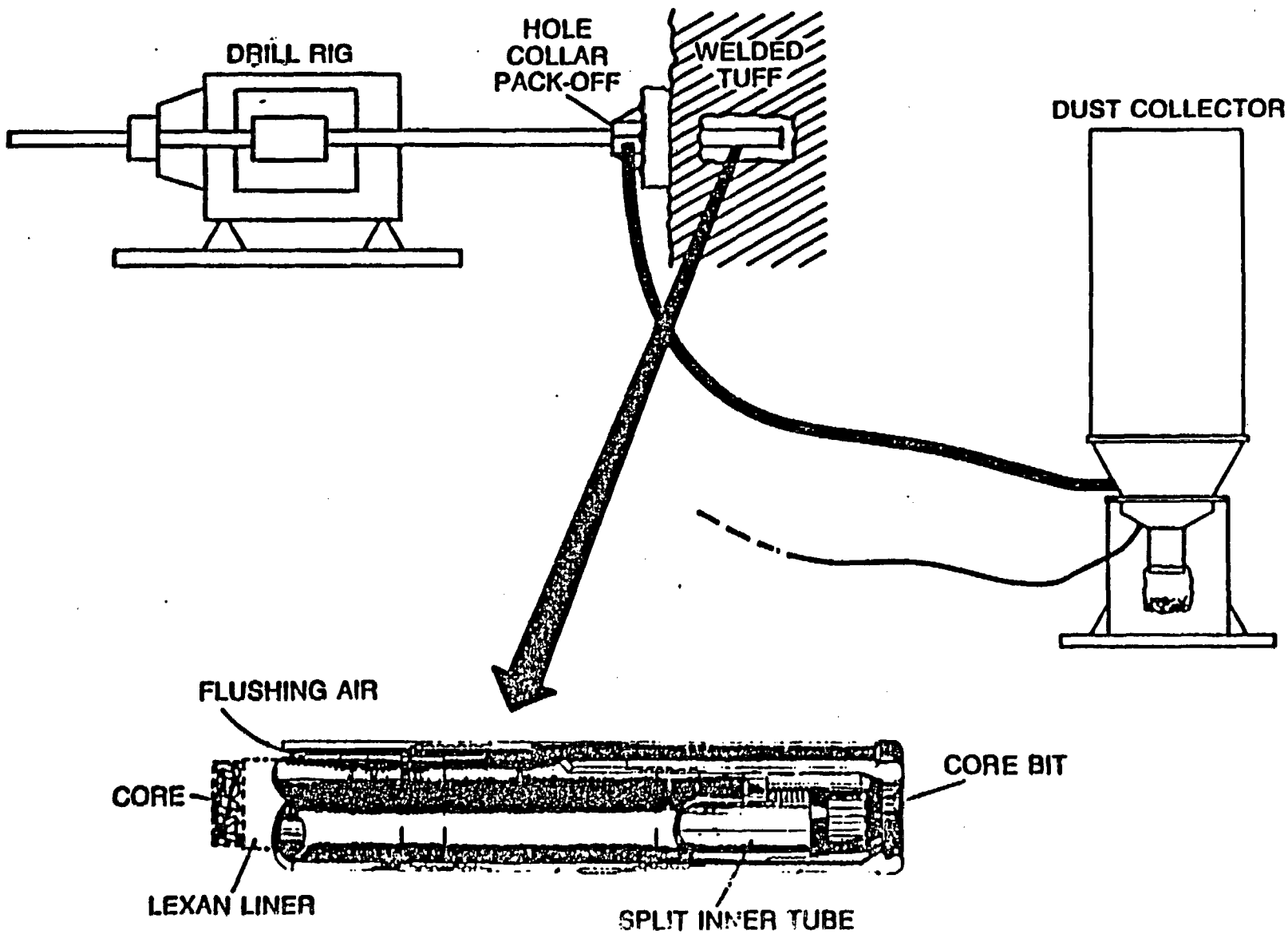
7. Provide air cored holes for others to use.

APPROACH

1. Air core 50 ft horizontal hole to check out dust collection equipment and procedures and measure fugitive dust emissions.

