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DIRECT-CURRENT SOUNDINGS ON THE LA MESA SURFACE NEAR KILBOURNE AND HUNTS HOLES, NEW MEXICO

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This paper is a resume of a profile of resistivity soundings made on the La Mesa surface in southwestern Dona Ana County, New Mexico, from 3 mi west of Kilbourne Hole to 2 mi northwest of Lanark (Fig. 1). The resistivity profile consisted of eight soundings, including one in Kilbourne Hole. A ninth sounding, not shown on the profile, was made in Hunts Hole. The only geoelectrical control available in the study area was from the Texaco S. H. Weaver-Federal 1 well (King and others, 1971) at the east end of the profile. Resistivities for the various geoelectrical units recognized in the Texaco well were used along the line to the west as faithfully as possible, changes in the geoelectrical layer resistivities being made only when demanded by theoretical curve matches to the field sounding data.

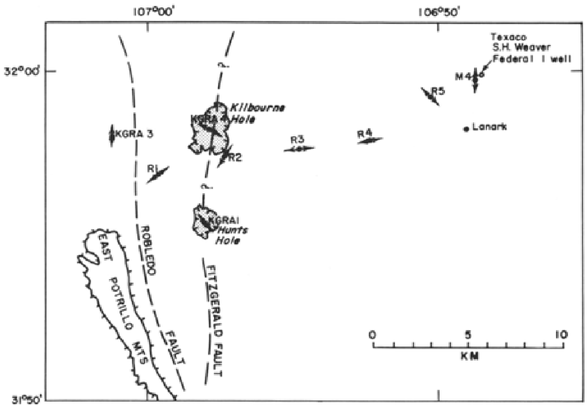

Figure 1. Index map showing location of electrical soundings near Kilbourne and Hunts Holes, New Mexico. Dashed lines show geologically mapped faults.

All the vertical electrical soundings (VES) were made with a collinear Schlumberger array using direct current (Keller and Frischknecht, 1966). The VES curves were interpreted using the U.S.G.S. automatic resistivity interpretation program and operations with Dar Zarrouk curves as described by Zohdy (1974 a, b, and 1975). An example of a set of field data, its computed theoretical curve, and the layered resistivity model for VES 3 is shown in Figure 2. Field data for the remainder of the soundings are shown in Figure 3.

The interpretation of the geoelectrical layering along the sounding profile is shown in Figure 4. The Texaco well was used as a base from which soundings along the profile toward the west were interpreted. Figure 5 shows the correlation between the geoelectrical layers interpreted for VES M4 and the deep induction log for the Texaco well. Although no ascending terminal branch was recorded on VES M4, such a branch was seen on every sounding from R5 to R2. It is reasonable to expect that if VES M4 could have been expanded to larger current electrode spacings, a rising terminal branch would have been recorded. The rising branches on VES 5 through VES 2 evidently reflect the presence of the top of a Tertiary volcanic sequence. By assuming a 30 ohm-m layer (the approximate resistivity recorded on the deep induction log near the top of the volcanic sequence identified on the Texaco well log by King and others, 1971) beneath VES M4 a model was calculated that gave a geoelectrical layering compatible with the electric log and that also fitted the sounding curve. The upper geoelectrical layers that vary from 30 to 230 ohm-m at VES M4 roughly correspond to sedimentary rock above the water table. At depths greater than about 120 m the sedimentary rocks are water saturated and the resistivity decreases accordingly. At depths below 375 m to the top of the Tertiary volcanic rocks the resistivity decreases markedly to about 2.4 ohm-m, although the lithologic log of the Texaco well does not show such an abrupt change in lithology. The most likely explanation for such a resistivity decrease is either an approximate five-fold increase in the pore water salinity or a large increase in the amount of clay and shale in the section that somehow was not recorded in the lithologic log. A third possibility, less likely, is an abrupt increase in water temperature. The 2.4 ohm-m layer is an excellent geoelectric marker and can be traced easily as far west as VES R2 on the east edge of Kilbourne Hole. Between VES M4 and VES R2 the base of the 2.2 to 2.4 ohm-m layer deepens by about 400 m, giving an apparent dip of 1 to 2 degrees west. The lowest unit shown in Figure 4 represents electrical basement.

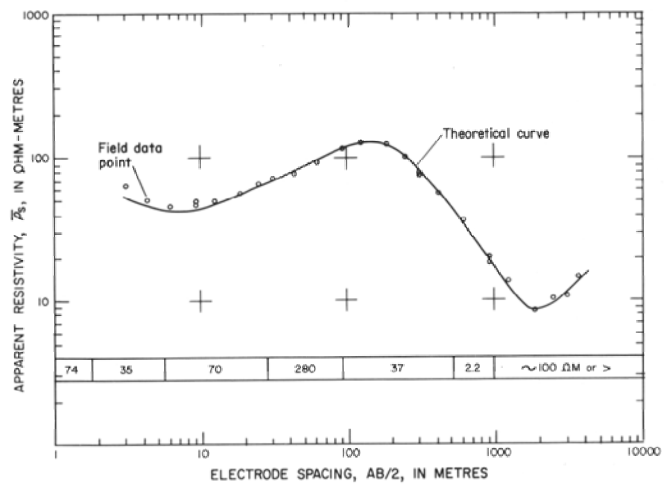

Figure 2. Field data, VES interpretation, and the theoretical sounding curve interpreted from the VES interpretation for sounding R3. Bar graph at bottom of figure shows the geoelectrical layering, with values in ohm-m, and layer contacts, in metres, as read from the graph abscissa.

