CONTINUOUS SEISMIC-REFLECTION SURVEY OF THE GREAT SALT LAKE, UTAH—EAST OF ANTELOPE AND FREMONT ISLANDS

By Patrick M. Lambert and John C. West

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MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Room 1016 Administration Building
1745 West 1700 South
Salt Lake City, Utah 84104

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CONTENTS

ILLUSTRATIONS

CONVERSION FACTORS

For readers who prefer to use metric (International System) units, conversion factors for inch-pound units used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
foot	0.3048	meter
mile	1.609	kilometer
feet per second	0.0003048	kilometer per second

Sea level: In this report "sea level" refers to the 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 "Sea Level Datum of 1929."

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ABSTRACT

A continuous seismic-reflection survey of the Great Salt Lake, Utah, was conducted east of Fremont and Antelope Islands in 1984 by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources and produced data along approximately 80 miles of seismic lines. The survey was conducted to determine depth to consolidated rock, and definition and continuity of overlying basin fill under the lake. Interpretation of the data indicates the presence of faulted rock dipping away from Fremont and Antelope Islands. A north-south-trending consolidated-rock ridge is identified 200 feet below lake bottom, 2.75 miles east of Fremont Island. Shallow rock is also inferred 380 feet below lake bottom, near Hooper Hot Springs, and 520 feet below lake bottom approximately 4 miles east of the south end of Antelope Island.

Interpretation of reflections from overlying basin fill indicates fine-grained, thinly-bedded deposits that become coarser with depth. Strong reflectors in the basin fill can be correlated with water-bearing strata penetrated by wells near the north end of Antelope Island and along the east shore of the lake. Many continuous, high-amplitude reflections can be identified in data from basin fill and may represent sedimentary sections or aquifer boundaries but cannot be defined because of a lack of subsurface control in the area.

INTRODUCTION

An evaluation of the ground-water resources of the East Shore area of the Great Salt Lake, Utah, was made during 1983-85 by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. As part of the East Shore investigation, a continuous seismic-reflection survey was conducted in October, 1984, on the Great Salt Lake, east of Fremont Island and Antelope Island (fig. 1). The purpose of the survey was to determine depth to consolidated rock, and definition and continuity of the overlying sediments under the lake.

The purpose of this report is to present interpretations of data collected during the seismic survey. The scope of the report includes correlation of collected data with previously published geologic, hydrologic, and geophysical data available for the study area and surrounding areas.

The East Shore area, as referred to in this report, is the area north of Salt Lake City and south of Willard between the western margin of the Wasatch Range and the eastern shore of the Great Salt Lake (D.W. Clark and others, U.S. Geological Survey, written commun., 1987) (fig. 1).

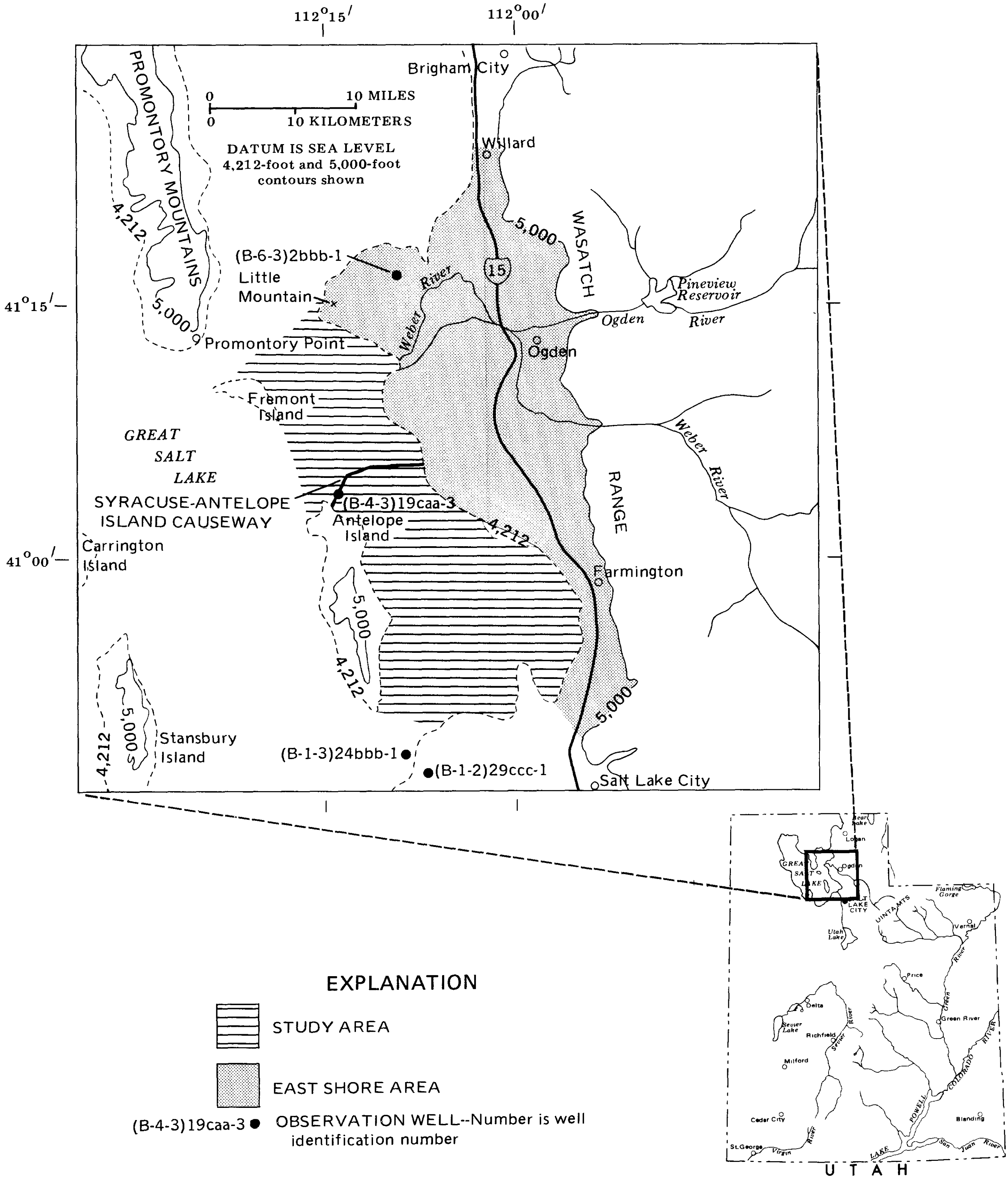


Figure 1.--Location of the study area and East Shore area.

