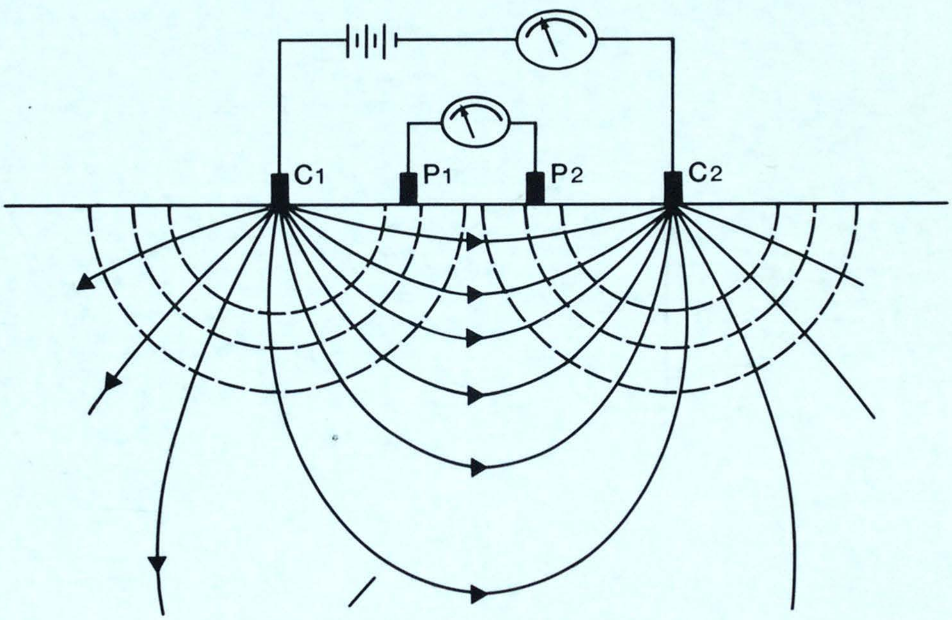
Water-Resources Investigations Report 87-4184

SURFACE-GEOPHYSICAL INVESTIGATIONS IN MELTON VALLEY, OAK RIDGE RESERVATION, TENNESSEE



Prepared by the
U.S. GEOLOGICAL SURVEY

in cooperation with the
U.S. DEPARTMENT OF ENERGY

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Patrick Tucci

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DEPARTMENT OF ENERGY

Nashville, Tennessee
1987

DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS

Multiply	By	To obtain
mile (mi)	1.602	kilometer
foot (ft)	0.3048	meter (m)
ohm-feet (ohm-ft)	0.3048	ohm-meter (ohm-m)
millimhos per meter at 25° Celsius (mmho/m)	1.000	millisiemens per meter at 25° Celsius (mS/m)

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SURFACE-GEOPHYSICAL INVESTIGATIONS IN MELTON VALLEY, OAK RIDGE RESERVATION, TENNESSEE

by Patrick Tucci

ABSTRACT

Surface-geophysical methods were valuable for refining knowledge of the geohydrology of Melton Valley, an area used for burial of low-level radioactive waste at the Oak Ridge Reservation in Tennessee. The valley is characterized by locally complex geologic structures in lithologies of interbedded shale and limestone. Radionuclides have been transported away from the burial areas by ground water along flow paths that are, in part, controlled by geologic structure and rock type.

Direct-current resistivity soundings were used to determine the depth to bedrock and to aid in the delineation of subsurface stratigraphy. Depth to bedrock, as indicated by an increase in resistivity in the interpreted geoelectric layering, was compared to auger-hole data at five sites, where bedrock depths ranged between 8 and 31 feet. Differences between interpreted and reported depth to bedrock ranged from 1 to 14 feet and were within 3 feet at four sites. The subsurface contact between shale and limestone was indicated by an increase in model-calculated resistivity from less than 100 to more than 150 ohm-meters at four different sites.

Terrain-conductivity profiles were used to aid in mapping surficial geologic contacts between shale and limestone units. Terrain conductivity for shale at 33-foot coil separation was generally greater than 15 millimhos per meter and ranged from about 10 to 40 millimhos per meter. Conductivity for limestone was generally less than 15 millimhos per meter and ranged from 5 to 25 millimhos per meter. Azimuthal conductivity surveys indicated that conductivity was generally greatest when the transmitter and receiver coils were oriented parallel to strike. This anisotropy in terrain conductivity shows the need to keep the coil orientation consistent throughout the length of a profile.

INTRODUCTION

Shallow-land burial of low-level radioactive waste in Melton Valley (fig. 1) has been practiced by Oak Ridge National Laboratory (ORNL) since 1951. Buried radioactive material has been leached and contaminants have been transported by ground water along flow paths that are, in part, controlled by geologic structure and rock type (Webster, 1976). The U.S. Geological Survey, in cooperation with the Department of Energy, has

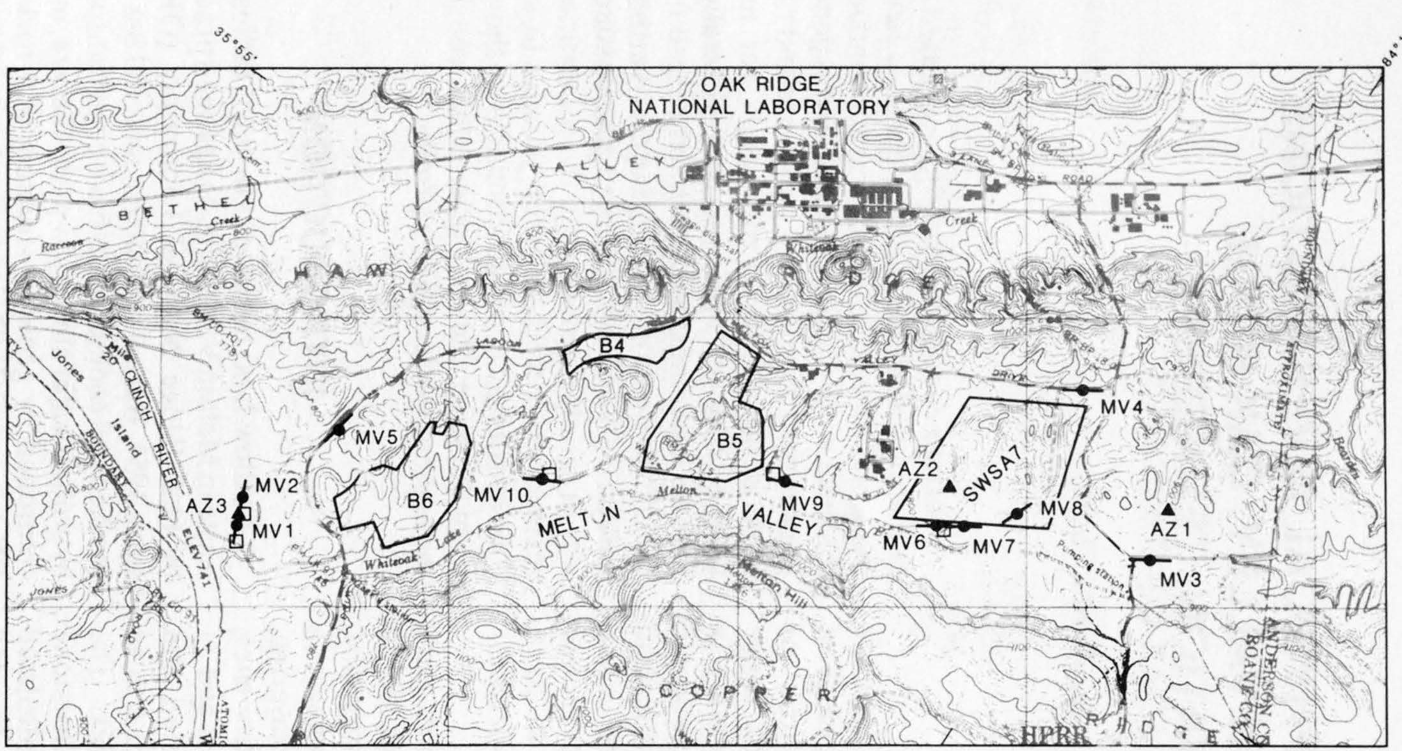


Figure 1.--Location of study area, auger holes, direct-current resistivity soundings, and azimuthal surveys.

conducted a study of the geohydrology of the burial grounds since 1975. Use of surface-geophysical methods to aid in refining knowledge of the geohydrology of the valley was started in 1985. This report describes the use of two surface-geophysical methods – direct-current (DC) resistivity and terrain conductivity – in Melton Valley. Detailed descriptions of the theory and field procedures of the methods are beyond the scope of this report. More detailed information concerning DC resistivity may be found in Zohdy and others (1974), and, for terrain conductivity, in McNeill (1980).

The targets for the geophysical surveys included determination of depth to bedrock and the delineation of subsurface stratigraphy. Terrain-conductivity profiles (fig. 2) were used to aid in mapping surficial geologic contacts between shale and limestone. Azimuthal conductivity surveys also were conducted at three sites (fig. 1) to determine the effect of anisotropy on terrain-conductivity measurements.

Geohydrologic Setting

Melton Valley is bounded on the northwest by Haw Ridge (fig. 1), which is underlain by the Rome Formation of Cambrian age (fig. 3). The Rome consists of massive sandstones, thinly bedded siltstones, shales, and mud stones (Haase, Walls, and Farmer, 1985). Copper Ridge, which bounds Melton Valley on the southeast (fig. 1), is underlain by the Knox Group of Cambrian and Ordovician age. The Knox Group consists of carbonates, principally dolostone with subordinate amounts of limestone and locally abundant sandstone.

Melton Valley is underlain by the Conasauga Group of Cambrian age (McMaster, 1963), which consists of six formations (in ascending order): Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, Nolichucky Shale, and Maynardville Limestone (Davis and others, 1984, p. 16). Although formation names indicate single lithologic types, some formations are actually composed of a variety of rock types. For example, the Maryville Limestone contains abundant interbedded shale in the lower part of the formation. The Maryville is the most permeable unit in the valley (Tucci, 1986) and is of particular importance because it underlies most of Burial Grounds 5 and 6.

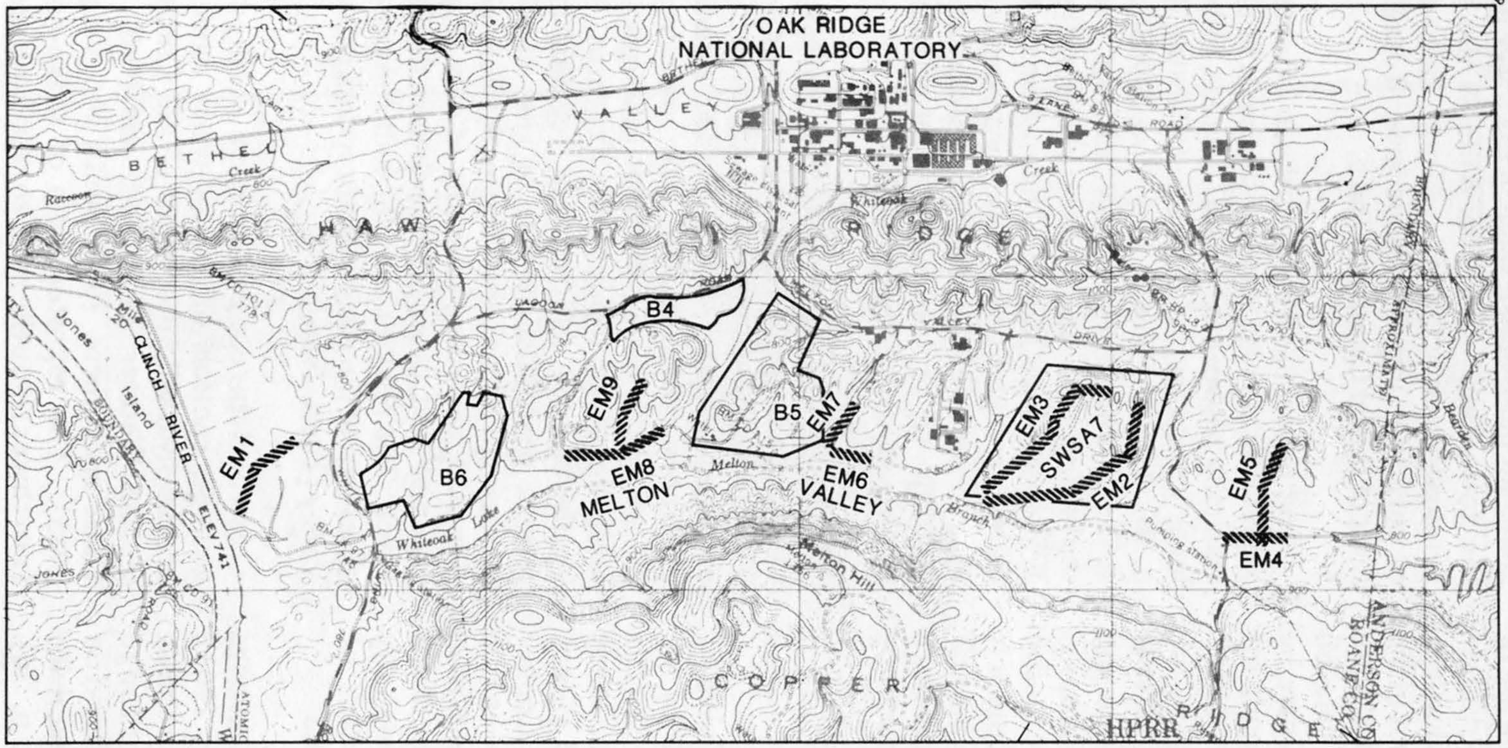
The formations strike northeast at about 56 degrees from north and dip southeast at angles generally between 20 and 40 degrees, although local variations are common (Webster, 1976, p. 8). Haase, Zucker, and Stow (1985) show several tear faults across Melton Valley, including one approximately parallel to Whiteoak Creek (fig. 3). The motion on these faults is complex and is typically a combination of strike- and dip-slip movement. Sledz and Huff (1981, p. 40) reported major joint orientations that are parallel and normal to strike.

