GL02281

REPORT ON THE SUPPLEMENTAL RECONNAISSANCE RESISTIVITY SURVEY IN THE BEOWAWE AREA LANDERS AND EUREKA COUNTIES, NEVADA FOR CHEVRON OIL COMPANY

McPHAR GEOPHYSICS

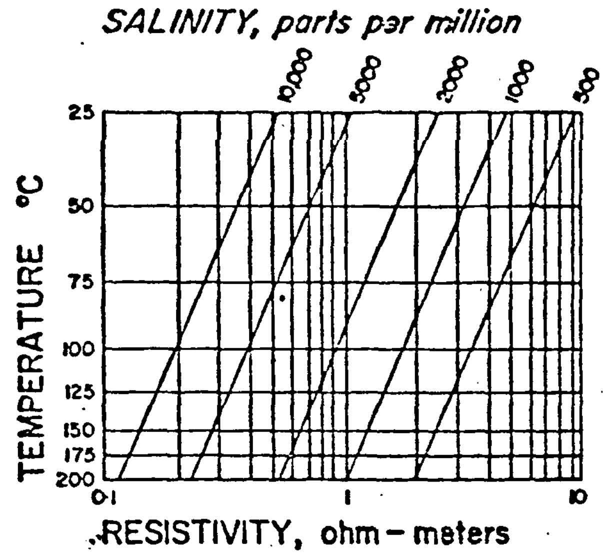
NOTES ON GEOTHERMAL EXPLORATION USING THE RESISTIVITY METHOD

Many geophysical methods have been tried in the exploration for geothermally "hot" areas in the upper regions of the earth's crust. The only method that has been consistently found to be successful has been the resistivity technique. In this geophysical method, the specific resistivity (or its reciprocal, the specific conductivity) of the earth's subsurface is measured during traverses over the surface.

The principle of the technique is based on the fact that the resistivity of solution-saturated rocks will decrease as the salinity of the solutions is increased and/or the temperature of the system is increased (see Figure 1). Therefore, volumes of the earth's crust that contain abnormally hot and saline solutions can often be detected as regions of low resistivity.

The resistivity measurements are usually made using grounded current and potential electrodes, but some useful data can sometimes be obtained using electromagnetic techniques. The field data shown on plan maps in Figure 2 are from the Broadlands Area in New Zealand; in this area there are substantial flows of hot water and steam at the surface.

The results show resistivity lows measured with a Wenner Configuration Resistivity Survey and a loop-loop electromagnetic survey. The anomalous pattern is much the same in both cases and the regions of low resistivity correlate well with the areas of increased rock temperature.

