Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SEM22-P08 会場:コンベンションホール 時間:5 月 25 日 15:30-16:45

3-D magnetotelluric inversion with minimum gradient support
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3-D MT inversion has progressed fast in recent a few decades. Madden and Mackie (1993) developed first practical 3-D inversion of magnetotelluric (MT) data by using the conjugate gradients (CG) to solve equations of inversion. Newman et al. (2000) introduced non-linear conjugate gradients (NLCG) in 3D MT inversion. Zhdanov (2000) used quasi-linear approximation in 3-D Electromagnetic inversion. Siripunvaraporn et al. (2005) proposed a new scheme of 3-D inversion in data space. Most of the inverse algorithms cited above involve a regularized inversion using a smoothness constraint. These algorithms provide smooth solutions, but few are suitable for clearly imaging geo-electrical interfaces. In the present study, we introduce a new constraint to address this limitation. Portniaguine and Zhdanov (1999, 2002) proposed a focusing geophysical inversion using the minimum gradient support (MGS) functional and used the MGS functional in gravity and magnetic inversion. Zhang (2009, 2010) used this theory to invert 2-D MT data and obtain clear images of geo-electrical interfaces.

In our research, the subsurface resistivity structure is divided by cubes. The conductivity in each cube is assumed uniform. Through changing the cube's volume, the accuracy of inversion can be ensured. Integral equation (IE) method by modified Neumann series (MNS) which was proposed by Singer (1995) and Avdeev et al. (2000) is used for forward calculation, which allows us to avoid calculation of large-scale linear equations. GPBi-CG is used to get the solution in modified Neumann series, and the efficiency is increased. The quasi-Newton method is used to optimize the objective functional. This approach is a kind of Newton method with simplified calculation of the Hessian matrix by using BFGS update (Koyama, 2002). In addition, BFGS update does not require search for the exact minimum point on line unlike the NLCG, and therefore iteration times of 3-D forward calculation can be reduced. For derivation of the sensitivity matrix, we use the method which was presented by Newman (2000).

We investigated some synthetic models and compared the results with those obtained by a smoothing inversion. For synthetic models having sharp geo-electrical interfaces, the MGS inversion was found to image structures with sharp interfaces more clearly and accurately with smaller RMS data misfit. On the other hand, the synthetic test indicated that the MGS inversion provides larger RMS data misfit and so is not advantageous compared to smoothing inversion for models with smooth interfaces.

キーワード: magnetotelluric, inversion, minimum gradient support, quasi-Newton method
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