GL02084

REPORT ON THE RECONNAISSANCE RESISTIVITY SURVEY OF THE SAN EMIDIO AREA WASHOE COUNTY, NEVADA FOR CHEVRON OIL COMPANY

2/74

McPHAR GEOPHYSICS

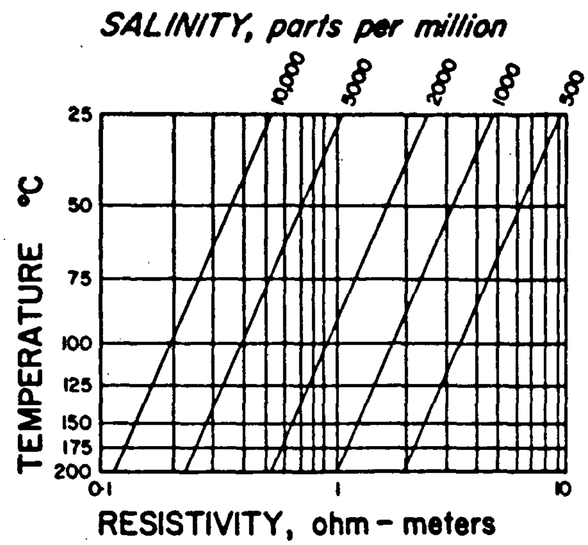
NOTES ON GEOTHERMAL EXPLORATION USING THE RESISTIVITY METHOD

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.