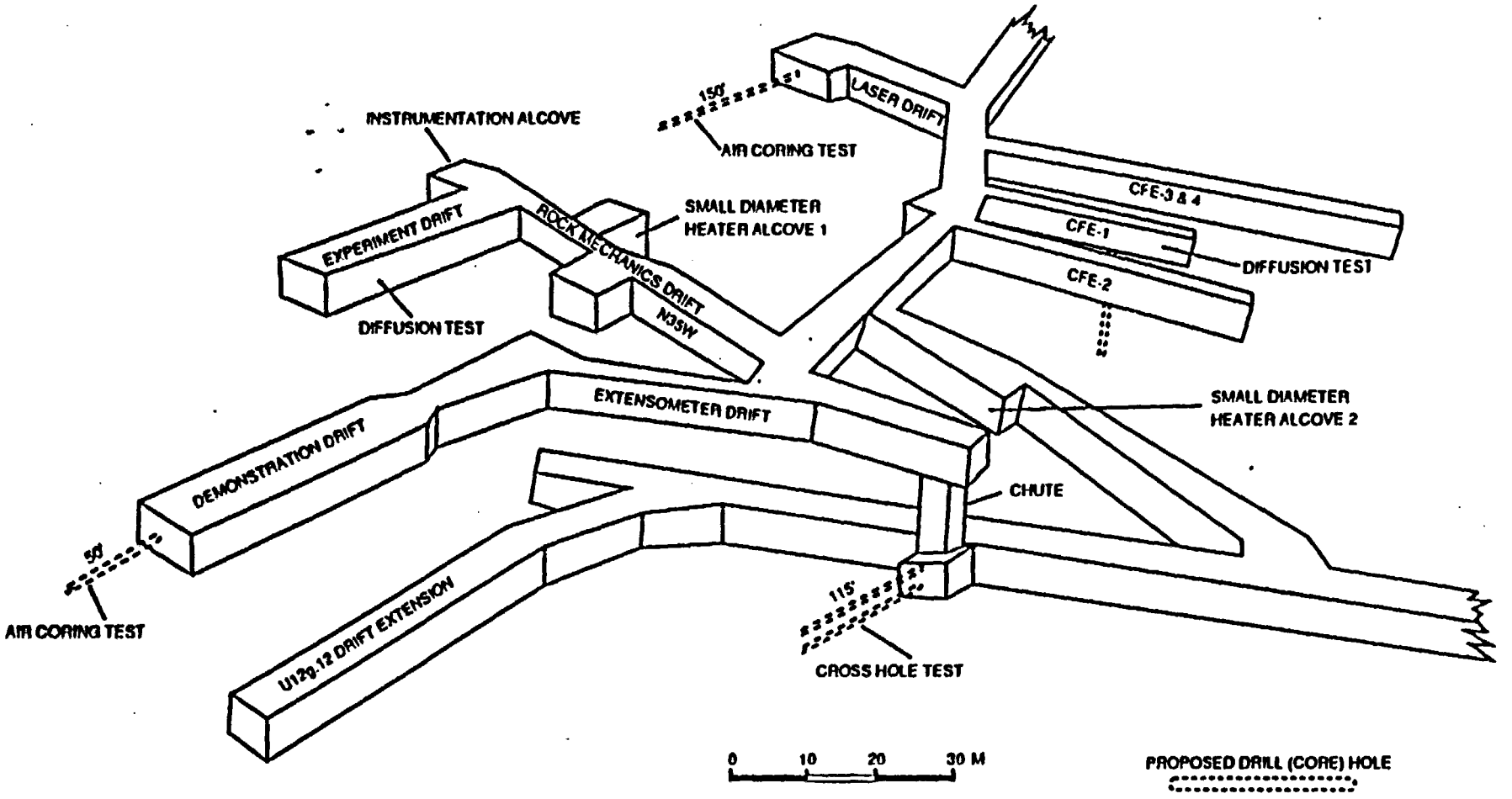
2. Air core 150 ft horizontal hole with express purpose of technology validation, methodology refinement, and procedures development.

