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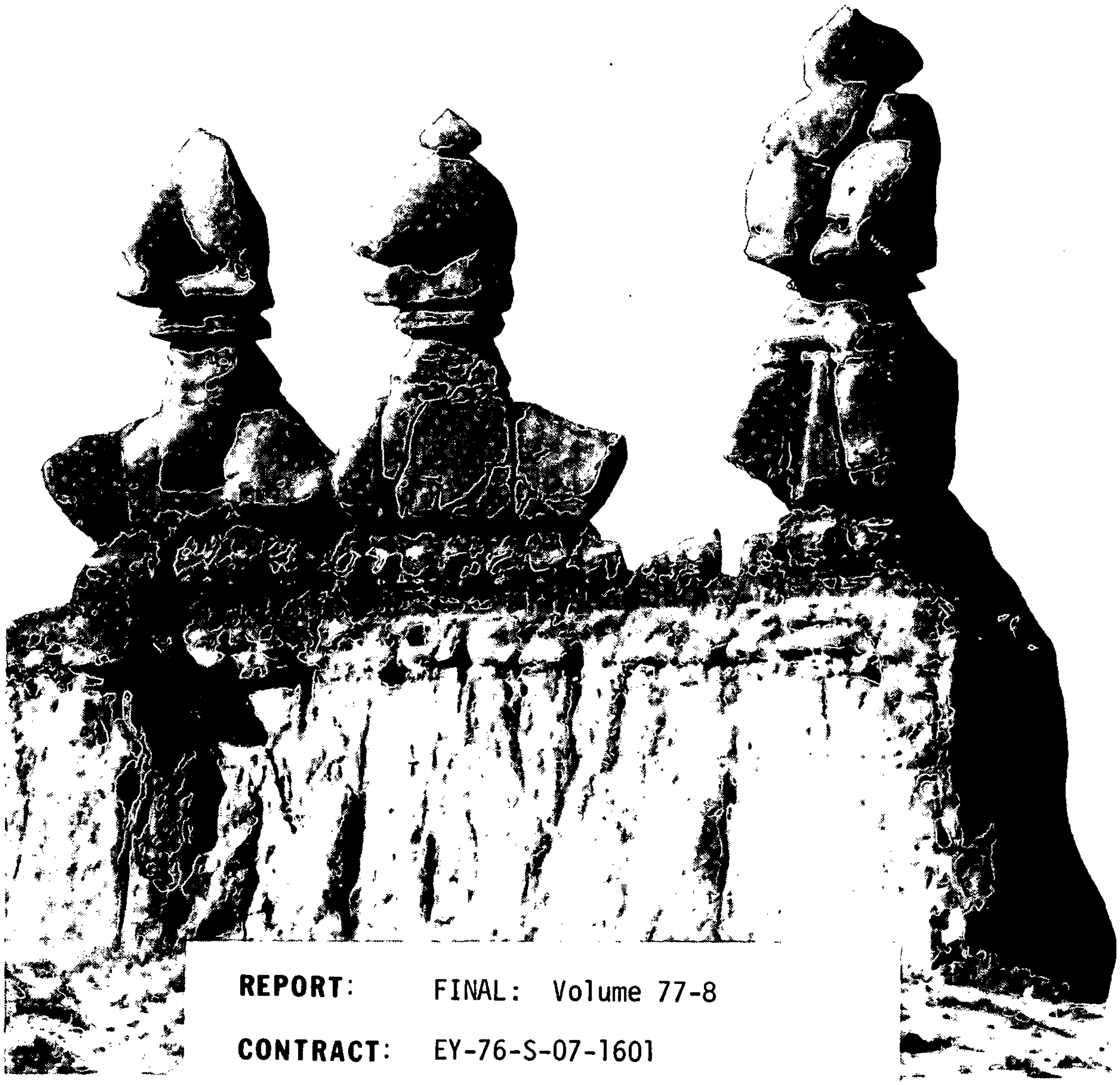
DEPARTMENT OF GEOLOGY AND GEOPHYSICS



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ELECTRICAL ENERGIZING OF WELL CASINGS

By

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1.0 Introduction

Electrical measurements of several kinds were made at Roosevelt Hot Springs KGRA using the casings of two producing wells as electrodes. One purpose of these measurements was to determine if a "mise a la masse" measurement could provide useful information on the fault system which controls the near surface and deeper circulation. A second purpose was to determine if the introduction of the current deep into the conductive part of the system, via the well casing, would provide any additional information about the conductivity at depths below the near surface conductor.