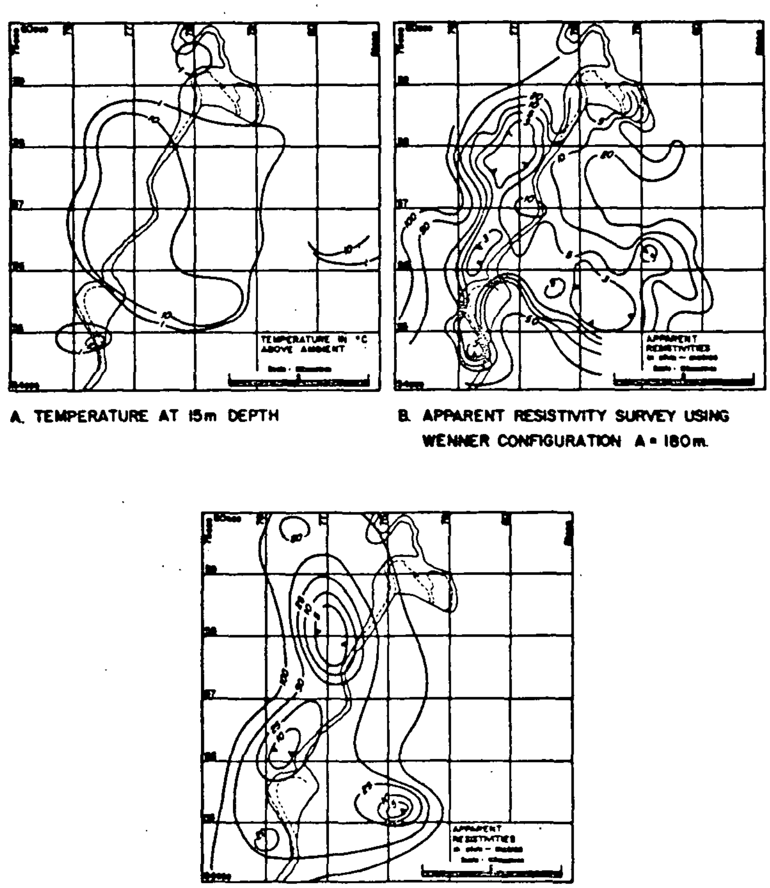


VARIATIONS OF SOLUTION RESISTIVITY
WITH TEMPERATURE AND SALINITY

FIG. 1

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

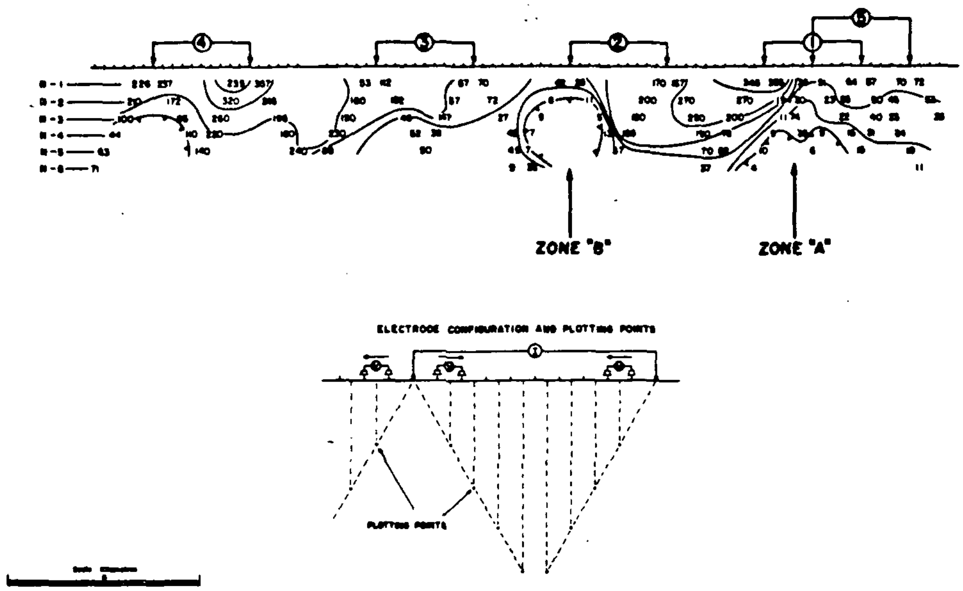


FIG. 3

RESISTIVITY SURVEY, IMPERIAL VALLEY–CALIFORNIA.

LINE–"O", FREQUENCY–0·125Hz.

