GEOLOGIC AND WELL-CONSTRUCTION DATA FOR THE H-9 BOREHOLE COMPLEX NEAR THE PROPOSED WASTE ISOLATION PILOT PLANT SITE, SOUTHEASTERN NEW MEXICO

By S. L. Drellack, Jr. (Fenix and Scisson, Inc.)

and J. G. Wells (U.S. Geological Survey)

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CONTENTS

ILLUSTRATIONS

PLATE

TABLES

CONVERSION FACTORS

All measurements related to the drill site are given in inch-pound units. These measurements include: The survey to locate the borehole (both horizontally and vertically), the drilling depths as provided by the driller, and the wire-line log recordings as provided by the logging company. Unless otherwise noted, altitude and depth measurements are referenced to ground level. The following table contains factors for converting to International System of Units (SI).

Multiply inch-pound units	By	To obtain SI units
foot	0.3048	meter
inch	25.40	millimeter
pound	0.4536	kilogram
pound per square inch	0.006895	megapascal
mile	1.609	kilometer

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level." NGVD of 1929 is referred to as sea level in this report.

The use of trade names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

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ABSTRACT

The H-9 complex, a group of three closely spaced boreholes is located 5.5 miles south of the proposed Waste Isolation Pilot Plant (WIPP) site in east-central Eddy County, New Mexico. The holes were drilled during July, August, and September 1979 to obtain geologic and hydrologic data to better define the regional ground-water-flow system. The geologic data presented in this report are part of a site-characterization study for the possible storage of defense-associated radioactive wastes within salt beds of the Salado Formation of Permian age. The geologic data include detailed descriptions of cores, cuttings, and geophysical logs.

Each borehole was designed to penetrate a distinct water-bearing zone: H-9a (total depth 559 feet) was completed just below the Magenta Dolomite Member of the Rustler Formation; H-9b (total depth 708 feet) was completed just below the Culebra Dolomite Member of the Rustler Formation; H-9c (total depth 816 feet) was completed below the Rustler Formation-Salado Formation contact. The geologic units penetrated in borehole H-9c are eolian sand of Holocene age (0-5 feet); the Gatuna Formation of Pleistocene age (5-25 feet); and the Dewey Lake Red Beds (25-455 feet), the Rustler Formation (455-791 feet), and part of the Salado Formation (791-816 feet), all of Permian age. Three sections (484-501 feet, 615-625 feet, 692-712 feet) in the Rustler Formation penetrated by borehole H-9c are composed of remnant anhydrite (locally altered to gypsum) and clay and silt residue from the dissolution of much thicker seams of argillaceous and silty halite. This residue indicates that the eastward-moving dissolution within the Rustler Formation, found west of the WIPP site, is present at the H-9 site.

INTRODUCTION

The H-9 borehole complex (SW¼NW¼ sec. 4, T. 24 S., R. 31 E.) was drilled in east-central Eddy County, New Mexico (fig. 1), at the request of the Waste Isolation Pilot Plant (WIPP) project office of the U.S. Department of Energy. Sandia National Laboratories is evaluating the WIPP site for the Department of Energy as a potential repository for the disposal of defense-associated transuranic wastes in Permian salt beds. The U.S. Geological Survey is participating in this evaluation by developing information on the ground-water hydrology of the region, obtaining geologic borehole data, and conducting hydrologic tests in boreholes on and near the WIPP site. This report provides well-construction information and lithologic data about the Rustler and Salado Formations and the top of the salt interval within the Salado Formation at the H-9 borehole complex. The geologic information will provide a basis for determining the occurrence and movement of ground water in certain water-bearing zones above and below the salt. An understanding of the regional geology and hydrology is necessary for predicting the capability of the water-bearing zones to transport radionuclides to the biosphere in the event the storage facility is breached. Previous studies (Mercer and Orr, 1979; Powers and others, 1978) indicate water-bearing zones within and at the lower contact of the Rustler Formation of Permian age probably require the most detailed study.

The H-9 borehole complex is one in a series of four complexes that has been drilled near the WIPP site for determining regional geologic and hydrologic characteristics. At each complex, a cluster of three boreholes (fig. 2) was completed in successively deeper water-bearing zones. The borehole designated "a" penetrated the Magenta Dolomite Member of the Rustler Formation, the "b" borehole penetrated the Culebra Dolomite Member of the Rustler Formation, and the "c" borehole penetrated the Rustler Formation-Salado Formation contact.

Data for the geologic section at the H-9 borehole complex are tabulated in plate 1 and table 1. Most of each borehole was drilled by the air-rotary method. Drill cuttings collected at 5-foot intervals and cores from selected intervals were used to describe the rocks penetrated in each borehole (tables 2-7). Wire-line geophysical logs (plate 1) were made in the H-9c borehole to (1) aid in the recognition and correlation of rock units, (2) assist in identification of major lithologies, and (3) provide information about rock porosities for hydrologic evaluation.

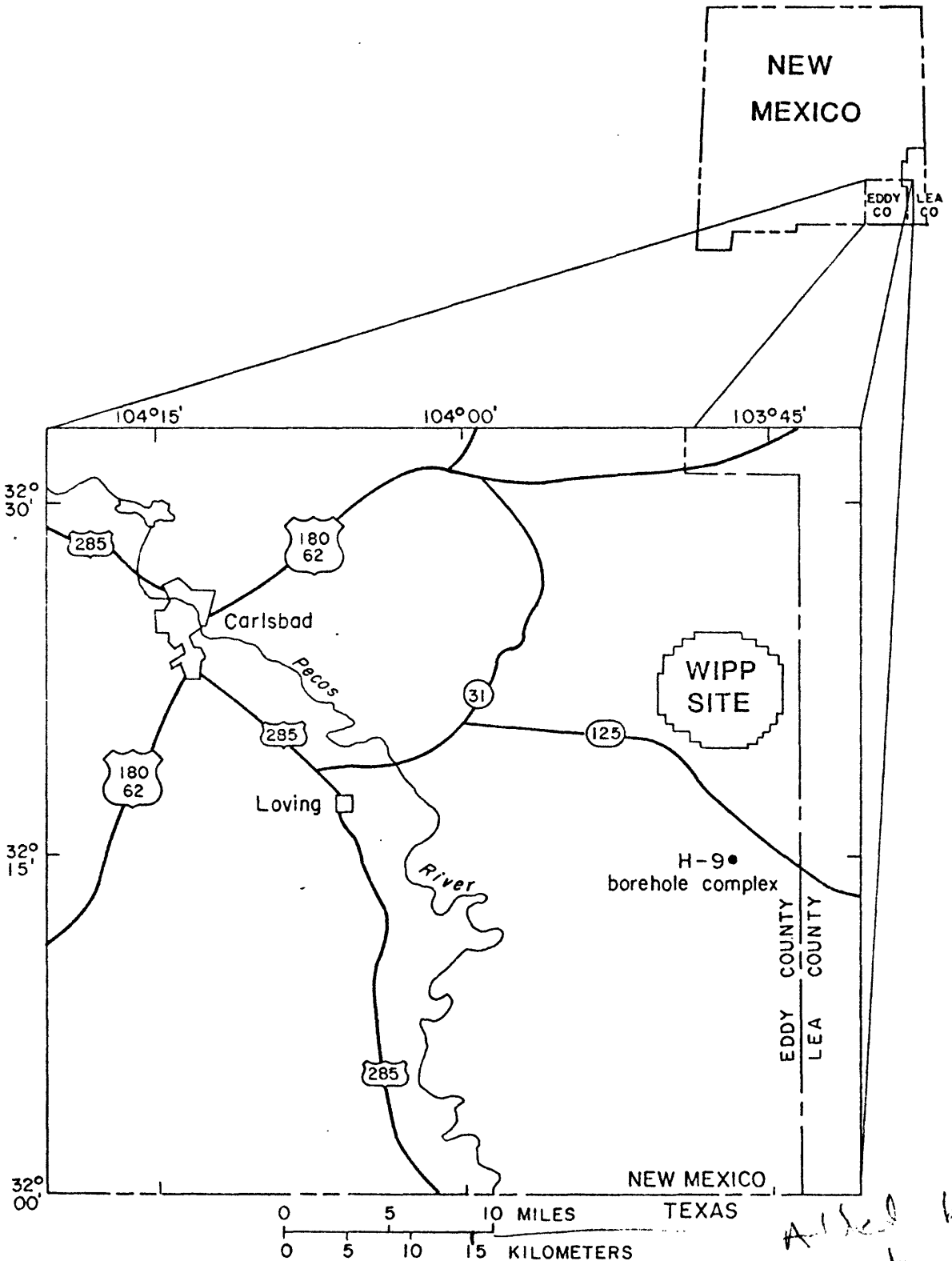

Figure 1.--Location of H-9 borehole complex with respect to the Waste Isolation Pilot Plant site.