EQUIPMENT CONFIGURATION



EQUIPMENT/OPERATING SPECIFICATIONS

- Longyear 38-electric over hydraulic power system
- Triple tube retrievable wireline coring method
- RPM - 60-120
- Air Pressure - 60-120 psi
- Air volume - 150-400 cfm
- Drill airflow monitoring system
- Bits - diamond impregnated bits with matrix and face design for optimum air circulation
- Optimally positioned stabilizers
- Lexan liners for core encapsulation
- Special design dust-tight collar pack-off and diverter



GTUF LOCATION OF AIR-CORED
HOLES EVALUATED IN THIS REPORT

PRELIMINARY TEST RESULTS

Rig

- Penetration rates (depending on fractures, bit condition, and formation encountered) - averaged 5 ft/hr
- Core recovery - ~97%
- Lexan liner - successfully used with minor field modification
- Bit life - ~~~50-90~~ ~100-160 AS NOW PREDICTED ft/bit
- Reaming shells - ~1 per each 3 bits used
- Air requirements in ESF - for normal dry air coring low pressure (120 psi) mine air is adequate

Dust Control Technique (DCT)

- Provides safe drilling environment
- Removal of 99.8% of all dust and cuttings
- Vacuum assists long hole drilling

ANTICIPATED FUTURE PROBLEMS
AND
POSSIBLE SOLUTIONS

Depth limitations due to cumulative air loss to fractures

Use optimal DCT/drilling system

Use ODEX-type system with casing advance

Possible hole instability at Yucca Mountain

Use dry air coring with ODEX-type system

Drill rod vibrations

Proper size and placement of stabilizers

Moisture in hole

Solution is dependent on amount of moisture

Failure of DCT filters

Seal DCT exhaust to mine exhaust ventilation

Bit failure

Use appropriate bit design

Hole deviation

Periodic surveys and proper selection of in-hole tools/drilling techniques

UPCOMING PROTOTYPE TESTS THAT REQUIRE AIR CORED HOLES

1) Cross-Hole Prototype Test Core Holes

2) Diffusion Test Core Holes

3) Wet versus Dry Prototype Test Holes

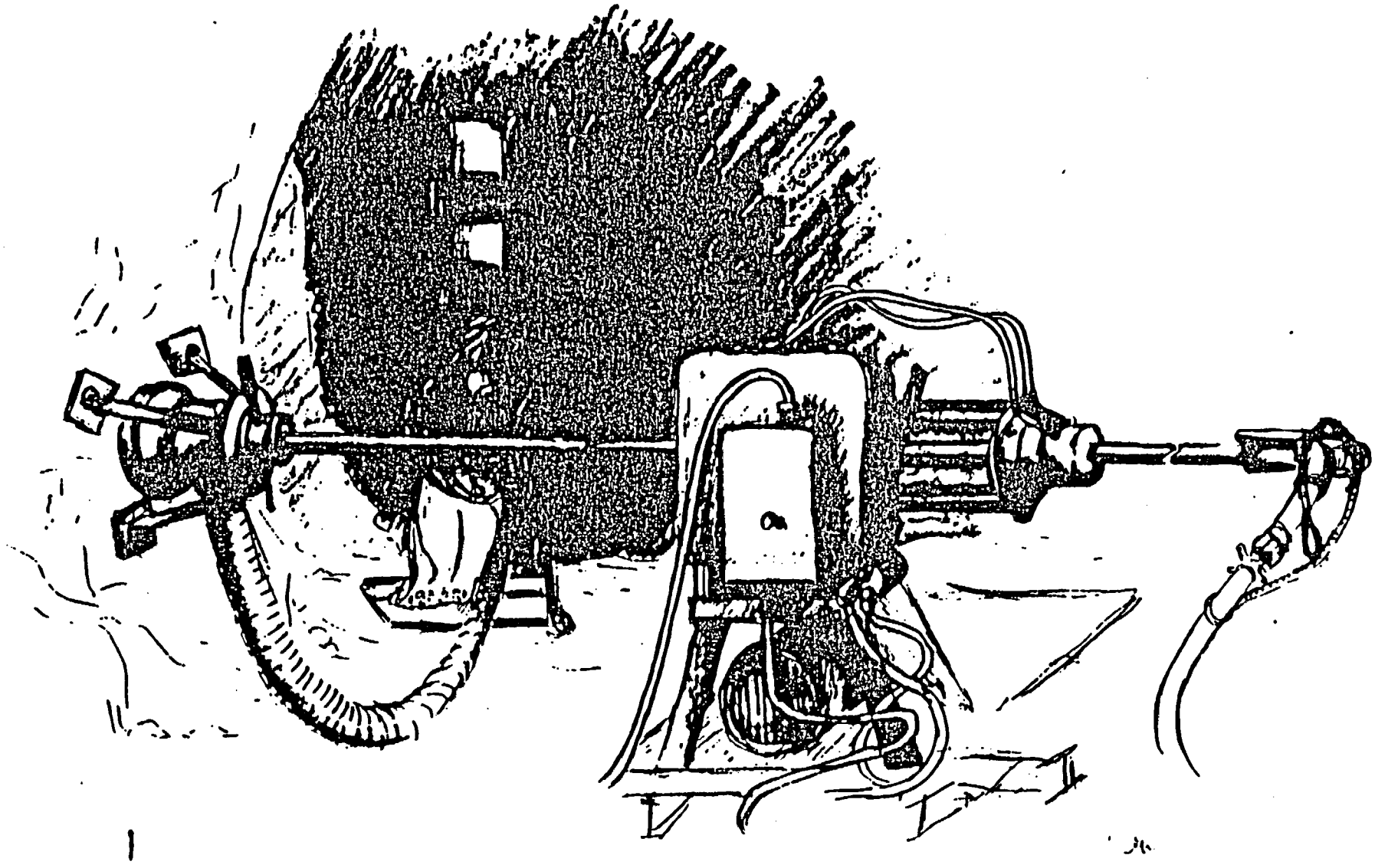
PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

