GEOPHYSICS, VOL. 34, NO. 4 (AUGUST 1969), P. 584-600, 19 FIGS., 1 TABLE

APPLICATION OF DEEP ELECTRICAL SOUNDINGS FOR GROUNDWATER EXPLORATION IN HAWAII†

ADEL A. R. ZOHDY* AND DALLAS B. JACKSON*

Forty-five resistivity soundings, using Schlumberger and equatorial dipole electrode configurations, were made on the islands of Oahu and Hawaii to determine the applicability of direct current resistivity methods for locating fresh-water aquifers in the State of Hawaii. The soundings were made on the northwestern part of the island of Oahu near the town of Waialua and on the island of Hawaii on the "saddle" area near Pohakuloa and Humuula.

Interpretation of 32 sounding curves obtained on the island of Oahu indicates that it is possible to correlate five stratigraphic units underlain by a vesicular basalt basement and that the determination of the approximate depth to the fresh-water–saline-water interface within the basalt is feasible. Two of these Schlumberger soundings with electrode spacings $\overline{AB}/2$ reaching 6000 ft yielded sounding curves of the maximum and minimum types whose terminal branches asymptotically approach a resistivity of about 30 ohm-m, which is believed to be the true resistivity of basalt saturated with sea water. Near the town of Waialua the aquifer is a coral zone as well as parts of the weathered vesicular basalt basement.

On the island of Hawaii, near Pohakuloa, an exploratory well drilled in basalt to a depth of 1001 ft (prior to the resistivity survey) proved to be dry. Interpretation of thirteen deep soundings made with Schlumberger and equatorial arrays suggests that the minimum depth to a conductive layer, which may represent basalt saturated with fresh water, is about 2700 ft below land surface. The groundwater appears to be dike impounded.

INTRODUCTION

The effectiveness of the resistivity method in solving subsurface water problems and in minimizing drilling costs has been established in many parts of the world (Breusse, 1963). On the Hawaiian Islands, the method was used by Swartz more than a quarter of a century ago (Swartz, 1937, 1939, 1940a, 1940b). Since then, the interpretation techniques have improved considerably through the calculation of many theoretical curves for a variety of earth models, as well as through the development of new methods of interpretation.

During the months of December 1965 and January and October 1966, resistivity surveys were made by the U. S. Geological Survey, in cooperation with the Department of Land and Natural Resources of the State of Hawaii and the Institute of Geophysics in Hawaii. The surveys were made to help solve some of the hydrogeological problems on the islands of Oahu and Hawaii, Hawaii (Zohdy and Jackson, 1968). Electrical soundings were made on the northern part of the island of Oahu near Waialua, and on the island of Hawaii near Pohakuloa and Humuula. A 2.5 kw generator was used for power supply and a potentiometric chart recorder was used for potential difference measurements.

Intermediate and deep electrical soundings were made using the Schlumberger and the bipole-dipole equatorial electrode configurations (Figure 1). In the bipole-dipole equatorial array,

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* U. S. Geological Survey, Denver, Colorado 80225.

the length of the current line AB is large (bipole) in comparison to the length of the potential line $\overline{MN}$ (dipole). A dipole equatorial sounding (DES) is made by increasing the distance R and the measured apparent resistivity is plotted as a function of the effective spacing $\overline{R}$. For a horizontally stratified laterally homogeneous medium a DES curve is identical to a Schlumberger sounding curve (Berdichevskii and Petrovskii, 1956). The sounding curves were interpreted by curve-matching techniques using three-layer master curves (Compagnie Générale de Géophysique, 1963; Orellana and Mooney, 1966) and auxiliary point charts (Kalenov, 1957; Zohdy, 1965). The graphical interpretation of a few curves was checked for accuracy by modeling the results on a digital computer using a program based on the work of Mooney et al (1966).

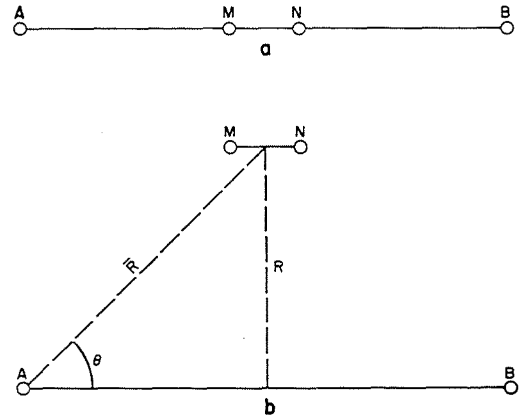

FIG. 1. Electrode configurations (plan view). Current electrodes, A, B; potential electrodes, M, N; arrays: a. Schlumberger; b. Bipole-dipole equatorial.

ELECTRICAL SOUNDINGS ON THE ISLAND OF OAHU

Thirty-two electrical soundings were made on the northern part of the island of Oahu, near Waialua (Figure 2). The maximum $\overline{AB}/2$ spacings of the Schlumberger array ranged from 600 ft to 6000 ft. Interpretation of the electrical soundings suggest the ranges given in Table 1 for the true resistivity of the various rock types encountered with the water conditions noted.

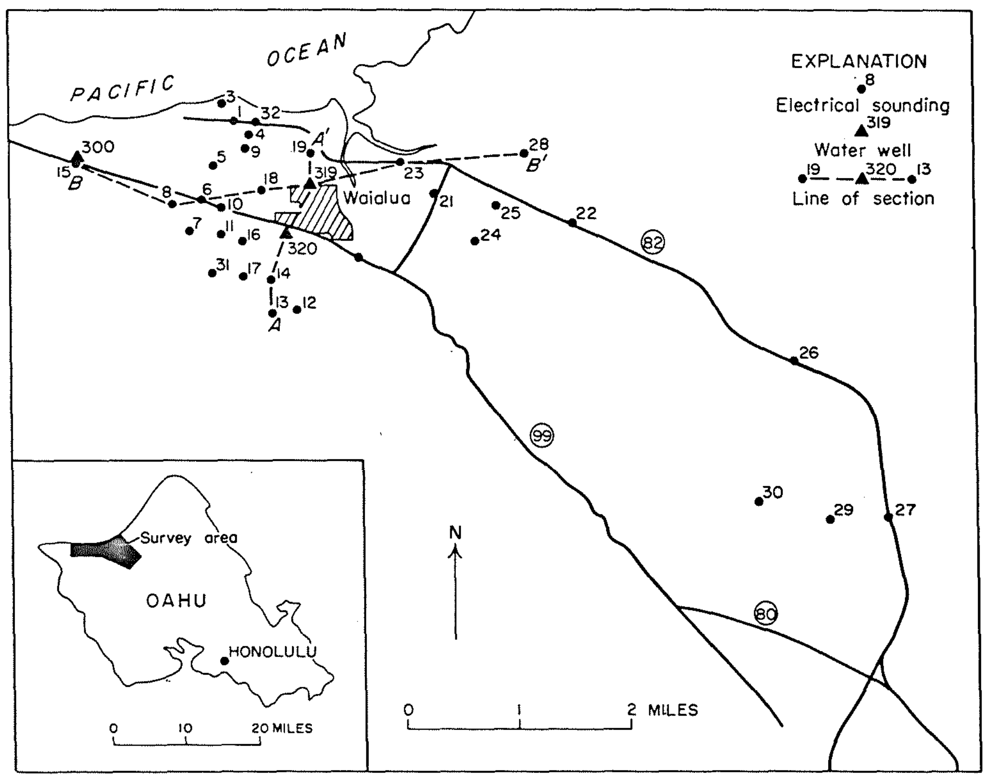

FIG. 2. Index map showing location of electrical soundings on the island of Oahu.

Table 1. Range of resistivity obtained from electrical soundings

Rock type	Resistivity, in ohm-m
Clay saturated with brackish to saline water	<3
Clay saturated with brackish to fresh water	5–8
Clay, silty sand, and some gravel saturated with fresh water	11–25
Sand and coral	40–400
Weathered basalt saturated with fresh water	30–60
Fresh basalt saturated with saline water	30–40
Fresh basalt saturated with fresh water	300–700

Electric logs were not available to check the values listed, but several sounding curves were sufficiently diagnostic to support their validity.

In the Waialua area six layers are electrically distinguishable from one another. These layers may or may not all be present in the geologic section at any given locality. The six layers numbered from top to bottom are: 1) cultivated top soil; 2) coral and sand (first coral); 3) clay; 4) coral, sand, and some clay (second coral); 5) clay, silt, and sand, and 6) basalt (weathered or fresh). Where the second coral reef is not separated from the underlying basalt by a thick clay layer, it was difficult to distinguish electrically from the basalt. Under these conditions, information on the second coral was inferred either from other sounding curves or from nearby wells.

