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Basic Data Report for Drillhole WIPP 15 (Waste Isolation Pilot Plant-WIPP)

MASTER

Sandia National Laboratories, University of New Mexico

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Basic Data Report

for

Drillhole

WIPP 15

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Compiled by

Sandia National Laboratories
(Division 4511)

and

University of New Mexico
(Department of Geology)

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1.0 ABSTRACT

WIPP 15 is a borehole drilled in March, 1978, in section 18, T.23S., R. 35E. of south-central Lea County. The purpose of WIPP 15 was to examine fill in San Simon Sink in order to extract climatic information and to attempt to date the collapse of the sink. The borehole was cored to total depth (810.5 feet) and encountered, from top to bottom, Quaternary calcareous clay, marl and sand, and claystones and siltstones of the Triassic Santa Rosa Formation (?). Neutron and gamma ray geophysical logs were run to measure density and radioactivity.

The sink has about 547 feet of Quaternary fill indicating subsidence and deposition. Diatomaceous beds exposed on the sink margin yielded samples dated by ^{14}C at $20,570 \pm 540$ years BP and greater than 32,000 years BP; these beds are believed stratigraphically equivalent to diatomaceous beds at 153-266 feet depth in the core. Aquatic fauna and flora from the upper 98 feet of core indicate a pluvial period (probably Tahokan) followed by an arid or very arid time before the present climate was established.

Aquifer pump tests performed in the Quaternary sands and clays show transmissivities to be as high as 600 feet squared per day. As the water quality was good, the borehole was released to the lessee as a potential water well.

2.0 INTRODUCTION

The introduction describes background information on the Waste Isolation Pilot Plant (WIPP) and the investigations involving WIPP 15.

2.1 The Purpose of WIPP

The purpose of the WIPP is distinct from that of several other projects for the disposal of radioactive waste. The WIPP is planned to demonstrate disposal technology for the transuranic (TRU) waste resulting from this nation's defense programs of over 30 years. After a period (5 years) of limited (pilot) operation, it is anticipated that the WIPP will be converted to a full-scale repository for permanent disposal of defense TRU waste. The WIPP plans also include an underground research facility to examine, on a large scale, the interactions between bedded salt and high-level radioactive defense waste with its resultant thermal and radiation fluxes. There is no plan at this time to dispose of high-level waste or spent fuel in the WIPP.

Additional information on the WIPP and characterization of the WIPP site may be found in Powers, et. al. (1978).

2.2 The Purpose of WIPP 15

During investigations of dissolution of evaporites in southeastern New Mexico, it was apparent that more information on the climate in the local area during the Pleistocene would be quite useful. Pleistocene deposits were thought to be most complete in some of the playas or lakes where deposition was probably continuous regardless of the climatic

fluctuations. Likely targets included Laguna Grande de la Sal, the West Texas salt flat graben, and San Simon Sink/Swale. Of these targets, San Simon Sink and Swale seemed the most appropriate; the area was believed to have suffered dissolution over a period of time, additional collapse had occurred during historic times, and marginal lake beds showed an abundant flora and fauna. Laguna Grande was less well known, and the extreme salinity may have distorted the record of climate indicators. The West Texas salt flats were felt to be a very good target, but the area is further from the WIPP site.

Two drilling locations were chosen: WIPP 15 was located in the bottom of San Simon Sink and WIPP 17 was located north of the Sink near the axis of the Swale. Two locations were chosen in the event the information from WIPP 15 needed supplementing. However, the information from WIPP 15 was believed adequate, and plans for drilling WIPP 17 were abandoned.

WIPP 15 was drilled, then, in order to investigate the Quaternary stratigraphy and the history of climatic changes and structural events that resulted in Pleistocene lake(s) in San Simon Sink. It was believed that the Sink resulted from dissolution of the underlying evaporites, and it was thought that the borehole might provide some evidence of the units in which dissolution had occurred.

3.0 GEOLOGIC DATA FOR BOREHOLE WIPP 15

by

Roger Y. Anderson¹ and Sandra J. Anderson¹

3.1 Abstract

WIPP-15 was drilled in San Simon Sink, Lea County, New Mexico, to determine Quaternary stratigraphy and the history of climatic changes and structural events that resulted in Pleistocene lake(s) in the sink.

The borehole encountered, from top to bottom, Quaternary calcareous clay, marl, and sand, and claystones and siltstones of the Triassic Santa Rosa Formation (?). Total depth of borehole is 810.5 feet.

Neutron and gamma ray geophysical logs were run to measure density and radioactivity.

Fossils from the upper 30 meters of core reflect Pleistocene environmental and climatic conditions. Radiocarbon dates on fossils from diatomaceous beds believed stratigraphically equivalent to the lower clay unit in the core give dates of 20,570 years B. P. and greater than 32,000 years B.P.

The timing of collapse in San Simon Sink, as revealed by stratigraphy of the sink hole fill, will add to the geologic history of the WIPP site and facilitate safety assessment for storage of radioactive wastes.

¹Department of Geology, University of New Mexico, Albuquerque, N.M.

3.2 Introduction

Borehole WIPP-15 is one of a series of exploratory boreholes drilled by Sandia National Laboratories on behalf of the WIPP Project Office of the DOE.

WIPP-15 was cored to obtain paleoclimatic data from the sub-surface at San Simon Sink and to examine the relationship between surficial features and deposits and subsurface structure.

3.3 Description of WIPP-15

WIPP 15 is located in San Simon Sink, Lea Co., New Mexico, 1793 feet from the west line, 2426 feet from the north line (NW1/4SE1/4SW1/4) of Section 18, T.23S., R.35E. (Fig. 1). The borehole was drilled to a depth of 810.5 feet from an elevation of 3269.34 feet above sea level. Drilling started March 8, 1978, and finished April 4, 1978.

The first 9.67 feet were drilled with air using a split sample spoon. A 4 3/4 inch x 2 3/4 inch core bit and air were used to 13.25 feet where drilling with mud began. A 4 inch rock bit was used from 29.35 feet to 566.2 feet and a tungsten carbide bit was used to complete the hole to the total depth of 810.5 feet. The hole was opened to 6 1/8 inch to a depth of 592 feet. Blank casing was installed from 0-445 feet, slotted casing from 445 feet to 540 feet, and blank casing again from 540-555 feet.

FIGURE 2. INDEX MAP SHOWING LOCATION OF BOREHOLE WIPP 15

Gamma ray and neutron logs were run by USGS at 493.2 feet and at total depth, 810.5 feet.

Borehole WIPP 15A was drilled April 4 and 5, 1978, nine feet from WIPP 15 to recover core lost from 29-75 feet. A 4 inch hole was drilled with air from 0-29 feet. Core was recovered from 34.2-61.3 feet (total depth) using mud and a wire line core barrel with split inner barrel and a 3.95 inch diamond bit.

A detailed history of borehole WIPP 15 and WIPP 15A was compiled by Fenix and Scisson, Inc. (Appendix C) and is summarized in Table 1.

Recovered core was examined and logged at the drill site by Roger Y. Anderson.

Borehole WIPP 15 penetrated 547 feet of Quaternary clay, sand, and marl. The upper 160 feet of section are generally light gray, very calcareous, gypsiferous, and contain organic debris. The texture varies from sandy clay to clayey sand. Clay and silt which are predominantly calcareous are termed marl. Mottled brown calcareous and light blue gray clay grades into olive gray clay at 213 feet.

These calcareous clays are underlain by 321 feet of reddish brown sand containing pebbles of Triassic sandstone and caliche in the upper part. The sand is often calcareous, partially inundated with calcareous cement in places, and often silty and/or clayey. Clay and silt interbeds are especially common in the upper 150 feet of the sand unit.

The Quaternary sediments rest unconformably on 230 feet of the Triassic Chinle Formation. The Chinle is a dark red-brown laminated claystone and siltstone. Minor faults, fractures, breccia zones, and bedding dips of 10-15° are common. Five feet of gray-purple conglomerate occur at 746 feet.

Two thin sections of the Triassic sandstone in the core show iron-stained quartz, feldspar, and lithic framework grains with an estimated 5-10% cherty cement. Calcite is replacing both cement and framework grains and is the sole constituent of the rock in places. Quartz grains are strained or composite and may exhibit crystal faces as the result of silica overgrowths. Feldspars are degraded in some cases and fresh in others. Some have been completely replaced with calcite. Lithic grains are predominantly chert and sedimentary rock fragments. Clay coatings are common.

The hole ends in a light gray sandstone which may be part of the Triassic Santa Rosa Formation.

A stratigraphic summary of the borehole is presented in Table 2. Geologic and geophysical logs are presented in Figure 2. Table 3 is a detailed lithologic log and Figure 3 shows the stratigraphic details for borehole WIPP 15.

The location of WIPP 15, the measurements of depth in the borehole, and the original logs of the core are in English units of measure. The following conversion factors will give metric units.

<u>Multiply English Units</u>	<u>by</u>	<u>To obtain metric unit</u>
inch (in)	2.54	centimeter (cm)
inch (in)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)

3.4 Fossil Occurrences

Aquatic snails, ostracods, diatoms, and plants occur in the calcareous clay and marl of the upper 98 feet (30 meters) of core (Fig. 4) and fossil pollen also occurs between 215 and 217 feet. For complete description, identification, and precise stratigraphic location of fossils, pollen analysis and stratigraphy in the core and surrounding area, and environmental interpretations, see the Preliminary Report on Referred Fossils (Appendix A).

Triassic palynomorphs, similar to those observed elsewhere by Dunay and Traverse (1971) in the Chinle Formation, were recovered from the core by Roger Y. Anderson at a depth of 705 feet.

3.5 Radiocarbon Data

Two samples from diatomite beds believed stratigraphically equivalent to the lower clay unit (153-226 feet) of WIPP 15 were collected on the north side of San Simon Sink, Sec. 18, T.23S., R.35E., Lea Co., NM. These samples were dated with radiocarbon methods in the Geochron Laboratories Division of Krueger Enterprises, Inc., Cambridge, Massachusetts in December, 1978 (Appendix A).

A date of $20,570 \pm 540$ C-14 years BP was determined on the gastropod shell sample (Physa sp., Lymnaea sp., Helisoma sp.). The sample of charophyte oogonia (Chara sp.) from the same stratigraphic unit was dated at greater than 32,000 C-14 years BP.

3.6 Brief History of Geologic Events

1. An exposure of Triassic Chinle siltstone and shale was subjected to subsidence and the area filled with about 320 feet of quartzose, well-sorted medium to fine-grained sand.

2. Caliche and Triassic sandstone pebbles up to several centimeters in diameter were shed into the area along with the sand beginning about 150 feet above the base of the sand sequence.

3. Episodes of increased clay deposition alternated with sand deposition, culminating in a 40-foot thick clay bed 350 feet above the base of the sand section. This unit is calcareous at the base, contains a Pleistocene "pluvial" pollen flora (Appendix A), and is believed equivalent to calcareous diatomite marl dated by radiocarbon analysis (see above).

4. Sand was deposited over the 40-foot thick clay bed; the sand was succeeded by an influx of reworked diatomaceous marl from the margins of the swale.

5. The upper 39 feet of the sequence contains calcareous organic-rich clay and playa sediments associated with collapse of San Simon Sink to form the present surface expression.

Company DEPT. OF ENERGY
Well WIP 15
Sec 18 Twp. 23S Rg. 35E
Location 2426' FNL 1973' FWL
County LEA State NEW MEX.
Area SAN SIMON SINK

Feet above or
below datum

Log Measured from GL
Drilling Measured from GL
Permanent Datum GL

Contractor U.S. GEOLOGICAL SURVEY
Spec. 3-8-78 Comp. 4-5-78
TD 810'
Geologist (s) HUDSON/MERCER
on well.

MUDSTONE, CLAY

SILTSTONE

SANDSTONE

GYPSUM
NC NO CORE		

NS
NO SAMPLE
NC
NO CORE
LS
LAND SURFACE
MB
MARKER BED
OZ
ORE ZONE

Company DEPT. OF ENERGY
Well WIP 15
Sec 18 Twp. 23S Rg. 35E
Location 2426' FNL 1973' FWL
County LEA State NEW MEX.
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Feet above or
below datum

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Permanent Datum GL

Contractor U.S. GEOLOGICAL SURVEY
Spec. 3-8-78 Comp. 4-5-78
TD 810'
Geologist (s) HUDSON/MERCER
on well.

*DENSITY INCREASES LEFT

Fig. 3. Detailed stratigraphic section for borehole WIPP 15

SAN SIMON SINK
(WIPP-15)

Figure 4. Fossil occurrence in WIPP-15.

See Fig. 2 for key to lithology. (Modified from J.P. Bradbury)

Table 1

Abridged History of Borehole WIPP 15
(From WIPP #15 Field Engineering Summary)

<u>Core No.</u>	<u>Interval</u>	<u>Cored</u>	<u>Recovered</u>	<u>% Recovery</u>
1	0" - 12"	12"	12"	100
2	12" - 26"	14"	12"	86
3	26" - 34"	8"	6"	75
4	34" - 48"	14"	8"	57
5	48" - 60"	12"	9"	75
6	60" - 66"	6"	6"	100
7	66" - 78"	12"	8"	67
8	78" - 84"	6"	6"	100
9	84" - 96"	12"	12"	100
10	96" - 108"	12"	12"	100
11	108" - 116"	8"	7"	88
12	116" - 145"	29"	19"	66
13	145" - 159"	14"	14"	100
14	13.25' - 15.70'	2.45'	0'	0
15	15.70' - 18.00'	2.30'	2.6'	113
16	18.00' - 22.55'	4.55'	2.25'	49
17	22.55' - 23.85'	1.30'	0.9'	69
18	23.85' - 26.35'	2.50'	2.0'	80
19	26.35' - 28.35'	2.00'	0'	0
20	28.35' - 29.35'	1.00'	2.15'	215
21	75.00' - 85.3'	10.3'	10.3'	100
22	85.3' - 90.2'	4.9'	4.8'	98
23	90.2' - 95.2'	5.0'	4.65'	93
24	95.2' - 102.7'	7.5'	7.65'	102
25	102.7' - 108.2'	5.5'	5.5'	100
26	108.2' - 113.2'	5.0'	4.9'	98
27	113.2' - 118.2'	5.0'	5.15'	103
28	118.2' - 123.2'	5.0'	5.1'	102
29	123.2' - 128.2'	5.0'	5.0'	100
30	128.2' - 133.2'	5.0'	4.9'	98
31	133.2' - 138.2'	5.0'	5.1'	102
32	138.2' - 143.2'	5.0'	5.0'	100
33	143.2' - 149.2'	6.0'	6.1'	102
34	149.2' - 153.2'	4.0'	3.7'	93
35	153.2' - 158.2'	5.0'	4.2'	84
36	158.2' - 162.2'	4.0'	2.7'	68
37	162.2' - 164.2'	2.0'	3.5'	175
38	164.2' - 168.2'	4.0'	3.9'	98
39	168.2' - 173.2'	5.0'	4.9'	98
40	173.2' - 178.2'	5.0'	3.9'	78
41	178.2' - 183.2'	5.0'	6.3'	126
42	183.2' - 188.2'	5.0'	5.1'	102
43	188.2' - 193.2'	5.0'	5.0'	100
44	193.2' - 198.2'	5.0'	5.2'	104
45	198.2' - 203.2'	5.0'	5.0'	100

Table 1 (cont)

