Physics of the Earth and Planetary Interiors, 66 (1991) 24–38
Elsevier Science Publishers B.V., Amsterdam

Geological noise in magnetotelluric data: a classification of distortion types

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(Received January 4, 1990; revision accepted April 25, 1990)

ABSTRACT

Bahr, K., 1991. Geological noise in magnetotelluric data: a classification of distortion types. Phys. Earth Planet. Inter., 66: 24–38.

Decomposition of the magnetotelluric impedance tensor into parameters relevant to a general Earth model that allows for galvanic distortion and regional induction has become a powerful data evaluation tool. Two similar techniques that incorporate superimposition of local three-dimensional and regional two-dimensional structures are considered. Both techniques have two serious limitations: (1) the conductivity structure might be less complex than assumed in the general model and therefore irrelevant model parameters are derived; (2) the regional conductivity structure may be more complicated than indicated by a two-dimensional model. The first problem is addressed in this paper by considering seven classes of general model of increasing complexity. Procedures are suggested that can be used to assign a particular datum to only one of the model classes. Therefore dimensionality parameters are suggested which include conventional and regional skew as well as local and regional structural dimensionality indicators. To address the second problem, an extension of the decomposition technique is presented that allows for a departure from the purely two-dimensional case for regional structures. An example, together with field data, is provided from the German deep drilling site. It explains how the decomposition technique recovers the two impedance phases belonging to a large regional anomaly although the impedance tensors are influenced by strong local distortion. This example also illustrates how the length scale of inductive structures can be estimated from the frequency dependence of the structural dimensionality parameters.

1. Introduction

The most important improvement in our understanding of experimental magnetotelluric data arises from techniques that evaluate all four complex elements of the magnetotelluric impedance tensor. These methods provide quantitative solutions for cases in which the measured impedance tensor does not conform to the ideal two-dimensional tensor. They may be split into two groups: (1) decomposition schemes which assume a priori general conductivity models and extract the parameters of a particular model from the elements of the tensor (Larsen, 1977; Zhang et al., 1987; Bahr, 1988; Groom and Bailey, 1989); (2) mathematical treatments of the impedance tensor as a rank 2 matrix (Eggers, 1982; Spitz, 1985; Cevallos, 1986; LaTorraca et al., 1986).

The latter group has recently been reviewed by Groom and Bailey (1990). The concepts offered by these techniques have seldom been applied to experimental data, probably because they do not take into account static shifts which seriously affect the measured impedance in many field situations. In contrast, in the decomposition schemes of the first group, a part of the general model is used to describe local conductivity structures that are responsible for static shifts. It has become

0031-9201/91/$03.50