All the measurements were made using a Resistivity-IP transmitter and a standard resistivity-IP receiver (Geomite), as well as a general purpose high impedance amplifier and oscilloscope. The current excitation was a square wave with an amplitude of 20 amps and a frequency of 0.3 Hz. The current electrodes were the well casings of Phillips Petroleum Company wells numbers 13-10 and 12-35. The depth of the casing in these wells are 522 m (13-10) and 1340 m (12-35). The distance between the wells is about 4 km (*figure 1*) giving a bipole oriented at N25E^{o}, which is situated over the near surface zone of low resistivity (Ward and Sill, 1975; 1976).

2.0 Equipotential Measurements

Figure 1 shows a plot of the equipotentials in the near vicinity of the wells. These potential measurements were made using 100 m dipoles, end to end. Since only the amplitude of the potential difference could be measured, it was assumed that the potentials smoothly varying in summing the potential differences to get the potentials. The zero reference for the potential measurements is a measurement point 100 m west of well 13-10.

As can be seen in Figure 1, the equipotentials are highly distorted from the regular circular shape that would be observed in a homogeneous earth. The equipotentials around the southern electrode are roughly parallel the mountain front in the east, except for a pronounced bulge to the southeast into Big Cedar Cove. The flattening of the contours parallel to the mountain front are caused in part by the strong resistivity contrast between the conductive alluvium and the resistive granite of the mountains. The bulge of the contours into Big Cedar Cove could be due to the extension of a conductor into this region or perhaps just a greater thickness of alluvium in the cove.

To the south of electrode 13-10, the contours bend abruptly from N-S to approximately E-W. These equipotentials are roughly parallel the E-W faults (shown dotted on Figure 1) that terminate the southern end of the system. To the west and the north, around electrode 12-35, the contours tend to be more regular, perhaps indicating less drastic conductivity contrasts.

Figure 2 shows two potential profiles, one to the NE from 13-10 and the second in a SW direction. To the SW the semilog plot shows a long region of nearly constant slope, indicating that over these distances the potential is falling off as the log of the radius. This is as would be expected for a line electrode. Evidently the well casing (500 m) looks like a vertical line electrode over distances from a few hundred meters to a few kilometers. The line to the northeast shows more deviations from the linear trend as might be expected since this is in the direction of strong conductivity contrasts between the alluvial fill and the mountains.

The potential difference measurements can also be used to calculate apparent resistivities. In the vicinity of the electrodes, such apparent resistivities ranged from 10 to 50 ohm-meter, in general agreement with other surface measurements (Ward and Sill, 1976). These apparent resistivities were also used to look for conductive zones where the profiles crossed certain of the faults, without much success.

3.0 Vector Electric Field and Resistivity Measurements

At distances between 2 and 15 km, potential measurements were made with an orthogonal set of 300 m dipoles. This set up is essentially the same as that used in the roving bipole-dipole scheme, except that vertical line electrodes were used. One part of this experiment was to have been dual measurements using surface point electrodes as well as the vertical line electrodes. The purpose was to see if introducing current deep into the system would provide additional information on the conductivity of the system at great depth. Unfortunately experimental difficulties prevented the reoccupation of the measurement sites using the surface point electrodes (the motor generator burst into flames and started a range fire).

Figure 3 shows the results of the measurements using the well casing electrodes. The measurement site is shown as a dot, the vector shows the direction of the calculated electric field for a homogeneous earth and the line through the point shows the direction of the observed electric field. The number next to the station is the apparent resistivity calculated from the magnitude of the electric field.

In general there is quite a bit of variability between the calculated and observed electric field directions. This is probably not surprising as it is well known that local conductivity anomalies can easily distort the electric field. There doesn't seem to be any overall systematic pattern in the electric field deviations from the theoretical pattern. Locally the patterns may be systematic, for example the three stations extending south from 13-10 along the west side of the range, all show deflections toward the conductive valley.

The apparent resistivities calculated from the magnitude of the observed electric field are about what might be anticipated from other resistivity surveys. Values from 10 to 50 ohm-meter are observed to the west in the alluvial valley fill and in the near vicinity of the electrodes which are in the near surface conductive region. The values in the Mineral Range and to east of the range are generally greater than 150 ohm-meter. There is some slight indication that the resistivity may be generally lower towards the northeast from the dipole. Toward the southeast the apparent resistivities generally increase with distance.