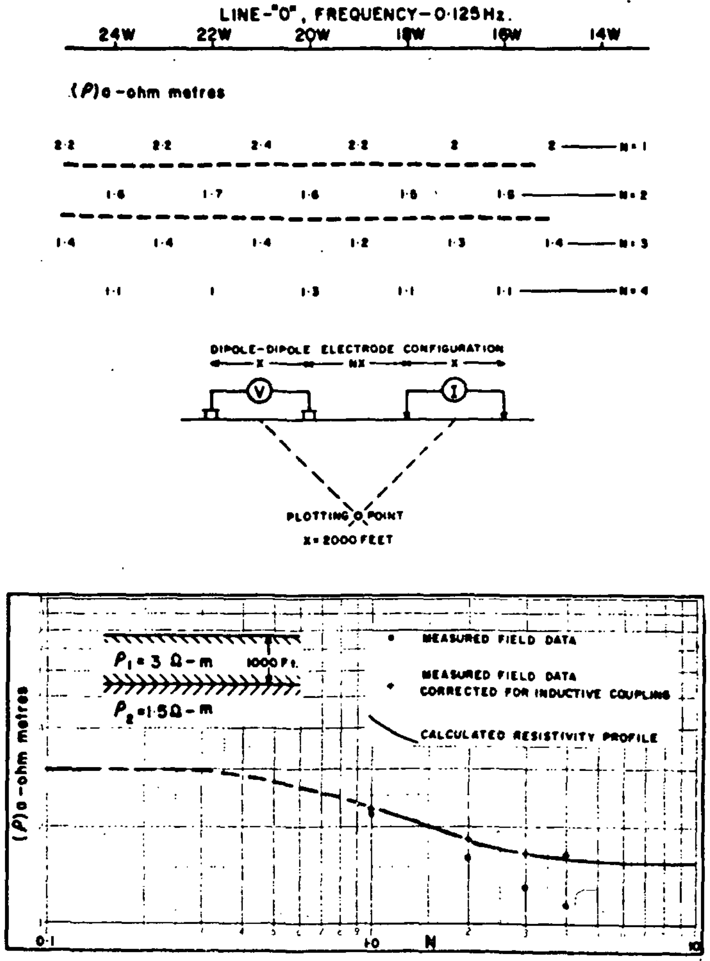
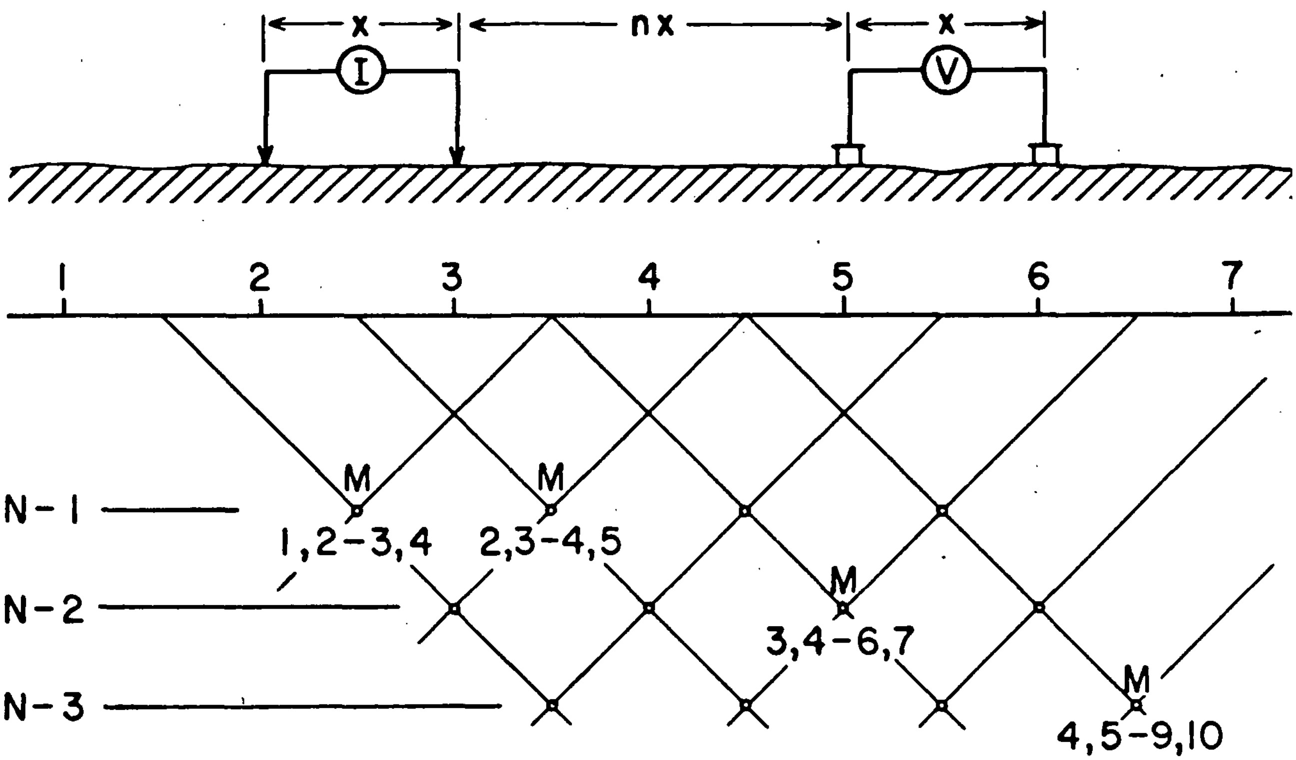


FIG. 4

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.

McPHAR GEOPHYSICS

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1. INTRODUCTION

At the request of Chevron Oil Company, McPhar Geophysics has completed a Reconnaissance Resistivity Survey in the San Emidio area, Washoe County, Nevada. The survey area is located in T.29N., T.30N. and R.22E., R.23E.