First coral zone

The first sand and coral lies almost at the surface near the ocean shore. Consequently, it is represented by the uppermost high-resistivity "first" layer on the electrical sounding (ES) curves 1, 3, and 32 (Figure 3) which were obtained at the sounding stations nearest the shore (see Figure 2). Farther from the shoreline, the first coral, whose presence is unmistakably indicated by the maximum on each curve of ES 4, 5, 9, and 19 (see ES 4 and 5 curves in Figure 4), is presumably buried under a cover of about 4–15 ft of soil. At all of the above sounding stations

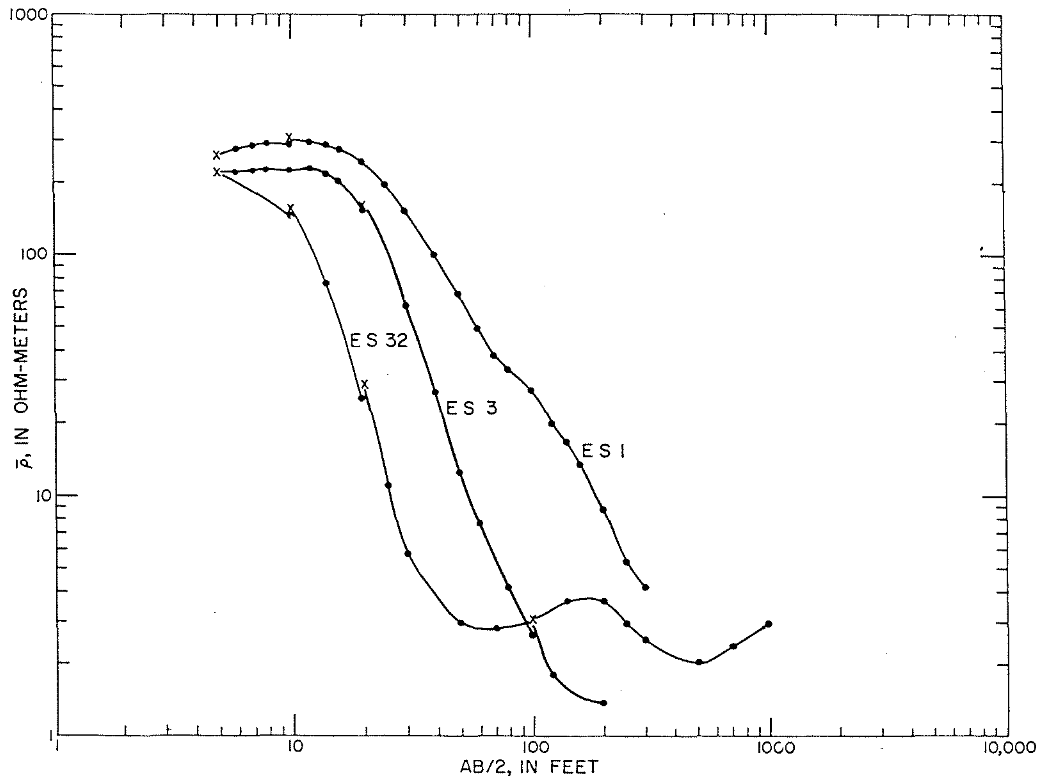

Fig. 3. Electrical sounding (ES) curves 1, 3, and 32. First coral is represented by the uppermost high-resistivity "first" layer. Second coral is represented by the high-resistivity "third" layer on ES 1 and 32 and may be absent on ES 3.

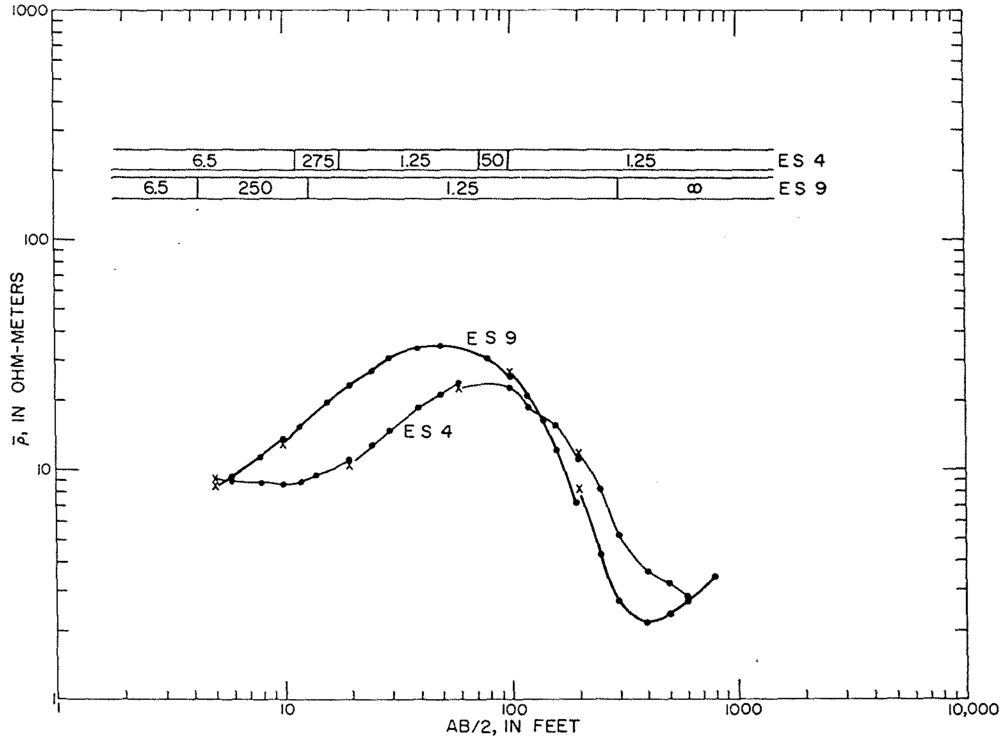

FIG. 4. ES curves 4 and 9. First coral is represented by the high-resistivity "second" layer. Second corals probably present on ES 4. The resistivity values for each layer interpreted from each curve are listed in the bar graphs, and the depth and/or thickness can be obtained from the electrode spacing scale.

the first coral is underlain by clay and then by either the second coral or the basalt.

On the basis of the interpretation of the ES curves and the drilling data from available wells and test holes, an isopach map of the first coral was made (Figure 5). It appears that the first coral diminishes in thickness and probably disappears to the south of State Highway 99 (Figure 2).

Second coral zone

The second coral zone is probably an important aquifer. Its detection on an electrical sounding curve and a reliable interpretation of its thickness are subject to the following conditions: 1) the "effective relative thickness" (Flathe, 1963) of the second coral should be large; 2) the second coral, which has a high resistivity with respect to the overlying clay, is more easily detected on an ES curve when it is underlain by a conductive clay layer of significant thickness that separates it from the generally high resistivity basaltic bedrock than when it is not. In the absence of an underlying clay layer, the terminal branch of the ES curve is generally of the *A* type (Kalenov, 1957; Keller and Frischknecht, 1966, p. 134–135), whereas, in its presence the terminal branch is of the *KH* type. For example, the ES 32 curve (Figure 3) is of the *HKH* type and clearly shows the presence of a high-resistivity layer (second coral) at a depth less than 100 ft as indicated by the formation of a maximum (*K*-type part of the curve) at the $\overline{AB}/2$ spacing of about 180 ft. The curvature of the maximum, however, is too sharp to correspond to a resistive layer of large lateral extent (Alfano, 1959). In other words, the sharpness of the maximum indicates that the ES curve is slightly distorted either because of the presence of near-surface heterogeneities or because of a discontinuity in the lateral extent of the second coral layer at depth.