The survey was conducted by John C. West, F.P. Haeni, D.W. Clark, and Peggy Gallagher of the U.S. Geological Survey. Special thanks are extended to the Utah Division of Parks and Recreation for providing the boat used during the survey.

High-resolution continuous seismic profiling has been used in a variety of hydrologic studies. The method has been used to help determine the thickness of glacial stratified drift aquifers in Connecticut (Haeni and Melvin, 1984), and to evaluate the extent of PCB contamination in rivers in that State (Frink and others, 1982). The method has also been used in a study of shallow aquifers in Florida (Missimer and Gardner, 1976). The reports of these studies also contain discussions on the theory on which the seismic technique is based.

NUMBERING SYSTEM FOR WELLS IN UTAH

The system of numbering wells in Utah is based on the cadastral land-survey system of the U.S. Government (fig. 2). The number, in addition to identifying the well, describes its position to the nearest 10-acre tract in the land net. The State is divided into four quadrants by the Salt Lake Base Line and Salt Lake Meridian. These quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section; the section number is followed by three letters indicating the quarter section (160-acre tract), the quarter-quarter section (40-acre tract), and the quarter-quarter-quarter section (10-acre tract)—generally 10 acres[1]. The letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of the section and subsequent quarters. The number after the letters is the serial number of the well within the 10-acre tract. If a well cannot be located within a 10-acre tract, one or two location letters are used for the 160- or 40-acre tract and the serial number is omitted. Thus, (B-4-3)19caa-3 designates the third well constructed or visited in the NE¼ of NE¼ of SW¼, sec. 19, T. 4 N., R. 3 W, illustrated in figure 2.

[1]Although the basic land unit, the section, is theoretically 1 square mile, many sections are irregular. Such sections are subdivided into 10-acre tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

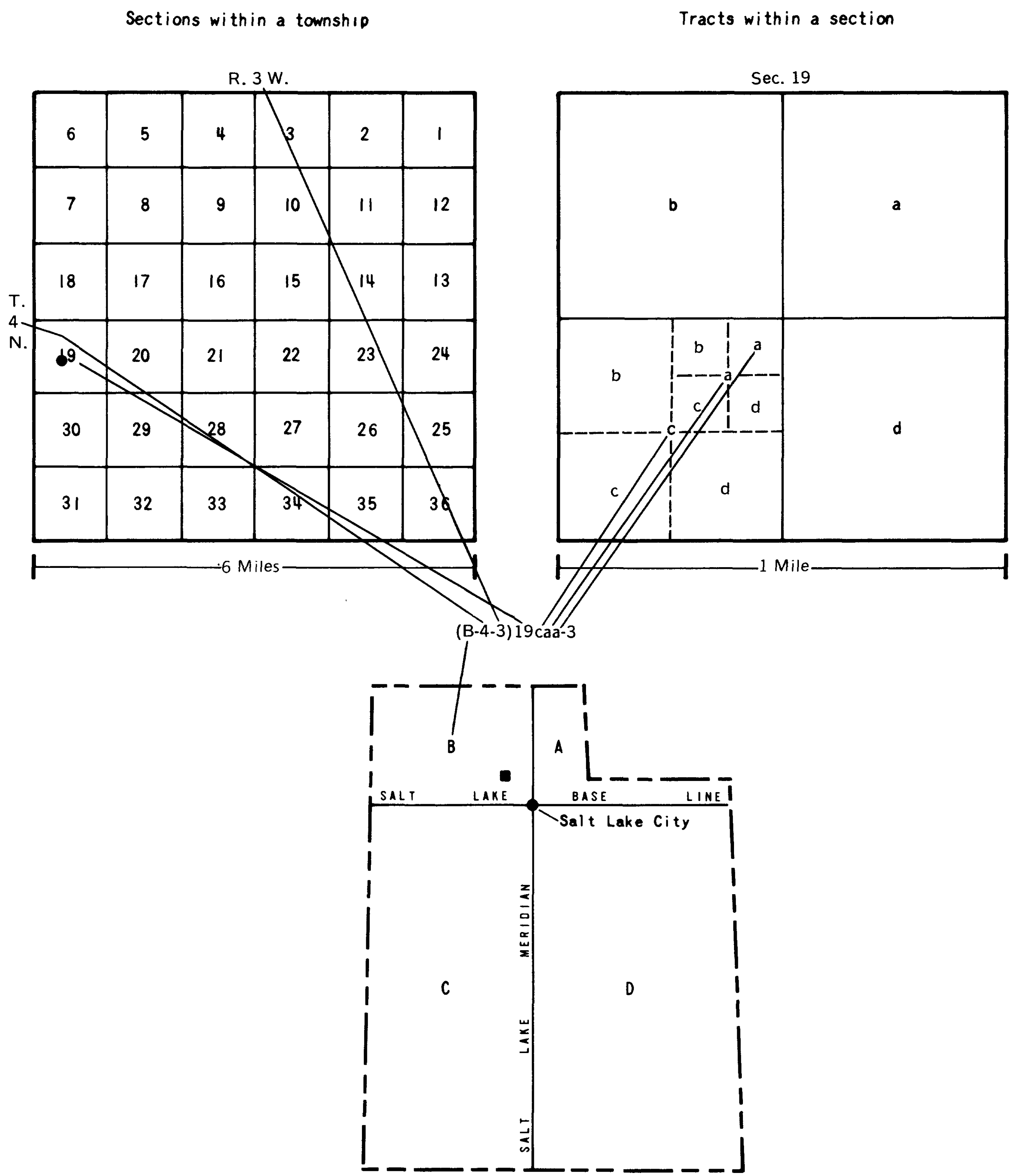


Figure 2.--Numbering system for wells in Utah

GEOLOGIC SETTING

In the vicinity of the study area, basin fill of Tertiary and Quaternary age was deposited in a series of elongate, northerly-trending troughs formed by normal faulting. The consolidated rock of Paleozoic and Precambrian age which underlie the troughs of the area consist mainly of quartzite, schist, gneiss, limestone, dolomite, and shale. Antelope Island, Fremont Island, and Little Mountain consist of Precambrian and Cambrian schist and quartzite. Rocks of Paleozoic age, other than the Cambrian quartzite of Antelope Island, are not exposed near the study area, but they have been encountered in deep wells north of Little Mountain.