Core No.	Interval		Cored	Recovered	% Recovery
46	203.2'	-206.6'	3.4'	3.2'	94
47	206.6'	-213.2'	6.6'	6.6'	100
48	213.2'	-218.2'	5.0'	4.98'	100
49	218.2'	-226.3'	8.1'	8.3'	103
50	226.3'	-231.4'	5.1'	5.0'	98
51	231.4'	-238.2'	6.8'	6.8'	100
52	238.2'	-246.7'	8.5'	8.5'	100
53	246.7'	-253.2'	6.5'	6.5'	100
54	253.2'	-261.2'	8.0'	8.0'	100
55	261.2'	-269.2'	8.0'	7.9'	99
56	269.2'	-277.2'	8.0'	8.1'	101
57	277.2'	-285.2'	8.0'	8.0'	100
58	285.2'	-293.2'	8.0'	8.0'	100
59	293.2'	-298.2'	5.0'	5.0'	100
60	298.2'	-303.2'	5.0'	4.5'	90
61	303.2'	-312.2'	9.0'	9.5'	104
62	312.2'	-321.2'	9.0'	9.0'	100
63	321.2'	-333.2'	12.0'	9.9'	83
64	333.2'	-341.7'	8.5'	8.5'	100
65	341.7'	-348.2'	6.5'	6.5'	100
66	348.2'	-358.2'	10.0'	10.0'	100
67	358.2'	-364.2'	6.0'	6.0'	100
68	364.2'	-372.6'	8.4'	7.6'	91
69	372.6'	-381.2'	8.6'	6.2'	72
70	381.2'	-384.4'	3.2'	4.2'	131
71	384.4'	-391.2'	6.8'	6.5'	96
72	391.2'	-396.2'	5.0'	3.9'	78
73	396.2'	-400.9'	4.7'	4.5'	96
74	400.9'	-407.9'	7.0'	7.0'	100
75	407.9'	-417.2'	9.3'	9.2'	99
76	417.2'	-426.2'	9.0'	8.6'	96
77	426.2'	-435.2'	9.0'	9.1'	101
78	435.2'	-443.2'	8.0'	3.0'	38
79	443.2'	-446.2'	3.0'	3.0'	100
80	446.2'	-453.2'	7.0'	7.0'	100
81	453.2'	-460.2'	7.0'	8.0'	114
82	460.2'	-468.2'	8.0'	8.0'	100
83	468.2'	-477.2'	9.0'	9.5'	106
84	477.2'	-479.9'	2.7'	2.0'	74
85	479.9'	-489.2'	9.3'	1.0'	11
86	489.2'	-491.2'	2.0'	2.6'	130
87	491.2'	-493.2'	2.0'	2.0'	100
88	493.2'	-498.2'	5.0'	5.0'	100
89	498.2'	-505.7'	7.5'	6.9'	92
90	505.7'	-513.2'	7.5'	7.3'	97
91	513.2'	-523.7'	10.5'	8.6'	82
92	523.7'	-533.2'	9.5'	8.0'	84
93	533.2'	-543.2'	10.0'	8.5'	85

Table 1 (cont)

<u>Core No.</u>	<u>Interval</u>		<u>Cored</u>	<u>Recovered</u>	<u>% Recovery</u>
94	543.2'	-547.2'	4.0'	2.6'	65
95	547.2'	-548.2'	1.0'	0.0'	0
96	548.2'	-553.2'	5.0'	6.0'	120
97	553.2'	-560.2'	7.0'	7.0'	100
98	560.2'	-563.2'	3.0'	3.0'	100
99	563.2'	-566.2'	3.0'	2.0'	67
100	566.2'	-573.2'	7.0'	6.4'	91
101	573.2'	-577.2'	5.0'	4.0'	80
102	577.2'	-580.5'	3.3'	4.0'	121
103	580.5'	-585.2'	4.7'	3.3'	70
104	585.2'	-588.2'	3.0'	3.5'	117
105	588.2'	-597.2'	9.0'	8.5'	94
106	597.2'	-600.2'	3.0'	3.0'	100
107	600.2'	-609.7'	9.5'	9.9'	104
108	609.7'	-618.2'	8.5'	9.5'	112
109	618.2'	-626.8'	8.6'	10.0'	116
110	626.8'	-635.2'	8.4'	8.6'	102
111	635.2'	-640.2'	5.0'	5.0'	100
112	640.2'	-648.2'	8.0'	9.0'	113
113	648.2'	-654.9'	6.7'	6.8'	102
114	654.9'	-657.2'	2.3'	2.3'	100
115	657.2'	-657.9'	0.7'	0.7'	100
116	657.9'	-666.2'	8.3'	4.5'	54
117	666.2'	-670.2'	4.0'	4.2'	105
118	670.2'	-678.2'	8.0'	9.3'	116
119	678.2'	-682.9'	4.7'	3.9'	83
120	682.9'	-691.2'	8.3'	9.2'	111
121	691.2'	-694.7'	3.5'	3.4'	97
122	694.7'	-704.7'	10.0'	10.2'	102
123	704.7'	-713.7'	9.0'	8.3'	92
124	713.7'	-721.7'	8.0'	8.3'	104
125	721.7'	-728.8'	7.1'	7.2'	101
126	728.8'	-736.8'	8.0'	8.0'	100
127	736.8'	-745.2'	8.4'	8.2'	98
128	745.2'	-753.2'	8.0'	7.9'	99
129	753.2'	-761.2'	8.0'	5.3'	66
130	761.2'	-764.2'	3.0'	5.1'	170
131	764.2'	-773.2'	9.0'	8.8'	98
132	773.2'	-781.7'	8.5'	9.0'	106
133	781.7'	-786.7'	5.0'	4.5'	90
134	786.7'	-796.2'	9.5'	9.9'	104
135	796.2'	-805.2'	9.0'	9.0'	100
136	805.2'	-810.2'	5.0'	4.9'	98
137	810.2'	-810.5'	0.3'	0.3'	100

NOTE: Information taken from drilling records

Table 2

Stratigraphic summary of borehole WIPP 15

Rock Unit	Depth Interval Feet
Quaternary	
Clay	0 - 34.0
Marl	34.0 - 99.0
Sand	99.0 - 153.3
Clay	153.3 - 226.0
Sand	226.0 - 547.2
Triassic	
Chinle	547.2 - 790.5
Santa Rosa (?)	790.5 - 812.0

Table 3
Lithologic log for borehole WIPP-15
Color designations are from rock-color chart (Goddard, and others, 1963); (no
core designates intervals where core was lost during drilling operations)

Lithologic Description	Depth Interval feet
Clay, light olive gray (5Y 6/1) to yellowish gray 5Y 8/1), calcareous, sandy, and/or silty, stringers of organic debris; sand is well-rounded, well-sorted quartz and gypsum	0 - 11.0
No core	11.0 - 12.0
Clay, very light gray (N8) to light gray (N7), unconsolidated, with dark gray (N3) mottling of organic debris; "limonitic" cemented zones and stains	12.0 - 13.3
No core	13.3 - 15.4
Clay, same as unit at 12.0 - 13.3	15.4 - 20.3
No core	20.3 - 22.5
Clay, same as unit at 12.0 - 13.3 feet, silty	22.5 - 25.5
No core	25.5 - 26.5
Clay, same as unit at 22.5 - 25.5	26.5 - 34.0
Sand, pale yellowish brown (10 YR 6/2), well rounded, well sorted gypsum and quartz, very calcareous, silty and clayey	34.0 - 39.0
Marl, very light gray (N8) to light gray (N7), or pale yellowish brown (10 YR 6/2) silt-clay, unconsolidated ...	39.0 - 41.5
Marl, sandy at base, fining upward to very light gray (N8) clay. Light bluish gray (5B 7/1) to light greenish gray (5G 8/1) mottling, organic rich layers, dark gray (N3) ..	41.5 - 51.0
Sand, yellowish gray (5Y 7/2), silty, very calcareous	51.0 - 59.5
Sand, same as unit at 51.0 - 59.5 feet, but non-calcareous .	59.5 - 61.0
No core	61.0 - 63.0
Marl, same as unit at 39.0 - 41.5 feet	63.0 - 65.2
No core	65.2 - 73.2

Table 3: Lithologic log for borehole WIPP-15, cont.

Lithologic Description	Depth Interval feet
Sand, pale olive (10Y 6/2), calcareous, pebbly, clayey	73.2 - 78.0
Marl, yellowish gray (5Y 7/2), calcareous silty clay or clayey silt limonitic(?) veins, dark yellowish orange (10YR 6/6), gypsum crystals and stringers	78.0 - 88.0
Sand, same as unit at 51.0 - 59.5 feet	88.0 - 94.5
Marl, same as unit at 39.0 - 41.5 feet, yellowish gray (5Y 7/2), caliche pebs 1 cm diameter	94.5 - 99.0
Sand, moderate greenish yellow (10Y 7/4) to pale olive (10Y 6/2) clayey and calcareous quartzose, subrounded, moderate sorting. Caliche pebs at 112 to 114 feet. Calcareous fracture filling and light brown (5YR 6/4) calcareous sand at 118 feet grades up to pale olive (10Y 6/2) sand. Moderate brown (5YR 3/4) clay blebs at 120 feet. Gypsum veins at 127 feet. Calcareous veins from 127 to 133 feet	99.0 - 133.0
Sand, dusky yellow (5Y 6/4), very calcareous, calcareous zones are yellowish gray (5Y 8/1)	133.0 - 153.3
Sand, same as unit at 99.0 - 133.0 feet with lenses of light brown (5YR 6/4) sand and yellowish gray (5Y 8/1) calcareous zones	153.3 - 158.2
No core	158.2 - 159.4
Clay, moderate brown (5YR 3/4), with light bluish gray (5B 7/1) sand in veins	159.4 - 169.0
Sand, moderate brown (5YR 3/4), clayey, silty, pebbly from 169 - 171 feet; caliche peb. .5 cm in diameter, slightly calcareous, lenses of light bluish gray (5B 7/1) sand. Gypsum vein .5 cm thick at 182 feet	169.0 - 184.0
Clay, moderate brown (5YR 3/4) to grayish red (10R 4/2); silty and/or sandy in thin lenses. Laminations at 207 feet 11 cm zone with 24 laminations; 12 cm zone with 22 laminations. Dark yellowish orange (10YR 6/6) sand in irregular blebs at 208-210 feet. Calcareous clay from 210 - 213 feet	184.0 - 213.0

Table 3: lithologic log for borehole WIPP-15, cont.

Lithologic Description	Depth Interval feet
Clay, light olive gray (5YR 6/1), calcareous, organic debris, mottled with moderate reddish brown (10R 4/6) clay from 220 - 222 feet. Moderate reddish brown sand and clay mottled with light olive gray (5Y 6/1) clay 222 to 226 feet	213.0 - 226.0
Sand, moderate reddish brown (10R 4/6), clayey, calcareous, unconsolidated, moderate brown clay (5YR 3/4) at 233-234 feet. Caliche pebs, 3 cm in diameter at 238-239 feet. Light bluish gray (5B 7/1) sand, very calcareous w/ calcareous blebs, from 239 to 243 feet. Calcite veins in clayey sand 244 - 245 feet	226.0 - 245.0
Clay, moderate reddish brown (10R 4/6), calcareous, mottled with light olive gray (5Y 6/1) clay, fractures with calcite	245.0 - 251.0
Sand, same as unit at 226.0 - 245.0 ft, moderate brown (5YR 3/4) clay lenses at 263, 273, 276 feet. Caliche pebbles at 267 feet and 271 feet	251.0 - 284.0
Clay, sandy and calcareous; alternated with zones of clayey calcareous sand, light olive gray (5Y 6/1) clay blebs ..	284.0 - 292.0
Sand, same as unit at 226.0 - 245.0 feet. Pebbles at 294.0 - 295.0 feet, caliche pebble zone from 296 - 297 feet, and at 299 feet	292.0 - 299.0
Clay, same as unit at 184.0 - 213.0 feet, light olive gray (5Y 6/1) calcareous clay in fractures. Pebble conglomerate at 301 feet, 302.5 feet	299.0 - 304.5
Sand, same as unit at 226.0 - 245.0 feet. Frequent calcareous-cemented zones. Caliche pebbles at 319 ft ..	304.5 - 321.2
No core	321.2 - 322.3
Sand, same as unit 226.0 - 245.0 feet. Caliche pebble conglomerates at 322.3, 341 - 342, 346, 349 - 350, 362 - 366, 373 feet pebbles of sandstone, limestone, siltstone, caliche up to 4 cm in diameter. Moderate brown (5YR 3/4) clay and sandy clay lenses at 330 - 332, 346 and 367 - 371 feet. Sand in fractures in clay zones	322.3 - 380.0

Table 3: lithologic log for borehole WIPP-15, cont.

Lithologic Description	Depth Interval feet
No core	380.0 - 381.0
Sand, same as unit at 226.0 - 245.0 feet. Clayey very angular 3-5 mm diameter caliche, limestone, and sandstone pebbles at 384 feet	381.0 - 391.2
No core	391.2 - 392.4
Sand, same as unit at 226.0 - 245.0 feet. Very clayey. Pebbles at 392.4 - 394, 396, 398, and scattered throughout unit. Diameters from 1 mm - 1 cm. Clay blebs from 406 - 411 feet, clay content decreases from 411 - 217 feet, grading into light brown (5YR 5/6) sand	392.4 - 411.0
Sand, light brown (5YR 5/16), unconsolidated quartzose, medium to fine grained, clayey and/or calcareous zones, calcareous blebs. Calcareous zones are consolidated, cemented zones from 418 - 426 feet	411.0 - 435.2
No core	435.2 - 439.5
Sand, same as unit at 411.0 - 435.2 feet	439.5 - 442.5
No core	442.5 - 444.2
Sand, same as unit at 411.0 - 435.2 feet	444.2 - 460.2
No core	460.2 - 461.2
Sand, same as unit at 411.0 - 435.2 feet	461.2 - 480.0
No core	480.0 - 489.2
Sand, same as unit at 411.0 - 435.2 feet	489.2 - 498.3
No core	498.3 - 503.2
Sand, same as unit at 411.0 - 435.2 feet	503.2 - 523.7
No core	523.7 - 525.5

Table 3: lithologic log for borehole WIPP-15, cont.

Lithologic Description	Depth Interval feet
Sand, same as unit at 411.0 - 435.2 feet, light olive gray (5Y 3/4) sand and clay blebs and moderate brown (5YR 3/4) clay from 544.5 - 547.2 feet	525.5 - 547.2
Claystone, dark reddish brown (10R 3/4) to grayish red (5R 4/2), hard, silty, mottled with light bluish gray (5B 7/1) clay, and limonitic stained clay. Calcareous blebs from 550 - 554 feet. Gypsum vein at 554 feet. Limestone and clay pebbles at 557 feet	547.2 - 565.0
No core	565.0 - 569.0
Claystone, same as unit at 547.2 - 565.0 feet. Fractures and deformation, mottling from 569.0 - 573.0 feet. Calcareous zones and dessication features and fracture zones 591 - 594 feet. Calcite-filled fractures at 607 feet, grades down to medium gray (N5) claystones	569.0 - 640.5
Claystone, medium gray (N5) to dark reddish brown (10R 3/4), hard, silty, calcareous blebs, blebs of light bluish gray (5B 7/1) clay	640.5 - 658.0
No core	658.0 - 661.0
Claystone, same as unit at 547.2 - 565.0 feet, intra-formational pebble conglomerate with clay interbeds from 679 - 683 feet	661.0 - 706.0
Siltstone, light greenish gray (5G 8/1) banded with grayish red (10R 4/2), sandy, clayey, laminated, fractured and brecciated. Dips 10°	706.0 - 716.5
Claystone, grayish red (10R 4/2) and light greenish gray (5G 8/1), silty, laminated, calcareous blebs	716.5 - 722.0
Siltstone, grayish red (10R 4/2) to pale red (10R 6/2), clayey laminated, alternating w/bands of silty sandstone and claystone, calcareous zones and light greenish gray (5G 8/1) zones. Micaceous sand at 728 feet. Clay balls and lenses at 734 feet. Dip 10°	722.0 - 746.5

Table 3: lithologic log for borehole WIPP-15, cont.