The depth of weathering within the Conasauga is variable and ranges from less than 5 feet in low-lying areas to as much as 40 feet on the ridges (Webster, 1976, p. 9). This variation is probably related to the weathering characteristics of the different lithologies that underlie these topographic features. The weathered zone, referred to as "regolith" in this report, generally consists of silty clay with increasing residual rock fragments with depth. Alluvium, consisting primarily of silty to sandy clay, and sand, overlies bedrock near the Clinch River. The regolith and alluvium comprise the upper part of the ground-water system in Melton Valley (Tucci, 1986, p. 7).

Several investigators have studied the geologic controls on ground-water movement and on hydraulic properties of the Conasauga Group (Webster, 1976; Sledz and Huff, 1981; Davis and others, 1984; Smith and Vaughan, 1985). The reported ratio of strike-normal (northwest-southeast) to strike-parallel

35°55'

84°17'30"

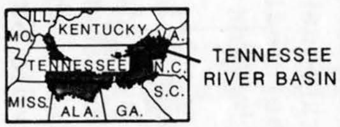


Base from Tennessee Valley Authority,
U.S. Geological Survey, Bethel Valley,
Tenn., 1:24,000, 1968

0 1000 2000 3000 4000 5000 FEET
0 500 1000 METERS

CONTOUR INTERVAL 20 FEET
DATUM IS SEA LEVEL

N



MAP LOCATION

EXPLANATION

B4 BURIAL GROUND AND NUMBER

EM1 TERRAIN CONDUCTIVITY PROFILE AND DESIGNATION

SWSA7 SOLID WASTE STORAGE AREA -- 7 (Proposed)

Figure 2.--Location of terrain-conductivity profiles.

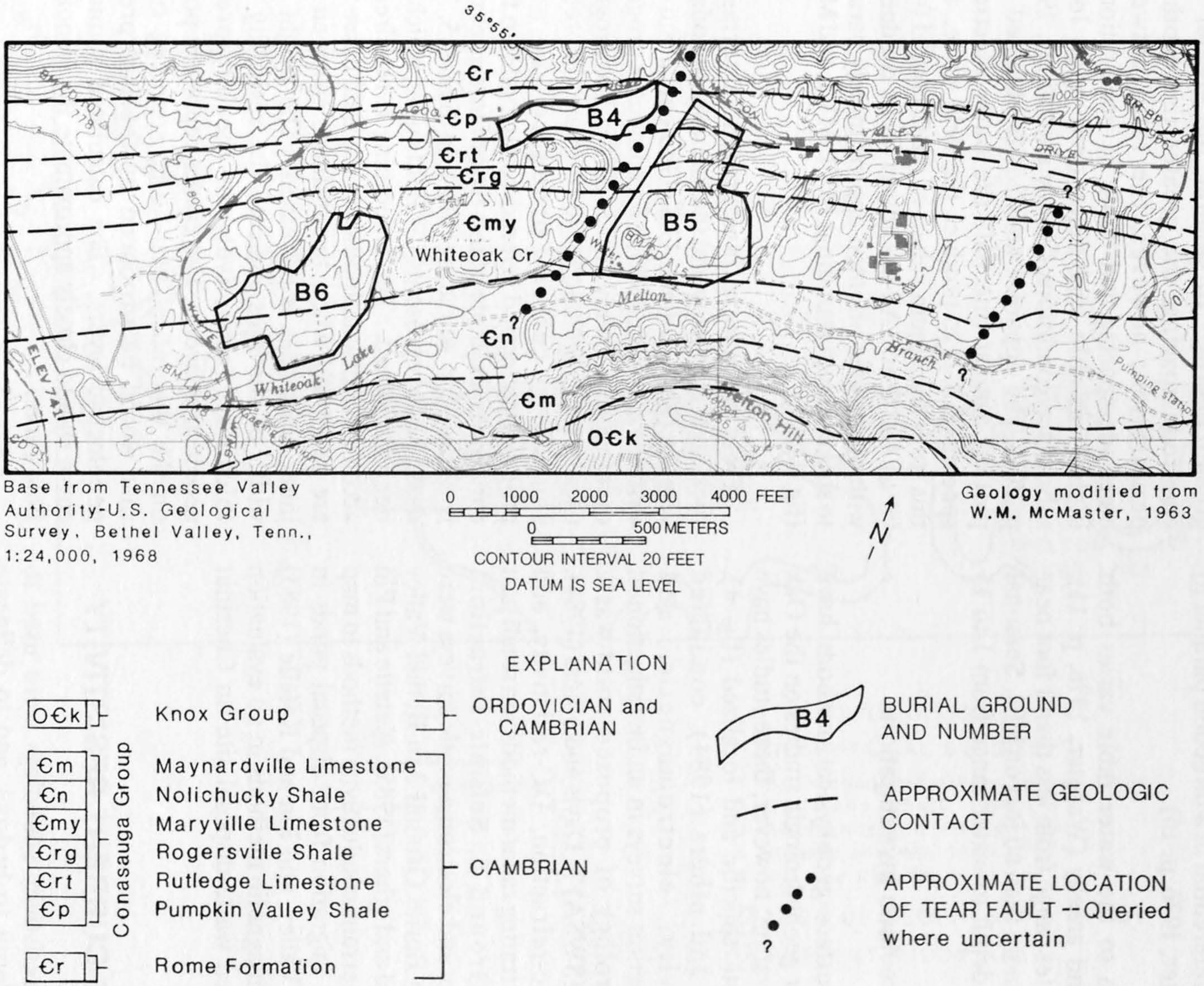


Figure 3.--Generalized geology of Melton Valley.

(northeast-southwest) hydraulic conductivity values range from 1:3 to 1:20 (Rothschild and others, 1984, p. 106-107). Because of this anisotropy in hydraulic conductivity, ground-water flow in the unweathered bedrock tends to be preferential in a direction parallel to strike (Webster, 1976, p. 16).

The depth to the water table varies both temporally and areally (Webster, 1976, p. 11). Depths to water range from less than 1 foot near drainages to more than 60 feet on hills. Seasonal variations in depth to water range from 1 to 15 feet.

Previous Investigations

Various surface-geophysical methods have been used for geohydrologic studies on the Oak Ridge Reservation; however, these studies have been very site specific and localized (fig. 4). Rothschild and others (1984), conducted DC-resistivity, electromagnetic, and seismic-refraction surveys in an investigation of the geohydrology of proposed solid-waste storage area (SWSA) 7. Davis and others (1984), used seismic-refraction, DC-resistivity, and ground-penetrating radar methods in a small part of Burial Ground 6. Seismic-refraction, DC-resistivity and electromagnetic surveys were conducted in Burial Ground 3 in Bethel Valley by Rothschild and others (1985). Ketelle and Pin (1983) used terrain-conductivity methods to map contaminant migration from disposal ponds in Bear Creek Valley, and Pin and Ketelle (1983) used electromagnetic methods in an evaluation of a proposed waste-disposal site on Chestnut Ridge.

DIRECT-CURRENT RESISTIVITY

Ten DC-resistivity soundings were used to determine depth to bedrock and to delineate subsurface stratigraphy. The soundings were obtained using the Schlumberger electrode array configuration, which consists of four in-line electrodes. The inner electrode pair (M and N) records electrical potential as current is passed through the outer pair (A and B). The distance between the electrode pairs is increased to probe greater depths. In general, the greater the electrode spacing, the greater the depth of penetration; however, the ratio between electrode spacing and depth of penetration is highly variable and dependent upon local subsurface conditions (Zohdy and others, 1974, p. 20). The apparent resistivities obtained are plotted against one half the outer electrode spacing (AB/2) to produce the field curve. For this study maximum values of AB/2 ranged from 98 to 460 feet. All soundings were conducted with electrodes oriented approximately parallel to strike, except soundings MV1, MV2, and MV5 (fig. 1).

Field data were interpreted in terms of rock-layer resistivity and thickness by an updated version (K.J. Hollett, U.S. Geological Survey, written commun., 1985) of a computer program developed by Zohdy (1973, 1975). The program uses iterative techniques to compare theoretical sounding curves produced by the program-generated layered-earth model to field curves. An example of this type of interpretation is shown for sounding MV1 in figure 5. The dashed line represents the field curve, which has been smoothed. The smoothing is required to account for discontinuities in the field curve that are produced when the distance between the inner electrodes is increased. The height and width of the bars indicate the resistivity and thickness, respectively, of the interpreted geoelectric layers. The circles represent points on the theoretical best-fitting sounding curve that would be produced by the interpreted geoelectric layers. The calculated sounding curve should closely approximate the smoothed field curve.