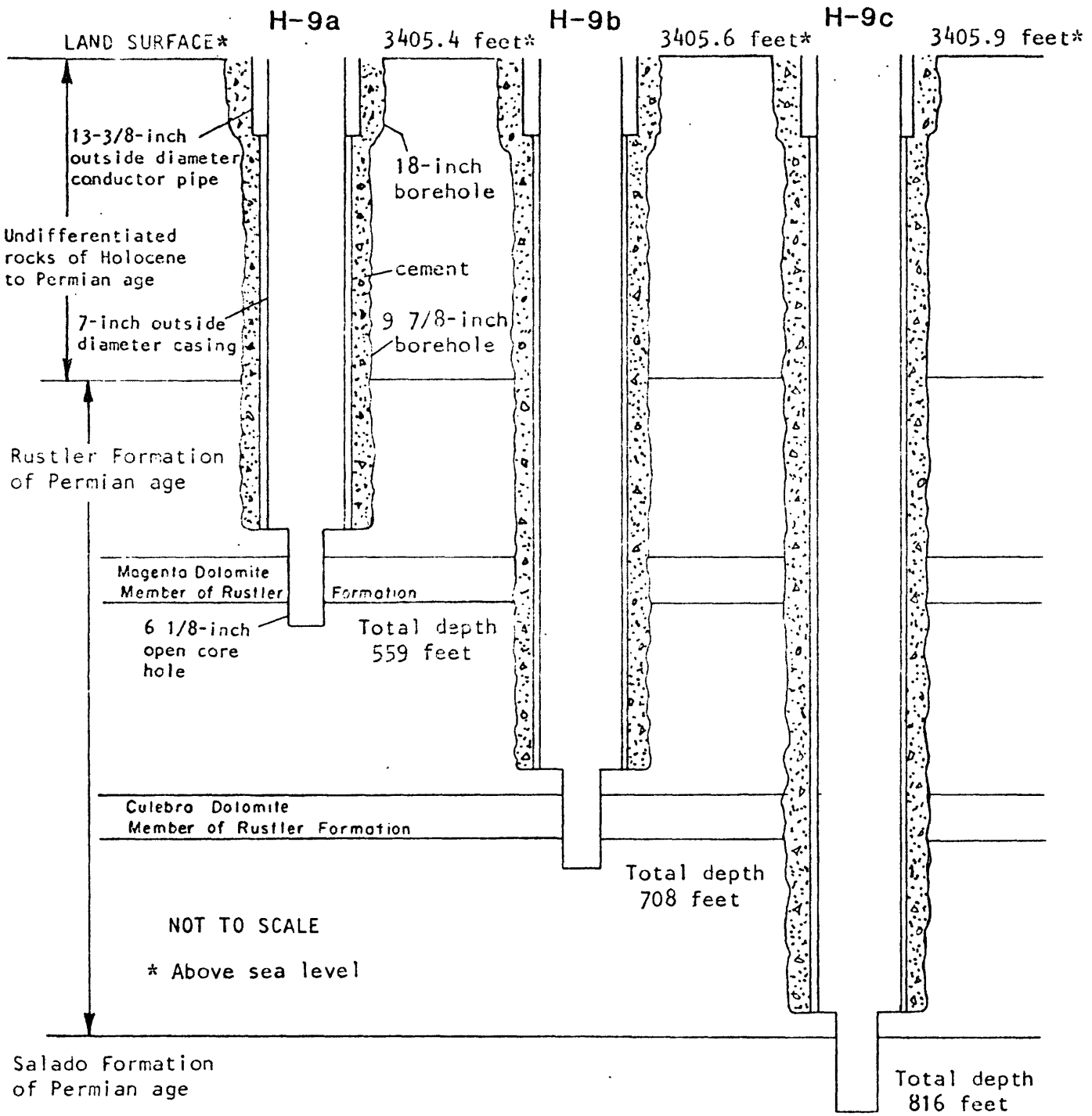

Figure 2.--Schematic diagram of the H-9 borehole complex.

BOREHOLE DRILLING AND SAMPLING METHODS

The H-9 borehole complex, 5.5 miles south of the proposed WIPP site, drilled during August and September 1979, consists of three boreholes (H-9a, H-9b, and H-9c) located 100 feet apart in an equilateral triangle. Borehole H-9c was drilled first and penetrated the Rustler Formation-Salado Formation contact 24 feet above the total depth of 816 feet measured from a land-surface altitude of 3,405.9 feet above sea level. Borehole H-9b was drilled next, to a total depth of 708 feet and penetrated the Culebra Dolomite Member. Borehole H-9a was drilled last to a total depth of 559 feet and penetrated the Magenta Dolomite Member (fig. 2).

Rotary and air-rotary/air-mist drilling procedures were used to drill borehole H-9c. The air-rotary method facilitates the identification of unknown zones that might contain water by using dry compressed air to cool the bit and remove the cuttings. A standard rock bit was used for drilling when cuttings were being collected at 5-foot intervals in selected zones of borehole H-9c from ground level to a depth of 505 feet. Wire-line coring procedures were used at the other selected intervals to cut continuous cores at 505-562 feet (which included the Magenta Dolomite Member at 523-554 feet), 620-681 feet (which included the Culebra Dolomite Member at 647-677 feet), and 789-816 feet (which included the Rustler Formation-Salado Formation contact at 791 feet and the top of the salt also at 791 feet). The cuttings and core were examined and described at the drillsite and then transported to the Sandia National Laboratories warehouse in Carlsbad, New Mexico, for storage.

The depths reported from cores for the base of the Culebra Dolomite Member and for the top of the salt in the Salado Formation are believed to be incorrect because of core loss. Sections probably were lost from one core but recovered in the next core and labeled with that depth. The core loss explains the discrepancy between the depth reported from geophysical logs (677 feet for the base of the Culebra, 791 feet for the top of salt) and from cores and samples (690 feet for the base of the Culebra, 798 feet for the top of the salt); depths recorded from geophysical logs are considered to be correct.

Prior to setting casing, a suite of wire-line geophysical logs was made from land surface to depths ranging from 780 feet to the full depth of borehole H-9c under open-hole, fluid-filled conditions. The logging was done to facilitate the identification and correlation of rock units and to provide a depth determination independent of that indicated by drill-pipe measurements. The geophysical logs include: (1) A gamma-ray curve, which recorded variations in the content of potassium and other radioactive elements; (2) a gamma-gamma curve, which recorded variations in rock density; and (3) a neutron curve, which recorded porosity.

The casing was set in borehole H-9c at 783 feet below land surface and the annular space between formation and casing was filled with cement. Afterwards, the interval from 789 to 816 feet was cored and 16.7 feet were recovered.

Borehole H-9a and H-9b were air-mist drilled to just above the Magenta and Culebra Dolomite Members, respectively. Forty-five feet of borehole H-9a and 40 feet of borehole H-9b were cored after the casing was set and cemented to the surface, as in borehole H-9c. The holes were geophysically logged after the total depth of each hole was reached.

GEOLOGIC DATA

Borehole H-9c, with a total depth of 816 feet, is the deepest borehole at the H-9 complex. For this reason, the geologic section penetrated by borehole H-9c is summarized in table 1.

