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Short Communication

TELLURIC POTENTIALS RECORDED SIMULTANEOUSLY AT THREE SITES NEAR CANBERRA, A.C.T. (AUSTRALIA)

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ABSTRACT

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Surface telluric potentials have been recorded near Canberra at three sites simultaneously, the three stations being of order 15 km apart. The evident control of the telluric polarization at one station by the geologic fault pattern mapped there is particularly well documented. The data recorded demonstrate the need for a thorough study of the conditions of the "current channelling" problem, where a local inhomogeneity perturbs a field induced over a much larger area.

INTRODUCTION

The experiment described arose during field tests of three sets of telluric recording equipment, which had been designed to record in the low-frequency range, and which were constructed for the ultimate purpose of operation in conjunction with a magnetometer array. The experiment is the first study of its kind to be carried out in Australia, and is unusual in that three instruments were in use, rather than two.

The telluric potentials measured arise in conjunction with natural earth currents, and are induced by magnetic variations. They are a fundamental phenomenon of importance, being used in both the telluric and the magnetotelluric methods of geophysical exploration (see, for example, Keller and Frischknecht, 1966). These two methods are to some extent complementary, as they give their best results under different circumstances. The telluric method is best applied in the study of a large scale structure such as an undulating sedimentary basement, and the magnetotelluric method is most satisfactory in the study of simple horizontal layering. The standard interpretation procedures of both methods, however, and that of the magnetotelluric method especially, would be inadequate to treat telluric data similar to that obtained at the YRD station of the experiment to be described. This note gives a well documented example of a local perturbation in a large-scale telluric field, and points out the need for a thorough examination of the possibility of solving interpretation problems of the three-dimensional current-channelling type.

Theoretical treatment of simple two-dimensional structures has been well studied (for example d'Erceville and Kunetz, 1962; Rankin, 1962), and recent expansion in computer facilities has led to a renewed interest in the numerical solution of more complicated two-dimensional cases (Madden and Swift, 1969; Wright, 1970; Jones, 1970; Jones and Price, 1970). The work of Dyck and Garland (1969), in modelling the cause of an anomaly in geomagnetic variations by a conducting body immersed in a uniform current field, appears to be the first contribution to the class of three-dimensional problems.

THE EXPERIMENT

Three observing sites were occupied concurrently at different places on the outskirts of Canberra, A.C.T., Australia. The sites, YRD, BCN, and HMN, are shown in Fig.1. The topography of the district is hilly, but the sites were chosen in the flattest areas possible: typical relief relative to the sites would be a hill 200 m higher, 3 km away. Fences and power lines were avoided as far as possible.

The potential differences were measured over distances of 500 m, between earthing electrodes of lead plates buried at a depth of 1 m. At each site, two components of the telluric field were recorded, in the magnetic north and magnetic east directions. Recording was on paper chart, with frequencies higher than 0.03 Hz filtered out. The experiment

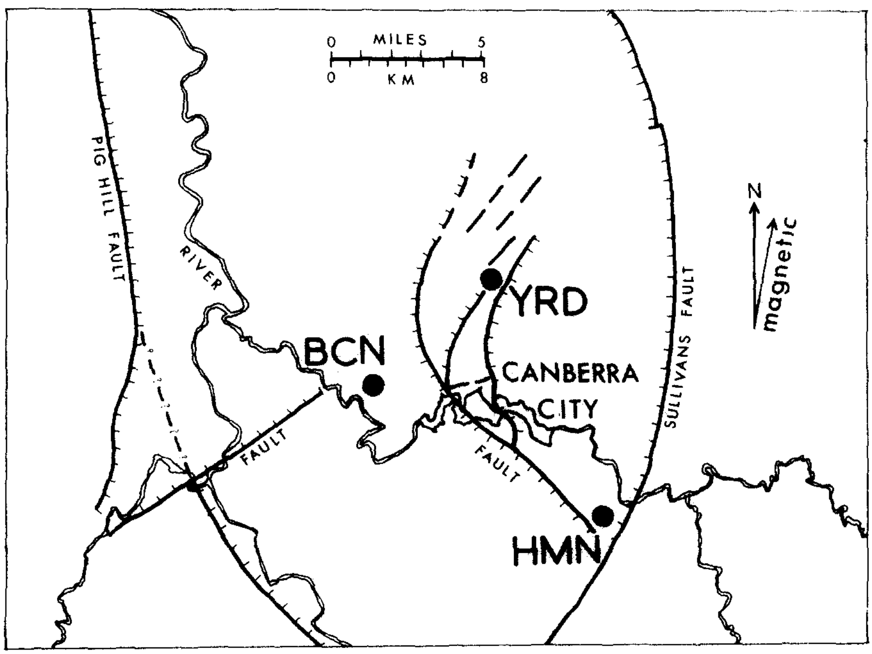

Fig.1. Sketch map of the Canberra district, showing the observing sites occupied, and the main structural fault lines. (After Öpik, 1958.)

was run for three weeks, during which time a wide variety of telluric activity was recorded.

DATA AND DISCUSSION

An example of the data recorded is presented in Fig.2, which shows the telluric signal of a train of geomagnetic micropulsations superimposed on the telluric signal of a geomagnetic bay. The profiles have been traced from the chart records, and arranged for easy comparison. It may be seen that the north components are quite consistent, even though the sites are 15 km apart and separated by geographic features and geologic faults. On the other hand, the east components vary from station to station. The morphology of the E traces is similar (with the reservation that HMN-E is disturbed by cultural noise), but the amplitudes of the signals vary, most noticeably at the longer periods: BCN-E has a greater response than YRD-E. At a first inspection, the data show the telluric fields to be reasonably smooth over the area in question. The difference in amplitude of the E traces might be linked with varying distance of the stations from Sullivans Fault.