Lithologic Description	Depth Interval feet
Conglomerate, grayish purple (5P 4/2), rounded limestone claystone, siltstone pebbles, graded up, .5 - .1 cm in diameter, calcareous cement; interbeds of light brownish gray (5YR 6/1) and light greenish gray (5G 8/1) silty clay	746.5 - 751.5
Sandstone, light brownish gray (5YR 6/1), cross bedded, calcareous cement, light bluish gray (5B 7/1) clayey silt at 757 feet, dips 20°	751.5 - 759.0
Claystone, moderate brown (5YR 3/4) to grayish red (10R 4/2), silty, calcareous in places, laminated, 15-20° dip. 1 cm thick zones of light bluish gray (5B 7/1) calcareous clay banded in moderate brown (5YR 3/4) clay, at 762 feet. Cross bedded, silty calcareous sand from 767.5 - 768.5 feet. Fault with 80° dip at 771 feet	759.0 - 781.0
Siltstone, some claystone, moderate reddish brown (10R 4/6), clayey, sandy, calcareous; light bluish gray (5B 7/1) reduced zones. Much faulting and fracturing	781.0 - 790.5
Sandstone, light brownish gray (5YR 6/1), fine to medium grained, moderately consolidated, cross bedded, some clay matrix. Dips 12-15°. Moderate brown (5YR 3/4) clay at 795.5 to 797 feet. Unconsolidated sand 797 - 798 feet, very calcareous zone at 803 feet	790.5 - 812.0

4.0 HYDROLOGIC DATA

by

Don D. Gonzalez

WIPP 15 was drilled in an effort to characterize a topographic depression referred to as "San Simon Sink" and to determine its relationship to deep dissolution and an understanding of the pluvial lake environment of San Simon Swale.

The stratigraphic section and final well completion for WIPP 15 is shown in Fig. 5.

The hole was drilled to a total depth of 810 feet into the Santa Rosa Sandstone, a major aquifer in southeast Texas, particularly along the Pecos River. Overlying the Santa Rosa Sandstone are about 225 feet of Triassic Chinle rocks consisting of silt and mudstones, not noted for capabilities to retain and/or yield water of appreciable quantities. The upper 555 feet of well was cased in Quaternary sands and clays; the casing was slotted from 445-540'. Water levels during drilling and completion were reported as about 100 feet below land surface.

Attempts to bail-test the hole produced insignificant results because of high yields and excessive in-flow of sands due to the lack of well development. A chemical analysis of water taken from WIPP 15 after 150 bails is shown on Table 4.

Table 4
Quality of Groundwater
WIPP 15
Quaternary Sands/Clays

Bailed Sample: March 12, 1979, @ 1400 hours

<u>Alkalinity (CaCO₃)</u> mg/l	<u>Hardness (CaCO₃)</u> mg/l	<u>Dissolved Calcium (Ca)</u> mg/l	<u>Dissolved Magnesium (Mg)</u> mg/l	<u>Dissolved Sodium (Na)</u> mg/l
810	420	35	81	300
<u>Dissolved Potassium (K)</u> mg/l	<u>Dissolved Sulphate (SO₄)</u> mg/l	<u>Dissolved Chloride (Cl)</u> mg/l	<u>Dissolved Fluoride (F)</u> mg/l	<u>Dissolved Sodium + Potassium (Na + K)</u> mg/l
19	170	93	2	320
<u>Dissolved Silica</u> mg/l	<u>Sodium Absorption Ratio</u>	<u>Specific Conductance</u> micro-mhos	<u>PH</u> not determined	<u>Temperature</u> Deg C
35	6.4	1900		18
<u>Dissolved Barium (Ba)</u> μg/l	<u>Dissolved Boron (B)</u> μg/l	<u>Dissolved Solids (TDS)</u> mg/l	<u>Dissolved gross alpha (natural Ur)</u> μg/l	<u>Dissolved gross-beta (Cs-137)</u> pC/l
200	1000	1220	< 23	27
<u>Dissolved radium-226 (radon method)</u> pC/l	<u>Dissolved Uranium (U)</u> μg/l			
0.21	0			

On October 9, 1979, WIPP 15 was tested using conventional aquifer pump-test methods for estimates of transmissivity in an unconfined aquifer. The saturated thickness was 430 feet of Quaternary sands and clays; there were no observation holes. The aquifer was pumped for 72 hours at a rate of 5.72 gallons per minute resulting in a maximum drawdown of 7.62 feet (Fig. 6). The drawdown portion of the test curve (Fig. 6) shows the effects of borehole storage and development (first 2-3 minutes) and the final rate of drawdown associated with the pump rate. The transmissibility calculated on the basis of late drawdown data was 323 feet squared per day. The recovery portion of the data, Fig. 7, typifies a normal recovery, the late portion of the curve indicating that time period where the aquifer is responding to the initial pumping stress as close to a natural condition as possible. The calculation of transmissibility resulting from late data, 616 feet squared per day, is the best estimate for the transmissive capabilities of this unconfined aquifer near the vicinity of WIPP 15.

The relatively high value for transmissibility and small amounts of drawdown versus pumping rate show that pumping could be sustained for long periods of time and certainly could fulfill domestic demands several fold. The water quality, as indicated by the analysis of a bailed sample, shows that water drained from this aquifer could be used for livestock and agriculture, and is marginal for domestic use. Hardness and total dissolved solids are slightly higher in concentration than normal domestic standards.

Figure 5. Stratigraphic and well completion diagram for WIPP 15, San Simon Sink

Figure 6 Plot of data collected during drawdown of WIPP-15 well test, October 19-22, 1979.

Figure 7. Plot of data collected during recovery of WIPP-15 well test, October 22-23, 1979.

5.0 REMARKS

Following the drilling and testing of WIPP 15, the borehole was turned over to the control of the rancher holding the lease in order that he might use the well, if desired, for watering stock. At the time of publication of this report, the well had not been produced. Production of water from WIPP 15 may have an effect on benchmarks in San Simon Sink; this will have to be accounted for in any future releveled of the lines.

WIPP 15 overlies the Capitan reef. It may be that the dissolution and collapse resulted from circulation of Capitan water. This has not been demonstrated for San Simon Sink, and the feature does not resemble either at the surface or in the subsurface the "breccia pipes" drilled in WIPP 16 and WIPP 31. The basic data reports for these latter boreholes have not yet been completed for comparison.

The basic conclusion from the fossil evidence (Bradbury, Appendix A) is that San Simon Sink was definitely a lake at one time, probably during the Tahoka Pluvial of about 20,000 to 10,000 years b.p. Certain species indicate an arid or perhaps very arid period following the pluvial and before the present arid climate was established. Other recent work on late Cenozoic climates for the area are Bachman (1980) and Widdicombe (1980).

6.0 BIBLIOGRAPHY

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APPENDIX A-1

Report on Quaternary Fossils from San Simon Sink,
Lea County, New Mexico¹

by

J. Platt Bradbury
Branch of Paleontology & Stratigraphy
U.S. Geological Survey

¹The report on referred fossils is reprinted with the approval of
J. P. Bradbury

REPORT ON REFERRED FOSSILS

1

STRATIGRAPHIC RANGE	Pleistocene to Holocene	SHIPMENT NUMBER	0-78-32-D
GENERAL LOCALITY	San Simon Sink, Carlsbad, New Mexico	REGION	Lea County
QUADRANGLE OR AREA	Oil Center, 15 minute quadrangle	DATE RECEIVED	12/07/78
KINDS OF FOSSILS	pollen, diatoms, ostracodes, Chara, plants	STATUS OF WORK	complete
REFERRED BY	R. Y. Anderson	DATE REPORTED	12/18/79
REPORT PREPARED BY	J. P. Bradbury		

97 samples from a core in San Simon Sink, Lea County, New Mexico (Figure 1) were received and checked for microfossil content. The location of the core was approximately in the center of the sink, about 500 m east and 850 m north of the southwest corner of Section 18, T23S, R35E, Oil Center 15 minute quadrangle, New Mexico. Seven additional samples, Woodwell Tank no. 1, Woodwell Tank no. 2, Pollen Trap 3-8/3-10 78, Pollen Trap 3-13/3-17 78, Pollen Trap 3-20/3-24 78 and two samples of Drilling Mud were studied for pollen content in order to evaluate the pollen stratigraphy of the core samples. After initial inspection, 40 samples were prepared for pollen analysis. 17 of these proved barren of pollen. All the samples were checked for the presence of ostracodes, CHARA, silicified or carbonized plant remains, and snails. Sixty-one samples were checked for the presence of diatoms. The analytical results of this study are presented in Tables 1 and 2, and in the following text.

SUMMARY OF ANALYTICAL PROCEDURES AND RESULTS

The modern pollen rain was determined by the analysis of two samples from Woodwell Tank, both of which contained sparse but reasonably well-preserved pollen and from three pollen trap samples. The pollen trap samples consisted of 25 cm squares of aluminum foil, coated with vaseline and taped to a doghouse roof 3 m above the ground at the drill site. After several days of exposure, the aluminum foil was removed and the vaseline rinsed off with xylene. The residue was washed in methyl alcohol and prepared by HCl, HF and acetolysis pollen-analytical procedures. The pollen trap samples contained abundant, well-preserved pollen. The exposure times for the three pollen trap samples were 8 III 1978 to 10 III 1978, 13 III 1978 to 17 III 1978, and 20 III 1978 to 24 III 1978, and represent a reasonably complete sampling of the early spring pollen rain in southern New Mexico. The Woodwell Tank samples presumably contain a longer modern pollen rain record although it is not known if the tank becomes dry seasonally, and how this might affect deposition of pollen. @

A-1-1

REPORT ON REFERRED FOSSILS

2

STRATIGRAPHIC
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Drilling mud was analyzed for pollen from dates representing the middle and end of the coring operation. Drilling mud from 17 III 1978, taken during the middle of the coring operation contained pollen and was assigned pollen sample number D5971. The mud sample from the end of the coring operation (30 III 1978) was barren of pollen.

Samples from the WIPP-15 core were processed for pollen using standard HCl, HF, acetolysis techniques. The pollen sum was approximately 200 grains excluding aquatics unless low pollen density precluded attaining this sum. In this case, all pollen grains on two 22 mm square coverslips were counted.

All the 97 samples of the core were examined under a binocular stereo microscope for calcareous microfossils (CHARA, ostracodes and snails) and for plant remains. The presence of diatoms in selected samples was determined by microscope examination of the powdered sediment immersed in index-of-refraction oil (1.7).

All samples below 66.2 m depth were barren of fossils. Well-preserved pollen and carbonized plant fragments were present in samples D6049-A and D6049-B, 66.2 and 65.6 m depth respectively, but above this depth the core was barren of all microfossils until 27.6 m depth where silicified plant remains became common. The lowest diatoms were found at a depth of 19.8 m; the lowest ostracodes and CHARA oospores at a depth of 16.6 m. The distribution of calcareous and siliceous microfossils in the upper 27.6 m of the core are presented in Table 2 and graphically in Figure 2. (See Figure 4 of Chapter 3.)

DISCUSSION

THE MODERN POLLEN RAIN

The natural vegetation of the Permian Basin is dominated by herbaceous plants, principally Gramineae, Chenopodiaceae and Amaranthaceae, and Compositae. There are local concentrations of shin or pygmy oaks (QUERCUS MOHRIANA) on sandy soils, particularly dune mantled areas, and of junipers (JUNIPERUS spp.) in rocky soils associated with escarpments and low cliffs such as are produced by the swales and sinks in this part of the basin. @

A-1-2

REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURVEY

X

3

STRATIGRAPHIC
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The modern pollen rain as represented by the pollen trap samples (Table 3) is clearly biased by the predominance of JUNIPERUS pollen that is produced in the early spring. The comparatively higher values of Chenopodiaceae-Amaranthaceae (Cheno-Am), Gramineae, and Compositae pollen in the Woodwell Tank samples suggest that they more accurately reflect the modern pollen rain on an annual basis because these plants bloom and pollinate in the mid-summer and fall of the year. Modern pollen spectra from the Llano Estacado are characterized by wide variability, but the two most abundant taxa are Compositae and Chenopodiaceae-Amaranthaceae (Oldfield and Schoenwetter, 1975, Hafsten, 1961), and the Woodwell Tank pollen spectra conform to this general pattern. They are distinctive because they contain somewhat larger percentages of QUERCUS pollen than is usual for the Llano Estacado. This may be a result of the numbers of pygmy oaks that grow on the sand dunes in the Los Medanos area west of San Simon Sink.

POLLEN STRATIGRAPHY IN THE LLANO ESTACADO

Between 1958 and 1963 several investigators have studied the pollen stratigraphy of late Quaternary playa lakes, spring-fed draws, and other basins in the Llano Estacado (Figure 2) in connection with archaeological excavations of paleoindian sites in west Texas and southeastern New Mexico. Thirteen sites, which together span the time beginning approximately 30,000 years ago and ending during the Altithermal (perhaps 5000 years ago) provide the baselines to interpret the fragmentary pollen record at San Simon Sink (Wendorf and Hester, 1975, Wendorf, 1961). As a result of these studies the pollen-climatic history of the Llano Estacado has been subdivided into "pluvial", "interpluvial", "subpluvial", "post pluvial" and related climatic episodes. The underlying concept for such divisions rests chiefly on the relative proportion of arboreal (mostly PINUS) pollen to non-arboreal (herb) pollen. Unfortunately these episodes are not well dated, and they are often so similar palynologically that correlation is difficult. In addition, the inherent variation in pollen profiles that results from differential pollen preservation and variable pollen input makes the detailed interpretations of the pollen record necessarily tentative (Schoenwetter, 1975, Oldfield, 1975, Oldfield and Schoenwetter, 1975). @

A-1-3

REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURVEY

4

STRATIGRAPHIC
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Nevertheless, at a more general level there are three diagnostic pollen zones that successively characterize the late Quaternary history of the Llano Estacado for the last 30,000 years. These are best expressed in the long and comparatively continuous profiles from Rich Lake, White Lake, and Illusion Lake in the west Texas panhandle (Figure 1).

The three principal climatic periods in the Llano Estacado have been designated by the names Pre Tahoka, Tahoka, and Post Tahoka (Wendorf, 1975). The Tahoka is a pluvial period, characterized by very high percentages of PINUS pollen and sparse records of PICEA pollen. The climate is presumed to have been both cooler and moister. Pine forests with some admixture of spruce covered the Llano and basins were filled with kales. The Tahoka Pluvial began approximately 17,000-18,000 years ago and may have ended as early as 14,000 years ago although the radiocarbon dating control is not considered adequate to completely describe this period (Oldfield, 1975). The Tahoka Pluvial is considered to generally coincide with at least part of the last full glacial, and by analyzing paleoenvironments from other dated localities in Texas, Wendorf (1975) has suggested that the Tahoka Pluvial may have lasted until the close of the Pleistocene, perhaps 10,000 years ago.

