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PRELIMINARY RESULTS OF THE INVESTIGATION OF THE SALINE-WATER RESOURCES IN THE HUECO BOLSON NEAR EL PASO, TEXAS

By

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United States Geological Survey

Prepared by the U.S. Geological Survey
in cooperation with
The Texas Water Development Board and
The City of El Paso

1967

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LOCATION OF THE AREA

The Hueco Bolson, as defined in this report, is in the extreme western part of Texas and includes that part of El Paso County between the Franklin and Hueco Mountains north of the Rio Grande (fig. 1).

PURPOSE AND SCOPE OF THE INVESTIGATION

The principal source of water for the city of El Paso, including the needs for industry and military establishments, is ground water from the Hueco Bolson. Data collected since 1935 show that the amount of water withdrawn from the bolson each year for the past 30 years has exceeded the natural recharge. The ground water is being mined, and the city is using every available source of fresh water within a reasonable distance.

Recognizing the needs for additional sources of water, the city proposed a study of the saline water resources of the Hueco Bolson as a potential source of fresh water through desalination.

The purpose of this report is to describe the methods used in investigating the saline-water resources and to present the results obtained from a geophysical survey and a deep test well. A more detailed discussion of the field procedures and interpretation of the geophysical surveys is being prepared for future publication.

METHODS OF INVESTIGATION

The first step in the study of the saline water was to determine by geophysical methods the thickness and extent of the alluvial or unconsolidated materials underlying the Hueco Bolson. The geophysical surveys were made by the Regional Geophysics Branch of the Geological Survey. Initially, a gravity survey was made by the Regional Geophysics Branch of the Geological Survey of most of the Hueco Bolson in El Paso County to determine the configuration of the bedrock (fig. 1). From these data, lines were laid out for a seismic survey, which consisted of one 20-mile, east-west refraction profile about 3 miles south of the Texas-New Mexico State line and two shorter lines in the southeastern part of El Paso County (fig. 2).

Reversed profiles about 5 miles long were shot along the lines of survey. The recording unit recorded on photographic paper the output of 12 vertical seismometers evenly spaced along a cable at intervals of 650 feet.

The procedure for shooting a profile was as follows: The cable was laid at one end of the profile and the output from a dynamite charge exploded at each end of the profile was recorded. The cable was then moved forward 7,150 feet and the previous shot points at each end of the profile were reshot. This procedure of reshooting at the same shot points and moving the cable was continued along the entire distance of the profile. In addition, intermediate shots at about 7,150-foot intervals were used to record velocity changes occurring in the shallow sediments. The dynamite charges, loaded in holes approximately 14 feet deep, varied from 50 to 600 pounds.

On an experimental basis, a resistivity survey was made to determine the effect of the fresh water-salt water interface and the bedrock configuration on electrical soundings. This survey was also made by the Regional Geophysics Branch. One line of this survey was along Horizon Boulevard in the southeastern part of El Paso County, another line was along the western end of the northern eastward-trending seismic line (fig. 2). Two types of electrode configuration were used: (1) Schlumberger and (2) equatorial. Quantitative interpretations were made by matching theoretical sounding curves to the field curves. This technique permits location of unit (geoelectric) that have similar resistivities (expressed in ohmmeters) from sounding to sounding.

The drilling of a deep test well was an integral part of the preliminary investigation of the saline-water resources of the Hueco Bolson. The purpose of the test hole was five-fold: (1) To provide information for a more precise interpretation of the gravity, seismic, and resistivity data; (2) to determine the chemical quality of the water and to relate the salinity to depth; (3) to determine the physical and hydrologic properties of the alluvial material; (4) to determine the thickness and depth of the bolson sediments; and (5) to estimate the volume of water containing 1,000 to 5,000 ppm (parts per million) dissolved solids. The location of the test hole in the NW$\frac{1}{4}$ of the NE$\frac{1}{4}$ of Sec. 19, Blk. 80, Township 1, was based on initial seismic field investigations which showed that the depth to bedrock probably was less than 5,000 feet. In addition, the test-hole site was along a 20-mile, eastward-trending seismic refraction profile 3 to 6 miles south of the Texas-New Mexico State line on land owned by the El Paso Public Service Board.

Drilling of the test hole by the El Paso Public Service Board began on Mar. 29, 1966, and was terminated at a depth of 4,363 feet on May 17, 1966, because of a lack of funds. During the drilling, samples of water were collected from several depth intervals, and samples of the materials penetrated were collected at 10-foot intervals from the land surface to the bottom of the hole. The specific conductance of the drilling mud was monitored during drilling to determine the intervals at which changes in salinity occurred. When the total depth was reached, the test hole was logged by dual induction--laterolog, borehole compensated sonic log, gamma ray log, caliper log, and compensated formation density log (gamma gamma). On the basis of the dual induction-laterolog, cores taken from selected intervals by a sidewall coring device were analyzed in the Geological Survey Laboratory to determine physical and hydrologic properties. Two other cores were obtained with a conventional core barrel.

