

GEOLOGIC AND WELL-CONSTRUCTION DATA FOR THE H-8 BOREHOLE COMPLEX NEAR THE  
PROPOSED WASTE ISOLATION PILOT PLANT SITE, SOUTHEASTERN NEW MEXICO

By J. G. Wells (U.S. Geological Survey) and  
S. L. Drellack, Jr. (Fenix and Scisson, Inc.)

---

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 82-4118

Prepared in cooperation with the

U.S. DEPARTMENT OF ENERGY

Albuquerque, New Mexico

1982



UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

---

For additional information  
write to:

District Chief  
U.S. Geological Survey  
Water Resources Division  
505 Marquette NW, Room 720  
Albuquerque, New Mexico 87102

For sale by:

Open-File Services Section  
Branch of Distribution  
U.S. Geological Survey, MS 306  
Box 25425, Denver Federal Center  
Denver, Colorado 80225  
(303) 234-5888

## CONTENTS

|                                              | Page |
|----------------------------------------------|------|
| Abstract .....                               | 1    |
| Introduction .....                           | 2    |
| Borehole drilling and sampling methods ..... | 5    |
| Geologic data .....                          | 6    |
| Summary .....                                | 8    |
| Selected references .....                    | 9    |

## ILLUSTRATIONS

|                                                                                                                       |   |
|-----------------------------------------------------------------------------------------------------------------------|---|
| Figure 1. Map showing location of the H-8 borehole complex with respect to the Waste Isolation Pilot Plant site ..... | 3 |
| 2. Schematic diagram of the H-8 borehole complex .....                                                                | 4 |

## PLATE

|                                                                 |           |
|-----------------------------------------------------------------|-----------|
| Plate 1. Lithologic and geophysical logs of borehole H-8c ..... | In pocket |
|-----------------------------------------------------------------|-----------|

## TABLES

|                                                                      |    |
|----------------------------------------------------------------------|----|
| Table 1. Summary of geologic units penetrated by borehole H-8c ..... | 10 |
| 2.-4. Drilling and well-completion record of:                        |    |
| 2. Borehole H-8a .....                                               | 11 |
| 3. Borehole H-8b .....                                               | 13 |
| 4. Borehole H-8c .....                                               | 15 |
| 5.-7. Lithology penetrated by:                                       |    |
| 5. Borehole H-8a .....                                               | 17 |
| 6. Borehole H-8b .....                                               | 25 |
| 7. Borehole H-8c .....                                               | 27 |

## 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 (SI) of units.

| <u>Multiply inch-pound units</u> | <u>By</u> | <u>To obtain SI units</u> |
|----------------------------------|-----------|---------------------------|
| 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.

**GEOLOGIC AND WELL-CONSTRUCTION DATA FOR THE H-8 BOREHOLE COMPLEX**  
**NEAR THE PROPOSED WASTE ISOLATION PILOT PLANT**  
**SITE, SOUTHEASTERN NEW MEXICO**

**By J. G. Wells (U.S. Geological Survey) and**  
**S. L. Drellack, Jr. (Fenix and Scisson, Inc.)**

**ABSTRACT**

The H-8 borehole complex, a group of three closely spaced boreholes, is located 9 miles south of the proposed Waste Isolation Pilot Plant site in southeastern 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 disposal 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-8a (total depth 505 feet) was completed just below the Magenta Dolomite Member of the Rustler Formation of Permian age; H-8b (total depth 624 feet) was completed just below the Culebra Dolomite Member of the Rustler Formation; and H-8c (total depth 808 feet) was completed just below the Rustler Formation-Salado Formation contact. The geologic units penetrated in borehole H-8c are surficial alluvium and eolian sand of Holocene age (0-4 feet); the Mescalero caliche (4-10 feet) and Gatuna Formation (10-153 feet), both of Pleistocene age; and the Dewey Lake Red Beds (153-399 feet), the Rustler Formation (399-733 feet), and part of the Salado Formation (733-808 feet), all of Permian age. The upper 41 feet of the Salado Formation penetrated by borehole H-8c is composed of residue from dissolution of halite and associated rocks and the hydration of anhydrite to gypsum, indicating that the eastward-moving dissolution on top of the Salado, found west of the WIPP site, has reached the H-8 site.

## INTRODUCTION

The H-8 borehole complex (SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 23, T. 24 S., R. 30 E.) was drilled in southeastern 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-8 borehole complex. The geologic and hydrologic tests will provide information on 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-8 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-8 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-8c 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.

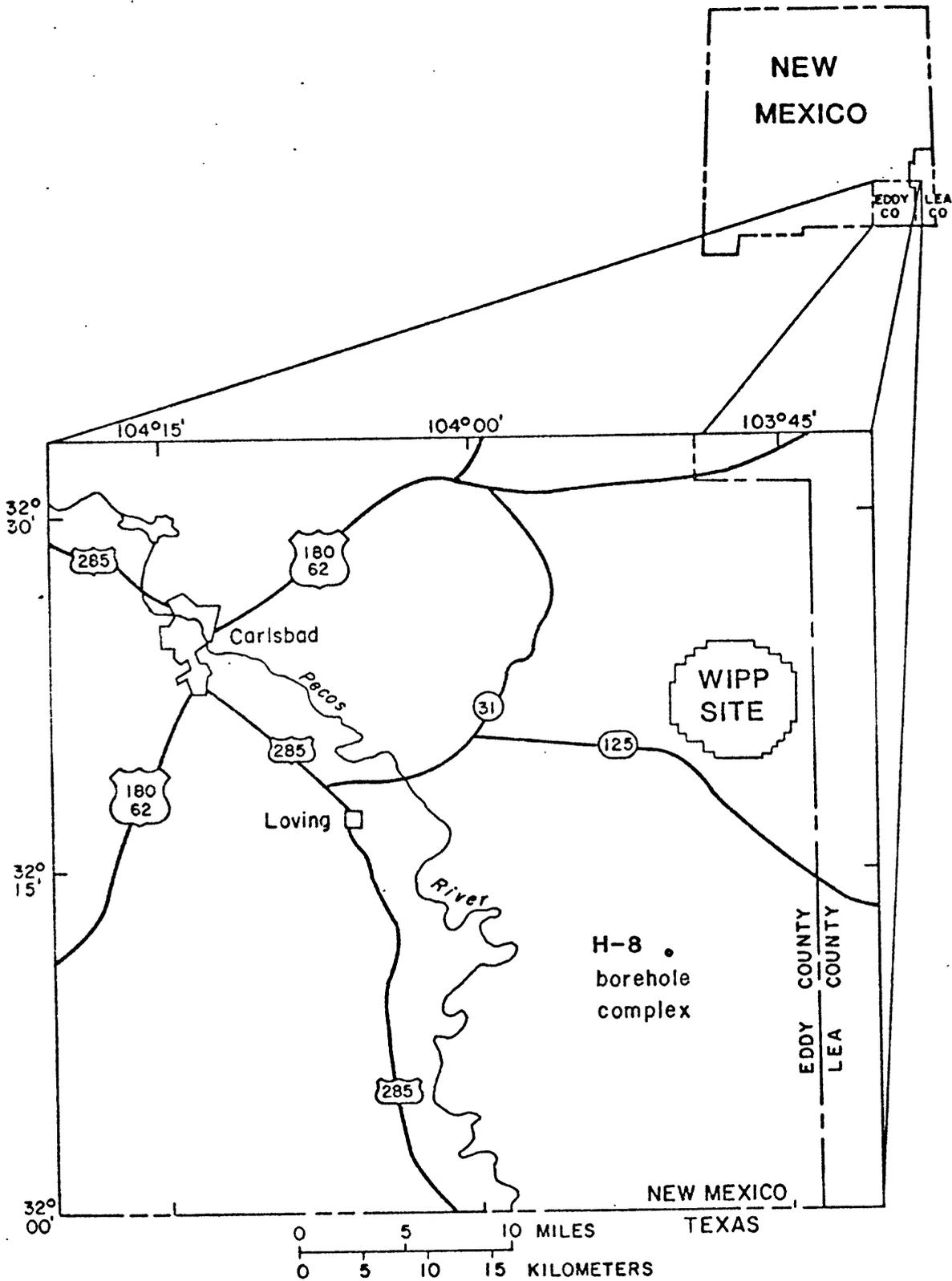


Figure 1.--Location of H-8 borehole complex with respect to the Waste Isolation Pilot Plant site.

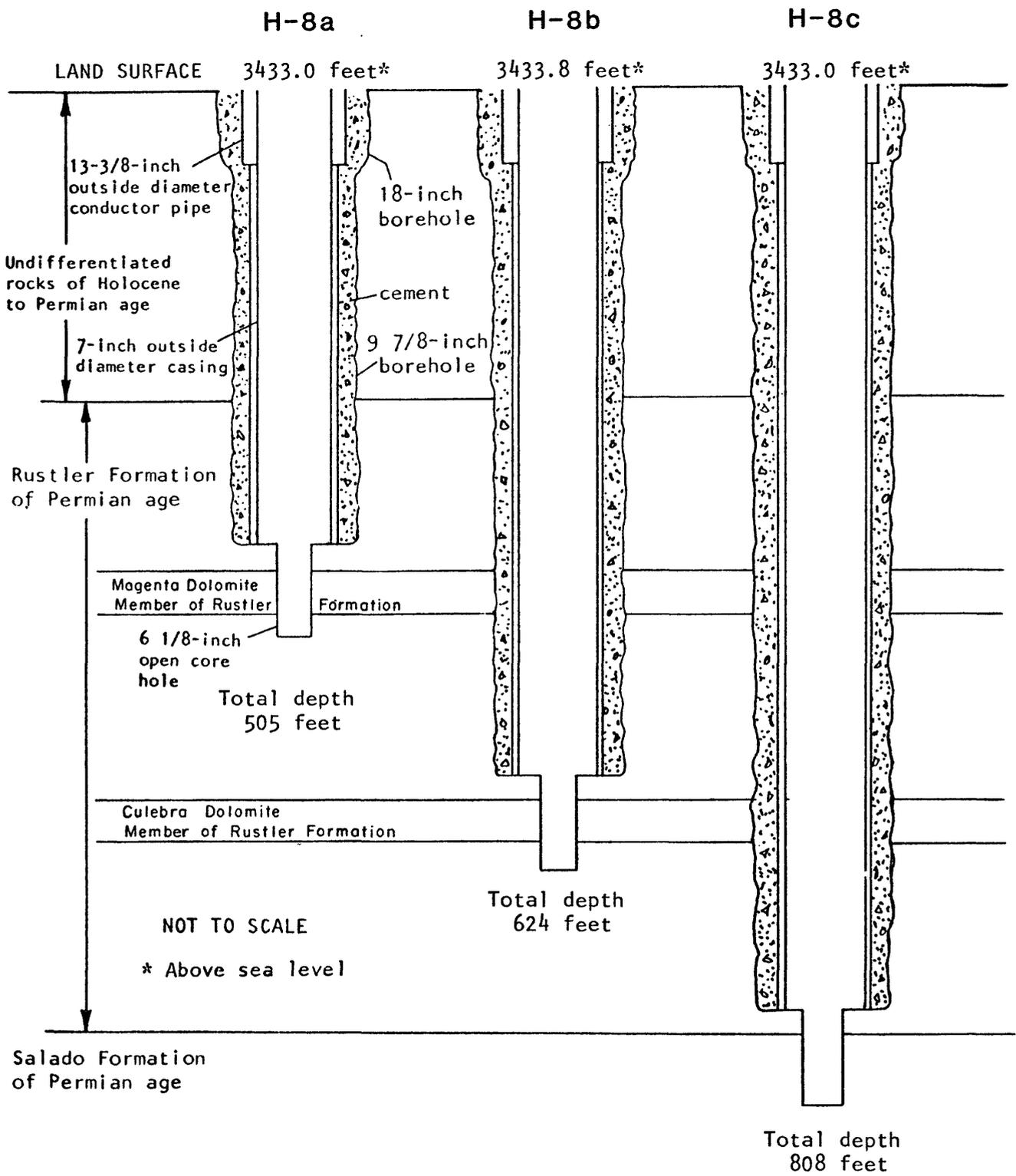


Figure 2.--Schematic diagram of the H-8 borehole complex.

