

resulted from shooting upslope on layer 4. The refracting bedrock surface beneath lines 1, 2, and 3 is irregular and slopes towards the east and south. The depths to the top of layer 4 ranged from 230 to greater than 900 ft. The top of layer 4 is below the sampling depth along line 4, along the eastern parts of lines 1 and 3, and along the central and southern parts of line 2. Bedrock depth control was provided by exploration well 9N/10W-16L3, northwest of the intersection of lines 1 and 2 (fig. 11), where the lithologic and borehole geophysical logs show that the depth to bedrock is 230 ft (fig. 9E).

VERTICAL ELECTRIC SOUNDINGS

Vertical electric soundings were made using direct current (DC) methods. The DC resistivity surveying technique involves the introduction of a very low frequency, direct current into the ground through two widely spaced electrodes, and the measurement of the potential difference between two electrodes placed near the center of the electrode array. This measured potential difference is then used to compute an apparent resistivity for the Earth materials beneath the array. Extending the distance between the electrodes in the array causes the flow path of the current to penetrate deeper into the Earth. The resulting apparent resistivities are considered averages of the actual resistivities of the individual layers of sediment and rock beneath the electrode array (Zohdy and others, 1974).

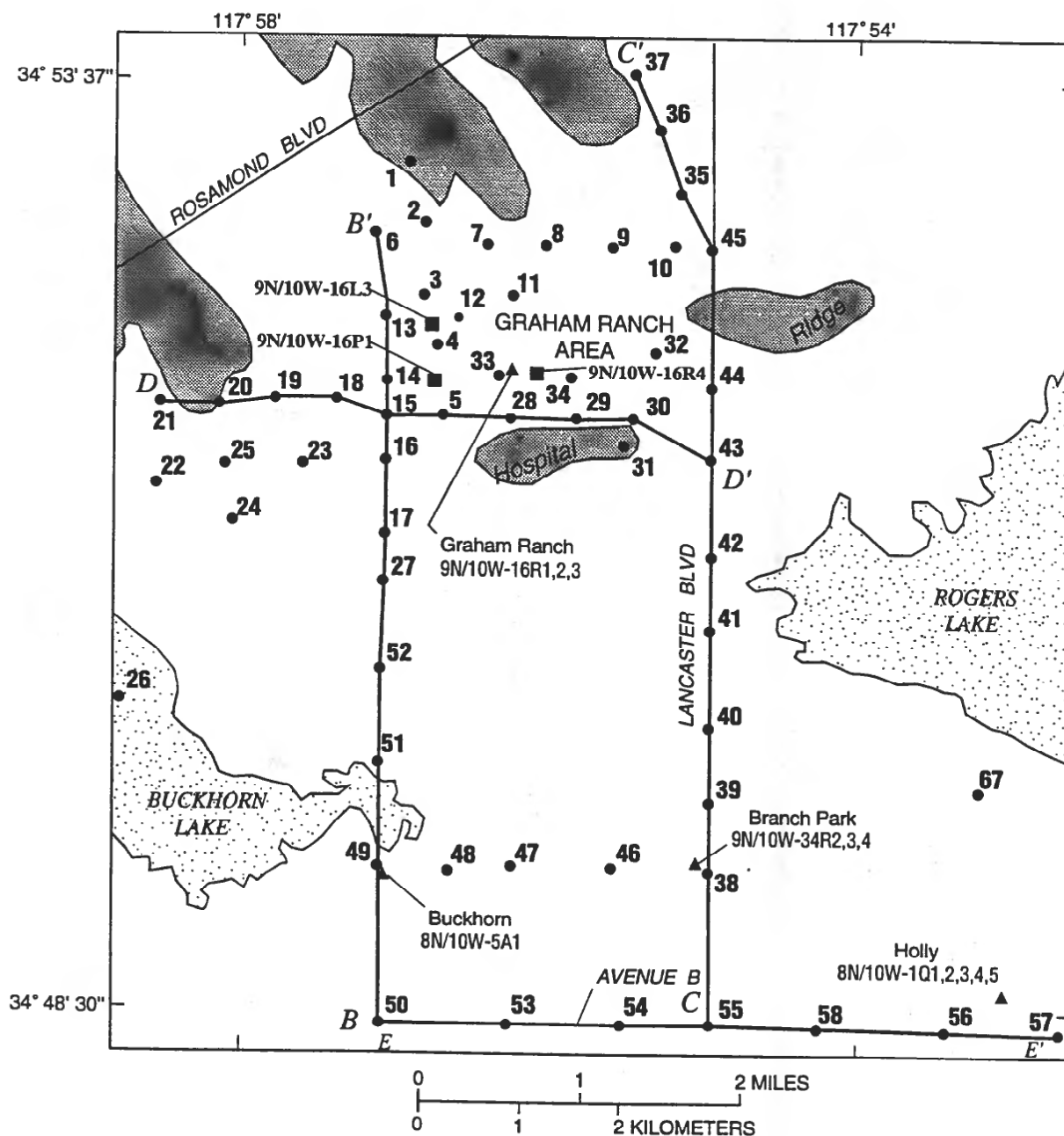
In October 1989, 67 vertical electric, deep soundings using the Schlumberger array configuration (Zohdy and others, 1974) were conducted at EAFB, 59 of which (numbers 1-58 and 67) were made in the Graham Ranch area and areas west and south of Rogers Lake (fig. 13). Eight additional electric soundings, numbers 59-66, were made on the northern part of Rogers Lake and are not discussed in this report. The purpose of these soundings was to determine the configuration of the bedrock surface and to provide information concerning the distribution and thickness of the unconsolidated sediments. The detailed survey, analysis, and interpretation of the Schlumberger data were made by Zohdy and Bisdorf (1990), and some of the results are summarized here.

