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RESULTS OF EXPLORATORY DRILL HOLE UE7nS EAST-CENTRAL YUCCA FLAT, NEVADA TEST SITE

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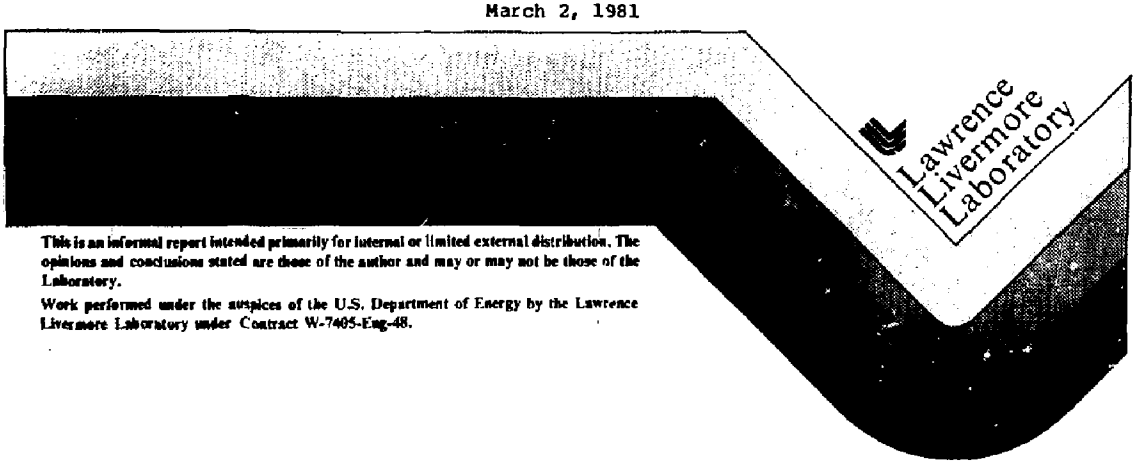

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EAST-CENTRAL YUCCA FLAT, NEVADA TEST SITE

ABSTRACT

Exploratory hole UE7nS was drilled to a depth of 672.1 m in East-Central Yucca Flat, Nevada Test Site, as part of a program sponsored by the Nuclear Monitoring Office (NMO) of the Advanced Research Projects Agency (ARPA). The purpose of the program is to determine the geologic and geophysical characteristics of selected locations that have demonstrated anomalous seismic signals. The purpose for drilling UE7nS was to provide the aforementioned data for emplacement site U7n. This report presents lithologic and stratigraphic descriptions, geophysical logs, physical properties, and water table measurements. An analysis of these data has been made and a set of recommended values is presented.

INTRODUCTION

Exploratory hole UE7nS was drilled as part of a program sponsored by the ARPA NMO to determine the geologic and geophysical characteristics of selected emplacement sites that have demonstrated anomalous seismic signals. It was located 137.1 m southwest of the site of the BOURBON event, which was a low to intermediate yield device detonated on January 20, 1967 in emplacement hole U7n. The BOURBON event was conducted prior to the increased emphasis on obtaining geologic data. About the only geologic information regarding the BOURBON emplacement hole was that the working point was in impure limestone above the water table. Interpretations of regional and teleseismic data indicated that the test was more characteristic of the seismic coupling of dry alluvium or tuff than of a hardrock environment.

The UE7nS hole was drilled to obtain additional physical properties for use in a reevaluation of the BOURBON seismic anomaly.

The seismic travel times recorded for the BOURBON event were initially questioned by R. Blandford of the Seismic Data Laboratory in Alexandria, Virginia. While plotting travel times (arrival time minus origin time) for

20 Yucca Flat nuclear events, he observed that the BOURBON signals disagreed with the others. The data were collected from long-range seismic monitoring stations at teleseismic distances (2000 km or greater) from the Nevada Test Site. The most significant variation of arrival times was evidenced in comparison with the LAMPBLACK event (U7i), located 1.6 km southwest of BOURBON at a similar depth of burial in tuff. Arrival times at both the Mina, Nevada and Kanab, Utah stations were more than 1 s apart for the two events. It is hypothesized that an error occurred in recording the origin time, or that the geologic environment at BOURBON was responsible.

LOCATION

Drill hole UE7nS is located in Northern Area 7, NTS at Nevada state coordinates: N 260 787.4 m; E 211 440.2 m. It is 137.2 m S45E of the U7n site. Ground elevation is 1331.9 m above mean sea level and total drill hole depth is 672.1 m (Fig. 1).

SUMMARY DRILLING HISTORY

Exploratory hole UE7nS was planned to penetrate several hundred meters of Paleozoic rock and to be of sufficient diameter to accept the U.S. Geological Survey (USGS) borehole gravimeter. The specific objective was to measure the large-scale porosity of the Paleozoic section, thereby geophysically characterizing the U7n, BOURBON site.

The hole was completed to a depth of 672.1 m using a 0.27 m bit, while 0.19-m casing was set to a depth of 670.2 m. Slotted casing was installed in the lowermost 62 m. (Appendix A details the drilling history.)

LITHOLOGIC SAMPLES

Standard cuttings were taken from surface to total depth, excepting the cored intervals. A coring history and core descriptions are presented in Tables 1 and 2. Sidewall samples were taken from 82.3 to 502.9 m.