The geologic section includes continental sediments of Quaternary age and marine red beds and evaporites of Permian age. The Quaternary sediments include, in order of increasing age, eolian sand with traces of caliche of Holocene age and the Gatuna Formation of Pleistocene age. The Permian rocks include, in order of increasing age, the Dewey Lake Red Beds, the Rustler Formation, and the upper 25 feet of the Salado Formation. The Permian rocks are present in the lower 791 feet of the geologic section penetrated by borehole H-9c.

The eolian sand and caliche are an informal unit that is 5 feet thick. The Gatuna Formation underlies the eolian sand and caliche and consists of 20 feet of moderate-reddish-orange to reddish-brown, very fine grained, friable sandstone.

Borehole H-9c penetrated the Dewey Lake Red Beds at 25 feet below land surface. The Dewey Lake Red Beds are reddish-brown, poorly to well consolidated sandstone, siltstone, and mudstone with greenish-gray reduction spots. At depths below 175 feet, the rocks contain veins of fibrous selenite.

The Rustler Formation, from 455 to 791 feet below land surface, consists chiefly of gypsum, remnant anhydrite, and poorly to moderately consolidated clay and silt. The formation also contains the Magenta and Culebra Dolomite Members and some well-consolidated siltstone. At the H-9 borehole complex, the Magenta is a light-olive-gray, fractured dolomite; the Culebra is a yellowish-brown to gray, clayey, pitted dolomite. Above and below the dolomite members are three distinct intervals composed of remnant anhydrite (locally altered to gypsum) and clay and silt residue from the dissolution of

much thicker seams of argillaceous and silty halite (Jones, 1973). The dissolution intervals (484-501) feet, 615-625 feet, and 692-712 feet) are similar to lithologies in the Rustler Formation penetrated by boreholes at Nash Draw and within the WIPP site boundary (Jones, 1973; Sandia National Laboratories and U.S. Geological Survey, 1980a, b).

The last 25 feet of section, between 791 and 816 feet below land surface, is the salt-rich Salado Formation composed of halite and argillaceous halite with traces of polyhalite. A summary of the geologic units penetrated by borehole H-9c is presented in table 1.

The lithologies penetrated by borehole H-9c are interpreted and correlated with selected geophysical logs in plate 1. Drilling and well-completion details of the H-9 boreholes are given in tables 2 through 4. Core descriptions from boreholes H-9a and H-9b are presented in tables 5 and 6 respectively, and the core and cuttings from borehole H-9c are described in table 7.

SUMMARY

The H-9 borehole complex, a group of three closely spaced boreholes, was drilled south of the WIPP site in east-central Eddy County, New Mexico, during July, August, and September 1979. The boreholes were drilled to obtain geologic data and to conduct hydrologic tests to better define the regional ground-water-flow system. The H-9 complex was drilled as part of a site-characterization study for the possible storage of defense-associated wastes within salt beds of the Salado Formation of Permian age. Cores and cuttings from the borehole complex and geophysical logs from borehole H-9c were described or interpreted for this study.

Each borehole was completed just below a distinct water-bearing zone. Borehole H-9a (total depth 559 feet) penetrated the Magenta Dolomite Member, a light-olive-gray, fractured dolomite of the Rustler Formation. Borehole H-9b (total depth 708 feet) penetrated the Culebra Dolomite Member, a yellowish-brown to gray, clayey, pitted dolomite of the Rustler Formation. Rocks penetrated by borehole H-9c (total depth of 816 feet) at the Rustler Formation-Salado Formation contact consist of reddish-brown and greenish-gray gypsiferous siltstone that grades to a thin, light-gray, clayey anhydrite bed followed by the argillaceous salt of the Salado Formation. Between the water-bearing zones in the Rustler Formation penetrated by H-9c are three intervals of dissolution, which consist of gypsum, remnant anhydrite, and silt and clay residue derived from halite and associated rocks that formerly were present.

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Table 1.--Summary of geologic units penetrated by borehole H-9c

Rock Unit	Depth interval[1/] (feet)
Holocene deposits[2/]	
Eolian sand and caliche	0-5
Pleistocene rocks	
Gatuna Formation	5-25
Permian rocks	
Dewey Lake Red Beds	25-455
Rustler Formation	455-791
Dissolution residue	484-501
Magenta Dolomite Member	523-554
Dissolution residue	615-625
Culebra Dolomite Member	647-677
Dissolution residue	692-712
Salado Formation	791
Top of salt interval	791
Total depth of borehole	816

[1/] Depth interval recorded from gamma-ray and bulk-density logs made by Dresser Atlas from August 8 to August 9, 1979.

[2/] Includes artificial fill for drill pad.

Table 2.--Drilling and well-completion record of borehole H-9a

Location: Sec. 4, T. 24 S., R. 31 E.
2,392.14 feet from north line
138.92 feet from west line

Altitude (land surface) above sea level: 3,405.4 feet. Datum for depth measurements in drilling and logging operations.

Lithologic log prepared by: S. L. Drellack, Jr., J. L. Gonzales (Fenix and Scisson Inc.), and R. R. Ives (U.S. Geological Survey)

Driller contractor: Shortes Drilling Company

Drilling record:

Commenced drilling on July 9, 1979, and completed September 5, 1979, at 559 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and cemented in place.

Drilled with a rock bit to 512 feet below land surface, hole widened from 7 7/8 to 9 7/8 inches and 510 feet of 7-inch outside-diameter casing was set and cemented in place.

44.9 feet of 3 1/2-inch outside-diameter core was recovered from 514 feet to a total depth of 559 feet, 0.1 foot of core not recovered (completed hole diameter was 6 1/8 inches).

The hole was blown dry and made ready for hydrologic sudies.

Core No.	Depth interval (feet) From	To	Revolutions per minute	Weight on bit (pounds)	Circulation medium	Feet cored	Feet recovered	Percent recovery
1	514	524	100	7,000	Airmist	10.0	10.1	101
2	524	534	110	7,000	Airmist	10.0	10.0	100
3	534	544	110	7,000	Airmist	10.0	4.8	48
4	544	550	110	7,000	Airmist	6.0	8.6	143
5	550	559	110	7,000	Airmist	9.0	11.4	127

Table 3.--Drilling and well-completion record of borehole H-9b

Location: Sec. 4, T. 24 S., R. 31 E.
2,391.04 feet from north line
238.63 feet from west line

Altitude (land surface) above sea level: 3,405.6 feet. Datum for depth measurements in drilling and logging operations.

Lithologic log prepared by: S. L. Drellack, Jr., J. L. Gonzales (Fenix and Scisson, Inc.), and R. R. Ives (U.S. Geological Survey)

Drilling contractor: Shortes Drilling Company

Drilling record:

Commenced drilling on August 14, 1979, and completed on August 28, 1979, at 708 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and cemented in place.

Drilled with a rock bit to 640 feet below land surface, hole widened from 7 7/8 to 9 7/8 inches and 637.53 feet of 7-inch outside-diameter casing was set and cemented in place.

33.7 feet of 3 1/2-inch outside-diameter core was recovered from 640 feet to a depth of 680 feet, 6.3 feet of core not recovered, drilled with a rock bit from 608 to 708 feet (completed hole diameter was 6 1/8 inches).

The hole was blown dry and made ready for hydrologic studies. Hole making 20 gallons of water per minute.

Core No.	Depth interval (feet) From	To	Revolutions per minute	Weight on bit (pounds)	Circulation pressure (pounds per square inch)	Feet cored	Feet recovered	Percent recovery
1	640	650	---No data recorded---			10.0	8.0	80
2	650	660	---No data recorded---			10.0	8.4	84
3	660	670	---No data recorded---			10.0	7.5	75
4	670	680	---No data recorded---			10.0	9.8	98

Table 4.--Drilling and well-completion record of borehole H-9c

Location: Sec. 4, T. 24 S., R. 31 E.
2,479.06 feet from north line
188.02 feet from west line

Altitude (land surface) above sea level: 3,405.9 feet. Datum for depth measurements in drilling and logging operations.

Lithologic log prepared by: S. L. Drellack, Jr., J. L. Gonzales, A. F. McIntyre, (Fenix and Scisson, Inc.), and R. R. Ives, (U.S. Geological Survey)

Drilling contractor: Shortes Drilling Company

Drilling record:

Commenced drilling on August 1, 1979, and completed on August 14, 1979, at 816 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and cemented in place.