Zohdy's program has an option that allows for a simplified interpretation by reducing the

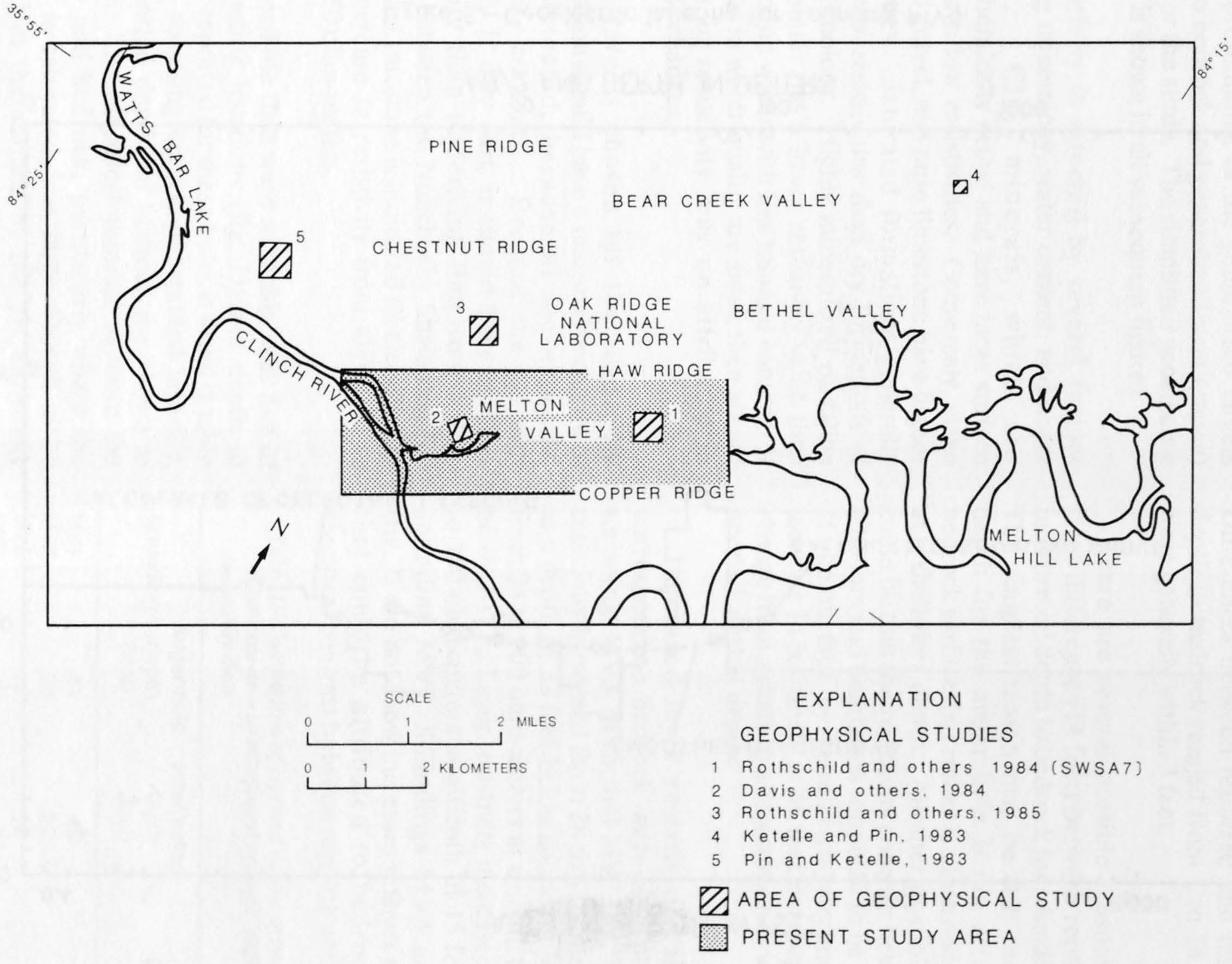


Figure 4.--Location of previous geophysical studies.

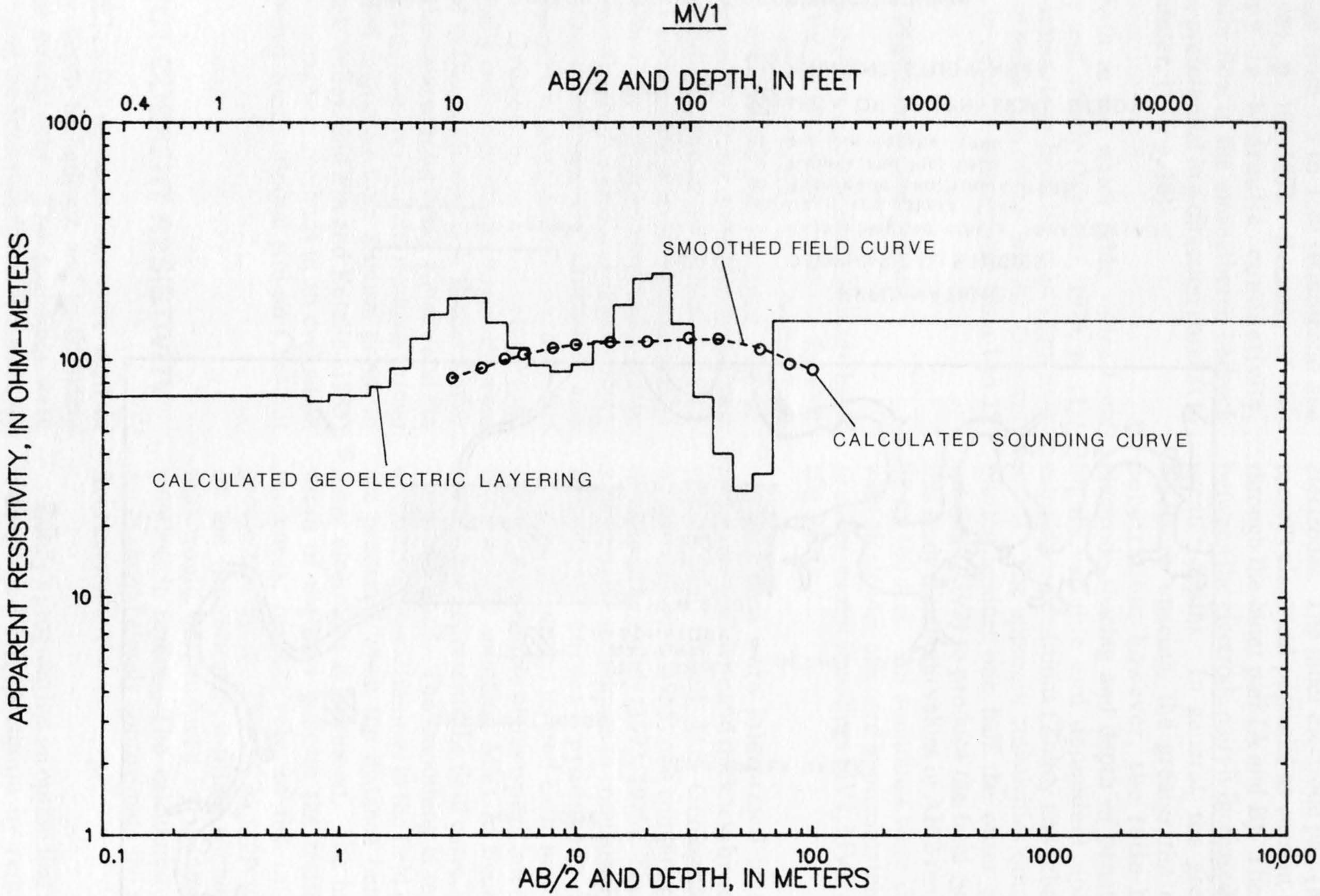


Figure 5.--Geoelectric layering for sounding MV1.

number of geoelectric layers calculated by the program. That option was used in this study, because the simplified layering was thought to be more representative of the generalized targets (depth to bedrock and generalized stratigraphy) chosen for the study. The simplified geoelectric layering is shown in all subsequent figures.

Resistivity is affected by several factors including mineralogy, water content, and water quality. Clay minerals, which are electrochemically active and have large surface areas, have low resistivities. Conversely, clean sand and gravel, and pure limestone have higher resistivities. Saturated formations generally have lower resistivities than dry formations of similar lithology. Highly mineralized or saline ground water has a lower resistivity value than fresh ground water with low mineral content. If variations in water quality are small then abrupt changes in resistivity may be attributed to lithologic changes.

The targets chosen for the resistivity investigation should have a reasonable chance of being detected, because of the expected resistivity contrasts. Because the regolith generally is clay rich, it should have a lower resistivity than underlying limestone. The contact between the Nolichucky Shale and the Maryville Limestone is indicated on electric logs by an increase in resistivity from about 60 to about 150 ohm-meters.

Auger-hole data were available near five of the sounding locations (fig. 1), and depth to bedrock reported for these holes is listed in table 1. The sounding curves, interpreted layering, and reported depths to bedrock are shown in figure 6. The electrical contrast between the regolith and bedrock, particularly where the regolith is saturated, was large enough to be detected at the surface by the DC-resistivity method. Resistivity values for unsaturated regolith were between 55 and 115 ohm-meters; and for saturated regolith, between 25 and 100 ohm-meters. Bedrock is indicated by resistivities generally greater than 100 ohm-meters for the program-generated geoelectric layering. Differences between reported and interpreted depth to bedrock ranged from 1 to 14 feet and were generally within 3 feet.

There are several possible reasons for the large difference (14 feet) between reported and interpreted depth to bedrock for sounding MV1. The simplest reason may be that the refusal depth for the auger hole is not actually the bedrock surface, but rather is a thin resistant bed at a shallower depth. Another possible reason could be that the resistivity contrast between the alluvium and bedrock is too small to be detected at the surface by geoelectric methods. The increase in resistivity at 45 feet may represent a change from a shale to a limestone bed within the bedrock at that depth.

Increased layer resistivities that may correspond to bedrock were also present in soundings MV3, MV5, and MV7 (fig. 7). Layer resistivity increased from 28 to 110 ohm-meters at a depth of 22 feet below sounding MV3, and from 24 to 100 ohm-meters at a depth of 11 feet below MV5. Layer resistivity increased from 30 to 150 ohm-meters at a depth of 15 feet below sounding MV7. Soundings MV4 and MV8 (fig. 7) did not show increases in layer resistivity that could be attributed to bedrock. The electrical contrast between regolith and bedrock

Table 1.--Comparison of reported depths to bedrock from auger-hole data to interpreted bedrock depths from resistivity data

Sounding	Auger-hole depth (feet)	Interpreted depth (feet)	Difference (feet)
MV1	31	45	-14
MV2	26	25	1
MV6	9	12	-3
MV9	8	6	2
MV10	11	13	-2

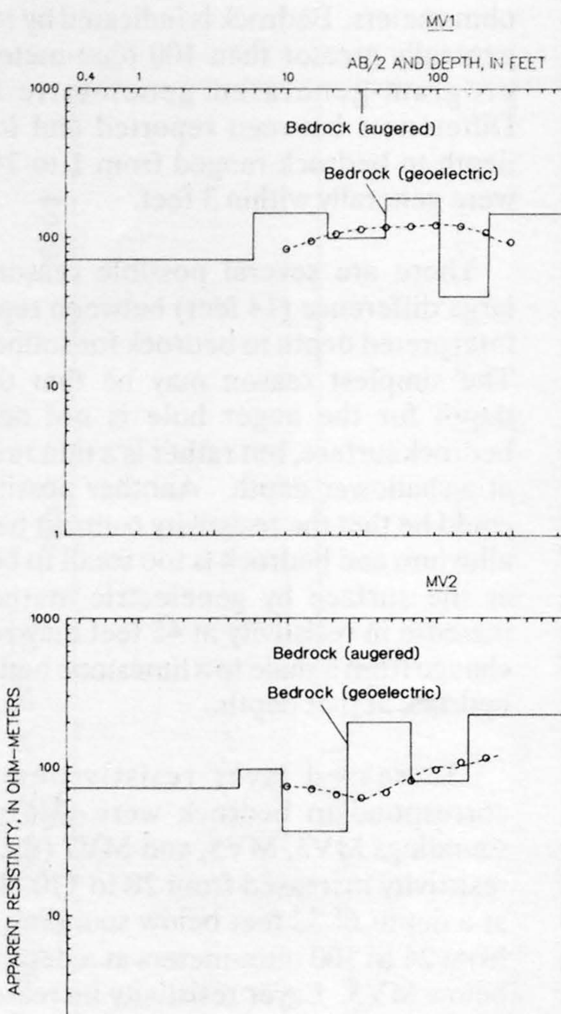
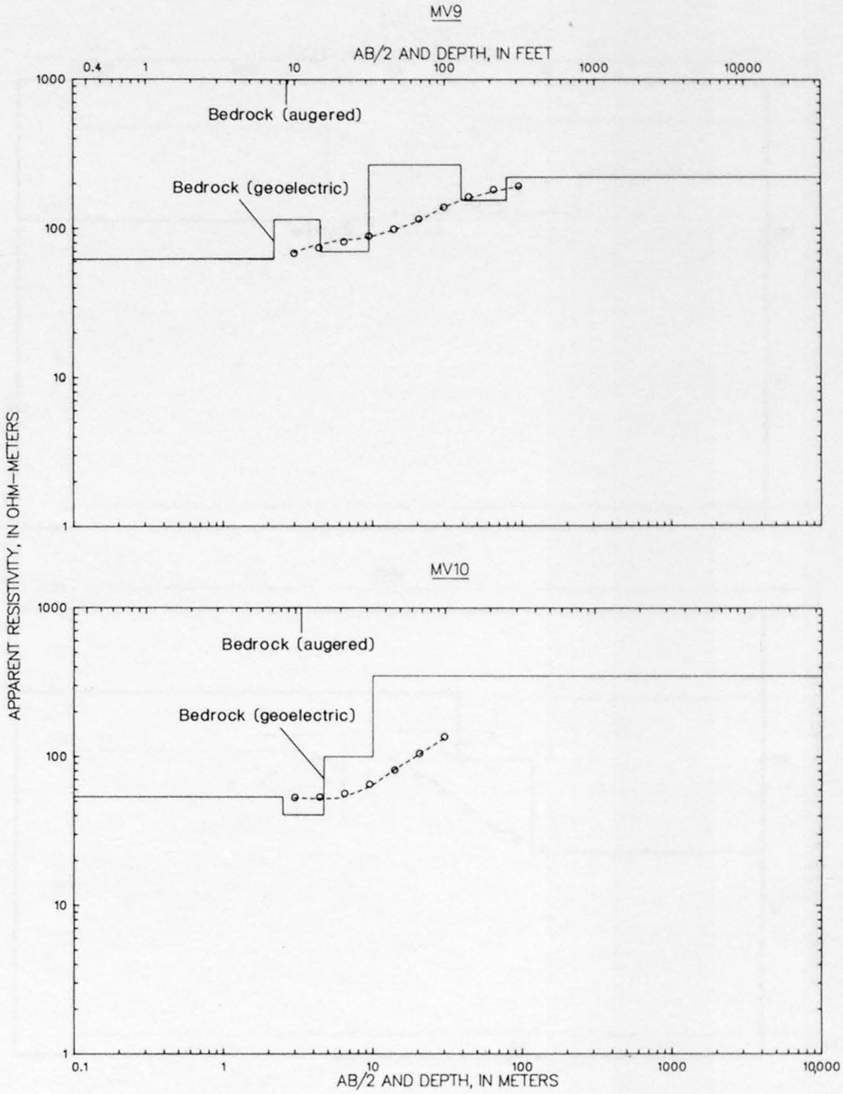