## BOREHOLE DRILLING AND SAMPLING METHODS

The H-8 borehole complex 9 miles south of the proposed WIPP site, drilled during July, August, and September 1979, consists of three boreholes (H-8a, H-8b, and H-8c) located 100 feet apart in an equilateral triangle. Borehole H-8c was drilled first and penetrated the Rustler Formation-Salado Formation contact 75 feet above the total depth of 808 feet measured from a land-surface altitude of 3,433.0 feet above sea level. Borehole H-8b was drilled next to a total depth of 624 feet and penetrated the Culebra Dolomite Member. H-8a borehole was drilled last to a total depth of 505 feet and penetrated the Magenta Dolomite Member (fig. 2).

Rotary and air-rotary/air-mist drilling procedures were used to drill borehole H-8c. The air-rotary method facilitates the identification of 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-8c from ground level to a depth of 463 feet. Wire-line coring procedures were used at the other selected intervals to cut continuous cores at 463-492 feet (which includes the Magenta at 466-488 feet), 557-614 feet (which includes the Culebra at 588-614 feet), and 735-808 feet (which includes the Rustler Formation-Salado Formation contact at 733 feet, marker bed 103 at 774-786, and the top of the salt at 798 feet found in the Salado Formation). The cuttings and cores were examined and described at the drillsite and then transported to the Sandia National Laboratories warehouse in Carlsbad, New Mexico, for storage.

The bottom section of the Culebra (608.0 to 610.4 feet) penetrated by borehole H-8c is described in table 7 as a mudstone. A part of the dolomite probably was dissolved and replaced by clay and silt. No core was collected from 610.4 to 614.0 feet; therefore the depth for the base of the Culebra (614 feet) has been reported from geophysical logs.

Prior to setting casing, a suite of wire-line geophysical logs was made the full depth of borehole H-8c 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-8c at 734 feet below land surface and the annular space between formation and casing was filled with cement. Afterwards, the interval from 735 to 808 feet was cored and 61.6 feet of core were recovered.

Boreholes H-8a and H-8b were rotary drilled to just above the Magenta and Culebra Dolomite Members, respectively. Fifty-one feet of borehole H-8a and 48 feet of borehole H-8b were cored after the casing was set and the annular space between formation and casing was filled with cement as in borehole H-8c. The holes were geophysically logged after the total depth of each hole was reached.

## GEOLOGIC DATA

Borehole H-8c, with a total depth of 808 feet, is the deepest borehole at the H-8 complex. For this reason, the geologic section penetrated by borehole H-8c 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, unconsolidated alluvium and eolian sand of Holocene age and the Mescalero caliche and the Gatuna Formation, both of Pleistocene age. The Permian rocks include, in order of increasing age, the Dewey Lake Red Beds, the Rustler Formation, and the upper 75 feet of the Salado Formation. The Permian rocks are present in the lower 655 feet of the geologic section penetrated by borehole H-8c.

The unconsolidated alluvium, eolian sand, and Mescalero caliche are informal units in the H-8c geologic section. The former two sediments make up a unit that is 4 feet thick. The Mescalero caliche is a well-lithified calcareous soil about 6 feet thick. The Gatuna Formation underlies the Mescalero caliche and consists of 143 feet of light-reddish-brown, friable, very fine to medium-grained, poorly sorted sandstone. Several conglomeratic zones that contain small chert and silicious pebbles and subangular to rounded clasts of siltstone and sandstone are present near the base of the Gatuna Formation.

Borehole H-8c penetrated the Dewey Lake Red Beds at 153 feet below land surface. The Dewey Lake Red Beds are reddish-brown siltstone and mudstone with greenish-gray reduction spots and contain some reddish-brown very fine grained sandstone. Veins of fibrous selenite, commonly present in the formation, are found at depths below 260 feet.

The Rustler Formation, from 399 to 733 feet below land surface, consists chiefly of gypsum, remnant anhydrite, and poorly to moderately consolidated clay and silt probably derived from argillaceous and silty halite. The formation also contains the Magenta and Culebra Dolomite Members. The Magenta Dolomite Member is a light-olive-gray dolomite with dark, horizontal, wavy laminations and numerous gypsum-filled fractures, veins, and pore spaces. The Culebra Dolomite Member is a very finely crystalline light-olive-gray argillaceous dolomite with numerous pits and fractures.

The last 75 feet of section, between 733 and 808 feet below land surface, is part of the Salado Formation. At the H-8 borehole complex, the upper 41 feet of the Salado is a distinct halite-free interval of unconsolidated clay and silt interlayered at irregular intervals with shattered bands of gypsum. This interval is considered to be dissolution residue derived from halite and associated rocks that formerly were present. The dissolution residue is underlain by marker bed 103, an anhydrite bed (774-786 feet), found more than 100 feet closer to the top of the Salado Formation than in geologic sections of boreholes within the WIPP site boundary (Sandia National Laboratories and U.S. Geological Survey, 1980a, b). The rocks of the Salado Formation at the H-8 borehole complex have probably thinned from ground-water dissolution of soluble minerals, particularly halite. Twelve feet of anhydrite and clay (786-798 feet) overlie the lower salt-rich part of the Salado Formation (798-808 feet) composed of halite, argillaceous halite, and traces of polyhalite. A summary of the geologic units penetrated by borehole H-8c is presented in table 1.

The lithologies penetrated by borehole H-8c are interpreted and correlated with selected geophysical logs in plate 1. Drilling and well-completion details of the H-8 boreholes are given in tables 2 through 4. Core descriptions from boreholes H-8a and H-8b are presented in tables 5 and 6, respectively, and the core and cuttings from borehole H-8c are described in table 7.

## SUMMARY

The H-8 borehole complex, a group of three closely spaced boreholes, was drilled south of the WIPP site in southeastern Eddy County, New Mexico, during July through 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-8 complex was drilled as 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. Cores and cuttings from the borehole complex and geophysical logs from borehole H-8c were described or interpreted for this study.

Each borehole was completed just below a distinct water-bearing zone. Borehole H-8a (total depth 505 feet) penetrated the Magenta Dolomite Member, a light-olive-gray fractured dolomite with dark, horizontal, wavy laminations. Borehole H-8b (total depth 624 feet) penetrated the Culebra Dolomite Member, a light-olive-gray argillaceous pitted and fractured dolomite. Rocks penetrated by borehole H-8c (total depth 808 feet) at the Rustler-Salado contact consist of the soft reddish brown clayey mudstone, anhydrite, and gypsum at the base of the Rustler Formation which grade to an unconsolidated clay and mud with gypsum fragments (dissolution residue), followed by the anhydrite (marker bed 103), and halite, argillaceous halite and polyhalite interval of the Salado Formation. The dissolution residue is derived from halite and associated rocks that formerly were present.

## SELECTED REFERENCES

- Bachman, G. O., 1974, Geologic processes and Cenozoic history related to salt dissolution in southeastern New Mexico: U.S. Geological Survey Open-File Report 74-194, 81 p.
- \_\_\_\_\_ 1976, Cenozoic deposits of southeastern New Mexico and an outline of the history of evaporite dissolution: U.S. Geological Survey Journal of Research, v. 4, no. 2, p. 135-149.
- Bachman, G. O., and Johnson, R., 1973, Stability of salt in the Permian Salt Basin of Kansas, Oklahoma, Texas, and New Mexico: U.S. Geological Survey open-file report, 62 p.
- Goddard, E. N., and others, 1948, Rock-color chart: Washington, National Research Council (reprinted by Geologic Society of America, 1975).
- Jones, C. L., 1973, Salt deposits of Los Medanos area, Eddy and Lea Counties, New Mexico, with sections on Ground-water hydrology, by M. E. Cooley, and Surficial geology by G. O. Bachman: U.S. Geological Survey open-file report, 67 p.
- Mercer, J. W., Davis, P. A., Dennehy, K. F., and Goetz, C. L., 1981, Results of hydrologic tests and water-chemistry analyses, wells H-4a, H-4b, H-4c, at the proposed Waste Isolation Pilot Plant site, southeastern New Mexico: U.S. Geological Survey Water-Resources Investigations 81-36, 92 p.
- Mercer, J. W., and Orr, B. R., 1979, Interim data report on the geohydrology of the proposed Waste Isolation Pilot Plant site, southeast New Mexico: U.S. Geological Survey Water-Resources Investigations 79-98, 178 p.
- Powers, D. W., Lambert, S. J., Shaffer, S. E., Hill, L. R., and Weart, W. D., editors, 1978, Geological characterization report, Waste Isolation Pilot Plant (WIPP) site, southeastern New Mexico--vol. I and II: Albuquerque, New Mexico, Sandia National Laboratories, SAND78-1596.
- Sandia National Laboratories and U.S. Geological Survey, compilers, 1980a, Basic data report for drillhole WIPP 19: Albuquerque, New Mexico, Sandia National Laboratories, SAND79-0276, 27 p., 4 appendices.
- \_\_\_\_\_ 1980b, Basic data report for drillhole WIPP 21: Albuquerque, New Mexico, Sandia National Laboratories, SAND79-0277, 18 p., 4 appendices.
- Vine, J. D., 1963, Surface geology of the Nash Draw quadrangle, Eddy County, New Mexico: U.S. Geological Survey Bulletin 1141-B, 46 p.