During the drilling, a water sample was collected from each of five widely separated zones to determine the chemical quality of the water and the relationship between quality and depth. The results of the chemical analyses are given in table 1. Of the five samples, three were collected by a modified drill-stem testing tool consisting of a rubber packer mounted on a sliding mandrel, below which was attached a 20-foot length of perforated pipe. The weight of the drill pipe caused the packer to expand against the wall of the well, isolating the sand interval to be tested from the overlying materials. Water was pumped from the well by forcing compressed air down a small-diameter pipe within the drill pipe. The sample was collected only after the water became relatively clear and free of sediment and after the conductivity of the water was relatively stable. The last two samples were collected by a Johnston oil-field drill-stem tester. In this type of tool, the water from the sand to be tested enters the drill pipe under its own hydrostatic pressure, rising in the tool to approximately the same level as in the formation (bolson sediments). When the pressure has become stabilized, the tool is closed, and the partially filled drill pipe is brought to the surface. The initial and final hydrostatic pressures are automatically recorded. Generally, the sample at the bottom of the tool is taken for analysis; however, to be relatively certain that this sample is representative of the interval tested, the conductivity of the water from each length of drill-stem pipe is measured.

Table 1.--Chemical analyses of water from city of El Paso deep test well

Producing interval	761-786	1,225-1,250	1,724-1,749	2,167-2,182	2,835-2,856	686-710	800-820
Date of collection	Mar. 31, 1966	Apr. 4, 1966	Apr. 8, 1966	Apr. 22, 1966	May 2, 1966	May 23, 1966	May 23, 1966
Silica (SiO_2)	31	29	12	20	14	24	32
Iron (Fe)	-	0.11	0.22	0.49	0.19	0.48	0.00
Manganese (Mn)	0.01	.91	1.4	.58	1.4	-	-
Calcium (Ca)	63	1,270	2,250	2,950	2,000	55	49
Magnesium (Mg)	14	186	115	578	125	7.4	11
Sodium (Na)	204	2,600	5,260	12,100	7,550	184	198
Potassium (K)	11	23	28	48	34	9.8	10
Bicarbonate (HCO_3)	59	41	33	34	10	85	72
Sulfate (SO_4)	23	668	1,820	2,250	1,690	56	55
Chloride (Cl)	415	6,360	11,000	23,900	14,300	322	354
Fluoride (F)	.6	-	-	-	-	.6	.6
Nitrate (NO_3)	2.0	-	-	-	-	3.2	2.5
Dissolved solids	805	11,200	20,500	41,900	25,700	704	747
Hardness as $CaCO_3$	214	3,940	6,090	9,740	5,500	168	168
Specific conductance ($Kx10_5$ at 25°C)	1,550	18,100	31,000	60,900	38,300	1,310	1,400
pH	8.5	6.4	6.4	7.1	5.0	8.1	7.3
Boron (B)	.05	.21	.25	.00	3.0	-	-
Temperature (°F)	-	-	-	*95	*102	-	-
Static level (ft)	335	361	350	360	795	330	331

* Bottom hole temperature.

INTERPRETATION OF RESULTS

Gravity and Seismic Surveys

A Bouguer anomaly map was constructed on the basis of about 420 gravity stations (fig. 1). The major feature of the map is the 50

Figure 1 (caption on next page) belongs near here.

milligal gravity minimum trending northward about 6 to 8 miles east of the Franklin Mountains. The gravity data were used to locate lines for the seismic survey.

The results of the seismic and gravity surveys are shown on figures 2 and 3. Figure 2 shows the configuration of a depth to the bedrock under-

Figure 2 (caption on next page) belongs near here.

lying the Hueco Bolson. The map shows a deep northward trending trough, the axis of which lies about 4 to 5 miles east of the Franklin Mountains. A comparison of figures 1 and 2 shows that the bedrock trough, as computed from seismic data, is displaced about 3 miles west of the large gravity low (fig. 1). The reason for this displacement is not known definitely, but Mattick (written communication, October 1966) suggests that it may be due to the granitic rocks, which are exposed on the west side of the bolson, dipping under the limestone which underlies the bolson deposits at or near the axis of the trough. If so, there is a possibility of a basement fault at the axis of the trough. Figure 2 shows also that the slope of the bedrock surface is steeper on the western side of the trough than on the eastern side. Figure 2 should be used with caution because the data are not sufficiently accurate to determine precise depths to bedrock except along the upper (profiles 15-18) and middle (profiles 21-23) seismic lines (fig. 2).

Figure 1. Bouquer anomaly map of the Hueco Bolson.

Figure 2. Map showing approximate depth to bedrock in the Hueco Bolson.

Figure 3 is a cross section along profile A-A' located about 3

Figure 3 (caption on next page) belongs near here.

miles south of the Texas-New Mexico state line. It was computed from seismic data. The dashed lines indicate calculated travel paths for seismic rays refracted along the basement or bedrock surface. Four major refracting horizons in the bolson fill with average velocities of about 2000, 6500, 6820, 7600, and 9400 feet per second were recorded. The average velocities recorded on the sonic log of the El Paso test well are shown in figure 3 directly below the well location. Comparison of the velocities shows that those of the sonic log are in good agreement with those of the major seismic refracting units. The velocity of the bedrock was about 16,000 feet per second, a reasonable range for velocity in either limestone or granite.