The Salt Lake Formation comprises most of the deposits of Tertiary age in the vicinity of the study area and consists of silt, clay, basalt, tuff, marl, and fangolmerate. The nearest outcrops of Tertiary sediments are several miles east of the East Shore area (Feth and others, 1966, p. 13). The existence of Tertiary sediments in the subsurface of the study area has not been confirmed; however, Tertiary sediments have been encountered in deep wells in the Salt Lake Valley.

The Pleistocene Lake Bonneville Group overlies consolidated rock, and Tertiary deposits where they exist, and consists mainly of interbedded gravel, sand, and clay (Feth and others, 1966, p. 16). Quaternary mirabilite deposits were encountered approximately 30 feet below lake bottom in shallow core holes drilled along the Southern Pacific Railroad causeway, northeast of Fremont Island (Eardley, 1962, p. 12). Interpretations of seismic data by Mikulich and Smith (1974, p. 1000) describe Pleistocene mirabilite deposits in two restricted basins in the north section of the lake, west of Promontory Point. More recent lake deposits consist of clay, silt, oolitic sand, salt, and algal bioherms (Gwynn and Murphy, 1980, p. 83).

Interpretations of geophysical data in the area describe a series of north-south-trending horsts and grabens under the lake. A gravity contour map of the study area, including identified structural features (Cook and others, 1966), is shown in figure 3. Interpretations of gravity and geologic data (Cook and others, 1966) along profile A-A' (location on fig. 3) across the East Antelope Island graben define a trough containing a maximum of 7,500 feet of basin-fill deposits (fig. 4a). Analysis of seismic-refraction data (Arnow and Mattick, 1968, p. 81) collected southeast of the lake in the Salt Lake Valley indicates a maximum of 4,800 feet of strata of Cenozoic age suggesting that the East Antelope Island graben becomes shallower to the south. Gravity data modeled by Glenn and others (1980, p. 45) and evaluated along profile B-B' (fig. 3) from southeast of Hill Air Force Base to the north tip of Antelope Island, defines a consolidated rock trough approximately 2,500 feet deep below the lake (fig. 4b).

