THE ELECTRICAL RESISTIVITY METHOD OF GEOPHYSICAL PROSPECTING AND ITS APPLICATIONS TO GEOTHERMAL EXPLORATION IN THE RIFT VALLEY OF KENYA

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ABSTRACT

In 1971 the East African Power and Lighting Co. Ltd. (EAPL) in collaboration with the United Nations Development Programme (UNDP) initiated an investigation in the Rift Valley of Kenya to explore and evaluate the potential of the geothermal resources for the production of electric power. The regions selected, Olkaria, Eburru and Lake Bogoria, for carrying out detailed geophysical and geochemical surveys had been previously recognised from extensive ground geological work, infra-red aerial photography, water well drilling and reconnaisance geophysical surveys carried out by various groups over the last ten years. This thesis reviews the previous work done and describes the work done by the author at the three prospects to outline the geothermal reservoirs using the electrical resistivity method. A ground magnetic survey was also carried out at the Olkaria prospect.

At the Olkaria area various electrical configurations were tested along a profile and it was found that the Polar-dipole array was the most suitable from the point of view of field operations depth of investigation and resolution. This array was used to carry out a detailed resistivity survey of the Olkaria area, in order to outline the boundaries of the geothermal system. A well defined resistivity low of 10-30 ohm-m bounded by resistivities of 100 ohm-m was defined at a depth of 250m - a resistivity contrast of 1:10 in going from the geothermal to the non-geothermal environment. At a depth of about 1 km the resistivity contrast was found to be lower i.e. 1:5. Several zones of low resistivity

of less than 10 ohm-m were also outlined at this depth. Boreholes sited in one of these low resistivity anomalies have been successful in producing a steam-water mixture under pressure, with a maximum temperature of 280°C at a depth of 1350 m. The magnetic survey outlined a large positive anomaly associated with the whole of the central part of the geothermal area, superimposed by a shallow negative anomaly. The positive anomaly has been interpreted as representing a reversely magnetised source at a depth of 3-4 km, and the negative anomaly as representing hydrothermally altered zones where the conversion of magnetic minerals into non-magnetic minerals have caused a local reduction in reversely magnetised rocks. The successful boreholes OLK.2,3,4, are located within one of these magnetic lows. The magnetic survey has shown that the technique offers considerable scope in mapping intrusives and hydrothermally altered zones when used in conjuction with other geophysical methods.

Electrical resistivity measurements made at the Eburru prospect indicate that the area is underlain by an extensive reservoir or flow of hot chloride water and that the steam supplying the fumaroles is channeled to the surface through faults from the boiling of this chloride water. The characteristic high resistivities of the surface rocks are attributed to the desaturation of rocks by the escaping steam. Resistivity measurements indicate that hot water from Eburru flows to the north towards Lake Elmenteita. A borehole at the summit of Eburru and another one at the northern foot of the volcano are suggested to test the vertical extent of the steam zone, and the temperature and character of the underlying hot water body.

The presence of hot water and steam around Lake Bogoria indicates that the heat flow in the immediate environs of the lake is large and that a large heat source must exist in the vicinity of the lake. Electrical resistivity and temperature measurements indicate that the source is in the southern bay, and that hot water flows from south-east to the west and north, and around the margins of the lake steam ascends through faults and mixes with the hot chloride water to produce springs. The most favourable site to test the geothermal potential is the south-eastern shore of the lake.