The San Emidio area is an arid, alluvium-filled valley, bounded on the east and west by mountains formed by assumed Pliocene volcanics. The valley is probably fault controlled and the north-trending faults could be conduits for geothermal fluids. Several wells are shown on the topography map of the area, but there is no indication of hot water.

The purpose of the Reconnaissance Survey was to locate and delineate low-resistivity zones that might indicate areas of concentrated thermal activity. Measurements were made with 2000 foot dipoles at one-through-four dipole separations along reconnaissance lines spaced approximately one mile apart. 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. Robert Anderson, geophysicist, under the supervision of Mr. William Mero of Chevron Oil Company.

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.
A	2000 feet	R-6139-1
B	2000 feet	R-6139-1
C	2000 feet	R-6139-1
D	2000 feet	R-6139-2
E	2000 feet	R-6139-2

Also enclosed with this report is Dwg. No. RP 4956, at a scale of 1" = 2000'. The definite, probable and possible resistivity low anomalies are indicated by bars, in a manner shown in the legend, on this plan map as well 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.

3. DISCUSSION OF RESULTS

The Reconnaissance dipole-dipole survey of the San Emidio area consists of four parallel north-south lines and one east-west line through the center of the valley. Anomalous responses of varying magnitude have been located along each survey line. A discussion of the resistivity results along each line follows.

Line A

Two broad, anomalous responses have been located along this line between 80N to 300N and 520N to 660N. A definite, shallow anomaly occurs between 80N to 160N and a moderate depth, definite anomaly occurs at 230N to 270N. These responses are connected by a probable anomaly from 160N to 230N and a probable anomaly extends from 270N to 300N. The shallow, definite response must be a near-surface phenomenon; the resistivity exhibits an increase on n = 3 and n = 4. The anomaly between 230N and 270N suggests some continuity with depth and appears to be a better drill target than the previous anomaly.

The anomalous response on the north end of the survey line appears as a definite, deep anomaly between 580N and 620N and extends as probable anomalies from 560N to 580N and 620N to 660N and a possible anomaly from 520N to 560N.

The resistivity measured between 340N and 480N is probably representative of the alluvial sediments that do not contain thermal and/or saline fluids.

Line B

This line was surveyed along the eastern edge of the valley. A very weak, shallow, possible anomaly with no continuity with depth occurs between 40N and 100N.

Line C

The survey results along this line, through the center of the valley, have located a broad anomalous response from 200N to 440N that is interpreted as a moderate to deep definite anomaly from 260N to 340N and probable anomalies from 200N to 260N and 340N to 440N.

The data measured beneath the definite anomaly approximate a two-layered earth and provide a "curve-matching" fit with a near-surface layer having a resistivity of 2.7 ohm feet and depth between 800 feet and 1000 feet, with the bottom layer having a resistivity of .9 ohm feet.

Line D

A weak, moderate to deep, possible anomaly has been located between 0 and 120S. The remainder of this line indicates a relatively high apparent resistivity.

The anomalous responses located on the more easterly lines do not extend far enough west to be located on this line.

Line E

The definite anomaly located between 60E and 170E on this east-west line does not appear to correspond to the definite anomalous responses on Line A and Line C. The attached resistivity scale model case provides a possible explanation for the apparent discrepancy.

The resistivity scale model case indicates that the measured resistivity pattern could be obtained from two parallel dipping conductors approximately one and a half units apart. This interpretation is shown on the plan map as two parallel zones connecting the anomalous responses on the north-south lines.

4. CONCLUSIONS AND RECOMMENDATIONS

The Reconnaissance Dipole-Dipole Resistivity Survey of the San Emidio area has outlined two parallel zones of low resistivity which may represent an area of increased thermal activity. These zones appear to be relatively narrow. They could possibly be fault zones containing thermal fluids from a much deeper source.

The trend of the zones appears to cut across the suspected regional trend of the area. Geological investigations in the San Emidio area should be conducted to determine the validity of this interpretation.

A definite, deep anomaly has been located in the extreme north end of the survey area. Additional work may be required to determine the extent of this anomaly.

