GL02278

PHOENIX GEOPHYSICS INC.

REPORT ON THE
RECONNAISSANCE RESISTIVITY SURVEY
OF THE
BEOWAWE AREA, LANDER COUNTY, NEVADA
FOR
CHEVRON OIL COMPANY

PHOENIX GEOPHYSICS INC.

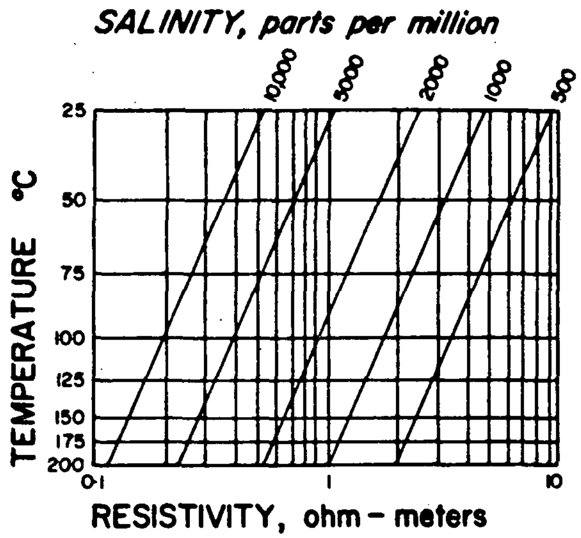
NOTES ON GEOTHERMAL EXPLORATION USING THE RESISTIVITY METHOD

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.