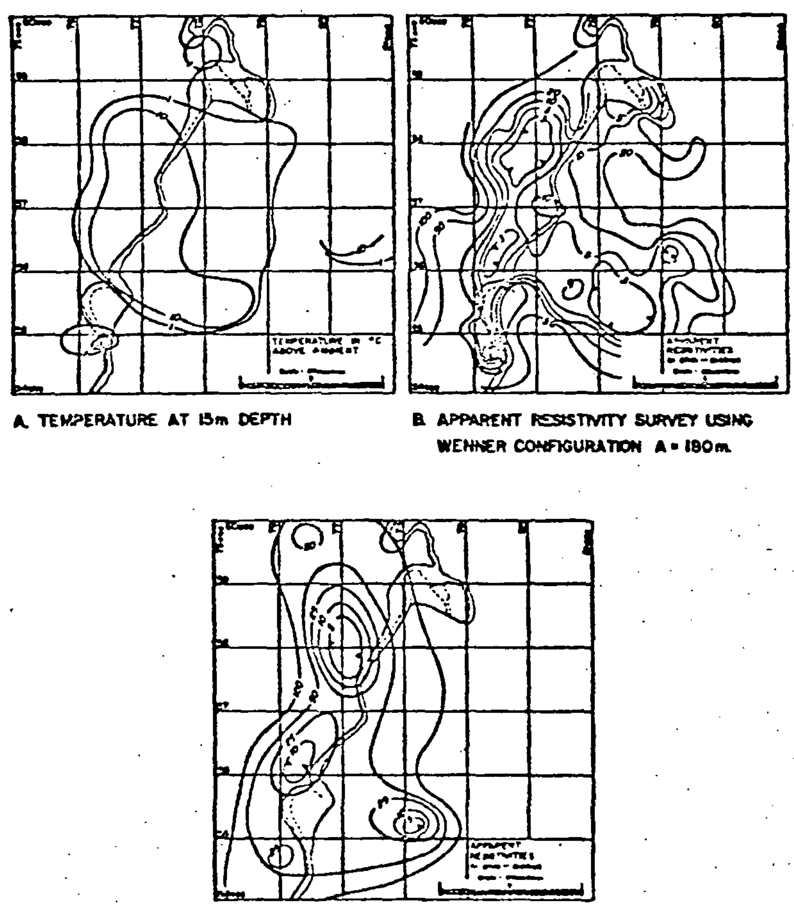


VARIATIONS OF SOLUTION RESISTIVITY
WITH TEMPERATURE AND SALINITY

FIG. I

GEOPHYSICAL SURVEY

BROADLANDS AREA, NEW ZEALAND



A. TEMPERATURE AT 15m DEPTH

B. APPARENT RESISTIVITY SURVEY USING WENNER CONFIGURATION A = 180m.

C. APPARENT RESISTIVITY SURVEY USING LOOP TO LOOP ELECTROMAGNETIC METHOD

FIG. 2

If the rock volume saturated with hot solutions does not extend to the surface it will be necessary to use large electrode intervals to detect the resistivity lows. The resistivity data shown in "pseudo-section" form in Figure 3 is from Java. Along this line there are two deep regions of low resistivity detected for the larger electrode intervals used. Zone A is associated with surface manifestations of geothermal activity. The source of the resistivity low at Zone B is unknown.

If the abnormally hot region occurs in a sedimentary basin, the general resistivity level can be quite low, due to the high porosity in normal sediments. This is the case in the Imperial Valley of California. The resistivities shown in Figure 4 are from an area near El Centro, California. The largest electrode separation used was 12,000 feet.

The results show a two-layer geometry with the upper layer having a thickness of approximately one-half electrode interval (i.e. 1,000 feet). The resistivity in the upper layer is 3.0 ohm-meters; the resistivity of the lower layer is 1.5 ohm-meters. Due to the small resistivity contrast, additional measurements would be necessary to determine the possible geothermal importance of the lower resistivity layer at depth.

The results shown in Figure 4 are from a dipole-dipole electrode configuration survey. Our dipole-dipole data is plotted as a "pseudo-section" for several values of n; the separation between the current electrodes and potential electrodes, as well as the location of the electrodes along the survey line, determine the position of the plotting point. The two-dimensional array of

APPARENT RESISTIVITY SURVEY, DIENG PLATEAU AREA, JAVA, INDONESIA

Pseudo Section Plotting Method Along Dieng–Batur Road

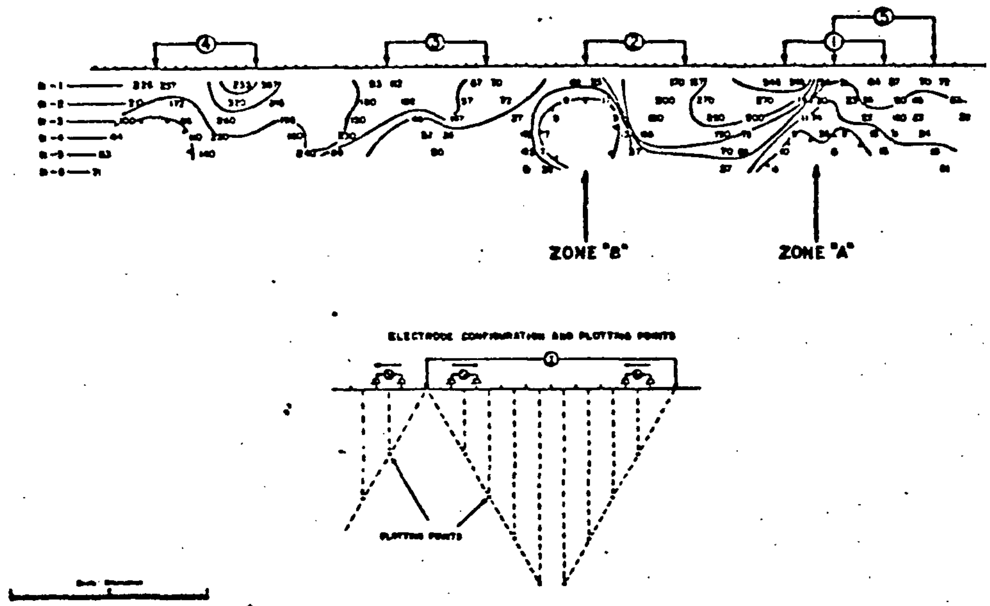


FIG. 3

RESISTIVITY SURVEY, IMPERIAL VALLEY–CALIFORNIA.