Before the Tahoka Pluvial the pollen records from the Llano Estacado indicate a comparatively long interval (17,000 - 30,000 years ago) dominated by ARTEMISIA pollen. PINUS pollen frequencies are generally low, although occasionally they are high enough to suggest pluvial conditions, and this zone has been subdivided on that basis (Oldfield and Schoenwetter, 1975). In general, however the paleoenvironmental picture is one of cold, arid conditions and extensive vegetative cover of sagebrush (Wendorf, 1975). This period has been subdivided into the Arch Lake Interpluvial, the Terry Subpluvial and the Rich Lake Interpluvial. @.

A-1-4

REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURVEY

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The post Tahoka period is characterized by a predominance of herbaceous pollen types, principally Chenopodiaceae, Amaranthaceae, Gramineae, and Compositae. PINUS pollen is generally low, seldom more than 20 percent, and ARTEMISIA pollen is of reduced importance, approaching modern values for this species. As in the earlier periods, the Post Tahoka has been subdivided on the basis of increased PINUS pollen values into comparatively moister episodes (subpluvials). For the most part, however, the climate of this period is closely comparable to that of the present. The post Tahoka period is generally terminated by erosional truncation in the Llano Estacado and the pollen records seldom extend to modern times. The hiatus is assumed to have occurred during the Altithermal when severe arid conditions reduced vegetation to a point that wind deflation excavated blowouts in old (Tahoka Pulvial) lake deposits. Radiocarbon age control for this event is scarce, but is estimated at between 5000 and 7000 years ago (Oldfield and Schoenwetter, 1975). The post Altithermal period is too poorly represented in the Llano Estacado to merit much discussion. The few pollen analyses available suggest a return to moister situations and generally modern climatic conditions.

POLLEN STRATIGRAPHY AT SAN SIMON SINK

The foregoing brief summary of the vegetation and suggested climatic history of the Llano Estacado, makes it possible to interpret the sparse pollen evidence from San Simon Sink (Figure 3, Table 1). The San Simon Sink sediments are often barren of pollen, but the marly silts and clays in the upper 10 m were regularly productive. Below that depth only two samples were productive enough to provide interpretable results.

The pollen stratigraphy of San Simon Sink (Figure 3, Table 1) can be divided into two zones. The uppermost zone (0.15 m to 10 m) is dominated by Cheno-Am and Compositae pollen and is generally similar to both local and regional modern pollen spectra and to pollen profiles of Holocene age from the Llano Estacado. This part of the San Simon Sink profile contains generally more ARTEMISIA pollen than the modern pollen spectra from the Llano. The ARTEMISIA pollen grains in this section are very degraded, and it is possible that they have been reworked from older deposits in San Simon Sink, or that their increased representation is a result of differential preservation which has selectively removed the more delicate pollen grains. @

REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURVEY

X

6

STRATIGRAPHIC
RANGESHIPMENT
NUMBER

0-78-32-Da

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREADATE
RECEIVEDKINDS OF
FOSSILSSTATUS
OF WORKREFERRED
BYDATE
REPORTEDREPORT
PREPARED BY

Despite the anomalously high ARTEMISIA content of the upper part of the San Simon Sink profile, there is little doubt that this section represents Holocene climatic conditions. Nevertheless, it is not inherently obvious how much of the Holocene is represented by this section. There are no radiocarbon dates and although the pollen profiles (Figure 3) show some systematic variation that might suggest that a climatic zoning is possible, there are not enough complete Holocene pollen profiles in the Llano Estacado to provide confident correlations. As essentially modern sample from Loving Salt Lake (Figure 1) (Hafsten, 1961) contains percentages of the major pollen types that are very close to the mean values of the upper San Simon Sink section (Table 3), and some additional evidence exists to suggest that the upper 10 m of the San Simon Sink sediment section represents only the post Altithermal position of the Holocene. First, although there are only a few records, the pre-Altithermal pollen profiles are often characterized by comparatively high PINUS pollen values; between 25 and 50 percent (Hafsten, 1961). Because of this the early Holocene (10,000 to 6,000 years ago) has been subdivided into two sub pluvial episodes, the San Jon Subpluvial and the Lubbock Subpluvial separated by a very brief interval of drier climate (Oldfield and Schoenwetter, 1975). The comparatively long and continuous pollen record of the upper sediments at San Simon Sink does not contain any samples with comparable PINUS percentages. Second, the San Simon Sink profile, especially in the basal 5 m, is distinguished by rather high percentages of EPHEDRA pollen. Hafsten (1961) considers EPHEDRA to be one of the most important pollen indicators of exceptionally arid climate, and the high EPHEDRA percentages at Crane Lake are interpreted as representing the most recent fill of this basin, accumulating after 6,000 years ago.

It is general consensus that during the Altithermal the Llano Estacado experienced very arid climates and that lacustrine deposition was replaced by active wind erosion and transportation forming blowouts and sand dunes in many areas of the region (Haynes, 1975). During this time it is unlikely that San Simon Sink was often the site of pond or lacustrine environments. It is possible that some deflation occurred, removing previously deposited sediments.

CONTINUED ON 0-78-32-Db a

A-1-6

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PALEONTOLOGY AND STRATIGRAPHY BRANCH.

REPORT ON REFERRED FOSSILS

1

STRATIGRAPHIC RANGE	Pleistocene to Holocene	SHIPMENT NUMBER	0-78-32-Db
GENERAL LOCALITY	San Simon Sink, Carlsbad, New Mexico	REGION	Lea County
QUADRANGLE OR AREA	Oil Center, 15 minute quadrangle	DATE RECEIVED	12/07/78
KINDS OF FOSSILS	pollen, diatoms, ostracodes, Chara, plants	STATUS OF WORK	complete
REFERRED BY	R. Y. Anderson	DATE REPORTED	12/18/78
REPORT PREPARED BY	J. P. Bradbury		

CONTINUED FROM 0-78-32-Da

At 13.1 m in the San Simon Sink sediment section rare PINUS pollen occurs in association with large numbers of the green alga, BOTRYOCOCCUS (Figure 3, Table 1). Although only PINUS pollen has been identified₂ from this level, they are so few in number (only 6 grains on 2 22 mm slides) that assignment of this sample to the Tahoka Pluvial climatic episode where PINUS pollen greatly dominates the lacustrine clays of the Llano Estacado, is speculative. The large numbers of BOTRYOCOCCUS testify to the existence of a freshwater lacustrine system in the sink, and this would seem a likely consequence of pluvial climates in the region, however.

Below 13.1 m the San Simon Sink sediments are barren of pollen until a depth of 66 m. At this level, two samples, 65.6 and 66.2 m contain a pollen assemblage that is dominated by ARTEMISIA pollen and large percentages of herbaceous pollen types. Analogues for this type of pollen assemblage in the Llano Estacado first appear during the Rich Lake Interpluvial, tentatively dated between 17,000 and 26,000 years ago (Haynes, 1975). Pollen is abundant and reasonably well preserved in these samples, and it seems reasonable to accept a correlation of these levels with the Rich Lake Interpluvial or perhaps the somewhat earlier Arch Lake Interpluvial (Olfield and Schoenwetter, 1975).

OTHER MICROFOSSILS FROM SAN SIMON SINK

The margins of San Simon Sink contain extensive outcrops of diatomaceous marls with gastropods, ostracodes, charophytes, and silicified plant remains, particularly sedges. Although the outcrops have not been extensively sampled, the following ecological and climatic information is available concerning these fossiliferous deposits.

Diatoms:

ACHNANTHES AFFINIS	10 percent
CYCLOTELLA MENEGHINIANA	2
CYMBELLA PUSILLA	11
DENTICULA ELEGANS	48
EPITHEMIA ARGUS	1
MASTOGLOIA SMITHII v. LACUSTRIS	1

D

A-1-7

REPORT NOT TO BE QUOTED OR PARAPHRASED IN PUBLICATION WITHOUT A FINAL RECHECK BY THE
PALEONTOLOGY AND STRATIGRAPHY BRANCH.

REPORT ON REFERRED FOSSILS

X

2

STRATIGRAPHIC
RANGEGENERAL
LOCALITYQUADRANGLE
OR AREAKINDS OF
FOSSILSREFERRED
BYREPORT
PREPARED BYSHIPMENT
NUMBER

0-78-32-0b

REGION

DATE
RECEIVEDSTATUS
OF WORKDATE
REPORTED

MASTOGLOIA ELLIPTICA v. DANSEI	1 percent
NAVICULA HALOPHILA v. SUBCAPITATA	4
NAVICULA OBLONGA	1
NAVICULA CRYPTOCEPHALA	4
NITZSCHIA SUBTILIS	4
NITZSCHIA OBTUSA v. SCHWEINFURTHII	3
NITZSCHIA AMPHIBIA	1
NITZSCHIA DENTICULA	1
RHOPALODIA GIBBA	3
SYNEDRA ACUS?	5

In addition to these dominants, the following species occurred in small numbers:

AMPHIPRORA PALUDOSA
 AMPHORA cf. VENETA
 ANOMOEONEIS COSTATA
 ANOMOEONEIS cf. VITREA v. LANCEOLATA
 CAMPYLODISCUS CLYPEUS
 COCCONEIS PALCENTULA
 CYMBELLA CYMBIFORMIS
 FRAGILARIA PINNATA
 FRAGILARIA BREVISTRIATA
 GOMPHONEMA AFFINE
 RHOPALODIA GIBBERULA
 SYNEDRA PUCHELLA
 SYNEDRA ULNA

This diatom flora is characteristic of alkaline, brackish water. All the species are either tolerant of moderate concentrations of dissolved solids, or prefer such environments. A close analog of this diatom assemblage can be found at Swimming Pool Spring, Sandoval Co., New Mexico which had a salinity of about 7 parts per thousand in 1928; many of the same species were also present in the brackish lake that existed at Zuni Salt Lake, Catron Co., New Mexico in the Late Pleistocene or Holocene. Both Swimming Pool Spring and Zuni Salt Lake are or were partly fed by mineralized springs issuing along the fault zones or through subterranean conduits and it seems possible that a similar situation existed at San Simon Sink, where ground water @

REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURV

3

STRATIGRAPHIC
RANGE

SHIPMENT
NUMBER

0-78-32-Db

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREA

DATE
RECEIVED

KINDS OF
FOSSILS

STATUS
OF WORK

REFERRED
BY

DATE
REPORTED

REPORT
PREPARED BY

dissolving subsurface evaporites could supply the necessary amounts of sodium, calcium, chlorine and sulfate ions to support the diatom flora.

Snails: This information was kindly provided by Art Metcalf, University of Texas, El Paso.

Sample A (sample without plant debris):

AQUATIC SPECIES:

Fossariform lymnaeid - 10 specimens
GYRAULUS PARVUS (Say) - 226
PHYSA VIRGATA Gould - 410

TERRESTRIAL SPECIES:

PUPILLA BLANDII Gould - 73

Sample A (sample with plant debris present. After counting out 200 G. PARVUS, I stopped. There were several hundred more plus some PHYSA in the sample)

AQUATIC SPECIES:

Fossariform lymnaeid cf. FOSSARIA MODICELLA (Say) - 2
GYRAULUS PARVUS - 200
PHYSA VIRGATA - 43

TERRESTRIAL SPECIES:

PUPILLA BLANDII - 31

Sample B

AQUATIC SPECIES:

Fossariform lymnaeid - 18
GYRAULUS PARVUS - 32
PHYSA VIRGATA - 165

TERRESTRIAL SPEICES:

Succineid shells, unidentifiable to species - 2
PUPILLA BLANDII - 1 @

A-1-9

REPORT ON REFERRED FOSSILS

10

U.S. GEOLOGICAL SURVEY

4

STRATIGRAPHIC
RANGE

SHIPMENT
NUMBER

0-78-32-Db

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREA

DATE
RECEIVED

KINDS OF
FOSSILS

STATUS
OF WORK

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BY

DATE
REPORTED

REPORT
PREPARED BY

I was a bit surprised at the lack of diversity in the fauna, compared to that encountered in some other deposits in southeastern New Mexico (such as George Bachman's fauna in Nash Draw). As you can see, the fauna is overwhelmingly aquatic. GYRAULUS PARVUS and PHYSA VIRGATA, as well as some FOSSARIA, tolerate a wide range of habitat situations. However, G. PARVUS is most commonly associated with lotic or slowly flowing waters and is almost always found associated with aquatic vegetation. Spring-fed pools should fill the bill nicely. Both G. PARVUS and P. VIRGATA occur in parts of New Mexico and Texas today, with P. VIRGATA widespread and G. PARVUS more restricted.

PUPILLA BLANDII is not found at lower elevations in southern New Mexico today, where it is restricted to montane areas above ca. 7,000 ft. elevation. In northeastern New Mexico it occurs in grasslands above some 6,000 feet, especially along creeks and pools. For example it occurs in tall grass bordering the small creek just west of Springer, Colfax County. I suspect that it has not occurred in the San Simon area during most of the Holocene.

Ostracodes and charophytes: Information provided by R. M. Forester, U.S.G.S.

WIPP-15 core, 17.2 m depth

LIMNOCYTHERE STAPLINI Gutentag & Benson, 1962
CYPRINOTUS (HETEROCYPRIS) GLAUCUS Furtos, 1933
Cyprididae, genus and species indeterminate (fragments)
CHARA HORNEMANII? Wallman, 1853

Plant layer, above main diatomite

LIMNOCYTHERE STAPLINI
CYPRINOTUS (HETEROCYPRIS) GLAUCUS
CANDONA COMPRESSA (Koch, 1838)
SCIRPUS seeds

@

A-1-10

REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURV

X

5

STRATIGRAPHIC
RANGE

SHIPMENT
NUMBER

0-78-32-Db

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREA

DATE
RECEIVED

KINDS OF
FOSSILS

STATUS
OF WORK

REFERRED
BY

DATE
REPORTED

REPORT
PREPARED BY

San Simon B, lateral equivalent to diatomite
LIMNOCYHERE STAPLINI
CYPRINOTUS (HETEROCYPRIS) GLAUCUS
POTAMOCYPRIS sp. indet.
CHARA HORNEMANII?

San Simon A VI marls below diatomite
LIMNOCYHERE STAPLINI
CYPRINOTUS (HETEROCYPRIS) GLAUCUS
CANDONA sp. (juveniles)
Cyprididae genus and species indeterminate
CHARA HORNEMANII?
CHARA sp. cf. CHARA CANESCENS

All the samples contain essentially the same ostracode fauna and charophyte flora, and although there are minor differences in the frequencies of species present, LIMNOCYHERE STAPLINI dominates in each sample. This ostracode is most commonly found in very shallow (less than 2 m depth) water that ranges in salinity from less than 1 o/oo to as much as 200 o/oo. It is a species that is often found in ponds or playa systems of arid regions where it hatches during the rainy season and breeds before the system dries up. We have found it in the salt marshes in Death Valley, California for example.

The subdominant ostracode, CYPRINOTUS (HETEROCYPRIS) GLAUCUS, lives in fresh to slightly saline water often within the range of 0.5 to 10 or 12 o/oo. I believe its presence with LIMNOCYHERE STAPLINI and the absence of a typical freshwater assemblage implies that this habitat had a salinity of about 3 to 10 o/oo, was very shallow (perhaps occasionally desiccating) and alkaline. Aquatic vegetation was locally abundant. The other ostracodes, present in low abundance, suggest the presence of freshwater (less than 3 o/oo) nearby and perhaps a cooler climate than present.

