The Joint Decoupled 3D Magnetotelluric Axial Anisotropic Inversion

Wisart Thongoy [a], Weerachai Siripunvaraporn [a,b], Tawat Rung-Arunwan [c] and Puwis Amatyakul [a,b]*

[a] Department of Physics, Faculty of Science, Mahidol University, Bangkok, 10400, Thailand
[b] Thailand Center of Excellence in Physics, Ministry of Higher Education, Science, Research and Innovation, Bangkok, 10400, Thailand
[c] Curl-E Geophysics Co., Ltd., Nakhon Pathom, 73170, Thailand.
* Corresponding author. E-mail address: puwis.mahidol@gmail.com

Abstract

Utilizing the naturally occurring electromagnetic fields traveling down to the Earth's surface, the Magnetotelluric method studies the resistivity distribution of the subsurface through the variation of such fields. It has been shown in many previous studies that anisotropic properties of the subsurface could result in difficulties in the interpretation, or even lead to misinterpretation in case of ignoring the effect. For the Magnetotelluric method, anisotropy is represented as the resistivity tensor. Understanding the effect of each tensor element on the Magnetotelluric responses is a crucial step to study the anisotropic effects. Our past study shows that, for the case of axial anisotropy (only diagonal elements of the tensor are non-zero), ρ_x highly affects Z_{xy} and Z_{yy}, but has a weak influence on Z_{yx}, and Z_{xx}. ρ_y has a high influence on Z_{yx}, and Z_{xx}, but this is weak on Z_{xy}, and Z_{yy}. Surprisingly, ρ_z has a weak effect on all impedance tensor responses. Following this result, we design a new inversion process, as ρ_x, and ρ_y are highly affected by different set of impedance tensor responses, they can be inverted separately. Hence, instead of the conventional method that takes the whole impedance tensor to invert for ρ_x, ρ_y, and ρ_z, we design a ρ_x-mode inversion which takes Z_{xy}, and Z_{yy} as the input to recover ρ_x element, and a ρ_y-mode inversion which takes Z_{yx}, and Z_{xx} to recover ρ_y element. We show that the models inverted from the conventional inversion and the decoupled inversion (ρ_x-, and ρ_y- mode) can equally represent the true model. However, for the case of limited computing resources, ρ_x-, and ρ_y-mode must run sequentially resulting in greater computational time compared to the conventional inversion. To resolve the situation, we developed a joint decoupled inversion of ρ_x-, and ρ_y-mode. The joint inversion process managed to operate the common parts of the decoupled inversion together while maintaining the separable properties of the decoupled inversion. Based on our test models, the joint decoupled inversion is faster than the conventional inversion by about 25% per iteration while yielding comparable results.

Keywords: magnetotelluric, electrical resistivity anisotropy, magnetotelluric inversion