The ES 5 curve (Figure 6) also indicates the presence of the second coral layer but in a more subtle manner. The curve appears to represent a five-layer earth model of the *KHA* type, but more likely it corresponds to a six-layer earth model of the *KHKH* type. The observed data

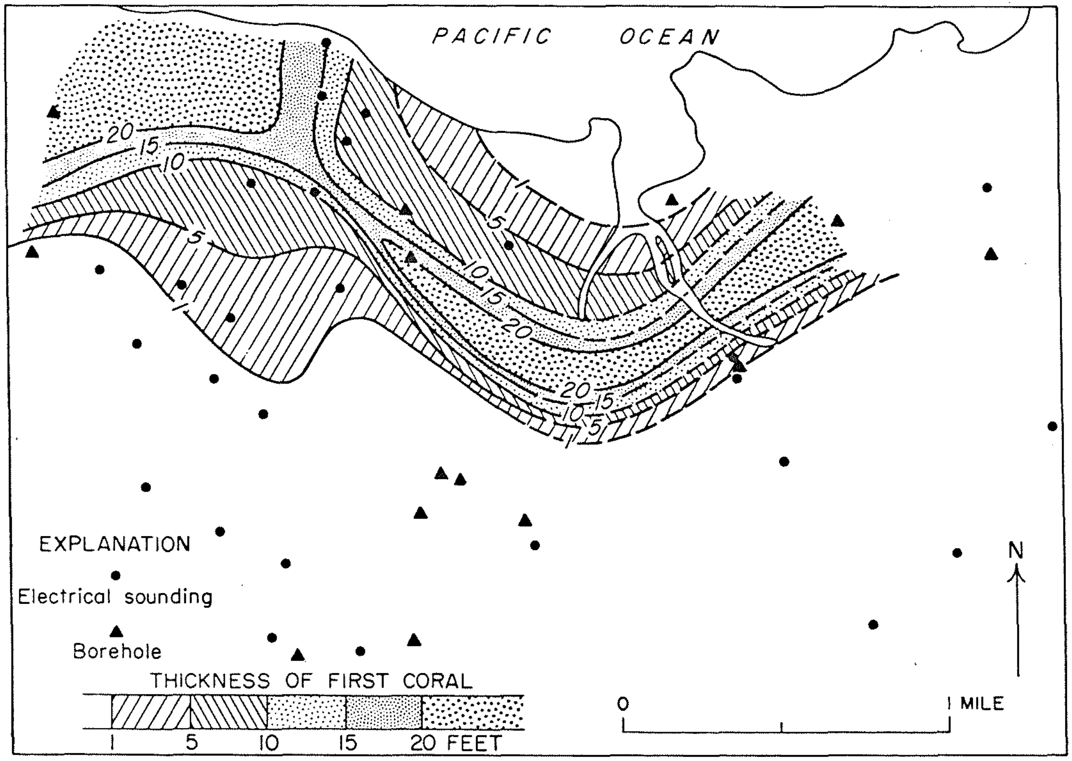

FIG. 5. Isopach map of the first coral in the Waialua area, Oahu, Hawaii. State Highway 99 is immediately south of the contoured area (see Figure 2 for location).

were interpreted by the auxiliary point method and the resulting six-layer earth model was checked by calculating the corresponding six-layer curve on an IBM 360/65 computer. The comparison and the six-layer earth model are shown. The layer of resistivity 52 ohm-m is interpreted to be the second coral layer.

A north-south cross section AA′ based on two wells and three electrical soundings (Figure 7) indicates the presence of the second coral zone as encountered in well 319 and as interpreted from ES 19. (See Figures 2 or 11 for location of cross section.) A second cross-section BB′, which trends in an east-west direction (Figure 8), is based on the interpretation of six electrical soundings, four wells, and a structural contour map of the basalt surface.

Alluvial deposits.—Both coral reefs are absent south of State Highway 99 (Figure 2) and the sediments are composed mainly of clay with thin lenses of gravel, boulders, and coral fragments. The geoelectric section, however, is fairly homogeneous and has a resistivity range of about 5 to 15 ohm-m. The ES curves 7, 11, 14, and 17 (Figure 9) testify to the relative simplicity of the section in this area. It is interesting to note the effects of near-surface heterogeneities on the ES 14 curve, where a small heterogeneity near one of the potential electrodes (M or N) caused the set of apparent resistivity values between $\overline{AB}/2$ of 200 ft and 500 ft, with $\overline{MN}=80$ ft to be shifted upward. When the $\overline{MN}$ spacing was changed to 100 ft at $\overline{AB}/2=500$ ft, the apparent resistivity values returned to the proper level. However, a small near-surface heterogeneity at one of the current electrodes (A or B) produced a singular disturbance on the ES 7 curve at $\overline{AB}/2=160$ ft. Generally such effects are easily recognized on sounding curves of the Schlumberger type (Kunetz, 1966).

The variation in the magnitude of the true resistivity of the clay (1 to 15 ohm-m) is not random. A definite increase in the clay resistivity is

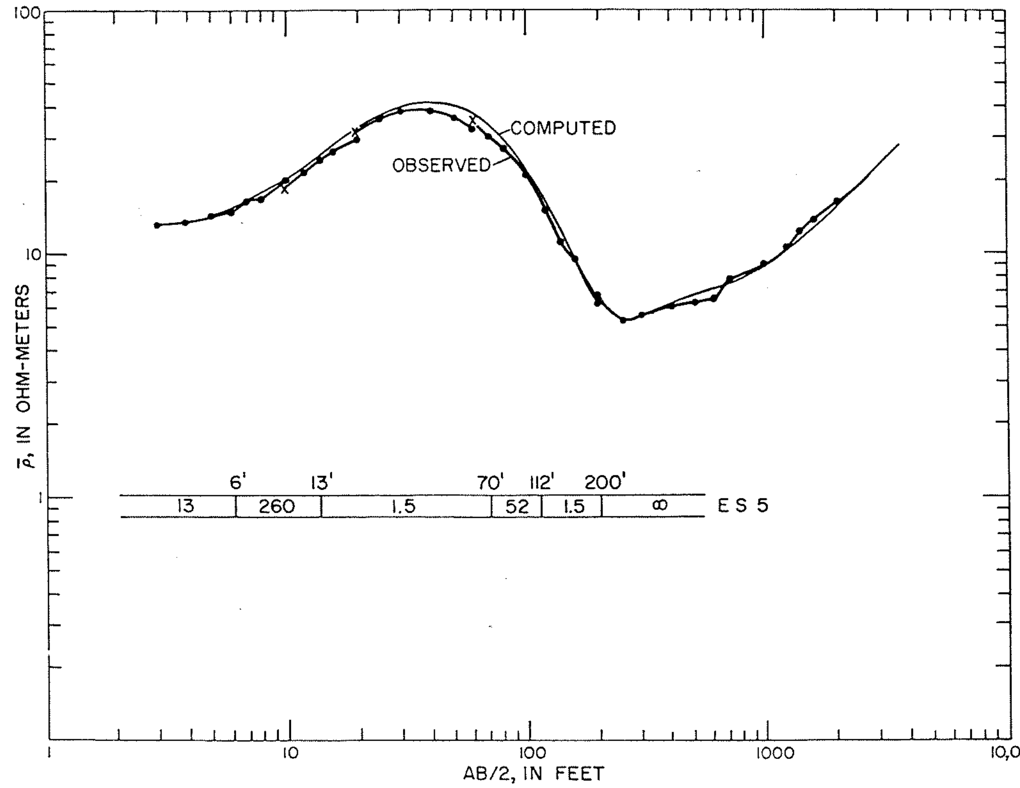

FIG. 6. ES 5 curve. Theoretical curve calculated by computer. Interpretation indicates: Top soil (13 ohm-m), first coral (260 ohm-m), clay (1.5 ohm-m), second coral (52 ohm-m), clay (1 ohm-m), basalt (very high resistivity in relation to overlying clay layer).

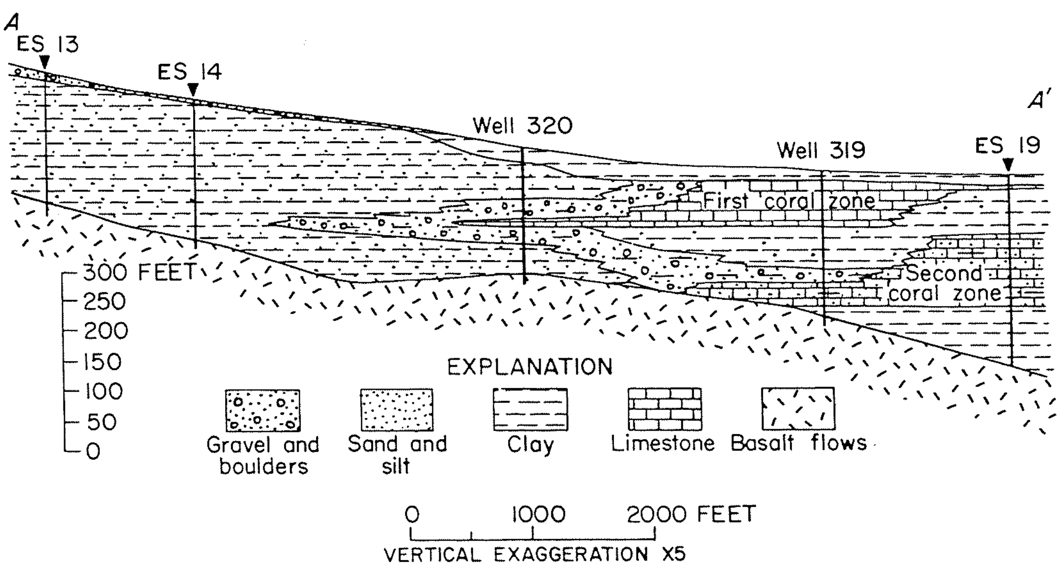

FIG. 7. North-south section AA′ showing first and second coral zones in the Waialua area Oahu, Hawaii. ES, electrical sounding.