4.0 Conclusions

Distortions of the equipotentials in the vicinity of the electrodes provides some information about the conductivity structure, which is in general agreement with the results from other electrical measurements. For example the angular nature of the contours to the SE of the southern electrode, show the effects of the large conductivity contrasts that exist between the dome fault and the Mineral Range and also the strong fault control of the termination of the system to the south.

The potential falls off more or less logarithmically with distance, indicating that the well casing is acting as a vertical line source at least for distances between a few hundred meters and few kilometers.

The vector field measurements at large distances don't reveal any significant surprises. To the southeast the apparent resistivity increases with distance (depth). In this direction the measurement profile passes through or near several of the volcanic domes in the Mineral Range. In looking for the deep seated source one might consider the region of the domes, but these resistivity measurements do not show any gross effects of a deep conductor. However, there is some slight indication that the resistivity is smaller to the northeast of the dipole.

The final part of this experiment, which was to test whether any appreciable difference would be measured between surface and deep electrodes, was aborted due to equipment failure and later the withdrawal of permission to use the well casings as electrodes.

References

Ward, S. H. and W. R. Sill, 1975, Dipole-dipole Resistivity Surveys, Roosevelt Hot Springs KGRA, NSF-GI-43741, Final Report Volume 2.

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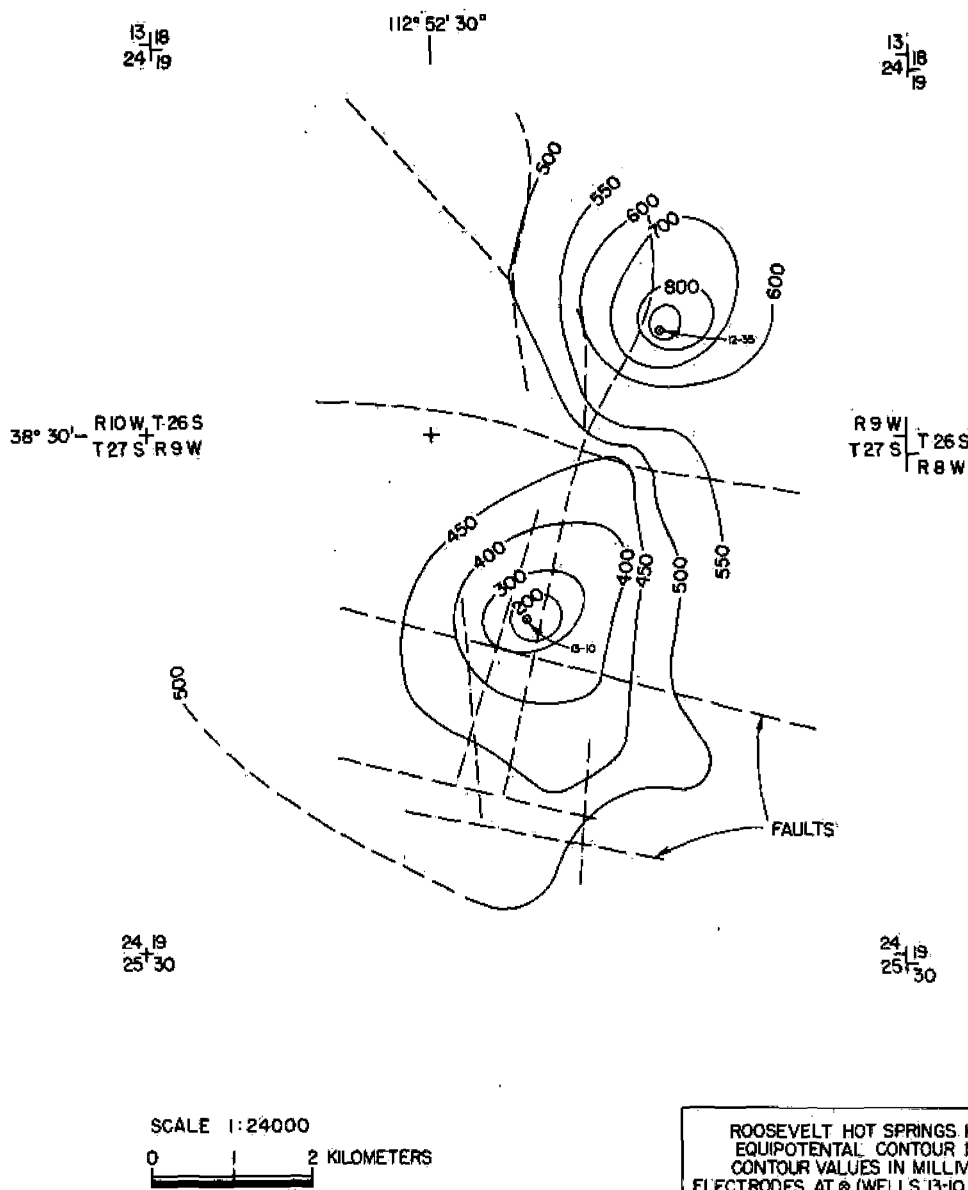
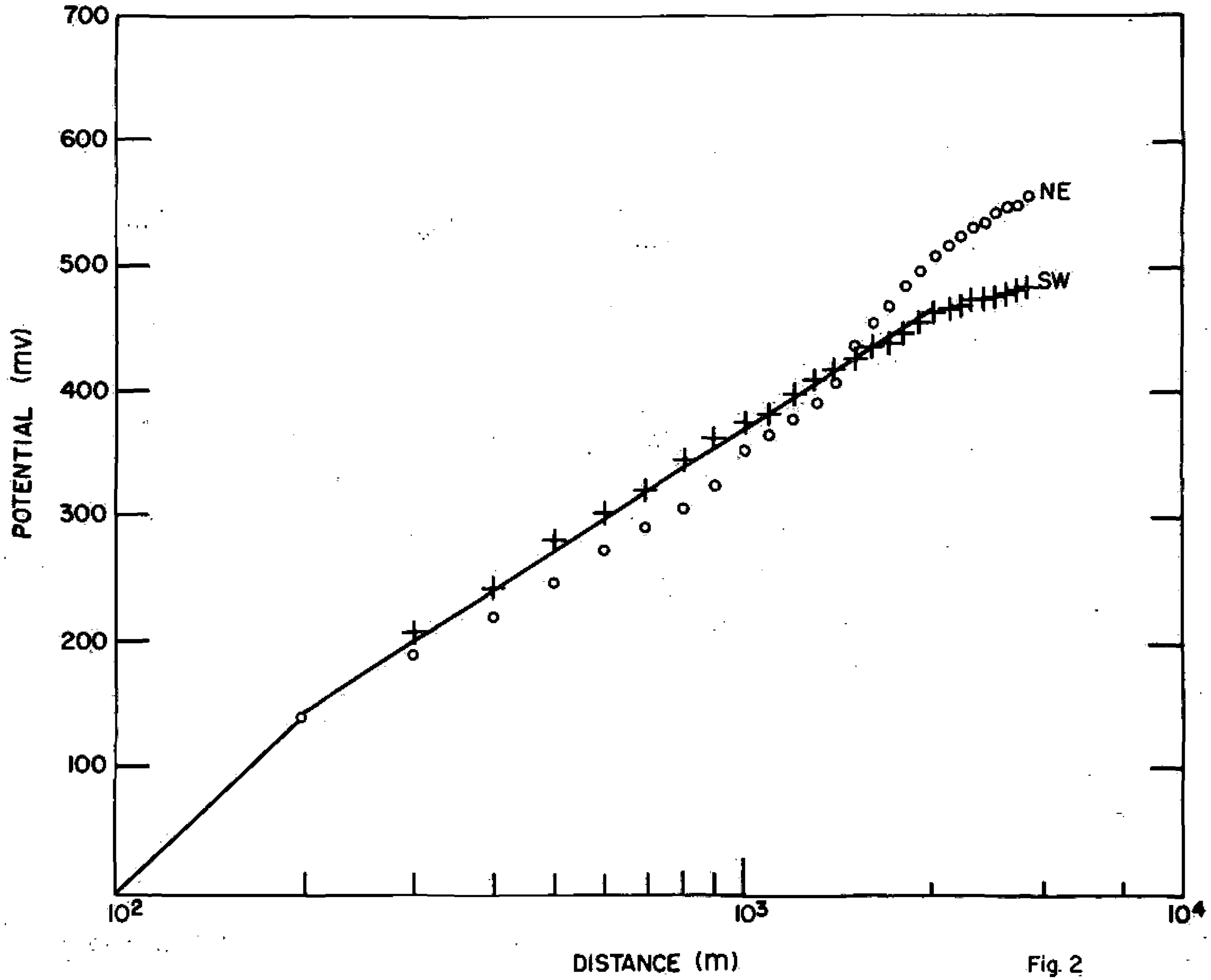


