ガルバニックディストーションがある場合のMTインピーダンスの回転不変量

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Rotational invariants of the magnetotelluric impedance tensor with galvanic distortion

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As shown by Szarka and Menvielle (1997), a complex magnetotelluric (MT) impedance tensor having 4 independent complex elements (8 independent real elements) has 7 independent rotational invariants. For example, determinant invariant scalar impedance is most often used in MT studies both on land and at seafloor. Here we consider a case where impedance has galvanic distortion: i.e., there is distortion of the electric field due to near-surface, small-scale lateral heterogeneities of the electrical conductivity.

We apply a model of galvanic distortion proposed by Groom & Bailey (1989), in which distorted impedance tensor is expressed by a product of the site gain, three elementary real tensors (the twist, shear and anisotropy) and the regional (undistorted) impedance tensor. If we calculate the determinant invariant Zdet of distorted impedance, it is shown that amplitude (or apparent resistivity) of Zdet is biased downward by twist and shear. This property is inconvenient when we use the determinant invariants to estimate a regionally averaged (background) 1-D profile (e.g. Berdichevsky, 1980).

Recently we examined the behavior of another (less well-known) rotational invariant, the sum of squares (ssq) of impedance elements, ssq(Z) = Zxx^2+Zxy^2+Zyx^2+Zyy^2. The effective 1-D scalar impedance is derived as, Zssq = [ssq(Z)/2]^(1/2). Then we found that Zssq is not biased by distortions (shear, and anisotropy) but only by site gain (static shift). This means that, if we have many MT measurements in a region, a reasonable estimation of regional 1-D background model can be obtained by inverting averaged Zssq (not Zdet) over all stations. Such a 1-D model is convenient for various aspects of MT analyses as a good starting and/or a priori model.

Another finding is that the ratio of corresponding apparent resistivities (rho-ssq/rho-det) will always be greater than unity under the presence of galvanic distortion. If the regional structure is 1-D, the ratio Zssq/Zdet will be a real number (phase=0), otherwise it will be a complex number. Thus these quantities (ratio and phase) can be used as an indicator for the presence of galvanic distortion and 3-dimensionality of regional structure, which tells us the right treatment of a given dataset.