The interpretation of the Schlumberger soundings at EAFB indicated that the electrical resistivity of the bedrock may be only a few hundred ohm-meters, and as low as 100 ohm-m. The relatively low resistivities

for igneous rock may be related to the weathering and alteration of the quartz monzonite. Saturated, coarse-grained sediments, indicative of sand-and-gravel freshwater aquifers, are characterized by resistivities ranging from 30 to 70 ohm-m. Fine-grained clay-rich sediments are characterized by resistivities lower than 15 ohm-m. In general, for saturated, unconsolidated sediments, the higher the resistivity the coarser grained the material. However, the occurrence of brackish ground water will decrease the resistivity of the sediments and deviate from this generalization.

Interpreted resistivity at depths of 328, 656, 984, and 1,640 ft for the Graham Ranch area and the areas south and west of Rogers Lake are shown in figures 14A-14D. At the 328-foot depth (fig. 14A), a sharp northeast trending resistivity contrast occurs between an area of larger resistivities (greater than 100 ohm-m) northwest, and an area of lower resistivities (less than 70 ohm-m) southeast of the contrast. The resistivity contrast represents the northern edge of a small, buried structural basin in the Graham Ranch area, and suggests the existence of a geologic fault (Zohdy and Bisdorf, 1990). Two regions of relatively intermediate to high resistivity, 70 to greater than 100 ohm-m, material occur about 1 mi south of the northern edge of the basin, at the 328-foot depth beneath Hospital Ridge and probably represent the southern edge of this small basin. A short resistivity sounding 31 made on Hospital Ridge measured resistivities from 33 to 150 ohm-m in the upper 130 ft, and 60 ohm-m at depths greater than 130 ft. The interpreted resistivities near Hospital Ridge are lower than expected for quartz monzonite. Zohdy and Bisdorf (1990) concluded that the low resistivities of 60 ohm-m measured at depth beneath Hospital Ridge indicated that the ridge is composed of floating, weathered granitic blocks. An alternative interpretation is that Hospital Ridge is rooted, and the low interpreted resistivities may be attributed to the highly fractured, altered bedrock exposures. Field observations of Hospital Ridge, and other exposures of quartz monzonite on EAFB indicate that many fractures and faults in these outcrops are in-filled with clay-sized quartz and feldspar minerals.

At the 656-foot depth (fig. 14B), the zone between 70 to 100 ohm-m has migrated southeastward from the region of high resistivity contrast and has coalesced with the regions of 70 to 100 ohm-m material near Hospital Ridge to form the crude outline of a basin. Geoelectrically, the basin appears to be open to the south and east at this depth. A region



EXPLANATION

- PLAYA SURFACE
- BEDROCK
- B—B' LINE OF SECTION
- Buckhorn 8N/10W-5A1
- 9N/10W-16R4
- 47 • SCHLUMBERGER SOUNDING AND NUMBER
- CLUSTER SITE, NAME, AND NUMBER--Site at which one or more observation wells are completed at different depths. See table 3
- WELL AND NUMBER

Figure 13. Location of 59 vertical electric soundings and cross sections B-B', C-C', D-D', and E-E' in the Graham Ranch area and vicinity on Edwards Air Force Base. Modified from Zohdy and Bisdorf (1990).