The same calcareous and siliceous microfossils sparsely occur in the WIPP-15 core samples to a depth of 27.6 m. Although the microfossils are often well preserved, they are never as common in the core as they are in the marginal outcrops of the sink. Several lines of evidence suggest that at least some of these fossils have been reworked from the marginal outcrops into the center of the sink where the core was taken after a phase of collapse that deepened the basin. @

REPORT ON REFERRED FOSSILS

PALEONTOLOGICAL SURVEY

X

6

STRATIGRAPHIC
RANGE

SHIPMENT
NUMBER

0-78-32-0b

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREA

DATE
RECEIVED

KINDS OF
FOSSILS

STATUS
OF WORK

REFERRED
BY

DATE
REPORTED

REPORT
PREPARED BY

The greatest abundance of microfossils occurs in the upper 10 m of the core where they are associated with a Holocene pollen assemblage. The best paleoenvironmental information that relates to the diatomaceous marls comes from the presence of PUPILLA BLANDII which Metcalf indicates is restricted to cool, moist environments above 7,000 feet in this part of New Mexico today. If this type of habitat applies generally to the diatomaceous marls on the sink margins, then it should also apply to the occurrence of the same microfossils in the WIPP-15 core. Such an environment existed on the Llano Estacado during the Tahoka Pluvial, tentatively dated between 13,000 and 20,000 years ago (HAYNES, 1975), and probably correlating with the terminal Wisconsin glacial event. Pollen evidence for the Tahoka Pluvial on the Llano Estacado consists of an extreme dominance of coniferous arboreal pollen (spruce and pine) that suggests a depression of vegetation zones of about 4000 feet (Oldfield and Schoenwetter, 1975). San Simon Sink (elevation 3300 feet) would have had an environment analogous to elevations in southern New Mexico of about 7,000 feet. The pollen assemblage in the core however, indicates a Holocene age and is in conflict with the assumed environmental conditions relating to the calcareous and siliceous microfossils. A radiocarbon date on the snails from the marginal diatomaceous marls of 20,520 years BP is consistent with their environmental interpretation, and it seems quite probable that at least the top 10 m of the WIPP-15 core consists largely of reworked Tahoka Pluvial lake or pond sediments that were redeposited during the Holocene.

It is curious that with the exception of one sparse pollen sample that merits only speculative interpretation (13.1 m) there is no pollen evidence of the Tahoka Pluvial climate in the WIPP-15 core. Perhaps the sparse representation of calcareous and siliceous microfossils between 10 and 27.6 m were deposited in place during this period of time. They are so sparse, however, and often in very sandy lithologies, that it is difficult to imagine they were deposited by normal lacustrine depositional processes.

CONTINUED ON 0-78-32-0c @

A-1-12

REPORT ON REFERRED FOSSILS

1

STRATIGRAPHIC RANGE	Pleistocene to Holocene	SHIPMENT NUMBER	0-78-32-Dc
GENERAL LOCALITY	San Simon Sink, Carlsbad, New Mexico	REGION	Lea County
QUADRANGLE OR AREA	Oil Center, 15 minute quadrangle	DATE RECEIVED	12/07/78
KINDS OF FOSSILS	pollen, diatoms, ostracodes, Chara, plants	STATUS OF WORK	complete
REFERRED BY	R. Y. Anderson	DATE REPORTED	12/18/79
REPORT PREPARED BY	J. P. Bradbury		

CONTINUED FROM 0-78-32-Db

Under pluvial environments, the center of the sink should have been filled with fine-grained clayey marls, which would have likely contained pollen. Perhaps the pollen, and many of the calcareous and siliceous microfossils were deposited in this way during the Tahoka Pluvial but were subsequently destroyed by solution and oxidation accompanying post Tahoka collapse events. It is also possible that the San Simon basin that existed during Tahoka time was sufficiently offset from the sink center that exists today that the spot where the WIPP-15 core was taken was outside the area of normal lacustrine deposition. A third possibility is that during the Tahoka Pluvial San Simon Sink was an active limnokrene from which water flowed away from the spring pool itself. In such a situation, fine sediment containing pollen and other microfossils might not accumulate in the center of the spring but be restricted to the marginal areas where shallow water and emergent vegetation reduced the flow enough for fossiliferous deposits to build up. The considerably increased precipitation associated with the Tahoka Pluvial (Oldfield and Schoenwetter, 1975) may have been partly responsible for the development of a limnokrene at San Simon Sink. A limnokrene environment is consistent with the abundance of GYRALUS PARVUS reported by Metcalf and with the diatom association, although the diatoms are not restricted to such environments.

At the time the diatomaceous marls accumulated on the present margins of the sink, San Simon Sink may have been higher than at present and the water could have flowed along San Simon Swale to the southeast. The presence of diatomaceous marls nearly 25 m above the modern playa floor suggests this possibility, although it is difficult to reach firm conclusions about the Pleistocene topography of the sink and swale because there has been so much recent collapse. @

A-1-13

REPORT ON REFERRED FOSSILS

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2

STRATIGRAPHIC
RANGESHIPMENT
NUMBER

0-78-32-Dc

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREADATE
RECEIVEDKINDS OF
FOSSILSSTATUS
OF WORKREFERRED
BYDATE
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PREPARED BY

Unfortunately the available information about the WIPP-15 core and the marginal deposits in San Simon Sink does not make it easy to refine the paleolimnological interpretation and to choose between the three possible alternatives outlined above. It is nevertheless clear that during the Tahoka Pluvial, perhaps as recently as 10,000 years ago (Wendorf, 1975) and certainly after 20,000 years ago, San Simon Sink was filled with water. Filling was probably partly a result of normal increases in precipitation and runoff associated with cooler and moister climates, and partly from inflow from subterranean aquifers under hydrostatic pressure. The Permian reef complex beneath the sink is a good candidate for such an aquifer.

The direct and indirect relationship between pluvial climates, hydrology, and dissolution of underlying Permian salt beds have important implications regarding the integrity of this area for storage of nuclear wastes.

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A-1-14

REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURVEY

X

3

STRATIGRAPHIC
RANGE

SHIPMENT
NUMBER

0-78-32-Dc

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREA

DATE
RECEIVED

KINDS OF
FOSSILS

STATUS
OF WORK

REFERRED
BY

DATE
REPORTED

REPORT
PREPARED BY

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A-1-15

REPORT ON REFERRED FOSSILS

16

U.S. GEOLOGICAL SURVEY

X

4

STRATIGRAPHIC
RANGE

SHIPMENT
NUMBER

0-78-32-Dc

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREA

DATE
RECEIVED

KINDS OF
FOSSILS

STATUS
OF WORK

REFERRED
BY

DATE
REPORTED

REPORT
PREPARED BY

Sample No.	D-5966	D-5967	Pollen trap
Depth or location	Woodwell Tank no. 1 109 grains	Woodwell Tank no. 2 130 grains	3-8/3-10 78 211 grains
Pollen			
PINUS	5	4	1
EPHEDRA	-	-	-
JUNIPERUS	5	5	52
QUERCUS	14	15	7
Compositae	30.5	23	20.5
ARTEMISIA	7	2	2
Cheno Ams	25	22	8
Gramineae	8	10	6
ULMUS	2	0.8	1.5
TAMARIX	-	-	-
ERIOGONUM	1	-	-
PROSOPIS	1	6	-
TYPHA	-	0.8	-
JUGLANS	-	0.8	-
Labiatae	-	1.5	-
BETULA	-	0.8	0.5
ALNUS	-	-	-
SALIX	-	0.8	1
CELTIS	-	-	0.5
Polygonaceae	-	-	0.5
Malvaceae	-	-	0.5
CARYA	-	-	-
Liliaceae	-	-	-
Moraceae	-	-	-
ALTERNANTHERA	-	-	-
Algae			
PEDIASTRUM	-	0.8	-
BOTYROCOCCUS	-	-	- a

A-1-16

REPORT ON REFERRED FOSSILS

5

STRATIGRAPHIC
RANGE

GENERAL
LOCALITY

QUADRANGLE
OR AREA

KINDS OF
FOSSILS

REFERRED
BY

REPORT
PREPARED BY

SHIPMENT
NUMBER

0-78-32-Dc

REGION

DATE
RECEIVED

STATUS
OF WORK

DATE
REPORTED

Sample No.

D5969

D5970

D5971

Depth or location

Pollen Trap

Pollen Trap

Drilling
Mud

3-13/3-17 78
210 grains

3-20/3-24 78
210 grains

17 III 1978
45 grains

Pollen

PINUS
EPHEDRA
JUNIPERUS
QUERCUS
Compositae
ARTEMISIA
Cheno-Am
Gramineae
ULMUS
TAMARIX
ERIOGONUM
PROSOPIS
TYHPA
JUGLANS
Labiateae
BETULA
ALNUS
SALIX
CELTIS
Polygonaceae
Malvaceae
CARYA
Liliaceae
Moraceae
ALTERNANTHERA

7
2
27
15
21
4
14
3.5
4
0.5
-
-
-
-
-
-
-
-
0.5
-
-
-
0.5
0.5
0.5
-
-

3.3
-
59
5
16
1.4
4.3
2.4
6
1
-
-
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-
0.5
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11
2
2
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22
13
26
18
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4
-
-

Algae

PEDIASTRUM
BOTYROCOCCLUS @

A-1-17

REPORT ON REFERRED FOSSILS

6

STRATIGRAPHIC
RANGE

GENERAL
LOCALITY

QUADRANGLE
OR AREA

KINDS OF
FOSSILS

REFERRED
BY

REPORT
PREPARED BY

SHIPMENT
NUMBER

0-78-32-Dc

REGION

DATE
RECEIVED

STATUS
OF WORK

DATE
REPORTED

Sample no.	D6049-Q	D6049-P	D6049-O	D6049-N	D6049-M
Depth or location	0.15 m 211 gr.	0.64 m 200 gr.	1.2 m 204 gr.	2.2 m 86 gr.	3.0 m 206 gr.
Pollen					
PINUS	12	13	18.5	3	10
EPHEDRA	1	2.5	2	1	3.5
JUNIPERUS	4	5.5	2.5	-	0.5
QUERCUS	5	2	5	2	9
Compositae	21	27.5	29	29	20.5
ARTEMISIA	11	9	8	22	15
Cheno-Ams	26	26.5	18.5	12	21
Gramineae	9	8	14	28	19
ULMUS	0.5	-	-	-	-
TAMARIX	-	-	-	-	-
ERIOGONUM	-	-	-	-	-
PROSOPIS	-	-	-	-	-
TYPHA	-	-	-	-	1
JUGLANS	-	-	-	-	-
Labiatae	0.5	-	-	-	-
BETULA	-	-	0.5	-	-
ALNUS	-	-	0.5	-	-
SALIX	1	-	1	-	-
CELTIS	-	-	-	-	-
Polygonaceae	0.5	1	1.5	-	-
Malvaceae	-	0.5	-	-	-
CARYA	-	-	-	-	-
Liliaceae	3	2.5	0.5	2	-
Moraceae	0.5	-	-	-	-
ALTERNANTHERA	1	-	0.5	-	1
Algae					
PEDIASTRUM	-	-	-	-	-
BOTYROCOCCLUS	3	2	1	1	2

CONTINUED ON 0-78-32-Dd @

A-1-18

REPORT NOT TO BE QUOTED OR PARAPHRASED IN PUBLICATION WITHOUT A FINAL RECHECK BY THE
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REPORT ON REFERRED FOSSILS

19

U.S. GEOLOGICAL SURVEY

1

STRATIGRAPHIC RANGE	Pleistocene to Holocene	SHIPMENT NUMBER	0-78-32-Dd
GENERAL LOCALITY	San Simon Sink, Carlsbad, New Mexico	REGION	Lea County
QUADRANGLE OR AREA	Oil Center, 15 minute quadrangle	DATE RECEIVED	12/07/78
KINDS OF FOSSILS	pollen, diatoms, ostracodes, Chara, plants	STATUS OF WORK	complete
REFERRED BY	R. Y. Anderson	DATE REPORTED	12/18/79
REPORT PREPARED BY	J. P. Bradbury		

CONTINUED FROM 0-78-32-Dc

Sample no.	D6049-L	D6049-K	D6049-J	D6049-I
	4.7 m	5.1 m	5.6 m	6.2 m
Depth or location	209 grains	183 grains	207 gr.	196 gr.
Pollen				
PINUS	5.5	11	6	5
EPHEDRA	4.5	4	11	9
JUNIPERUS	1	0.5	1	0.5
QUERCUS	4	7	1	3.5
Compositae	30.5	20.5	23.5	28.5
ARTEMISIA	14	9	11	12.5
Cheno-Ams	20	24	25	16.5
Gramineae	18	14	18	18
ULMUS	-	-	-	-
TAMARIX	-	-	-	-
ERIOGONUM	-	-	-	-
PROSOPIS	-	-	-	-
TYPHA	-	-	-	-
JUGLANS	1	-	4	-
Labiatae	-	-	-	1
BETULA	-	-	-	-
ALNUS	-	-	-	-
SALIX	-	-	-	-
CELTIS	-	-	-	1.5
Polygonaceae	1.5	1	-	-
Malvaceae	-	-	-	-
CARYA	-	-	-	-
Liliaceae	-	-	-	1
Moraceae	-	-	-	-
ALTERNANTHERA	1	0.5	-	0.5
Algae				
PEDIASTRUM	-	1	8	-
BOTYROCOCCLUS	-	-	-	a

A-1-19

REPORT NOT TO BE QUOTED OR PARAPHRASED IN PUBLICATION WITHOUT A FINAL RECHECK BY THE PALEONTOLOGY AND STRATIGRAPHY BRANCH.

REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURVEY

X

2

STRATIGRAPHIC
RANGESHIPMENT
NUMBER

0-78-32-dd

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREADATE
RECEIVEDKINDS OF
FOSSILSSTATUS
OF WORKREFERRED
BYDATE
REPORTEDREPORT
PREPARED BY

Sample no.	D6049-H	D6049-G	D6049-F	D6049-E
	6.9 m	7.1 m	8.1 m	9.1 m
Depth or location	100 grains	198 grains	206 gr.	200 grains
Pollen				
PINUS	7	3.5	3	9
EPHEDRA	3	7.5	3.5	8.5
JUNIPERUS	-	-	2.5	1
QUERCUS	6	1	4	3.5
Compositae	37	29	23	26
ARTEMISIA	4	12	14	10
Clematis	15	13	14	13.5
Gramineae	27	31	32.5	26.5
ULMUS	-	-	0.5	-
TAMARIX	-	-	-	-
ERIOGONUM	-	-	-	-
PROSOPIIS	-	-	-	-
TYPHA	-	-	-	-
JUGLANS	-	-	-	-
Labiatae	-	-	-	-
BETULA	-	-	-	-
ALNUS	-	-	-	-
SALIX	-	-	-	-
CELTIS	-	-	-	-
Polygonaceae	-	-	0.5	-
Malvaceae	-	-	-	-
CARYA	-	-	-	-
Liliaceae	1	1	-	1
Moraceae	-	-	-	-
ALTERNANTHERA	-	-	0.5	0.5
Algae				
PEDIASTRUM	-	3	7	3
BOTYROCOCBUS	-	-	-	0

A-1-20

REPORT ON REFERRED FOSSILS

21

U.S. GEOLOGICAL SURVEY

X

3

STRATIGRAPHIC
RANGE

SHIPMENT
NUMBER

0-78-32-Dd

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREA

DATE
RECEIVED

KINDS OF
FOSSILS

STATUS
OF WORK

REFERRED
BY

DATE
REPORTED

REPORT
PREPARED BY

Sample no.	D6049-D	D6049-C	D6049-B	D6049-A
	10.1 m	13.1 m	65.6 m	66.2 m
Depth or location	206 grains	6 grains	206 gr.	267 grains
Pollen				
PINUS	3	100	3.5	4
EPHEDRA	11	-	-	0.3
JUNIPERUS	2	-	4	9
QUERCUS	2	-	0.5	1
Compositae	23	-	18	9
ARTEMISIA	14	-	31	46
Cheno-Ams	27	-	15	6
Gramineae	18	-	26	20
ULMUS	-	-	-	1.5
TAMARIX	-	-	-	-
ERIOGONUM	-	-	-	-
PROSOPIS	-	-	-	-
TYPHA	-	-	-	-
JUGLANS	-	-	-	0.3
Labiataeae	-	-	-	-
BETULA	0.5	-	-	-
ALNUS	-	-	-	-
SALIX	-	-	-	-
CELTIS	-	-	-	-
Polygonaceae	-	-	-	-
Malvaceae	-	-	-	-
CARYA	-	-	-	-
Liliaceae	0.5	-	-	-
Moraceae	-	-	-	-
ALTERNANTHERA	0.5	-	0.5	-
Algae				
PEDIASTRUM				
BOTYROCOCCUS	27	198 @		

A-1-21

REPORT ON REFERRED FOSSILS

X

4

STRATIGRAPHIC
RANGE

GENERAL
LOCALITY

QUADRANGLE
OR AREA

KINDS OF
FOSSILS

REFERRED
BY

REPORT
PREPARED BY

SHIPMENT
NUMBER

0-78-32-Dd

REGION

DATE
RECEIVED

STATUS
OF WORK

DATE
REPORTED

DISTRIBUTION OF MICROFOSSILS IN SAN SIMON SINK CORE, WIPP-15

depth in meters

0.15 0.64 1.1 1.6 2.2 2.6 3.0 4.7 5.1 5.6

Diatoms

AMPHORA COFFAEIFORMIS								+	
AMPHORA sp. cf. A. HYALINA						+	+		
ANOMOEONEIS COSTATA					+	+			
A. SPHAEROPHORA			+	+					+
CAMPYLODISCUS CLYPEUS			+	+		+		+	
COCCONEIS PLACENTULA					+				
CYCLOTELLA MENEGHINIANA					+				
CYMBELLA PUSILLA									+
DENTICULA ELEGANS	+	+	+	+	+	+	+	+	+
EPITHEMIA ADNATA			+				+	+	
E. ARGUS	+	+	+	+	+	+	+	+	+
FRAGILARIA									
BREVISTRIATA	+	+	+		+	+	+		+
F. CONSTRUENS v.									
SUBSALINA								+	
F. CONSTRUENS v. VENTER								+	
F. VIRESCENS									
MASTOGOLIA BRAUNII								+	
M. ELLIPTICA								+	
NITZSCHIA spp.			+		+		+		
PINNULARIA MICRO-									
STARURON	+			+					
RHOPALODIA GIBBA				+		+			
R. GIBBERULA			+			+	+		+

CHARA

Ostracodes

CANDONA sp.							+		
CYPRIDEIS sp.								+	
LIMNOCYTHERE STAPLINI							+		

Snails

Plant remains

A-1-22

REPORT ON REFERRED FOSSILS

X

5

STRATIGRAPHIC
RANGESHIPMENT
NUMBER

0-78-32-Dd

GENERAL
LOCALITY

REGION

QUADRANGLE
OR AREADATE
RECEIVEDKINDS OF
FOSSILSSTATUS
OF WORKREFERRED
BYDATE
REPORTEDREPORT
PREPARED BY

DISTRIBUTION OF MICROFOSSILS IN SAN SIMON SINK CORE, WIPP-15

depth in meters

	6.2	6.9	7.1	7.6	8.1	8.6	9.1	9.6	10.1	10.6
Diatoms										
AMPHORA COFFAEIFORMIS										
AMPHORA sp. cf. A. HYALINA										
ANOMOEONEIS COSTATA					+					
A. SPHAEROPHORA										
CAMPYLODISCUS CLYPEUS										
COCCONEIS PLACENTULA										
CYCLOTELLA MENEGHINIANA										
CYMBELLA PUSILLA										
DENTICULA ELEGANS	+		+							
EPITHEMIA ADNATA										
E. ARGUS		+	+				+			
FRAGILARIA										
BREVISTRIATA		+								
F. CONSTRUENS v. SUBSALINA										
F. CONSTRUENS v. VENTER										
F. VIRESCENS										
MASTOGOLIA BRAUNII										
M. ELLIPTICA										
NITZSCHIA spp.										
PINNULARIA MICROSTAUON										
RHOPALODIA GIBBA										
R. GIBBERULA										
CHARA										+
Ostracodes										
CANDONA sp.										
CYPRIDEIS sp.							+			
LIMNOCYTHERE STAPLINI										+
Snails										+
Plant remains							+	@		

A-1-23

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REPORT ON REFERRED FOSSILS

U.S. GEOLOGICAL SURVEY

X

6

STRATIGRAPHIC
RANGE

GENERAL
LOCALITY

QUADRANGLE
OR AREA

KINDS OF
FOSSILS

REFERRED
BY

REPORT
PREPARED BY

SHIPMENT
NUMBER

0-78-32-Dd

REGION

DATE
RECEIVED

STATUS
OF WORK

DATE
REPORTED

DISTRIBUTION OF MICROFOSSILS IN SAN SIMON SINK CORE, WIPP-15

depth in meters

11.1 11.6 12.1 12.6 13.1 13.6 14.1 14.7 15.1

Diatoms

AMPHORA COFFAEIFORMIS
AMPHORA sp. cf. A. HYALINA
ANOMOEONEIS COSTATA
A. SPHAEROPHORA
CAMPYLODI3CU3 CLYPEUS
COCCONEIS PLACENTULA
CYCLOTELLA MENEHINIANA
CYMBELLA PUSILLA
DENTICULA ELEGANS
EPITHEMIA ADNATA
E. ARGUS
FRAGILARIA
BREVISTRIATA +
F. CONSTRUENS v. SUBSALINA
F. CONSTRUENS v. VENTER
F. VIRESCENS +
MASTUGLOIA BRAUNII
M. ELLIPTICA
NITZSCHIA spp. +
PINNULARIA MICROSTAUON
RHOPALODIA GIBBA

CHARA + + +

Ostracodes + + + + +
CANDONA sp. +
CYPRIDEIS sp.
LIMNOCYTHERE
STAPLINI +

Snails + + +

Plant remains

CONTINUED ON 0-78-32-De @

REPORT ON REFERRED FOSSILS

X

1

STRATIGRAPHIC
RANGE

Pleistocene to Holocene

GENERAL
LOCALITY

San Simon Sink, Carlsbad, New Mexico

QUADRANGLE
OR AREA

Oil Center, 15 minute quadrangle

KINDS OF
FOSSILS

pollen, diatoms, ostracodes, Chara, plants

REFERRED
BY

R. Y. Anderson

REPORT
PREPARED BY

J. P. Bradbury

SHIPMENT
NUMBER

0-78-32-De

REGION

Lea County

DATE
RECEIVED

12/07/78

STATUS
OF WORK

complete

DATE
REPORTED

12/18/79

CONTINUED FROM 0-78-32-Dd

DISTRIBUTION OF MICROFOSSILS IN SAN SIMON SINK CORE, WIPP-15

	depth in meters							
	15.6	16.2	16.6	17.1	17.6	18.1	18.6	19.2 19.6
Diatoms								
AMPHORA COFFAEIFORMIS			+					
AMPHORA sp. cf. A. HYALINA								
ANOMOEONEIS COSTATA		+	+					
A. SPHAEROPHORA								
CAMPYLODISCUS CLYPEUS								
COCCONEIS PLACENTULA								
CYCLOTELLA MENEHINIANA								
CYMBELLA PUSILLA								
DENTICULA ELEGANS		+	+					
EPITHEMIA ADNATA								
E. ARGUS		+	+					
FRAGILARIA BREVISTRIATA								
F. CONSTRUENS v. SUBSALINA								
F. CONSTRUENS v. VENTER								
F. VIRESCENS								
MASTOGLOIA BRAUNII		+						
M. ELLIPTICA								
NITZSCHIA spp.		+						
PINNULARIA MICROSTAUON								
RHOPALODIA GIBBA								
R. GIBBERULA								
CHARA	+	+	+					
Ostracodes								
CANDONA sp.	+							
CYPRIDEIS sp.								
LIMNOCYthere STAPLINI		+	+					
Snails								
Plant remains					+	+	+	+

a

A-1-25

REPORT ON REFERRED FOSSILS

20

U.S. GEOLOGICAL SURVEY

2

STRATIGRAPHIC
RANGE

GENERAL
LOCALITY

QUADRANGLE
OR AREA

KINDS OF
FOSSILS

REFERRED
BY

REPORT
PREPARED BY

SHIPMENT
NUMBER

0-78-32-De

REGION

DATE
RECEIVED

STATUS
OF WORK

DATE
REPORTED

DISTRIBUTION OF MICROFOSSILS IN SAN SIMON SINK CORE, WIPP-15

	depth in meters								
	19.8	22.1	22.6	22.8	23.6	24.6	25.6	26.6	27.6
Diatoms									
AMPHORA COFFAEIFORMIS									
AMPHORA sp. cf. A.									
HYALINA			+						
ANOMOEONEIS COSTATA									
A. SPHAEROPHORA									
CAMPYLODISCUS CLYPEUS									
COCCONEIS PLACENTULA									
CYCLOTELLA MENEGHINIANA									
CYMBELLA PUSILLA									
DENTICULA ELEGANS									
EPITHEMIA ADNATA									
E. ARGUS			+						
FRAGILARIA BREVISTRIATA									
F. CONSTRUENS v. SUBSALINA									
F. CONSTRUENS v. VENTER									
F. VIRESCENS									
MASTOGOLIA BRAUNII									
M. ELLIPTICA									
NITZSCHIA spp.									
PINNULARIA MICROSTAURON									
RHOPALODIA GIBBA			+						
R. GIBBERULA									

CHARA

Ostracodes

CANDONA sp.

CYPRIDEIS sp.

LIMNOCYthere STAPLINI

Snails

Plant remains

+ + + + + + + + +

@

A-1-26

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REPORT ON REFERRED FOSSILS

X

3

STRATIGRAPHIC
RANGE

GENERAL
LOCALITY

QUADRANGLE
OR AREA

KINDS OF
FOSSILS

REFERRED
BY

REPORT
PREPARED BY

SHIPMENT
NUMBER

0-78-32-De

REGION

DATE
RECEIVED

STATUS
OF WORK

DATE
REPORTED

	Woodwell Tank			Loving Salt Lake Eddy Co. New Mexico	Pollen traps, March 1978			
	1	2	$\bar{X}$		8-10	13-17	20-24	$\bar{X}$
PINUS	5	4	4.5	12.5	1	7	3.3	3.8
ephedra	0	4	0	3.0	0	2	0	0.7
EPHEDRA								
JUNIPERUS	5	5	5	-	52	27	59	46
QUERCUS	14	15	14.5	3.0	7	15	5	9
Compositae	30.5	23	26.7	18.0	20.5	21	16	19.2
ARTEMISIA	7	2	4.5	5.5	2	4	1.4	2.5
Cheno-Ams	25	22	23.5	31.0	8	14	4.3	8.8
Gramineae	8	10	9	26.0	6	3.5	2.4	4
pollen sum	109	130		201	211	210	210	

Table 3. Percentage values of dominant pollen types in stock tank and pollen trap samples, San Simon Sink, Lea County, New Mexico. The sample from Loving Salt Lake, Eddy Co., New Mexico was taken below a 55 cm salt crust (Hafsten, 1961) and represents essentially modern conditions. This locality is 57 km west of San Simon Sink. @

J. Platt Bradbury
J. Platt Bradbury

A-1-27

Figure 1. Index map of the Llano Estacado, modified from Appendix A. 1. San Simon Sink, 2. Loving Salt Lake, 3. White Lake, 4. Illusion Lake, 5. Rich Lake.

Figure 3. Pollen diagram from the upper 10 meters of San Simon Sink, Lea County, New Mexico.

APPENDIX A-2

Radiocarbon Age Determination

Report of Analytical Work

by

Krueger Enterprises, Inc.
Geochron Laboratories Division

KRUEGER ENTERPRISES, INC.

GEOCHRON LABORATORIES DIVISION

24 BLACKSTONE STREET • CAMBRIDGE, MA. 02139 • (617)-876-3691

RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-5878

Date Received: 5 October 1978

Your Reference: letter of 2 October 1978

Date Reported: 19 December 1978

Submitted by: Roger Y. Anderson
Department of Geology
The University of New Mexico
Albuquerque, NEW MEXICO 87131

Sandia Labs. Req. No. 13-4403

Sample Name: WIPP Site, N.Mexico. North side of San Simon Sink. Sample A. Shells.

AGE = 20,570 $\pm$ 540 C-14 years B.P. (C-13 corrected)

Description: Sample of gastropod shells: Physa sp., Lymnaea sp., Helisoma sp.

Pretreatment: No pretreatment due to fragile nature of shells.

Comment:

$\delta C_{PDB}^{13} = -4.2$ ‰

Notes: This date is based upon the Libby half life (5570 years) for C^{14} . The error stated is $\pm 1 \sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

KRUEGER ENTERPRISES, INC.

GEOCHRON LABORATORIES DIVISION

24 BLACKSTONE STREET • CAMBRIDGE, MA. 02139 • (617) - 876 - 3691

RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-5879

Date Received: 5 October 1978

Your Reference: letter of 2 October 1978

Date Reported: 19 December 1978

Submitted by: Roger Y. Anderson
Department of Geology
The University of New Mexico
Albuquerque, NEW MEXICO 87131

Sandia Labs. Req. No. 13-4403

Sample Name: WIPP Site, N.Mexico. North side of San Simon Sink. Sample B. Oogonia.

AGE $\approx$ Greater than 32,000 C-14 years B.P.

Description: Sample of Charophyte oogonia.

Pretreatment: No pretreatment due to fragile nature of shells.

Comment:

$\delta C_{PDB}^{13} = -3.7$ ‰

Notes: This date is based upon the Libby half life (5570 years) for C^{14} . The error stated is $\pm 1 \sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

APPENDIX B

Drilling and Testing Plan

by

R. O. Statler, 1133

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date: February 17, 1978

to: Distribution

from:
R. D. Statler, 1133

subject: WIPP Nos. 15 & 17 Drilling Program, Schedule and Coring Plan

The exploratory holes designated as WIPP No. 15 and WIPP No. 17 are scheduled to be drilled in early spring 1978, commencing with WIPP No. 15 on approximately March 27, 1978. WIPP No. 17 will be drilled immediately following WIPP No. 15.

The enclosed document describes the drilling plan, schedule and coring plan as they are presently understood.

PDSeward:1135:jh

Distribution w/enclosures:

D. Davis, Jr., DOE/ALO, Albuquerque, N. M.
R. Y. Anderson, UNM, Geology Dept., Albuquerque, N. M.
J. W. Mercer, USGS/WRD, Albuquerque, N. M.
E. Shuter, USGS/WRD, Denver, Co.
R. E. Ashlock, F&S, Las Vegas, NV
W. E. Cunningham, F&S, Carlsbad, N. M. (3)
1130 H. E. Viney
1135 P. D. Seward
1135 J. E. Magruder
5311 L. R. Hill
5311 D. W. Powers (3)
5311 S. J. Lambert
5311 Archives (2)
5342 J. W. McKiernan
9512 F. L. McFarling
1133 R. D. Statler (5)

WIPP NOS. 15 & 17
DRILLING PLAN SCHEDULE
AND TEST PLANS

A. OBJECTIVE

The exploratory holes designated as WIPP 15 and WIPP 17 will be drilled in early spring 1978. WIPP No. 15 is located in the SW $\frac{1}{4}$ of the NW $\frac{1}{4}$ of Section 18, T23S, R35E, Lea County, New Mexico. WIPP No. 17 is located in the NW $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Section 2, T23S, R34E, Lea County, New Mexico.