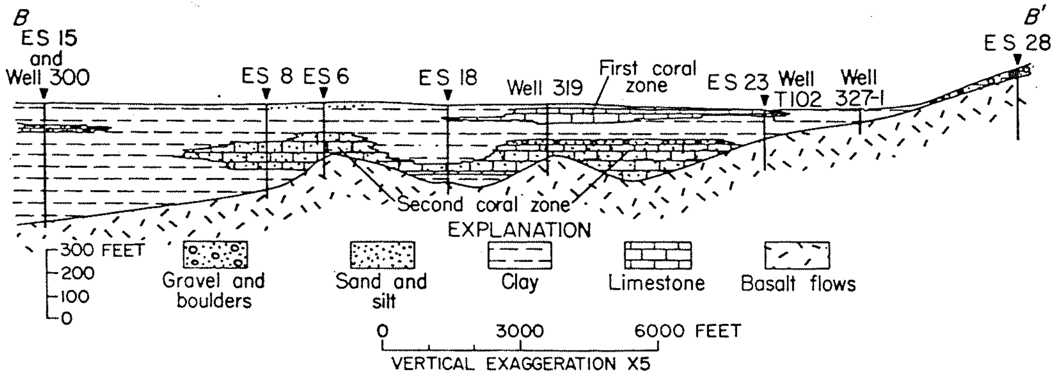

FIG. 8. East-west section BB′ showing first and second coral zones in the Waialua area, Oahu, Hawaii. ES, electrical sounding.

observed away from the shoreline (Figure 10). This increase reflects primarily the decrease in salinity of the ground water that saturates the clay.

The Waianae and the Koolau Volcanic series

The resistivity of the Waianae basalt seems to be, in general, exceptionally low (30 to 50 ohm-m). These low values are probably caused by an increased porosity due to a high degree of weathering for the near-surface basaltic layers, whereas at greater depths, where the basalt flows may be fresher, they are caused by the salinity of the ground water.

A map of the estimated configuration for the top of the Waianae basalt is shown in Figure 11.

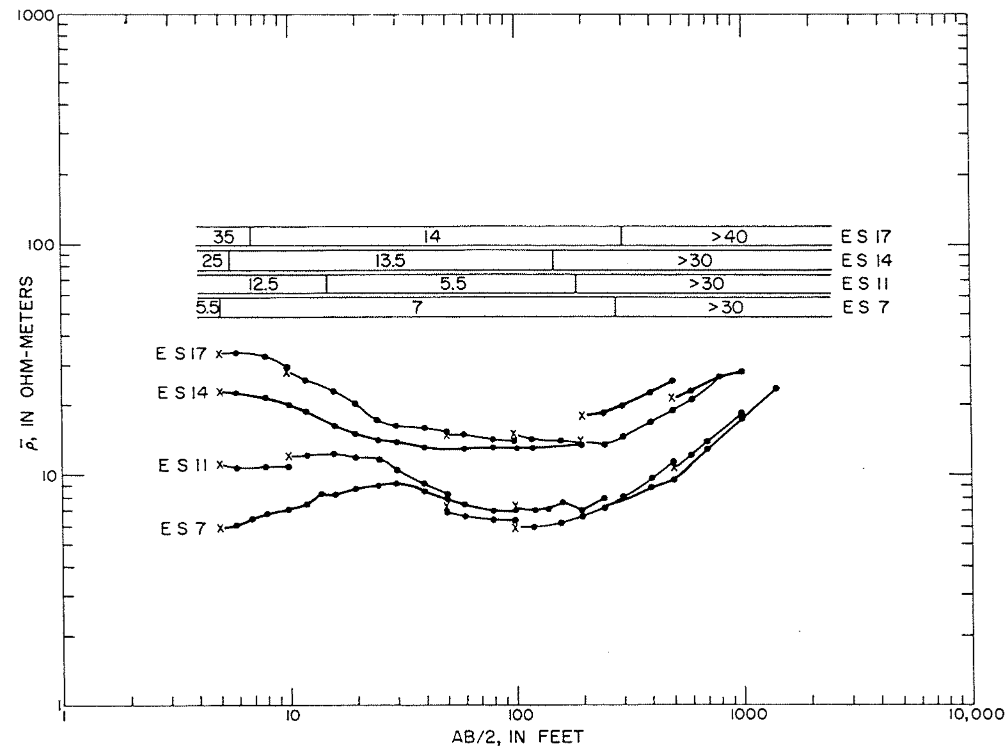

FIG. 9. ES curves 7, 11, 14, and 17 show relatively thick sections of clayey sediments (5.5 to 14 ohm-m) underlain by weathered basalt (>30 ohm-m). Waialua area, Oahu, Hawaii.

The depths are referred to sea level and are based on the interpretation of the electrical soundings and a few wells and test holes that are sufficiently deep to penetrate the basalt. The map indicates the probable location of buried channels. Where the channels are filled with the second coral, they form an aquifer of good yield. Good yield is also obtained from the upper layers of the basalt flows. It is interesting to note that the two western buried channels converge towards an offshore channel which cuts into the coral reefs (see bathymetric contours in Figure 11). The discharge of fresh water into the ocean through the buried channels and through the weathered upper layers of the basalt ridge, west of the buried channels, probably has reduced the growth of the coral reef in this area, which in turn has led to the formation of the offshore channel.

Nine soundings were made on the sloping range of the Koolau Volcanic series northwest of Schofield Plateau. According to these soundings, the resistivity of the Koolau basalt of Pliocene(?) age is much higher than that of the Waianae basalt of Pliocene(?) age in the survey area. This

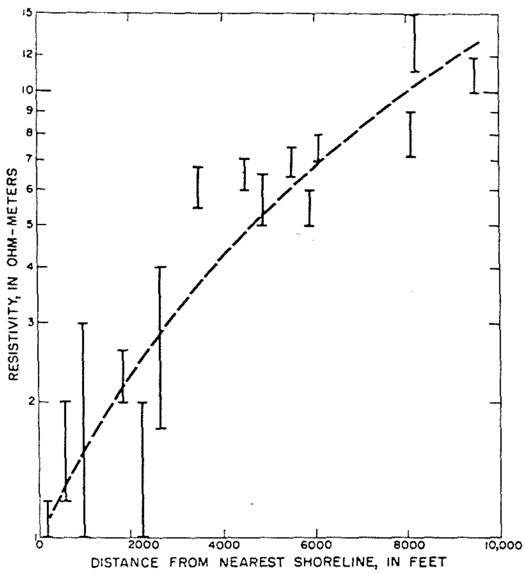

FIG. 10. Dependence of clay resistivity on distance of an ES station from the shoreline in the Waialua area, Oahu, Hawaii. Bars indicate possible clay resistivity ranges in accordance with the principal of equivalence (Keller and Frischknecht, 1966).

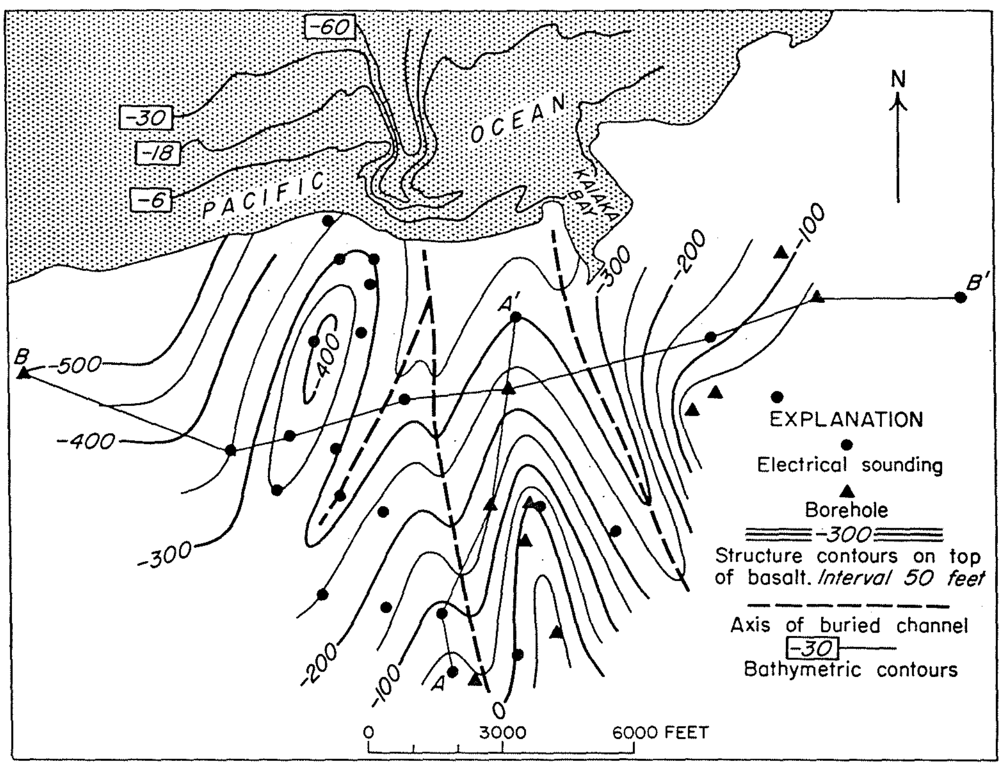

FIG. 11. Map of the top of basalt of the Waianae Volcanic Series as inferred from the resistivity data and well logs in the Waialua area. Oahu, Hawaii.

