LATERAL RESOLUTION OF A TWO DIMENSIONAL

M.T. PROBLEM

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LATERAL RESOLUTION OF A TWO DIMENSIONAL M.T. PROBLEM

by

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ABSTRACT

Most MT inversion problems invert the observations in terms of a layered model. An MT inverse problem of a two dimensional model of a layer over a half space is formulated and Maxwell's equations applied. Analytical solutions of the wave equation are formulated using Fourier transform technique; a numerical solution of the the integral equations is then obtained by assuming periodicity of the interface. The non-linear relationship between apparent resistivity and the calculated measurements of the electromagnetic waves is used to generate synthetic data at the surface of the model.

An iterative scheme to determine the model using the generated data is formulated by linearizing the forward problem using a Generalized Taylor Expansion. A Spectral Expansion is then used to construct a model whose response agrees with the observed data. The constructed model analyzed using the Backus and Gilbert technique.

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INTRODUCTION

Electromagnetic wave propagation in different media is studied using Maxwell's equations. Any solutions of these equations that satisfy the boundary conditions are considered possible electromagnetic field that could be produced by the distribution of charges and currents in the media. Solving the wave equation can be a complex task therefore the problem is usually restricted to the simplest meaningful form.

Geophysicists examine electromagnetic wave propagation into the earth's interior using Maxwell's equations to determine physical properties of the earth. To simplify the wave equation the properties of the earth are assumed to be linear, isotropic and homogeneous. The general solution of the wave equation is first obtained and then boundary conditions matched at the earth's interfaces. The study of the electromagnetic waves propagation into the earth is referred to as depth sounding.

The depth sounding method used in this thesis is referred to as the magnetotelluric or MT method. The concept behind the MT method is that distributed currents in the E layer of the atmosphere emit time varying electromagnetic fields which are assumed to be plane waves

incident to the earth's surface. These waves induce currents in the earth subsurface that in turn produce magnetic fields. These fields undergo reflection and refractions at different earth interfaces. The electromagnetic fields (electrical and magnetic components) reflected back to the earth surface are measured, and these measurements are then used to determine the electrical properties of the subsurface. The penetration of the electromagnetic waves into the the earth's interior depends on the frequency of the electromagnetic wave and the physical properties of the earth (skin depth rule).

Early investigations on the MT problems were mainly concerned with the solutions of layered earth models (Tichonov, 1950; Cargnaird, 1953). Unfortunately this is not the geology normally encountered in field experiments. The purpose of this thesis is to examine the lateral resolution of MT method for a two dimensional earth model. This model is closer to geology encountered in the field. The model consists of three regions: region 0 the air layer of zero conductivity, region 1 of conductivity σ_1 and region 2 of conductivity σ_2. We assume the interface between region 0 and region 1 to be planar and the interface between region 1 and region 2 to be non-planar.

We first obtain the general solution of the wave