Table 1.--Summary of geologic units penetrated by borehole H-8c

| Rock unit                               | Depth interval <sup>1/</sup><br>(feet) |
|-----------------------------------------|----------------------------------------|
| Holocene deposits <sup>2/</sup>         |                                        |
| Unconsolidated alluvium and eolian sand | 0-4                                    |
| Pleistocene rocks                       |                                        |
| Mescalero caliche                       | 4-10                                   |
| Gatuna Formation                        | 10-153                                 |
| Permian rocks                           |                                        |
| Dewey Lake Red Beds                     | 153-399                                |
| Rustler Formation                       | 399-733                                |
| Magenta Dolomite Member                 | 466-488                                |
| Culebra Dolomite Member                 | 588-614                                |
| Salado Formation                        | 733-                                   |
| Dissolution residue                     | 733-774                                |
| MB 103 <sup>3/</sup>                    | 774-786                                |
| Top of salt interval                    | 798                                    |
| Total depth of borehole                 | 808                                    |

<sup>1/</sup>Depth interval recorded from gamma-ray and bulk-density logs made by Dresser Atlas on July 31, 1979.

<sup>2/</sup>Includes artificial fill for drill pad.

<sup>3/</sup>MB, marker bed.

Table 2.--Drilling and well-completion record of borehole H-8a

Location: Sec. 23, T. 24 S., R. 30 E.  
1,962.59 feet from the north line  
1,486.59 feet from the east line

Altitude (land surface) above sea level: 3,433.0 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: Pennsylvania Drilling Company

Drilling record:

Commenced drilling on September 7, 1979, and completed on September 18, 1979, at 505 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and the annular space between formation and casing was filled with cement.

Drilled with a rock bit to 83 feet below land surface. 145.9 feet of 2.4-inch diameter core was recovered from 83 feet to a depth of 272 feet, 19.35 feet of core not recovered, hole widened from 3 3/4 to 7 7/8 inches.

Drilled with a rock bit to 454 feet below land surface, hole widened from 7 7/8 to 9 7/8 inches and 452 feet of 7-inch outside-diameter casing was set and the annular space between formation and casing was filled with cement.

49.3 feet of 3 1/2-inch outside-diameter core was recovered from 454 feet to a total depth of 505 feet, 1.7 feet of core not recovered (completed hole diameter was 6 1/8 inches).

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

Table 2.--Drilling and well-completion record of borehole H-8a - Concluded

| Core no. | Depth interval (feet) |       | Revolutions per minute | Weight on bit (pounds) | Circulation pressure (pounds per square inch) | Feet cored | Feet recovered | Percent recovery |
|----------|-----------------------|-------|------------------------|------------------------|-----------------------------------------------|------------|----------------|------------------|
|          | From                  | To    |                        |                        |                                               |            |                |                  |
| 1        | 83                    | 92    | ND*                    | ND                     | ND                                            | 9          | 5.9            | 66               |
| 2        | 92                    | 102   | ND                     | ND                     | ND                                            | 10         | 5.45           | 54               |
| 3        | 102                   | 112   | ND                     | ND                     | ND                                            | 10         | 7.4            | 74               |
| 4        | 112                   | 122   | ND                     | ND                     | ND                                            | 10         | 0              | 0                |
| 5        | 122                   | 132   | ND                     | ND                     | ND                                            | 10         | 7.1            | 71               |
| 6        | 132                   | 139   | ND                     | ND                     | ND                                            | 7          | 6.35           | 91               |
| 7        | 139                   | 142   | ND                     | ND                     | ND                                            | 3          | 2.65           | 88               |
| 8        | 142                   | 152   | ND                     | ND                     | ND                                            | 10         | 4.2            | 42               |
| 9        | 152                   | 162   | ND                     | ND                     | ND                                            | 10         | 7.2            | 72               |
| 10       | 162                   | 167   | ND                     | ND                     | ND                                            | 5          | 4.4            | 88               |
| 11       | 167                   | 177   | ND                     | ND                     | ND                                            | 10         | 9.0            | 90               |
| 12       | 177                   | 182   | 100                    | 3,000                  | 200                                           | 5          | 5.8            | 116              |
| 13       | 182                   | 192   | --                     | ---                    | ---                                           | 10         | 8.3            | 83               |
| 14       | 192                   | 202   | ND                     | ND                     | ND                                            | 10         | 10.0           | 100              |
| 15       | 202                   | 212   | ND                     | ND                     | ND                                            | 10         | 9.5            | 95               |
| 16       | 212                   | 222   | ND                     | ND                     | ND                                            | 10         | 10.5           | 105              |
| 17       | 222                   | 232   | ND                     | ND                     | ND                                            | 10         | 10.0           | 100              |
| 18       | 232                   | 242   | ND                     | ND                     | ND                                            | 10         | 10.0           | 100              |
| 19       | 242                   | 252   | 100                    | 2,000                  | 150                                           | 10         | 6.2            | 62               |
| 20       | 252                   | 262   | ND                     | ND                     | ND                                            | 10         | 7.4            | 74               |
| 21       | 262                   | 272   | ND                     | ND                     | ND                                            | 10         | 8.5            | 85               |
| 22       | 454                   | 464** | ND                     | ND                     | ND                                            | 10         | 9.8            | 98               |
| 23       | 465                   | 475   | ND                     | ND                     | ND                                            | 10         | 10.2           | 102              |
| 24       | 475                   | 485   | 25                     | 8,000                  | 100                                           | 10         | 9.6            | 96               |
| 25       | 485                   | 495   | 75                     | 8,000                  | 100                                           | 10         | 8.3            | 83               |
| 26       | 495                   | 505   | 75                     | 8,000                  | 180                                           | 10         | 11.4           | 114              |

\* Not determined

\*\* Depth correction after core #22, 464 feet to 465 feet

Table 3.--Drilling and well-completion record of borehole H-8b

Location: Sec. 23, T. 24 S., R. 30 E.  
1,994.76 feet from north line  
1,405.41 feet from east line

Altitude (land surface) above sea level: 3,433.8 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: Pennsylvania Drilling Company

Drilling record:

Commenced drilling on August 6, 1979, and completed on August 12, 1979, at 624 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and the annular space between formation and casing was filled with cement.

Drilled with a rock bit to 92 feet below land surface. Lost bit, widened hole from 7 7/8 to 9 7/8 inches to retrieve bit, recovered bit at 84 feet below land surface and brought bit to land surface. Drilled with a rock bit from 92 to 575 feet below land surface, hole widened from 7 7/8 to 9 7/8 inches and 574 feet of 7-inch outside-diameter casing was set and the annular space between formation and casing was filled with cement.

44 feet of 3 1/2-inch outside-diameter core was recovered from 576 feet to a total depth of 624 feet, 4 feet of core not recovered (completed hole diameter was 6 1/8 inches).

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

Table 3.--Drilling and well-completion record of borehole H-8b - Concluded

| Core no. | Depth interval (feet) |      | Revolutions per minute | Weight on bit (pounds) | Circulation pressure (pounds per square inch) | Feet cored | Feet recovered | Percent recovery |
|----------|-----------------------|------|------------------------|------------------------|-----------------------------------------------|------------|----------------|------------------|
|          | From                  | To   |                        |                        |                                               |            |                |                  |
| 1        | 576                   | 578* | 85                     | 10,000                 | 150                                           | 2.0        | 1.3            | 65               |
| 2        | 580                   | 590  | 80                     | 6,000                  | 150                                           | 10.0       | 10.3           | 103              |
| 3        | 590                   | 594  | 80                     | 6,000                  | 150                                           | 4.0        | 2.0            | 50               |
| 4        | 594                   | 604  | 110                    | 7,000                  | 150                                           | 10.0       | 9.9            | 99               |
| 5        | 604                   | 614  | 110                    | 7,000                  | 150                                           | 10.0       | 10.0           | 100              |
| 6        | 614                   | 624  | 110                    | 7,000                  | 150                                           | 10.0       | 10.5           | 105              |

\* Depth correction after core #1, 578 feet to 580 feet

Table 4.--Drilling and well-completion record of borehole H-8c

Location: Sec. 23, T. 24 S., R. 30 E.  
2,059.36 feet from north line  
1,470.14 feet from east line

Altitude (land surface) above sea level: 3,433.0 feet. Datum for depth measurements in drilling and logging operations.

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

Drilling contractor: Pennsylvania Drilling Company

Drilling record:

Commenced drilling on July 27, 1979, and completed on August 6, 1979, at 808 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and the annular space between formation and casing was filled with cement.

Drilled with a rock bit to 735 feet below land surface (with two interim coring intervals at 463-492 and 557-614 feet), geophysical-wireline logs were made by Dresser Atlas.

Hole was widened from 7 7/8 to 9 7/8 inches and 734 feet of 7-inch outside-diameter casing was set and the annular space between formation and casing was filled with cement.

61.6 feet of 3 1/2-inch outside-diameter core was recovered from 735 feet to a total depth of 808 feet, 11.4 feet of core not recovered (completed hole diameter was 6 1/8 inches).

Hole was blown dry and made ready for hydrologic studies.

Table 4.--Drilling and well-completion record of borehole H-8c---Concluded

| Core no. | Depth interval (feet) |       | Revolutions per minute | Weight on bit (pounds) | Circulation pressure (pounds per square inch) | Feet cored | Feet recovered | Percent recovery |
|----------|-----------------------|-------|------------------------|------------------------|-----------------------------------------------|------------|----------------|------------------|
|          | From                  | To    |                        |                        |                                               |            |                |                  |
| 1        | 463                   | 473   | 80                     | 10,000                 | 50-100                                        | 10.0       | 9.4            | 94               |
| 2        | 473                   | 482.5 | 60                     | 10,000                 | 100                                           | 9.5        | 9.4            | 99               |
| 3        | 482.5                 | 492   | 60                     | 10,000                 | 125                                           | 9.5        | 8.6            | 91               |
| 4        | 557                   | 565.8 | 87                     | 10,000                 | 150                                           | 8.8        | 6.1            | 69               |
| 5        | 565.8                 | 569.8 | 100                    | 11,000                 | 150                                           | 4.0        | 4.0            | 100              |
| 6        | 569.8                 | 578   | 80                     | 11,000                 | 150                                           | 8.2        | 8.8            | 107              |
| 7        | 578                   | 587   | 80                     | 12,000                 | 50                                            | 9.0        | 8.8            | 98               |
| 8        | 587                   | 596   | 80                     | 10,000                 | 100                                           | 9.0        | 9.0            | 100              |
| 9        | 596                   | 605   | 80                     | 12,000                 | 20                                            | 9.0        | 8.9            | 99               |
| 10       | 605                   | 614   | 80                     | 12,000                 | 150                                           | 9.0        | 5.4            | 60               |
| 11       | 735                   | 745   | 80                     | 10,000                 | 100                                           | 10.0       | 3.3            | 33               |
| 12       | 745                   | 755   | 80                     | 10,000                 | 100                                           | 10.0       | 10.2           | 102              |
| 13       | 755                   | 765   | 80                     | 10,000                 | 100                                           | 10.0       | 10.5           | 105              |
| 14       | 765                   | 776*  | 80                     | 10,000                 | 100                                           | 11.0       | 11.0           | 100              |
| 15       | 778                   | 788   | 85                     | 10,000                 | 75                                            | 10.0       | 10.2           | 102              |
| 16       | 788                   | 798   | 85                     | 10,000                 | 75                                            | 10.0       | 6.4            | 64               |
| 17       | 798                   | 808   | 80                     | 10,000                 | 150                                           | 10.0       | 10.0           | 100              |

\*Hole measured and depth corrected to 778.