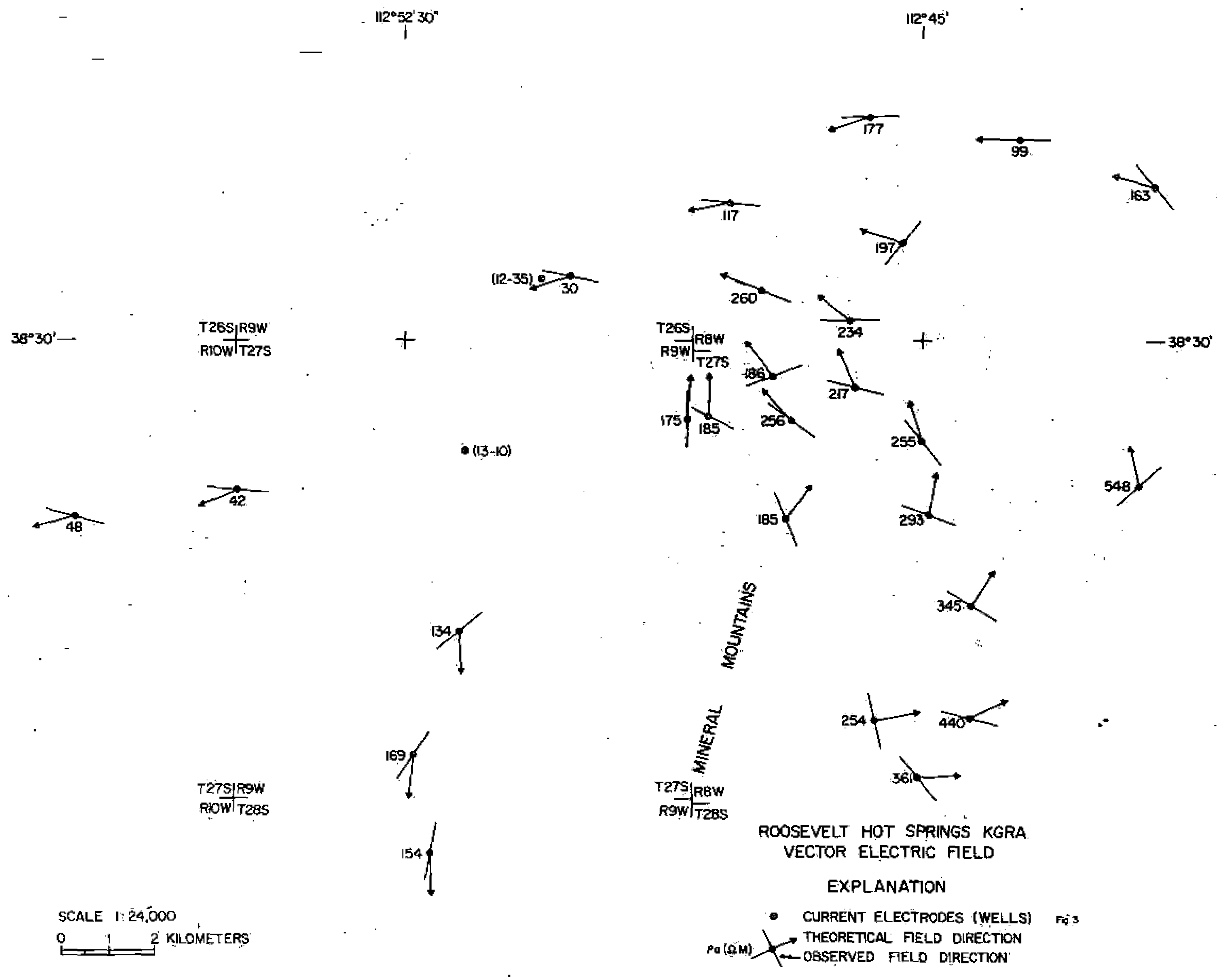
ROOSEVELT HOT SPRINGS KGRA
EQUIPOTENTIAL CONTOUR MAP
CONTOUR VALUES IN MILLIVOLTS
ELECTRODES AT ⊗ (WELLS 13-10 AND 12-35)

Fig. 1



POTENTIAL (mv)
700
600
500
400
300
200
100
NE
SW
10^2
10^3
10^4
DISTANCE (m)

Fig. 2



ROOSEVELT HOT SPRINGS KGRA
VECTOR ELECTRIC FIELD

EXPLANATION