GL02272

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

McPHAR GEOPHYSICS

NOTES ON GEOTHERMAL EXPLORATION

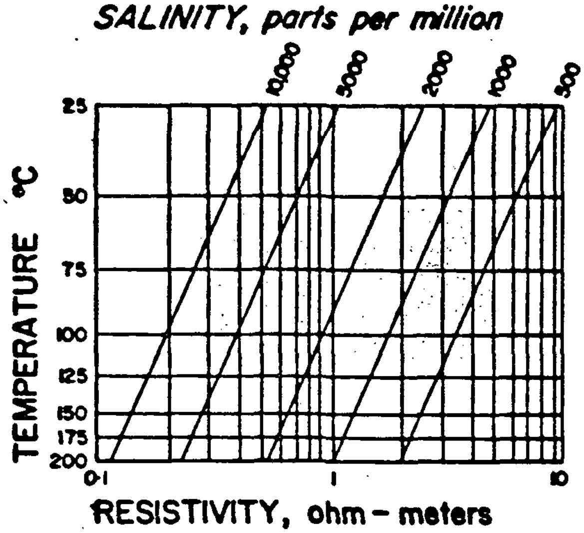
USING THE RESISTIVITY METHOD

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.

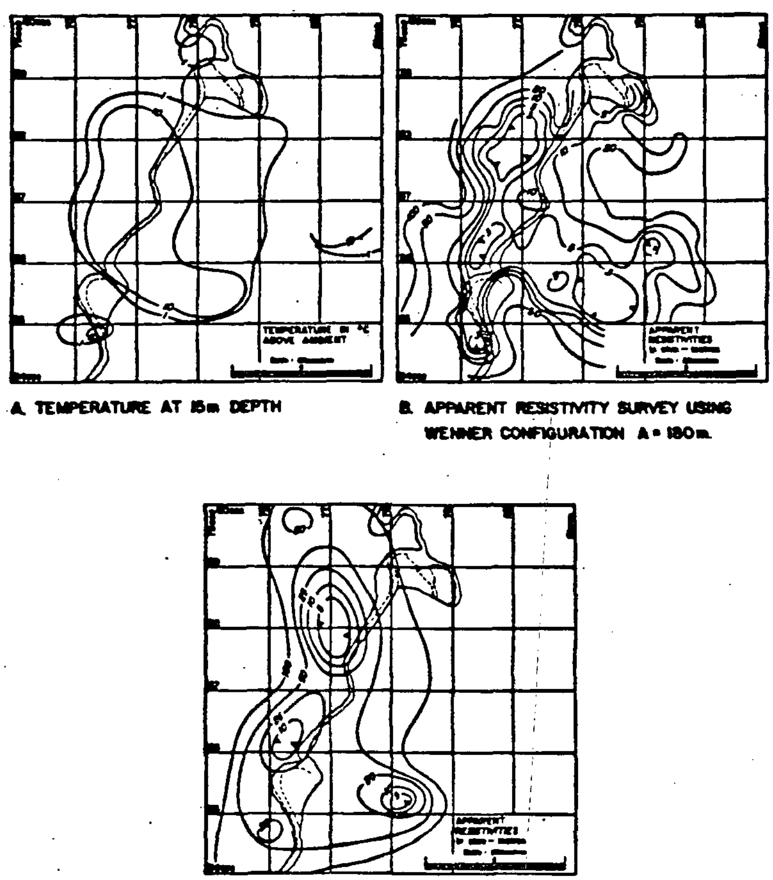


VARIATIONS OF SOLUTION RESISTIVITY
WITH TEMPERATURE AND SALINITY

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

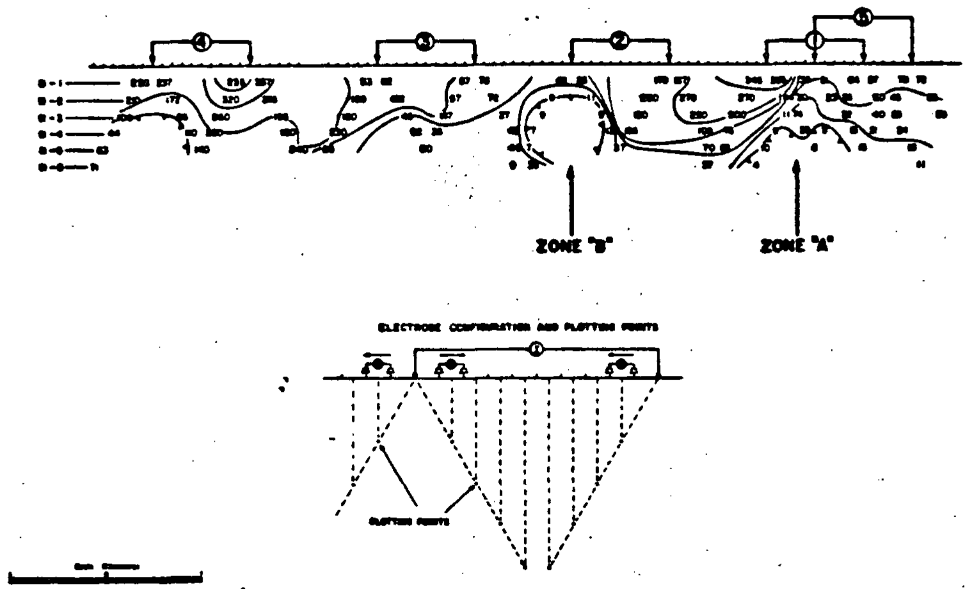


FIG. 3

RESISTIVITY SURVEY, IMPERIAL VALLEY–CALIFORNIA.