- Underground coring using dry air can be performed while providing health protection by utilization of appropriate work practices, engineering, and administrative controls.

- Horizontal air coring in fractured welded tuff (to at least 150 ft) can be accomplished by proper selection, integration, and minor modification of standard drilling equipment, using appropriate procedures and engineering controls.

- Prototype test of air coring in shaft-size space should be conducted prior to ES construction

- Long (150+ ft) horizontal air cored hole in Topopah Spring welded tuff should be considered prior to in situ testing in ESF



MATRIX OF HOLE-TYPE AND FOOTAGE

	HORIZ	VERT	ANG	TBD	TOTAL
DRY CORED	13 / 760	10 / 254	2 / 100	40 / 160	65 / 1274
DRY BORED	0 / 0	0 / 0	0 / 0	10 / 40	10 / 40
DRY PERCUSSED	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
TOTAL	13 / 760	10 / 254	2 / 100	50 / 200	75 / 1314

TOTAL DRY FOOTAGE

	HORIZ	VERT	ANG	TBD	TOTAL
WET CORED	2 / 60	0 / 0	14 / 386	0 / 0	16 / 446
WET BORED	14 / 143	14 / 143	24 / 240	0 / 0	52 / 526
WET PERCUSSED	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
TOTAL	16 / 203	14 / 143	38 / 626	0 / 0	68 / 972

TOTAL WET FOOTAGE

ORIENTATION	HORIZ	VERT	ANG	TBD	TOTAL
TOTAL	29 / 963	24 / 397	40 / 726	50 / 200	143 / 2286

TOTAL HOLES CORED =	81	TOTAL FOOTAGE CORED =	1720
TOTAL HOLES BORED =	62	TOTAL FOOTAGE BORED =	566
TOTAL HOLES PERCUSSED =	0	TOTAL FOOTAGE PERCUSSED =	0
TOTAL HOLES =	143	TOTAL FOOTAGE =	2286

SAMPLE MATRIX

NO. OF HOLES / FOOTAGE

Rev. Date 5/27/88

Fig. 1. Hole types and respective total footages (rounded to nearest foot) for drill holes required by PIs for funded prototype tests.