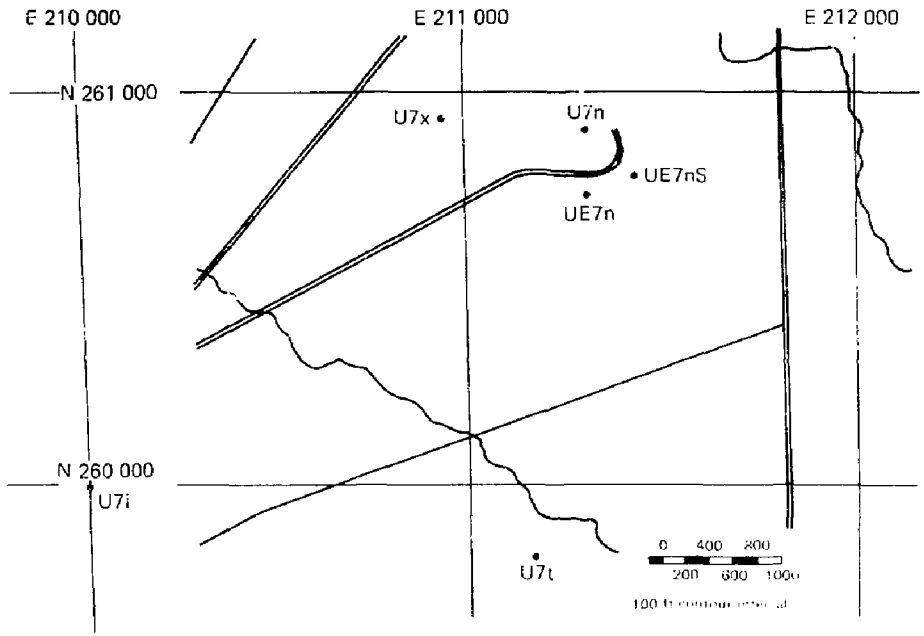

FIG. 1. Location of U7n, UE7nS and holes.

TABLE 1. Cored intervals and geologic descriptions.

Core No.	Depth (m)	Recovery (m)	Recovery (%)
1	507.8-509.6	1.8	100
2	525.5-527.3	0.9	50
3	548.0-550.8	2.8	100
4	563.3-565.1	1.8	100
5	578.5-581.6	3.1	100
6	593.7-595.6	1.4	75
7	609.0-612.0	3.0	100
8	624.2-627.3	3.1	100
9	643.1-646.2	3.1	100
10	654.7-657.7	3.0	100
11	667.5-670.5	3.0	100

TABLE 2. Core descriptions.

Run No.	Depth (m)	Description
1	507.8-509.6	Limestone, medium gray with bands (25-50 mm) of varicolored siltstone, bedding planes are locally clay-filled and dip about 55°, zone partially-to-highly brecciated.
2	525.5-527.3	Limestone, medium gray, highly brecciated, fractures controlled by bedding plane.
3	548.0-550.8	Limestone, medium gray to blue gray, locally banded and partially brecciated, indistinct bedding planes dip about 45°.
4	563.3-565.1	Limestone, medium gray, some varicolored filler in bedding planes, 50% of core is shattered, remaining segments are 40 to 150 mm long.
5	578.5-581.6	Limestone, medium gray, silty with varicolored filler in bedding planes, dense, slightly marbled, fractures average 1 per 0.3 m.
6	593.7-595.6	593.7-594.0 Limestone, dark gray, bedding planes have yellow-brown, silty filler. 594.0-595.0 Shale, yellowish tan, carbonaceous, highly fractured, reddish stain on fractures (fault zone). 595.0-595.6 Limestone, brown and gray, mottled with recrystallized calcite and limonite pseudomorphs.
7	609.0-612.0	Limestone, gray with brown clayey silt inclusions, most fractures healed with slightly irregular, crystallized calcite, indistinct bedding planes dip about 45°.
8	624.2-627.3	Limestone, reddish gray, clayey secondary calcite in fractures and brecciated zones, locally vuggy, indistinct bedding planes dip about 50°.
9	643.1-646.2	Shale, light to dark gray, highly calcareous, interbedded with silty limestone, mottled, common veinlets of secondary calcite.
10	654.7-657.7	Limestone, reddish gray, upper 1.8 m intact, lower 1.3 m fractured, partly rehealed with secondary calcite, prominent, tight, 60° joint pattern.
11	667.5-670.5	Limestone, reddish gray, massive, relic brecciation completely healed with reddish (iron stained?) calcite, fractures probably drill-induced.

GEOPHYSICAL LOGGING

Twenty-five runs were made with various logging tools between July 7 and July 14, 1976. The USGS ran its small-hole gravimeter on August 9, 1976. Table 3 summarizes these logs. Figure 2 is a standard plot of log and sample data used for containment evaluation.

CALIPER LOG

The caliper log shows the borehole to be relatively "in-gauge" throughout both the 0.44-m and 0.27-m-diameter drill bit segments. One exception is noted between drill depths 495 and 505 m (Fig. 2). This interval represents the basal 8 m of the tuff section and the uppermost 2 m of the carbonate section. This rugose zone is often found at the tuff/Paleozoic contact where the basal, less competent tuff overlies the weathered carbonate surface.

DENSITY LOG

Two density log runs (1-2 and 3-4) were made and each required logging the 0.44-m and 0.27-m sections of the hole separately. Computer corrections for proximity have been made and the end product shows the same general values as those derived from the USGS gravimeter run. The log plot (Fig. 2) depicts the gravimeter trace superimposed over the dual proximity log for visual comparison.

SONIC VELOCITY LOGS

Quality of the velocity logs is good but not highly definitive due to the highly fractured and variable dip conditions encountered within the carbonate section. Three types of velocity measurements were made: wet sonic, dry-hole sonic, and seismic. Agreement among these three methods is generally good and reflects the normal results obtained under these conditions. Sound speed in the basal tuff section averages 3500 m/s, compared to 5000 m/s in the carbonate section (Fig. 2).