The seismic records for the lower seismic line were inadequate for the construction of a cross section (Mattick, written communication, November 1966).

Figure 3. Seismic refraction profile along line A-A', 3 miles south of the Texas-New Mexico State line.

Electrical Resistivity

Electrical soundings were made in two areas of the Hueco Bolson (fig. 2) on an experimental basis to determine if electrical soundings could furnish information on the fresh water-salt water interface and on the bedrock configuration. The results of these soundings are shown by means of cross sections B-B' and C-C' (fig. 4).

Figure 4 (caption on next page) belongs near here.

Section B-B', a profile along the western end of the northern seismic line (fig. 2), shows the position of the fresh water-salt water interface in that part of the city of El Paso well field between War Highway and U.S. Highway 54. The interface dips gently eastward toward the center of the bolson at about 2 degrees. On the basis of the dual induction laterolog from the city of El Paso deep test well and the depth of the fresh water-salt water interface as determined from the resistivity data, the interface probably represents the approximate boundary between water having less than 5,000 ppm (parts per million) and more than 5,000 ppm dissolved solids. Actually, water containing more than 1,000 ppm dissolved solids is not considered fresh water, but for the purposes of this discussion, the term "fresh water" as it is applied to the interface is defined as water having less than 5,000 ppm dissolved solids. The 5,000 ppm dissolved-solids value represents the upper limit of salinity in water that the city of El Paso considers suitable for desalination. In the deep test well, this interface occurs at a depth of about 1,050 feet. The depth to bedrock in section B-B' could not be determined from electrical soundings because of equipment problems and because of the high conductivity of the saline-water layer.

Figure 4. Electrical resistivity profile along lines B-B' and C-C'.

Section C-C' shows that in the western two-thirds of the profile, the limestone bedrock dips gently toward the Rio Grande. In the vicinity of soundings 8 and 9, the limestone slopes steeply upward toward the east, possibly indicating a normal fault; east of sounding 9 the bedrock slopes gently downward toward the Hueco Mountains. The depth to bedrock along section C-C' is in close agreement with that determined by seismic refraction. The profile also shows that the fresh water-salt water interface is deepest near the center of the profile, giving a lens-shaped appearance to the "fresh-water" body.

Deep test well

The deep test well, originally scheduled to be drilled to a depth of 5,000 feet, was terminated at 4,363 feet because of a lack of funds. Although preliminary analysis of the geophysical data indicated that bedrock could be expected at about 3,300 feet, the well was still in alluvium at its completeddepth. Reevaluation of the seismic data which was based in part on data from the test well indicated that the depth to the bedrock is about 7,000 feet.

According to the chemical analyses of the water and the salinity value determined from resistivity curves on the dual induction laterolog of the test well, the water becomes increasingly mineralized to a depth of about 2,600 feet. The contact between water containing less than 500 ppm dissolved solids and salt water is not sharp, but consists of a zone of diffusion. The mineral content of the water in the zone of diffusion increases gradually with depth until a value of about 5,000 ppm of dissolved solids is reached, after which the increase in the mineralization is more rapid. In the test hole, fresh water extends from the water table (335 feet) to 600 feet; water having 500 to 1,000 ppm dissolved solids from 600 to 900 feet, and 1,000 to 5,000 ppm from 900 to 1,050 feet. The zone from 600 to 1,050 feet is considered as the zone of diffusion. Below 1,050 feet, mineralization increased to 11,200 ppm dissolved solids between 1,225 and 1,250 feet; 25,000 ppm between 1,724 and 1,749 feet; and 41,900 ppm between 2,167 and 2,182 feet. Water from 2,835 and 2,856 feet was considerably less saline, containing only 25,700 ppm dissolved solids. Insufficient data are available to fully explain this decrease in salinity. It is possible that this sample of water is not representative of the zone tested. During previous tests, the water level rose in the formation tester to or near the regional water level in the bolson (about 350 feet); however, the water from 2,835 to 2,856 feet rose to a level of 870 feet, indicating that the tester was opened an insufficient length of time. Although no water samples were collected below 2,850 feet, the dual-induction log indicates that the mineralization of the water below 3,250 feet increases to possibly more than 100,000 ppm dissolved solids at 4,339 feet, the drilled depth of the test hole.

Water below the zone of diffusion (1,050 feet) is very hard and of the sodium-chloride type, in which chloride is the principal anion.

A log compiled from the microscopic examination of the well cuttings is given in table 2. Particular attention was given to size analyses of the clastic sediments to determine the influence of grain-size distribution on porosity and permeability and a possible relationship between grain size and variations in the chemical quality of the water.

In general, the bolson sediments consist of beds of sand, gravel, clay, silt, and caliche. From the land surface to about 630 feet, the sediments consisted principally of fine to very coarse sand and granules. Thereafter, interbedded layers of very fine to medium sand and sandy clay prevailed to a depth of about 900 feet, generally changing from very fine to fine sand and sandy clay to a depth of about 2,300 feet. From 2,300 feet feet to the bottom of the test hole, clay predominated, and the individual beds of sand were considerably thinner than in the upper half of the test hole. The sediments below 2,300 feet probably represent lacustrine deposition. Silty clay first appeared at 1,020 feet, free silt at 1,240 feet, and platy clay at 2,810 feet. Selenite (gypsum) crystals/first appeared at about 3,410 feet and appeared in most of the samples thereafter.

