Transient EM Screening in Two Concentric Spherical Shell Model

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Summary
Different results have been obtained by Negi and Wait in connection with the effect of overburden in electromagnetic exploration by assuming different definitions of screening factor. Both definitions are based on frequency domain considerations. We shall describe the screening characteristics for a transient field with a two-concentric shell model with screening factor \( \text{screening factor} = \frac{(\text{magnetic field of target and screen} - \text{magnetic field of screen alone})}{\text{field of target alone}} \). It is found that the screening factor does become more than one in some situations which means that the EM response of target is more in some cases when the screen is present than when it is absent.

Introduction

Sliechter [1] has reported that an appreciably increased secondary field is observed when a long thin wire of high conductivity is immersed in salt water in presence of a transverse magnetic field compared to that when wire is suspended above the salt water level. This paradoxical result, that is, the enhancement of response with reduced conductivity contrast and some similar results by Gaur [2] and Lowrie and West [3] spurred theoretical attempts to understand electromagnetic screening phenomena, led by Negi [4].

Negi [4] studied the steady state screening characteristics in the case of a spherical body with spherical shell overburden. His theory confirms the existence of the paradoxical result that under favorable conditions an ore body with a cover can show up better than an uncovered one. Negi and Raival [5] considered the cylindrical bodies and report that the paradoxical phenomena is independent of geometrical configuration of the conducting bodies. The response factor of inner body in presence of an overburden, \( C_i^d \), was defined by

\[
C_i^d = C_i - C_i^b
\]

where \( C_i \) is the response factor for composite system and \( C_i^b \) is the response of a uniform sphere with electrical characteristics of the overburden. Roy [6] has criticized this definition on two grounds, one that this definition is entirely arbitrary and...
second that it is unfair to compare $C_i^a$ which is the response of the sphere which properties as $(\sigma_3 - \sigma_2), (\mu_3 - \mu_2)$, and $(\varepsilon_3 - \varepsilon_2)$ where $(\sigma_3, \mu_3, \varepsilon_3)$ and $(\sigma_2, \mu_2, \varepsilon_2)$ denote the conductivity, permeability and dielectric constant of the inner sphere and shell respectively, with response of sphere with physical properties as $(\sigma_3, \mu_3, \varepsilon_3)$.

Wait [7] considered a simple physical system consisting of a sphere which is covered by a shell with airgap in between. He considered a different screening factor

$$S_n = \left( \frac{X_n^1}{X_n^2} \right)/X_n^3$$

where $n$ represents the order of the induced multiple field and $X_n^1$, $X_n^2$ and $X_n^3$ represent the response factors for composite system, shell alone and sphere alone respectively. The main difference between Negi's and Wait's definitions are that in the former case the real and imaginary parts of the response factors are separated first and they are separately compared, whereas in the later case complex response factors are compared and then the real and imaginary parts of the screening factors separated.

In the present paper we consider a two-shell model and define the screening factor as suggested by Wait [7] except that we would work in time domain rather than the frequency domain so that the two components of the responses as in frequency domain considerations, do not appear in our definition of the screening factor.

**Basic equations**

The configuration of the system considered is shown in Fig. 1. It consists of two concentric thin spherical shells at radii $b$ and $a$ having thicknesses $d_1$ and $d_2$ and conductivities $\sigma_1$ and $\sigma_2$ respectively. Let the source of the primary magnetic field be a uniform magnetic current $Q$ which ends at $T$ (at $r = 1$) on the polar axis as shown.