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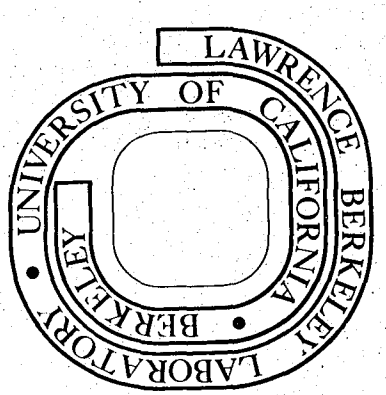

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SELF-POTENTIAL SURVEY AT THE CERRO PRIETO GEOTHERMAL FIELD, BAJA CALIFORNIA, MEXICO

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Introduction

In December 1977, two self-potential survey lines were run across the producing area of the Cerro Prieto geothermal field, located about 30 km south of Mexicali, Baja California, Mexico. The purpose of the survey was to determine whether significant self-potential variations were related to the known geothermal activity.

Instrumentation and Measurement Procedure

Self-potential measurements were made using copper-copper sulfate electrodes and a Fluke model 8020A digital multimeter. A "leapfrog" survey technique, in which the leading and trailing electrodes of a short measuring dipole are alternated to reduce cumulative error due to electrode polarization, was used, and the polarization of the survey electrodes was checked periodically in a bath of copper sulfate solution. Dipole spacing was 100 m on line B-B' and 150 m on line A-A'. The potential at the 0 km point on line B-B' was arbitrarily set equal to zero, and all other potentials on both lines refer to this point. Telluric current variations were recorded continuously across a stationary dipole located between 0 and 250 m W on line B-B'.

Survey Results

The locations of the survey lines are shown in Fig. 1. The tortuous course of line B-B' was necessitated by the presence of numerous irrigation canals to the east of the railroad tracks. The self-potential data for line A-A' are shown in Fig. 2, together with a geologic cross-section along a parallel line about 900 m to the southwest. The data for line B-B', projected onto a straight line parallel to a line connecting points B and B' in order to reduce scalar distortion, are shown in Fig. 3. Also shown in Fig. 3 are a geologic cross-section along roughly the same straight line and an electrical model for the self-potential profile (discussed below).

The most significant feature of the self-potential profile along line A-A' is the 150 mV potential decrease extending from about 2N to 5S. A similar 120 mV decrease, with somewhat greater slope, extends from about 0 to 4E on line B-B'. Except for a steep drop centered at about 5E, the potential on line B-B' appears to show a generally

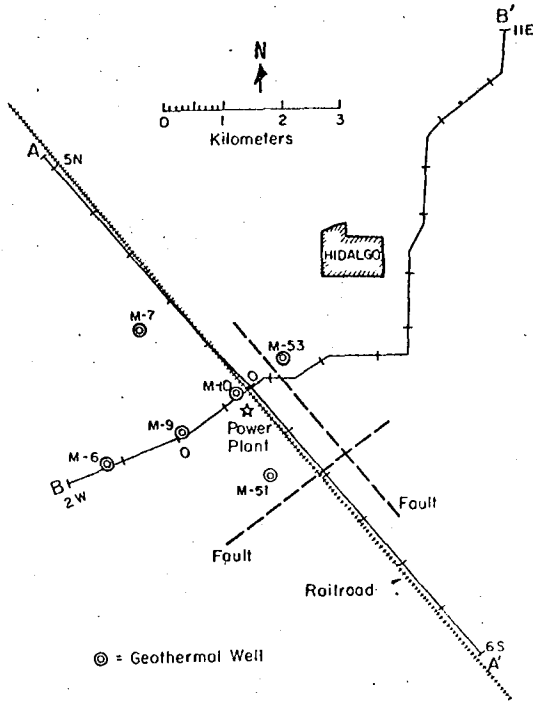

Fig. 1. Self-potential survey lines, Cerro Prieto geothermal field, Baja California, Mexico.

positive trend to the east beginning at about 4E. As the typical background noise level for the area is of the order of ±5 to ±10 mV (for example, between 4N and 2N on A-A'), the 150 mV variation on line A-A' and the 120 mV variation on line B-B' are well above the noise level. It is possible that these variations were caused by cumulative error, as the survey lines were not run in closed loops. However, experience with the survey method used indicates that loops of 5-10 km length usually close within 20 mV or less.