Table 2.--Sample log of city of El Paso deep test well, El Paso County, Texas

	Thickness (feet)	Depth (feet)
and, medium to very coarse, granules, and caliche	30	30
and, fine to coarse, and granules	11	41
lay, medium to dark brown, calcareous	8	49
and, fine to very coarse, granules, and pebbles	10	59
lay, dark brown, sandy	3	62
and, medium to very coarse, and granules	8	70
and, fine to very coarse	10	80
ranules and pebbles	22	102
lay, brown, hard	2	104
and, fine to very coarse, and granules	16	120
and, coarse to very coarse, and granules	10	130
lay, buff, calcareous	10	140
and, very fine to coarse, granules, and clay, buff, calcareous, soft	10	150
and, coarse, and granules	4	154
Clay, buff, hard, calcareous	6	160
Sand, very fine to very coarse, some granules	180	340
Sand, fine to coarse, and clay, buff	10	350
Sand, very fine to very coarse, some granules	50	400
Clay, buff, sandy, some granules	30	430
Sand, medium to very coarse, granules	30	460
Clay, buff, sandy	10	470
Sand, coarse to very coarse, some granules, and tan, sandy clay	50	520
Sand, fine to medium, some calcareous, buff clay	20	540
Sand, fine to coarse, some buff, very sandy clay	40	580
Sand, fine to very coarse, granules, and buff clay	20	600
Clay, buff, calcareous, sandy	20	620

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Table 2.--Sample log of city of El Paso deep test well, El Paso County, Texas - continued

	Thickness (feet)	Depth (feet)
Sand, medium to very coarse---	10	630
Clay, light buff, calcareous, sandy, and very fine to medium sand, some granules of sandstone----------------	80	710
Clay, buff, sandy, and very fine to fine sand-----------	20	730
Sand, very fine to very coarse, some granules--------	10	740
Sand, very fine to fine, and buff, sandy clay------------	40	780
Sand, fine to very coarse, granules, and buff, very sandy clay-----------------	20	800
Sand, very fine to medium, some granules of sandstone, and buff, sandy clay--------	70	870
Sand, very fine to fine, some buff, sandy clay------------	20	890
Sand, fine to medium, some buff sandy clay----------------------	20	910
Clay, buff, sandy, and very fine to fine sand-----------	50	960
Clay, buff, some fine, slightly cemented sand-----	10	970
Clay, buff, sandy, and very fine sand-----------------	20	990
Sand, very fine to fine, slightly cemented----------	10	1,000
Sand, very fine to fine, and buff, silty to very sandy clay---------------------	80	1,080
Sand, very fine to fine, some slightly cemented, and light buff, silty to sandy clay--	70	1,150
No record-------------------	50	1,200
Clay, light buff, silty to very sandy, and very fine to fine sand--------------	50	1,250
Clay, grey, silty to sand, some very fine sand and arkosic granules, some silt	10	1,260
Sand, very fine to fine, some silt, and grey to light buff, silty to sandy clay, few arkosic granules-------	40	1,300

Continued on next page

Table 2.--Sample log of city of El Paso deep test well, El Paso County, Texas - continued

	Thickness (feet)	Depth (feet)
lay, light buff, silty to sandy, and very fine to fine sand, some silt---------	20	1,320
and, very fine, some silt, few flakes biofite, some magnetite-------------------	10	1,330
lay, light buff, silty to sandy, and very fine to fine sand, some silt--------------	80	1,410
lay, buff, silty to sandy, and very fine to fine sand, some very coarse----------------	10	1,420
and, clear red, green and black, very fine to medium, some pink to buff, silty clay----------------------	10	1,430
lay, pink, silty to very silty, and clear and red, very fine to medium sand----	10	1,440
and, very fine to fine, granules and arkosic pebbles, some pink, silty clay-------	10	1,450
Sand, very fine to fine, and pink, silty clay, some caliche--------------	30	1,480
Sand, very fine to medium, some pink, silty clay, granules and arkosic pebbles-------------------	10	1,490
Clay, pink, silty, and very fine sand and silt, some caliche-------------------	40	1,530
Clay, pink to grey, silty to sandy, granules, and arkosic pebbles, very fine sand, some silt------------	40	1,570
Sand, very fine to medium, some buff to gray, silty to sandy clay-------------	10	1,580
Sand, very fine to fine, and pink, silty clay, and caliche-------------------	30	1,610
Granules and arkosic pebbles, pink, silty clay, and some very fine to fine sand----	20	1,630

Continued on next page

Table 2.--Sample log of city of El Paso deep test well, El Paso County, Texas - continued