SEISVIEWER

The Birdwell seisviewer is an instrument that incorporates a scanning transducer to record irregularities in the borehole. The log shows an abundance of fractures and bedding planes in the carbonate rocks. The average

TABLE 3. Geophysical logs, UE7n-S.

Log	Run date	Run No.	Logger	Interval top-bottom (m)
Velocity				
Three-dimensional sonic velocity, 12-ft spacing	7/8/76	1	Birdwell	600-667
Dry-hole acoustic log (DHAL)	7/12/76	1	Birdwell	495-597
Vibroseis	7/10/76	1	Birdwell	91-669
Three-dimensional sonic velocity, 6-ft spacing	7/8/76	2	Birdwell	600-668
Three-dimensional sonic velocity, 3-ft spacing	7/9/76	3	Birdwell	594-669
Three-dimensional sonic velocity, 3-ft spacing	7/9/76	4	Birdwell	594-669
Density				
Density--dual proximity	7/8/76	1	Birdwell	7-668
Borehole gravimeter	8/9/76	1	USGS	387-662
Density--dual proximity	7/8/76	2	Birdwell	7-668
Density--single proximity	7/10/76	3	Birdwell	15-670
Density--single proximity	7/10/76	4	Birdwell	15-670
Other scientific logs				
Electric log--induction	7/8/76	1	Birdwell	24-668
Electric log	7/9/76	1	Birdwell	594-670
Continuous dipmeter	7/9/76	1	Schlumberger	579-670
Epithermal--neutron	7/10/76	1	Birdwell	15-497
Epithermal--neutron	7/10/76	2	Birdwell	497-670
Gamma ray--neutron	7/11/76	1	Birdwell	0-670
Borehole magnetometer	7/12/76	1	LLL	27-669
Seisviewer	7/12/76	1	Birdwell	607-670

TABLE 3. (Continued.)

Log	Run date	Run No.	Logger	Interval top-bottom (m)
Construction logs				
Caliper log	7/8/76	1	Birdwell	0-670
Fluid density	7/7/76	1	Birdwell	631-649
Fluid density	7/12/76	2	Birdwell	594-616
Nuclear annulus investigation log	7/13/76	1	Birdwell	457-479
Nuclear cement top locator	7/13/76	1-3	Birdwell	474-520
Nuclear cement top locator	7/13/76	4-6	Birdwell	3-482
Nuclear cement top locator	7/14/76	7	Birdwell	1.5-519

dip computed from this log is 41° SW, which is compatible with measurements made on oriented core samples. Birdwell interpretations are presented in Appendix B.

BOREHOLE GRAVIMETER

In August 1976, a borehole gravity survey was conducted by the USGS. The objective was to determine in situ formation densities, utilizing an instrument not affected by casing, borehole irregularity, and other borehole conditions.[1] Borehole gravity stations (Appendix C) were chosen to enable determination of limestone density, and also the density contrast between the tuff and limestone. The calculated densities were not corrected for nearby structure.

1. J. W. Schmoker and B. A. Kososki, Principal Facts for Borehole Gravity Stations in Test Wells UE 19j,UE7nS and UE5n, Nevada Test Site, Nye Co., Nevada (1978) (USGS Open File Report 78-212).

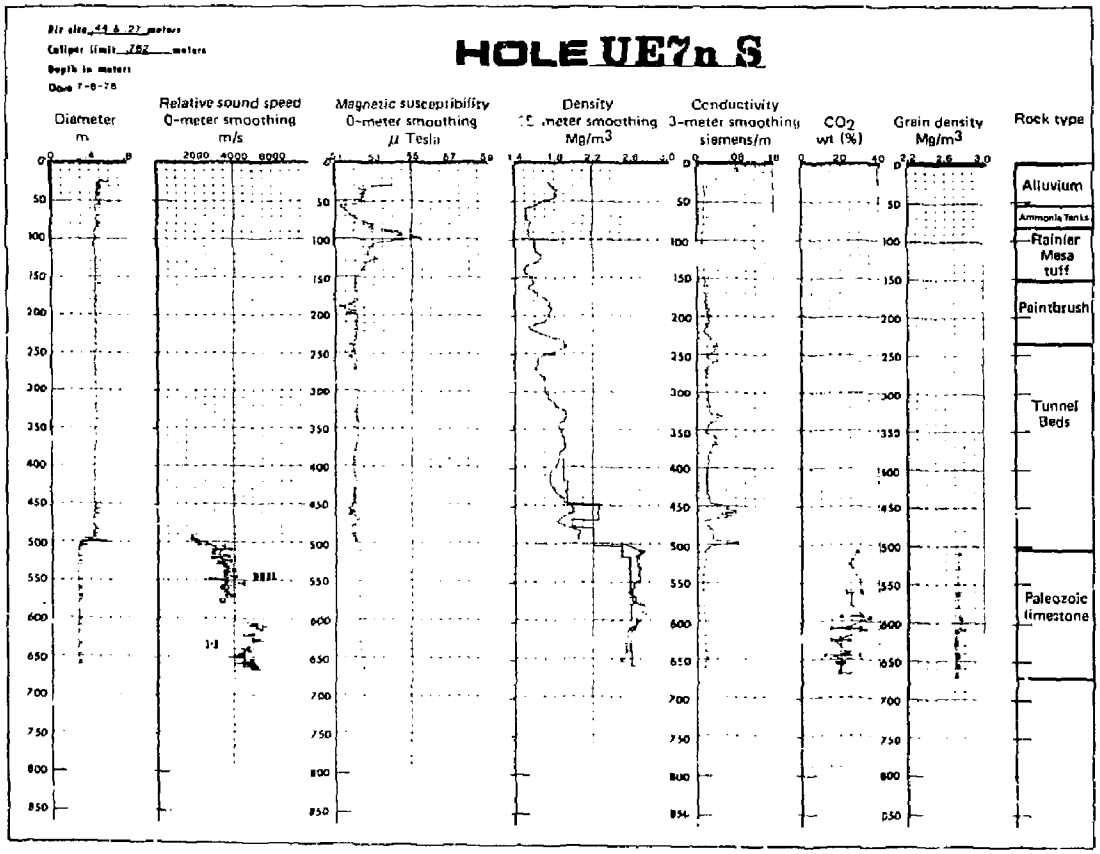

FIG. 2. Plot of sample and geophysical log data from UE7nS.