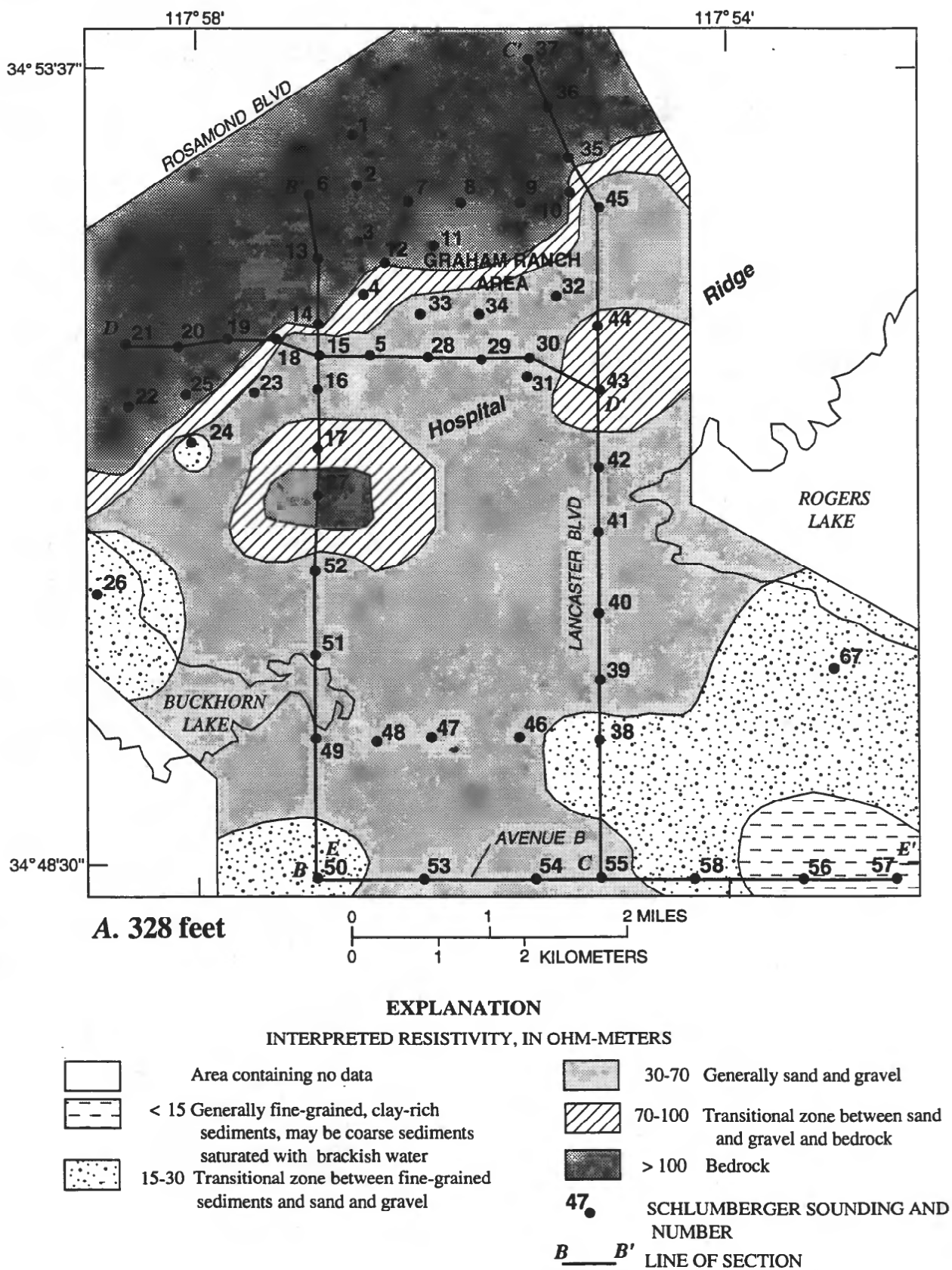
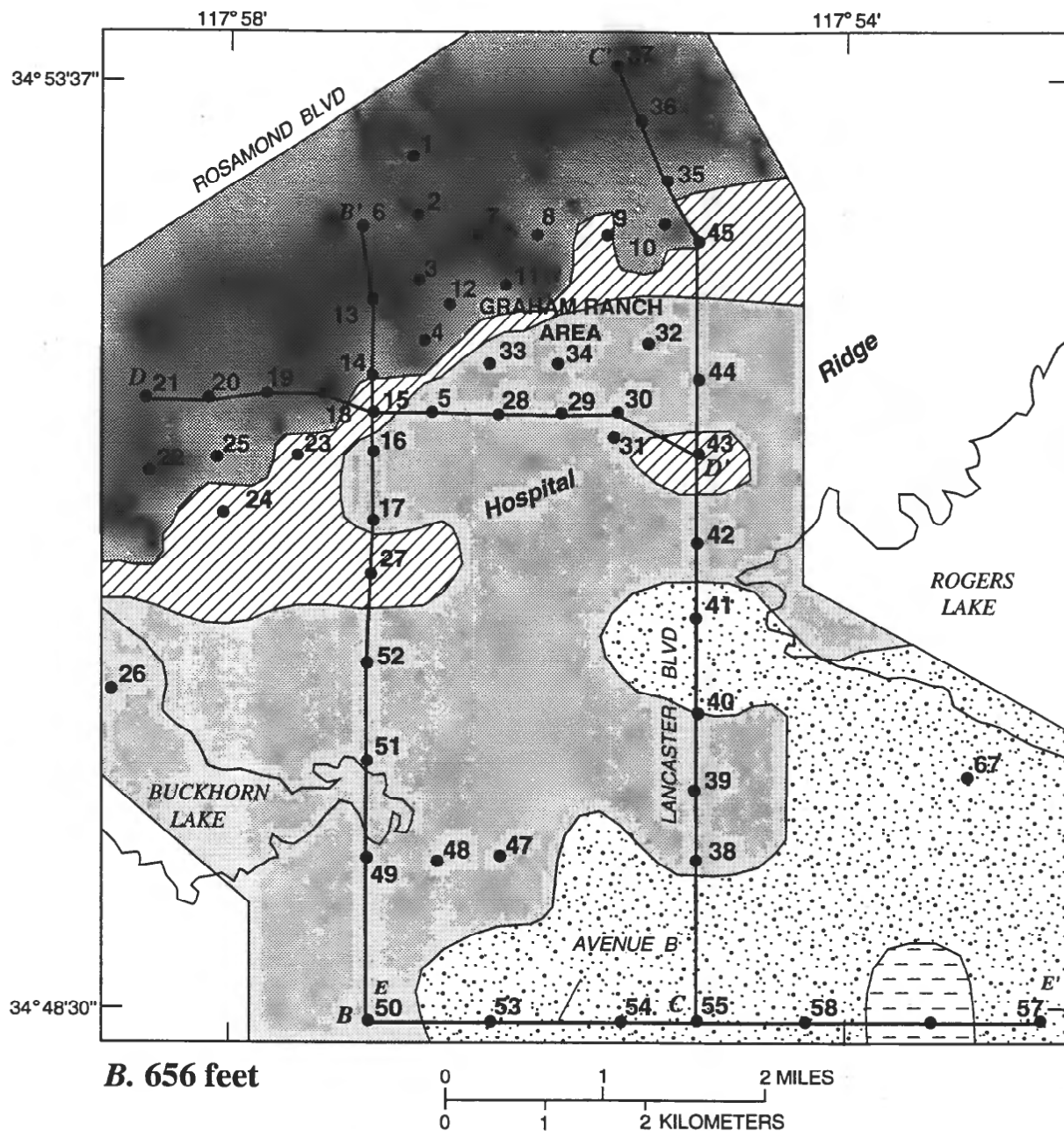


Figure 14. Interpreted resistivities of rock formations and associated rock types at depths of 328, 656, 984, and 1,640 feet below land surface for the Graham Ranch area and vicinity on Edwards Air Force Base. Modified from Zohdy and Bisdorf (1990).