	Thickness (feet)	Depth (feet)
and, very fine to very coarse	10	1,640
lay, pink, very silty	10	1,650
and, very fine to fine, silt, and pink to gray, silty to sandy clay, some caliche, few granules	90	1,740
and, very fine to fine, some gray, silty clay, and volcanic ash	10	1,750
and, fine to very coarse, some granules, and pink to rey, silty clay	30	1,780
ranules, arkosic, some pink to grey, silty clay, and very fine sand	10	1,790
and, very fine, silt, and pink to grey, very silty to very sandy clay, some caliche	50	1,840
and, very fine to fine, silt, and pink to grey, silty clay, some caliche	90	1,930
Sand, very fine to medium, some pink, silty clay	10	1,940
Clay, pink, silty, and very fine to fine sand, silt	20	1,960
Clay, grey, silty to sandy, arkosic granules, and very fine sand, silt	20	1,980
Granules, arkosic, some very fine sand, and caliche	10	1,990
Clay, pink, silty to very silty, some very fine sand	10	2,000
Clay, pink to gray, silty to very sandy, and arkosic granules	60	2,060
Sand, very fine, some slightly cemented, and pink to grey silty to very silty clay, some arkosic granules	40	2,100
Sand, very fine to fine, some slightly cemented, and pink to gray, silty clay, some volcanic ash	100	2,200

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Table 2.--Sample log of city of El Paso deep test well, El Paso County, Texas - continued

	Thickness (feet)	Depth (feet)
Clay, light buff to grey, silty, and very fine sand---	10	2,210
Sand, very fine, silt, and pink, silty to very silty, clay, some volcanic ash-----	30	2,240
Sand, very fine to fine, silt, some slightly cemented, and pink to grey, silty to sandy clay, some volcanic ash-----	110	2,350
Clay, pink, silty, and very fine sand, and well cemented silt----------------------	10	2,360
Clay, buff to pink, silty, and very fine to coarse sand----	40	2,400
Clay, buff to light brown, silty, some arkosic granules	10	2,410
Clay, light buff to light brown, silty to sandy, and very fine sand, silt, some slightly cemented-----------	90	2,500
Sand, very fine, silt, and buff to pink, silty clay, some volcanic ash-----------	60	2,560
Sand, very fine to fine, silt, and pink to grey, silty clay---------------	30	2,590
Clay, light buff to grey, silty, and very fine sand, silt----------------------	190	2,780
Clay, buff, silty, and very fine sand, silt, and some volcanic ash--------------	30	2,810
Clay, buff to grey, silty, platy, and very fine to fine sand, silt, some slightly cemented-----------------	90	2,900
Sand, very fine, silt, and buff to light brown, silty to sandy clay------------	50	2,950
Clay, light brown, silty, some platy, very fine sand, and silt-----------------	40	2,990
Sand, very fine, silt, and buff, light brown and grey, silty to sandy clay, some platy--	130	3,120

Continued on next page

Table 2.--Sample log of city of El Paso deep test well, El Paso County, Texas - continued

	Thickness (feet)	Depth (feet)
nd, very fine, silt, slightly cemented, and light-brown and grey, silty to sandy, platy clay, some volcanic ash-------	50	3,170
ay, light brown and grey, silty to sandy, some platy, and very fine sand, silt, some slightly cemented, and some volcanic ash-----------------	230	3,400
ay, light-brown to brown, silty, some platy, some silt, and trace of selenite---------	20	3,420
nd, very fine, silt, and buff to light brown silty clay, trace of selenite-------------	20	3,440
ay, buff to light-brown, silty, platy, and very fine sand, some c cemented silt and selenite----	90	3,530
ay, buff to light-brown, silty to sandy, some platy, and very fine sand, some slightly cemented silt, trace of granules and arkosic selenite----------	40	3,570
Silt, some slightly cemented, and light-brown, silty to very silty clay, some selenite-----------------	60	3,630
No record------------------	10	3,640
Silt and light-brown clay, silty, platy, selenite----	50	3,690
No record------------------	10	3,700
Sand, very fine, silt, and light-brown, silty clay---	10	3,710
Clay, light-brown, silty, some platy, and silt, some selenite-----------------	90	3,800
Sand, very fine, silt, and light-brown to brown, silty, platy clay, some selenite-	40	3,840
Clay, light-brown to brown, silty, and silt, some selenite-----------------	60	3,900
Silt, fine, cemented--------	10	3,910
Clay, brown, silty, some selenite-----------------	20	3,930

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Table 2.--Sample log of city of El Paso deep test well, El Paso County, Texas - continued

	Thickness (feet)	Depth (feet)
ay, brown, silty, platy, and very fine sand, silt, some selenite	30	3,960
ilt and brown, silty, platy clay	20	3,980
lay, light-brown to brown and grey, silty, platy, some very fine sand, silt, some selenite	70	4,050
lay, light-brown to brown, platy, silt, and some selenite	40	4,090
lay, light-brown to brown, silty, platy, very fine sand, slightly cemented silt, and selenite	10	4,100
Sand, very fine, some slightly cemented silt and light-brown to brown and grey, silty to sandy, some platy clay, selenite	40	4,140
Clay, brown and grey, silty, platy, some very fine sand, silt, some selenite, and trace of volcanic ash	40	4,180
Sand, very fine, silt, and light-brown to brown, silty, some platy clay, selenite, and trace of volcanic ash	150	4,330
Clay, brown, light red, and grey, silty, platy, some very fine sand, silt, some selenite, and trace of volcanic ash	30	4,360