The small areal extent of the anomalous responses measured during this survey suggests that if a geothermal reservoir does exist, it may not be large enough for economic development of geothermal energy.

McPHAR GEOPHYSICS INCORPORATED

Bruce S. Bell,
Geologist

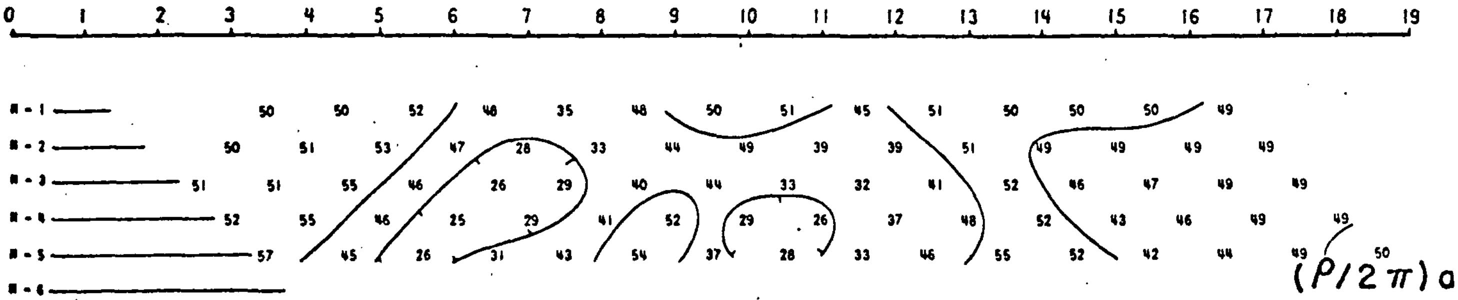
Philip G. Hallof,
Geophysicist

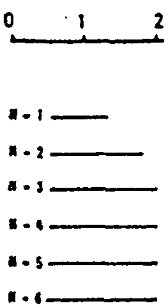
Dated: February 11, 1974

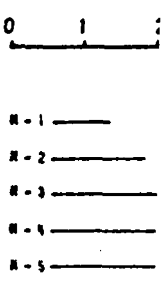
McPHAR GEOPHYSICS LIMITED

Theoretical Induced Polarization and Resistivity Studies

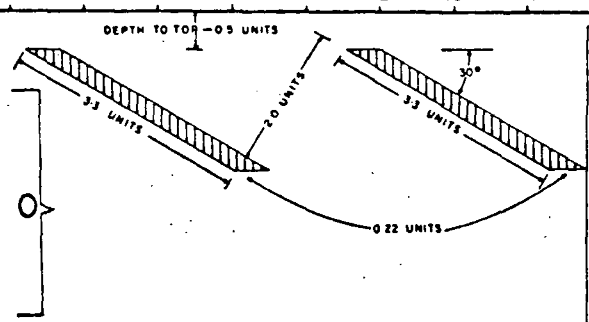
Scale Model Cases

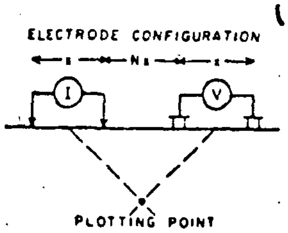


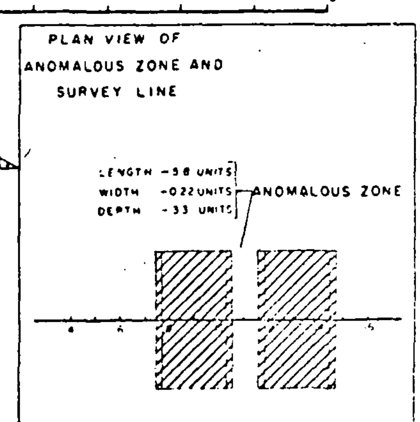




$(\rho/2\pi)_1 = 50 \quad (\rho/2\pi)_2 = 2{\cdot}0$







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