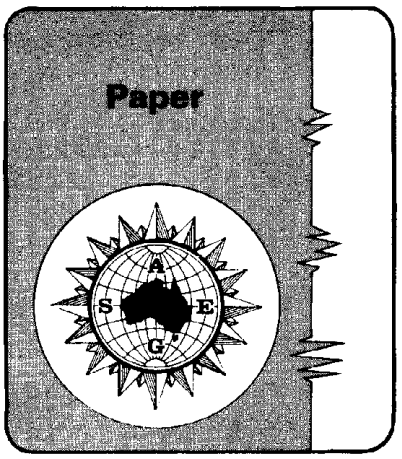

Electrodynamic Problems in Geophysics

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The aim of this brief communication is to make known to the reader a recent Ph.D. thesis by one of us (YCT) entitled "Riemann Boundary Value Problems in Electromagnetism". It deals with electromagnetic problems in geophysics, for both the steady-state and transient cases. The method is quite new and models the case of ore bodies buried in a conducting medium. The model consists of a series of spherical shells in a conducting medium below a horizontal surface. The only other work of this nature is that of Lee (1974, 1975a, 1975b) and this employs a completely different method and complements the present work.

After an introductory chapter, the basic features of the analytical method used is given. It is a completely new mathematical technique for solving boundary value problems with mixed-coordinate geometries. Thio calls it the method of transformation of local elements (TOLE).

Using the method a solution is given in full detail to the steady-state problem of a sphere in a halfspace excited by a point current-source. Though a solution to this problem has been provided by conventional methods using a bispherical coordinate system, the solution given is new and different in form from the known solution and leads directly to an image theory which is not immediately obvious from the solution obtained by conventional means.

The solution to the complete case of a system of concentric spherical shells in a multiply layered medium follows. Solution of this problem is not obtainable by conventional methods of matching boundary conditions. Siegel's dipolar model (1959) for a small sphere in a halfspace and, later, that of Gleeson and Thio (1973, 1975, 1976) for a sphere in a two-layer earth are examined in the light of the complete solution made available now in these cases. The validity of the models used by these authors is found to depend critically on the two geometric parameters, namely (r_0^2/rr') and $(r_0/2z_0)$ and where r, r_0 and z_0 is the radius of the point, source point and the nearest planar interface from the centre of the sphere respectively.

The steady-state solutions are relevant to resistivity and induced polarisation modelling.

Next, the transient electromagnetic (TEM) case of finding the decay of an initial EM field set up by a steady current in a loop is treated. An analytic solution for the complete case of a system of concentric spherical shells embedded in a multiply layered medium and co-axial with the loop is obtained. The solution to this problem has not been given before. Discontinuity in both electrical conductivity and magnetic permeability is incorporated. This is an important development as the work of Lee treats only the case where the magnetic permeability of the ore body remains the same as the host-rock. Thio's solution makes it possible now to analyse the effects of differences in magnetic permeability between the ore body (e.g. iron ore) and the host-rock.

A particular case of this general TEM problem is that of the sphere in a homogeneous halfspace. The only other results available for this particular geometry is those of Lee which was obtained with an integral-equation method. The two methods are grossly independent of each other and the form of solutions obtained differs. A comparison was made of the results from both solutions but so far only for a limited set of parameters. Lee also provided numerical results for a sphere in a two-layer earth while this is not done in Thio's thesis. In the case and time scales where thorough comparison was made, the results of the two authors agree.

Next, using the analytic solutions, asymptotic expansions are obtained for the decaying EM field at large times in the case of a sphere in a half-space. These asymptotic expansions are new and yielded valuable information and is an important part of the thesis. One result was that the character of decay at large times differs in the presence of a magnetic anomaly and this is potentially useful for discriminating between a magnetic and non-magnetic anomaly. It is also likely to be important in explaining and interpreting TEM decay curves in a traverse obtained with instruments capable of measuring TEM signals for long decay intervals (such as the 150 ms of the Australian SIROTEM equipment) when an magnetic anomaly is present.

The incorporation of magnetic anomalies as well as electrical ones in the analytical solution, even in the special case of a sphere in a homogeneous halfspace, is a new feature.

The two problems, namely the steady-state and axisymmetric transient response of concentric spherical shells in a layered medium, solved in full requires only scalar versions of Maxwell's equations. The TEM problem of a sphere off the

axis of the loop requires the full vector form of Maxwell's equations. The complete solution to this problem has not been given. However, the basis for a solution to this general problem has been developed to the extent where a solution can now be obtained but with a considerable amount of effort. For its immediate relevance to the TEM technique currently being developed for geophysical exploration, a solution to this problem is a compelling extension to the thesis. This is a project contemplated for the next two years.

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