Of the core samples taken by means of a Schlumberger wire-line side-wall coring device or a conventional oil-field core barrel, 24 were analyzed in the Geological Survey laboratory for bulk density, specific gravity, porosity, and permeability. The permeability of the samples ranged from 0.0007 to 9.0 gpd (gallons per day) per foot; the porosity ranged from 35.4 to 54.4 percent. These ranges in properties are within the predetermined limits of unconsolidated gravel, sand, silt, and clay. Because of the small size of the side-wall cores, however, it was necessary to disaggregate and repack the samples into specially built permeameters. Consequently, the porosity and permeability values from a repacked sample generally will be slightly higher than for the undisturbed sample (A. I. Johnson, written communication, December 1966).

Upon completion of logging and coring of the test hole, the test hole was completed as a multi-screened observation well. Two sand zones were selected on the basis of the dual-induction log, which indicated that each sand section might contain water of different quality--that is, less than and more than 250 ppm of chloride. The 12-inch surface casing was perforated with a Schlumberger perforating gun opposite sands from 686 to 710 feet. The surface casing had been set through the fresh-water zone during drilling operations to prevent contamination by the underlying saline water. A 4-inch casing, slotted opposite more mineralized water sands from 800 to 820 feet, was set inside the 12-inch casing and cemented off from the perforations in the surface casing. Results of the chemical analyses of water jetted from each zone are shown in table 1. Periodic water-level measurements and water samples will be taken from the dual observation well to determine any changes in head or chemical quality.

The data obtained from the test hole can be used to roughly estimate the volume of water containing 1,000 to 5,000 ppm dissolved solids (saline) that may be available for development. This estimate can be made by comparing the volume of fresh water--less than 250 ppm chloride (roughly equivalent to 1,000 ppm dissolved solids) to conform to its definition in previously published reports--to that of the water having 1,000 to 5,000 ppm dissolved solids and applying this ratio to that part of the bolson in Texas underlain by fresh water. According to the dual-induction log, the total thickness of bolson deposits (including sand, gravel, silt, and clay) containing fresh water is about 550 feet as compared to about 150 feet of sediments containing saline water, a ratio of about 3.5 to 1. The volume of fresh-water-bearing material in the bolson has been estimated at about 50 million acre-feet, of which only 7½ million acre-feet is theoretically available, assuming a specific yield of 15 percent. If it can be assumed that this ratio of 3.5 to 1 is applicable to that part of the bolson underlain by fresh water, then slightly less than 15 million acre-feet of saline (1,000 to 5,000 ppm dissolved solids) water-bearing material underlies the bolson. Doubtlessly the specific yield of these sediments is less than 15 percent, consequently the volume of water containing 1,000 to 5,000 ppm dissolved solids theoretically recoverable is on the order of 2 million acre-feet.

CONCLUSIONS

Seismic-refraction surveying in conjunction with gravity surveying and test-well data proved to be a useful method for determining the depth and configuration of the bedrock underlying the Hueco Bolson in El Paso County, Tex. Although the resulting bedrock map generally is not sufficiently accurate for an exact determination of depths to bedrock, it can be used to make a reasonable estimate of the volume of unconsolidated sediments in the bolson and as an aid in further studies of ground-water availability.

The resistivity survey, which covered only a small part of the bolson, indicated that electrical soundings may furnish sufficient data for locating the fresh water-salt water interface as well as the bedrock surface to a depth of at least 3,000 feet. Greater depths can be determined, but because of instrumental difficulties and insufficient time, only one profile was suitable for analysis. The interface referred to in the report actually is a misnomer because it does not separate fresh water (water having less than 1,000 ppm dissolved solids) from saline water; it separates bodies of water containing less than 5,000 ppm from water containing more than 5,000 ppm dissolved solids. Nevertheless, this interface is useful because water containing less than 5,000 ppm is suitable for desalination.

On the basis of the deep test well, the thickness of the sediments containing water having between 1,000 and 5,000 ppm dissolved solids is fairly thin compared to that containing fresh water. Obviously, the data from only one well are inadequate for determining the quantity of saline water (1,000 to 5,000 ppm dissolved solids) that underlies the bolson. Additional testing will be necessary and should include pump tests in the zone of diffusion to determine more accurately the hydrologic properties of these sediments.

Development of the saline-water resources would produce at least two tangible benefits: (1) It would furnish fairly low salinity water for desalination; and (2) it would make more of the fresh water available for pumping by reducing the salt-water head and decreasing the possibility of upward movement of salt water into the fresh water.