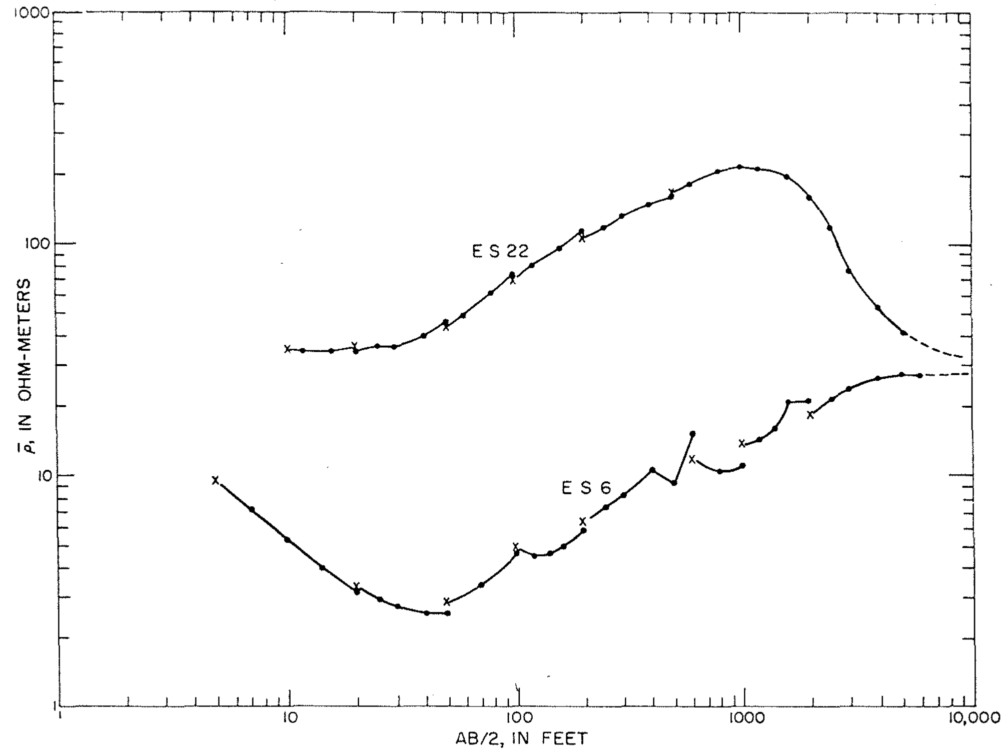

FIG. 12. Comparison of ES curves 6 and 22 obtained over the Waianae and the Koolau basalts respectively.

is probably due to the fact that the Koolau basalt was studied at higher elevations than the Waianae basalt, where its *upper layers* were beyond the reach of the low-resistivity saline waters.

The resistivity of the saline-water saturated basalt, of the Waianae or the Koolau type, is of the order of 30 ohm-m. This conclusion is based on the comparison of the results of two deep soundings ES 6 (over the Waianae basalt) and ES 22 (over the Koolau basalt) (Figure 12). Although the two ES curves are basically different types, their terminal branches approach the same asymptotic value of about 30 ohm-m. The question, however, arises as to the certainty that the 30 ohm-m material represents saline-water-saturated basalt. The answer is reached by considering ES 6. If 30 ohm-m is the resistivity of *fresh-water*-saturated basalt which is underlain by salt-water-saturated basalt of lower resistivity, the thickness of the fresh-water lens beneath ES 6 should be of the order of 5000–6000 ft; this thickness is determined by extending the terminal branch of ES 6 to apparent resistivity values of less than 30 ohm-m for $\overline{AB}/2>6000$ ft. An interpreted thickness of 5000–6000 ft of fresh water would be difficult to reconcile in view of the sounding location. The center of ES 6 is less than one mile from the shoreline, its elevation is less than 40 ft above sea level, and the groundwater in that part of the island is not dike-impounded water. Therefore a thickness of 5000–6000 ft of fresh water is impossible under the Ghyben-Hertzberg[1] assumption of hydrostatic conditions and also is highly improbable under hydrodynamic conditions (Todd, 1959). Assuming that the individual layers are homogeneous and isotropic, it can be shown (Maillet, 1947) that an isotropic layer of a thickness $H=5000$–6000 ft is theoretically equivalent to an anisotropic layer of smaller thickness $h=H/\lambda$, where

[1] The Ghyben-Hertzberg relationship predicts that in coastal areas underlain by salt water the fresh-salt water interface will be depressed approximately 40 ft below sea level for every one foot of fresh water above sea level (Todd, 1959).

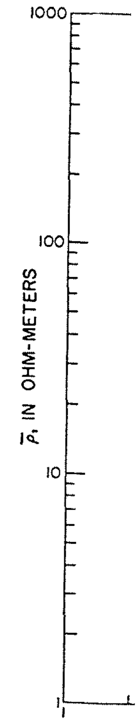

FIG. 13. I

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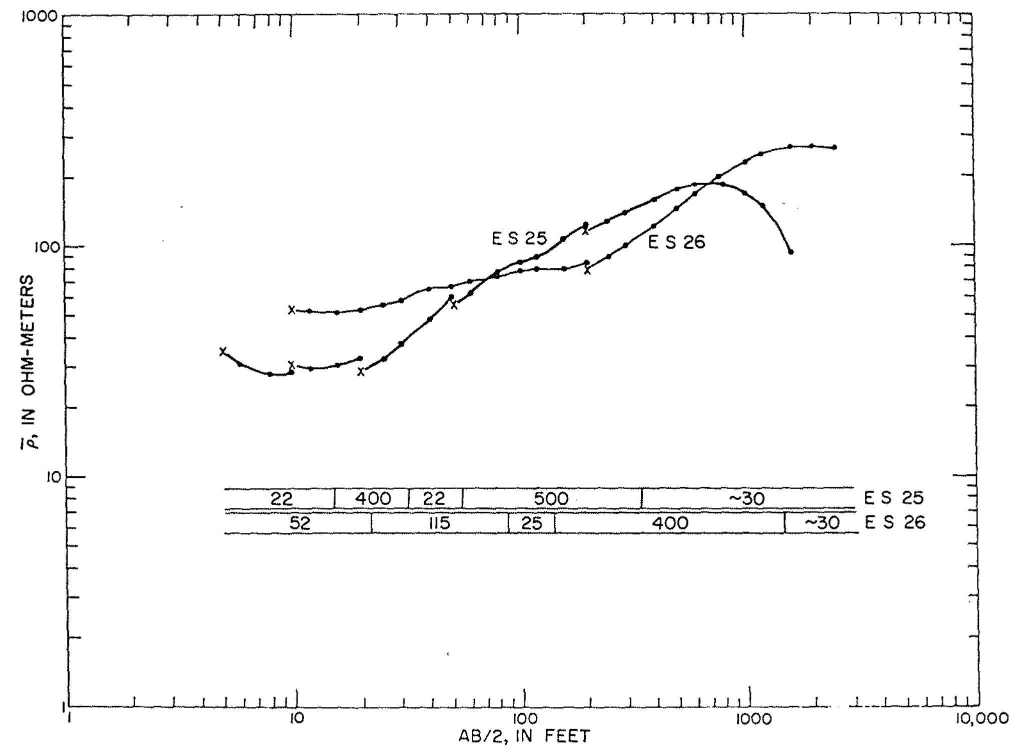


FIG. 13. ES curves 25 and 26, obtained over the Koolau basalt, Schofield Plateau, Oahu, Hawaii.

λ is the coefficient of anisotropy. In the present example, however, realistic values of λ, 1.2–2, do not give a reasonable thickness for the fresh-water saturated lens. Consequently, it is concluded that the 30 ohm-m layer is saline-water-saturated basalt.