LINE-"O", FREQUENCY–0·125 Hz.

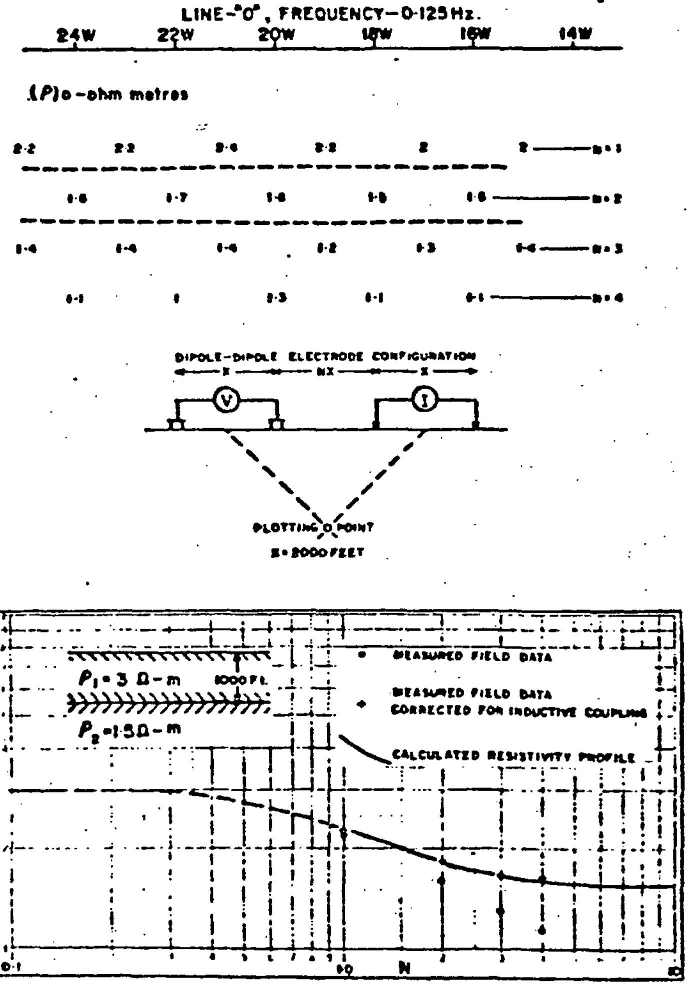
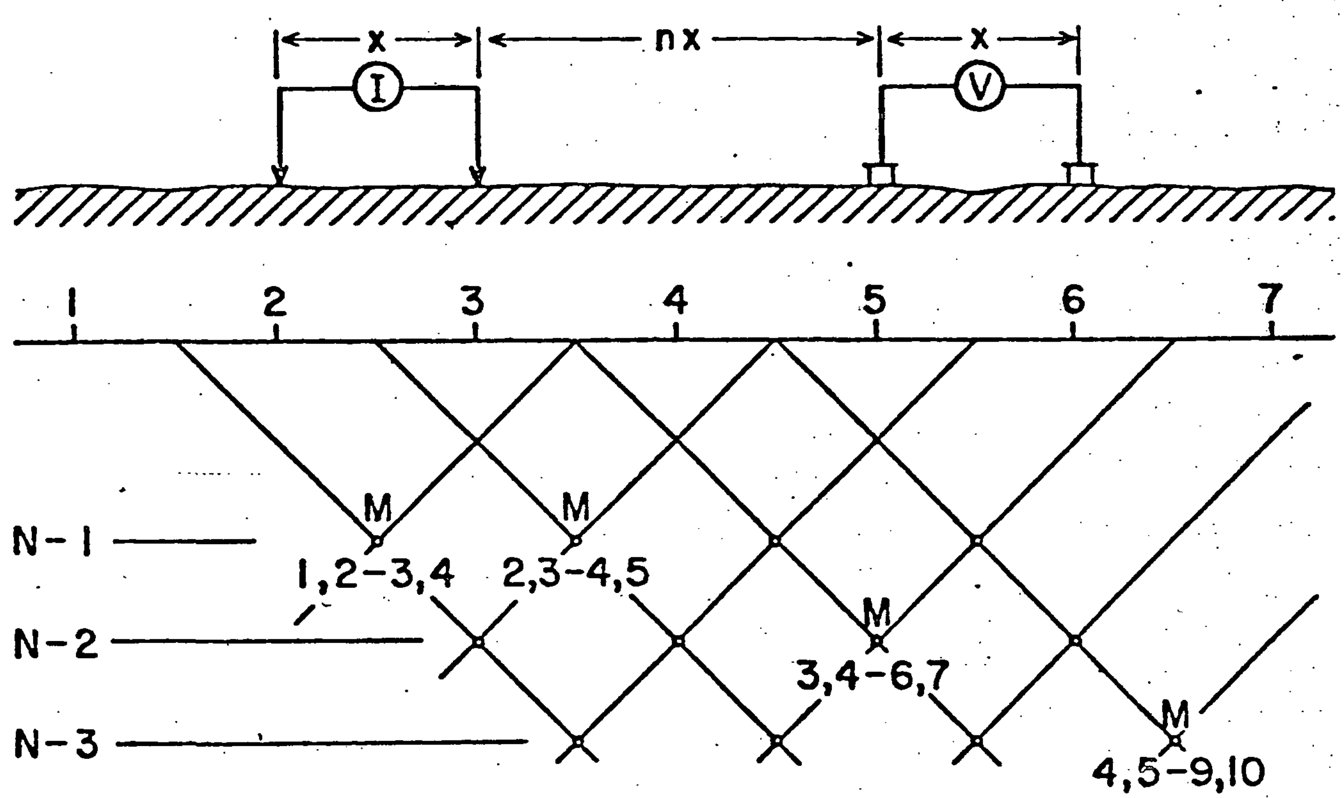