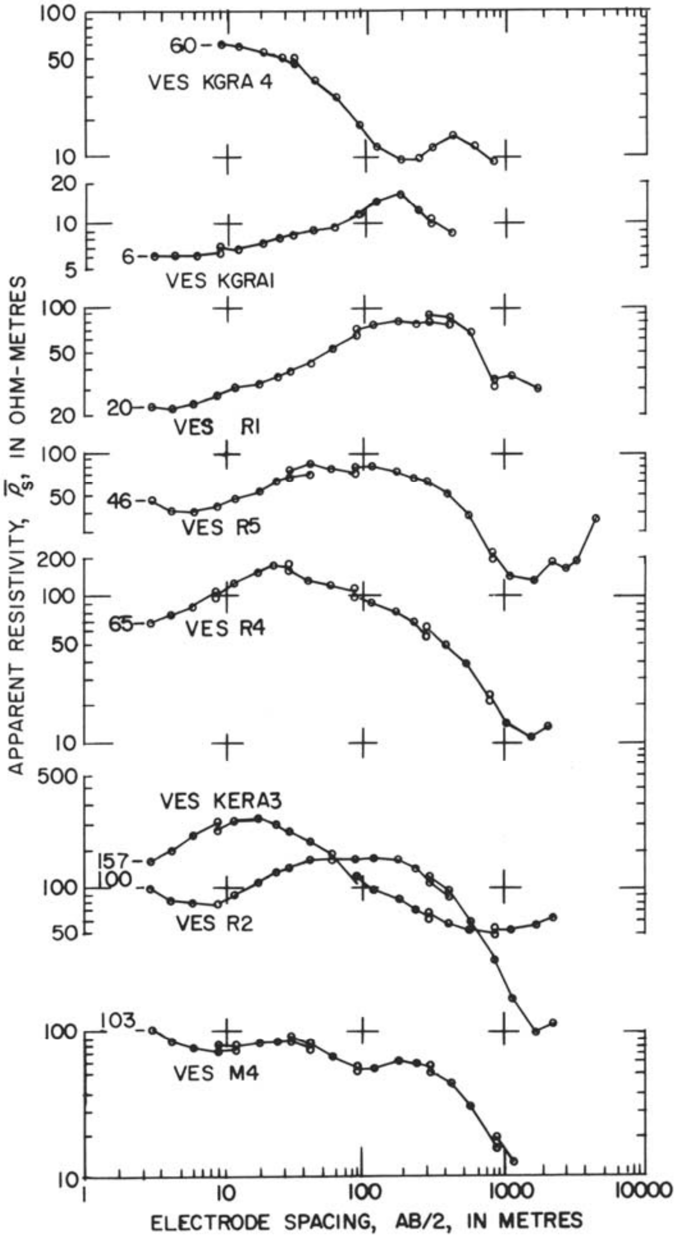

Figure 3. Field data for soundings discussed in this paper with the exception of VES R3 which is shown in Figure 2. The graph scale is log-log and the ordinate value, in ohm-m, is shown for the first field point of each curve.

VES R1 west of Kilbourne Hole is distorted, and interpretation of only the upper part of the geoelectric section was made. Whether the low-resistivity geoelectrical layer of 2.2 to 2.4 ohm-m continues beneath Kilbourne Hole to VES R1 is unknown, and accordingly on the profile (Fig. 4) it is indicated by dashed lines. Between soundings VES R1 and KGRA 3 the geoelectrical section changes dramatically. The section here is probably upfaulted to the west in the general vicinity of the Robledo fault.

The sounding within Kilbourne Hole (KGRA 4 on Fig. 4) could only be expanded to 800 m; nonetheless it shows a very different sequence of geoelectrical layering from the soundings to either the east or west. The solution for this sounding is only approximate because it was based on a laterally homogeneous and isotropic model—hardly expectable conditions in a rubble-choked vent. Nevertheless, for shallow layers the solution is probably valid. The most interesting feature of the sounding is the layer of less than 10 ohm-m at an interpreted depth of 155 m. This is unlike any geoelectrical layer at a comparable depth at either soundings R1 or R2. This low-resistivity (high conductivity) zone within the vent probably represents either hydrothermal alteration or hot water. The interpretation for sounding KGRA 1 in Hunts Hole is similar to that of KGRA 4 except that at Hunts Hole the less-than-10 ohm-m layer occurs at a depth of about 110 m.