LINE-"O", FREQUENCY–0·125 Hz.

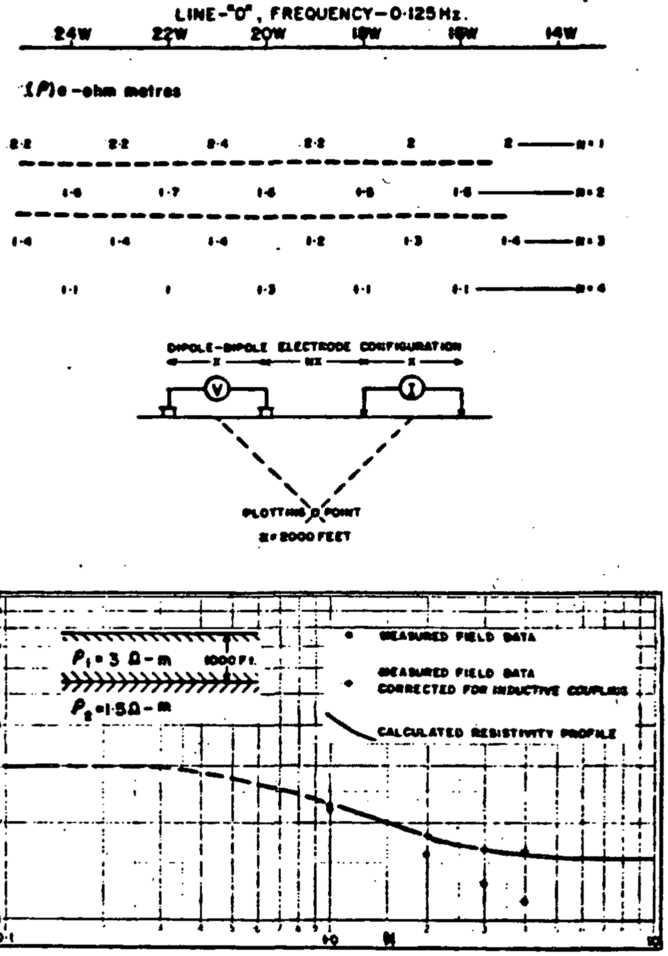
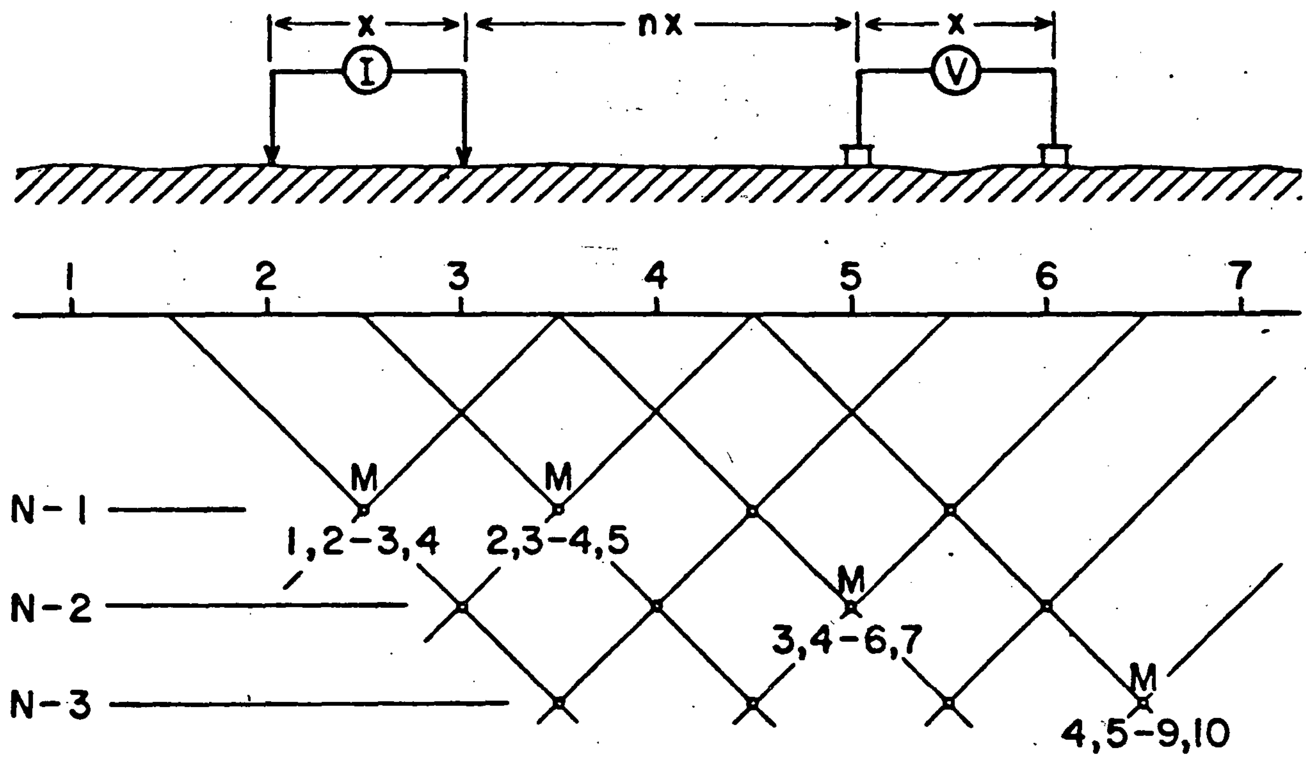