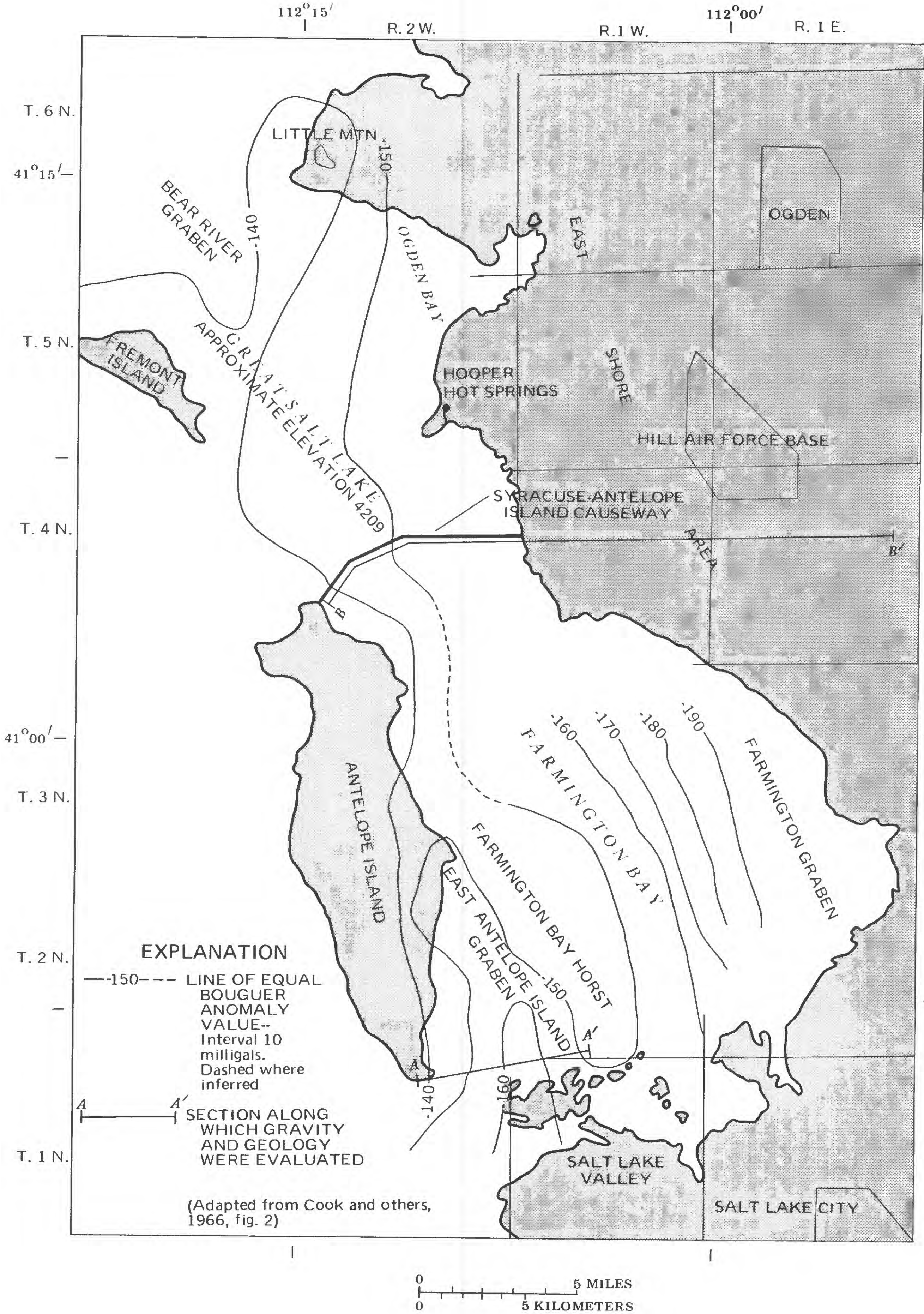
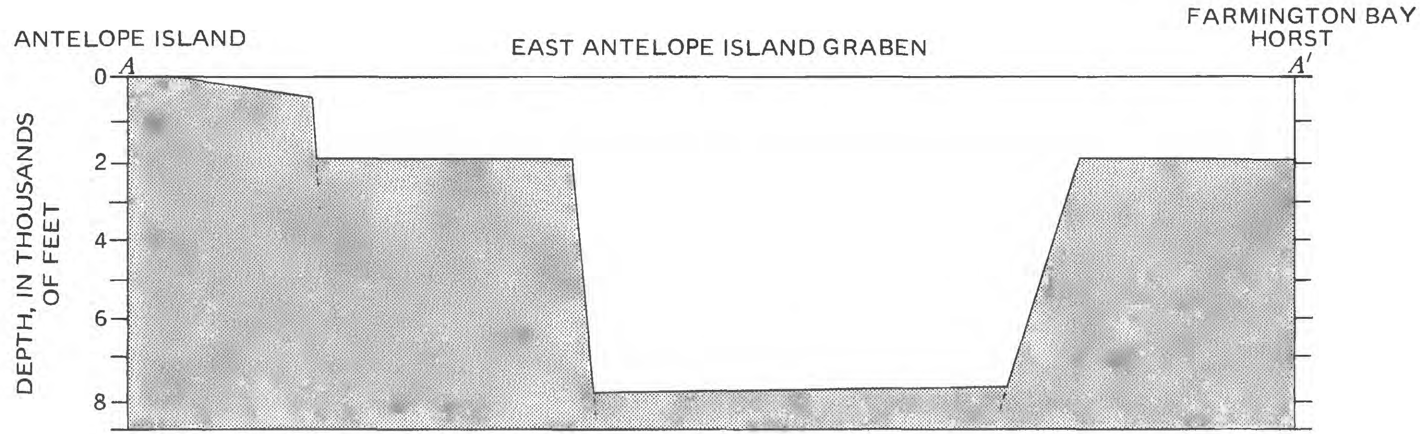
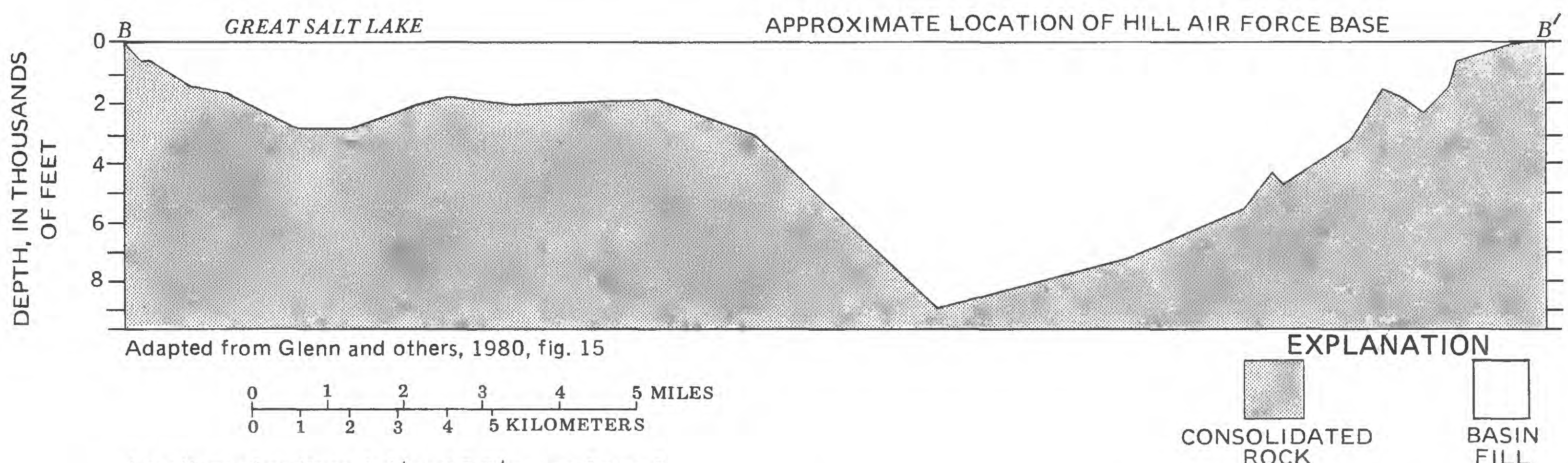


Figure 3.--Bouguer gravity anomalies.

A.



B.



Locations of sections A-A' and B-B' are on figure 3.

Figure 4.--Geologic cross-sections interpreted from gravity data (a) along A-A' across the East Antelope Island graben and part of the Farmington Bay horst, and (b) along B-B' from Hill Air Force Base to the north tip of Antelope Island.

Geologic and geophysical logs from wells in the study area and in the adjacent East Shore area were used to identify boundaries between consolidated rock and basin fill, and to determine approximate thicknesses of those sections. Locations of these wells are shown in figure 1. Well (B-4-3)19caa-3, located northeast of Antelope Island, was drilled to a depth of 481 feet and is the only well in or near the study area reported to have bottomed in Precambrian consolidated rock (well data in the files of the Utah Division of Oil, Gas and Mining, Salt Lake City, Utah). Well (B-6-3)2bbb-1, northeast of Little Mountain, was drilled to a depth of 4,817 feet and encountered the top of the Paleozoic section at 3,660 feet (well data in the files of the Utah Division of Oil, Gas and Mining, Salt Lake City, Utah). An increase in resistivity recorded on the electric log of the Morton Salt well, (B-1-3)24bbb-1, is interpreted as consolidated rock at a depth of about 3,650 feet (Arnow and Mattick, 1968, p. 81).