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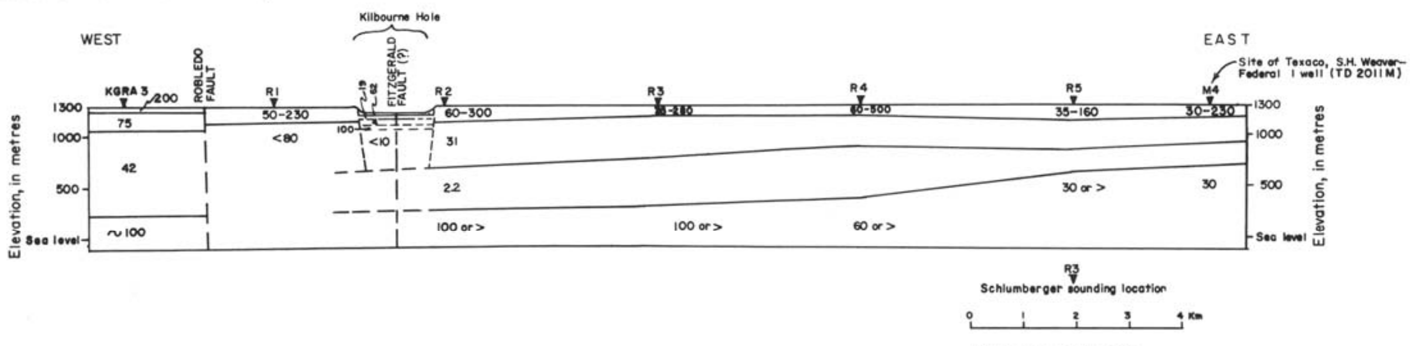

Figure 4. Sounding profile from VES M4 on the east to VES KGRA 3 on the west (sounding locations shown in Fig. 1). Line of profile goes through the center of each sounding except for R1 and KGRA 4 which are projected into a line between KGRA 3 and R2. Horizontal and vertical boundaries are dashed where uncertain. Values on cross-section in ohm-m.

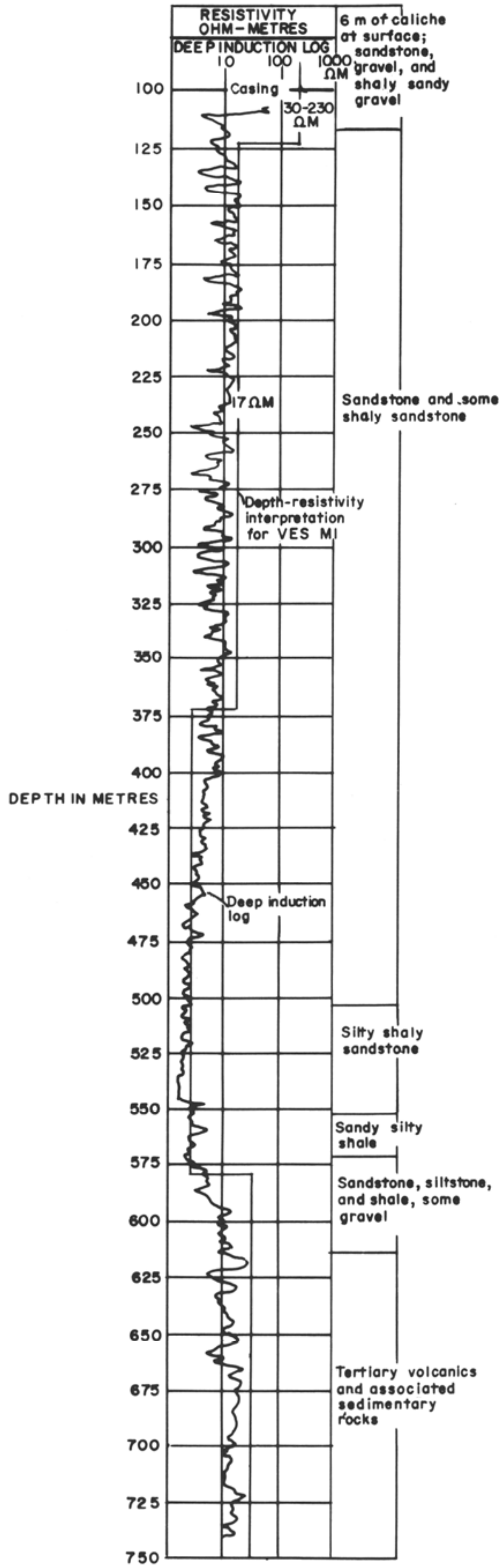

Figure 5. Deep induction log for the Texaco S.H. Weaver-Federal 1 well, and the depth-resistivity interpretation for VES M4 adjacent to the well. The generalized lithologic log for the well is shown to the right of the electric log.