Table 5.--Lithology penetrated by borehole H-8a

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

| Lithologic description                                                                                                                                                                                                                                                                                                                        | Depth interval<br>(feet) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Sandstone, moderate-reddish-brown (10R 4/6) to moderate-brown (5YR 4/4), very fine grained, moderately to well consolidated, calcareous; few thin, moderate-brown (5YR 4/4) mudstone bands, thickest at 82.1 to 82.4 feet, contains few small caliche fragments; few thin zones of moderate-reddish-orange (10R 6/6), fine-grained sand ----- | 83.0-86.3                |
| Sandstone, moderate-reddish-brown (10R 4/6), fine-grained, poorly consolidated -----                                                                                                                                                                                                                                                          | 86.3-88.9                |
| No core -----                                                                                                                                                                                                                                                                                                                                 | 88.9-92.0                |
| Sandstone, moderate-reddish-brown (10R 4/6) to moderate-brown (5YR 4/4), very fine grained, moderately consolidated, slightly calcareous, with scattered, less than 10- to 80-millimeter long fragments of moderate-brown (5YR 4/4) mudstone, few resemble mud clasts -----                                                                   | 92.0-94.4                |
| Sandstone, moderate-reddish-brown (10R 4/6) to moderate-reddish-orange (10R 6/6), fine-grained, poorly consolidated -----                                                                                                                                                                                                                     | 94.4-95.6                |
| Sandstone, same as in unit from 83.0 to 86.3 feet; contact with upper unit is a 0.1-foot zone with less than 1- to 7-millimeter diameter fragments of caliche and very coarse sand grains -----                                                                                                                                               | 95.6-97.45               |
| No core -----                                                                                                                                                                                                                                                                                                                                 | 97.45-102.0              |
| Sandstone and mudstone, same as in unit 92.0 to 94.4 feet but mudstone in much larger fragments forming thick irregular zones -----                                                                                                                                                                                                           | 102.0-107.0              |
| Sandstone, same as in unit from 94.4 to 95.6 feet -----                                                                                                                                                                                                                                                                                       | 107.0-108.2              |
| Sandstone, same as in unit from 83.0 to 86.3 feet with no mudstone, upper 30 millimeters of unit contains many 1-millimeter or less diameter fragments of caliche -----                                                                                                                                                                       | 108.2-109.4              |

Table 5.--Lithology penetrated by borehole H-8a - Continued

| Lithologic description                                                                                                                                                                                             | Depth interval<br>(feet) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| No Core -----                                                                                                                                                                                                      | 109.4-122.0              |
| Sandstone, same as in unit from 92.0 to 94.4 feet with few irregular bands and fragments of moderate-brown (5YR 4/4) mudstone and few small scattered fragments of caliche -----                                   | 122.0-128.0              |
| Sandstone, same as in unit from 94.4 to 95.6 feet -----                                                                                                                                                            | 128.0-129.1              |
| No core -----                                                                                                                                                                                                      | 129.1-132.0              |
| Sandstone, same as in unit from 94.4 to 95.6 feet but slightly coarser grained -----                                                                                                                               | 132.0-133.1              |
| Sandstone, moderate-brown (5YR 4/4), very fine grained, slightly silty, moderately consolidated; upper 0.3 feet of unit is conglomerate of rounded quartz and caliche pebbles in sandy coarse-grained matrix ----- | 133.1-134.9              |
| Sandstone, moderate-brown (5YR 4/4), fine-grained, poorly to moderately consolidated, two zones of conglomerate same as in unit from 133.1 to 134.9 feet at 136.3 to 136.9 and 137.9 to 138.3 feet -----           | 134.9-138.3              |
| No core -----                                                                                                                                                                                                      | 138.3-139.0              |
| Conglomerate, moderate-brown (5YR 3/4) to grayish-red (5R 4/2), medium-grained sand with numerous quartz and caliche pebbles -----                                                                                 | 139.0-140.7              |
| No core -----                                                                                                                                                                                                      | 140.7-142.0              |
| Sandstone, moderate-brown (5YR 3/4) to grayish-red (5R 4/2), medium to coarse-grained, moderately consolidated, contains many small chert pebbles -----                                                            | 142.0-142.2              |
| Sandstone, same as in unit from 134.9 to 138.3 feet, few scattered chert pebbles -----                                                                                                                             | 142.2-146.1              |

Table 5.--Lithology penetrated by borehole H-8a - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                             | Depth interval<br>(feet) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 146.1-152.0              |
| Sandstone, same as in unit from 134.9 to 138.3 feet, few scattered small caliche fragments -----                                                                                                                                                                                                                                                                                                                                                                   | 152.0-155.0              |
| Siltstone, sandy, moderate-reddish-brown (10R 4/6), moderately to poorly consolidated, calcareous -----                                                                                                                                                                                                                                                                                                                                                            | 155.0-159.2              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 159.2-162.0              |
| Sandstone, moderate-reddish-brown (10R 4/6) to moderate-brown (5YR 4/4), very fine grained, silty, poorly consolidated, contains few elongated caliche fragments in upper two feet; band of well consolidated very calcareous sandstone at 163.8 to 164.0 feet, large irregular-shaped caliche fragments at 164.5 to 164.7 feet; contains few scattered fragments of moderate-reddish-brown (10R 4/6) siltstone with greenish-gray (5GY 6/1) reduction spots ----- | 162.0-165.0              |
| Siltstone, moderate-reddish-brown (10R 4/6), moderately consolidated with many scattered 1- to 8-millimeter diameter, greenish-gray (5GY 6/1) reduction spots -----                                                                                                                                                                                                                                                                                                | 165.0-166.3              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 166.3-167.0              |
| Siltstone, same as in unit from 165.0 to 166.3 feet, faintly laminated with dark-reddish-brown (10R 3/4) mudstone; contains many scattered greenish-gray (5GY 6/1) reduction spots; few 10- to 20-millimeter long mudstone clasts at 167.6-167.8 feet -----                                                                                                                                                                                                        | 167.0-176.0              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 176.0-176.2              |
| Mudstone and siltstone, moderate-reddish-brown (10R 4/6), few laminae grading to very fine grained sandstone, greenish-gray (5GY 6/1) reduction spots; some small-scale cross-bedding -----                                                                                                                                                                                                                                                                        | 176.2-181.8              |

Table 5.--Lithology penetrated by borehole H-8a - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Depth interval<br>(feet) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 181.8-182.0              |
| Mudstone and siltstone, some grading to very fine grained sandstone, same as in unit from 176.2 to 181.8 feet; greenish-gray (5GY 6/1) reduction spots present -----                                                                                                                                                                                                                                                                                                                                                                       | 182.0-190.3              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 190.3-192.0              |
| Sandstone, moderate-reddish-brown (10R4/6), very fine grained, parts grading to siltstone, 1- to 5-millimeter greenish-gray (5GY 6/1) reduction spots, numerous 1/2- to 2-millimeter wide calcite veins from 192.0 to 195.5 feet dipping approximately 65°, 25°, and less; slightly coarser grained with a porous texture from 195.5 to 197.9 feet; laminae with some small-scale cross-bedding from 198.5 to 201.5 feet -----                                                                                                             | 192.0-202.0              |
| Siltstone, some mudstone laminae, moderate-reddish-brown (10R 4/6) with the mudstone laminae approaching dark-reddish-brown (10R 3/4), 1- to 4-millimeter greenish-gray (5GY 6/1) reduction spots present, some reduction zones up to 0.1 foot thick in 202.0 to 203.5 feet, laminae and thicker reduction zones of very fine grained sandstone dipping as much as 34° at 202.0 to 203.5 feet; few hairline to 1-millimeter thick calcite veins present, usually parallel to laminations, some dipping 24°, a few dipping almost 90° ----- | 202.0-211.5              |
| Siltstone, mudstone laminae, same as in unit from 202.0 to 211.5 feet, 10-millimeter wide vugs lined with calcite crystals up to 1 millimeter in size associated with 1- to 2-millimeter wide calcite-filled fractures/veins dipping 60° at 217.8 feet, other calcite veins and filled fractures similar to units above, having dips parallel to laminae, 25°, 60°, and almost 90° -----                                                                                                                                                   | 211.5-222.0              |

Table 5.--Lithology penetrated by borehole H-8a - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Depth interval<br>(feet) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Siltstone, mudstone laminae, same as in unit from 202.0 to 211.5 feet -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 222.0-232.0              |
| Siltstone grading to very fine grained sandstone, similar to unit from 202.0 to 211.5 feet, moderate-reddish-brown (10R 4/6), laminated, some dark-reddish-brown (10R 3/4) mudstone laminae, greenish-gray (5GY 6/1) reduction spots and calcite veins; 5 millimeters of vertical displacement (of laminae) across a 1-millimeter wide calcite-filled fracture dipping 62° at 237.5 feet; some calcite-lined vugs in the almost vertical calcite veins, some horizontal offset along vertical fractures, a 6-millimeter wide fracture dipping 80° at 241.6 feet, the top 0.3 feet of which is lined with 1-millimeter diameter calcite crystals leaving a central void, the bottom part of this fracture is filled with opaque white (N9) calcite with inclusions of angular fragments of the host siltstone ----- | 232.0-242.1              |
| Siltstone grading to very fine grained sandstone with some mudstone laminae, same as in unit from 232.0 to 242.1 feet; reduction zone at 244.7 to 244.9 feet; few laminae of medium-grained sandstone in 245.4 to 247.7 feet -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 242.1-247.7              |
| Sandstone, moderate-reddish-brown (10R 4/6), friable, fine- to medium-grained; some greenish-gray (5GY 6/1) reduction zones and dark-reddish-brown (10R 3/4) mudstone -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 247.7-248.2              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 248.2-252.0              |
| Mudstone, dark-reddish-brown (10R 3/4), firm -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 252.0-253.7              |