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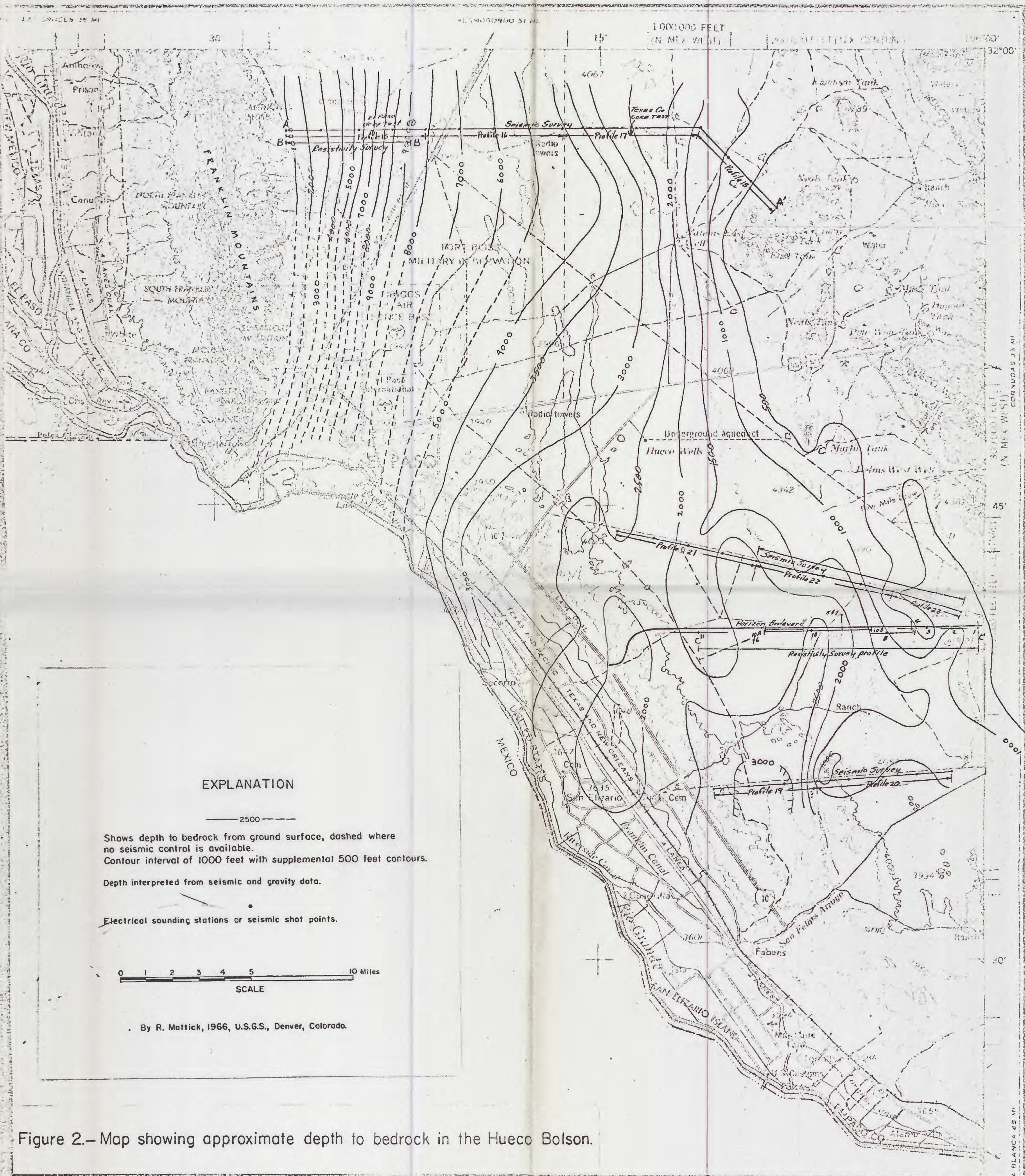
Figure I.– Bouquer anomaly map of the Hueco Bolson.



EXPLANATION

—— 2500 – – –

Shows depth to bedrock from ground surface, dashed where no seismic control is available.
Contour interval of 1000 feet with supplemental 500 feet contours.

Depth interpreted from seismic and gravity data.

Electrical sounding stations or seismic shot points.

0 1 2 3 4 5 10 Miles

SCALE

By R. Mattick, 1966, U.S.G.S., Denver, Colorado.

Figure 2.– Map showing approximate depth to bedrock in the Hueco Bolson.

FIGURE 3.-Seismic refraction profile along line A-A', 3 miles south of the Texas-New Mexico State line

