

Anomalous magnetotelluric phases induced by a convex conductor model

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It is usually thought that magnetotelluric phase is in the range between 0 and 90 degree. However, anomalous phases exceeding 90 degree are observed in the low frequency band (lower than 0.01 Hz) at various area in the earth (e.g. Teshikaga area, eastern Hokkaido (Ichihara, 2008), Variscan terranes, Southwestern Iberia (Heise and Pous, 2003), Western Oregon, USA (EMSLAB, 1988), Las Canadas caldera, Canary island (Pous et al., 2003), Damara belt in Namibia (Weckmann et al., 2003), Andean subduction zone, Chile (Lezaeta, 2001)). The anomalous phase has been concern for resistivity modeling because model response for 1-D or simple 2-D structure allows only the phase between 0 and 90 degree.

Several studies challenged to explain the anomalous phase problem. Egbert (1990) firstly explained the anomalous phase by a conceptual model which induces reversed electric field. After the study, several schematic models induce the anomalous phases have been suggested which (e.g. Weckmann (2003), Pous et al. (2002), Lezaeta and Haak (2003), Pek and Verner (1997)). However, the anomalous phase problem has not been well understood yet. In addition, the suggested model seems to be complicated to explain field EM data.

In this study, we suggest a simple 3-D conceptual model to explain the anomalous phases called the convex conductor model. The convex conductor model consists of a large elongated (regional) conductor and a small (local) conductor contacting the regional conductor. The regional conductor must be elongated at one side in the view from the local conductor. In the coordinate system that Y-axis is parallel to long axis of the regional conductor, over 90 degree phases are induced in YX component around the edges of the local conductor. In detail, anomalous phases appear at only one side of the local conductor where the regional conductor is elongated. The convex conductor model is quite simple and thus can be widely applied to the field data showing anomalous phases.

We also tried to investigate what conditions of convex conductor originate the anomalous phase around the 3-D structures. We used 3D EM modeling program (Fomenko and Mogi, 2002) and computed phase responses to various conditions, such as size, depth, and position of the protrusion for the convex conductors and found that the anomalous phase appeared when the structures satisfied specific conditions. This means that the anomalous phase gives a constraint for the structure of conductor.