Table 5.--Lithology penetrated by borehole H-8a - Continued

| Lithologic description                                                                                                                                                                                                                                                                        | Depth interval<br>(feet) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Sandstone, moderate-reddish-brown (10R 4/6), fine- to medium-grained, hard to slightly friable, laminated; some dark-reddish-brown (10R 3/4) mudstone laminae, some small-scale cross-bedding, variable porosity -----                                                                        | 253.7-255.6              |
| No core -----                                                                                                                                                                                                                                                                                 | 255.6-262.0              |
| Sandstone, same as in unit from 253.7 to 255.6 feet, cross-beds dipping 24° at 265.2 feet -----                                                                                                                                                                                               | 262.0-266.4              |
| Siltstone, greenish-gray (5GY 6/1), hard; calcite crystals on a nearly vertical fracture at 266.5 feet -----                                                                                                                                                                                  | 266.4-267.0              |
| Siltstone and mudstone, grading to very fine grained sandstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), few greenish-gray (5GY 6/1) reduction spots; 20-millimeter wide, firm to hard mud-filled fracture at 268.0 feet, predominately mudstone at 270.5 feet ----- | 267.0-270.5              |
| No core -----                                                                                                                                                                                                                                                                                 | 270.5-272.0              |
| No description -----                                                                                                                                                                                                                                                                          | 272.0-454.0              |
| Anhydrite, medium-gray (N5), very finely crystalline, with numerous, very irregular, very thin stringers and small to medium sized blebs of olive-gray (5Y 4/1) to olive-black (5Y 2/1) gypsum; healed fracture, 1- to 2-millimeter displacement, dipping 51° at 455.7 feet -----             | 454.0-459.8              |
| Anhydrite, medium-light-gray (N6), to medium-gray (N5), and light-bluish-gray (5B 7/1), very finely crystalline -----                                                                                                                                                                         | 459.8-461.3              |

Table 5.--Lithology penetrated by borehole H-8a - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                      | Depth interval<br>(feet) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Gypsum, olive-gray (5Y 4/1) to olive-black (5Y 2/1) and brownish-gray (5YR 4/1), very finely crystalline, mottled, anhydritic; slightly dolomitic at 462.5 to 463.8 feet -----                                                                                                                                                                                                                              | 461.3-463.8              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                               | 463.8-464.0              |
| Depth correction -----                                                                                                                                                                                                                                                                                                                                                                                      | 464.0-465.0              |
| Gypsum, same as in unit from 461.3 to 463.8 feet; laminated with light-olive-gray (5Y 6/1) dolomite; many 1- to 3-millimeters thick, white (N9) gypsum veins along bedding planes -----                                                                                                                                                                                                                     | 465.0-469.5              |
| Dolomite, light-olive-gray (5Y 6/1) and olive-gray (5Y 4/1), silty texture, thinly laminated; some small-scale cross-bedding; very gypsiferous at 473.0 to 475.0 feet; few scattered hair-line fractures, some gypsum-filled; many white (N9), 1- to 3-millimeter thick gypsum veins along bedding planes at 473.0 to 475.0 feet; gradational contact with unit above -----                                 | 469.5-475.0              |
| Dolomite, same as in unit from 469.5 to 475.0 feet; few scattered white (N9), thin gypsum-filled fractures mostly along bedding planes, but at 475.5 and 483.1 feet 5- to 10-millimeter thick gypsum veins dip approximately 60°; broken rock contains a few irregular voids at 479.0 to 482.0 feet; dolomite laminae have dips ranging from 0-10° -----                                                    | 475.0-484.6              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                               | 484.6-485.0              |
| Dolomite, same as in unit from 469.5 to 475.0 and 475.0 to 484.6 feet; laminae from 490.0 to 491.8 feet are very wavy and contorted; 4-millimeter thick selenite-filled fracture dipping 70° at 486.0 feet, another 2- to 3-millimeter wide selenite-filled fracture dipping 75° at 488.4 feet, and several 1- to 2-millimeter thick filled fractures that are nearly vertical at 489.0 to 492.5 feet ----- | 485.0-492.5              |

Table 5.--Lithology penetrated by borehole H-8a - Concluded

| Lithologic description                                                                                                                                                                                                                                                                              | Depth interval<br>(feet) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Gypsum, olive-gray (5Y, 4/1) to olive-black (5Y 2/1), silty, dolomitic, numerous very irregular translucent to transparent selenite stringers, selenite-filled fractures at 492.0 to 493.0 feet same as in unit from 485.0 to 492.5 feet -----                                                      | 492.5-495.4              |
| Anhydrite, medium-light-gray (N6), olive-gray (5Y 4/1) to light-bluish-gray (5B 7/1), very finely crystalline, numerous blotches of olive-black (5Y 2/1) gypsum; irregular, horizontal, 10- to 40-millimeter thick, light-olive-gray (5Y 6/1) siltstone bands at 500.7, 501.8, and 503.4 feet ----- | 495.4-505.0              |
| Bottom of cored interval                                                                                                                                                                                                                                                                            |                          |

Table 6.--Lithology penetrated by borehole H-8b

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

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Depth interval<br>(feet) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Gypsum, dark-yellowish-brown (10R 4/2), finely crystalline, argillaceous, dark-greenish-gray (5G 4/1) mud from 576.0 to 576.5 feet; 10-millimeter thick olive-gray (5Y 4.1) mud seam at 576.9 feet, between medium to coarsely crystalline gypsum -----                                                                                                                                                                                                                                                                          | 576.0-577.3              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 577.3-578.0              |
| Gypsiferous anhydrite, pale-yellowish-brown (10YR 6/2) and dark-yellowish-brown (10YR 4/2), very finely crystalline massive; many thick (1-6 cm), mostly low-angle, branching veins and filled fractures of dusky-yellowish-brown (10YR 2/2) gypsum, coarsely crystalline; many scattered gypsum inclusions 1 to 2 millimeters in diameter; an almost vertical, 10-millimeter thick, gypsum-healed fracture at 582.7 to 584.6 feet; a 7- to 10-millimeter thick, gypsum-healed fracture dipping 70° at 585.4 to 586.1 feet ----- | 578.0-587.6              |
| Gypsum, dark-yellowish-brown (10YR 4/2) and dusky-yellowish-brown (10YR 2/2), finely crystalline, very faintly banded -----                                                                                                                                                                                                                                                                                                                                                                                                      | 587.6-591.1              |
| Dolomite, light-olive-gray (5Y 6/1), hard, very finely crystalline, few 1- to 3-millimeter pits; softer zone from 591.1 to 591.4 feet -----                                                                                                                                                                                                                                                                                                                                                                                      | 591.1-592.0              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 592.0-594.0              |
| Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, competent, with very finely crystalline dolomite-filled vugs less than 1 millimeter to greater than 30 millimeters throughout core, horizontal to vertical fractures widened from dissolution at 596.0 to 603.9 feet; light-olive-gray (5Y 6/1) mud-filled horizontal fractures, less than 5 millimeters wide at 595.9, 596.7, 597.5, 597.9, and 599.5 feet, selenite filling vugs at 596.8 feet -----                                                             | 594.0-603.9              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 603.9-604.0              |

Table 6.--Lithology penetrated by borehole H-8b - Concluded

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Depth interval<br>(feet) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, numerous pits ranging in size from less than 1 millimeter to greater than 50 millimeters in diameter; some crystal-lined vugs; dusky-yellow (5Y 6/4) dolomitic and clay-filled fractures oriented horizontal to vertical, same as in unit from 603.9 to 604.0, greater dissolution from 610.0 to 614.0 feet, 75 to 80 percent of vugs are interconnected, pits approximately 10 to 50 millimeters in diameter; competency decreases steadily with depth because of increase in porosity and number of pits ----- | 604.0-614.0              |
| Dolomite, similar to unit from 604.0 to 614.0 feet, dusky-yellow (5Y 6/4), clayey fill in some pits, some with translucent medium-crystalline gypsum; argillaceous light-olive-gray (5Y 5/2) laminae, dipping 6°; some pits and numerous fractures coated with a dark-yellowish-orange (10YR 6/6) stain from 617.8 to 618.3 feet -----                                                                                                                                                                                                                                         | 614.0-618.3              |
| Dolomite fragments in dolomitic light-olive-gray (5Y 6/1) mud matrix, dolomite fragments stained like fractures and pits in unit above -----                                                                                                                                                                                                                                                                                                                                                                                                                                   | 618.3-618.6              |
| Mudstone, dark-greenish-gray (5GY 4/1), moderately hard to firm, slightly calcareous, gypsiferous in parts, with numerous 1- to 3-millimeter wide, very-light-gray (N7) gypsum veins from 620.0 to 621.5 feet, dipping low angle to 54°; from 618.6 to 618.8 feet some mud as clasts up to 30 millimeters in size in mud matrix -----                                                                                                                                                                                                                                          | 618.6-621.5              |
| Mud with gypsum: mud, similar to unit from 618.6 to 621.5 feet; white (N9) to light-gray (N7) gypsum and bands of crystal aggregates; horizontal, pale-reddish-brown (10R 5/4), mottled, finely to medium-crystalline gypsum band 20-millimeters thick at 621.5 feet -----                                                                                                                                                                                                                                                                                                     | 621.5-622.6              |
| Mud with gypsum: similar to unit from 621.5 to 622.6 feet but moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) mud -----                                                                                                                                                                                                                                                                                                                                                                                                                                       | 622.6-624.2              |
| Gypsum, dark-yellowish-brown (10YR 4/2) to pale-red (5R 5/2), finely crystalline -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 624.2-624.5              |
| Bottom of cored interval                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |

Table 7.--Lithology penetrated by borehole H-8c

[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<br>(feet) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Caliche, moderate-pink (5R 7/4), very sandy -----                                                                                                                                                                           | 4.0-10.0                 |
| Sandstone (70 percent), moderate-reddish-orange (10R 6/6),<br>very fine to medium-grained, rounded to subrounded,<br>unconsolidated; caliche (30 percent), same as in unit from<br>4.0 to 10.0 feet -----                   | 10.0-15.0                |
| Sandstone, same as in unit from 10.0 to 15.0 feet; trace<br>caliche, same as in unit from 4.0 to 10.0 feet -----                                                                                                            | 15.0-20.0                |
| Sandstone, moderate-reddish-orange (10R 6/6) to pale-reddish-<br>brown (10R 5/4), very fine to fine-grained, rounded to<br>subrounded, mostly quartz grains, unconsolidated -----                                           | 20.0-35.0                |
| Sandstone, moderate-reddish-brown (10R 4/6), very fine to<br>fine-grained, rounded to subrounded, mostly quartz grains,<br>unconsolidated -----                                                                             | 35.0-38.0                |
| Sandstone, moderate-reddish-brown (10R 4/6) to moderate-olive-<br>brown (5Y 4/4), mostly fine-grained, some medium-grained,<br>rounded to subrounded, mostly quartz grains, poorly<br>consolidated, calcareous cement ----- | 38.0-60.0                |
| Sandstone, same as in unit from 38.0 to 60.0 feet; trace<br>friable, moderate-olive-brown (5Y 4/4) to dark-reddish-<br>brown (10R 3/4) mudstone -----                                                                       | 60.0-65.0                |
| Sandstone (95 percent), same as in unit from 38.0 to 60.0 feet;<br>mudstone (5 percent), same as in unit from 60.0 to 65.0 feet;<br>unit slightly more consolidated -----                                                   | 65.0-90.0                |
| Sandstone (60 percent), same as in unit from 38.0 to 60.0 feet;<br>soft, moderate-olive-brown (5Y 4/4) to dark-reddish-brown<br>(10R 3/4) mud (40 percent); trace mudstone, same as in unit<br>from 60.0 to 65.0 feet ----- | 90.0-115.0               |