Figure 6.--Interpreted geoelectric layering and bedrock depth



EXPLANATION

------ SMOOTHED FIELD CURVE

∘ ∘ ∘ CALCULATED SOUNDING CURVE

CALCULATED GEOELECTRIC LAYERING

determined by augering for soundings MV1, MV2, MV6, MV9, and MV10.

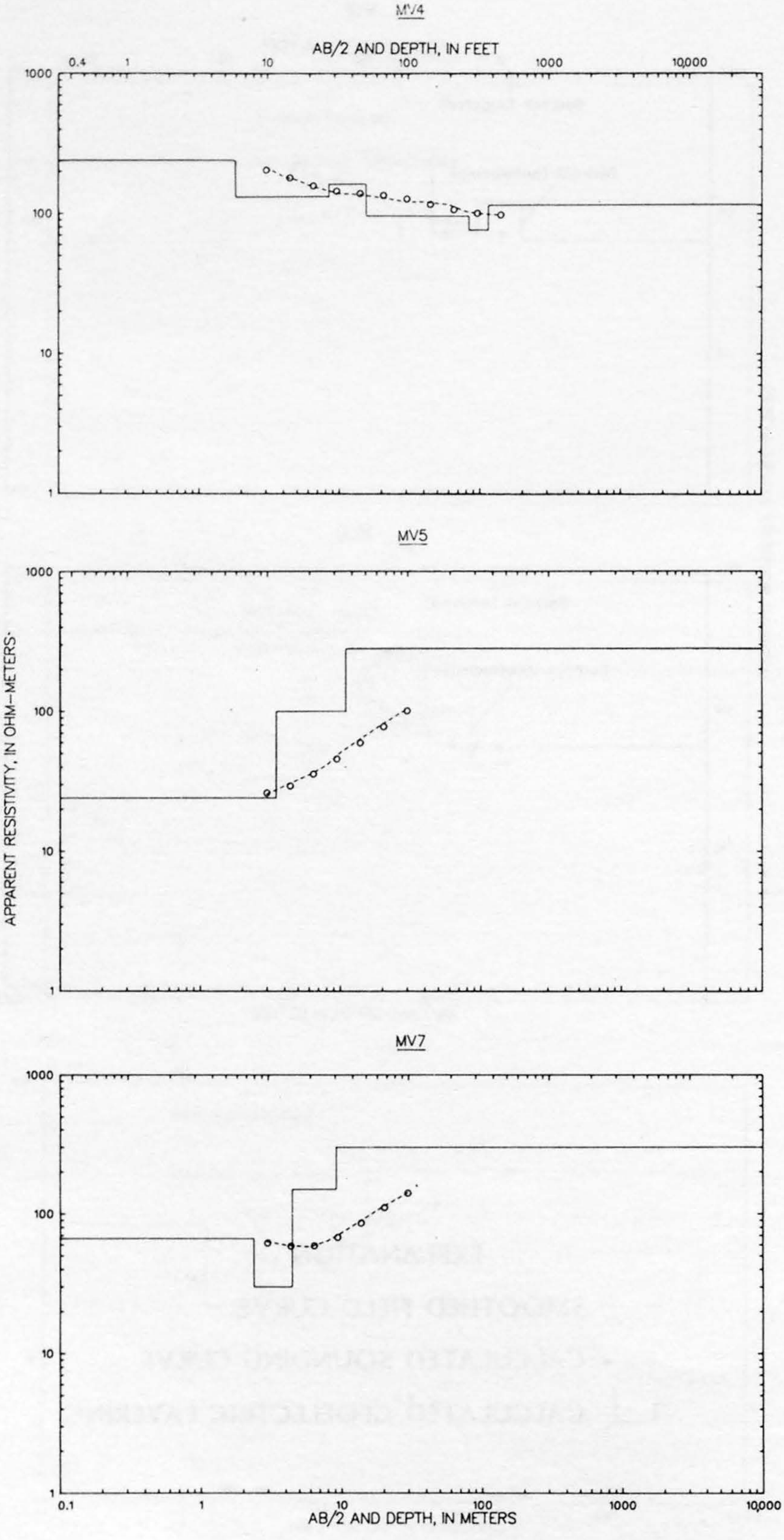
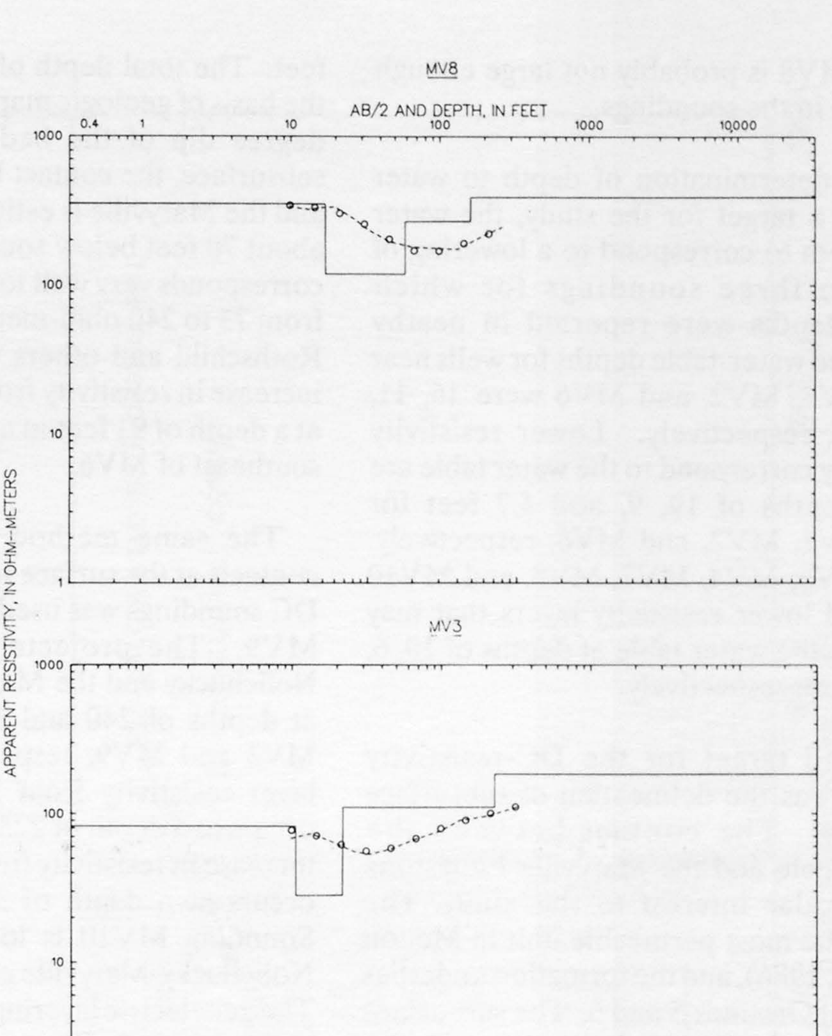


Figure 7.--Interpreted geoelectric layering for



EXPLANATION

------ SMOOTHED FIELD CURVE

∘ ∘ ∘ CALCULATED SOUNDING CURVE

CALCULATED GEOELECTRIC LAYERING

soundings MV4, MV5, MV7, MV8, and MV3.

at MV4 and MV8 is probably not large enough to be detected in the soundings.

Although determination of depth to water table was not a target for the study, the water table does seem to correspond to a lowering of resistivity in three soundings for which water-table depths were reported in nearby wells. Reported water-table depths for wells near soundings MV1, MV2, and MV6 were 16, 11, and, 3.5 feet, respectively. Lower resistivity layers that may correspond to the water table are present at depths of 19, 9, and 4.7 feet for soundings MV1, MV2, and MV6, respectively. Soundings MV3, MV4, MV7, MV8, and MV10 also exhibited lower resistivity layers that may correspond to the water table at depths of 10, 6, 8, 17, and 9 feet, respectively.

The second target for the DC-resistivity investigation was the delineation of subsurface stratigraphy. The contact between the Nolichucky Shale and the Maryville Limestone was of particular interest to this study. The Maryville is the most permeable unit in Melton Valley (Tucci, 1986), and the formation underlies most of Burial Grounds 5 and 6. The subsurface contact between the Nolichucky and the Maryville should be detectable at the surface with DC soundings, because of the contrast in electrical properties of the two formations. Resistivity values in the Maryville are about twice those of the Nolichucky, as indicated by electric logs.

None of the soundings are near wells that penetrate the contact between the Nolichucky and the Maryville; however, a well near sounding MV6 provides a comparison between subsurface lithology and geoelectric layers (fig. 8). The driller's log for that well indicates a change from regolith to interbedded limestone and shale at a depth of 9 feet. There is a corresponding increase in layer resistivity at 12 feet. A reported change in lithology to shale at 30 feet corresponds to a drop in layer resistivity at 37 feet. The total depth of the well is 40 feet. On the basis of geologic mapping and projecting a 20 degree dip of the beds in this area into the subsurface, the contact between the Nolichucky and the Maryville is estimated to be at a depth of about 70 feet below sounding MV6. This depth corresponds very well to an increase in resistivity from 73 to 240 ohm-meters at a depth of 68 feet. Rothschild and others (1984, p. 45), report an increase in resistivity from 82 to 352 ohm-meters at a depth of 91 feet in a sounding about 300 feet southeast of MV6.

The same method of projecting geologic contacts at the surface into the subsurface below DC soundings was used for soundings MV3 and MV9. The projected contact between the Nolichucky and the Maryville is estimated to be at depths of 240 and 30 feet below soundings MV3 and MV9, respectively. An increase in layer resistivity from 110 to 185 ohm-meters occurs at a depth of 225 feet at MV3 (fig. 9). An increase in resistivity from 70 to 270 ohm- meters occurs at a depth of 31 feet at MV9 (fig. 9). Sounding MV10 is located very close to the Nolichucky-Maryville contact shown on figure 3. The geoelectric layering below MV10 indicates a sharp increase in resistivity from 100 to 350 ohm-meters at a depth of 33 feet (fig. 9). If this increase in resistivity corresponds to the contact between the Nolichucky and the Maryville, then assuming a 20 degree dip, the surface expression of the contact should be about 90 feet northwest of MV10.