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B. 656 feet

0 1 2 MILES
0 1 2 KILOMETERS

EXPLANATION

INTERPRETED RESISTIVITY, IN OHM-METERS









	Area containing no data		30-70	Generally sand and gravel
	< 15 Generally fine-grained, clay-rich sediments, may be coarse sediments saturated with brackish water		70-100	Transitional zone between sand and gravel and bedrock
	15-30 Transitional zone between fine-grained sediments and sand and gravel		> 100	Bedrock
			47	SCHLUMBERGER SOUNDING AND NUMBER
			B — B'	LINE OF SECTION

Figure 14. Interpreted resistivities of rock formations and associated rock types at depths of 328, 656, 984, and 1,640 feet below land surface for the Graham Ranch area and vicinity on Edwards Air Force Base. Modified from Zohdy and Bisdorf (1990)—*Continued*.

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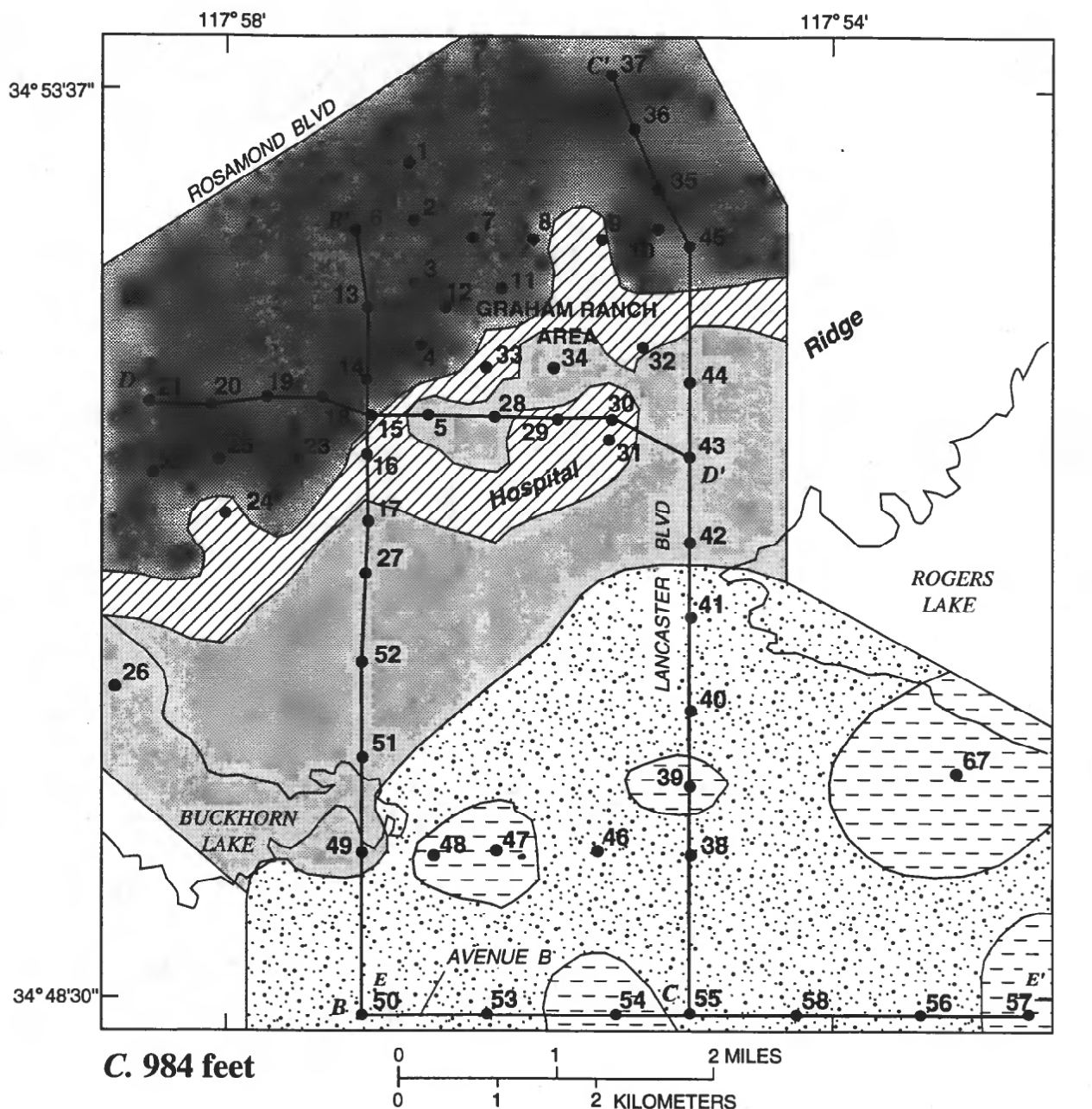
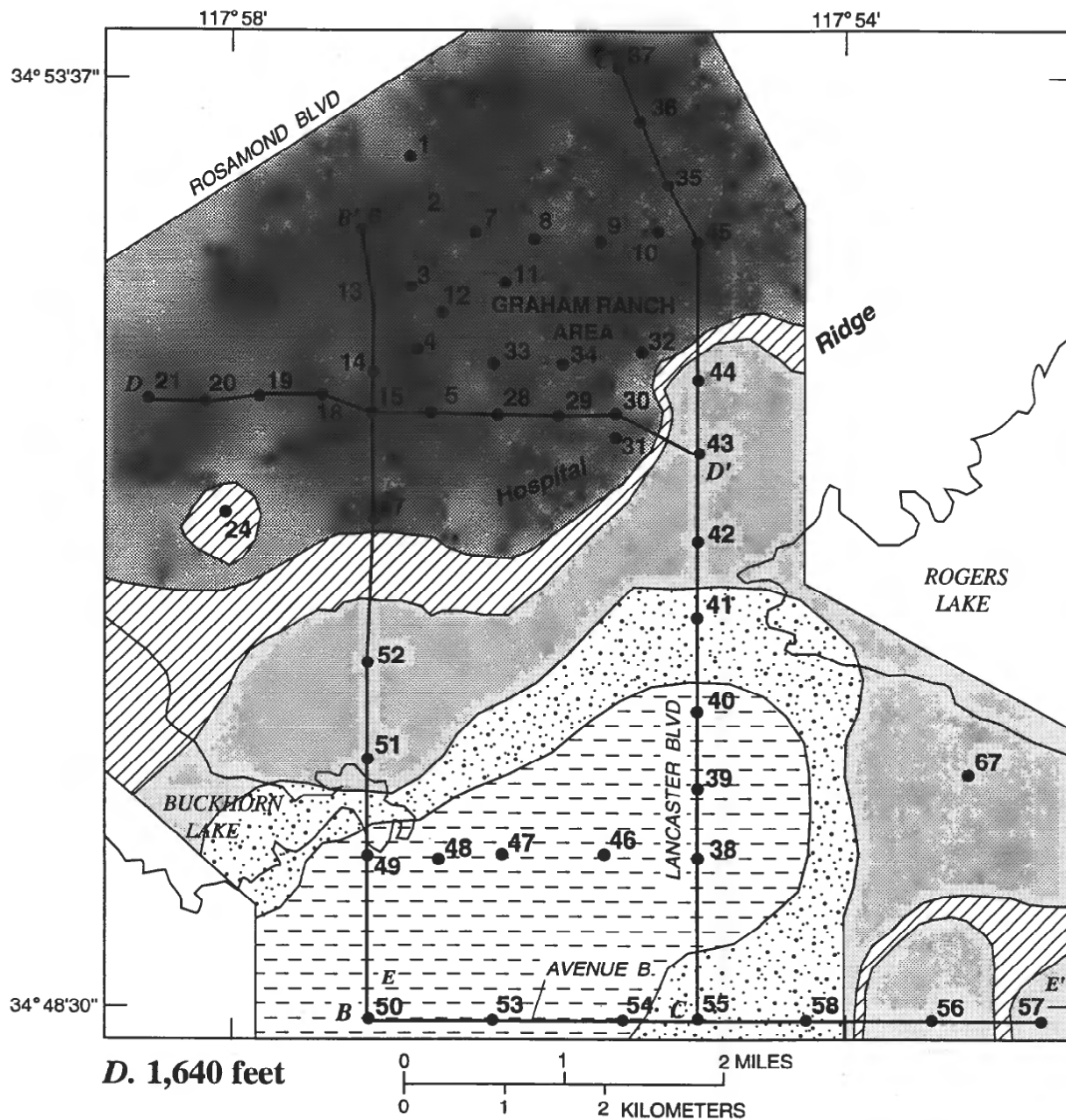


Figure 14. Interpreted resistivities of rock formations and associated rock types at depths of 328, 656, 984, and 1,640 feet below land surface for the Graham Ranch area and vicinity on Edwards Air Force Base. Modified from Zohdy and Bisdorf (1990)—Continued.

PWS-0194-0050



D. 1,640 feet

0 1 2 MILES
0 1 2 KILOMETERS

EXPLANATION

INTERPRETED RESISTIVITY, IN OHM-METERS









	Area containing no data		30-70 Generally sand and gravel
	< 15 Generally fine-grained, clay-rich sediments, may be coarse sediments saturated with brackish water		70-100 Transitional zone between sand and gravel and bedrock
	15-30 Transitional zone between fine-grained sediments and sand and gravel		> 100 Bedrock
			47 SCHLUMBERGER SOUNDING AND NUMBER
			B—B' LINE OF SECTION

Figure 14. Interpreted resistivities of rock formations and associated rock types at depths of 328, 656, 984, and 1,640 feet below land surface for the Graham Ranch area and vicinity on Edwards Air Force Base. Modified from Zohdy and Bisdorf (1990)—*Continued*.

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of less than 30 ohm-m resistivity south and west of Rogers Lake has expanded from its coverage at the 328-foot depth. On each of the 328- and 656-foot depth maps, there is a large region of resistivities between 30 and 70 ohm-m material which encompasses the principal sediments from which ground water is produced by base production wells near Branch Park and in the Graham Ranch area.