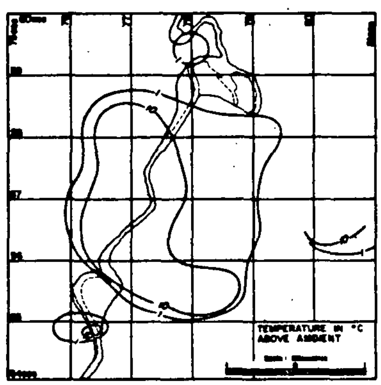


VARIATIONS OF SOLUTION RESISTIVITY
WITH TEMPERATURE AND SALINITY

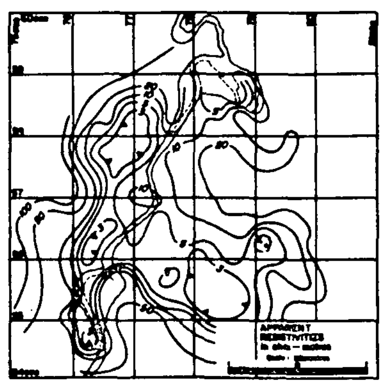
FIG. I

GEOPHYSICAL SURVEY

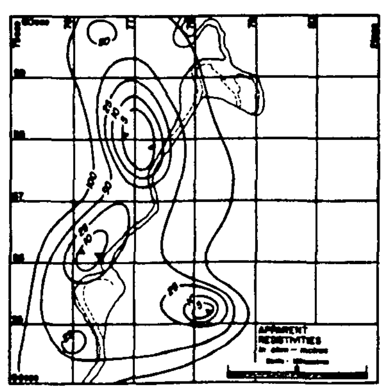
BROADLANDS AREA, NEW ZEALAND



A. TEMPERATURE AT 15m DEPTH



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



C. APPARENT RESISTIVITY SURVEY USING LOOP TO LOOP ELECTROMAGNETIC METHOD

COIL SEPARATION • 65 metres FREQUENCY • 440 Hz

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–Bator Road

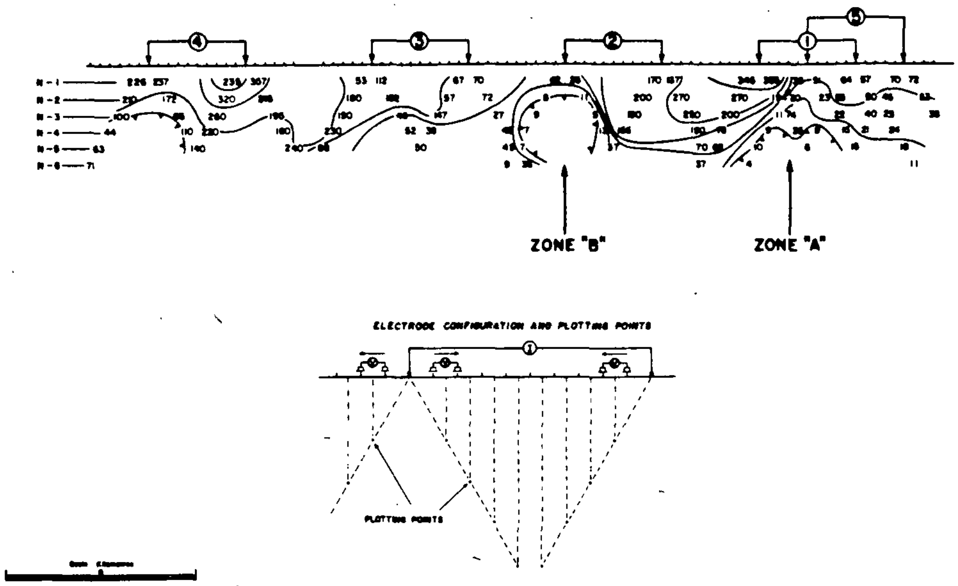


FIG. 3

RESISTIVITY SURVEY, IMPERIAL VALLEY-CALIFORNIA.

LINE-"O", FREQUENCY–0·125Hz.