TERRAIN CONDUCTIVITY

Nine terrain-conductivity profiles (fig. 2) were obtained using a Geonics EM34-3 Terrain Conductivity Meter, primarily to aid in mapping geologic units. Results of this study indicate that terrain-conductivity values for shale range from 10 to 40 mmhos/m (millimhos per meter) and are generally greater than 15 mmhos/m. Terrain-conductivity values for limestone range

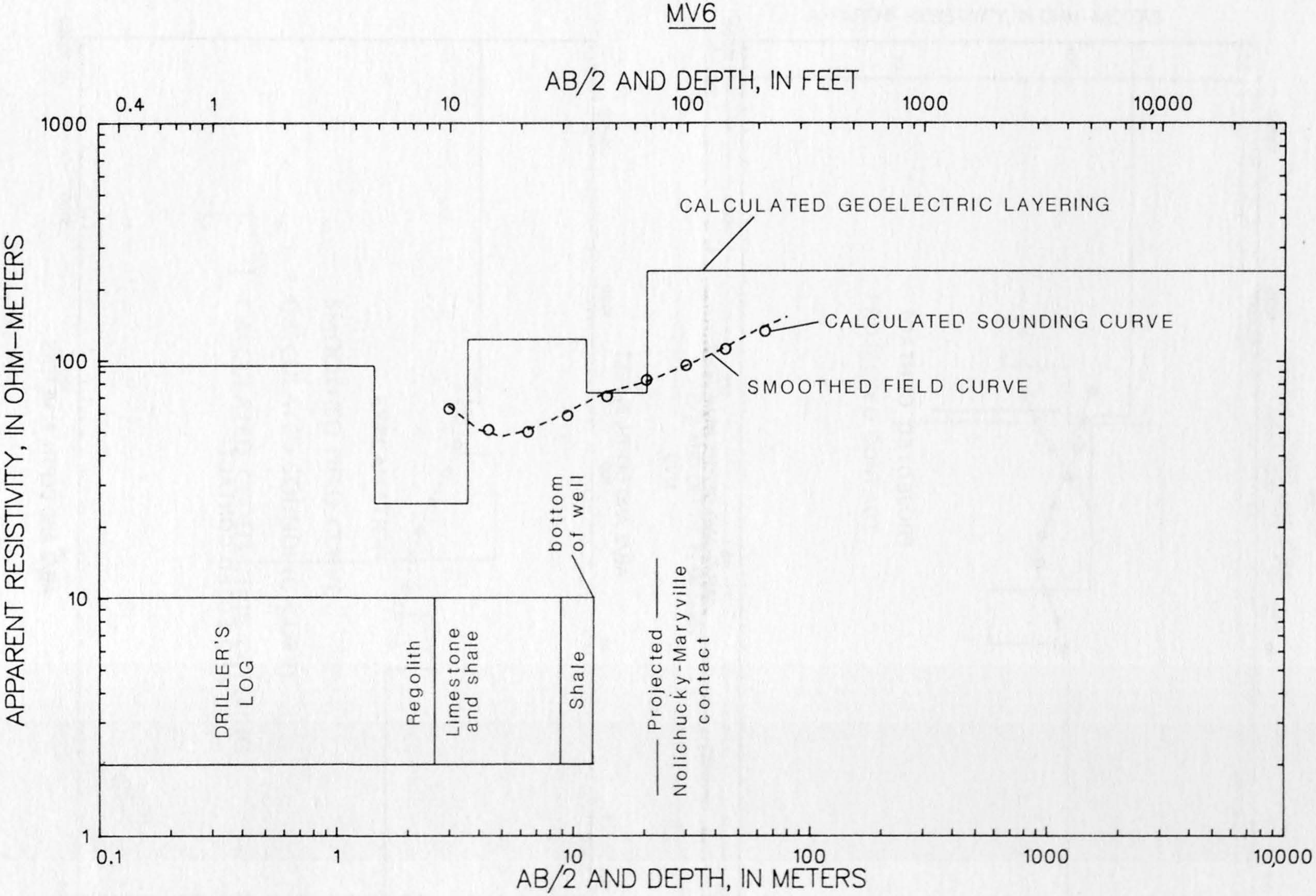


Figure 8.--Comparison between driller's log and geoelectric layering for sounding MV6.

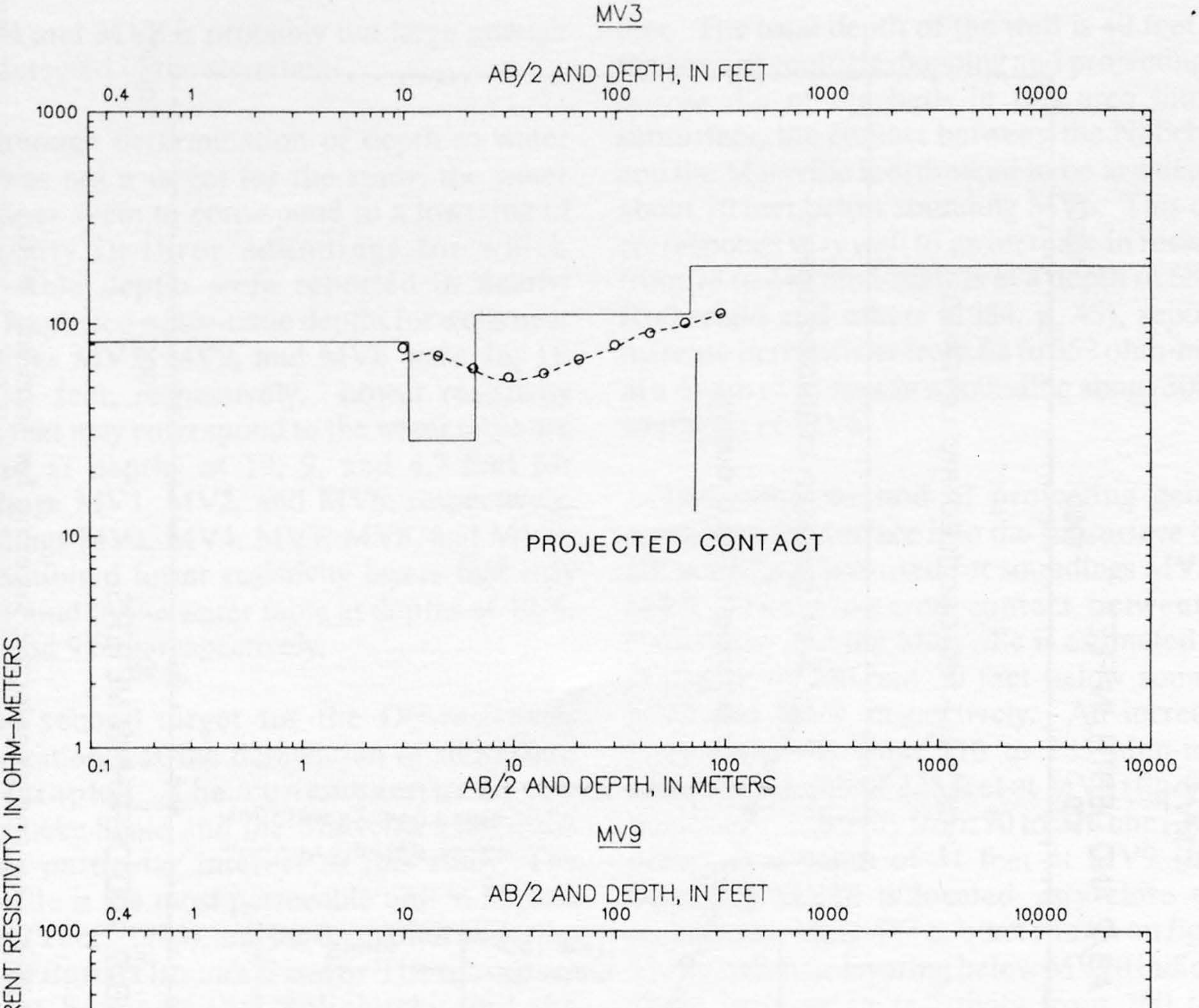
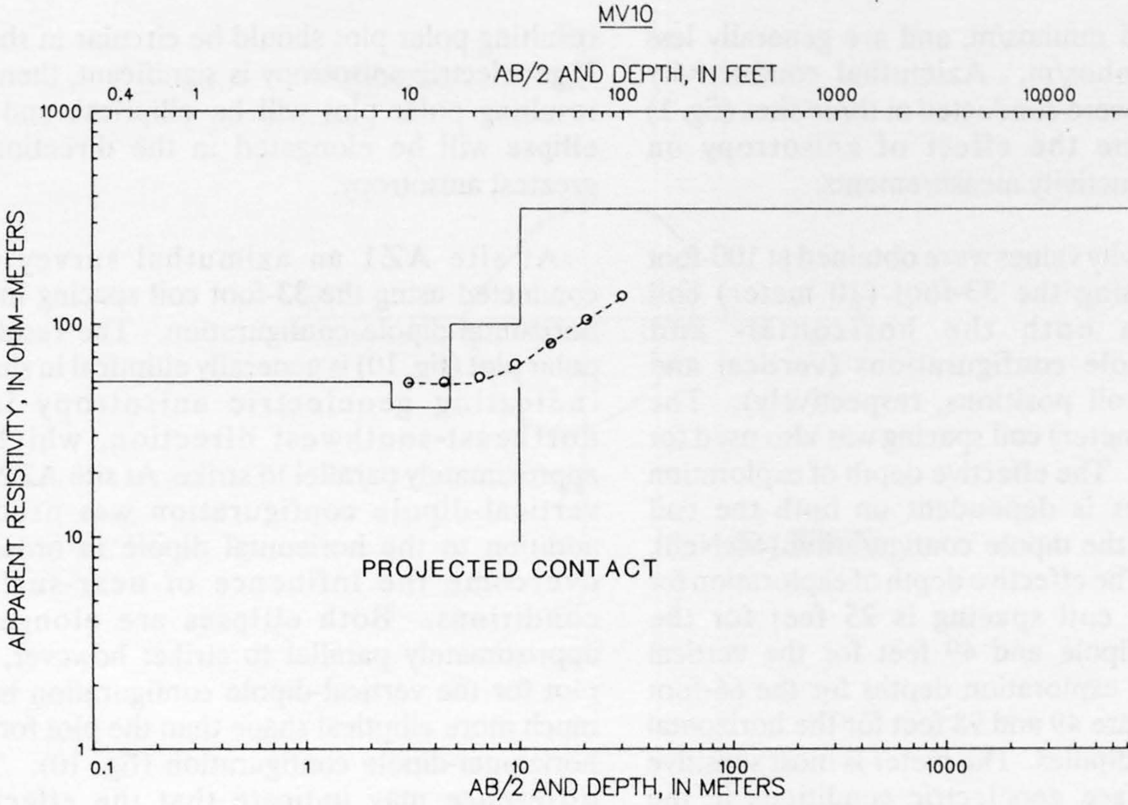


Figure 9.--Comparison between the projected Nolichucky-Maryville



EXPLANATION

SMOOTHED FIELD CURVE

CALCULATED SOUNDING CURVE

CALCULATED GEOELECTRIC LAYERING

contact and geoelectric layering for soundings MV3, MV9, and MV10.

from 5 to 25 mmhos/m, and are generally less than 15 mmhos/m. Azimuthal conductivity surveys also were conducted at three sites (fig. 1) to determine the effect of anisotropy on terrain-conductivity measurements.

Conductivity values were obtained at 100-foot spacings, using the 33-foot (10 meter) coil spacing in both the horizontal- and vertical-dipole configurations (vertical and horizontal coil positions, respectively). The 66-foot (20 meter) coil spacing was also used for profile EM5. The effective depth of exploration of the meter is dependent on both the coil spacing and the dipole configuration (McNeill, 1980, p. 6). The effective depth of exploration for the 33-foot coil spacing is 25 feet for the horizontal dipole and 49 feet for the vertical dipole. The exploration depths for the 66-foot coil spacing are 49 and 98 feet for the horizontal and vertical dipoles. The meter is most sensitive to near-surface geoelectric conditions in the horizontal-dipole configuration, but is much less sensitive to near-surface conditions in the vertical-dipole configuration (McNeill, 1980, p. 6-7).