FIG. 4

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 completed a Reconnaissance Resistivity Survey in the Beowawe Area, Landers and Eureka Counties, Nevada. The survey area is located in T.31N., T.32N. and R.47E., R.48E. and R.49E.

The Beowawe area appears to be a down-dropped fault block underlain by Tertiary andesitic basalt flows which overlie Paleozoic silicious sediments. Faulting is evident in the area, the most pronounced is the Malpais fault which produced a scarp over 200 feet high. Eleven wells have been drilled by Magma Power Company in the area. The maximum recorded depth is 2052 feet with a maximum well temperature of 414°F. Numerous fumaroles and hot springs are located in the area and currently three of Magma's wells are blowing steam. This area has been designated a KGRA.

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-five dipole separations along reconnaissance lines spaced approximately one mile apart. A frequency of 0.125 Hz was used in order to minimise attenuation of the electric field due to eddy current dissipation of energy and at the same time avoid telluric noise.

The survey was supervised and conducted by Mr. Robert Anderson, geophysicist.

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.
1	2000 feet	IP 6180-1
2	2000 feet	IP 6180-1
3	2000 feet	IP 6180-1
4	2000 feet	IP 6180-2
5	2000 feet	IP 6180-2

Also enclosed with this report is Dwg. No. RP-4983, a plan map of the survey area showing the location of 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 apparent resistivity measured during this survey is relatively high compared to most areas McPhar has previously surveyed for Chevron Oil Company. In areas of high resistivity, geothermal reservoirs are more easily identified due to the high conductivity of the reservoirs compared to the surrounding rock. World-wide production of geothermal resources is in areas having resistivities less than 10 ohm meters.

This survey has located some areas of resistivity less than 10 ohm meters. A discussion of the results along each survey line follows:

Line 1

The anomaly interpreted on this line between 100N and 150N is probably a definite anomaly but since one critical set of dipole readings could not be obtained, the pattern is not complete and the anomaly is shown as probable

A cliff exists between 100N and 120N so it is almost impossible to obtain the essential data at this location. But from the readings obtained on each side of the cliff it appears that a shallow anomaly with possible continuity with depth is associated with the Malpais fault.

The missing data is across the area where Magma Power Company drilled their wells.

Line 2

A definite deep anomaly occurs between 100N and 140N and extends as a probable anomaly from 140N to 150N and a possible anomaly 150N to 180N.

The true resistivity section across the anomalous area indicates a conductive zone of less than 10 ohm meters underlying 2000 feet of high resistivity material. The conductive zone appears to increase in depth to the north.

Line 3

A probable deep anomaly exists between 110N and 170N.

One set of dipole readings has again not been recorded due to the steep cliff. The resistivity measured on each side of the missing data approximates a layered earth but the near-surface layer south of the Malpais fault has a lower resistivity than the surface layer to the north. The underlying layer, approximately 2000 feet deep, has a uniform resistivity above 15 ohm meters, for the entire survey line.

Line 4

A probable anomaly occurs between 40N and 120N and appears to be open to the south.

The true resistivity sections indicate a conductive source having a resistivity between 15 to 20 ohm meters at approximately 1000 feet deep beneath 40N to 80N and increasing in depth to the north.

Line 5

A shallow definite anomaly of less than 10 ohm meters occurs between

120N and 140N and does not exhibit any continuity with depth.

Possibly a low resistivity zone exists beneath 60N to 80N but the present data does not extend far enough south to allow interpretation.

4. CONCLUSIONS AND RECOMMENDATIONS

The Reconnaissance Resistivity survey of the Beowawe area has located anomalous responses along each survey line that appear to coincide with the Malpais Fault. The most interesting anomaly occurs on Line 2 between 100N and 140N at depth. This is the approximate location of a well which has just been completed by Chevron Oil Company.

This survey confirms that the test well was required and properly located. However, the data does not provide an alternative well site within the depth penetration limits of this survey.

A correlation of the resistivity data with the available well-hole data may assist in determining the location for another well.

McPHAR GEOPHYSICS INCORPORATED

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Dated: July 18, 1974