Table 7.--Lithology penetrated by borehole H-8C - Continued

| Lithologic description                                                                                                                                                                                                                                                         | Depth interval<br>(feet) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Mud (90 percent), moderate-olive-brown (5Y 4/4), soft;<br>sandstone (10 percent), same as in unit from 38.0 to 60.0<br>feet; trace mudstone, same as in unit from 60.0 to 65.0<br>feet; few rounded, granule-size quartz and chert<br>fragments -----                          | 115.0-130.0              |
| Mud (95 percent), same as in unit from 115.0 to 130.0 feet;<br>sandstone (5 percent), same as in unit from 38.0 to 60.0<br>feet; few quartz and chert fragments same as in unit from<br>115.0 to 130.0 feet -----                                                              | 130.0-135.0              |
| Caliche (90 percent), same as in unit from 4.0 to 10.0 feet,<br>in large angular fragments (cavings); mud (10 percent),<br>same as in unit from 115.0 to 130.0 feet; many rounded and<br>angular quartz and chert granules and pebbles -----                                   | 135.0-140.0              |
| Mud (70 percent), same as in unit from 115.0 to 130.0 feet;<br>sandstone (30 percent), same as in unit from 38.0 to 60.0<br>feet; quartz and chert granules and pebbles, same as in unit<br>from 135.0 to 140.0; trace caliche, same as in unit from<br>4.0 to 10.0 feet ----- | 140.0-145.0              |
| Mud (95 percent), same as in unit from 115.0 to 130.0 feet;<br>sandstone (5 percent), same as in unit from 38.0 to 60.0<br>feet; few rounded to angular quartz and chert granules<br>and pebbles -----                                                                         | 145.0-153.0              |
| Mud (70 percent), moderate-reddish-brown (10R 4/6), soft;<br>moderate-reddish-brown (10R 4/6) siltstone (30 percent),<br>with greenish-gray (5GY 6/1) reduction spots; trace<br>very fine grained, moderate-reddish-brown (10R 4/6)<br>sandstone -----                         | 153.0-170.0              |
| Mud (60 percent) and siltstone (40 percent) same as in unit<br>from 153.0 to 170.0 feet; with reduction spots and specks<br>of manganese dioxide; trace sandstone, same as in unit from<br>153.0 to 170.0 feet -----                                                           | 170.0-175.0              |
| Mud (50 percent) and siltstone (50 percent) same as in unit<br>from 153.0 to 170.0 feet -----                                                                                                                                                                                  | 175.0-180.0              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                 | Depth interval<br>(feet) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Mud (60 percent) and siltstone (40 percent), same as in unit from 153.0 to 170.0 feet; trace sandstone, same as in unit from 153.0 to 170.0 feet -----                                                                                                                                                                 | 180.0-200.0              |
| Sandstone (70 percent), moderate-reddish-brown (10R 4/6), partly friable, very fine grained, rounded to subrounded, predominantly quartz, calcareous cement; soft, calcareous, moderate-reddish-brown (10R 4/6) mud (30 percent), trace of very fine grained, greenish-gray (5GY 6/8) sandstone -----                  | 200.0-205.0              |
| Sandstone (90 percent), same as in unit from 200.0 to 205.0 feet, very fine to fine-grained; mud (10 percent), same as in unit from 200.0 to 205.0 feet -----                                                                                                                                                          | 205.0-210.0              |
| Sandstone (90 percent) and mud (10 percent), same as in unit from 200.0 to 205.0 feet -----                                                                                                                                                                                                                            | 210.0-215.0              |
| Sandstone (60 percent) and mud (20 percent), same as in unit from 200.0 to 205.0 feet, pale-red (5R 6/2) to grayish-black (N2) hard sandstone (20 percent), medium- to coarse-grained, quartz dominant, rounded to subrounded; traces of rounded and angular quartz fragments greater than 2 millimeters in size ----- | 215.0-220.0              |
| Mud (60 percent) and sandstone (30 percent), same as in unit from 200.0 to 205.0 feet; individual grains of white (N9) to clear quartz (10 percent), less than 4 millimeters to greater than 6 millimeters in size -----                                                                                               | 220.0-225.0              |
| Sandstone, same as in unit from 205.0 to 210.0 feet -----                                                                                                                                                                                                                                                              | 225.0-230.0              |
| No samples -----                                                                                                                                                                                                                                                                                                       | 230.0-235.0              |
| Sandstone (60 percent), same as in unit from 200.0 to 205.0 feet; moderate-reddish-brown (10R 4/6) siltstone (30 percent), soft; mud (10 percent), same as in unit from 200.0 to 205.0 feet -----                                                                                                                      | 235.0-240.0              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Depth interval<br>(feet) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Sandstone (90 percent) and mud (10 percent), same as in unit from 200.0 to 205.0 feet -----                                                                                                                                                                                                                                                                                                                                                                                               | 240.0-245.0              |
| Sandstone (80 percent) and siltstone (20 percent), same as in unit from 235.0 to 240.0 feet -----                                                                                                                                                                                                                                                                                                                                                                                         | 245.0-250.0              |
| Sandstone (60 percent), moderate-reddish-brown (10R 4/6) to greenish-gray (5GY 6/1), very fine grained, with clear to white (N9) gypsum, trace very fine grained veins; siltstone (40 percent), same as in unit from 235.0 to 240.0 feet; slightly calcareous matrix -----                                                                                                                                                                                                                | 250.0-255.0              |
| Sandstone (70 percent), same as in unit from 250.0 to 255.0 feet; siltstone (20 percent), same as in unit from 235.0 to 240.0 feet; soft, incompetent, pale-reddish-brown (10R 5/4) mud (10 percent), with rounded medium-grained quartz grains -----                                                                                                                                                                                                                                     | 255.0-260.0              |
| Sandstone (50 percent), very fine grained, moderate-reddish-brown (10R 4/6), pale-reddish-brown (10R 5/4), and greenish-gray (5GY 6/1), indurated, grains are subrounded quartz, calcareous matrix, with traces of clear veins of gypsum, less than 1.0 millimeter in width; hard, calcareous cement, moderate-reddish-brown (10R 4/6) siltstone (40 percent); mud (10 percent), same as unit from 255.0 to 260.0 feet; traces of angular chert fragments larger than 3 millimeters ----- | 260.0-265.0              |
| Sandstone (80 percent), same as in unit from 260.0 to 265.0 feet; siltstone (20 percent), same as in unit from 260.0 to 265.0 feet; traces of angular to subrounded white (N9) quartz grains, greater than 2 millimeters -----                                                                                                                                                                                                                                                            | 265.0-270.0              |
| Sandstone (80 percent), same as in unit from 260.0 to 265.0 feet; siltstone (20 percent), same as in unit from 260.0 to 265.0 feet; trace of quartz grains, same as in unit from 265.0 to 270.0 feet -----                                                                                                                                                                                                                                                                                | 270.0-275.0              |
| Sandstone (90 percent), same as in unit from 260.0 to 265.0 feet; siltstone (10 percent), same as in unit from 260.0 to 265.0 feet, traces of white (N9) amorphous gypsum inclusions, larger than 1 millimeter in diameter -----                                                                                                                                                                                                                                                          | 275.0-280.0              |

