Developement of reliability evaluation technique for inversion of magnetotelluric data using Markov Chain Monte-Carlo methods

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Magnetotelluric (MT) method, one of electromagnetic survey methods, is used for resource exploration and active fault survey. Subsurface resistivity structure is generally estimated by inversion algorism, based on the least- square scheme using observed apparent resistivity and phase. The optimal resistivity model obtained by the inversion is a kind of approximated solution, because of the noise at measurement and the constraints at inversion. Therefore, we should discuss the reliability of estimated model. Previous researches confirm the reliability with changing a portion of the optimal model, how apparent resistivity and phase calculated from modified model differ from the observed ones. However, this reliability test is qualitative and subjective. In this research, we develop a new way of the reliability test of optimal model objectively and quantitatively.

Sensitivity around the estimated model parameters can be obtained at linear approximation, but it is difficult to obtain sensitivity in the whole parameter range. Therefore, we use Markov Chain Monte-Carlo (MCMC) method, is used for quantitative evaluation of parameter estimation accuracy. However, evaluating a huge number model parameters takes a lot of computation time. In this research, we use principle component analysis (PCA), which can extract the major structure from data, and make a trial to extract of the major resistivity anomalies in an optimal model obtained by inversion. Concretely, we use PCA and extract the vertical and horizontal principle components which show features of resistivity model. By changing the principle components in each direction randomly, we can sample new models in accordance MCMC. Based these new models, the average and variance of each parameter are used to discuss the reliability of optimal model quantitatively.

To examine the validity of this technique, we used MT synthetic data (TE mode) on a model having high and low resistivity anomalies. As a result of PCA on the model, two resistivity anomalies appeared in the first principle component. We changed the first principle component score, and get many new models having resistivity anomalies changed vertically and horizontally. Furthermore, we checked the reliability of position, size, value and smoothness of anomalies. The obtained reliability corresponds to sensitivity trend of MT inversion in TE mode.
We also applied this technique to more complicated resistivity models. In consequence, anomalies in the models were detected, and the quantitative reliability of each anomaly was evaluated. In future prospects, we use this technique for resistivity model obtained by inversion in TM mode and BOTH mode, and adopt it to MT inversion with real data.

Keywords: magnetotelluric, PCA, MCMC, 2-D inversion