LITHOGRAPHY AND STRATIGRAPHY

Table 4 is a lithologic log of drill hole UE7nS. The stratigraphic correlation of drill holes U7n and UE7nS is depicted in Figs. 3 and 4. The stratigraphic sequence in the tuffs is essentially the same at both locations.

STRUCTURE

A possible thrust fault was suggested by F. M. Byers[2] at a depth of 594 m in UE7nS (Figs. 3 and 4). At this depth, a zone of highly brecciated and altered rock (silty limestone) separates the overlying Ranger Mountain member of the Ordovician Pogonip Group from the younger Aysees (?) member. Paleontologic[3] studies confirm the presence of the Ranger Mountain member. Physical properties of the two members appear quite similar from geophysical logs and laboratory sample analysis.

The tuff/Paleozoic contact slopes about 16° from UE7nS to U7n. The regional dip of the Paleozoic sedimentary rocks has been determined by core and dipmeter measurements to be 45° to the southwest, which dip is normal to the southeast bearing between U7n and UE7nS. The sloping contact of the tuff and older rocks is attributed to erosion. Because the bearing of the holes is normal for the dip of the Paleozoic rocks, the correlation of carbonate units is assumed to be horizontal between the holes.

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2. F. M. Byers, USGS, Denver, Colo., private communication (Feb. 22, 1977).
3. F. M. Byers, USGS, Denver, Colo., private communication (Mar. 6, 1978).

TABLE 4. Lithologic log of exploratory hole UE7nS.

Depth (m)	Description
0-54.0	Alluvium, light to medium brown, cuttings generally tuffaceous clasts with less than 25% Paleozoic silicates and carbonates, slight to moderate caliche coating on clasts.
54.0-83.8	Timber Mountain tuff, Ammonia Tanks member, medium pink-brown to gray-brown ash-flow tuff, non- to slightly welded, common sanidine, quartz, and biotite, locally moderately calcareous.
83.8-150.8	Timber Mountain tuff, Rainier Mesa member, light pink-brown to gray ash flow tuff, slightly welded, common sanidine, biotite, and quartz phenocrysts, changes through basal 9 m to pale gray, glassy shard zone.
150.8-238.0	Paintbrush tuff, light gray to brown, reworked and bedded tuff, common biotite, rare to common volcanic lithics, mafic zone between 184.0-19.0 m, partially zeolitized throughout entire unit.
238.0-502.9	Tunnel Beds and older ash flow and ash fall units, light gray to medium brown, partially zeolitized, possible Crater Flat ash flow from 418.0-447.0 m, local argillic alteration from 448.0-466.0 m and 497.0-502.9 m, possible prevolcanic colluvium at base of unit.
502.9-594.0	Pogonip Limestone, Ranger Mountain member, medium-gray, brecciated, reddish-brown to yellow, clay-filled seams and bedding planes.
594.0-666.0	Pogonip Limestone, Aysees member(?), limey shale between 594-595 m, highly shattered with reddish staining, interval generally mottled, reddish-gray, recrystallized limestone with occasional shale or silty interbeds.
666.0-672.1	Pogonip Limestone, Ranger Mountain member, gray, fractured, local brecciated zones of reddish-gray argillaceous material.

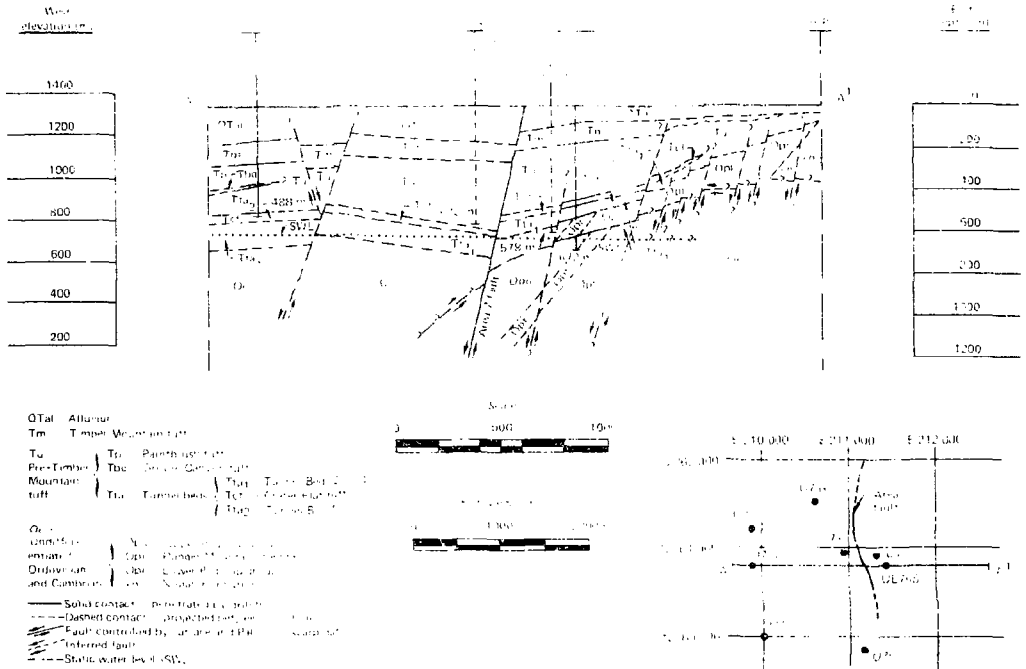

FIG. 3. East-west [illegible] UE7nS.