The purpose of these two holes will be to extract continuous small diameter core from the surface to the depth at which solid rock is encountered. It is not possible to predict the exact depth of either hole; however, it is felt that WIPP No. 15 will be on the order of 300 feet and WIPP No. 17 will be approximately 1000 feet.

WIPP No. 15 will be drilled in the portion of the San Simon Swale which represents the most recent area of subsidence while WIPP No. 17 will be drilled in what is believed to be the center of the oldest (and deepest) subsidence. Cores from both holes will be analyzed by a team of geologists under the direction of Dr. Roger Anderson of the University of New Mexico. By using various age-dating techniques, we hope to establish a dissolution rate within the San Simon Swale which may be used to infer future dissolution effects at the WIPP Los Medanos site.

B. SCHEDULE

1. Land and archaeological survey complete November, 1977.
2. Land use permits, drilling permits, land lease and archaeological clearance complete February, 1978.
3. FAO on Fenix and Scisson placed February, 1978.
4. Drilling contract awarded March, 1978.
5. Access roads and drilling pads complete by March 15, 1978.
6. Notice to proceed to drilling contractor by March 20, 1978 (WIPP No. 15).
7. Expect spudding of hole to be approximately March 27, 1978.
8. Estimate hole completion by March 31, 1978.
9. Demobilize from WIPP No. 15 and move to WIPP No. 17 by April 3, 1978.
10. Expect spudding of WIPP No. 17 by April 3, 1978.
11. Estimate hole completion by April 11, 1978.

Note: If core recovery is considered incomplete on either hole, the services of USGS/WRD Drilling, Sampling and Testing Techniques Project Group

may be used to obtain core in the missing formations. In this instance, complete recovery will be delayed until June, 1978 due to their scheduling.

C. ORGANIZATION

Technical direction will originate within Sandia Division 5311 under Dennis Powers. Scientific consultation will be provided by the University of New Mexico under Dr. Roger Anderson, Field Operations, managed by R. D. Statler, Sandia Division 1133, will be conducted by W. E. Cunningham, Fenix & Scisson Drilling Contract and associated support service contracts will be let and administered by F&S as arranged for by Federal Agency Order through Nevada Operations Office, DOE.

Identification of marker bids, core logging and other geologic interpretations will be provided as appropriate by Dr. Roger Anderson, UNM, Jerry Mercer, USGS/WRD and Joe Gonzales, F&S.

Administrative assistance and logistical support of Sandia programs will be provided by P. D. Seward and J. E. Magruder, Sandia Division 1135.

D. FIELD OPERATIONS

1. Sites selected and state antiquities permit applied for WIPP No. 17 site, and lease negotiated with owner of WIPP No. 15 site. Land surveys made on both sites. Land survey should consist of a plot showing township, range, section and distance in feet to the closest section boundary. Plot should show route of a 25 ft. wide access road and layout of 150 feet X 150 feet drill pad (may not be required on WIPP No. 15 as access route exists and native soil compaction may be adequate to accomodate rig and associated equipment).
2. Archaeological survey taken in conjunction with land surveys for filing with the land use permit application for WIPP No. 17.
3. Temporary land use permit application for WIPP No. 17 filed with the State of New Mexico for access road and drill pad.
4. File "Notice of Intention to Drill Exploratory Well" with N. M. State Engineer.

5. Award drill contract, purchase long lead time items. Negotiate other pertinent contracts as appropriate (mud, coring, logging, etc.).
6. Award dirt contract, construct minimum access road and drill pad (WIPP No. 17 may require stabilization of 6" caliche base, WIPP No. 15 should require repairs only to existing access road). Metal mud and water tanks to be provided by contractor.
7. Move in rig and associated equipment for continuous core extraction:
8. Dry punch hole and extract first core to a depth of 7'±.
9. Pick up 3-1/4" X 2-1/4" diamond core bit with split barrel and rotary to 32 feet at appropriate speed to assure continuous recovery using fresh water as drilling fluid. If additives are required to drilling fluid, particular care must be taken to avoid materials that contain vegetative matter or pollens. If possible, samples of any additives should be made available to the duty geologist for field analysis prior to mixing with the drilling fluid. Samples of drilling fluids will be taken twice a day using clean sample bottles. Samples will be returned to Albuquerque per the instructions of the duty geologist for analysis.
10. Pick up 8-3/4" bit and ream hole to 32 feet. Set 7" O. D. used casing as conductor pipe at 32 feet cemented to surface. Install appropriate well head equipment to provide blow out protection.
11. Pick up 3-1/4" X 2-1/4" diamond core bit and rotary to T.D. extracting continuous core. If continuous core is not attained particular note should be made of the missing intervals and the physical properties of any formation, if attainable. If it is determined that recovery from those formations would be questionable using standard coring procedures in an additional nearby hole, the USGS/WRD Drilling, Sampling and Testing Techniques Project Group will be called upon to provide their expertise and special equipment to gain core from the missing intervals.
12. If aquifers are encountered, contractor should be prepared to case and cement these formations in accordance with the State Engineer's specifications.

13. Upon completion of coring operation, condition hole, log with USGS/WRD Geophysical Logging Equipment and plug to surface using a grout mixture of 50% Class "C" cement / 50% flyash with fresh water. A dispersant or friction reducing agent to improve flow characteristics of grout during pumping may be used. A silica sand (about 5% by weight) may be added to reduce loss to the formation.
14. Rig down and move to next hole or release rig.

Actual procedures to be followed during coring operations will be published as an appendix to this document.

APPENDIX A: CORE AND CORE HANDLING PROGRAM

Cores with 2 1/4" nominal diameter are to be taken continuously from ground surface to the T.D. of both holes. It is recognized that formations may be encountered which are soft and/or rubblized; therefore, particular attention must be paid to rate of rotation, penetration and drilling fluid properties to assure as complete a recovery as possible.

A split core barrel is to be utilized to ease the removal of core from the barrel and to lessen the possibility of damaging or mixing core components.

A duty geologist will log and measure core as it is removed from core barrel. Core will then be sealed within plastic sleeving and packaged in standard cardboard boxes. If core is soft and/or badly rubblized additional cushioning material will be placed around core within box. Boxes will then be marked with hole identity and core interval. Core will then be carefully loaded in a transport vehicle by contractor personnel as supervised by duty geologist, and taken to core storage in Carlsbad for subsequent shipment to Albuquerque.

A coring record should be kept showing: date and tour, sequence of core interval, depth of interval, footage of core recovered and percentage. If significant intervals are missing, the depth and interval of missing core should be recorded as well as any determinable physical properties of the formation. Rig operating conditions such as RPM, weight on bit, circulating pressure should also be kept.

For sake of consistency a routine has been established for handling and marking core at the drill pad as follows:

1. Coring contractor and roustabouts will lay barrel down and open barrel. The duty geologist will photograph core and supervise removal from core barrel and placement in troughs in the order they come out of barrel for inspection and measurement. Troughs are marked orange or red indicating top end and black indicating down direction.
2. If core is suitable for marking, each major piece should be marked with a water proof black ink arrow pointing in the direction the hole is advancing. If core is not suitable for marking, the above is to be marked on sleeving using an indelible, water proof black marking pen.

3. Log, identify and measure all core pieces, express to closest 1/10th of foot. Note: All depth measurements are from the top side of the Kelly Bushing unless otherwise specified.
4. Move troughs to core shed and separate into appropriate lengths. Sleeve and seal and insert into boxes. Tape boxes and mark outside of box with hole identity and depths of core interval.
5. Transport boxed core to core storage taking particular care in handling and delivery to avoid core damage.

APPENDIX C

Hole History

compiled by

R.D. Statler, 1133, and P.D. Seward, 1134

DATE: July 11, 1978

MAIN RIG & CONTRACTOR

NO. OF COMPRESSORS & CAPACITY:

TOTAL DEPTH: 870.5' GL

AVERAGE MAN:REL DEPTH:

FROM REFERENCE ELEVATION @

JUNK & PLUGS LEFT IN HOLE:

SURVEYS PAGE:

CORING PAGE: 3

CU. FT. CMT. TOTAL IN PLUGS, ETC:

LOGGING DATA: USGS Logs

BOTTOM HOLE COORDINATES:

REFERENCE:

REMARKS: * Site Prep Items

WIPP #15
HOLE HISTORY

- 3-8-78** Moved in Boyles Bros. rig #3625 and rigged up. Cut core #1 thru #11 from 0" to 116" using a 2-3/8" O.D. x 18" long split sample spoon. The spoon was driven with a 160# drive hammer using a 30" stroke. Opened hole to 5-7/8" using air. Made up a Pitcher core barrel with a 4-3/4" x 2-3/4" core bit. Cut core #12 and #13 from 116" to 159" (13.25'). Opened hole to 8-3/4" to 159". Ran 14' of 7" O.D., J-55 casing to 159". Worked days only.
- 3-9-78** Mixed up a fresh water mud. Made up a wire line core barrel with a split inner barrel. A 3.975" x 2-1/8" diamond core bit was used. Cut core #14 thru #20 from 13.25' to 29.35'. Made up 4" rock bit, opened core hole and drilled 4" hole from 29.35' to 75'. Cut core #21 from 75' to 80'.
- 3-10-78** Continued cutting core #21 from 80' to 85.3'. Cut core #22 thru #36 from 85.3' to 162.2'.
- 3-13-78** Rig secured from 3-10-78 to 3-13-78. Cut core #37 thru #46 from 162.2' to 206.6'.
- 3-14-78** Cut core #47 thru #59 from 206.6' to 298.2'.
- 3-15-78** Cut core #60 thru #76 from 298.2' to 426.2'.
- 3-16-78** Cut core #77 thru #87 from 426.2' to 493.2'. Cleaned out 20' of fill at 426.2', 9' of fill at 443.2' and 12' of fill at 446.2'. Raised viscosity of mud at 489.2' and circulated hole, viscosity in returns was 47 seconds.
- 3-17-78** Cleaned out bridges and 20' of fill to bottom. Cut core #88 thru #93 from 493.2'. Ran USGS logs.
- 3-20-78** Rig secured from 3-17-78 to 3-20-78. Cleaned out 15' of fill, losing 70% of returns. Cut core #94 thru #96 from 543.2' to 553.2'. Reduced mud viscosity from 75 to 50 seconds and cut loss circulation to 30%. Cut core #97 and #98 from 553.2' to 563.2'.
- 3-21-78** Cleaned out 3' of fill and cut core #99 thru #101 from 563.2' to 577.2'. Changed out to tungsten carbide bit at 566.2'.
- 3-22-78** Cleaned out bridge at 557' and 3' of fill on bottom. Cut core #102 thru #106 from 577.2' to 600.2'.
- 3-23-78** Cleaned out 2' of fill and cut core #107 thru #110 from 600.2' to 635.2'. Lost approximately 100 barrels of mud.
- 3-24-78** Cut core #111 thru #114 from 635.2' to 657.2'.
- 3-27-78** Rig secured from 3-24-78 to 7-27-78. Washed 80' to bottom and cut core #115 thru #118 from 657.2' to 678.2'. Lost 90 barrels of mud.
- 3-28-78** Fluid level at 60'. Cleaned out 2' of fill and cut core #119 thru #122 from 678.2' to 704.7'. Lost 90 barrels of mud.

3-29-78 Cleaned out 1.6' of fill and cut core #123 thru #127 from 704.7' to 745.2'. Lost 60 barrels of mud.

3-30-78 Cleaned out 2' of fill and cut core #128 thru #132 from 745.2' to 781.7'. Lost 30 barrels of mud.

3-31-78 Cleaned out 1' of fill and cut core #133 thru #137 from 781.7' to 810.5'. Changed out to diamond core bit.

4-3-78 Rig secured from 3-31-78 to 4-3-78. Conditioned mud for logging. Ran USGS logs.

4-4-78 Opened hole to 6-1/8" to 592', conditioned mud to run casing. Ran 4½" O.D., 11.3#, HW casing with two 1/16" slots, 1' long on opposite sides of the casing as follows:

<u>No. Joints</u>		<u>Depth</u>
1	Blank casing	555' - 540'
3	Slotted casing	540' - 445'
15	Blank casing	445' - 0'

The bottom of joint #1 was belled in and a pipe clamp was welded on top of joint #19 and landed on the 7" O.D. surface casing. A locked cap was welded on top of the 4½" O.D. collar of joint #19. Rigged down. Hole suspended.

WIPP #15
HOLE HISTORY

CORE RECORD

<u>Core No.</u>	<u>Interval</u>	<u>Cored</u>	<u>Recovered</u>	<u>% Recovery</u>
1	0" - 12"	12"	12"	100
2	12" - 26"	14"	12"	86
3	26" - 34"	8"	6"	75
4	34" - 48"	14"	8"	57
5	48" - 60"	12"	9"	75
6	60" - 66"	6"	6"	100
7	66" - 78"	12"	8"	67
8	78" - 84"	6"	6"	100
9	84" - 96"	12"	12"	100
10	96" - 108"	12"	12"	100
11	108" - 116"	8"	7"	88
12	116" - 145"	29"	19"	66
13	145" - 159"	14"	14"	100
14	13.25' - 15.70'	2.45'	0'	0
15	15.70' - 18.00'	2.30'	2.6'	113
16	18.00' - 22.55'	4.55'	2.25'	49
17	22.55' - 23.85'	1.30'	0.9'	69
18	23.85' - 26.35'	2.50'	2.0'	80
19	26.35' - 28.35'	2.00'	0'	0
20	28.35' - 29.35'	1.00'	2.15'	215
21	75' - 85.3'	10.3'	10.3'	100
22	85.3' - 90.2'	4.9'	4.8'	98
23	90.2' - 95.2'	5.0'	4.65'	93
24	95.2' - 102.7'	7.5'	7.65'	102
25	102.7' - 108.2'	5.5'	5.5'	100
26	108.2' - 113.2'	5.0'	4.9'	98
27	113.2' - 118.2'	5.0'	5.15'	103
28	118.2' - 123.2'	5.0'	5.1'	102
29	123.2' - 128.2'	5.0'	5.0'	100
30	128.2' - 133.2'	5.0'	4.9'	98
31	133.2' - 138.2'	5.0'	5.1'	102
32	138.2' - 143.2'	5.0'	5.0'	100
33	143.2' - 149.2'	6.0'	6.1'	102
34	149.2' - 153.2'	4.0'	3.7'	93
35	153.2' - 158.2'	5.0'	4.2'	84
36	158.2' - 162.2'	4.0'	2.7'	68
37	162.2' - 164.2'	2.0'	3.5'	175
38	164.2' - 168.2'	4.0'	3.9'	98
39	168.2' - 173.2'	5.0'	4.9'	98
40	173.2' - 178.2'	5.0'	3.9'	78
41	178.2' - 183.2'	5.0'	6.3'	126
42	183.2' - 188.2'	5.0'	5.1'	102
43	188.2' - 193.2'	5.0'	5.0'	100
44	193.2' - 198.2'	5.0'	5.2'	104
45	198.2' - 203.2'	5.0'	5.0'	100
46	203.2' - 206.6'	3.4'	3.2'	94
47	206.6' - 213.2'	6.6'	6.6'	100
48	213.2' - 218.2'	5.0'	4.98	100
49	218.2' - 226.3'	8.1'	8.3'	103
50	226.3' - 231.4'	5.1'	5.0'	98
51	231.4' - 238.2'	6.8'	6.8'	100