FIG. 4

data is then contoured (see below). The contour plots are not sections of the

DIPOLE-DIPOLE PLOTTING METHOD



electrical properties of the earth; they are convenient graphical representations of the measurements made. However, with experience the contour patterns can be interpreted to give some information about the source of the anomaly.

If the contour patterns indicate very simple geometries, more quantitative interpretations can often be made. For instance, if the contours are horizontal for a lateral distance of four to six electrode intervals, a horizontally layered geometry is indicated. In this situation, theoretical type-curves for dipole-dipole measurements in a layered geometry can be used in "curve fitting" techniques to give the true resistivities and depths for the earth.

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1. INTRODUCTION

At the request of Mr. William Mero, geologist for Chevron Oil Company, Minerals Division, McPhar Geophysics has conducted an additional Reconnaissance Resistivity Survey line in the Beowawe area, Landers and Eureka Counties, Nevada.

The origional survey of the Beowawe area was conducted in June 1974, and consisted of five survey lines which located some possible to definite anomalies adjacent to the Malpais fault (see report on Beowawe area for Chevron Oil Company dated July 18, 1974).

The additional line discussed in this report was surveyed one mile east of the original survey area in an attempt to locate a low resistivity zone that may indicate an extension of the anomalous response of the previous survey. Measurements were made with 2000 foot dipoles at one-through-five dipole separation. A frequency of 0.125 Hz was used in order to minimize attenuation of the electric field due to eddy current dissipation of energy and at the same time avoid telluric noise.

The survey was conducted by Mr. Daniel Merchant, geophysical technician.

2. PRESENTATION OF RESULTS

The resistivity survey results are shown on the following data plots in the manner described in the notes which accompany this report.

Line	Electrode Intervals	Dwg. No.
B-6	2000 feet	R 6244 - 1

Also enclosed with this report is Dwg. RP-4983R, a revised plan map of the survey area showing the location of all the survey lines and an interpreted true resistivity along each survey line, at a scale of 1" = 2000 feet. The definite, probable and possible Resistivity low anomalies are indicated by bars, in a manner shown in the legend, on the plan map as on the data plots. These bars represent the surface projection of the anomalous zones as interpreted from the location of the transmitter and receiver electrodes when the anomalous values were measured. The interpreted true resistivity sections along each survey line have been compiled with the aid of two-dimensional theoretical curves and three dimensional model studies.

3. DISCUSSION OF RESULTS

The previous resistivity survey of the Beowawe area located anomalous responses that appear to coincide with the Malpais Fault along each survey line. The most interesting anomaly, on Line 2, at depth between 100N and 140N, has been drilled by Chevron Oil Company.

The apparent resistivity measured during this survey is generally consistent with the previous survey except between 180N and 220N. The Malpais Fault crosses Line 6 at approximately 210N; station 200N is on the up-thrust side of the fault and station 220N on the down-dropped side. It is believed that the elevation change across this dipole has produced the high resistivity between 180N and 200N and the low resistivity centered at 200N to 220N. The attached theoretical resistivity scale model study, case T-V30°-250-1 shows the resistivity pattern across a valley which is similar to the results obtained on Line 6.