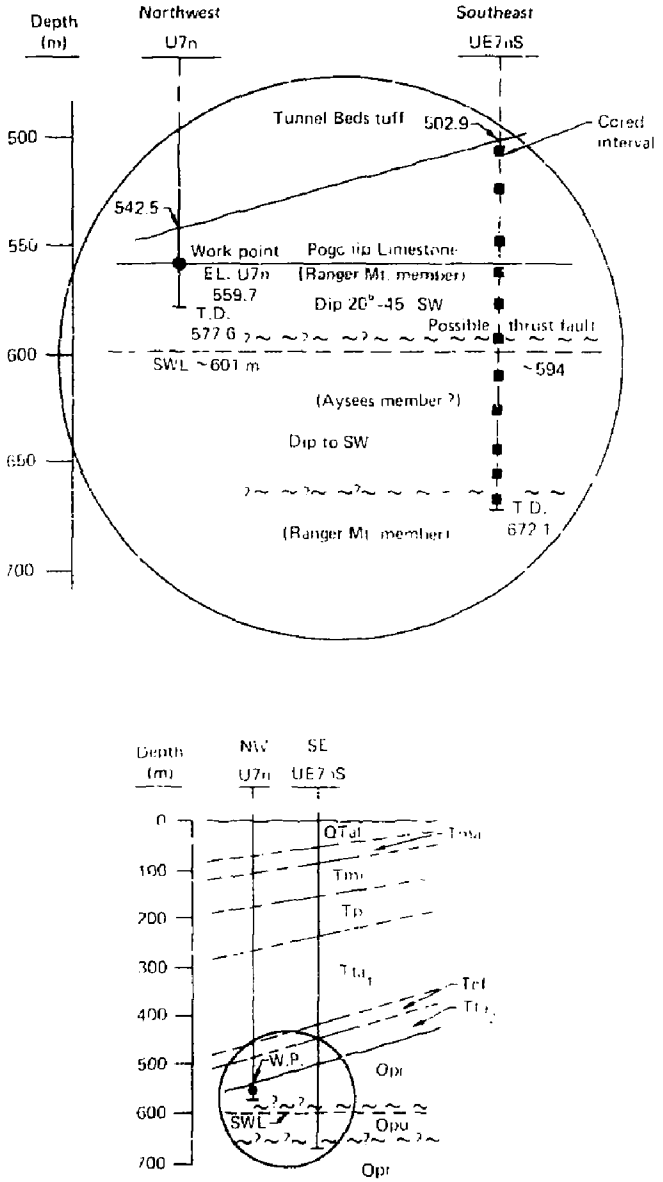

FIG. 4. Geologic cross section U7n-UE7nS, work point elevation.

WATER TABLE DEPTH

The static water level at UE7nS was found at a depth of 601.[illegible] m below [illegible] surface (98.2 m below the tuff/Paleozoic contact). Assuming the piezometric surface remains at this elevation (730.8 m above mean sea level), the working point at U7n was 4[illegible] m above the water table.

PHYSICAL PROPERTY DETERMINATIONS

In addition to the geophysical logging, certain laboratory physical property determinations were conducted on sidewall samples of the tuffs and [illegible] from the carbonate section. Grain density and water content [illegible] (Appendix D) and x-ray analysis of the mineralogy (Appendix E) [illegible] on the tuff samples.

[illegible] Electrical and Engineering Company (REECO, NTS) chemically [illegible] carbonates at the Nevada Test Site for CO_2 (Appendix F). A [illegible] x-ray analysis was conducted on the same samples by LLNL. Samples [illegible] .4 m showed trace amounts of illite and 40-50% quartz. Samples [illegible] .0 m showed trace amounts of illite, montmorillonite, [illegible], [illegible] quartz. Samples at 609.4 and 645.0 m showed [illegible] illite. [illegible] [illegible] analyses with calculated percentages [illegible] Appendix [illegible].

[illegible] the LLNL standard medium characterization [illegible], median [illegible] are calculated for a working point at [illegible] m [illegible] and [illegible] equivalent working point at [illegible] m in UE7n. [illegible] radius of the averaging interval is [illegible]5 m. The [illegible] in Paleozoic carbonates.

TABLE 5a. U7n BOURBON data summary for working point.

Data summary for WP 560 m = 520 m in UE7nS

Averaging radius = 15 m

Averaging interval = 505-535 m

WP medium is limestone

Parameter	Mean value	Units	No. points	Std dev	Estimated error	Data-range	Depth-range	Averaging method	Log-type	Run No.
Bulk density	2.71	mg/m^3	--	--	0.14	2.32-3.25	505-535	--	Density DP	1
Grain density	2.73	mg/m^3	31	±.02	0.01	2.70-2.79	509.6-670.5	Num	Sample core	1
Water content	0.13	wt	0	--	--	--	--	Calc	Calculated	--
Porosity	0.50	vol	--	--	--	--	--	Calc	Calculated	--
Saturation	50.0	vol	--	--	--	--	--	Calc	Calculated	--
Gas porosity	0.30	vol	--	--	--	--	--	Calc	Calculated	--
CO_2 content	23.3	wt	31	±5.7	±0.66	11.8-35.0	509.6-670.5	Num	Sample core	1
Composite velocity	3208	m/s	--	--	--	--	--	Int	DHAL	1
Seismic velocity	4640	m/s	4	--	--	--	501.7-669.0	Int	Vibroseis	1

TABLE 5b. U7n BOURBON data summary for overburden parameters.