Drilled with a rock bit to 785 feet below land surface (with two interim coring points at 505-562 and 620-681 feet), geophysical wire-line logs were made by Dresser Atlas.

Hole was widened from 7 7/8 to 9 7/8 inches and 783 feet of 7-inch outside-diameter casing was set and cemented in place.

16.7 feet of 3 1/2-inch outside-diameter core was recovered from 789 feet to a total depth of 816 feet, 10.3 feet of core not recovered (completed hole diameter was 6 1/8 inches).

The hole was blown dry and made ready for hydrologic studies. Geophysical logs were made by the U.S. Geological Survey after hole was completed.

Core No.	Depth interval (feet) From	To	Revolutions per minute	Weight on bit (pounds)	Circulation pressure (pounds per square inch)	Feet cored	Feet recovered	Percent recovery
1	505	514	80	—	100	9.0	9.0	100
2	516.4*	525.6	80	7,000	20	9.2	9.25	100
3	525.6	535	85	7,000	200	9.4	9.4	100
4	535	544	70	7,000	75	9.0	9.2	102
5	544	553	70	7,000	75	9.0	8.6	96

Table 4.--Drilling and well-completion record of borehole H-9c - Concluded

Core No.	Depth interval (feet) From	To	Revolutions per minute	Weight on bit (pounds)	Circulation pressure (pounds per square inch)	Feet cored	Feet recovered	Percent recovery
6	553	562	90	7,000	100	9.0	9.25	103
7	620	629	90	7,000	70/100	9.0	8.8	98
8	629	638	90	7,000	70	9.0	8.9	99
9	638	642	110	7,000	100	4.0	3.6	90
10	642	645	100	7,000	80	3.0	2.8	93
11	645	654	80	8,000	80	9.0	9.0	100
12	654	663	80	8,000	60	9.0	1.4	16
13	663	672	80	8,000	60	9.0	0.8	8.9
14	672	681	95	8,000	80	9.0	3.2	36
15	789	798	100	7,000	150	9.0	0.7	7.8
16	798	807	110	6,000	200/250	9.0	6.4	71
17	807	816	110	6,000	200/250	9.0	9.6	107

*NOTE: Correction in pipe tally after first core to 516.4 feet.

Table 5.--Lithology penetrated by borehole H-9a

[Color designation from Rock-Color Chart (Goddard and others, 1948). Depth interval refers to depth reported by driller.]

Lithologic description	Depth interval (feet)
Gypsum, olive-black (5Y 2/8) to dark-gray (N3) and olive-gray (5Y 4/1), finely crystalline, mottled; horizontal, 20-millimter-thick, fissile, moderate-reddish-brown (10R 4/6) siltstone band at 514.1 feet; irregular network, 1- to 7-millimeter-thick, fibrous, white (N9) selenite veins at 520.0 to 520.6 feet	514.0-521.4
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline; numerous 1- to 2-millimeter-diameter pits filled with translucent to transparent gypsum	521.4-522.3
Dolomite, light-olive-gray (5Y 6/1), with very thin, wavy olive-gray (5Y 4/1) laminae, very finely crystalline; numerous 1- to 2-millimeter diameter pits, filled with translucent to transparent gypsum at 522.3 to 523.1 feet; irregular bleb, 30 millimeters wide by 30 millimeters long and some irregular 1- to 4-millimeter-thick, fibrous, translucent to transparent selenite veinlets at 522.9 to 523.4 feet, some vertical veinlets at 523.5 to 523.9 feet	522.3-523.9
Dolomite, light-olive-gray (5Y 6/1), with very thin wavy olive-gray (5Y 4/1) laminae, very silty	523.9-524.5
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline	524.5-525.8
Dolomite, same as in unit from 522.3 to 523.9 feet; highly brecciated, angular fragments 2 millimeters to 60 millimeters in size, interstices 1- millimeter to 40-millimeters wide, many as much as 20-millimeters deep, filled with platey translucent to transparent gypsum (selenite); fracture at 526.7 to 529.0 feet with 2- to 3-millimeter displacement, dipping 72° filled with translucent to transparent gypsum (selenite)	525.8-529.0
Dolomite, light-olive-gray (5Y 6/1), dusky-yellow (5Y 6/4), with some very thin, wavy, olive-gray (5Y 4/1) laminae; silty, highly fractured, hairline to 3-millimeter-thick interstices filled with translucent to transparent gypsum (selenite)	529.0-534.1

Table 5.--Lithology penetrated by borehole H-9a - Concluded

Lithologic description	Depth interval (feet)
Dolomite, same as in unit from 523.9 to 524.1 feet, several fractures hairline to 3-millimeters wide, dipping 48-67°, filled with translucent crossfibrous selenite from 534.6 to 535.0 and 536.5 to 538.8 feet, as much as 10 millimeters of displacement in laminae across some fractures; fractures from 535.6 to 536.5 are void or filled with soft medium-light-gray (N6) to light-olive-gray (5Y 6/1) mud and some angular dolomite inclusions as much as 4-millimeters wide ----------	534.1-538.8
No core ----------	538.8-544.0
Dolomite, similar to units from 523.9 to 524.5 and 534.1 to 538.8 feet; several brecciated zones (some as fracture fill) of laminated dolomite in a translucent to transparent crossfibrous selenite matrix; several crossfibrous selenite-filled fractures dipping 45-68°, hairline to 20-millimeters wide; as much as 20 millimeters of vertical displacement in laminae across some fractures; wavy gypsum (selenite) laminae parallel to dolomite laminae as thick as 2 millimeters at 544.0-547.5 feet ----------	544.0-547.5
Gypsum, dark-yellowish-brown (10YR 4/2), mottled light-olive-gray (5Y 6/1) and medium-light-gray (N6), finely to medium crystalline, faintly laminated, portions slightly argillaceous; few wavy 2- to 4-millimeter-wide, horizontal selenite laminae; remnant anhydrite and gypsiferous anhydrite bands from 553.8 to 554.7 feet ----------	547.5-554.7
Anhydrite and gypsiferous anhydrite, dark-yellowish-brown (10YR 4/2) and medium-light-gray (N6), very finely crystalline; some gypsum-healed fractures have "chicken wire" appearance; scattered 5- to 10-millimeter-wide gypsum blebs; few gypsum bands at 554.7 to 555.8, same as in unit from 547.5 to 554.7 feet; few 1- to 3-millimeter-thick, wavy, cross-fibrous selenite laminae present in gypsum bands ----------	554.7-559.0
	Bottom of cored interval

Table 6.--Lithology penetrated by borehole H-9b

[Color designation from Rock-Color Chart (Goddard and others, 1948). Depth interval refers to depth reported by driller.]

Lithologic description	Depth interval (feet)
Gypsum, dark-yellowish-brown (10YR 4/2) to dusky-yellowish-brown (10YR 2/2), olive-gray (5Y 4/1), mottled, laminated, slightly argillaceous, finely to medium crystalline NOTE: Some of core lost at 642.0	640.0-642.0
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, numerous pits, 1 to 5 millimeters in size; 30-millimeter-wide fracture filled with argillaceous dolomite at 644.1 feet, dipping 40°; open fracture at 645.0 feet dipping 80°; core broken and "crumbly", parts argillaceous from 647.1 to 648.0 feet	642.0-648.0
No core	648.0-650.0
Dolomite, same as in unit from 642.0 to 648.0 feet; larger pits, from 1 millimeter to 20 millimeters in diameter, irregularly spaced throughout length of core; slightly argillaceous but more argillaceous towards bottom of core; parts broken and cobbly; some thin continuous and discontinuous nearly horizontal fractures throughout core	650.0-658.4
No core	658.4-660.0
Dolomite, same as in unit from 642.0 to 648.0 feet; pits continue to be numerous; at 662.5 feet approximately 30 percent of pits filled with light-gray (N7) translucent to transparent gypsum; several gypsum-filled fractures ranging from hairline to 2-millimeters wide, almost vertical; light-gray (N7), with light-olive-gray (5Y 6/1) finely crystalline gypsum inclusions 30-millimeters wide by 30-millimeters long at 666.5 feet; unit becomes dense with pits very rare from 666.8 to 667.5 feet	660.0-667.5
No core	667.5-670.0