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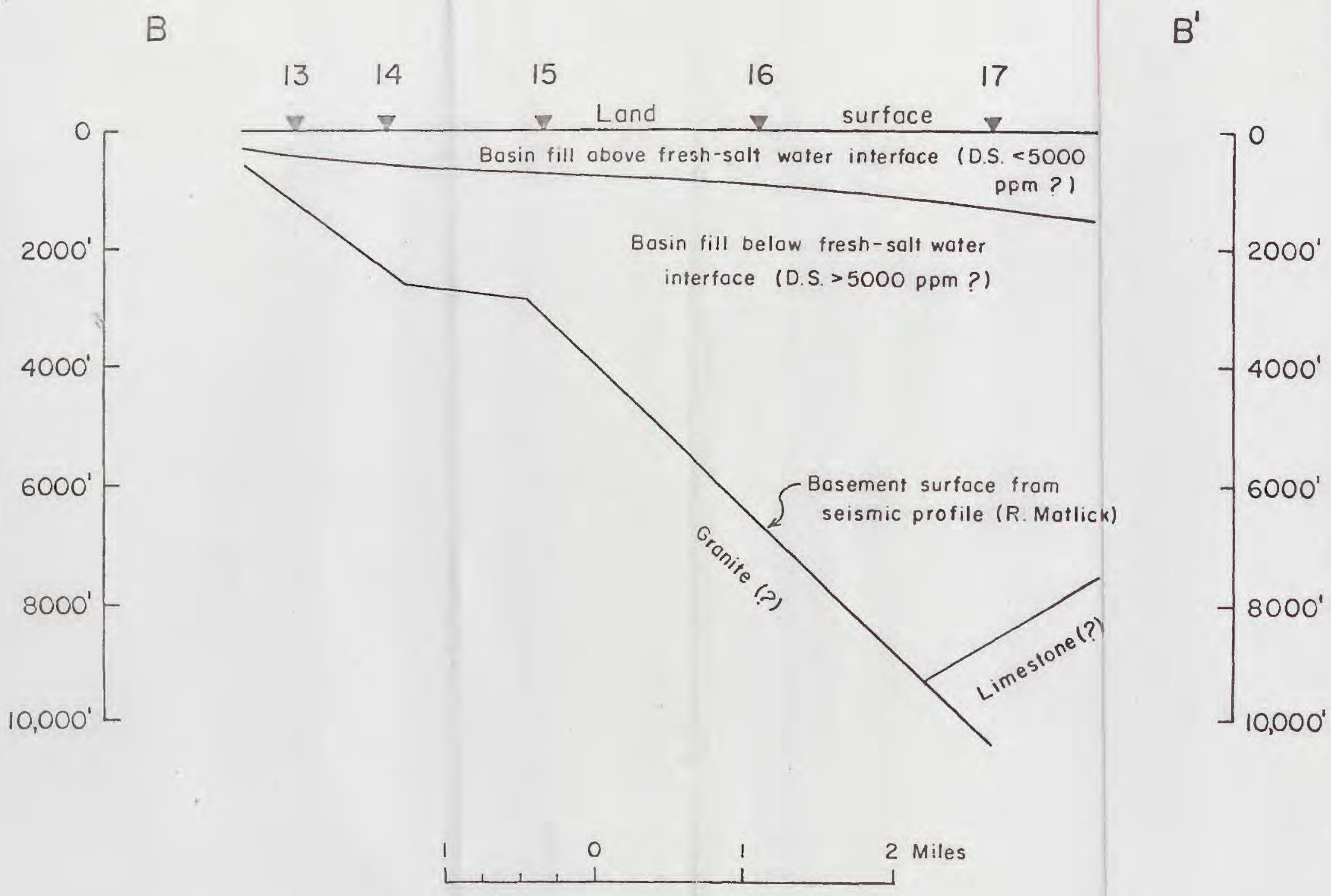
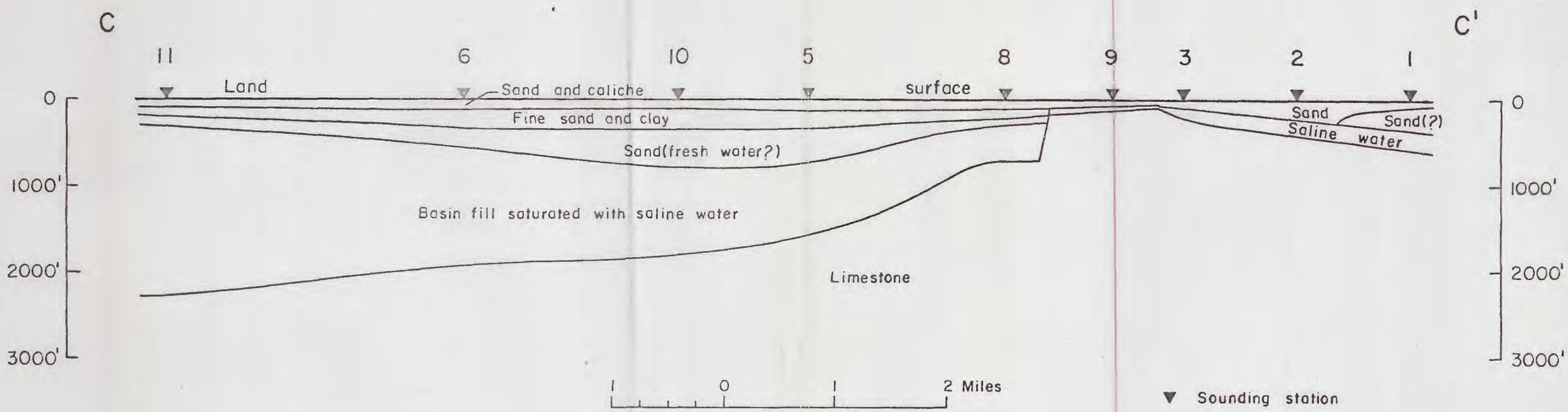


Resistivity profile along line near Texas-New Mexico state line



Resistivity profile along Horizon Boulevard in southeastern El Paso County, Texas

FIGURE 4.-Electrical resistivity profile along lines B-B' and C-C'