Azimuthal Conductivity Surveys

Terrain-conductivity values may be in part controlled by the orientation of joints in the underlying bedrock in relation to the compass orientation of the transmitter and receiver coils. This "geoelectric anisotropy" is known to have an effect on DC-resistivity values (Leonard-Mayer, 1984). Changes in conductivity values obtained during profiling may be the result of a change in the compass orientation of the coils or a change in subsurface lithology. To test the effect of geoelectric anisotropy on terrain-conductivity values, azimuthal conductivity surveys were conducted at three sites by keeping the transmitter coil at a fixed point and changing the compass orientation of the coils in 30-degree increments about this central point. If geoelectric anisotropy is insignificant, then the resulting polar plot should be circular in shape. If geoelectric anisotropy is significant, then the resulting polar plot will be elliptical, and the ellipse will be elongated in the direction of greatest anisotropy.

At site AZ1 an azimuthal survey was conducted using the 33-foot coil spacing in the horizontal-dipole configuration. The resulting polar plot (fig. 10) is generally elliptical in shape, indicating geoelectric anisotropy in a northeast-southwest direction, which is approximately parallel to strike. At site AZ2 the vertical-dipole configuration was used in addition to the horizontal dipole in order to overcome the influence of near-surface conditions. Both ellipses are elongated approximately parallel to strike; however, the plot for the vertical-dipole configuration has a much more elliptical shape than the plot for the horizontal-dipole configuration (fig. 10). This difference may indicate that the effect of geoelectric anisotropy is more pronounced in bedrock than in regolith. The difference also may be caused by different instrument response in the horizontal- and vertical-dipole configurations (J.D. McNeill, Geonics Limited, written commun., 1986).

Site AZ3 is near the Clinch River, and is underlain by alluvium, which lacks the structures found in bedrock in the study area. Geoelectric anisotropy should, therefore, be insignificant at this site. Coil spacings of 33 and 66 feet were used in both the horizontal- and vertical-dipole configurations. The resulting plots (fig. 11) are not circular; however, they do not show the elliptical shapes of AZ1 and AZ2. Geoelectric anisotropy may be "random" in that there is no preferred orientation at this site. Inhomogeneities within the alluvium may also account for the variations in conductivity values. The 66-foot coil spacing was used to probe below the alluvium and to show the effects of geoelectric anisotropy in the underlying bedrock. The plot for the horizontal-dipole configuration

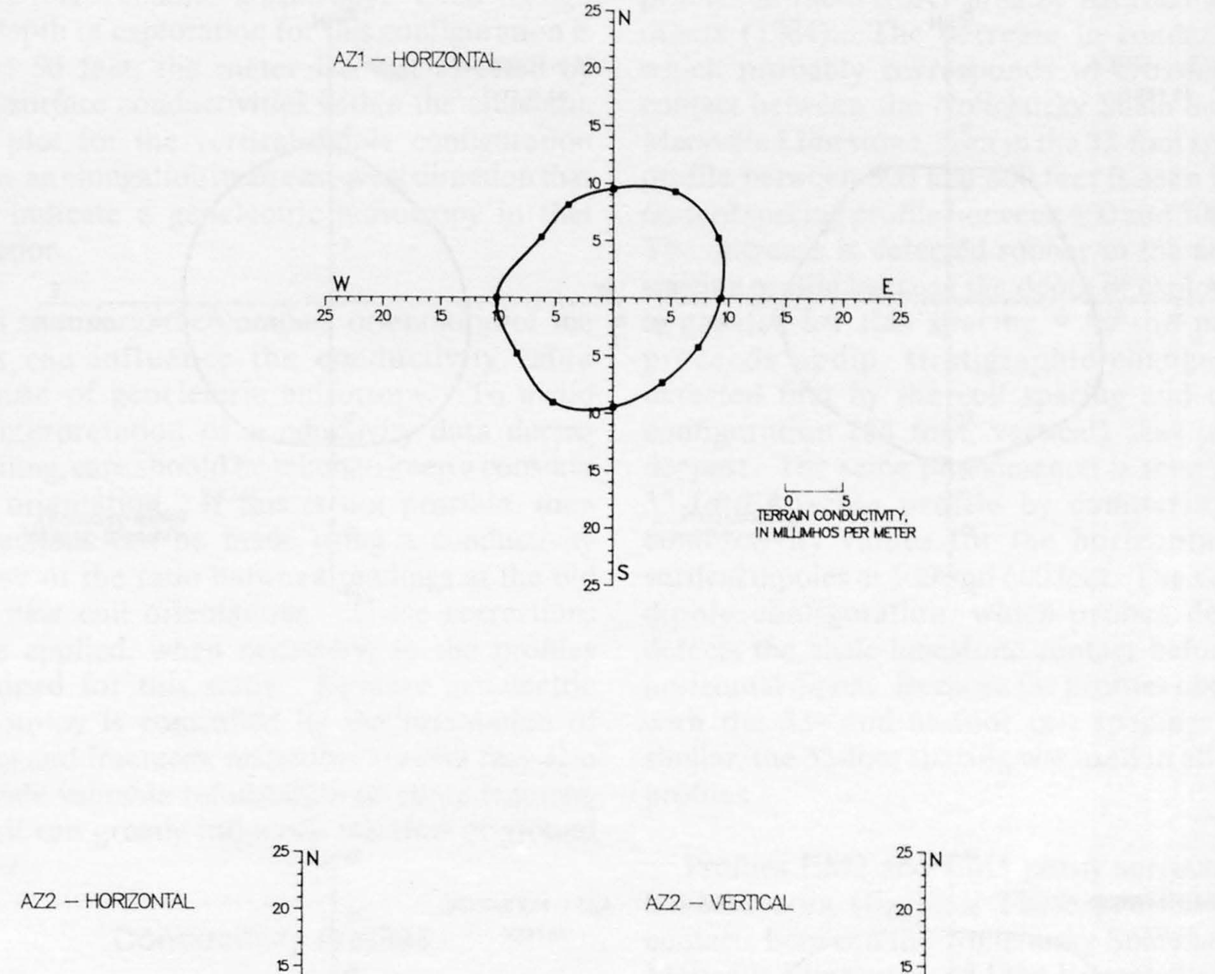


Figure 10.--Polar plots of azimuthal surveys at sites AZ1 and AZ2.

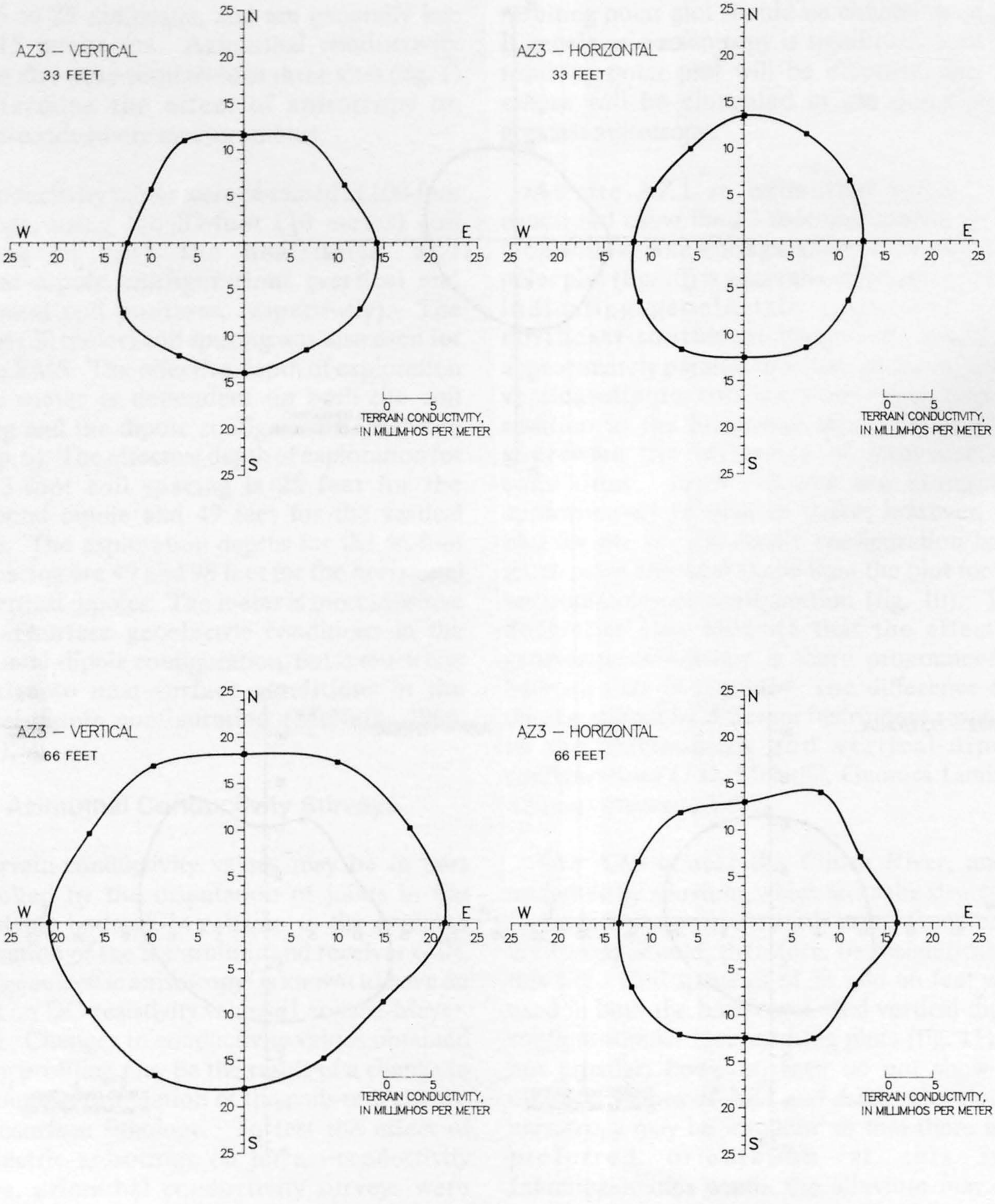


Figure 11.--Polar plots of azimuthal surveys at site AZ3.

shows this "random" anisotropy. Even though the depth of exploration for this configuration is about 50 feet, the meter is most affected by near-surface conductivities within the alluvium. The plot for the vertical-dipole configuration shows an elongation in an east-west direction that may indicate a geoelectric anisotropy in that direction.

In summary, the compass orientation of the coils can influence the conductivity value because of geoelectric anisotropy. To avoid misinterpretation of conductivity data during profiling, care should be taken to keep a constant coil orientation. If this is not possible, then corrections can be made using a conductivity ellipse or the ratio between readings at the old and new coil orientations. These corrections were applied, when necessary, to the profiles obtained for this study. Because geoelectric anisotropy is controlled by the orientation of joints and fractures, azimuthal surveys may also provide valuable information on these features, which can greatly influence the flow of ground water.

Conductivity Profiles

Changes in subsurface lithology were determined by a series of nine terrain-conductivity profiles. These profiles were oriented approximately parallel and perpendicular to strike in areas where stratigraphic changes or faults that cut across strike were expected to occur. Ideally, when profiling across the contact between a shale and a limestone, a decrease in conductivity will be observed, because shale generally has a higher conductivity (lower resistivity) than limestone.

Coil spacings of 33 and 66 feet were used for profile EM5. Comparison of the profiles for EM5 (fig. 12) shows a similarity between the overall shape of the profiles, but slightly lower conductivity values for the 66-foot spacing. Similar results were reported for conductivity profiles in the SWSA7 area by Rothschild and others (1984). The decrease in conductivity, which probably corresponds to crossing the contact between the Nolichucky Shale and the Maryville Limestone, seen in the 33-foot spacing profile between 500 and 600 feet is seen in the 66-foot spacing profile between 400 and 500 feet. The decrease is detected sooner in the 66-foot spacing profile because the depth of exploration is greater for this spacing. As the profile proceeds updip, stratigraphic changes are detected first by the coil spacing and dipole configuration (66 foot, vertical) that probes deepest. The same phenomenon is seen in the 33-foot spacing profile by comparing the conductivity values for the horizontal and vertical dipoles at 500 and 600 feet. The vertical dipole configuration, which probes deeper, detects the shale-limestone contact before the horizontal dipole. Because the profiles obtained with the 33- and 66-foot coil spacings were similar, the 33-foot spacing was used in all other profiles.