Although the variation on line A-A' appears to be purely monoclinal, the profile on line B-B' appears to be returning to a possible zero level to the east. If we assume that both variations represent the flexural portions of very long-wavelength anomalies, the variations may be re-

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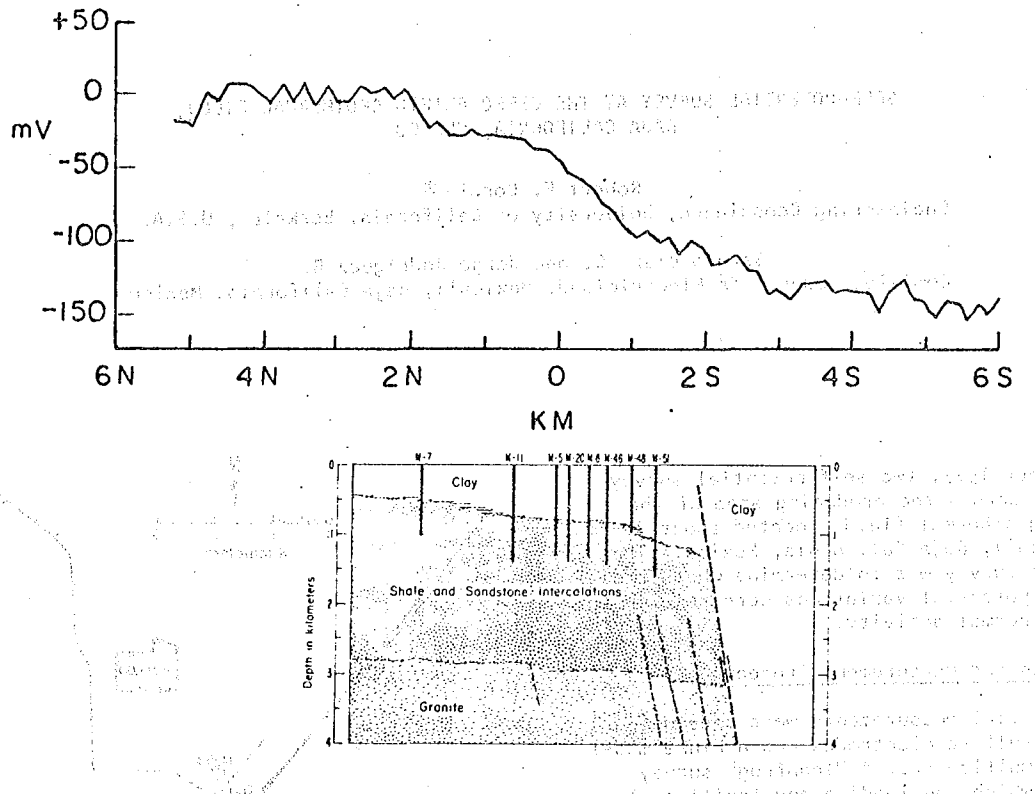

Fig. 2. Self-potential profile and geologic cross-section for line A-A'. (Cross-section from Manon, et al., 1977.)

lated to thermal activity along the major faults at about 2S on line A-A' (Fig. 2) and 2E on line B-B' (Fig. 3), which are thought to act as conduits for the thermal fluids (Noble, et al., 1977).

Fig. 3 illustrates one way by which electrical activity confined to a fault zone may generate anomalies similar to those seen on lines A-A' and B-B'. The dashed line on the self-potential profile is the signal generated by the electrical model shown at the bottom of the figure. The key assumptions for the model are that the activity is horizontally dipolar in nature, extends to a depth of several km along the fault zone, and increases in magnitude with increasing depth. These assumptions do not seem to be geologically unreasonable. A dipping fault plane, or a change in resistivity across the fault zone, could shift the inflection point of the curve so that it is no longer directly above the fault. Also, the apparent wavelength of the anomaly will be increased if the traverse is not perpendicular to the strike of the fault. This may be the case on line A-A', where the strike of the fault crossing the line is not well established.

We have not made any assumptions about the source of the electrical activity in the fault zone. Scuh activity may be generated by a flow of fluid in the fault zone (electrokinetic coupling) or by the elevated temperature of the thermal fluid (thermoelectric coupling) (Corwin, 1976). Analytical techniques for relating thermal and electrical activity are presently being developed, and will be applied to the Cerro Prieto case once more complete field data are obtained (in the spring of 1978).