At the 984-foot depth (fig. 14C), the small basin in the Graham Ranch area appears closed. The low-resistivity region south and west of Rogers Lake has extended southwestward, increasing the areal distribution of fine-grained sediments in this part of the East Antelope structural basin. At this depth, the coarse-grained deposits indicated by the 30 to 70 ohm-m zone are primarily restricted to a narrow northeast-trending band south of Hospital Ridge, and north and west of Branch Park.

The deepest part of the small basin in the Graham Ranch area probably is less than 1,640 ft as indicated in figure 14D. At this depth, the region of high resistivities greater than 100 ohm-m extends from the northwest to south of Hospital Ridge, west of Lancaster Boulevard. A second region of high resistivity is present at the 1,640-foot depth in the southeast corner of the surveyed area. Between these regions, there is a large region of resistivities less than 15 ohm-m that extends to the southwest. To the north and east of this low-resistivity region, there is a region of resistivities of 30 to 70 ohm-m. Distribution of interpreted resistivities at the 1,640-foot depth is well correlated to the distribution of isostatic gravity residuals (fig. 10). The regions of interpreted low resistivities are associated with the regions of larger negative residuals on the gravity map and generally conform to the shape of the northeast corner of the East Antelope structural basin. The regions of interpreted high resistivities are associated with the regions of smaller negative residuals on the gravity map and generally conform to the northeast boundaries of the structural basin.

The altitude and shape of the interpreted bedrock surface is shown in cross sections in figures 15A-D. The surface of the granitic basement is delineated by the contact between the 70 to 100 ohm-m zone and the greater than 100 ohm-m zone. The south to north cross sections, *B-B'* and *C-C'*, indicate shallow basement rocks north of the Graham Ranch area (figs. 15A and 15B). This is confirmed by the penetration of poorly consolidated, weathered bedrock at

an altitude of about 2,190 ft above sea level and competent bedrock at about 2,080 ft above sea level in exploration well 9N/10W-16L3, near sounding 13. Proceeding from north to south, the bedrock surface deepens, indicating the subdued impression of the small basin in this area near sounding 45 to 44 and sounding 14 to 16 (figs. 15A and 15B). The bedrock surface continues to deepen, except for a bedrock ridge detected beneath sounding 43 (fig. 15B), and more subtly beneath sounding 17 (fig. 15A). The bedrock surface slopes steeply into the East Antelope structural basin beneath soundings 42 (fig. 15B) and 51 (fig. 15A), where the interpreted altitude of the basement surface is about 2,000 ft below sea level. Another ridge is encountered beneath soundings 39 (fig. 15B) and 49 (fig. 15A), and beyond this, the interpreted bedrock surface deepens southward to the ends of the cross sections.

The west to east cross sections, *D-D'* and *E-E'* (figs. 15C and 15D) also show the transition from a shallow to a deep basement. Cross section *D-D'* runs along the northern flank of Hospital Ridge, from west of the Graham Ranch area east to Lancaster Boulevard (fig. 13). This cross section shows the small basin identified in the southern part of the Graham Ranch area, deepening from west to east to a minimum altitude of about 1,000 ft above sea level beneath sounding 28 (fig. 15C). At the Graham Ranch site (fig. 13) at wells 9N/10W-16R1, 16R2, and 16R3, 1,800 ft north-northeast of sounding 28 and about 500 ft east of sounding 33 (not shown on fig. 15C) bedrock was not encountered at a bottom hole altitude of 1,350 above sea level. This is consistent with the resistivity measurements, which indicate that the altitude of the basement surface is less than 1,330 ft above sea level (fig. 15C). Furthermore, lithologic and borehole geophysical logs of alluvium penetrated in well 9N/10W-16R1 were consistent with the interpreted resistivities from sounding 33. This information was used to site production well 9N/10W-16R4 1,200 ft east of the Graham Ranch site (fig. 8).

Cross section *E-E'* runs along Avenue B from sounding 50 to 57 across the northeast part of the East Antelope structural basin (fig. 13), where the minimum altitude of the basement surface is less than 2,500 ft below sea level beneath sounding 53 (fig. 15D). East of sounding 53, the bedrock surface slopes upward to an altitude of about 1,250 ft above sea level at sounding 57 on the rim of the East Antelope structural basin (fig. 15D). The Holly site boreholes, drilled about 1,000 ft northeast of