Profiles EM2 and EM3 nearly surround the SWSA7 area (fig. 2). These profiles cross contacts between the Nolichucky Shale and the Maryville Limestone, and the Rogersville Shale and Maryville Limestone. Both profiles show areas of high and low terrain conductivity that correspond to areas underlain by shale and limestone, respectively. A decrease in conductivity occurs between 900 and 1,100 feet on profile EM2 (fig. 13); however, the Nolichucky-Maryville contact was originally mapped at a distance of 2,100 feet. That contact was located by extrapolation of core data obtained in the northern part of SWSA7 to the southern part, and may be in error (C.S. Haase, Martin Marietta Energy Systems, oral commun., 1986). Sounding MV7, which is located at a distance of about 1,200 feet on the profile, indicates resistivities of 150 to 300 ohm-meters at a depth of 15 feet. These resistivity values are more typical of the Maryville Limestone than the Nolichucky Shale. Because of the low

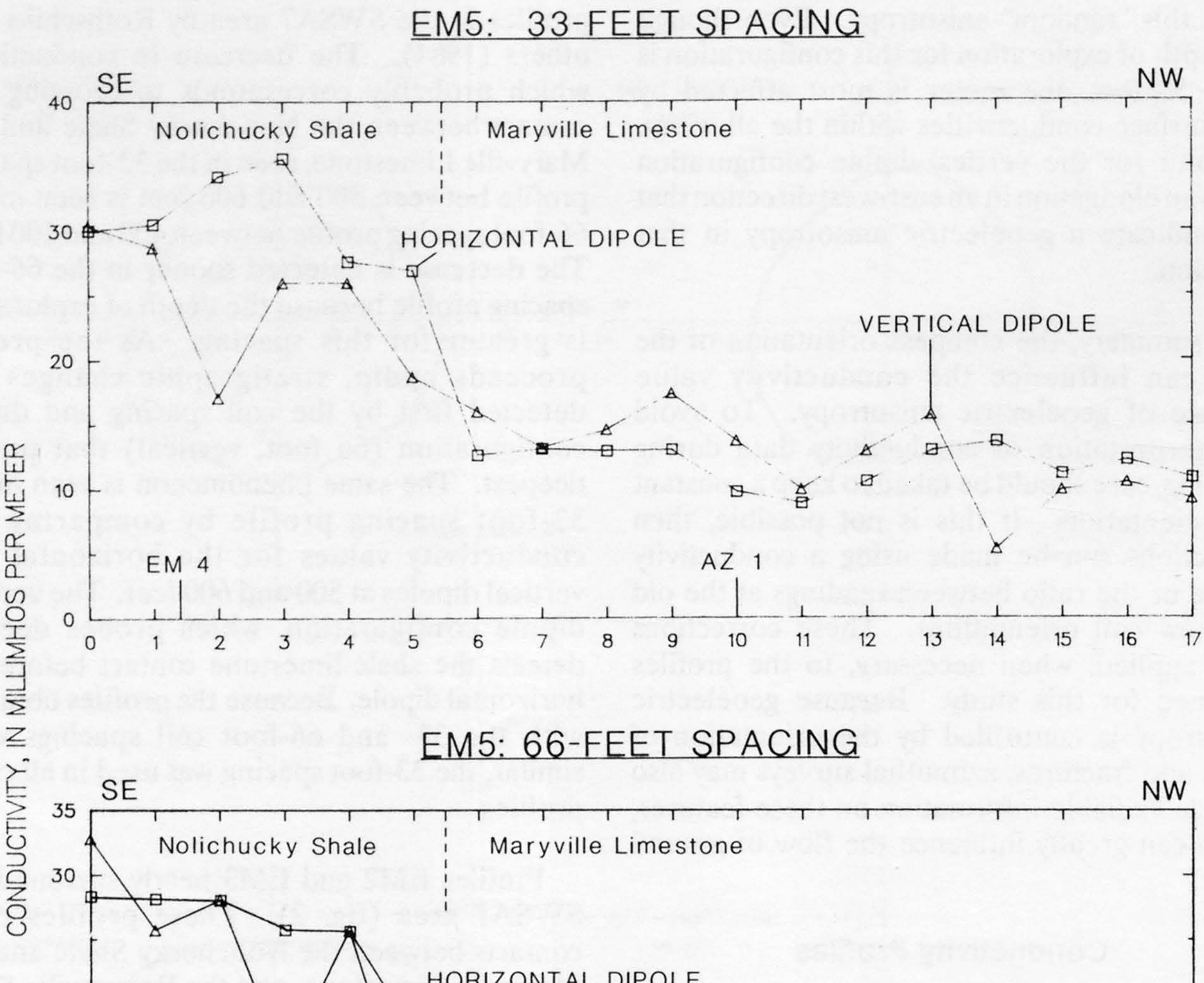


Figure 12.--Comparison of terrain-conductivity values using 33- and 66-foot coil spacings for profile EM5.

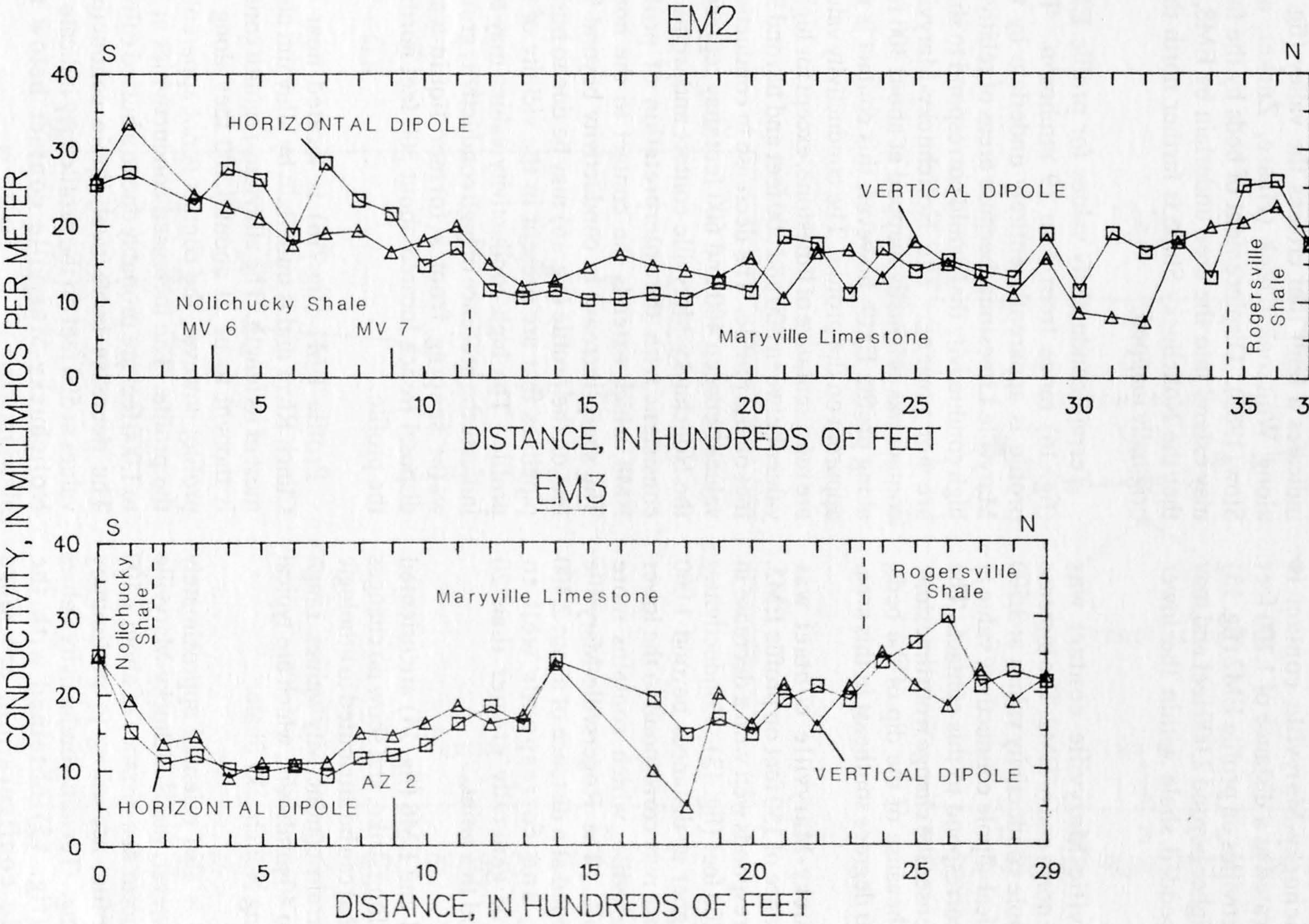


Figure 13.--Terrain-conductivity profiles EM2 and EM3.

conductivities present beyond 1,100 feet on the profile and the high resistivities in sounding MV7, the Nolichucky-Maryville contact is thought to be located at a distance of 1,100 feet on EM2. Conductivities on profile EM2 (fig. 13) generally were higher beyond 2,000 feet and may represent interbedded shale within the lower Maryville.

The Rogersville-Maryville contact was mapped near the north end of EM2. The increase in horizontal-dipole conductivity values at 3,500 feet and the vertical-dipole conductivity value at 3,300 feet may correspond to this contact. The vertical-dipole senses the change from limestone to shale sooner because of the dip of the beds, which is about 30 degrees southeast in this area.

The Nolichucky-Maryville contact was mapped at a distance of 150 feet on profile EM3. This contact corresponds well with a decrease in conductivity at 200 feet (fig. 13). Conductivities generally are higher at distances beyond 1,000 feet. This increase may correspond to the lower part of the Maryville, which contains more interbedded shale. The Rogersville-Maryville contact was mapped at a distance of about 2,300 feet on EM3, and corresponds well to conductivities of generally greater than 20 mmhos/m beyond this point.

Profiles EM4 and EM6 (fig. 14) are oriented approximately along strike, and show no changes in conductivity that can be attributed to lithologic variations. Terrain-conductivity values range from about 16 to 40 mmhos/m, which are typical for the underlying Nolichucky Shale.

Profile EM8 is also oriented approximately along strike; however, the Nolichucky-Maryville contact should occur at a distance of about 1,100 feet on the profile, according to preliminary geologic mapping. Terrain-conductivity values in that area (fig. 15) obtained with the vertical-dipole configuration, are more representative of shale than of limestone. Recent geologic mapping in Melton Valley indicates a fault that crosses the valley (fig. 3) along Whiteoak Creek (Haase, Zucker, and Stow, 1985). Displacement of beds by the fault may extend into the area underlain by EM8, so that the Nolichucky Shale is farther north than originally mapped.

Terrain-conductivity values for profile EM7 (fig. 16) range from 4 to 19 mmhos/m. The profile is apparently entirely underlain by the Maryville Limestone, because areas of relatively high conductivity that would correspond to shale are not present. The Nolichucky-Maryville contact was originally mapped at about 300 feet along profile EM9; however, this contact is not apparent on the profile. The conductivity values are representative of limestone, except for higher values between 300 and 500 feet and beyond 900 feet on the profile. The decrease in conductivity values between 400 and 600 feet may represent the Nolichucky-Maryville contact and would be consistent with the interpretation of profile EM8, which extends the contact to the north. The sharp increase in conductivity beyond 900 feet on the profile (fig. 16) may be due to buried pipelines that are present in the vicinity of the profile. The high conductivity values may also indicate the presence of high conductivity ground water seeping from a former liquid-waste disposal trench located about 300 feet north of the profile.

Profile EM1 (fig. 16) is located near the Clinch River and is underlain by alluvium along most of its length. The alluvium-regolith contact is thought to be at about 1,100 feet along the profile; however, the contact is not apparent on the profile. The increased conductivities at 900 to 1,000 feet are probably due to a buried culvert. The decrease in vertical-dipole conductivity values at 500 feet on the profile may indicate the Nolichucky-Maryville contact below the alluvium.

