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Publication Date
1982-04-01

LBL-14319

LBL--14319

DE82 020065

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April 1982

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DEEP ELECTROMAGNETIC SOUNDING IN

CENTRAL NEVADA

M. Wilt, N.E. Goldstein, J.R. Haught and H.F. Morrison

ABSTRACT

Sixteen shallow and deep controlled source electromagnetic soundings were performed in Buena Vista Valley, near Winnemucca, Nevada, to investigate an intra-basement conductor previously detected with magnetotellurics. The survey was carried out with the LBL EM-60 system using a remote magnetic reference for low-frequency geomagnetic noise cancellation, 100-m- and 2.8-km-diameter transmitter loops, and a minicomputer for in-field processing. EM soundings were made at distances from 0.5 to 30 km from three loops over the frequency range 0.02 to 500 Hz. Data were interpreted by means of 1-D inversions and the resulting layered models were pieced together to yield an approximate 2-D geoelectric model along the N-S axis of the valley. The EM soundings and one MT sounding show a 3 to 7 ohm-m zone at a depth of four to seven km. The conductor appears to be deepest at the northern end of the valley and shallowest beneath a basement ridge that seems to divide Buena Vista Valley into two basinal structures. Similar intra-basement conductors are also reported 50-75 miles south in the Carson Sink-Fallon areas, suggesting a common source, probably related to an anomalously hot, thin crust.

INTRODUCTION

During the Spring of 1981 a deep electromagnetic sounding survey was undertaken by Lawrence Berkeley Laboratory (LBL) in Buena Vista Valley, Nevada to confirm the presence of a relatively shallow intra-basement conductor, first detected with magnetotelluric measurements, and to delineate the conductor by means of the LBL controlled-source system, modified for deep sounding work. Shallow crustal conductors have been reported at various places within the Basin and Range Province and they are presumed related to the heat source that causes numerous hot springs, high regional heat flow and widespread, epithermal gold and mercury mineralization.

Sixteen controlled-source electromagnetic soundings and one magneto-
telluric sounding were made in Buena Vista Valley, Pershing County, Nevada
(Fig. 1). The EM soundings were made relative to three loop sources with
source-receiver separations ranging from 0.5 to 30 km. Two of the loops were
four-turns and 100 m in diameter, similar to those we have previously used
for investigations to depths of about 2 km. The other was a 6.25 km^2,
single-turn, large-moment source capable of providing signal for deeper
exploration. This large-diameter source had a moment of 2 x 10^{8}MKS,
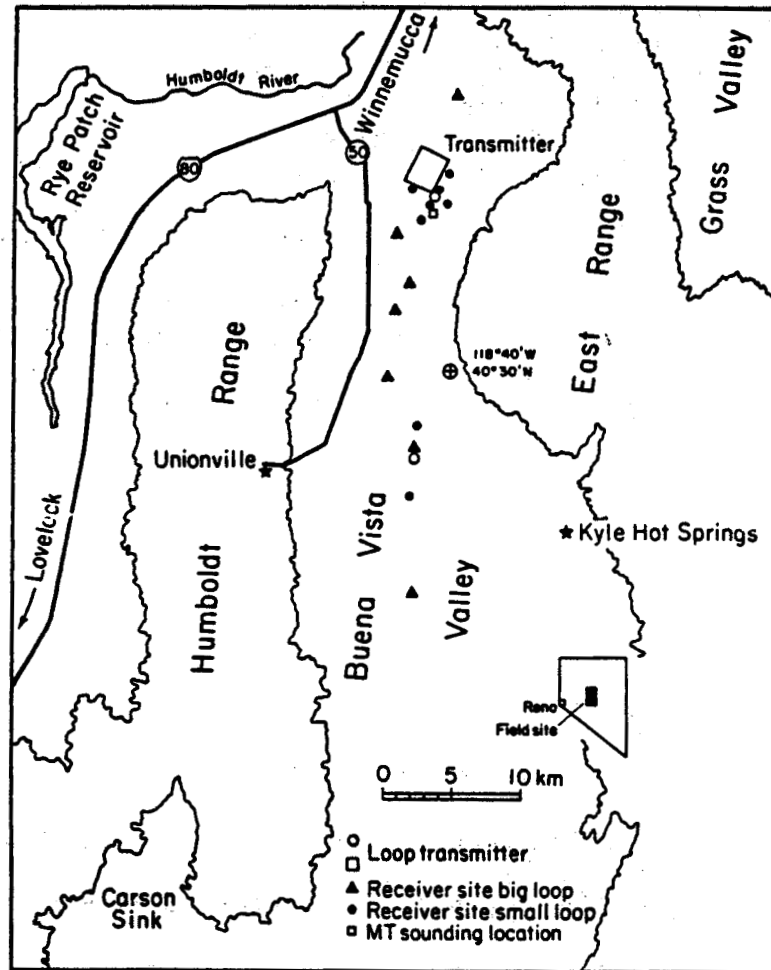approximately 80 times greater than the smaller loops.