Table 6.--Lithology penetrated by borehole H-9b - Concluded

Lithologic description	Depth interval (feet)
Dolomite, light-olive-gray (5Y 6/1) to (5Y 5/2), very finely crystalline, dense, no pits; 1- to 10-millimeter-wide gypsum-filled fractures present from 670.4 to 670.9 feet; white (N9), opaque, very finely crystalline, and translucent, gypsum inclusions from 670.4 to 670.5 feet	670.0-670.9
Mudstone, olive-gray (5Y 4/1) and medium-gray (N5), moderately to well indurated, dolomitic, faintly laminated	670.9-671.8
Mudstone, medium-dark-gray (N5) to dark-greenish-gray (5GY 4/1), moderately to well indurated; irregular, high-angle, 1- to 4-millimeter-wide, sometimes branching, gypsum veins; some clear to translucent selenite, light-gray (N7) tint	671.8-674.2
Mud, moderate-reddish-brown (10R 4/6), trace greenish-gray (5G 6/1), indurated; numerous selenite crystals, veins and crystal aggregates from 674.2 to 678.7 feet; trace of mottled, finely crystalline gypsum	674.2-679.7
Gypsum, dark-yellowish-brown (10YR 4/2), some light-olive-gray (5Y 6/1) to light-gray (N7), finely crystalline, mottled, argillaceous	679.7-679.8
No core	679.8-680.0
	Bottom of cored interval

Table 7.--Lithology penetrated by borehole H-9c

[Color designation from Rock-Color Chart (Goddard and others 1948). Depth interval refers to depth reported by driller except where lithologic and descriptive depths have been corrected to coincide with geophysical logging depths.]

Lithologic description	Depth interval (feet)
Sand, moderate-reddish-orange (10R 6/6), very fine grained, subrounded to rounded quartz grains, silty, very poorly consolidated, calcareous cement, trace of moderate-orange-pink (10R 7/4) sandy caliche	0-20.0
Sand, moderate-reddish-orange (10R 6/6) to moderate-reddish-brown (10R 4/6), very fine grained, subrounded to rounded quartz grains, silty, very poorly consolidated, calcareous cement; trace of caliche, same as in unit from 0 to 20.0 feet	20.0-25.0
Sand (50 percent), same as in unit from 20.0 to 25.0 feet; slightly calcareous, hard, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) siltstone (50 percent); trace of manganese dioxide on siltstone	25.0-35.0
Siltstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), poorly consolidated, calcareous, some approaching sandstone	35.0-38.0
Siltstone (70 percent), moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), very hard, slightly calcareous; fissile, hard, dark-reddish-brown (10R 3/4) mudstone (30 percent)	38.0-45.0
Siltstone (90 percent), same as in unit from 38.0 to 45.0 feet; mudstone (10 percent), same as in unit from 38.0 to 45.0 feet; trace of poorly consolidated, very fine grained to fine-grained, subrounded to rounded, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) sandstone; trace of friable, very fine grained to fine-grained, rounded to subrounded, greenish-gray (5GY 6/1) sandstone	45.0-50.0
Siltstone, same as in unit from 38.0 to 45.0 feet	50.0-55.00

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Siltstone (60 percent), same as in unit from 38.0 to 45.0 feet; moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) sandstone (30 percent), same as in unit from 45.0 to 50.0 feet; greenish-gray (5GY 6/1) sandstone (10 percent), same as in unit from 45.0 to 50.0 feet	55.0-60.0
Siltstone, same as in unit from 38.0 to 45.0 feet; trace of mudstone at 60.0 to 65.0 feet, same as in unit from 38.0 to 45.0 feet	60.0-70.0
Siltstone, same as in unit from 38.0 to 45.0 feet; trace moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) sandstone; trace of greenish-gray (5GY 6/1) reduction spots	70.0-75.0
Siltstone (90 percent), same as in unit from 38.0 to 45.0 feet; greenish-gray (5GY 6/1) sandstone (10 percent), same as in unit from 45.0 to 50.0 feet	75.0-80.0
Siltstone, same as in unit from 38.0 to 45.0 feet; trace of mudstone, same as in unit from 38.0 to 45.0 feet	80.0-85.0
Siltstone (80 percent), same as in unit from 38.0 to 45.0 feet; mudstone, (20 percent), same as in unit from 38.0 to 45.0 feet	85.0-90.0
Siltstone (90 percent), moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), very well indurated, slightly calcareous, some approaching mudstone; mudstone (10 percent), same as unit from 38.0 to 45.0 feet; trace, moderately consolidated greenish-gray (5GY 6/1) siltstone	90.0-100.0
Siltstone, same as in unit from 90.0 to 100.0 feet, trace of mudstone, same as in unit from 38.0 to 45.0 feet	100.0-110.0
Siltstone, same as in unit from 90.0 to 100.0 feet, trace of mudstone, same as in unit from 38.0 to 45.0 feet; trace of very fine grained, rounded to subrounded, greenish-gray, (5GY 6/1) sandstone	110.0-115.0

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Siltstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), well indurated, slightly calcareous, some approaching mudstone, very few greenish-gray (5GY 6/1) reduction spots; trace of mudstone same as in unit from 38.0 to 45.0 feet; trace of moderately consolidated, greenish-gray (5GY 6/1) siltstone	115.0-165.0
Siltstone, same as in unit from 115.0 to 165.0 feet; trace of moderately indurated, dark-reddish-brown (10R 3/4) mudstone	165.0-175.0
Siltstone, same as in unit from 115.0 to 165.0 feet; trace of mudstone same as in unit from 165.0 to 175.0 feet; trace of fibrous, platey, translucent to transparent selenite	175.0-190.0
Siltstone (90 percent), same as in unit from 115.0 to 165.0 feet; mudstone (10 percent), same as in unit from 165.0 to 175.0 feet; trace of selenite, same as in unit from 175.0 to 190.0 feet	190.0-200.0
Siltstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), moderately indurated, some approaching mudstone, with few greenish-gray (5GY 6/1) reduction spots; trace of selenite, same as in unit from 175.0 to 190.0 feet	200.0-210.0
Siltstone (95 percent), same as in unit from 200.0 to 210.0 feet; selenite (5 percent), same as in unit from 175.0 to 190.0 feet; trace of fissile, moderately indurated, dark-reddish-brown (10R 3/4) to moderate-reddish-brown (10R 4/6) mudstone at 225.0 to 245.0 feet	210.0-245.0
Siltstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), indurated, with few greenish-gray (5GY 6/1) reduction spots; trace of selenite, trace of mudstone, same as in unit from 210.0 to 245.0 feet	245.0-270.0

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Siltstone, dark-reddish-brown (10R 3/4), approaching very fine grained sandstone, moderately indurated, few greenish-gray (5GY 6/1) reduction spots; trace of selenite, trace of mudstone; same as in unit from 210.0 to 245.0 feet --	270.0-275.0
Siltstone, same as in unit from 245.0 to 270.0 feet; trace of selenite; trace of mudstone, same as in unit from 225.0 to 245.0 feet ----------	275.0-310.0
Siltstone, same as in unit from 245.0 to 270.0 feet; trace of selenite; trace of mudstone, same as in unit from 210.0 to 245.0 feet; trace of indurated, very fine-grained, light-greenish-gray (5GY 8/1) sandstone ----------	310.0-315.0
Siltstone (60 percent), same as in unit from 245.0 to 270.0 feet; mudstone (40 percent), same as in unit from 210.0 to 245.0 feet; trace of selenite; trace of sandstone, same as in unit from 310.0 to 315.0 feet ----------	315.0-320.0
Siltstone (50 percent), same as in unit from 245.0 to 270.0 feet; sandstone (30 percent), same as in unit from 310.0 to 315.0 feet; mudstone (20 percent), same as in unit from 210.0 to 245.0 feet; trace of selenite ----------	320.0-330.0
Siltstone, same as in unit from 245.0 to 270.0 feet; trace of sandstone, same as in unit from 310.0 to 315.0 feet; trace of mudstone, same as in unit from 210.0 to 245.0 feet; trace of selenite ----------	330.0-340.0
Siltstone, same as in unit from 200.0 to 210.0 feet; trace of selenite; trace of mudstone, same as in unit from 210.0 to 245.0 feet ----------	340.0-345.0
Siltstone (80 percent), same as in unit from 245.0 to 270.0 feet; mudstone (20 percent), same as in unit from 165.0 to 175.0 feet; trace of selenite ----------	345.0-350.0
Siltstone, pale-reddish-brown (10R 5/4) to moderate-reddish-brown (10R 4/6); trace of selenite ----------	350.0-355.0