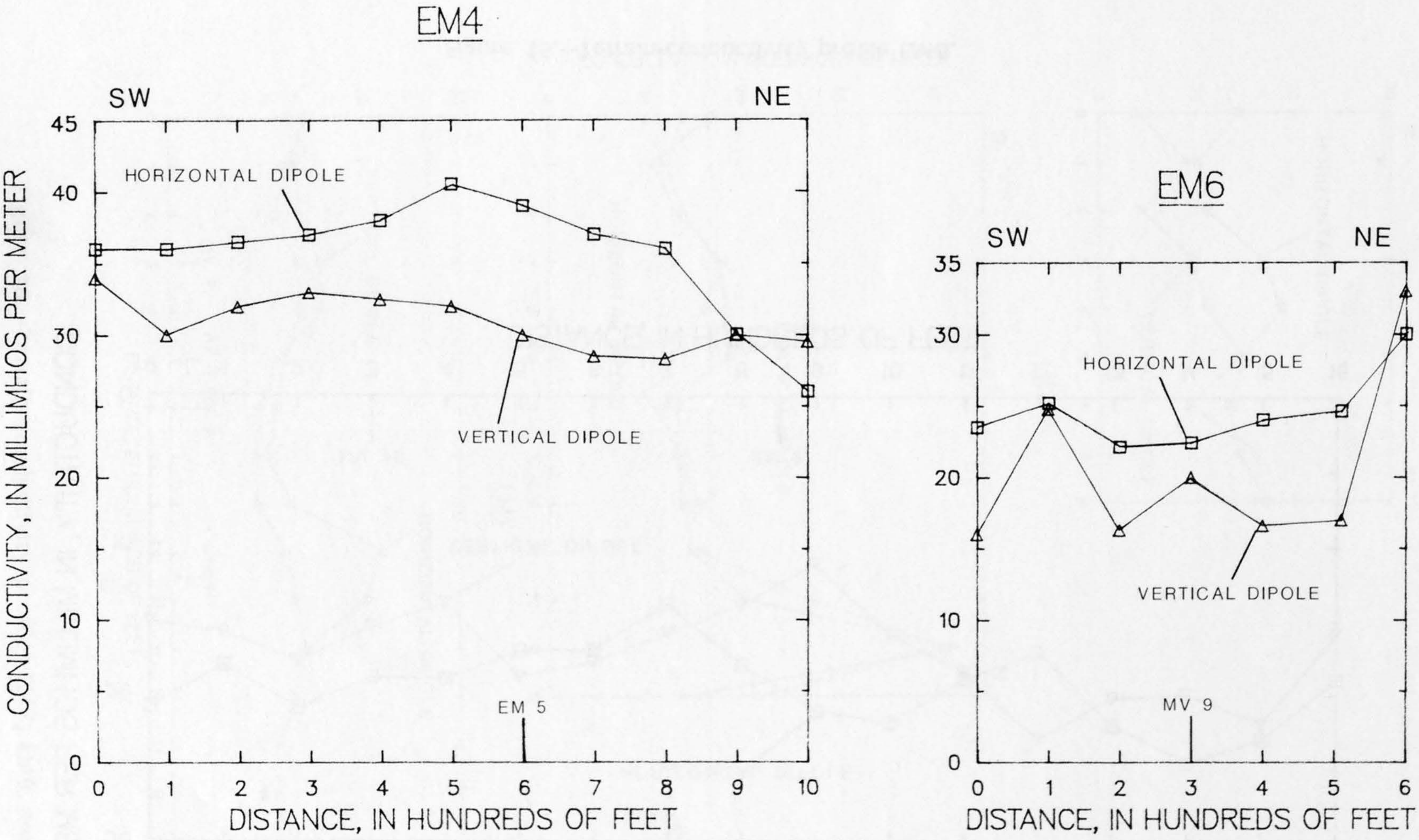


Figure 14.--Terrain-conductivity profiles EM4 and EM6.

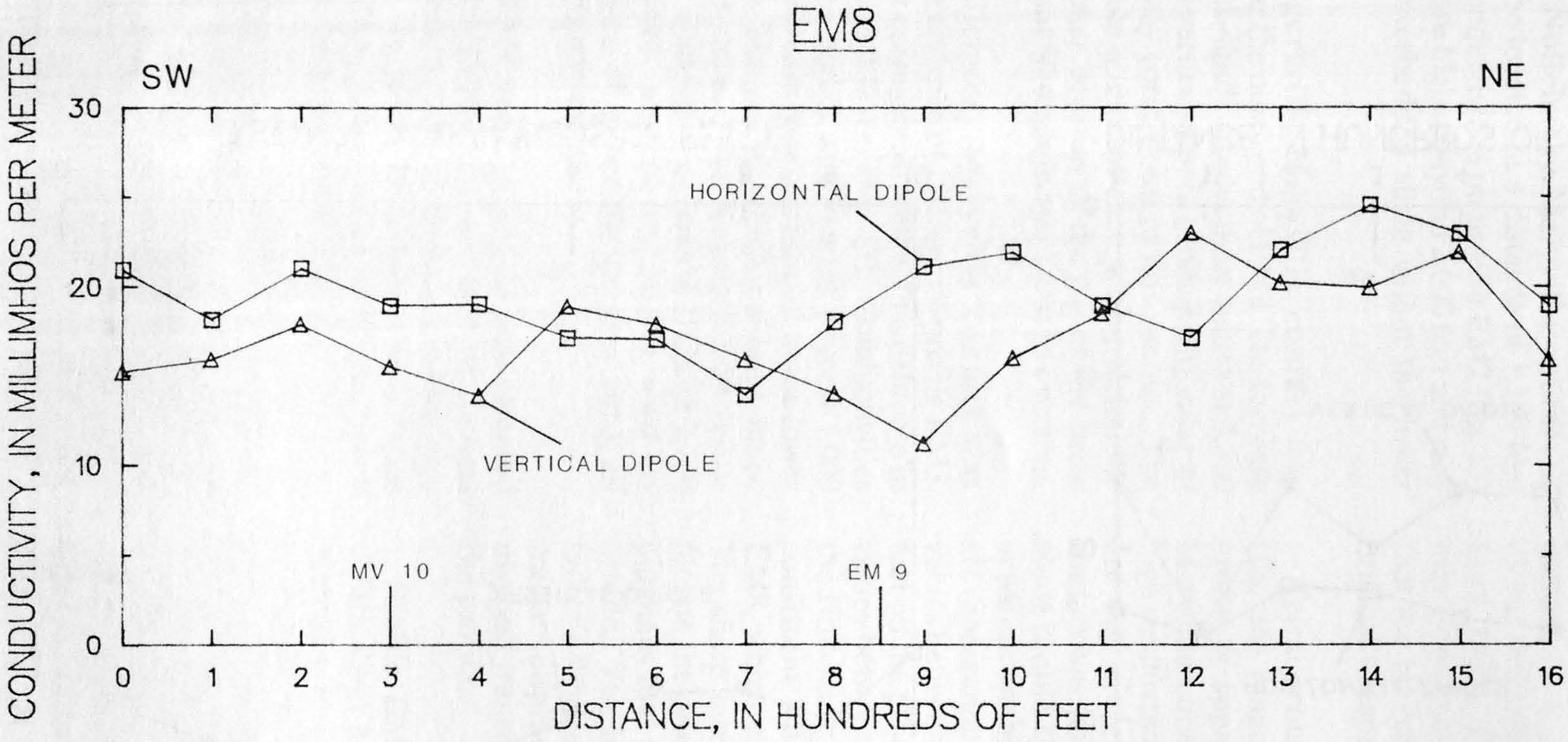


Figure 15.--Terrain-conductivity profile EM8.

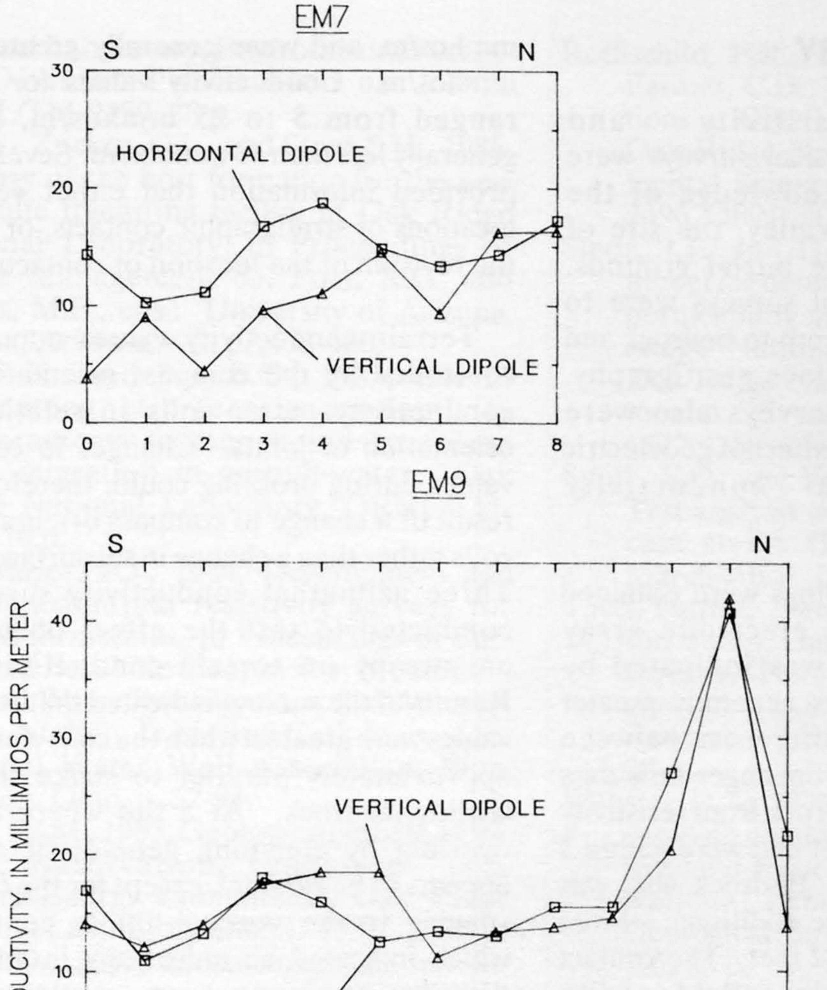


Figure 16.--Terrain-conductivity profiles EM7, EM9, and EM1.

SUMMARY

Direct-current resistivity and terrain-conductivity geophysical surveys were used to aid in refining knowledge of the geohydrology of Melton Valley, the site of low-level radioactive-waste burial grounds. Targets for the geophysical surveys were to determine location of the depth to bedrock and the delineation of subsurface stratigraphy. Azimuthal conductivity surveys also were conducted to investigate the effect of geoelectric anisotropy on terrain- conductivity measurements.

Ten DC-resistivity soundings were obtained using the Schlumberger electrode array configuration. Bedrock was indicated by geoelectric layer resistivities generally greater than 100 ohm-meters. Differences between reported depth to bedrock from auger-hole data and interpreted depth to bedrock from resistivity data ranged from 1 to 14 feet and were within 3 feet for four of five sites. Bedrock also was indicated from data for three additional sites at depths ranging from 11 to 22 feet. The contact between Nolichucky Shale and Maryville Limestone was indicated by large increases in geoelectric layer resistivity in four soundings. Resistivity values for the Nolichucky range from 70 to 110 ohm-meters; for the Maryville, from 185 to 350 ohm-meters. Although determination of the depth to water table was not a target for the resistivity survey, the water table appears to correspond to a lowering of resistivity values in eight soundings.

Nine terrain-conductivity profiles were obtained to aid in mapping geologic units. Conductivity values were obtained at 100-foot spacings, primarily using the 33-foot coil spacing in both the horizontal- and vertical- dipole configurations. Crossing the contact between shale and limestone along a profile resulted in a decrease in conductivity values. Terrain conductivities for shale ranged from 10 to 40 mmhos/m, and were generally greater than 15 mmhos/m. Conductivity values for limestone ranged from 5 to 25 mmhos/m, and were generally less than 15 mmhos/m. Several profiles provided information that either verified the locations of stratigraphic contacts, or prompted the revision of the location of contacts.

Terrain-conductivity values may be partly controlled by the compass orientation of the conductivity meter coils in relation to the orientation of joints. Changes in conductivity values during profiling could, therefore, be the result of a change in compass orientation of the coils rather than a change in subsurface lithology. Three azimuthal conductivity surveys were conducted to test the effect of geoelectric anisotropy on terrain-conductivity values. Results of the surveys indicated that conductivity values were greatest when the coils were oriented approximately parallel to strike in areas of shallow bedrock. At a site where bedrock is overlain by alluvium, geoelectric anisotropy appears to be random, except for the 66-foot coil spacing in the vertical-dipole configuration, which indicated an anisotropy in an east-west direction.

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