A closer study of the data, however, discloses a very strong polarization of the field at YRD. It is the main purpose of this note to present the YRD polarization as a case history, and consider its implications.

Throughout the experiment, the YRD east and north variations were observed to be virtually identical to each other, but of opposite sign. To test that the telluric signals were indeed polarized in a strict line southeast–northwest, two instruments were subsequently run concurrently at the site, arranged as shown in Fig.3. An example of the activity re-

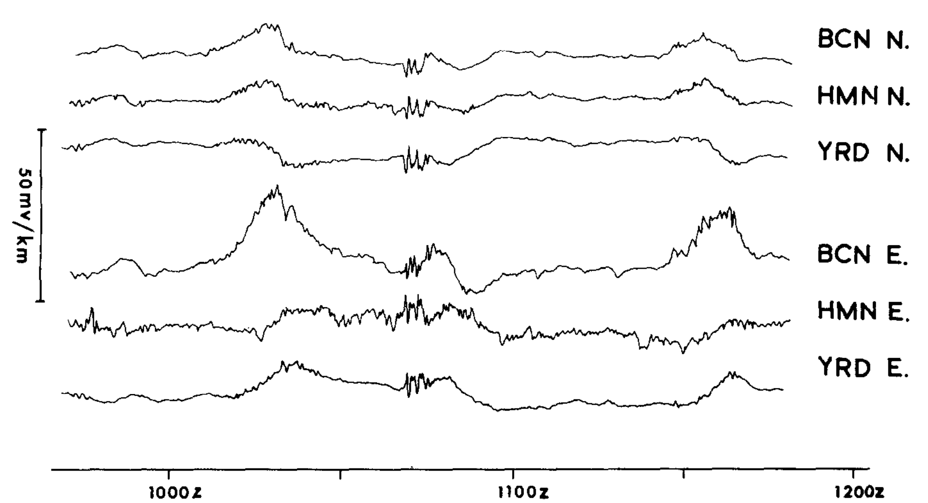

Fig.2. An example of the telluric activity recorded. August 18, 1970. N and E denote the telluric components in the directions of magnetic north, and east, respectively.

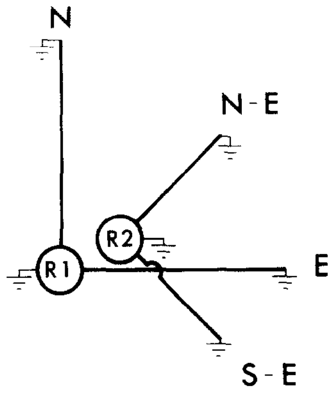

Fig.3. Plan of two instruments arranged to check the polarization at YRD.

corded by them is shown in Fig.4. Simple calculations using the ratios of the signal amplitudes confirm that the direction of polarization is along an axis 122°–302° (magnetic), which is within several degrees of southeast–northwest (true). The direction of polarization at YRD is thus perpendicular to the geological faulting of the area, mapped thoroughly by Öpik (1958), and sketched in Fig.1.

The interpretation, that the fault pattern controls the polarization, is most compelling. It is accounted for if the fault planes are imagined to be very good conductors of electricity, perhaps due to ground water content. Then, if they effectively short-circuit any electric component directed along them, the lines of equipotential will be parallel to their strike, and a telluric signal will be recorded only at right angles to the geological faulting pattern. (It should, incidentally, be noted that this is evidently not always the case. For example, Srivastava et al. (1963) observed telluric polarization parallel to geologic lineations in Alberta.)

Highly conducting fault planes account for the YRD polarization, and this is evidently

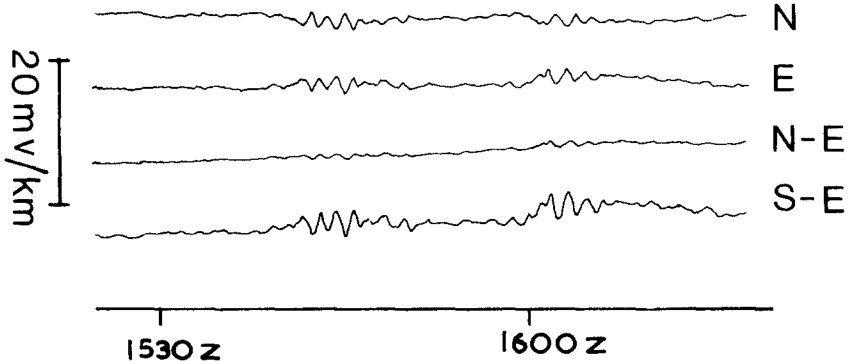

Fig.4. An example of the data showing the polarization at the YRD site, August 25, 1970.

a local perturbation of a telluric field of a larger scale. The theory of the case would not be investigated by considering the induction problem for an infinite dyke model, but rather (in a manner similar to Dyck and Garland's (1969) treatment of an analogous problem), by considering the fault planes as small conducting sheets, channelling current induced over a larger area. In the calculation of the large-scale currents, the presence of the conducting sheets would at first be disregarded.

A further point is that no estimate is obtained in the experiment of the current actually flowing along the fault planes. The extent to which a structural problem can be solved under circumstances such as these must at present be regarded as undetermined. There is a need for a theoretical investigation of the circumstances of the general current-channelling problem, where a local inhomogeneity perturbs the field induced over a region of larger scale, in order to determine under what conditions useful interpretations may be expected possible from the data observed.

CONCLUSION

The contribution of this note has been to present a case history of fault planes causing telluric polarization *perpendicular* to their strike. They must therefore be planes of high conductivity, and thus be causing current channelling. The extent of this is evidently undetected, and there is a need to examine the conditions of such problems, to determine under what circumstances they may be soluble.

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