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Siltstone (70 percent), same as in unit from 245.0 to 270.0 feet; mudstone (30 percent), same as in unit from 210.0 to 245.0 feet; trace of selenite	355.0-360.0
Siltstone (60 percent), same as in unit from 245.0 to 270.0 feet, with traces of white (N9) siltstone (possibly gypsiferous); mudstone (40 percent), same as in unit from 165.0 to 175.0 feet; trace of selenite	360.0-365.0
Siltstone (60 percent), same as in unit from 360.0 to 365.0 feet; mudstone (40 percent), same as in unit from 165.0 to 175.0 feet; trace of selenite	365.0-370.0
Siltstone (60 percent), same as in unit from 360.0 to 365.0 feet; mudstone (40 percent), same as in unit from 165.0 to 175.0 feet; trace of selenite	370.0-395.0
Siltstone (70 percent), same as in unit from 245.0 to 270.0 feet; mudstone (30 percent), same as in unit from 165.0 to 175.0 feet, traces of moderate-orange-pink (10R 7/4) in interval from 405.0 to 410.0 feet; trace of selenite	395.0-420.0
Siltstone (60 percent), same as in unit from 245.0 to 270.0 feet; mudstone (40 percent), same as in unit from 165.0 to 175.0 feet; trace of selenite	420.0-445.0
Siltstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), friable to moderately indurated, some approaching very fine grained sandstone; few greenish-gray (5GY 6/1) reduction spots; trace of translucent, milky white gypsum inclusions up to 1/2 millimeter in size; trace of clear selenite	445.0-455.0
Siltstone (70 percent), same as in unit from 445.0 to 455.0 feet; very finely crystalline, very-light-gray (N8) some light-olive-gray (5Y 6/1) gypsum, (30 percent); trace selenite	455.0-460.0
Gypsum (50 percent), same as in unit from 455.0 to 460.0 feet; very finely crystalline, light-olive-gray (5Y 6/1) anhydrite (30 percent); siltstone (20 percent), same as in unit from 445.0 to 455.0 feet	460.0-465.0

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Anhydrite (60 percent), same as in unit from 460.0 to 465.0 feet; gypsum (40 percent), same as in unit from 455.0 to 460.0 feet, some possibly altered from anhydrite by drilling fluid ------	465.0-470.0
Anhydrite (80 percent), light-olive-gray (5Y 6/1), and light-gray (N7); gypsum (20 percent), same as in unit from 455.0 to 460.0 feet ----------	470.0-475.0
No samples ----------	475.0-485.0
Anhydrite (90 percent), same as in unit from 470.0 to 475.0 feet; clear selenite (10 percent) ----------	485.0-490.0
Siltstone (35 percent), same as in unit from 445.0 to 455.0 feet; gypsum (30 percent), same as in unit from 455.0 to 460.0 feet; anhydrite (20 percent), same as in unit from 470.0 to 475.0 feet; clear selenite (15 percent) ----------	490.0-495.0
Anhydrite (60 percent), same as in unit from 470.0 to 475.0 feet; siltstone (40 percent), same as in unit from 445.0 to 455.0 feet; trace of grayish-red (10R 4/2) to dark-reddish-brown (10R 3/4) mudstone; trace of clear selenite; trace of sucrosic, white (N9) to light-olive-gray (5Y 6/1) gypsum ----	495.0-500.0
Siltstone (60 percent), moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), some with grayish-red (10R 4/2) tint, trace sandy; moderately to poorly indurated, with some greenish-gray (5GY 6/1) reduction spots, light-olive-gray (5Y 6/1) and light-gray (N7), anhydrite (30 percent), some approaching mudstone; clear selenite (10 percent); trace light-olive-gray (5Y 6/1) gypsum ---------- NOTE: End of cutting descriptions; core descriptions follow.	500.0-505.0
Gypsiferous anhydrite, dusky-yellowish-brown (10YR 2/2), dark-yellowish-brown (10YR 4/2) and medium-bluish-gray (5B 5/1), very finely crystalline, massive, slight "chicken wire" appearance; unit very gypsiferous toward bottom; very faintly laminated in parts ----------	505.0-513.8

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Siltstone, dark-reddish-brown (10R 3/4), moderately hard; high-angle, 2-millimeter-thick white (N9) gypsum vein through middle of core; 4- to 7-millimeter-thick gypsum band at top of interval; contact with unit above is wavy	513.8-514.0
Depth correction	514.0-516.4
Gypsum (90 percent), white (N9) to light-gray (N7), very finely crystalline, massive, unfractured; medium-dark-gray (N4) anhydrite (10 percent) as remnant blotches less than 20 to 100 millimeters in size, no anhydrite below 519.1 feet	516.4-522.2
Dolomitic gypsum, white (N9) to light-gray (N7); light-olive-gray (5Y 6/1) silty and clayey dolomite grains dispersed throughout interval	522.2-523.6
Gypsiferous silty dolomite, light-olive-gray (5Y 6/1), white (N9) to very-light-gray (N8) selenite veins, less than 5 millimeters in width and olive-gray (5Y 4/1) silty laminae, less than 2 millimeters in width; white (N9) gypsum blebs less than 1 millimeter; cross-bedded	523.6-525.0
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, fractures absent, hard, cross-bedded; olive-gray (5Y 4/1) silt band 10 millimeters in width at 525.1 feet	525.0-525.6
Dolomite, light-olive-gray (5Y 6/1), (5Y 5/2) and olive-gray (5Y 4/1); wavy laminae throughout with some small-scale cross-bedding; numerous gypsum blebs in some laminae from 525.6 to 529.8 feet, laminae usually less than 1-millimeter thick but as much as 4-millimeters thick from 527.4 to 528.2 feet; massive, no laminae from 526.5 to 527.4 feet; porous appearance, pin-point porosity, especially in some laminae from 525.9 to 526.2 and 529.8 to 534.0 feet; open fractures, one dipping 40° at 531.7 feet and one dipping 80° at 534.0 feet; several gypsum-filled fractures dipping 80° to almost vertical from 526.2 to 528.0 feet; gypsum-filled fracture dipping 60° at 530.4 feet and two parallel gypsum-filled fractures about 10-millimeters wide dipping 70° at 532.7 feet, have as much as 0.1-foot displacement; dolomite appears more clayey from 534.0 to 534.8 feet	525.6-537.0