WP-to-surface averages			
Bulk density =	1.86	mg/m^3	±.09
[illegible] velocity	1600	m/s	±80.

SUMMARY

[illegible] hole UE7nS was spudded on June 28, 1976, drilled to a [illegible] of 67.[illegible] m, and completed on July 15, 1976. Two bit sizes were [illegible] initial [illegible]8.0 m was drilled with a 0.44-m-diameter bit; a [illegible] diameter bit was used to complete the hole to total depth. Sloughing [illegible] were obtained.

[illegible] the downhole acoustic log, magnetometer, [illegible] conductivity [illegible] On completion of the hole, the [illegible] ran a borehole gravimeter from a point above the tuff/Paleozoic [illegible] to total depth. Densities derived from the [illegible] gravimeter [illegible] compatible with the standard density log values, but no correction [illegible] for geologic structure.

[illegible] alluvium/tuff contact was located 83.8 m below land surface, and the [illegible] Paleozoic contact 502.[illegible] m below surface. The water level in the hole [illegible] 601.1 m below land surface.

[illegible] of these data to the BOURBON site (U7n, [illegible] m to the [illegible]), indicates the BOURBON working point was 41.4 m above the water [illegible] 17.2 m below the Paleozoic surface.

ACKNOWLEDGMENTS

Former LLNL geologist, James Skrove generated much of the data for this report. UE7nS drilling was monitored daily by the Geology/Geophysics Division of the Lawrence Livermore National Laboratory, Nevada. Grain density was measured by LLNL technical staff member, Al Denning. Geophysical logs were

field-monitored by R. Carlson (LLNL), and computer-processed with sample data by the EG&G Company support group to LLNL Geology/Geophysics Data Management Group. The x-ray analyses were performed by W. Beiriger (LLNL); F. M. Byers (USGS) constructed the cross section; and N. Howard and H. L. McKague critically reviewed the manuscript.

APPENDIX A

HISTORY OF HOLE UE7nS

Spudded: 6-3-76 Completed: 7-15-76

Circulating media: air-foam

Ground elevation: 1331.9 m Total depth: 672.08 m

Bore hole record

Depth (m)		
From	To	Size (m)
0	25.0	0.91
[illegible]	548.03	0.44
[illegible]	672.08	0.27

Casing record

Size o.d. (m)	Weight kg/m	Depth (m) From	To
0.51	139.9	0	[illegible]
	Completion casing		
0.33	390.4	0	670.2[illegible]

Drilling log

6-3-76 Moved in Auger Rig #85127 and drilled 0.91-m hole from 0 to 8.8 m

6-4-76 Drilled 0.91-m hole from 8.8 m to 25.0 m. Rigged down and moved off. Hole suspended.

6-[illegible]-76 Hole suspended from 6-4-76 to 6-21-76. Moved in BIR 800 Rig #85132 and drilling equipment.

6-21-76 Moving in equipment and rigging up.

6-[illegible]-76 Rigged up. Ran and welded 0.51-m-o.d., 12.7-mm wall casing, set at 24.4 m. Cemented annulus (Halliburton).

6-24-76 Drilled rat and mouse holes. Drilled 0.44-m hole from 25.0 m to 43.3 m using conventional circulation with air-foam.

6-25-76 Drilled 0.44-m hole from 43.3 to 283.5 m.

6-26-76 Drilled 0.44-m hole from 283.3 to 493.2 m.

6-27-76 Drilled 0.44-m hole from 493.2 to 495.3 m and 0.27-m hole from 495.3 to 507.8 m. Pulled out of hole. Ran 0.22-m diamond core bit in hole, and cut Core #1 from 507.8 to 509.6 m, recovered 1.8 m.