Wells (B-1-2)29ccc-1 and (B-1-3)24bbb-1, southeast of Antelope Island, are the only wells in the area known to have encountered deposits of Tertiary age. Well (B-1-2)29ccc-1 was drilled to a depth of 3,265 feet and penetrated the Salt Lake Formation at 1,288 feet (well data in the files of the Utah Division of Oil Gas and Mining, Salt Lake City, Utah). A decrease in resistivity at 970 feet on the electric log of well (B-1-3)24bbb-1 was interpreted by Arnow and Mattick (1968, p. 79) as the base of the deposits of Quaternary age, and the well penetrates about 300 feet of Tertiary volcanic rock between depths of 2,300 and 2,800 feet (Arnow and Mattick, 1968, p. 80). The thicknesses of Quaternary and Tertiary deposits in the East Antelope Island graben (fig. 3) computed from seismic-refraction data, range from 600 to 2,500 feet for the Quaternary deposits and 0 to 3,400 feet for the Tertiary deposits (Arnow and Mattick, 1968, p. 79-80).

Two major confined aquifers, the Delta and the Sunset, have been defined in the Quaternary sediments of the East Shore area (Feth and others, 1966, p. 36-37). The aquifers are composed of interbedded deposits of gravel, sand, and silt. The sediments are finer grained near the lake where lacustrian deposits predominate. The top of the Delta aquifer is encountered between 500 and 700 feet below land surface east of the lake. Most of the water-production wells located in the East Shore area are completed in the Delta aquifer (D.W. Clark and others, U.S. Geological Survey, written commun., 1987). The Sunset aquifer is shallower than the Delta aquifer and is located between 250 and 400 feet below land surface in most areas east of the lake.

SEISMIC FIELD SURVEY

The surface-geophysical method used in this study is commonly referred to as continuous seismic profiling. The technique and equipment used in the survey were designed for use in shallow salt water, producing high-resolution seismic profiles with approximately 1,000 feet of penetration. A series of 20 pair-tip sparkers spaced 10 inches between tips were towed behind a 25-foot Boston Whaler[1] boat, 15 feet ahead of an array of hydrophones that extended 75

[1]Use of brand or trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

feet behind the boat. The energy source was a Del Norte 561 acoustic pulse generator with a 750-joule output. Towing speed averaged 5 miles per hour. Recording instruments included a Hewlett Packard 3968A 8-track analog tape recorder and an EPC 4100 graphic recorder with a filter unit using a 200-hertz lowcut, 2,000-hertz highcut filter.

Seismic data were collected along 12 lines totaling approximately 80 miles. The lines covered the east section of the lake from Farmington Bay to the north end of Fremont Island (pl. 1).

Some seismic data were digitized and then processed using a variety of techniques including deconvolution, migration, and band-pass filtering routines. Other than in seismic line 12, these techniques did not substantially improve the degree of resolution and the resulting definition of the reflecting surfaces.

SEISMIC INTERPRETATION

The strength or amplitude of the reflected signal and, thus, the ability to trace the reflector on seismic sections, depends on the contrast in acoustic impedance existing between two lithologic units or within lithologic units. Acoustic impedance is the product of the velocity of sound through a material and the material's density. Analysis of seismic-reflection data from previous studies indicates that identifiable reflections are produced from the boundary between consolidated rock under the Great Salt Lake and the overlying basin fill. Consolidated rock was identified off the west slope of Promontory Point and Antelope Island in marine seismic-reflection data interpreted by Mikulich and Smith (1974, p. 994).

Sound-wave velocity and density differences between lithologic units within the overlying basin fill are much smaller and, thus, reflections from those units may be more difficult to identify. Sedimentary units within the Quaternary sediments of the East Shore area have been delineated from land seismic data collected near Ogden and Hill Air Force Base (Feth and others, 1966, p. 28; Glenn and others, 1980, p. 62-65). And the top of the Tertiary unit was identified in the south end of the lake and west of the Promontory Mountains in marine seismic-reflection data interpreted by Mikulich and Smith (1974, p. 997). However, Mikulich and Smith (1974) did not report identification of units within Quaternary sediments under the Great Salt Lake other than shallow mirabilite salt deposits.

The quality of the seismic data recorded during this study was affected by shallow water and a hard salt layer covered by several feet of recent sediment at the bottom of the lake. This combination produced strong water-bottom multiple reflections that may have masked shallow reflectors in some areas. Seismic lines 5, 6, and 7, and 11, 12, and 13 (pl. 1) were affected the most by the described conditions and contain sections of poor quality data. Seismic lines 4, 5, 6, and 7 contain gaps in the data caused by equipment malfunctions. Data was not recorded along seismic line 8 due to equipment malfunctions, and line 8 does not appear on plate 1. Good quality data were recorded along the entire lengths of seismic lines 1, 2, 3, 9, and 10.

Structures interpreted from seismic data include consolidated-rock topography, depth to consolidated rock, and lithologic changes within basin fill. Estimated seismic velocities for the basin fill were obtained from seismic surveys conducted southeast and east of Great Salt Lake by Arnow and Mattick (1968) and Cook and others (1967). Average velocities of 6,000 feet per second for Quaternary sediments and 8,000 feet per second for Tertiary sediments were considered in interpreting the data and converting travel times to depths.

Seismic reflections have many properties or attributes that can be related to the lithology of the deposits from which they were produced. Figure 5 illustrates some of the terminology used in the following paragraphs to describe these attributes.