A possible anomaly has been interpreted between 200N and 220N, but this low resistivity may be due solely to topography.

The results of the resistivity survey on this line are inconclusive.

McPHAR GEOPHYSICS, INC.

Bruce S. Bell
Geologist

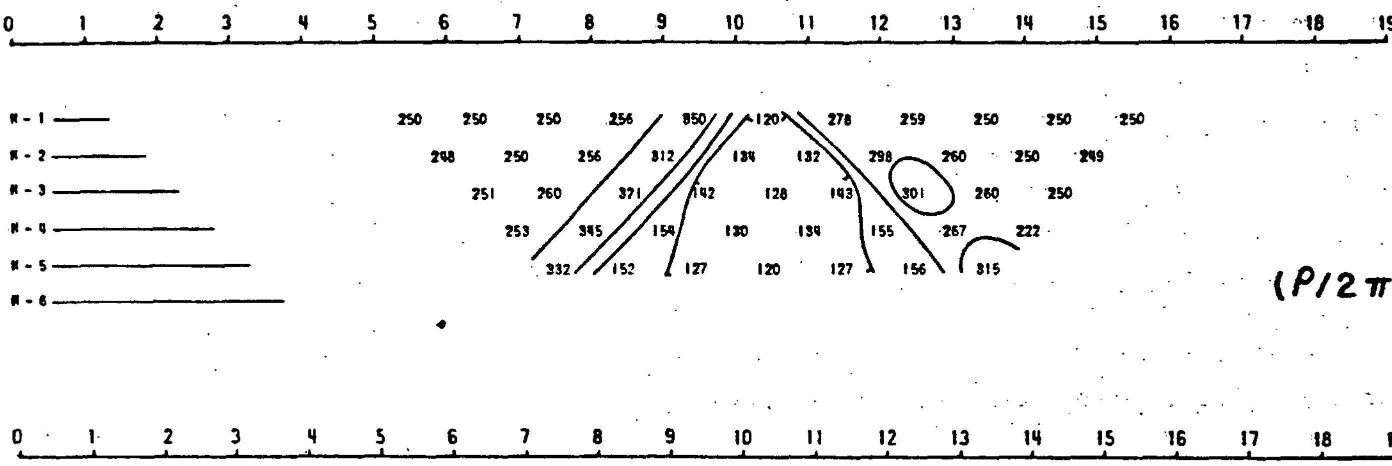
Philip G. Hallof
Geophysicist

Dated: November 29, 1974

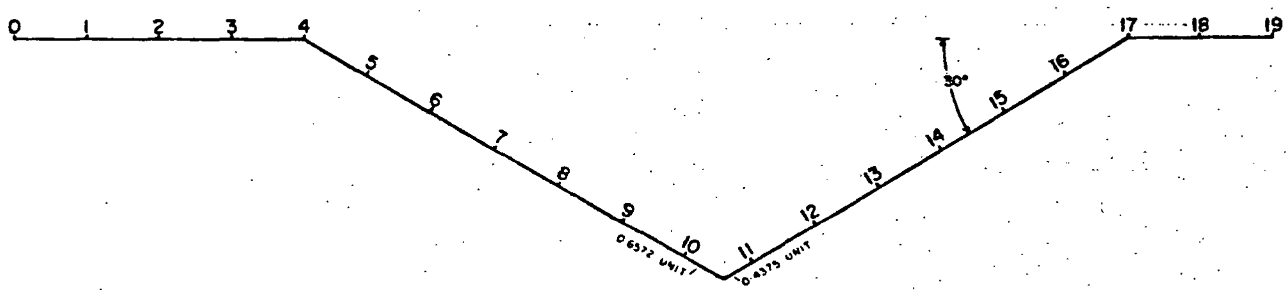
McPHAR GEOPHYSICS LIMITED

Theoretical Induced Polarization and Resistivity Studies

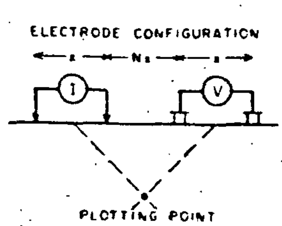
Scale Model Cases



$(\rho/2\pi)a$



$(\rho/2\pi)_1 = 250$



CASE

T-v30°-250-1