6-28-76	Reamed core hole and drilled 0.27-m hole from 507.8 to 525.4 m. Cut Core #2 from 525.4 m to 527.3 m, recovered 0.91 m. Reamed core hole and drilled 0.27-m hole from 527.3 to 532.5 m.
6-29-76	Drilled 0.44 m hole from 532.5 to 548.0 m. Cut Oriented Core #3 from 548.0 to 550.8 m, recovered 2.7 m. Reamed core hole and drilled hole from 550.8 to 551.7 m.
6-30-76	Drilled 0.27-m hole from 551.7 to 563.3 m. Cut Core #3 from 563.3 to 565.1 m, recovered 1.8 m. Reamed core hole and drilled 0.27-m hole from 565.1 to 575.5 m.
7-1-76	Drilled 0.27-m hole from 575.5 to 578.5 m. Cut Core #5 from 578.5 to 581.6 m, recovered 3.0 m. Reamed core hole and drilled 0.27-m hole from 581.6 to 590.7 m.
7-2-76	Drilled 0.27-m hole from 590.7 to 593.7 m. Cut Core #6 from 593.7 to 595.6 m, recovered 1.4 m. Reamed core hole and drilled 0.27-m hole from 595.6 to 609.0 m.
7-3-76	Cut Core #7 from 609.0 to 612.0 m, recovered 3.0 m. Reamed core hole and drilled 0.27-m hole from 612 to 624.2 m. Cut Core #8 from 624.2 to 627.3 m.
7-4-76	Recovered 3.0 m on Core #8. Reamed core hole and drilled 0.27-m hole from 627.3 to 643.1 m. Cut Core #9 from 643.1 to 646.1 m, recovered 3.0 m. Secured rig at 2400 hours.
7-6-76	Rig secured from 7-4-76 to 0 hours on 7-6-76. Reamed core hole and drilled 0.27-m hole from 646.1 to 654.7 m. Cut Core #10 from 654.7 to 657.8 m, recovered 3.0 m. Reamed core hole and drilled 0.27-m hole from 657.8 to 667.5 m.
7-7-76	Cut Core #11 from 667.5 to 670.6 m, recovered 3.0 m. Reamed core hole and drilled 0.27-m hole from 670.6 to 672.1 m. Ran Birdwell fluid density log. Fluid level was 642.2 m at 1845 hours and 635.5 m at 1914 hours. Ran bailer and took water sample.
7-8-76	Ran Birdwell caliper log to 670.3 m. Ran fluid density log. Fluid level at 545.9 m. Ran density and induction logs to 669.9 m. Started running 3-D logs.
7-9-76	Completed Birdwell 3-D logs. Ran Schlumberger dipmeter to 670.6 m. Ran vibroseis survey.
7-10-76	Completed vibroseis survey. Ran Birdwell 3-D logs. Ran density log to 670.6 m and neutron log to 670.3 m.
7-11-76	Ran Birdwell electric log to 670 6 m. Ran Hunt sidewall sample tool in hole and took samples from 504.4 to 82.3 m.
7-12-76	Cleaned out 0.6 m of fill and blew fluid from hole. Ran Birdwell fluid density log to 670.6 m, fluid level at 613.3 m. Ran seisviewer log. Monitored fluid level from 1210 hours to 1600 hours; fluid rose from 605.0 to 601.1 m. Ran dry hole acoustic log to 579.1 m. Ran magnetometer to 670.6.

APPENDIX A (Continued.)

7-13-76	Ran 48-mm-o.d. tubing in hole and hung off. Ran 0.19-m-o.d. casing.
7-13-76 7-14-76	Cemented casing and ran cement-stage-top locator log. Laid down drill pipe and started rigging down.
7-15-76	Rigged down. Hole completed.
8-8-76	Ran USGS gravimeter to 662.0 m, fluid level at 599.8 m. Hung tool at 387 m to stabilize.
8-9-76	Ran gravimeter survey from 387.1 to 662.0 m.

APPENDIX B

BIRDWELL INTERPRETATION OF SEISVIEWER IMAGERY LOG

Depth (m)	Feature	Remarks
607.01-607.32	BP[a]	Dip SSW 33
607.62-607.93	BP	Dip SSW 45
608.54-609.15	Frac.[b]	Dip ESE 68
609.76-610.06	BP	Dip SW 45 (exfoliated)
614.94-615.24	BP	Dip SW 48
616.16-616.46	BP	Dip SW 48
616.46-616.77	Frac.	Dip E 62 (intersects bedding)
617.07-617.38	BP	Dip SW 48
619.82-620.12	Frac.	Dip ENE 61
621.34-622.26	Frac.	Dip E 73 (intersecting fractures)
621.95-622.26	Frac.	Dip WSW 59 (intersecting fractures)
621.95-625.61	Frac.	Vertical NE-S
623.48-623.78	Frac.	Dip SE 51
625.30-626.22	Frac.	Dip NEE 70
627.13-627.74	Frac.	Dip NE 70
627.74-628.96	Frac.	Vertical S-NNW
629.57-629.88	BP	Dip SW 33 numerous BP of similar angle and direction until 637.6 m
637.80-638.11	BP	Dip ESE 38 numerous BP of similar angle and direction until 640.1 m
642.07	BP	Dip SSW 29
642.38-643.29	Frac.	Dip NNW 69

[a] BP = bedding plane.

[b] Frac. = fracture.

APPENDIX B (Continued.)

Depth (m)	Feature	Remarks
643.29-643.90	Frac.	Dip NNW 68
643.29-643.60	BP	Dip SSW 29 intersects fracture described above. Numerous BP of similar angle and direction until 649 m
646.65-647.26	Frac.	Dip NW 73 (intersects BP)
647.87-648.78	Frac.	Dip WNW 73 (intersects BP)
649.39-650.30	Frac.	Vertical WSW-N (terminates in fracture at 650.11 m)
650.30-650.91	Frac.	Dip E 65
651.52-652.83	Frac.	Dip E 53
655.73-656.39	Frac.	Vertical S-NW
656.10-656.40	BP	Dip SW 55 (numerous BP with similar dips and angle until 666 m)
667.07-668.90	Frac.	Dip E 82
667.68-668.90	Frac.	Dip W 78 (intersects fracture above)

APPENDIX C

BOREHOLE GRAVIMETER DATA

(Drift correction was negligible.)