The resistivity of Koolau basalt when saturated with fresh water ranges from 300 to 500 ohm-m, and is interpreted to be at 500 ohm-m at ES 25 and 400 ohm-m at ES 26 (Figure 13). A lower limit of about 250 ohm-m is possible from an interpretation (not given) of the ES 25 curve. The upper limit on the value of the resistivity, however, is indefinite except that it is not likely to exceed 1000 ohm-m in this area.

Interpretation of ES 24 (Figure 14) yields a depth to the fresh-water–salt-water interface of 800 ft below ground surface or 600 ft below sea level. There is standing fresh water at an elevation of 12–13 ft above sea level in wells near ES 24. If one applies the Ghyben-Hertzberg relationship to the water level in these wells, then the fresh-water–saline-water interface beneath ES 24 should be about 500 ft below sea level. Thus, if the Ghyben-Hertzberg relation holds for this area, one must conclude that the interpretation of ES 24 is incorrect. This could be resolved as follows: If one assumes that the resistivity of the basalt at ES 24 is 400 ohm-m instead of 350 ohm-m (see Figure 14), then, in accordance with the principle of equivalence (Kalenov, 1957), the calculated depth would be closer to the one predicted by the Ghyben-Hertzberg relation. However, the Ghyben-Hertzberg relation may not hold in this area because of the existing hydrodynamic conditions. Consequently, an attempt to change the estimated depths to the fresh-water–saline-water interface to achieve an exact correspondence between the depth determined from ES 24 and that predicted from application to the Ghyben-Hertzberg relation to the well data would be futile. Because the groundwater is not under static conditions, the fresh-water–saline-water interface should be depressed by a ratio greater than 40:1. Therefore the interpreted depth of 600 ft below sea level appears

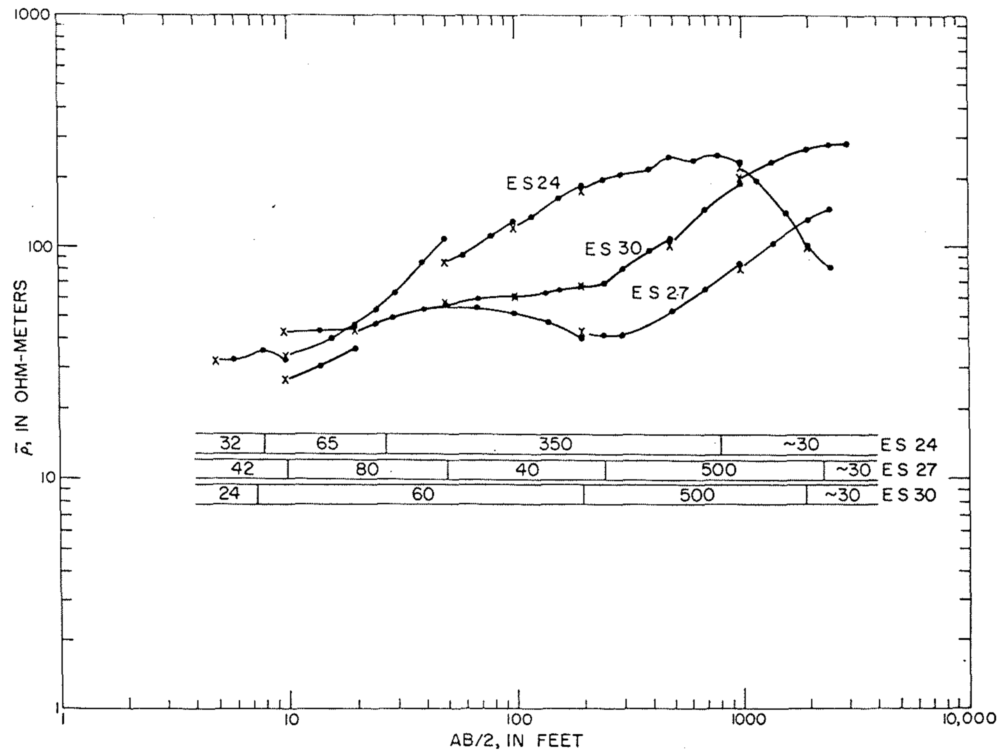


FIG. 14. ES curves 24, 27, and 30, obtained over the Koolau basalt, Schofield Plateau, Oahu, Hawaii.

consistent with that to be expected under hydrodynamic conditions.

Comparison of ES 27 and ES 30, which are at the southeast boundary of the survey area (Figure 2), with ES 24 indicates that the basalt must be at much greater depth in the southeast area. This interpretation was found to be in agreement with drilling data from two wells located approximately 2 miles northeast of ES 27. (Locations of wells are not shown in Figure 2.) The effect of salt water on the curves of ES 27 and 30 is somewhat speculative because the curves were not carried out sufficiently far. However, the data indicate that the fresh water extends to considerable depth.

ELECTRICAL SOUNDINGS ON THE ISLAND OF HAWAII

The resistivity survey on the island of Hawaii (Figure 15) was made at Pohakuloa and the Humuula sheep station which are located on the saddle between the volcanic mountains of Mauna Kea (White Mountain) and Mauna Loa (Long Mountain). The area lies at an average elevation of about 6200 ft above sea level and has an average rainfall of approximately 12 in/yr, whereas other parts of the island, at lower elevations, have an average rainfall of as much as 360 in/yr. The need for an adequate supply of fresh water near Pohakuloa prompted the drilling of a test well that reached a depth of 1001 ft. Although the possibility of perched or dike-impounded water at shallow depth exists, the test well proved to be dry. Subsequently the resistivity survey was made to evaluate the possibilities for successful groundwater exploration and exploitation in that area.

Thirteen electrical soundings were made near Pohakuloa and Humuula. Ten of these soundings were made with the Schlumberger electrode array and three with the equatorial electrode array. The maximum Schlumberger electrode spacings $\overline{AB}/2$, ranged from 3000 to 7000 ft; the maximum equatorial effective spacings $\overline{R}$ ranged from 8000 to 28,000 ft. The results of the thirteen electrical soundings indicated that the geoelectric section consists of the following:

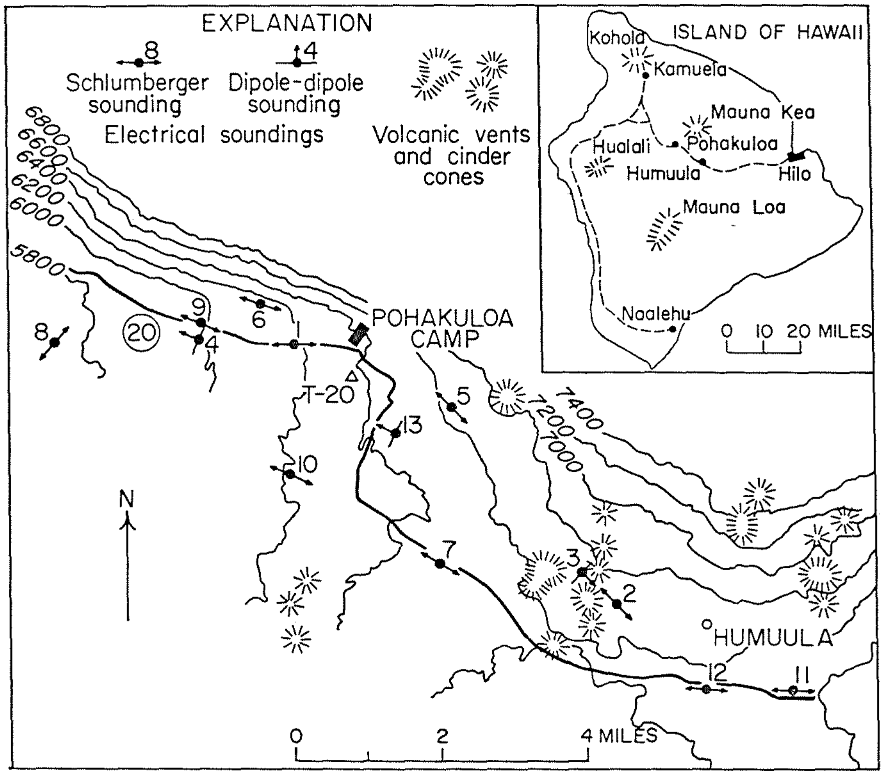


FIG. 15. Index map showing location of electrical soundings on the island of Hawaii, and important geographic features.