SURFACE BASED INVESTIGATIONS

UNSATURATED ZONE DRILLING

1) Neutron boreholes (ODEX)

2) deep UZ boreholes ✓

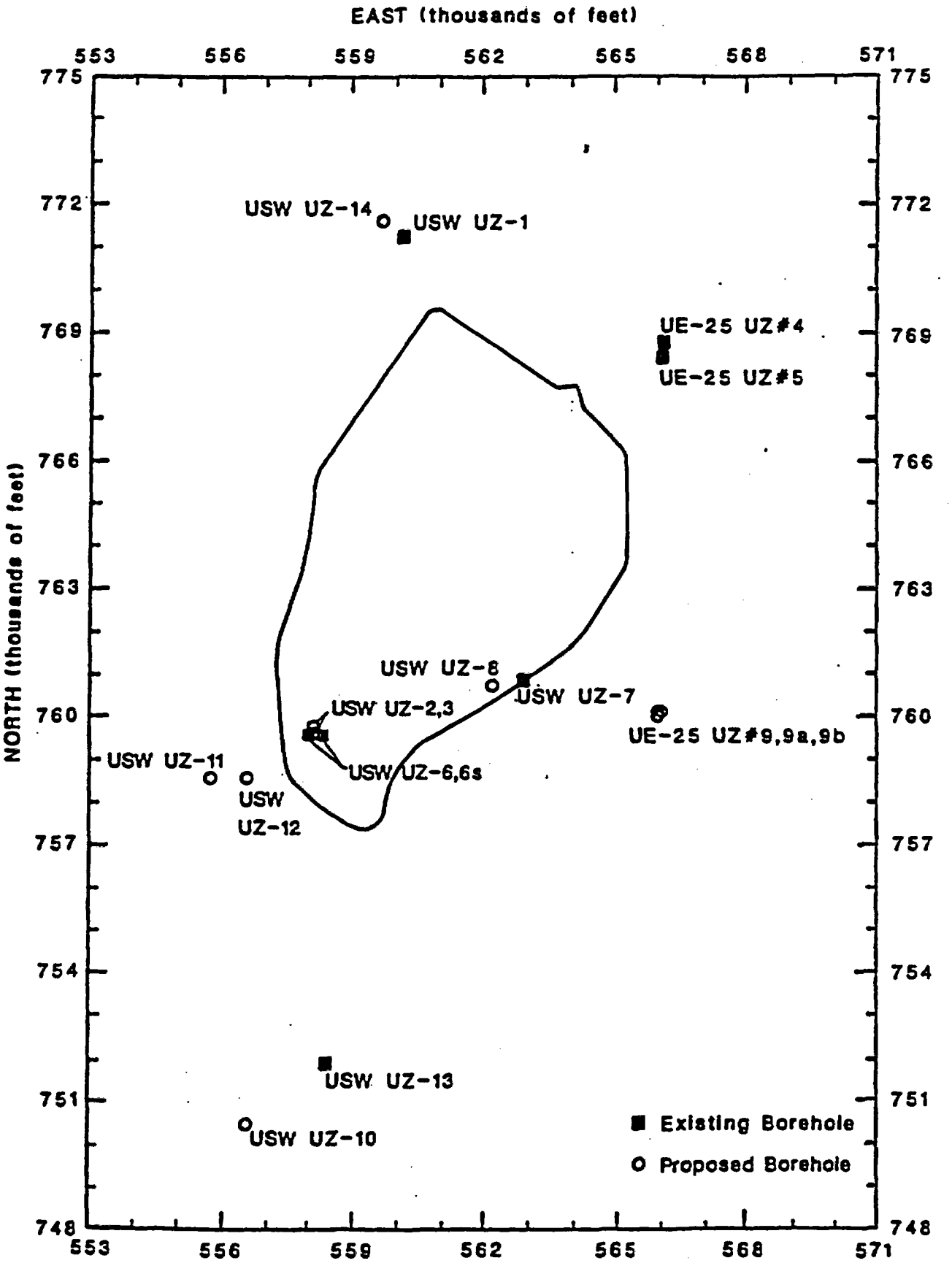
DEEP UZ BOREHOLES

SUMMARY STATS

• number required	17 - 19*
• total footage	18,500 - 22,500 ft**
• existing footage	5000 ft (27-22%)
• maximum depth	2500 ft
• diameter	6"/12"
• locations	(see map)

* includes provision for 2 Vertical Seismic Profiling Boreholes (prototype BH used for VSP)

** total footage could be as high as 37,000 ft if decision is made to extend all boreholes thru Calico Hills unit to the water table.



Map of Existing and Proposed Borehole Locations, Yucca Mountain, Nevada.