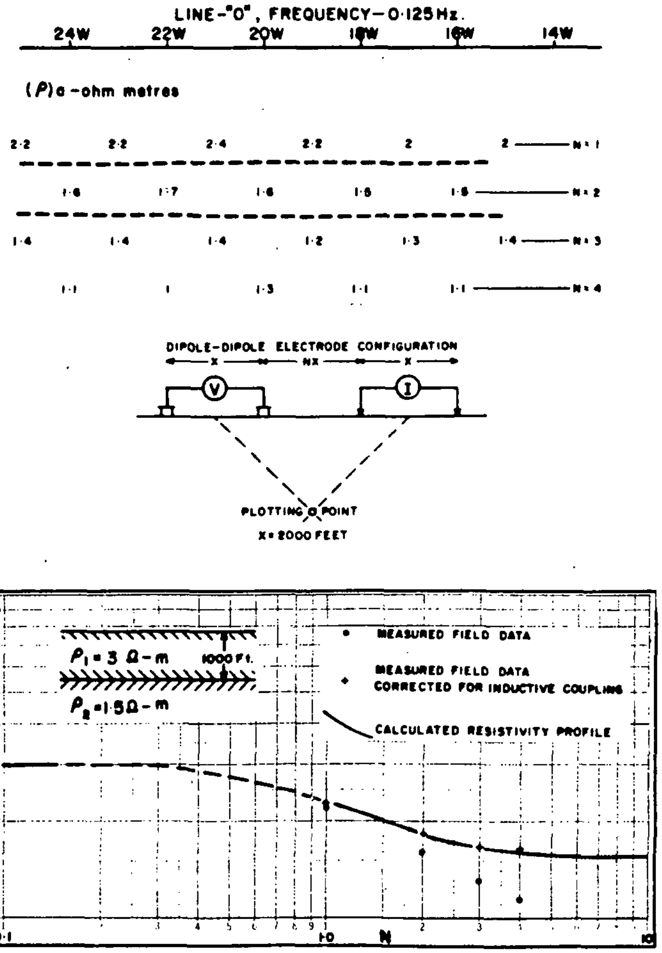
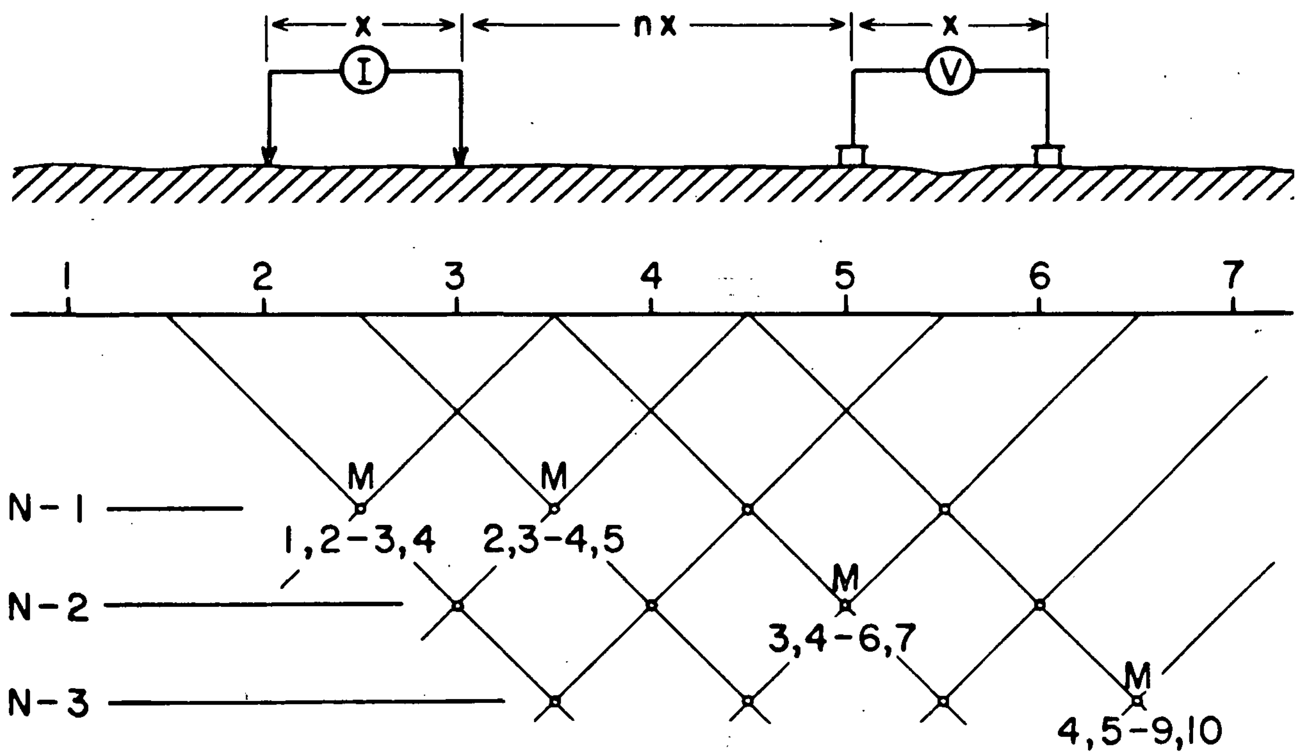


FIG. 4

data is then contoured (see below). The contour plots are <u>not</u> 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.

REPORT ON THE

RECONNAISSANCE RESISTIVITY SURVEY OF THE BEOWAWE AREA, LANDER COUNTY, NEVADA FOR CHEVRON OIL COMPANY

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1. INTRODUCTION

At the request of Mr. Robert Edmiston, geophysicist for Chevron Oil Company, Phoenix Geophysics has completed a Reconnaissance Resistivity Survey in the Beowawe area, Lander County, Nevada. The survey area is situated in T.30N, T.31N and R.47E of Lander County.

Several previous reconnaissance resistivity surveys conducted in the Beowawe area located some possible to definite anomalies adjacent to the Malpais Fault immediately to the east of this survey area. Several wells have been drilled in the vicinity of the previous anomalies which are coincident with thermal springs.

The purpose of this Reconnaissance Resistivity survey was to determine if areas of low resistivity, which may represent zones of increased thermal activity, extend to the west of the previously located anomalies located adjacent to the Malpais Fault. Measurements were made with 2000 foot dipoles at one-through-six dipole separations along four parallel 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. John Reynolds, geologist-crew chief, during the period July 19 to August 11, 1976. A transmitted current of

3.2 amps to 15 amps was required to obtain potentiometer readings that varied between 94 microvolts and 195 millivolts.