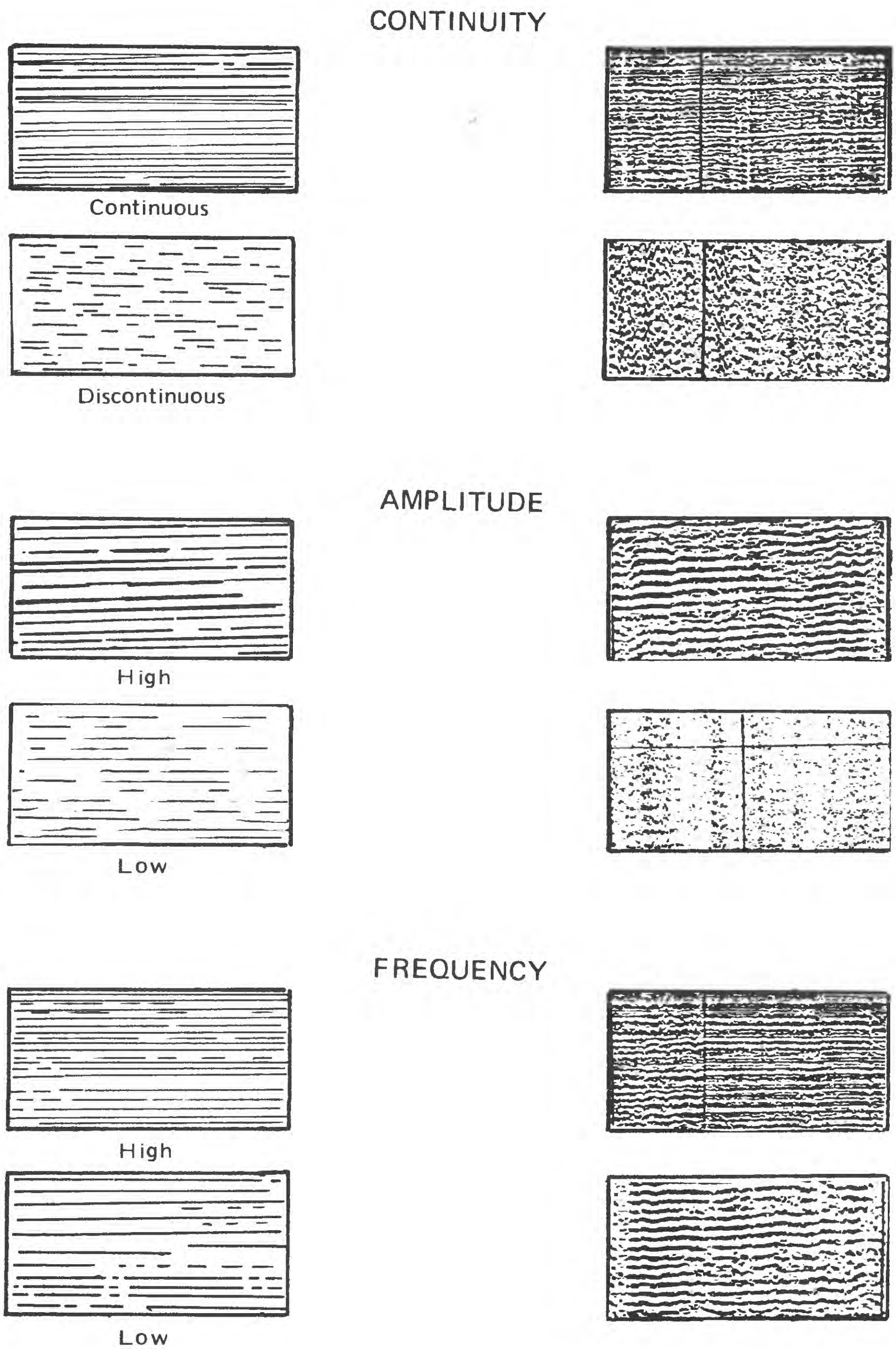
Consolidated-Rock Surface

Reflections interpreted as coming from consolidated rock were identified dipping away from Antelope Island in profiles F-F' and A-A' along seismic lines 1 and 2 (pl. 1). A depth to consolidated rock of 460 feet was computed from seismic data collected at line 2 that passes by well (B-4-3)19caa-3. This depth correlates well with the reported depth to consolidated rock of 480 feet from the driller's log of the well. The consolidated-rock reflector defined in profile F-F' dips steeply to the east and cannot be traced past 0.5 mile east of Antelope Island (pl. 1).

Profile A-A' along seismic line 2 (pl. 1) shows the strong consolidated-rock reflector sloping to the northwest away from Antelope Island and rising toward Fremont Island. Reflections computed to have come from 800 to 900 feet below land surface near the center of profile A-A' are fainter than those near the islands but show a similar undulating structure and are interpreted as reflections from the consolidated-rock surface (pl. 1). Gravity highs in the area of seismic line 2 (fig. 3) also indicate a shallow depth to consolidated rock in that area.

Consolidated rock was also identified at the west end of profile B-B' along seismic line 3 (pl. 1) dipping away from Fremont Island. The reflector terminates 0.75 mile east of the start of line 3 in a zone of cascading diffractions typical of those produced by faulted reflectors (Sheriff and Geldart, 1983, p. 102). A west-dipping reflector appears just east of the diffractions and outlines a large dome-shaped structure approximately 200 feet below lake bottom at its maximum elevation, 2.75 miles east of Fremont Island. The reflector dips sharply on the east side of the dome, breaks, and flattens abruptly suggesting a possible fault. Bouguer anomaly values in the area of the dome structure range from -140 milligals to -150 milligals, indicating a shallow depth to consolidated rock but not necessarily a rock high at the depth indicated by the seismic data. The reflector is interpreted as a consolidated-rock high possibly bounded on the west and east by normal faults. The appearance of the reflector is similar to that of the consolidated-rock reflectors defined near Fremont Island and Antelope Island, demonstrating the same intensity and undulating patterns.

Analysis of data near the east end of profile C-C' (pl. 1) indicates a discontinuous consolidated-rock reflector approximately 380 feet below lake bottom, just west of Hooper Hot Springs. Reflections recorded along seismic



(adapted from Badley, 1985, fig 4.1)

Figure 5.--Seismic-reflection attributes.

line 4, west of Hooper Hot Springs (not included in any illustration), also show a southwest-dipping reflector at the start of the line. These reflectors may represent a consolidated-rock ridge below Hooper Hot Springs that Cole (1982, p. 592) describes as part of the western edge of a north-south graben, east of the lake.

