Characteristics of Electrical Anisotropy in Magnetotelluric Responses

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Summary

The main purpose of this thesis is to extract characteristic responses of electrical anisotropy from magnetotelluric data. This is motivated by the fact that candidates of anisotropic signatures have been observed, but no definite criterion is established distinguishing anisotropy from other structures. This thesis develops theoretical machinery to investigate general properties of responses in anisotropic media, and discusses their imprints on observed data. The main body is divided into two parts: dimensionality analysis in layered structures (Chapter 3) and anomalous phase responses (Chapter 4).

In Chapter 1, we begin with a review of observations suggesting anisotropic structures. Then the current understanding of anisotropic responses and its limitation are discussed to orient our work. In Chapter 2, fundamental properties of MT responses are reviewed; emphasis is put on the rotational properties of the impedance tensor.

In Chapter 3, dimensionality analysis is quantitatively discussed for 1D anisotropic layered media. For this purpose, an analytical procedure expanding the impedance tensor is systematically formulated based on the known recursion formula. It enables us to perform calculation and interpretation of results in long periods. We then analytically confirm previous results on dimensionality analysis inferred from numerical simulations, and clarify more detailed dependence on model parameters in a general setting. It is conductance that mainly governs responses, especially the strike estimation. Moreover, the general form of expansion reveals a qualitative difference in the real and imaginary parts of the impedance, which can be evident in observations depending on the basement conductivity. These may serve as a characteristic of anisotropic stratified structures distinct from 2D or 3D isotropic structures.

In Chapter 4, we focus on anomalous phase responses called phases rolling out of quadrant, motivated by indications that 2D anisotropic media could produce these responses. However, they are also produced by 3D heterogeneity, and sounding curves show similar behaviors in both models. To fully describe such anomalous responses, we examine the rotational properties of phases and propose a diagram displaying them in a single picture. Numerical simulations suggest that the diagram directly contains the

information of subsurface structures assuming 2D anisotropic media: strike and anisotropy directions are determined up to two possibilities. Applications to observed data show that it puts a relatively severe constraint on such an interpretation; conversely, this diagram will offer a strong support for anisotropic media if responses are in harmony with the condition in different stations. Finally, in Chapter 5, the results are summarized, and implications for practical observations are given.

The presented characteristics of 1D and 2D anisotropic structures can be used to test the validity of interpretations with anisotropy. Furthermore, the use of the diagram for phases is not restricted to anisotropic media. It can be used for any observed responses to judge the existence of anomalous phase responses; if they do, modeling should be proceeded according to the spatial distribution and angle ranges of these anomalous sites.