APPLICATION

DEEP UZ BOREHOLES

1) CORE & CUTTINGS

- geology / mineralogy / petrology
- matrix hydrologic properties
- physical rock properties
- hydrochemistry - age dating
  - Cl^{36} (50 lbs per sample)
  - pore water squeezing (2.37" diameter core)

APPLICATION
DEEP UZ BOREHOLES

2) BOREHOLE

- geophysical logging (6"ø)
- air permeability testing (6"ø)
- in situ monitoring (12"ø)
  - pressure, temp, water potential
- shut-in pressure testing (6"ø)
- gas-sampling - hydrochemistry (12"ø)
- water injection testing (12"ø)
- gas tracer diffusion testing (12"ø)

BOREHOLE DIAMETER REQUIREMENTS

6" ϕ

- maximize quality of GP logs
- facilitate placement and seating of straddle packer assembly
- minimize impact of borehole skin effects on air permeability testing
- maximize stability of borehole for in-hole testing

BOREHOLE DIAMETER REQUIREMENTS

12" ϕ

- provide sufficient space to install downhole sensors
  - pressure transducers
  - thermocouple psychrometers
  - heat dissipation probes
  - thermistors
  - solenoid valves
  - electrical cable
  - teflon tubing
  - sensor screens
  - central support rod
- facilitate placement of grout and stemming materials to isolate individual instrument stations
- minimize equilibration times

BOREHOLE DRILLING SPECIFICATIONS

- CORING
  - CONTINUOUS IN NON to partially welded UNITS
  - 5 ft (2 ft) core every 10 feet IN welded UNITS
- DRY DRILLED & CORED
- 6 inch diameter to support
  - GP logging
  - AIR K testing
  - SHUT IN PRESSURE TESTING
- REAM (ENLARGE) TO 12 inch diameter to support
  - IN SITU INSTRUMENTATION/STEMMING
  - other tests identified under Borehole applications
- CLEAN BOREHOLE WALLS PRIOR TO AIR K TESTING

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LOS ALAMOS GEOCHEMISTRY
SCIENTIFIC NEEDS

U.S. DOE WORKSHOP ON DRY DRILLING AND CORING TECHNOLOGY

SCIENTIFIC NEEDS OF LOS ALAMOS NATIONAL LABORATORY GEOCHEMICAL WORK

A. E. NORRIS

LAS VEGAS, NEVADA
JULY 26, 1988

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LOS ALAMOS GEOCHEMISTRY SCIENTIFIC NEEDS

1. MINERALOGY–PETROLOGY TASK

GELS IN FRACTURES OBSERVABLE ONLY WITH DRY DRILLING

CORE LOGGING SHOULD NOTE PRESENCE OF GELS IN FRACTURES. S. LEVY SHOULD BE NOTIFIED

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LOS ALAMOS GEOCHEMISTRY SCIENTIFIC NEEDS

2. NATURAL ISOTOPE CHEMISTRY TASK

^{36}CL: USEFUL WATER TRACER IN UNSATURATED ZONE

COSMOGENIC ORIGIN

300,000 YEAR HALF-LIFE

WATER SOLUBLE; DRY DRILLING REQUIRED

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LOS ALAMOS GEOCHEMISTRY SCIENTIFIC NEEDS

2. ^{36}CL (CONTINUED)