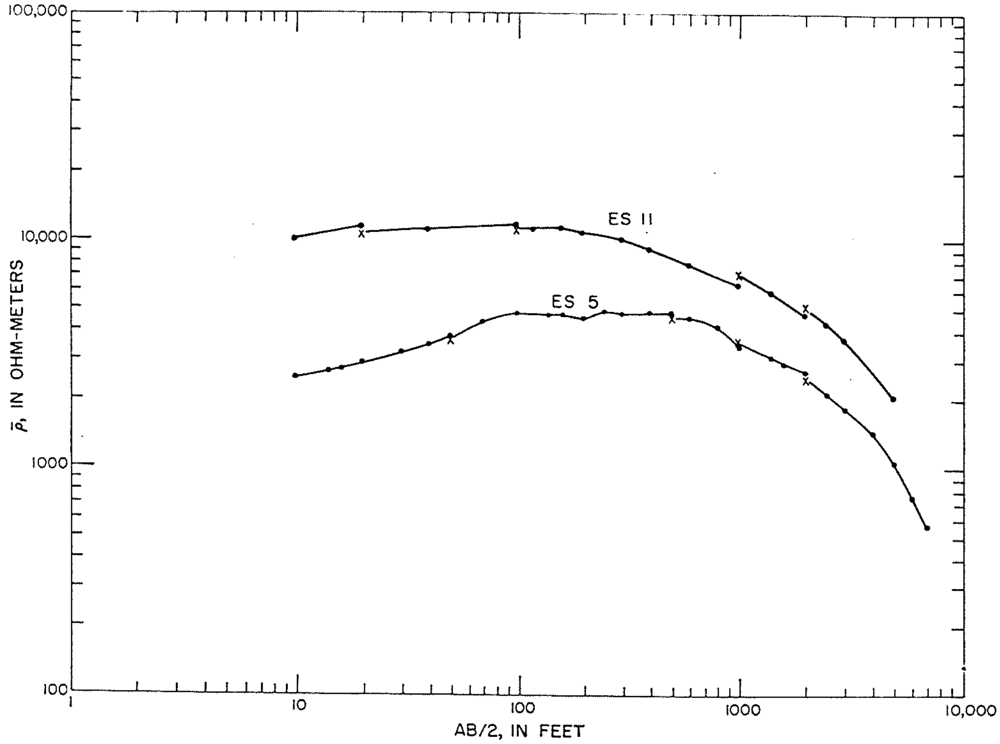
1) Near-surface layers that have highly variable resistivities ranging from about 200 ohm-m (volcanic ash, clay, and debris) to about 40,000 ohm-m (dry pohoehoe and Aa Aa basalt).
2) A "second" layer of wide lateral extent and consistent electrical properties. Its resistivity ranges from about 5500 to 6200 ohm-m and its thickness varies from about 300 to 1000 ft.
3) A "third" layer, also of wide lateral extent, that has a resistivity ranging from 1800 to 2800 ohm-m. Its thickness ranges from about 2000 to 3000 ft.
4) A "fourth" layer that has a resistivity of less than 1000 ohm-m, and a very large thickness.

In view of the high-resistivity values of the first three layers (with the exception of the shallow volcanic ash and debris layer near Pohakuloa), none of these layers should be expected to contain substantial amounts of subterranean water.

The shallowest depth to the conductive layer of resistivity less than 1000 ohm-m is at ES 5 where it is estimated to be about 2700 ft deep.[2] The second shallowest depth to the same conductive layer is at ES 2 at Humuula—3000 ft. To the east of ES 2 and near ES 11, the depth to the conductive layer is approximately 4400 ft. The ES 5 and ES 11 curves are shown in Figure 16.

The bipole-dipole equatorial array was used to extend electrical sounding data obtained by the Schlumberger array. One of the dipole equatorial soundings, DES 3, was made near the Humuula sheep station area to extend the data of ES 2. The near-surface lava flows at Humuula are more resistive (10,000 ohm-m) than most of those near

[2] A shallower depth of 1600 ft was originally estimated by Zohdy and Jackson (1968) on the basis of only four soundings made during the January 1966 survey. The present interpretation is based on the data obtained in January and October 1966.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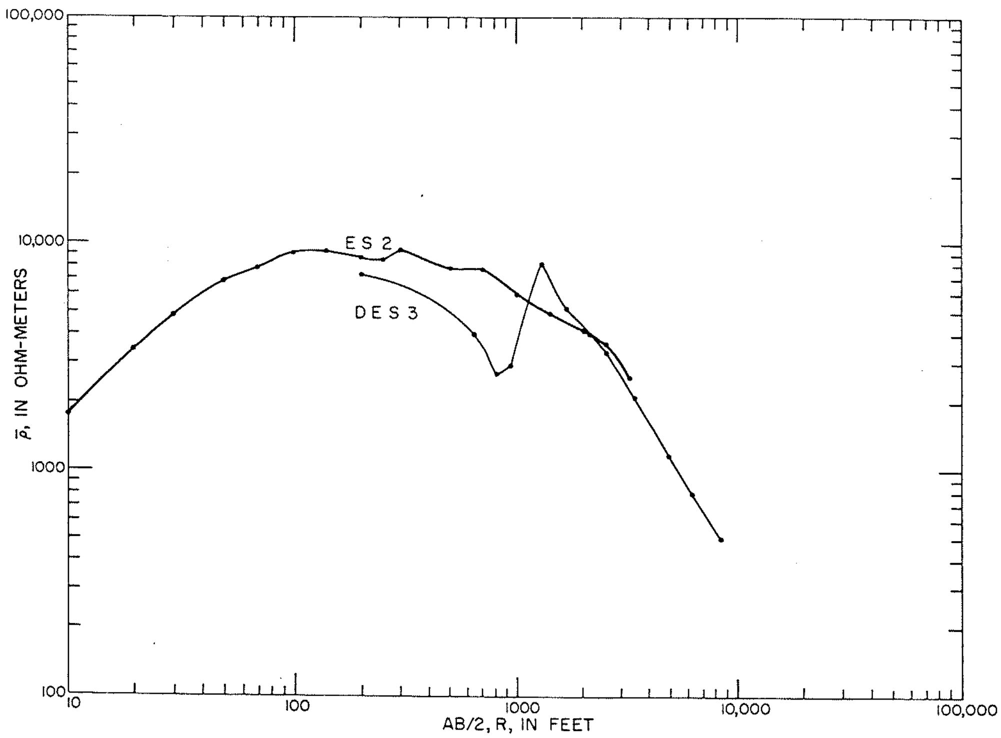
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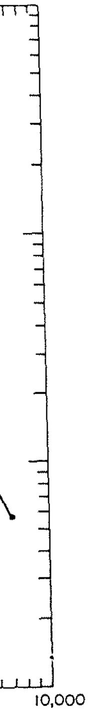

Fig. 16. ES 5 and ES 11 curves, obtained near Pohakuloa and Humuula, respectively, Hawaii.

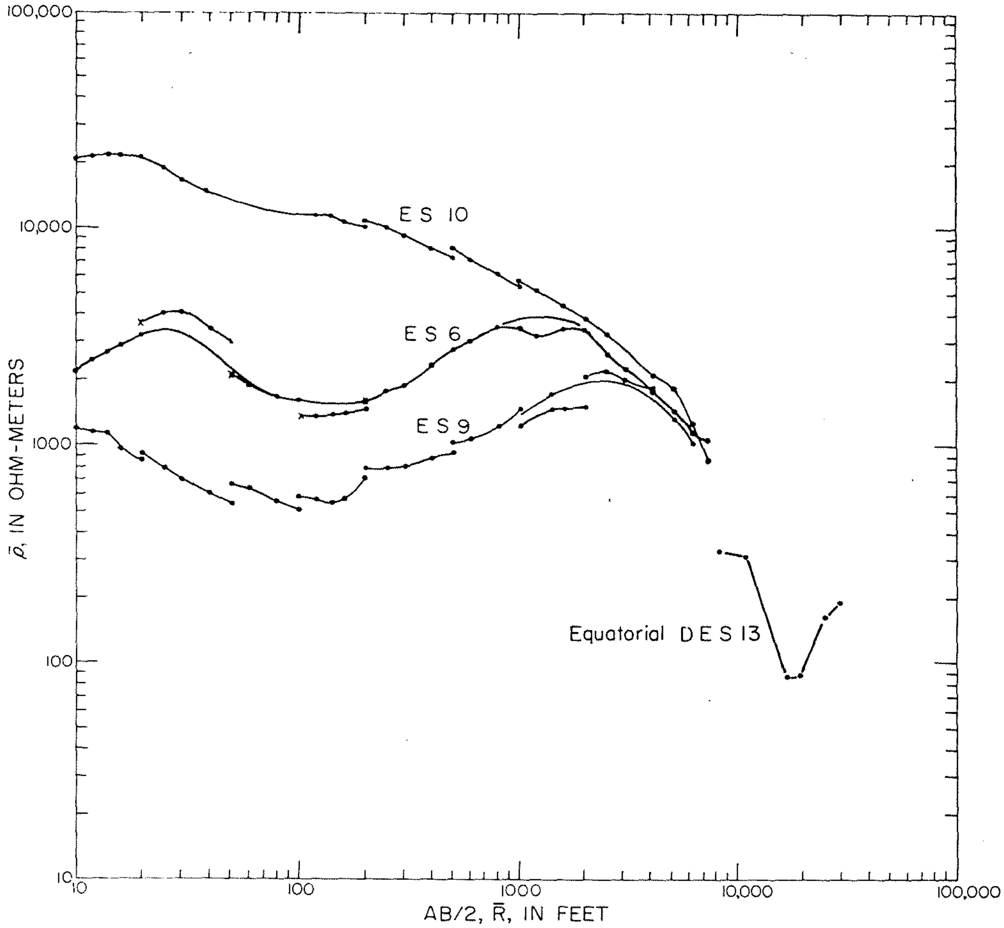

Fig. 18. ES 6, 9, and 10 curves and DES 13 curve, obtained near Pohakuloa, Hawaii, Hawaii.