Station No.	Depth (ft)	Depth (m)	Time	Uncorrected gravity	Tide correction	Terrain correction	Corrected gravity
1	1270.0	387.10	1532	58.286	.017	1.531	59.800
2	1370.1	417.61	1545	62.659	.006	1.586	64.249
3	1470.1	448.09	1557	66.937	.004	1.659	68.600
4	1538.0	468.78	1607	69.279	.013	1.701	70.993
5	1572.0	479.15	1616	70.691	.021	1.722	72.434
6	1650.0	502.92	1628	73.485	.032	1.769	75.286
7	1696.0	516.94	1637	74.784	.040	1.797	76.621
8	1752.0	534.01	1650	76.226	.051	1.830	78.107
9	1800.1	548.67	1700	77.470	.060	1.858	79.388
10	1846.0	562.66	1709	78.639	.067	1.884	80.590
11	1900.0	579.12	1720	80.001	.076	1.915	81.992
12	1960.0	597.41	1731	81.546	.085	1.948	83.579
13	2007.0	611.73	1740	82.685	.091	1.974	84.750
14	2048.0	624.23	1751	83.729	.099	1.997	85.825
15	2101.9	640.66	1800	85.106	.105	2.026	87.237
16	2172.1	662.06	1815	86.892	.113	2.063	89.068
17	2172.1	662.06	1851	86.896	.129	2.063	89.088
18	2101.9	640.66	1904	85.084	.133	2.026	87.243

APPENDIX D

GRAIN DENSITY AND WATER CONTENT OF TUFF SIDEWALL SAMPLES

Depth (m)	Grain density (mg/m^3)	Water content (wt%)
82.3	2.50	8.7
85.3	2.44	13.4
88.4	2.42	9.6
149.3	2.36	8.4
152.4	2.39	10.5
155.4	2.46	19.7
274.3	2.44	8.7
454.1	2.65	9.6
457.2	2.62	11.5
460.2	2.46	19.0
493.8	2.59	18.6
496.8	2.62	5.2
502.9	2.73	5.9

APPENDIX E

X-RAY ANALYSIS OF TUFF SIDEWALL SAMPLES

Depth (m)	Montmorillonite (%)	Illite/ Muscovite (%)	Clinoptilolite (%)	Quartz	Cristobalite	K and Na feldspar	Calcite (%)	Dolomite	Glass
82.3	--	--	--	W	T	W	>10	--	M
85.3	--	--	75	W	T	W	--	--	W
88.4	--	--	T	W	T	W	--	--	M
149.3	--	--	--	W	T	W	--	--	M
152.4	--	--	--	W	T	W	--	--	M
155.4	--	--	75	W	T	W	1	--	W
274.3	--	--	85	W	--	W	--	--	--
454.1	<10	T	45	W	W	W	--	--	--
457.2	10	--	75	W	W	W	--	--	--
460.2	<5	--	85	W	W	W	--	--	--
493.8	<10	--	75	W	T	W	--	--	--
496.8	<10	T	35	M	T	W	--	--	--
502.9	--	20	--	H	--	W	--	--	--

H = high

M = moderate

W = weak

T = trace

APPENDIX F

CO_2 ANALYSIS OF SELECTED INTERVALS OF CONVENTIONAL CORE FROM EXPLORATORY HOLE UE7nS; AREA 7, NTS

CHEMICAL ANALYSIS, PERCENTAGE DRY WEIGHT[a]

Depth (m)	Run 1 (%)	Run 2 (%)	Run 3 ( )
509.63-509.78	28.3	28.2	--
525.48-527.30	24.2	24.1	--
548.93-550.47	29.9	30.3	--
562.84-562.97	30.4	31.3	--
562.97-564.49	23.3	22.4	--
564.49-565.10	22.9	26.5	27.0
578.51-579.42	28.9	24.2	22.2
593.75-593.99	31.7	27.8	32.5
593.75-595.09	21.1	17.7	20.7
594.09-595.58	34.9	35.0	--
608.99-609.42	24.3	21.9	--
609.42-609.69	14.8	15.8	--
609.97-610.21	28.6	30.5	--
610.11-611.12	16.7	25.9	29.2
611.12-612.04	31.7	33.9	--
624.34-624.84	22.3	19.5	18.8
624.84-625.51	15.4	15.0	--
625.51-626.58	22.8	25.6	--
626.58-627.31	17.2	14.6	19.9
643.13-644.04	20.4	24.5	25.5

[a]Analytical method: gas evolution, Ascarite trap.

APPENDIX F (Continued.)

Depth (m)	Run 1 (%)	Run 2 (%)	Run 3 (%)
644.04-644.77	23.1	21.4	--
644.70-645.02	21.4	21.5	--
645.02-645.35	11.8	11.8	--
645.35-645.93	22.8	33.0	33.3
645.93-646.18	16.3	17.0	--
654.71-655.02	21.7	21.4	--
655.02-655.62	18.8	19.9	19.8
655.62-656.69	20.3	15.3	20.4
656.69-657.76	20.6	21.2	19.3
667.51-669.49	19.3	18.2	--
669.49-670.56	23.8	26.4	--

APPENDIX G

QUANTITATIVE CARBONATE ANALYSIS, WITH CO_2 CALCULATED

Depth (m)	$CaCO_3$% (x ray)	CO_2% (x ray)
509.08-509.78	45	27.6
525.48-527.30	42	25.2
548.03-550.47	50	30.0
562.84-562.97	47	28.2
562.97-564.49	43	25.8
564.49-565.10	47	28.2
578.51-579.42	45	27.6
593.75-593.99	45	27.6
593.75-595.09	35	15.0
595.09-595.58	48	28.8
608.99-609.42	45	27.6
609.42-609.60	34	20.4
609.97-610.21	50	30.0
610.21-611.12	48	28.8
611.12-612.04	55	33.0
624.23-624.84	43	25.8
624.84-625.51	34	20.4
625.51-626.58	45	27.6
626.58-627.31	42	25.2
643.13-644.04	50	30.0
644.65-644.77	44	26.4
644.77-645.02	47	28.2
645.02-645.35	28	16.8
645.35-645.93	52	31.2
645.93-646.18	38	22.8
654.71-655.02	42	25.2
655.02-655.62	41	24.6
655.62-656.69	41	24.6
656.69-657.76	42	25.2
667.51-669.49	48	28.8
669.49-670.56	50	30.0

BP/jb

LLNL* 1981/5