Seismic line 9 is located north of line 3, trending west across Ogden Bay to Fremont Island (pl. 1). The consolidated-rock reflector is identified on profile D-D', 0.3 mile east of the end of line 9 near Fremont Island (pl. 1). The east-dipping reflector reaches a maximum depth of 820 feet below lake bottom, 1.5 miles east of the island, and then rises to within 325 feet of lake bottom near D'. The reflector may represent a northern extension of the rock dome outlined in profile B-B', 2.5 miles to the south, and define a consolidated-rock structure that could impede possible westward movement of ground water under the lake. Unlike profile B-B', major faults in the consolidated-rock reflector are not indicated. The reflector terminates in a section of data masked by strong multiples and does not appear at the east end of profile D-D'.

Analysis of seismic data near the west end of profile E-E' on line 10 (pl. 1) indicates a consolidated-rock surface sloping away from Fremont Island. The reflector dips to the east and cannot be traced beyond E'. The rock reflector apparently is faulted 0.8 mile east of the west end of the profile, and a faint reflector dipping steeply eastward may represent a primary fault plane (pl. 1).

Although shallow consolidated-rock reflectors are not identified at the east ends of seismic lines 9 and 10, north of Hooper Hot Springs, it is possible that the bedrock ridge identified in profile C-C', west of Hooper Hot Springs (pl. 1), trends north and is exposed at Little Mountain.

Reflections from the consolidated-rock surface were identified in data from profile G-G' along seismic line 7 (pl. 1) about 4 miles east of Antelope Island. The reflector, at a computed depth of 520 feet below lake bottom, can be traced for about 2 miles. The location of the observed consolidated-rock high correlates with gravity highs in that area (fig. 4), and the rock high may represent part of the Farmington Bay horst.

Consolidated-rock reflectors were identified in data collected along the west ends of seismic lines 6 and 11 (not shown on profiles). The reflectors dip steeply away from Antelope Island and can only be traced to 1 mile east of Antelope Island. No consolidated-rock reflectors were identified from data collected along seismic lines 12 and 13.

A map showing depth to consolidated rock (below datum of lake bottom) was produced by converting seismic travel times to depths to rock (fig. 6). Faults identified from analysis of the seismic data could not be correlated from one line to another. Therefore, the dashed lines that indicate faults on the map do not accurately indicate fault strike, only the relatively upthrown and downthrown sides.

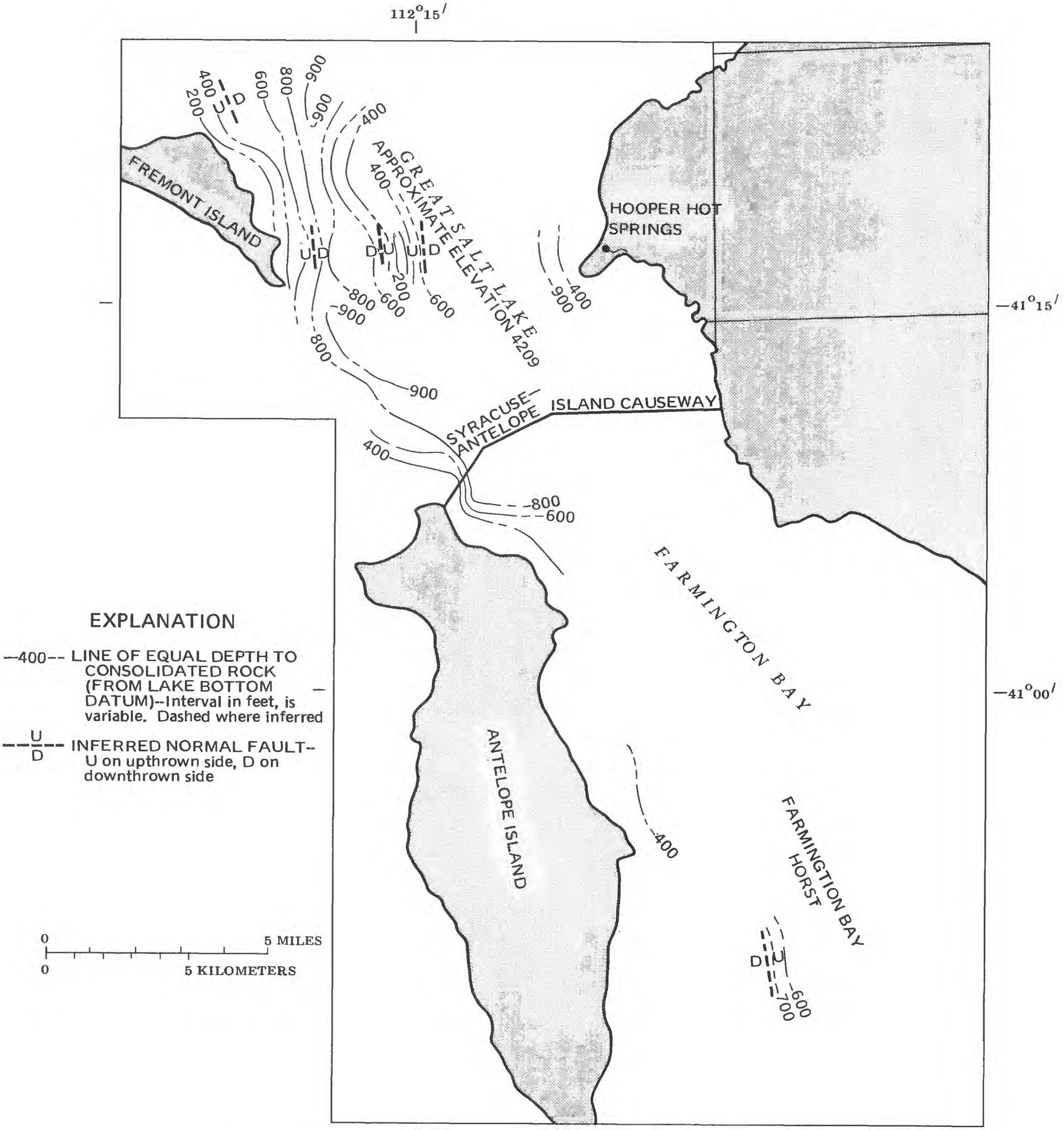


Figure 6.--Depth to consolidated rock (below datum of the lake bottom) and location of inferred faults.