Conclusions

Large-amplitude, long-wavelength self-potential anomalies are seen in the Cerro Prieto geothermal field. The inflection points of the anomalies are roughly centered over two major faults thought to act as conduits for the thermal fluids, and the form of the anomalies indicates that they may be generated by electrical activity extending to a depth of several km along the fault zones. Thus, self-potential measurements may be helpful in tracing thermally active fault zones in the Cerro Prieto area.

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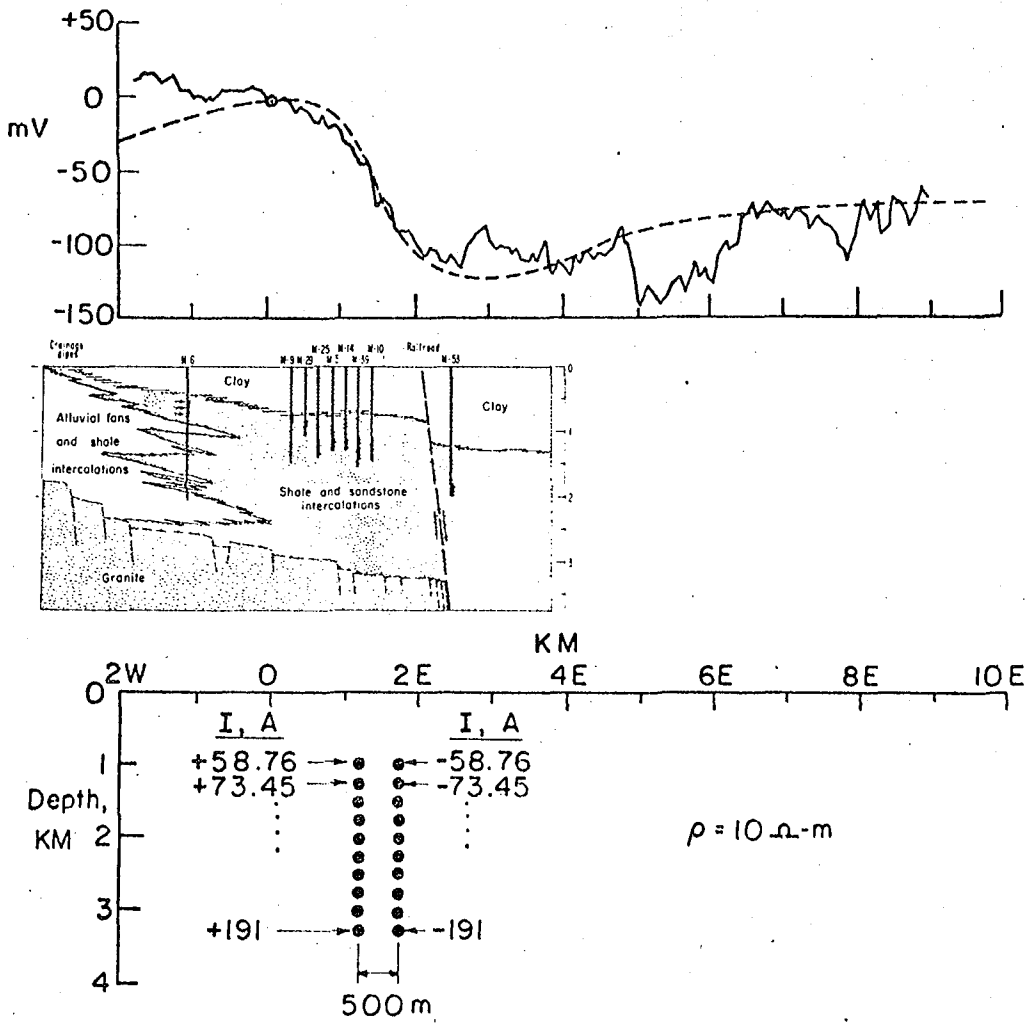

Fig. 3. Self-potential (projected onto a straight line), geologic cross-section (from Manon, et al., 1977), and electrical model for line B-B'. The dashed line on the self-potential profile is generated by the electrical model, which consists of a vertical sequence of current dipoles, each of magnitude ($\pm$ 58.76 z) amps, where z is the depth of the dipole in km.

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