WIRE LOG
HOLE HISTORY

<u>Core No.</u>	<u>Interval</u>	<u>Cored</u>	<u>Recovered</u>	<u>% Recovery</u>
52	238.2' -246.7'	8.5'	8.5'	100
53	246.7' -253.2'	6.5'	6.5'	100
54	253.2' -261.2'	8.0'	8.0'	100
55	261.2' -269.2'	8.0'	7.9'	99
56	269.2' -277.2'	8.0'	8.1'	101
57	277.2' -285.2'	8.0'	8.0'	100
58	285.2' -293.2'	8.0'	8.0'	100
59	293.2' -298.2'	5.0'	5.0'	100
60	298.2' -303.2'	5.0'	4.5'	90
61	303.2' -312.2'	9.0'	9.5'	104
62	312.2' -321.2'	9.0'	9.0'	100
63	321.2' -333.2'	12.0'	9.9'	83
64	333.2' -341.7'	8.5'	8.5'	100
65	341.7' -348.2'	6.5'	6.5'	100
66	348.2' -358.2'	10.0'	10.0'	100
67	358.2' -364.2'	6.0'	6.0'	100
68	364.2' -372.6'	8.4'	7.6'	91
69	372.6' -381.2'	8.6'	6.2'	72
70	381.2' -384.4'	3.2'	4.2'	131
71	384.4' -391.2'	6.8'	6.5'	96
72	391.2' -396.2'	5.0'	3.9'	78
73	396.2' -400.9'	4.7'	4.5'	96
74	400.9' -407.9'	7.0'	7.0'	100
75	407.9' -417.2'	9.3'	9.2'	99
76	417.2' -426.2'	9.0'	8.6'	96
77	426.2' -435.2'	9.0'	9.1'	101
78	435.2' -443.2'	8.0'	3.0'	38
79	443.2' -446.2'	3.0'	3.0'	100
80	446.2' -453.2'	7.0'	7.0'	100
81	453.2' -460.2'	7.0'	8.0'	114
82	460.2' -468.2'	8.0'	8.0'	100
83	468.2' -477.2'	9.0'	9.5'	106
84	477.2' -479.9'	2.7'	2.0'	74
85	479.9' -489.2'	9.3'	1.0'	11
86	489.2' -491.2'	2.0'	2.6'	130
87	491.2' -493.2'	2.0'	2.0'	100
88	493.2' -498.2'	5.0'	5.0'	100
89	498.2' -505.7'	7.5'	6.9'	92
90	505.7' -513.2'	7.5'	7.3'	97
91	513.2' -523.7'	10.5'	8.6'	82
92	523.7' -533.2'	9.5'	8.0'	84
93	533.2' -543.2'	10.0'	8.5'	85
94	543.2' -547.2'	4.0'	2.6'	65
95	547.2' -548.2'	1.0'	0.0'	0
96	548.2' -553.2'	5.0'	6.0'	120
97	553.2' -560.2'	7.0'	7.0'	100
98	560.2' -563.2'	3.0'	3.0'	100
99	563.2' -566.2'	3.0'	2.0'	67
100	566.2' -573.2'	7.0'	6.4'	91
101	573.2' -577.2'	5.0'	4.0'	75
102	577.2' -580.5'	3.3'	4.0'	121
103	580.5' -585.2'	4.7'	3.3'	70
104	585.2' -588.2'	3.0'	3.5'	117
105	588.2' -597.2'	9.0'	8.5'	94

WIFF V13
HOLE HISTORY

<u>Core No.</u>	<u>Interval</u>	<u>Cored</u>	<u>Recovered</u>	<u>% Recovery</u>
106	597.2' -600.2'	3.0'	3.0'	100
107	600.2' -609.7'	9.5'	9.9'	104
108	609.7' -618.2'	8.5'	9.5'	112
109	618.2' -626.8'	8.6'	10.0'	116
110	626.8' -635.2'	8.4'	8.6'	102
111	635.2' -640.2'	5.0'	5.0'	100
112	640.2' -648.2'	8.0'	9.0'	113
113	648.2' -654.9'	6.7'	6.8'	102
114	654.9' -657.2'	2.3'	2.3'	100
115	657.2' -657.9'	0.7'	0.7'	100
116	657.9' -666.2'	8.3'	4.5'	54
117	666.2' -670.2'	4.0'	4.2'	105
118	670.2' -678.2'	8.0'	9.3'	116
119	678.2' -682.9'	4.7'	3.9'	83
120	682.9' -691.2'	8.3'	9.2'	111
121	691.2' -694.7'	3.5'	3.4'	97
122	694.7' -704.7'	10.0'	10.2'	102
123	704.7' -713.7'	9.0'	8.3'	92
124	713.7' -721.7'	8.0'	8.3'	104
125	721.7' -728.8'	7.1'	7.2'	101
126	728.8' -736.8'	8.0'	8.0'	100
127	736.8' -745.2'	8.4'	8.2'	98
128	745.2' -753.2'	8.0'	7.9'	99
129	753.2' -761.2'	8.0'	5.3'	66
130	761.2' -764.2'	3.0'	5.1'	170
131	764.2' -773.2'	9.0'	8.8'	98
132	773.2' -781.7'	8.5'	9.0'	106
133	781.7' -786.7'	5.0'	4.5'	90
134	786.7' -796.2'	9.5'	9.9'	104
135	796.2' -805.2'	9.0'	9.0'	100
136	805.2' -810.2'	5.0'	4.9'	98
137	810.2' -810.5'	0.3'	0.3'	100

NOTE: Information taken from drilling records.

FENIX & SCISSON, INC.

HOLE HISTORY DATA

DATE: 7-10-78

HOLE No.: WIPP #15A	W.O. No.:	I.D. No.:
USER: Sandia Lab	TYPE HOLE: Exploratory	
LOCATION: New Mexico	COUNTY: Lea	AREA:
SURFACE COORDINATES: 9' from WIPP #15		GROUND ELEVATION:
RIG ON LOCATION:	SPUDDED: 4-4-78	COMPLETED: 4-5-78

CIRCULATING MEDIA: Air to 34.2', mud to 61.2'

No. of COMPRESSORS & SIZE:

BORE HOLE RECORD			CASING RECORD							
FROM	TO	SIZE	I. D.	WT./FT.	WALL	GRADE	CPL'G	FROM	TO	CU. FT. CMT.
0'	29'	4"								
29'	61.2'	3.975"								

TOTAL DEPTH: 61.2'

MANDREL DEPTH

PLUGS:

JUNK:

LOGGING DATA: NONE

SURVEYS PAGE:

CORING PAGE:

BOTTOM HOLE COORDINATES:

0

REFERENCE:

NON-OPERATIONAL TIME		OPERATIONAL DELAY TIME		WORKING TIME	
Move Rig up & down	_____ days	Equipment Repair	_____ days	Drilling Time	_____ days
Secured	_____ days	Caving	_____ days	Trip Time	_____ days
Bail & Run Mandrel	_____ days	Lost Circ.	_____ days	Single Shot Survey Time	_____ days
Logging	_____ days	Fishing	_____ days		_____ days
Survey	_____ days	W.O. Equipment	_____ days	Total	_____ days
Casing	_____ days		_____ days	Total Suspended Time	_____ days
Cement	_____ days		_____ days	Non-Operational Time	_____ days
Coring	_____ days		_____ days	Operational Delay Time	_____ days
	_____ days		_____ days	Working Time	_____ days
TOTAL	_____ days	TOTAL	_____ days	TOTAL ELAPSED TIME	_____ days

REMARKS:

Rig No.	Name	Type
		_____ days
		_____ days
		_____ days
		_____ days
		_____ days
		_____ days

WIPP #15A
HOLE HISTORY

4-4-78^o Moved Boyles rig #3625, 9' from the original hole to recover cores lost from 29' to 75'. Rigged up and drilled 4" hole from 0' to 29' with air. Rigged up air hammer.

4-5-78 Attempted to drive split sample spoon with no results. Rigged up wire line core barrel with a split inner barrel and a 3.975" diamond bit. Cut core #1 from 29' to 34.2' using air, no recovery. Cut core #2 thru #5 from 34.2' to 61.2' using mud. Rigged down. Hole completed.

CORE RECORD

<u>Core No.</u>	<u>Interval- Ft</u>	<u>Cored-Ft</u>	<u>Recovered-Ft</u>	<u>%Recovery</u>
1	29 - 34.2	5.2	0	0
2	34.2 - 37.8	3.6	3.6	100
3	37.8 - 43.2	5.4	5.4	100
4	43.2 - 52.0	8.8	8.8	100
5	52.0 - 61.2	9.2	9.2	100

APPENDIX D

LOGS

compiled by

S-E. Shaffer, 4511

WIPP 15 Logs¹

<u>Log</u>	<u>Company</u>	<u>Top of Logged Interval² (feet)</u>	<u>Bottom Logged Interval (feet)</u>	<u>Date</u>
Density	U.S.G.S.	6	806	4-3-78
Gamma	U.S.G.S.	6	806	4-3-78
Neutron	U.S.G.S.	8	806	4-3-78

¹Original data is retained in Sandia WIPP Central File, Division 4542, Sandia National Laboratories, Albuquerque, NM 87185.

²Depths measured from ground surfaces elevation officially 3269.34 feet above MSL.

Distribution:

U.S. Department of Energy, Headquarters
Office of Nuclear Waste Management
Washington, DC 20545

Larry Harmon, Project Coordinator (WIPP)
Colin A. Heath, Director, Division of Waste Isolation (2)

U.S. Department of Energy, Albuquerque Operations
P.O. Box 5400
Albuquerque, NM 87185

J. M. McGough, Manager, WIPP Project Office (2)
D. Jackson, Director, Public Affairs Division

U.S. Department of Energy
Carlsbad WIPP Project Office
Room 113, Federal Building
Carlsbad, NM 88220

U.S. Department of Energy
c/o Battelle Office of Nuclear
Waste Isolation
505 King Avenue
Columbus, OH 43201
Jeff O. Neff

Battelle Memorial Institute
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, OH 43201
S. Goldsmith, Manager
ONWI Library

Battelle Memorial Institute
Project Management Division
505 King Avenue
Columbus, OH 43201
Neal Carter, General Manager

Westinghouse Electric Corporation
P.O. Box 40039
Albuquerque, NM 87196
R. K. Brown
R. Jones (TSC)

Bechtel National, Inc.
Fifty Beale Street
P. O. Box 3965
San Francisco, CA 94119
D. L. Ledbetter
Dale Roberts

National Academy of Sciences, WIPP Panel:

Frank L. Parker, Chairman
Department of Environmental and
Water Resources Engineering
Vanderbilt University
Nashville, TN 37235

Konrad B. Krauskopf, Vice Chairman
Department of Geology
Stanford University
Stanford, CA 94305

Karl P. Cohen, Member
Consultant
928 N. California Avenue
Palo Alto, CA 94303

Neville G. W. Cook, Member
Dept. of Material Sciences and Engineering
University of California at Berkeley
Hearst Mining Building, #320
Berkeley, CA 94720

Fred M. Ernsberger, Member
Glass Research Center
PPG Industries, Inc.
Box 11472
Pittsburgh, PA 15238

Harold L. James, Member
1617 Washington St.
Port Townsend, WA 98368

Richard R. Parizek, Member
Department of Hydrogeology
Pennsylvania State University
University Park, PA 16802

D'Arcy A. Shock, Member
233 Virginia
Ponca City, OK 74601

John W. Winchester, Member
Department of Oceanography
Florida State University
Tallahassee, FL 32306

John T. Holloway
Senior Staff Officer
2101 Constitution Avenue, NW
Washington, DC 20418

WIPP Public Reading Room
Atomic Museum, Kirtland East AFB
Albuquerque, NM 87185

Attn: Ms. Gwynn Schreiner

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Ms. Marcia Lewis, Librarian

State of New Mexico
Environmental Evaluation Group
320 Marcy Street
P.O. Box 968
Santa Fe, NM 87503

Robert H. Neill, Director (2)

NM Department of Energy & Minerals
P.O. Box 2770
Santa Fe, NM 87501

Larry Kehoe, Secretary
Kasey LaPlante, Librarian

New Mexico State Geologist
P. O. Box 2860
Santa Fe, NM 87501

Emery C. Arnold

New Mexico State Library
P.O. Box 1629
Santa Fe, NM 87503

Ms. Ingrid Vollenhofer

New Mexico Tech
Martin Speer Memorial Library
Campus Street
Socorro, NM 87801

Zimmerman Library
University of New Mexico
Albuquerque, NM 87131
Ms. Alice Clark

USGS, Water Resources Division
P. O. Box 26659
Albuquerque, NM 87125
J. W. Mercer (2)

USGS, Conservation Division
Office of Mining & Resource Evaluation
P. O. Box 506
Carlsbad, NM 88220
C. B. John

USGS, Conservation Division
P. O. Box 1857
Roswell, NM 88201
W. Melton

USGS, Special Projects Branch
Federal Center, Bldg. 25
Denver, CO 80225
R. P. Snyder (2)

New Mexico Bureau of Mines and Mineral Resources
Socorro, NM 87801
F. E. Kottlowski, Director (2)

Klaus Kuhn
Gesellschaft fuer Strahlen-und
Umweltforschung MBH Muenchen
Institut fuer Tieflagerung
Berliner Strasse 2
3392 Clausthal-Zellerfeld
Federal Republic of Germany

Klaus Eckart Maass
Hahn-Meitner-Institut fuer Kernforschung
Glienicke Strasse 100
1000 Berlin 39
Federal Republic of Germany

Michael Langer
Bundesanstalt fuer Geowissenschaften
und Rohstoffe
Postfach 510 153
3000 Hannover 51
Federal Republic of Germany

Reinhard Kraemer
Kernforschung Karlsruhe
Postfach 3640
7500 Karlsruhe
Federal Republic of Germany

Helmut Rothemeyer
Physikalisch-Technische
Bundesanstalt
Bundesallee 100
3300 Braunschweig
Federal Republic of Germany

Rolf-Peter Randl
Bundesministerium fuer Forschung
und Technologie
Postfach 200 706
5300 Bonn 2
Federal Republic of Germany

Fenix & Scisson, Inc.
3170 W. Sahara Avenue
Spanish Oaks D-12
Las Vegas, NV 89102

J. A. Cross

Fenix & Scisson, Inc.
401 N. Canal Street
Carlsbad, NM 88220

Matt Wilson

Gayle Pawloski, L-222
Geologist CSDP
Lawrence Livermore Laboratory
Livermore, CA 94550

Roger Y. Anderson (5)
Dept. of Geology
University of New Mexico
Albuquerque, NM 87131

J. Platt Bradbury (5)
Paleontology & Stratigraphy Branch
U.S. Geological Survey
Denver, CO 80225

William Sliter, Chief
Paleontology & Stratigraphy Branch
M.S. 970
U.S. Geological Survey
Reston, VA 20092

U.S. Nuclear Regulatory Commission (3)
Division of Waste Management
Mail Stop 69755
Washington, DC 20555
Attn: J. Martin, M. Bell, H. Miller

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