Basin Fill

Reflections from basin fill overlying consolidated rock have similar attributes and indicate similar patterns of change with depth on most of the seismic profiles. In general, data representing the top 250 to 300 feet of sediment beneath the lake are characterized by continuous, high-frequency, parallel reflections indicating fine-grained, thinly bedded deposits. Deeper sediments produce high amplitude, low-frequency reflections indicating coarser grained deposits.

Strong reflections from basin fill have been identified dipping gradually away from Antelope and Fremont Islands (pl. 1). Due to the absence of wells with subsurface data near seismic lines, it is difficult to determine whether strong reflections from the basin fill come from Quaternary sediments, Tertiary sediments, or from the boundary between the two sections. However, Tertiary sediments are not encountered in or near the study area other than in deep wells drilled in the East Antelope Island graben (Salt Lake Valley) and their existence in the subsurface of the East Shore area has not been determined (Feth and others, 1966, p. 13). Also, the continuous, parallel configuration of the reflections observed above the consolidated-rock surface is not typical of the reflections recorded in other areas of the lake that have been identified by Mikulich and Smith (1974, p. 997) as coming from Tertiary deposits. Thus, it is likely that the strong reflections observed in the seismic data above the consolidated-rock reflector are from Quaternary sediments (estimated seismic velocity of 6,000 feet per second), and that deeper, continuous, high-amplitude reflections observed above consolidated rock represent substantial lithologic changes between fine-grained, clay-sand beds and sand-gravel beds.

Analysis of shallow reflections indicates that many small faults exist in the sediments above the consolidated-rock surface. Mikulich and Smith (1974, p. 995) suggest that similar faults indicated by seismic data collected in other areas of the lake could have been caused by movements near major faults or by compaction of the unconsolidated sediments.

Shallow reflectors defined near Antelope Island and the east shore of the lake can be correlated with water-yielding strata encountered by nearby wells, suggesting that the reflectors represent acoustic impedance contrasts between sand-gravel aquifers and associated clay-sand confining layers. Analysis of processed data recorded along seismic line 12 indicates a reflector that can be traced from the start of line 12 for 1 mile to the south (profile H-H', pl. 1). Computed depth of the reflector is from 540 to 600 feet below lake bottom. Most wells located along the east shore of the Great Salt Lake, east of seismic line 12, are perforated in Delta aquifer at depths ranging from 600 to 690 feet below land surface. It is possible that the reflector identified in profile H-H' represents the extension of the Delta aquifer of the East Shore area under the easternmost section of the lake.

Strong reflections, dipping gradually to the east above the consolidated-rock reflector at the west end of seismic line 1 (pl. 1), begin at a depth of 425 feet and fade 0.4 mile to the east at a depth of 460 feet. The reflector terminates abruptly in a diffraction near F'. The depth of the reflector correlates with a water-yielding section penetrated by well (B-4-3)19caa-3 (pl. 1), and indicates that the source of the sediments making up the freshwater aquifer was Antelope Island, and that the aquifer extends at least 0.4 mile east of the island.

The source of freshwater in well (B-4-3)19caa-3 has not been determined. Bolke and Waddell (1972, p. 17-18) suggested that at least some of the water in well (B-4-3)19caa-3 may be derived from precipitation on Antelope Island, citing chemical similarities between water collected from the well and three springs located at the north tip of Antelope Island. However, sodium chloride waters similar to those of Antelope Island are found in the Delta and Sunset aquifers, and it is possible that the source of the water that supplies well (B-4-3)19caa-3 is from the Delta and Sunset aquifers extending under the lake.

The interbedded sand and gravel composing the Delta and Sunset aquifers are discontinuous and cannot be correlated between wells near the shore of the lake. Lithologic boundaries between these aquifers and their associated confining layers, therefore, were not expected to produce high-amplitude reflections in the seismic data that could be traced east to west across the study area. Although some continuous reflectors can be correlated with water-yielding strata, they cannot be correlated with specific lithologic boundaries over the rest of the study area because of a lack of subsurface control near seismic lines.

SUMMARY AND CONCLUSIONS

In 1984, a continuous seismic-reflection survey of the Great Salt Lake, Utah, was conducted by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. Structures interpreted from seismic data include consolidated-rock topography, depth to consolidated rock, and lithologic changes within basin fill.

Consolidated rock can be traced on seismic profiles almost continuously between Antelope and Fremont Islands. Seismic profiles outline a north-south-trending consolidated-rock high 2.75 miles east of Fremont Island and 200 feet below lake bottom. Analysis of the data indicates that the consolidated-rock structure may be 2.5 miles in length in a northwest-southeast direction and could impede possible westward movement of ground water through sediments under the lake. Analysis of seismic data also indicates consolidated rock 380 feet below the lake bottom dipping steeply to the west, just west of Hooper Hot Springs. The shallow rock west of Hooper Hot Springs possibly is part of a northwest-southeast-trending, consolidated-rock ridge which is exposed at Little Mountain. A consolidated-rock high is indicated in data recorded 4 miles east of the south end of Antelope Island, about 520 feet below lake bottom, and may represent part of the Farmington Bay horst.

In general, analysis of data recorded from the basin fill indicates fine-grained, thinly bedded deposits within 250 to 300 feet of the lake bottom. Stronger, low-frequency reflections from deeper sediments indicate that the deposits become more coarse-grained with depth. High-amplitude reflections above consolidated-rock reflectors have been identified near the east shore of the lake and east of Antelope and Fremont Islands. These reflectors are interpreted as representing substantial lithologic changes between fine-grained, clay-sand beds and sand-gravel beds.

Reflectors in basin fill east of the north tip of Antelope Island and just west of a part of the east shore of the lake can be correlated with water-yielding strata identified in well logs and may represent lithologic boundaries between sand-gravel aquifers and their associated clay-sand confining layers. Other high-amplitude, continuous reflections from basin fill were observed, but could not be defined because of a lack of subsurface control in the area.

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