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Editorial: Advances in electromagnetic geophysical exploration

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Editorial on the Research Topic
Advances in electromagnetic geophysical exploration

Introduction

Geophysical exploration is an effective way to build a national resource security system and carry out "deep exploration of blindness" (Di et al., 2019). The application of advanced scientific and technological means to extract deep geological information has become the development direction of contemporary geophysical research. Electromagnetic exploration is one of the earliest and most widely used geophysical techniques for mineral resource exploration. Electromagnetic methods, such as magnetotelluric (MT), audio magnetotelluric (AMT), transient electromagnetic method (TEM), and controlled source electromagnetic method (CSEM), have made a great contribution to industrialization and urbanization by discovering underground deposits of various resources (Tikhonov, 1950; Cagniard, 1953; He, 2010; Tang et al., 2015; Liu et al., 2019).

Driven by the latest progress in electronics and intelligent algorithms, electromagnetic exploration is developing at a high speed. Many challenges faced by traditional geophysical methods are now solvable. Emerging sensing technologies and signal processing technologies can significantly improve the accuracy of data analysis in many applications (Zhang et al., 2021; Li et al., 2023). At the same time, new technologies are promoting the development of new geophysical theories and methods. This Research Topic brings together articles reporting the latest progress in MT denoising, data processing, forward modelling, and inversion methods.

Advances in electromagnetic geophysical exploration

The articles in this Research Topic synthesise advanced techniques across electromagnetic data processing, 1D/2D/3D forward modelling, and inversion methods, covering a broad range of applications of the electromagnetic method.

Wang et al. presented a novel approach to analyse MT time series based on forward modelling and the correspondence between frequency- and time-domain electromagnetic fields. The study focused on the electromagnetic responses of a given numerical model to two orthogonal polarization sources. The randomness of the polarization of natural field sources was simulated by a linear combination of the two polarization sources. The novel approach provides a technical basis to transform the forward modeling of electromagnetic responses from the frequency domain to the time domain. Moreover, time series not derived from the inversion model can be separated to study the distribution of noise.

Zhan et al. reported a new MT data processing method based on cepstral analysis, which can suppress different types of MT noise, and obtain smoother and more continuous apparent resistivity curves, this method shows better performance than EMD method in handing MT data.

Chen et al. combined the analyses of three new parameters (the amplitude ratio predicted amplitude ratio, the linear coherence between the predicted and observed electric fields and the dispersion degree of the magnetic polarization direction) to detect noisy data, and developed an automatic pre-selection strategy for MT single-site data processing. The results showed that these parameters can be used to identify contaminated data, and a reliable response function can be obtained.

Tong et al. introduced a new efficient spectral element approach originally developed by Patera to solve 2D MT forward problems based on Gauss-Lobatto-Legendre polynomials. It has implied the spectral element method on a resistivity half-space model to obtain a simple analytical solution and find that the magnetic field solutions simulated by the spectral element approach matched closely to the exact solutions. Moreover, the method can compute the two-dimensional magnetotelluric responses of the boundary problem without measuring Earth's curvature.

Zhu et al. proposed a rapid 3D MT forward modelling approach for arbitrary anisotropic conductivity in the Fourier domain. The study verified the classical 1D anisotropy model, calculated the 3D anisotropic model of land and ocean, and analysed the influence characteristics of the anisotropic medium on the MT response.

Li et al. reported a generic 3D forward modelling solver for CSEMs with multitype sources and operating environments. The numerical results showed that frequency domain CSEMs with a wire source were more suitable for detecting deep anomalies than time domain CSEMs with a loop source.

Ge and Li presented a finite difference algorithm for simulating the ocean wave-induced electromagnetic fields with variable seawater conductivity. The study revealed the impacts of variable seawater conductivity on the electromagnetic fields induced by the wind waves and swell as well as mixed ocean waves.

Su et al. reported a high-resolution 2D inversion method based on weighted horizontal and vertical constraints. The method ensured the horizontal continuity of resistivity and recovers the inclined strata, and improved the vertical resolution. The TEM data processing and inversion results were consistent with known geological information.

Tian et al. reported a new calculation method of arbitrary orientation single component electric field for the wide field electromagnetic method (WFEM). The study showed that the new method could reduce the influence of the azimuthal difference on the apparent resistivity parameters and thus improve the accuracy of interpretation.

Summary and outlook

The articles cover new methods in data processing, forward modelling, and inversion methods for electromagnetic exploration. These new electromagnetic processing methods can effectively analyse the characteristics of electromagnetic fields, improving the interpretation accuracy, and expand the applicability and flexibility of electromagnetic methods in the presence of complex environmental/topographical/geological conditions. Advances in electromagnetic geophysical exploration will contribute to the sustainable development of People-Earth system in the future.

Author contributions

JL: Supervision, Writing–review and editing. JG: Supervision, Writing–review and editing. CZ: Supervision, Writing–review and editing. XZ: Supervision, Writing–review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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