Table 7.--Lithology penetrated by H-9c - Continued

Lithologic description	Depth interval (feet)
Dolomite, light-olive-gray (5Y 6/1) and (5Y 5/2), wavy laminae throughout, some darker laminae approach olive-gray (5Y 4/1), some small-scale cross-bedding; core is similar to unit from 525.6 to 537.0 feet, more dense, laminae are less wavy; gypsum blebs less than 1-millimeter across from 542.8 to 544.0 feet; laminae from 543.6 to 544.0 feet more pronounced with greater amplitude of waviness; gypsum-filled fracture at 537.0 feet dips 45°, branching fracture dips nearly 90°; gypsum-filled fracture dipping 85° at 540.2 feet and a hairline gypsum-filled fracture dipping 60° at 543.4 feet	537.0-544.0
Dolomite, light-olive-gray (5Y 6/1) and (5Y 5/2), very wavy olive-gray (5Y 4/1) to light-olive-gray (5Y 5/2) laminae, some slightly gypsiferous laminae, some small-scale cross-bedding; horizontal, slightly wavy, 6-millimeter-thick, continuous, white (N9) gypsum-filled fracture (possible dip-slip fault) with 40- to 60-millimeter displacement dipping 76°, filled with soft, medium-gray (N5) and medium-bluish-gray (5B 5/1) gypsum; mottled, slightly chalky, white (N9) to light-olive-gray (5Y 6/1), and light-bluish-gray (5YR 6/1) clay filling fracture from 546.1 to 547.1 feet	544.0-547.1
Dolomite, same as in unit from 544.0 to 547.1 feet, numerous 10- to 20-millimeter, rectangular fragments, tightly packed; hairline to 2-millimeter-wide fractures showing offset in laminae, filled with white (N9) to transparent gypsum	547.1-547.5
Dolomite, light-olive-gray (5Y 6/1), with slightly wavy to straight light-olive-gray (5Y 5/2) and olive-gray (5Y 4/1) laminae, hairline to 2-millimeter-wide fractures showing offset in laminae, filled with white (N9) gypsum; continuous fracture dipping 70°, with 4-millimeter displacement, filled with white (N9) gypsum at 548.0 feet	547.5-548.6
Dolomite, same as in unit from 544.0 to 547.1 feet; very numerous wavy, continuous and discontinuous, 1- to 5-millimeter-thick bands of white (N9) gypsum; numerous hairline to 1-millimeter-wide fractures showing offset of laminae filled with transparent gypsum from 550.0 to 552.6 feet; very irregular, 30-millimeters long by 20-millimeters wide, white (N9) to transparent gypsum bleb at 522.0 feet	548.6-552.6

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
No core	552.6-553.0
Dolomite, light-olive-gray (5Y 6/1), wavy greenish-gray (5GY 2/1) laminations less than 2-millimeters wide; small blebs of light-gray (N7) gypsum less than 1-millimeter wide, scattered randomly	553.0-554.0
Dolomitic gypsum, light-gray (N7) to white (N9), finely to medium crystalline, stringers of light-olive-gray (5Y 6/1) dolomite less than 0.1-inch wide, gradational boundary with overlying unit, percentage of dolomite decreasing with depth, dolomite dispersed as intragranular and random stringers to a depth of 559.0 feet; light-gray (N7) finely to very finely crystalline, anhydrite blebs, less than 3 millimeters in size, increase in size and occurrence with depth	554.0-559.0
Anhydrite, light-gray (N7), hard, very finely to finely crystalline, mottled with very light-gray (N8) gypsum blebs less than 6 millimeters in width; few isolated blotches of light-olive-gray (5Y 6/1) dolomite, less than 30-millimeters wide	559.0-562.2
Note: End of core descriptions; cutting descriptions follow.	
Gypsum (50 percent), light-olive-gray (5Y 6/1), some light-gray (N7), and moderate-yellowish-brown (10YR 5/4), finely to medium-crystalline; dolomite cavings (30 percent); clear selenite (20 percent)	562.2-565.0
Gypsum (50 percent), same as in unit from 562.2 to 565.0 feet; dolomite (20 percent), same as in unit from 562.2 to 565.0 feet; selenite (20 percent), same as in unit from 562.2 to 565.0 feet; dolomite (10 percent), light-olive-gray (5Y 6/1) to translucent and pale-yellowish-brown (10YR 6/2)	565.0-570.0
Anhydrite (70 percent), translucent, and light-olive-gray (5Y 6/1) and dark-yellowish-brown (10YR 4/2); gypsum (25 percent), same as in unit from 562.2 to 565.0 feet; white (N9), chalky, clear selenite (5 percent)	570.0-575.0

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Anhydrite (80 percent), same as in unit from 570.0 to 575.0 feet; gypsum (20 percent), same as in unit from 562.2 to 565.0 feet; trace of clear selenite	575.0-585.0
Anhydrite (60 percent), same as in unit from 570.0 to 575.0 feet; gypsum (40 percent), same as in unit from 562.2 to 565.0 feet; trace of clear selenite	585.0-590.0
Gypsum (90 percent), same as in unit from 562.2 to 565.0 feet; anhydrite (10 percent), same as in unit from 570.0 to 575.0 feet; trace of moderate-reddish-brown (10R 4/6) silt; trace of clear selenite	590.0-595.0
Anhydrite (80 percent), same as in unit from 570.0 to 575.0 feet; gypsum (20 percent), same as in unit from 562.2 to 565.0 feet	595.0-605.0
Gypsum (80 percent), same as in unit from 562.2 to 565.0 feet; anhydrite (20 percent), same as in unit from 570.0 to 575.0 feet; trace of soft, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) mud	605.0-610.0
Gypsum (70 percent), white (N9), some light-olive-gray (5Y 6/1), some soft and chalky, some hard and finely crystalline; anhydrite (20 percent), same as in unit from 570.0 to 575.0 feet; mud (10 percent), same as in unit from 605.0 to 610.0 feet	610.0-615.0
Mud (60 percent), same as in unit from 605.0 to 610.0 feet; gypsum (40 percent), same as in unit from 610.0 to 615.0 feet	615.0-620.0
NOTE: End of cutting descriptions, core descriptions follow.	
Clay, moderate-reddish-brown (10R 4/6), minor amounts greenish-gray (5G 6/1) and light-olive-gray (5Y 6/1), soft; selenite veins, crystals and inclusions throughout, random orientation, veins dip up to 30° from 620.1 to 620.6 feet; silty and more indurated in 620.0-620.1 feet; light-olive-gray (5Y 6/1)) to olive-gray (5Y 4/1) and tinted green, very finely to finely crystalline, angular gypsum fragment at 621.3 feet, 0.4 by 0.2 foot in size	620.0-624.6

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Gypsum, dark-yellowish-brown (10YR 4/2), medium-light-gray (N6), mottled, argillaceous	624.6-624.8
Anhydrite, medium-light-gray (N6) to light-olive-gray (5Y 5/2), very dense; gypsiferous from 627.0 to 627.3 feet; 2-millimeter-wide gypsum-healed fracture dipping 58° at 625.5 feet	624.8-628.8
No core	628.8-629.0
Anhydrite, medium-light-gray (N6) to light-olive-gray (5Y 5/2), very finely crystalline, dense, gypsiferous, numerous thin, discontinuous, light-olive-gray (5Y 5/2) argillaceous laminae; becoming very argillaceous and containing many thin gypsum veins at 631.0 to 631.5 feet; 27- to 61-millimeter-thick, dark-greenish-gray (5G 4/1) clay parting dipping 35° at 631.5 to 631.7 feet; two 10-millimeter-thick gypsum-healed fractures at 635.2 to 635.3 feet, few other thinner gypsum-healed fractures throughout; gypsum gives anhydrite banded appearance at 635.3 to 637.9 feet; unit dips approximately 25°	629.0-637.9
No core	637.9-638.0
Anhydrite, light-gray (N7), very finely crystalline, hard, unfractured; white (N9) to very-light-gray (N8) gypsum, intercrystalline, less than 10 percent composition	638.0-641.6
No core	641.6-642.0
Anhydrite, medium-light-gray (N6) and light-olive-gray (5Y 5/2) to dark-yellowish-brown (10YR 4/2), dense, gypsiferous in parts; gypsum-healed fracture dipping 45° at 643.2 feet; unit becomes very gypsiferous and dark-yellowish-brown (10YR 4/2) from 644.4 to 644.8 feet	642.0-644.8
No core	644.8-645.0
Gypsum, dark-yellowish-brown (10YR 4/2), finely to medium-crystalline, many thin, slightly dolomitic, pale-brown (5YR 5/2) laminae which become very concentrated at 646.2 to 647.1 feet	645.0-647.1