078

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                           | Depth interval<br>(feet) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Siltstone (80 percent), same as in unit from 260.0 to 265.0 feet, with trace of white (N9) crystalline veins (selenite), wider than 1 millimeter; sandstone (20 percent), same as in unit from 260.0 to 265.0 feet -----                                                         | 280.0-285.0              |
| Siltstone, same as in unit from 260.0 to 265.0 feet, with traces of iron oxide spots -----                                                                                                                                                                                       | 285.0-290.0              |
| Siltstone (80 percent) and sandstone (20 percent), same as in unit from 260.0 to 265.0 feet -----                                                                                                                                                                                | 290.0-295.0              |
| Siltstone (60 percent) and sandstone (40 percent), same as in unit from 260.0 to 265.0 feet -----                                                                                                                                                                                | 295.0-300.0              |
| Sandstone (70 percent) and siltstone (30 percent), same as in unit from 260.0 to 265.0 feet -----                                                                                                                                                                                | 300.0-302.0              |
| No returns (lost circulation) -----                                                                                                                                                                                                                                              | 302.0-463.0              |
| Note: End of cuttings descriptions; core descriptions follow.                                                                                                                                                                                                                    |                          |
| No core -----                                                                                                                                                                                                                                                                    | 463.0-463.4              |
| Dolomitic gypsum, brownish-gray (5YR 4/1), very finely crystalline -----                                                                                                                                                                                                         | 463.4-466.6              |
| Dolomite, light-olive-gray (5Y 6/1), contains wavy brownish-gray (5YR 4/1) laminae, numerous gypsum blebs, 1 millimeter or less in diameter; few scattered 2- to 5-millimeter thick gypsum bands along bedding; some small-scale cross-bedding -----                             | 466.6-469.1              |
| Dolomite, olive-gray (5Y 4/1), faintly laminated and some cross-bedding; numerous gypsum blebs as large as 10 millimeters in diameter, gypsum veins parallel to laminae -----                                                                                                    | 469.1-471.0              |
| Dolomite, light-olive-gray (5Y 6/1) to brownish-gray (5YR 4/1), wavy, laminated, some small-scale cross-bedding, contains vertical gypsum-filled fracture 5- to 25-millimeters thick at 471.0 to 472.4 feet with many branching horizontal veins 1- to 6-millimeters thick ----- | 471.0-472.4              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Depth interval<br>(feet) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| No core-----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 472.4-473.0              |
| Dolomite, light-olive-gray (5Y 6/1) argillaceous, competent, with olive-gray (5Y 4/1) to brownish-gray (5YR 4/1), wavy, cross-bedded, horizontal laminae; numerous intermittent gypsum-filled fractures; from 473.4 to 474.1 feet, white (N9) gypsum, finely to very finely crystalline in fractures less than 1-millimeter to as much as 3-millimeters wide along core, dipping 0-45°; core broken from 475.1 to 476.9 feet; from 477.4 to 482.4 feet same as at 473.4-474.1 feet, fractures less than 1 up to 5-millimeters wide with inclusions, dipping up to 50° ----- | 473.0-482.5              |
| Dolomite, light-olive-gray (5Y 6/1), wavy laminae throughout with darker laminae approaching olive-gray (5Y 4/1); 1- to 10-millimeters thick, wavy translucent gypsum laminae, parallel to dolomite laminae, very numerous from 482.5 to 485.3 feet; gypsum blebs less than 1-millimeter across, numerous in some laminae; gypsum-filled fractures cutting both dolomite and gypsum laminae at 482.5 and 483.0 feet, dipping 62-65° -----                                                                                                                                   | 482.5-490.0              |
| Gypsum, dark-yellowish-brown (10YR 4/2) to dusky-yellowish-brown (10YR 2/2), mottled appearance, finely to medium-crystalline; dolomitic from 490.1 to 490.6 feet; several wavy translucent gypsum laminae 3- to 10-millimeters thick from 490.1 to 491.1 feet -----                                                                                                                                                                                                                                                                                                        | 490.0-491.1              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 491.1-492.0              |
| No samples (lost circulation) -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 492.0-557.0              |
| Mud, moderate-reddish-brown (10R 4/6) with greenish-gray (5GY 6/1) blotches, no bedding, incompetent and under gauged; medium-gray (N5) anhydrite blebs randomly dispersed are less than 5 percent of total core; clear to white (N9) conjugate selenite veins, nearly horizontal to 50°, less than 5 millimeters to 20 millimeters in width -----                                                                                                                                                                                                                          | 557.0-560.0              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                        | Depth interval<br>(feet) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Mud, moderate-reddish-brown (10R 4/6), same as in unit from 557.0 to 560.0 feet except unit contains no selenite veins, one gypsum band from 560.9 to 561.0 feet, very finely crystalline -----                                                                                                                                                                                                               | 560.0-561.6              |
| Mud, predominantly greenish-gray (5GY 6/1), with moderate-reddish-brown (10R 4/6), minor calcareous cement, massive; selenite, same as in unit from 557.0 to 560.0 feet, random orientation of veins, horizontal to 50°, 5-to 50-millimeters wide, anhydrite blebs, same as in unit from 557.0 to 560.0 feet, less than 4 milli-meters in diameter -----                                                      | 561.6-563.1              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                 | 563.1-565.0              |
| Gypsum, medium-gray (N5) to medium-dark-gray (N4), very finely crystalline, bedding dips approximately 50°; moderate-reddish-brown (10R 4/6) mud seam 0.1-foot thick from 565.2 to 565.3 feet; greenish-gray (5GY 6/1) mud inclusions within moderate-reddish-brown (10R 4/6) mud; gypsum below mud seam same as above seam, except contains wavy laminae instead of bedding, some laminae argillaceous ----- | 565.0-565.6              |
| Mud, moderate-reddish-brown (10R 4/6), soft; broken selenite fragments -----                                                                                                                                                                                                                                                                                                                                  | 565.6-566.7              |
| Mud, moderate-reddish-brown (10R 4/6), argillaceous gypsiferous fragments, unit grades downward to muddy gypsum, massive -----                                                                                                                                                                                                                                                                                | 566.7-566.8              |
| Gypsum, medium-dark-gray (N4) to dark-gray (N3), olive-gray (5Y 4/1) to white (N9) blotches, massive, finely to medium crystalline -----                                                                                                                                                                                                                                                                      | 566.8-567.5              |
| Gypsum, medium-dark-gray (N4) to white (N9), massive, finely to medium crystalline, traces of remnant anhydrite less than 5 millimeters in diameter -----                                                                                                                                                                                                                                                     | 567.5-568.0              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Depth interval<br>(feet) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Gypsum and Anhydrite, light-gray (N7) to very-light-gray (N8), finely crystalline, gradational into "chickenwire" anhydrite and blebs of gypsum surrounded by anhydrite forming lace pattern -----                                                                                                                                                                                                                                                                                                                         | 568.0-568.7              |
| Anhydrite, white (N9) to very-light-gray (N8), chalky, finely crystalline gypsum in the same pattern as unit from 568.0 to 568.7 feet -----                                                                                                                                                                                                                                                                                                                                                                                | 568.7-569.0              |
| Anhydrite, medium-light-gray (N6) to light-bluish-gray (5B 7/1), gypsiferous; 2- to 4-millimeter wide gypsum blebs numerous throughout; several irregular, horizontal to low-angle, translucent and dusky-yellowish-brown (10YR 2/2) tint gypsum "veins", interconnecting gypsum blebs from 569.5 to 570.0 feet -----                                                                                                                                                                                                      | 569.0-570.7              |
| Gypsum and anhydritic gypsum, and remnant anhydrite: gypsum, dark-yellowish-brown (10YR 4/2) to dusky-yellowish-brown (10YR 2/2), finely crystalline; anhydritic gypsum, argillaceous, olive-gray (5Y 4/1), from 572.1 to 572.4 feet, with some washing out of the mud in discontinuous seams; anhydrite, medium-light-gray (N5) and some light-olive-gray (5Y 6/1), remnant anhydrite shows a rectangular shaped pattern caused by the pattern of gypsum "veins"; from 576.0 to 577.4 feet unit is mostly anhydrite ----- | 570.7-578.0              |
| Gypsum and remnant anhydrite, same as unit from 570.7 to 578.0 feet -----                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 578.0-581.2              |
| Gypsum, dusky-yellowish-brown (10YR 2/2), very finely crystalline, olive-gray (5Y 4/1) argillaceous laminae, slightly mottled, very faintly laminated, laminae become more prominent in bottom two feet of unit -----                                                                                                                                                                                                                                                                                                      | 581.2-586.0              |
| Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, mostly hard, containing much light-olive-gray (5Y 6/1) mud in fractures and pits, pits are 1/2- millimeter to 10-millimeters; faintly laminated from 586.3 to 586.5 feet, contains many short, hairline fractures causing rock to be highly broken especially at 586.6 to 586.8 feet; contact between dolomite and overlying gypsum unit dips approximately 20° -----                                                                                        | 586.0-586.8              |

CM

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Depth interval<br>(feet) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 586.8-587.0              |
| Dolomite, light-olive-gray (5Y 6/1), hard, very finely crystalline, 1/2- to 40-millimeter diameter pits throughout, most pits concentrated in thick horizontal bands; numerous hairline to 2-millimeter thick high-angle fractures, some gypsum-filled, and some interconnecting; soft, light-olive-gray (5Y 6/1) 5- to 7-millimeter thick mud parting at 593.2 feet -----                                                                                                                                   | 587.0-596.0              |
| Dolomite, light-olive-gray (5Y 6/1) to yellowish-gray (5Y 7/2), very finely crystalline, numerous pits range in size from less than 1 to 15 millimeters, larger pits (greater than 50 millimeters) along irregular hairline fractures; grayish-yellow (5Y 8/4), dolomitic, silty residue filling approximately 40 percent of fractures, concentration of vugs approximately 0.2 inches wide, occurs at 600.5 to 601.0 feet; interval 602.0 to 604.9 feet is broken up, probably from heavy dissolution ----- | 596.0-604.9              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 604.9-605.0              |
| Dolomite, yellowish-gray (5Y 7/2) to light-olive-gray (5Y 6/1), parts are dusky-yellow (5Y 6/4), very finely crystalline; numerous vugs 1 to 10 millimeters in diameter, larger unfilled vugs in top 1.5 feet, and smaller vugs filled with a hard moderate-yellowish-brown (10YR 5/4) argillaceous material in bottom 1.5 feet; core is broken at 605.0 to 606.6 and 607.8 to 608.0 feet -----                                                                                                              | 605.0-608.0              |
| Mudstone, olive-black (5Y 2/1), moderately hard but easily broken into 75-millimeter and larger pieces; fractures dipping 40° at 608.4 feet and 34° at 610.2 feet, some selenite from 609.9 to 610.4 feet; indurated, 1-millimeter thick, light-olive-gray (5Y 6/1) argillaceous, dolomitic laminae at 608.9 feet -----                                                                                                                                                                                      | 608.0-610.4              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                             | Depth interval<br>(feet) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| No core -----                                                                                                                                                                                                                      | 610.4-614.0              |
| Note: End of core descriptions, cuttings descriptions follow.                                                                                                                                                                      |                          |
| No sample (lost circulation) -----                                                                                                                                                                                                 | 614.0-625.0              |
| Anhydrite (60 percent), light-olive-gray (5Y 6/1); white (N9) to translucent, finely crystalline, gypsum (25 percent); clear selenite (15 percent); trace of slightly gypsiferous moderate-reddish-brown (10R 4/6) siltstone ----- | 625.0-630.0              |
| Gypsum (50 percent) and anhydrite (20 percent), same as in unit from 625.0 to 630.0 feet; soft, moderate-reddish-brown (10R 4/6) and grayish-red (10R 4/2) mud (20 percent); clear selenite (10 percent) -----                     | 630.0-635.0              |
| Gypsum (70 percent), same as in unit from 625.0 to 630.0 feet; clear selenite (10 percent); anhydrite (10 percent), same as in unit from 625.0 to 630.0 feet; mud (10 percent), same as in unit from 630.0 to 635.0 feet -----     | 635.0-640.0              |
| Gypsum (50 percent), same as in unit from 625.0 to 630.0 feet; mud (30 percent), same as in unit from 630.0 to 635.0 feet; anhydrite (10 percent), same as in unit from 625.0 to 630.0 feet; clear selenite (10 percent) -----     | 640.0-645.0              |
| Gypsum (50 percent), same as in unit from 625.0 to 630.0 feet; mud (35 percent), same as in unit from 630.0 to 635.0 feet; anhydrite (10 percent), same as in unit from 625.0 to 630.0 feet; clear selenite (5 percent) -----      | 645.0-650.0              |
| Mud, same as in unit from 630.0 to 635.0 feet, traces of gypsum and anhydrite same as in unit from 625.0 to 630.0 feet -----                                                                                                       | 650.0-660.0              |
| Mud, same as in unit from 630.0 to 635.0 feet; traces of gypsum and anhydrite same as in unit from 625.0 to 630.0 feet; trace, soft, plyable, medium-gray (N5) clay -----                                                          | 660.0-670.0              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                | Depth interval<br>(feet) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Mud (80 percent), same as in unit from 630.0 to 635.0 feet; clay (20 percent), same as in unit from 660.0 to 670.0 feet; trace gypsum, same as in unit from 625.0 to 630.0 feet -----                                                                                                                                                                                                                                                                 | 670.0-680.0              |
| Clay (70 percent), same as in unit from 660.0 to 670.0 feet; mud (30 percent), same as in unit from 630.0 to 635.0 feet; trace gypsum, same as in unit from 625.0 to 630.0 feet -----                                                                                                                                                                                                                                                                 | 680.0-690.0              |
| Clay, same as in unit from 660.0 to 670.0 feet; trace mud, same as in unit from 630.0 to 635.0 feet; trace gypsum, same as in unit from 625.0 to 630.0 feet -----                                                                                                                                                                                                                                                                                     | 690.0-700.0              |
| Clay, same as in unit from 660.0 to 670.0 feet -----                                                                                                                                                                                                                                                                                                                                                                                                  | 700.0-730.0              |
| Clay (95 percent), same as in unit from 660.0 to 670.0 feet; mud (5 percent) same as in unit from 630.0 to 635.0 feet; trace gypsum, same as in unit from 625.0 to 630.0 feet ---                                                                                                                                                                                                                                                                     | 730.0-735.0              |
| Note: End of cuttings descriptions, core descriptions follow.                                                                                                                                                                                                                                                                                                                                                                                         |                          |
| Gypsum, translucent to transparent, some olive-black (5Y 2/1), some light-olive-gray (5Y 6/1); very argillaceous, stringers and blebs of soft, moderate-reddish-brown (10R 4/6), grayish-red (5R 4/2), and dark-reddish-brown (10R 3/4) clay; chalky, mottled, finely to medium-crystalline; light-red (5R 6/6) to moderate-reddish-orange (10R 6/6) gypsum stringers and blebs from 735.3 to 735.8 feet (possibly polyhalite altered to gypsum) ---- | 735.0-737.9              |
| Clay, grayish-red (10R 4/2) to dark-reddish-brown (10R 3/4), pliable, soft; very numerous blebs and stringers of fibrous, chalky, white (N9) gypsum, some gypsiferous bands 2- to 6-millimeters thick -----                                                                                                                                                                                                                                           | 737.9-738.3              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                         | 738.3-745.0              |
| Clay/mud, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), soft, pliable, silty -----                                                                                                                                                                                                                                                                                                                                                | 745.0-745.8              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                    | Depth interval<br>(feet) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Gypsum and gypsum fragments in mud matrix: gypsum, medium-gray (N5), light-olive-gray (5Y 6/1), grayish-red (10R 4/2) to dark-reddish-brown (10R 3/4), mottled, finely to medium crystalline, unit partly argillaceous; mud, same as in unit from 745.0 to 745.8 feet -----                               | 745.8-748.1              |
| Clay/mud, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), firm , pliable, silty; 0.1-foot thick "band" of mottled greenish-gray (5GY 6/1) and light-brown (5YR 5/6) very fine grained sandstone at 752.5 feet; 1-millimeter wide gypsum vein dipping 55° at 752.6 feet -----            | 748.1-753.4              |
| Sandstone, light-brown (5YR 5/6) and moderate-reddish-brown (10R 4/6), very fine grained, mottled with 1- to 3-millimeter irregularly shaped greenish-gray (5GY 6/1) blotches; angular upper contact with the mud, 0.1-foot thick mud seam at 754.1 feet, probably mud between two sandstone blocks ----- | 753.4-755.2              |
| Sandstone, pale-yellowish-brown (10YR 6/2) to pale-red (10R 6/2), very fine grained, indurated, non-calcareous, wavy, grayish-red (10R 4/2) laminae, some pebble-sized fragments grading to coarse sand-sized fragments at 755.2-755.7 feet -----                                                         | 755.2-755.7              |
| Mudstone, dark-reddish-brown (10R 3/4) to moderate-reddish-brown (10R 4/6), 0.2 foot greenish-gray (5G 6/1) mud seam at top of unit; angular, very finely crystalline; clear to white (N9) selenite veins, 1 to 20 millimeters thick, horizontal to 60° dip -----                                         | 755.7-759.2              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Depth interval<br>(feet) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Polyhalitic gypsum, white (N9) to moderate-red (5R 4/6), very finely to finely crystalline; massive, polyhalitic residue as stringers at 759.2 to 760.6 feet; at 760.6 to 762.2 feet are moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) polyhalitic residue stringers dipping 20°, soft, with blebs of greenish-gray (5G 6/1) mud; at 761.2 to 761.4 feet zone of grayish-pink (5R 8/2) remnant anhydrite/gypsum dissected by moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) mud; with blebs of white (N9) to clear, selenite, crystals less than 3 millimeters; at 762.2 to 764.3 feet gypsum, same as at 759.2 to 760.6 feet, polyhalite stringers dip approximately 10° ----- | 759.2-764.3              |
| Sandstone, same as at 755.2 to 755.7 feet, without wavy laminae, but with few greenish-gray (5G 6/1) silt/mud clasts less than 20 millimeters long and 10 millimeters wide; clear, individual selenite crystals, horizontal orientation, less than 1 millimeter long and 0.5 millimeter wide at 764.5 to 764.9 feet; dark-reddish-brown (10R 3/4) mud within hairline fractures -----                                                                                                                                                                                                                                                                                                                                | 764.3-765.7              |
| Sandstone, moderate-reddish-brown (10R 4/6) to light-brown (5YR 6/4), very fine to fine-grained; healed fractures filled with a light-brown (5YR 6/4) silt/mud; some selenite veins -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 765.7-767.4              |
| Mudstone, moderate-brown (5YR 3/4) to dark-reddish-brown (10R 3/4), with greenish-gray (5G 6/1) blotches, soft, massive; mudstone pseudomorphs after halite; clear, individual gypsum crystals within mud matrix, horizontal orientation -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 767.4-768.6              |
| Polyhalitic gypsum, white (N9) to moderate-reddish-brown (10R 4/6), moderate-red (5R 4/6), very finely to finely crystalline; gypsum appears to contain polyhalitic residue -----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 768.6-770.4              |