Figure 1. Location Map of the Deep Electromagnetic Soundings, Buena Vista
Valley, Pershing Co., Nevada

Features of the system, shown schematically in Figure 2, include an eight-
channel multiplexer, a two-channel digital oscilloscope for digitization,

storage and display, and an HP 9835 minicomputer for data processing. Phase
reference between loop current and observed magnetic fields was maintained by
means of oven-controlled quartz clocks.

A remote reference magnetometer, shown in the upper right corner of
Figure 2, was used for noise cancellation during both the MT and controlled-
source EM surveys. The MT noise cancellation technique was described by
Gamble et al. (1979). In the controlled-source work, a distant reference
magnetometer provides signals to buck-out the natural geomagnetic variations
at the receiver station. Our experience shows that a simple procedure of
analog scalar subtraction performed with the transmitter off will reduce the
geomagnetic "noise" by about 20db; thereby extending the useful frequency
range down to ~0.02Hz. The more elegant noise cancellation technique based
on finding the tensor coefficients did not work as well because of the large
amount of time needed to obtain the coefficients, and the instability of the
coefficients over longer time intervals.
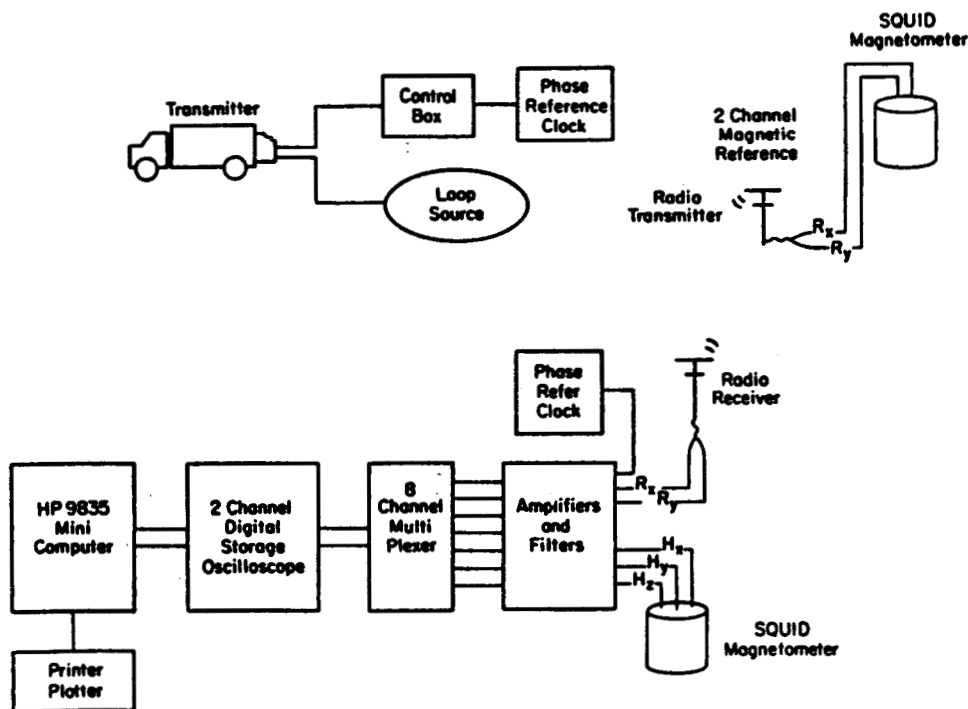
Figure 2. Schematic diagram of the EM-60 Controlled-Source EM System.