Pohakaloa (2000 ohm-m). The DES 3 curve (Figure 17) is very deformed between $\overline{R}=200$ ft and $\overline{R}\simeq 1700$ ft. This deformation was probably caused by the fact that the potential electrodes were moved over the saddle between two cinder cones (see Figure 15). The initial decrease in the apparent resistivity (between $\overline{R}=200$ ft and $\overline{R}$ $\simeq 900$ ft) reflects the possibility that the cinder cones deform the electric field in very much the same manner as two high-resistivity media sandwiching a conductive vertical layer between them (Vedrintsev, 1960). The effective spacing $\overline{R}$ at which the apparent resistivity increases abruptly correlates favorably with the location

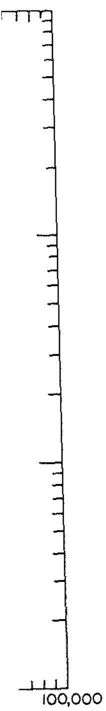

Fig. 17. ES 2 and DES 3 curves, obtained near Humuula, Hawaii, Hawaii.

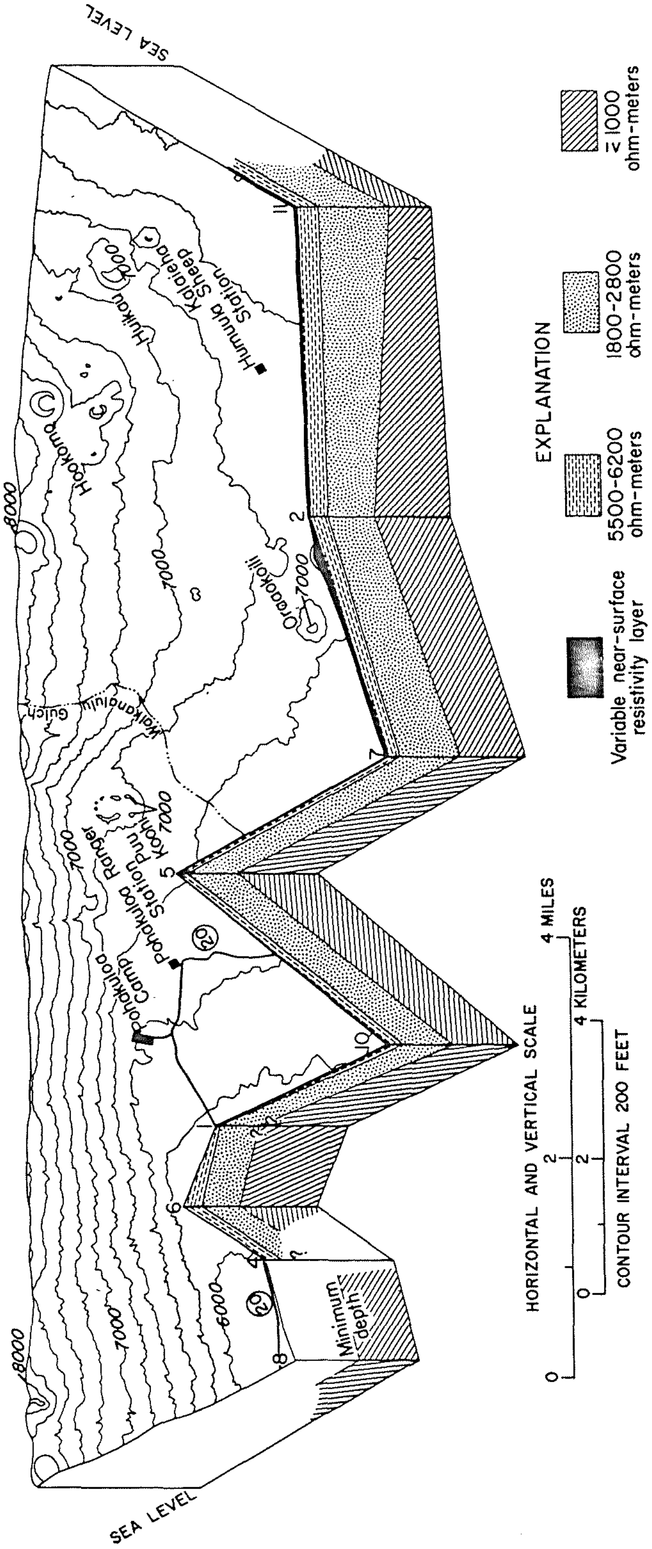

FIG. 19. Block diagram of the geoelectric section near Pohakuloa and Humuula, Hawaii. Base from U. S. Geological Survey Puuoo, Puukoli, and Aumoa quadrangles, 1956.

of the potential electrodes MN outside the region between the two cinder cones. At $\bar{R} \geq 2000$ ft the values of apparent resistivity on the DES 3 curve are in excellent agreement with the apparent resistivity values on the ES 2 curve at $2000 \leq \overline{AB}/2 \leq 3200$ ft. Therefore, they were considered usable for extending the interpretation of ES 2 to $\overline{AB}/2$ spacings of as much as 8000 ft.

An attempt was made to extend the information on the electrical properties in the Pohakuloa area to the maximum possible depth obtainable with the available resistivity equipment. Consequently the equatorial sounding DES 13 was made where the effective spacing $\bar{R}$ was expanded from $\bar{R} \simeq 8000$ ft to $\bar{R} \simeq 28{,}000$ ft. The length of the bipole AB was 10,000 ft and the maximum length of the dipole MN was 2000 ft. It appears from the curves shown in Figure 18 that the DES 13 curve continues the trend of the ES 6, 9, and 10 curves, and that the electrical resistivity in this part of the island decreases with depth to values of less than 100 ohm-m. The abrupt increase in resistivity at $\bar{R} > 20{,}000$ ft is most likely caused by significant lateral heterogeneities, in the vicinity of the potential dipole MN, which could be in the form of high-resistivity dikes. The effects of such high-resistivity dikes were observed on ES 8 and on DES 4.

A diagram of the geoelectric section based on the interpretation of ES 11, 2, 7, 5, 10, 1, 6, 4, and 8 is presented in Figure 19. The four basic geoelectric layers described earlier are shown to be remarkably continuous, except near ES 8 where strong lateral discontinuities were encountered.

These geoelectrical studies and the geological evidence indicate the presence of a dike system in the Pohakuloa and Humuula area and that the groundwater is probably dike impounded. The locations of the cinder cones in the survey area fall on arcs of circles and are presumably connected by a system of ring dikes. Consequently the groundwater table may exist at high elevations above sea level that would be very improbable in the absence of nearly impervious dikes. The impoundment of groundwater by impervious dikes is a well-known phenomenon on the Hawaiian Islands (Stearns, 1966).

SUMMARY AND CONCLUSIONS

The application of electrical soundings on the island of Oahu, near Waialua, proved to be very useful in extending the hydrogeologic knowledge about that part of the island. The survey gave valuable information on the areal distribution of subsurface units and the delineation of subsurface channels cut in basaltic lava flows. On the island of Hawaii, near Pohakuloa and Humuula, the electrical soundings revealed the presence of four major geoelectric layers. The fourth geoelectric layer, which possibly represents basalt saturated with dike-impounded fresh ground water, lies at a depth of the order of 3000 ft below the land surface. This layer is of great thickness and has a resistivity of less than 1000 ohm-m. The application of electrical soundings near Pohakuloa and Humuula should contribute to a sound evaluation of the cost of drilling a deep water well presently under consideration by the Department of Land and Natural Resources of the State of Hawaii.

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