SAMPLE SIZE: ~50 LBS/ANALYSIS

SAMPLE FORM: CUTTINGS OR CORE

SAMPLING FREQUENCY: VARIABLE, DEPENDING ON STRATIGRAPHY

ADDITIONAL DATA: STRATIGRAPHY; DEPTH WHERE SAMPLE COLLECTED

EXAMPLES: ES SAMPLING INTERVALS; UZ-1 DATA

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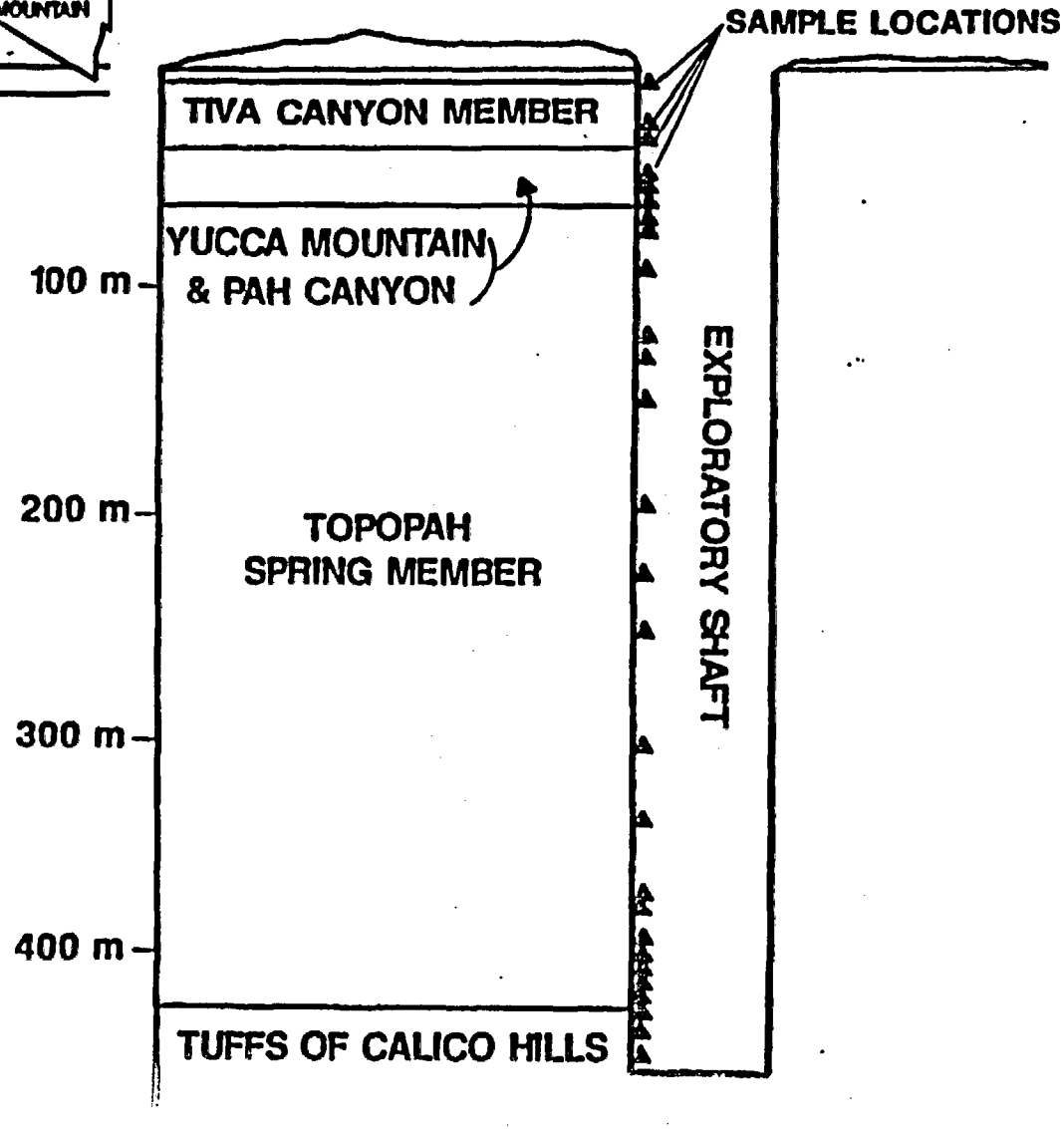
LOS ALAMOS GEOCHEMISTRY SCIENTIFIC NEEDS



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LOS ALAMOS GEOCHEMISTRY SCIENTIFIC NEEDS

UZ-1 DATA

DEPTH (feet)	$^{36}Cl/Cl$
170-176	$(2498 \pm 198) \times 10^{-15}$
395-400	$(390 \pm 48) \times 10^{-15}$

COSMOGENIC BACKGROUND (YW-6 AND ES DATA) 519×10^{-15}

INFERENCE: FIRST SAMPLE CONTAMINATED WITH BOMB PULSE ^{36}CL, PROBABLY TRANSPORTED BY INITIAL DRILLING FLUID

RECOMMENDATIONS: USE NO WATER FOR DRILLING; ARCHIVE MORE SAMPLES THAN DONE FOR UZ-1