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Dolomite, pale-brown (5YR 5/2), faintly horizontally banded, slightly darker, very thin laminae, very argillaceous, numerous pits, mostly 1 millimeter or less in diameter, some as large as 20 millimeters; some irregular gypsum inclusions a few millimeters to several centimeters in size from 647.1 to 647.5 feet	647.1-648.9
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, very hard, numerous pits, 1 millimeter to 10 millimeters in diameter, much more concentrated and larger towards bottom of core; many thin, discontinuous, branching, high-angle fractures throughout	648.9-655.4
No core	655.4-663.0
Dolomite, light-olive-gray (5Y 6/1), hard, very finely crystalline, fractured, angular pebble- to cobble-sized fragments; slightly argillaceous, few pits	663.0-663.8
No core	663.8-672.0
Dolomite, similar to unit from 648.9 to 655.4 feet; pits less than 5-millimeters wide, very numerous, 50 percent of pits filled with light-gray (N7) translucent gypsum; several hairline to 4-millimeter-wide gypsum-filled fractures, dipping 80° to vertical; light-gray (N7), and light-olive-gray (5Y 6/1) finely crystalline gypsum mass 0.2 by 0.3 feet at 672.2 feet, rock becomes denser with pits very rare from 674.0 to 674.9 feet	672.0-674.9
Dolomite, olive-gray (5Y 4/1), dark-greenish-gray (5GY 4/1), very argillaceous, wavy laminae, small-scale cross-bedding	674.9-675.2
No core	675.2-681.0
Dolomite (60 percent), light-olive-gray (5Y 6/1) and dark-yellowish-brown (10YR 4/2), very finely crystalline, dense; translucent and medium-light-gray (N6), finely crystalline gypsum (30 percent); clear selenite (10 percent); probably lost core from earlier intervals	681.0-685.0
NOTE: End of core descriptions, cutting descriptions follow.	

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Dolomite (50 percent), same as in unit from 681.0 to 685.0 feet, probably cavings from earlier cores; gypsum (15 percent), same as in unit from 681.0 to 685.0 feet; translucent and dark-yellowish-brown (10YR 4/2) anhydrite (20 percent); clear selenite (10 percent); olive-gray (5Y 4/1) to medium-dark-gray (N4), firm siltstone (5 percent)	685.0-690.0
Gypsum (50 percent), white (N9), very-light-gray (N8) to light-olive-gray (5Y 6/1), opaque to translucent, trace with moderate-reddish-brown (10R 4/6) stain; anhydrite (20 percent), same as in unit from 685.0 to 690.0 feet; dolomite (10 percent), same as in unit from 681.0 to 685.0 feet; clear selenite (10 percent); moderate-brown (5YR 4/4), poorly indurated, silty mud (10 percent)	690.0-695.0
Gypsum (65 percent), same as in unit from 690.0 to 695.0 feet; mud (20 percent), same as in unit from 690.0 to 695.0 feet; anhydrite (10 percent), same as in unit from 685.0 to 690.0 feet; clear selenite (5 percent)	695.0-700.0
Gypsum (65 percent) white (N9), light-gray (N7) to light-olive-gray (5Y 6/1), opaque to translucent, very finely to finely crystalline; translucent, light-gray (N7) and light-olive-gray (5Y 6/1) anhydrite (30 percent); clear selenite (5 percent)	700.0-705.0
Gypsum (75 percent), same as in unit from 700.0 to 705.0 feet; anhydrite (15 percent), same as in unit from 700.0 to 705.0 feet; clear selenite (5 percent); moderately consolidated, moderate-reddish-brown (10R 4/6) siltstone (5 percent)	705.0-715.0
Gypsum (60 percent), same as in unit from 700.0 to 705.0 feet; anhydrite (20 percent), same as in unit from 700.0 to 705.0 feet; siltstone (20 percent), same as in unit from 705.0 to 715.0 feet; trace of clear selenite, trace of greenish-gray (5GY 6/1) siltstone	715.0-720.0
Gypsum (60 percent), same as in unit from 700.0 to 705.0 feet; siltstone (30 percent), same as in unit from 705.0 to 715.0 feet; anhydrite (10 percent), same as in unit from 700.0 to 705.0 feet; trace of dark-greenish-gray (5GY 4/1) siltstone	720.0-725.0
Gypsum (60 percent), same as in unit from 700.0 to 705.0 feet; siltstone (20 percent), same as in unit from 705.0 to 715.0 feet; soft, greenish-gray (5GY 6/1) siltstone (20 percent); trace of anhydrite, same as in unit from 700.0 to 705.0 feet, trace of clear selenite	725.0-730.0

Table 7.--Lithology penetrated by borehole H-9c - Continued

Lithologic description	Depth interval (feet)
Gypsum (50 percent), same as in unit from 700.0 to 705.0 feet; moderately consolidated, greenish-gray (5GY 6/1) siltstone (30 percent); siltstone (20 percent), same as in unit from 705.0 to 715.0 feet; trace of clear selenite; trace anhydrite, same as in unit from 700.0 to 705.0 feet ------	730.0-740.0
Gypsum (50 percent), same as in unit from 700.0 to 705.0 feet; siltstone (45 percent), same as in unit from 730.0 to 740.0 feet; siltstone (5 percent), same as in unit from 705.0 to 715.0 feet; trace of clear selenite; trace of anhydrite, same as in unit from 700.0 to 705.0 feet ----------	740.0-745.0
Siltstone (50 percent), greenish-gray (5GY 6/1) to dark-greenish-gray (5G 4/1), moderately consolidated; gypsum (30 percent), same as in unit from 700.0 to 705.0 feet; siltstone (10 percent), same as in unit from 705.0 to 715.0 feet; soft, "gumbo", greenish-gray (5G 6/1) clay (10 percent) ----------	745.0-755.0
Siltstone (60 percent), same as in unit from 745.0 to 755.0 feet; gypsum (30 percent), same as in unit from 700.0 to 705.0 feet; siltstone (10 percent), same as in unit from 705.0 to 715.0 feet; trace of clear selenite; trace of clay, same as in unit 745.0 to 755.0 feet ----------	755.0-775.0
Siltstone (65 percent), same as in unit from 745.0 to 755.0 feet; gypsum (20 percent), same as in unit from 700.0 to 705.0 feet; clay (10 percent), same as in unit from 745.0 to 755.0 feet; siltstone (15 percent), same as in unit from 705.0 to 715.0 feet ----------	775.0-785.0
No samples ----------	785.0-789.0
NOTE: End of cutting descriptions, core descriptions follow.	
No core ----------	789.0-797.3
Mudstone, moderate-reddish-brown (10R 4/6), soft, non-bedded, angular contact with underlying unit; probably lost core from earlier intervals ----------	797.3-797.6
Anhydrite, light-gray (N7) to very-light-gray (N8) very finely crystalline, with moderate-reddish-brown (10R 4/6) mud seam at 797.8 feet, less than 5-millimeters wide, dipping 30°, probably lost core from earlier intervals; trace of clear halite at base of unit ----------	797.6-798.0

Table 7.--Lithology penetrated by borehole H-9c - Concluded

Lithologic description	Depth interval (feet)
Halite, translucent, and moderate-reddish-brown (10R 4/6), medium to coarsely crystalline, some moderate-reddish-brown (10R 4/6) polyhalite blebs	798.0-798.4
Argillaceous halite, translucent, very finely to finely crystalline, dark-reddish-brown (10R 3/4) mud, parts very argillaceous, trace of greenish-gray (5G 6/1) mud	798.4-803.4
Siltstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), hard, approaching very fine grained sandstone in size, halitic, mottled with irregular 1- to 5-millimeter-sized greenish-gray (5GY 6/1) blotches, trace of gypsum	803.4-804.4
No core	804.4-807.0
Siltstone, same as in unit from 803.4 to 804.4 feet, approaching very fine grained sandstone from 807.6 to 808.6 feet	807.0-809.9
Argillaceous halite, translucent, finely crystalline; moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) mud and some silt; trace of moderate-reddish-brown (10R 4/6) polyhalite	809.9-812.5
Halite, translucent, grayish-red (5R 4/2), and moderate-reddish-brown (10R 4/6), finely to medium-crystalline; slightly argillaceous from 812.5 to 814.0 feet, trace of moderate-reddish-brown (10R 4/6) polyhalite from 813.7 to 815.7 feet; dark-reddish-brown (10R 3/4) halitic mud seam from 815.5 to 815.7 feet	812.5-816.0
	Bottom of cored interval