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.
BE-76-1	2000 foot	R-U-5018-1
BE-76-2	2000 foot	R-U-5018-1
BE-76-3	2000 foot	R-U-5018-2
BE-76-4	2000 foot	R-U-5018-2

Also enclosed with this report is Dwg. No. RP-U-5018, a plan map of the survey area at a scale of 1" = 2000' showing the location of the survey lines and an interpreted true resistivity section along each survey line. The definite, probable and possible Resistivity low anomalies are indicated by bars, in a manner shown in the legend, on the plan map as well as on the data plots. These bars represent the surface projection of the anomalous responses as interpreted from the location of the transmitter and receiver electrodes when the anomalous values were measured

Since the Resistivity measurements is essentially an averaging process, as are all potential methods, it is frequently difficult to exactly pinpoint the source of an anomaly. Certainly, no anomaly can be located with more accuracy than the electrode interval length. In order to locate sources at some depth, larger electrode intervals must be used, with a corresponding increase in the uncertainties of location. Therefore, while the center of the indicated anomaly probably corresponds fairly well with source, the length of the indicated anomaly along the line should not be taken to represent the exact edges of the anomalous material.

The anomalies shown on the plan map are designated apparent depths of shallow, moderate, or deep. At larger dipole separations a greater volume of rock is averaged, in lateral extent as well as depth. Thus, the source of a deep-appearing anomaly detected along a single line may be at shallow depth to one side of the line. The data plots, therefore, cannot represent true depth. Depths can be calculated from the apparent resistivity data in the case of ideal horizontal layers, but even this calculation depends on an assumed resistivity contrast between the zone at depth and the overlying rock. Although ambiguous, the following simple depth designations are useful for correlating or comparing anomalous zones obtained on adjacent survey lines.

	Apparent Depth (dipole separations)	Drill Hole Depth (in dipole lengths)
Shallow	1 - 2	1/2 - 1
Moderate	2 - 3	1 - 1-1/2
Deep	3 - 5	1-1/2 - 2+

Thus, a shallow zone is one detected at a one-to-two dipole separation and should be tested by a drill hole from a half-to-one dipole length deep.

3. DISCUSSION OF RESULTS

The Reconnaissance Resistivity survey of the Beowawe area has located some weak anomalous responses that occur in the west end of the Whirlwind valley and have a true resistivity of approximately 10 ohm meters. Generally, these weak anomalous responses would probably not be of interest, but since they commence adjacent to the Malpais fault along which hot springs occur, additional work may be warranted.

A probable anomaly has been interpreted to occur on Line BE-76-1 between 150N and 270N. This anomaly occurs at shallow depth between 220N to 270N and appears to dip to the south. It could be assumed that this anomaly is the result of geothermal fluids ascending from the Malpais fault at depth beneath 150N, since the low resistivities at moderate depth beneath 160N to 180N have a true resistivity approaching 5 ohm meters.

The other interpreted probable anomalies located on Line BE-76-2 from 160N to 300N and Line BE-76-3 from 260N to 340N also have a true resistivity of approximately 10 ohm meters. These anomalies do not approach the surface as on the previous line, but again, both responses appear to originate adjacent to the fault and extend across the valley.

The remainder of the survey area exhibits true resistivities higher than the expected response from a thermally active area and indicates that no geothermal sources are present within the depth penetration of this survey.

4. CONCLUSIONS AND RECOMMENDATIONS

The Reconnaissance Resistivity survey of the Beowawe area has located three weak anomalous responses that have a true resistivity of approximately 10 ohm meters. Each anomaly appears adjacent to the Malpais fault and may represent thermal fluids ascending from depth. However, the true resistivity of these anomalies suggests that if the source is thermal fluids, the temperature of these fluids are not high enough nor is the areal extent large enough to be of commercial interest.

A complete evaluation of all geological, geophysical and geochemical data is required to determine if a test drill hole is warranted in this area. These survey results suggest a test hole is not warranted.

PHOENIX GEOPHYSICS INC.

Bruce S. Bell
Geologist

Dated: September 17, 1976