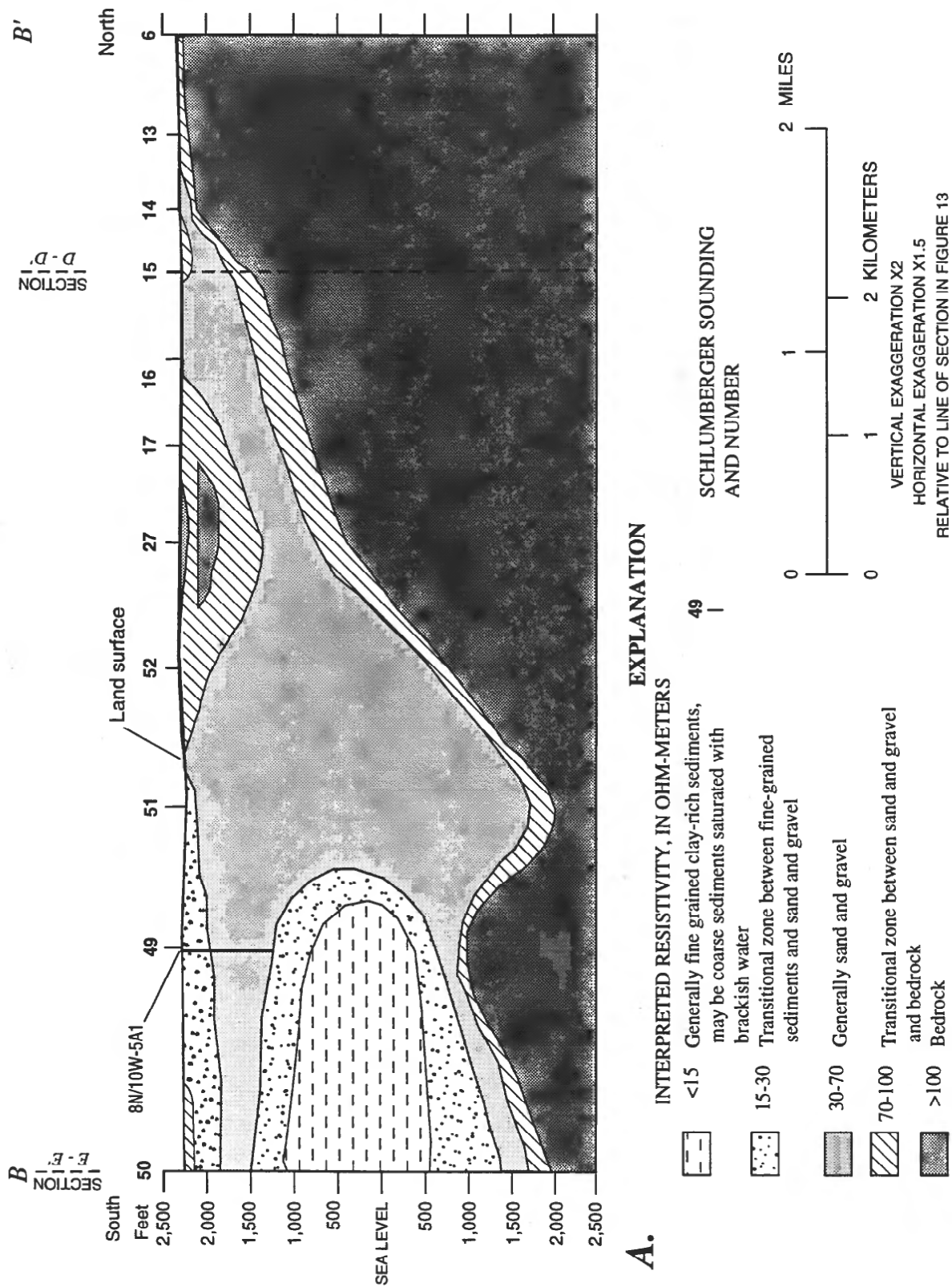
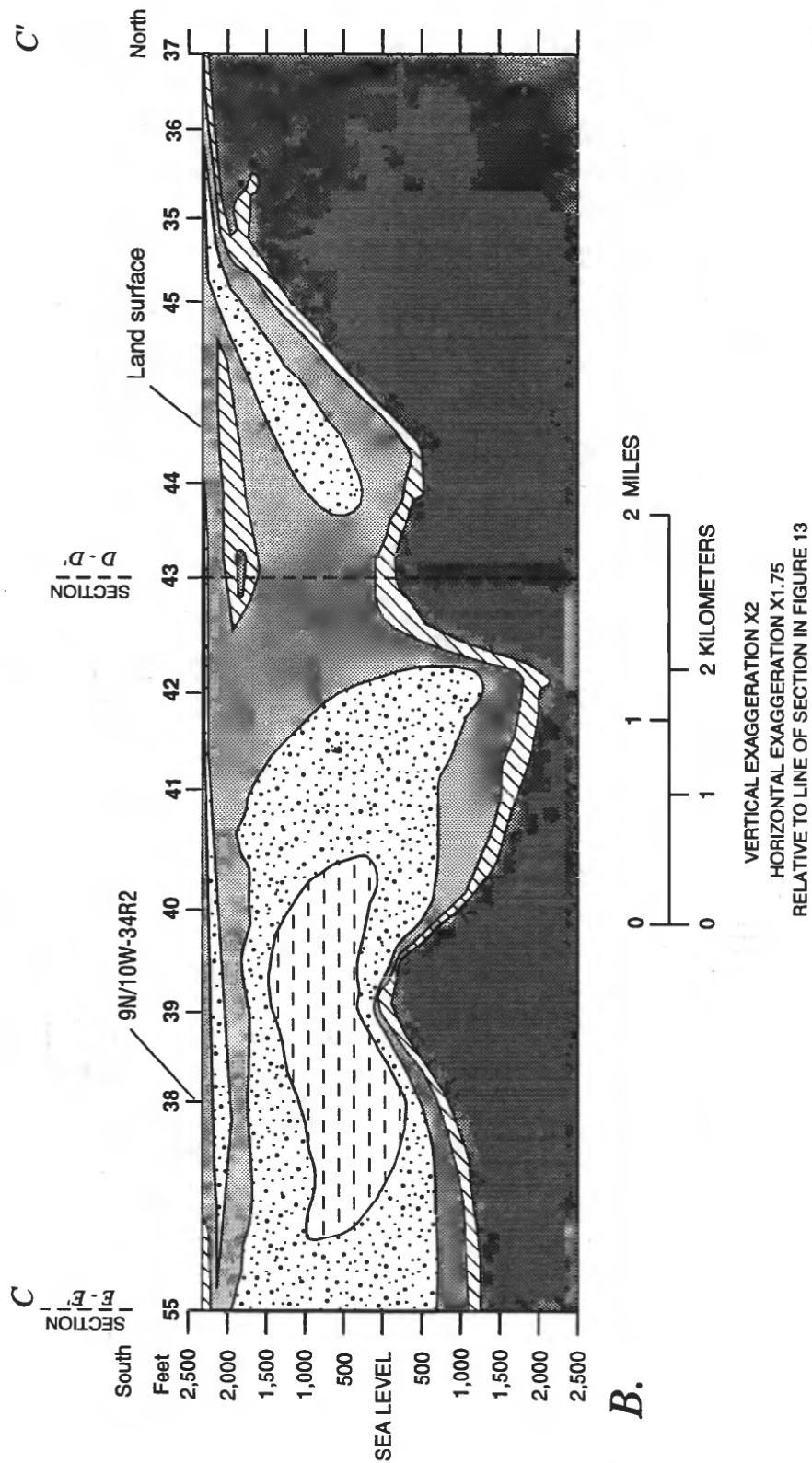