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                | Depth interval<br>(feet) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Mudstone, same as in unit from 767.4 to 768.6 feet, except unit contains gypsum rubble, same as in unit from 768.6 to 770.4 feet, gypsum fragments are angular, unsorted, less than 1 millimeter to greater than 10 millimeters in size; gypsum fragment at 773.3 to 773.4 feet dips 35° -----                                                                                                                                                        | 770.4-774.0              |
| Anhydrite, light-gray (N7) to medium-gray (N5), some olive-black (5Y 2/1), very finely crystalline to cryptocrystalline, very fine and faint "chicken wire" network of brownish-gray (5YR 4/1) hairline laminae; few vugs 5- to 30-millimeters wide, some void, some filled with chalky, slightly calcitic, very pale-orange (10YR 8/2) material; gypsum fragment at 774.7 to 774.8 feet has horizontal laminae; some white (N9) gypsum patches ----- | 774.0-785.0              |
| Anhydrite, medium-gray (N5) and medium-bluish-gray (5B 5/1), very finely crystalline; light-olive-gray (5Y 6/1), silty, irregular laminae, some greater than 2-millimeters thick; irregular voids 10 to 30 millimeters in size and numerous stringer-like voids 1- to 5-millimeters thick, general horizontal trend; dispersed, faint, moderate-red (5R 4/6) staining at 785.5 feet -----                                                             | 785.0-786.0              |
| Anhydrite, light-gray (N7) and light-olive-gray (5Y 6/1), very finely crystalline; few 1- to 6-millimeter, irregular, moderate-red (5R 4/6) polyhalite blebs -----                                                                                                                                                                                                                                                                                    | 786.0-788.3              |
| Clay, medium-dark-gray (N4), soft; irregular, 10- to 30-millimeter, light-red (5R 6/6) to moderate-red (5R 4/6), polyhalitic anhydrite blebs at 788.8 to 789.0 feet -----                                                                                                                                                                                                                                                                             | 788.3-789.0              |

*cy*

Table 7.--Lithology penetrated by borehole H-8c - Continued

| Lithologic description                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Depth interval<br>(feet) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Anhydrite, light-gray (N7) to medium-light-gray (N6), very finely crystalline, some parts having a branching network, 2 millimeters or less than 1 millimeter thick; network more predominant from 790.2 to 790.5 feet, of brownish-gray (5YR 4/1) argillaceous veinlets; soft, moderate-reddish-brown (10R 4/6) patches concentrated from 789.0 to 789.2 feet; irregular, continuous, horizontal-trending, filled fracture, 2 to 4 millimeters thick at 789.4 feet ----- | 789.0-791.2              |
| Clay, medium-gray (N5), soft -----                                                                                                                                                                                                                                                                                                                                                                                                                                        | 791.2-791.25             |
| Clay, moderate-reddish-brown (10R 4/6), soft -----                                                                                                                                                                                                                                                                                                                                                                                                                        | 791.25-791.8             |
| Anhydrite, olive-black (5Y 2/1), some brownish-gray (5YR 4/1), numerous irregular blebs and bands 5 to 30 millimeters thick of soft, moderate-reddish-brown (10R 4/6) clay; numerous irregular 10- to 30-millimeter thick-blebs of moderate-red (5R 4/6) polyhalite altered to gypsum blebs -----                                                                                                                                                                         | 791.8-793.0              |
| Clay, moderate-reddish-brown (10R 4/6) and medium-gray (N5), soft; some irregular 10- to 30-millimeter blebs of light-gray (N7) gypsum -----                                                                                                                                                                                                                                                                                                                              | 793.0-793.3              |
| Anhydrite, light-gray (N7) with common light-red (5R 6/6) polyhalite staining; some irregular vugs 5 millimeters to 20 millimeters, filled with soft moderate-reddish-brown (10R 4/6) and medium-gray (N5) clay; continuous, wavy, horizontal fracture, filled with medium-gray (N5) clay at 793.8 feet -----                                                                                                                                                             | 793.3-794.0              |
| Clay, medium-gray (N5), soft -----                                                                                                                                                                                                                                                                                                                                                                                                                                        | 794.0-794.2              |
| Siltstone, moderate-reddish-brown (10R 4/6), numerous irregular blebs and veinlets of white (N9) gypsum -----                                                                                                                                                                                                                                                                                                                                                             | 794.2-794.4              |
| No core -----                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 794.4-798.0              |
| Halite, translucent to transparent, moderate-reddish-orange (10R 6/6), medium crystalline -----                                                                                                                                                                                                                                                                                                                                                                           | 798.0-799.1              |

Table 7.--Lithology penetrated by borehole H-8c - Concluded

| Lithologic description                                                                                                                                                                                                                                                                                                                                                        | Depth interval<br>(feet) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Halite, translucent to transparent; abundant, soft, interstitial, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) clay -----                                                                                                                                                                                                                                 | 799.1-801.5              |
| Halite, translucent to transparent, numerous blebs and stringers of moderate-reddish-orange (10R 6/6) to moderate-red (5R 4/6) polyhalite; continuous horizontal band of moderate-red (5R 4/6) to light-red (5R 6/6) polyhalite with numerous vugs filled with halite at 804.5 to 804.8 feet -----                                                                            | 801.5-805.8              |
| Halite, translucent to transparent, medium to coarsely crystalline, medium-gray (N5) and moderate-reddish-brown (10R 4/6) interstitial clay; numerous dispersed blebs and stringers of light-red (5R 6/6) polyhalite from 805.8 to 806.3 feet; light red (5R 6/6) to pale-red (5R 6/2) halite and polyhalite bands, irregular, vuggy, argillaceous, 806.3 to 806.5 feet ----- | 805.8-808.0              |
| Bottom of cored interval                                                                                                                                                                                                                                                                                                                                                      |                          |