RESULTS

We performed 1-D inversions on all 16 electromagnetic soundings and the one magnetotelluric sounding. The data for most stations fitted well to 1-D models, and these layered-models were reasonably consistent from station to station (Fig. 3).

The low resistivity (10-20 ohm-m) of the upper km presents some problems for deep electromagnetic sounding. Although signals could be received at up to 30 km from the source, the higher frequencies were severely attenuated by the conductive surface layer, making it impossible for us to get useable data above about 5 Hz when source-receiver separations exceeded 15 km. The low resistivity surface also limited penetration of electromagnetic waves, thus making low frequency data collection mandatory. Without noise cancellation, collection at low frequency data would have been very difficult.

Figure 3. Geoelectric cross-section showing interpreted resistivities along the axis of Buena Vista Valley, Pershing Co., Nevada. Error bars are the standard error for the layer thicknesses.

Figure 3 is a composite of 1-D interpretations along a north-south line paralleling the valley. According to our convention, the layered-model interpretation is plotted at a point midway between the transmiter and the receiver. The resistivity cross-section reveals that the shallow portion of the crust beneath Buena Vista Valley can be approximated by four or five layers. The parameters of the top layer are resistivity of 20 ohm-m and a thickness of between 50 and 200 m. These parameters seem to be fairly consistent at most locations in the valley. This layer most likely represents partially saturated Quaternary alluvium. The second layer is some 200 to 500m thick and approximately 10 ohm-m in resistivity. This unit is thickest in the northern and southern parts of the valley and may be absent in the center of the valley; it likely represents saturated Tertiary sediments and volcanics. Deeper parts of the section indicate conductive sediments overlying resistive basement. Basement depth ranges from 0.5 to 2.5 km with a basement high which suggests that the valley may be subdivided structurally into two basins, a northern one 1 to 1.5 km deep and a southern one 2 to 2.5 km deep. The resistivity of the basement is poorly resolved with EM and MT soundings because it carries relatively little current and therefore does not contribute greatly to the received signals.

Evidence for a conductor within the basement was found on three electro-magnetic soundings and the MT sounding. For the EM soundings, a good electrical conductor (3 to 7 ohm-m) was indicated 4 to 7 km beneath the central portion of the valley. The MT sounding indicated a good conductor (approximately 25 ohm-m) 11 km in depth beneath the northern end of the valley. Fifty to 75 miles to the south in the Carson Sink, experiments by Keller et al. (1981) and by the U.S.G.S. (Stanley et al., 1976) have indicated conductors at about 5 km in depth. It is tempting, therefore, to speculate

on whether the conductors are related geologically, constituting a regional feature. On the basis of geothermal evidence, Stanley et al. (1979) have proposed that the conductor is caused by Tertiary and pre-Tertiary marine sediments saturated with water at 150°C or greater and with salinities of about 20,000 ppm. The widespread occurrence of the conductor seems to confirm that a broad area of the shallow crust is anomalously hot.

Although there are other surveys supporting the intra-basement conductor, our subsurface electrical model is only preliminary. The irregular valley shape, variable basement depth and the anomalously small radial fields and large tangential fields observed suggest 3-D complexities. 2-D modeling suggests that the depth to the conductor may be underestimated in the 1-D inversions.

ACKNOWLEDGEMENT

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