Figure 15. Interpreted resistivities of rock formations and associated rock types for the Graham Ranch area and vicinity on Edwards Air Force Base.

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PWS-0194-0054

Figure 15. Interpreted resistivities of rock formations and associated rock types for the Graham Ranch area and vicinity on Edwards Air Force Base--Continued.

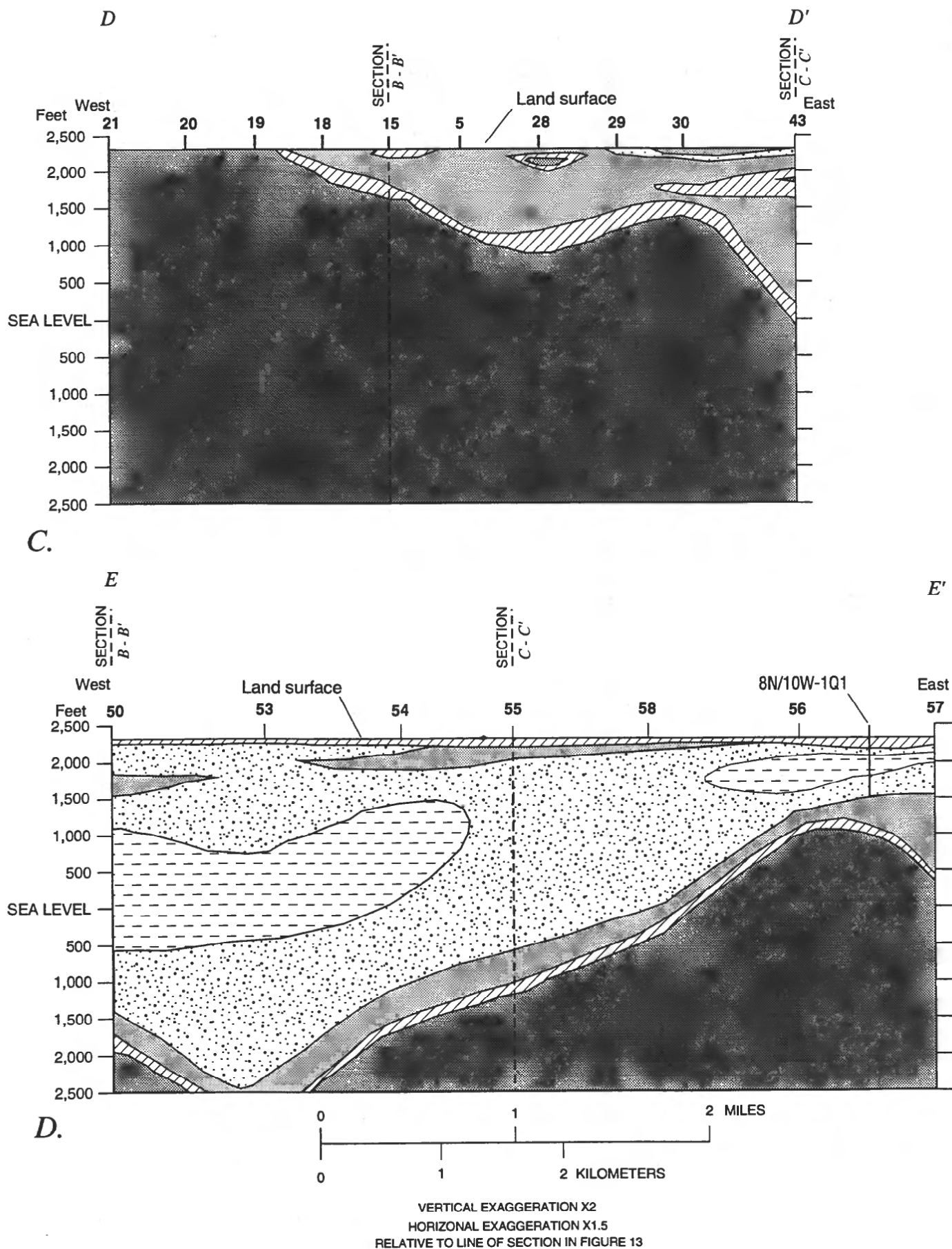


Figure 15. Interpreted resistivities of rock formations and associated rock types for the Graham Ranch area and vicinity on Edwards Air Force Base--*Continued*.

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