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Research on the Magnetotelluric Signal Processing and Impedance Tensor Estimation

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The interpretation of magnetotelluric inversion is grounded in previous data processing and exact impedance data got. The research, through the dual- and tri-degree of coherence of magnetotelluric signal and its zero distribution on the surface Z , showed that the MT signal generally possessed the characteristics of non-Gaussian, nonlinearity and non-minimum phase. In order to make the phase curve of impedance remain unaffected by the algorithm in the middle, we made use of wavelet analysis method to fracture and reconstruct the acoustic noise. We added the impulse noise and square wave common in the field data into the original signal, so as to imitate the effects from wavelet analysis method on noise separation. Through the calculation of power spectrums and correlation functions, we found the variance of data with added noise became greater and the signal was unstable. Besides, very tiny impulse interference nearly doubled the power. Based on this, we regarded the DB4 wavelet as the basic wavelet and conducted the reconstruction after completing three-stage wavelet decomposition and noise reduction. It can be found that the signal energy after noise reduction did not change much by comparing with the energy of original signal. Furthermore, the main parameters and the curvilinear amplitude trend showed small changes. Thus, it proved that the wavelet transform had good results on removing the impulse interference. We introduced the AR model parameter estimation into the magnetotelluric analysis of time series. The AR (p) model is the special case of the Auto Regressive Moving Average (ARMA) model. When the first N continuous data in its sequence are given, the following data can be

predicted through the prediction model. We confirmed the order of AR (p) model through the information content-based BIC criteria and determined the model parameter by the principle of least squares. Thus the accurate AR (p) model was established to fill up missing data in a certain segment during the gathering process of magnetotelluric information. Therefore, the deficiency and frame skipping problems on the time series data of magnetotelluric detection were solved and the utilization rate of data collection in the field could also increase.

For the long-periodic magnetotelluric method with a gathering time as long as half a month or so, we applied the statistical theory into the magnetotelluric spectrum estimation and superposed the power spectrums of several windows by the Welch method. The theoretical analysis indicated that the spectrum estimation through the periodogram approach had contradictions on the resolution ratio and variance performance, so that it was difficult for the algorithm to obtain better results. We utilized enhanced Welch method to estimate power spectrums. The result was the spectrum analysis of Rectangular window had very high level of noise, which was caused by less reduction in its side lobes. However, compared with the Hamming window and Kaiser Window, the Rectangular window had better resolution ratio. The Hamming window and Kaiser Window had low level of noise and good performance due to great reduction in their side lobes. But their resolution ratio decreased to some extent. Finally, we chose the Hamming window to implement spectrum analysis. We followed two conditions on the selection of frequency values, that is, the frequency (period) was evenly spaced in the logarithm coordinate; and there were 6-7 values in the frequency (period) every decimal space.

In the aspect of impedance tensor estimation, the noise of electric fields would result in high estimated values of impedance tensor elements and the noise of magnetic fields would lead to low estimated values of impedance tensor elements when we were estimating the impedance

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tensor with the traditional least square method. Based on this, the Robust statistical method established by Huber et al in the early 1980s has been widespread concerned in the impedance estimation and has developed rapidly. Chave (1987) brought the Robust method into the magnetotelluric approach to estimate power spectrums, correlation coefficients and transmission functions. On the basis of it, the author introduced the repeated median estimator into the magnetotelluric impedance tensor estimation. Compared with the M estimation method, the repeated median estimating algorithm can avoid three major parameters required in the calculating process of M estimator. Moreover, it can also get unbiased estimation from the impedance when the collapse point is less than 50%. 1) As the repeated median estimator is based on the sequencing algorithm, if the collapse point only locates on the left or right side of the median, there will be no impacts on estimated results. While the M estimator is

merely the weightiness of reducing the collapse point, so the Robust algorithm, on the basis of repeated median estimator, is less sensitive to the collapse point than the M estimator. When the collapse point is over 30% of the overall estimated sample, the M estimator cannot get the unbiased estimation from the impedance tensor. Whereas, based on the repeated median estimator, the Robust algorithm can increase this allowance to 50%. 2) It's no need for the repeated median estimator based Robust algorithm to set three major parameters including the scale parameter, weightiness controlled quantity and condition of convergence. Hence, the multiple solutions of M estimator results caused by differences in three major parameters will not appear in the Robust algorithm. This research gets a help to improve the magnetotelluric sounding data processing accuracy.

Key words: Magnetotelluric; Signal processing; Impedance; Robust estimation