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Electromagnetic Induction in the Earth

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Electromagnetic methods are of particular importance in geophysics as they provide a unique view of the Earth's interior through imaging its geoelectrical structures. The electrical conductivity of the Earth is sensitive to fluid content, ore minerals, lithological changes and temperature, which allow a wide range of applications. These include monitoring environmental problems, exploring natural resources, searching for potential natural hazards and studying the interior structure of the Earth and other planets. In this field of the Earth Sciences, research in electromagnetic methods is continuously advancing, improving the instrumentation and methodological aspects, leading to substantial results in their applications, and finding solutions to the challenges presented.

Hence, the list of references covering electromagnetic methods is very extensive. Fundamentals of the electromagnetic theory for the study of the Earth can be found at Nabighian (1987) and a further discussion in Berdichevsky (1999). Simpson and Bahr (2005) is an updated reference book on the magnetotelluric method, specifically. A significant number of review papers covering key aspects on electromagnetic methods with applications have been published in Surveys in Geophysics. Among them we mention Egbert (2002), Meju (2002), Pellerin (2002), Avdeev (2005), Edwards (2005), Nover (2005), Sheard et al. (2005), Bedrosian (2007) and Uyeshima (2007).

This special issue of Geologica Acta contains a selection of seven papers presented at the 18th Workshop on Electromagnetic Induction in the Earth (18th EMIW), held in El Vendrell, Spain, September 17-23, 2006. These biennial workshops, organized by the Working Group I-2 of the International Association of Geomagnetism and Aeronomy since 1972, have been largely supported by corporate and institutional funding. They have taken place in locations all over the world, each time hosted by persons and institutions closely related to the study of the Earth using electromagnetic methods. This is a well-established event that has always counted on excellent attendance by participants from universities, including a significant number of students, research institutions, and the industrial sector.

A well-balanced mix of talks, poster exhibits and discussions, review presentations, and open discussions on new or controversial topics provides a perfect platform for knowledge interchange, debates and collaborative work. The 18th EMIW in El Vendrell was no exception. The integration of the workshop venues and activities in this town near the Mediterranean Sea, with its unique cultural background, very much fulfilled the expectations of most of the attendees. There were 270 participants from 43 countries spanning all continents, with a total of 315 contributions. These contributions were organized in several sessions that covered a wide spectrum of topics related to instrumentation, processing, data analysis, modeling and inversion, petrophysical and laboratory studies, and applications at different levels: environment, energy and mineral exploration, crustal, lithospheric, marine, seismology and volcanology, and satellite studies. These sessions were completed with four invited review papers on selected topics, published by Weaver and Queralt (Eds.) (2007).

This current volume contains seven papers, which, although being limited in number and not covering all

sessions, present a diversity of innovative works. Three of these present methodological innovations related to data processing, inversion and monitoring of electromagnetic data. The other four present local and regional studies using the magnetotelluric method.

In the first paper (Saraev et al., 2010), the authors present a technique to monitor tidal phenomena through the registration of apparent resistivity variations using audiomagnetotelluric (AMT) instruments. They show that the type of relationship between resistivity and tidal variations is related to the geological medium over which the instruments are installed, depending on the sediment thickness and the degree of rock saturation. Over anisotropic media, this relationship is the inverse between E and B polarizations.

Rodríguez et al. (2010) develop an imaging technique for two-dimensional magnetotelluric interpretations following the Niblett-Bostick transformation for one-dimensional profiles. The algorithm uses series and parallel impedances, a self-contained pair of invariants of the impedance tensor, to avoid the need to decide on best angles of rotation for identifying TE and TM modes, and their analytical influence functions using a regularized Hopfield artificial neural network. Applications of the algorithm to simple synthetic models and to the standard COPROD2 dataset illustrate the performance of the approximation.

Pankratov and Geraskin (2010) introduce a fast and robust scheme of controlled source electromagnetic data processing which can recover response functions from extremely noisy field data, as illustrated by the dataset examples from Kola Peninsula, Norilsk region and Pechora province (Russia). The proposed software can be adapted to new data sets and noisy environments.

Lujan and Romo (2010) present the application of the inversion of the series and parallel (s-p) invariant impedances to the study of a seawater intrusion in a coastal aquifer in Ensenada, Baja California, Mexico, using AMT data. From the resistivity models and available hydrogeologic information, they used Archie's law to obtain porosity and TDS distributions in the aquifer.

Coppo et al. (2010) present the results of an AMT study conducted in Las Cañadas caldera in Tenerife (Canary Islands, Spain), in order to characterize physical rock properties at shallow depths and the thickness of a first resistive layer. This paper points out the ubiquitous existence in Tenerife of a conductive layer underlying the resistive cover which is the consequence of two different processes: a plastic breccia within a clayish matrix generated during huge lateral collapse; and hydrothermal alteration processes, related to major structural volcanic events.

A crustal study from a seismically active region is presented by Naganjaneyulu et al. (2010) using magnetotelluric (MT) data from the Kutch rift basin (India) in order to examine the presence of fluids and partial melt in the lower crust. With the aid of geological models, historical seismic and well information, the authors characterize the main structure of the 2D geoelectrical model which allows excluding fluid or magma instability hypotheses as the cause of the Bhuj earthquake of 2001.

Finally, in the paper of Zhao et al. (2010), a 2D resistivity model of the crust and upper mantle along 145 km in the eastern margin of the Tibetan plateau is constructed and interpreted on the base of MT data. The authors suggest that the formation of a low-resistivity layer in the middle crust is associated with the southeastward motion of the eastern margin of the Tibetan plateau, clockwise rotation of the Chuandian (Sichuan-Yunnan) block, and the westward obstruction from the Sichuan block in Huanan terrain. Seismicity, including the Wenchuan earthquake (M8.0) which occurred in the area in 2008, is also discussed.

We hope that this volume will be a useful reference for the geophysical electromagnetic community and related areas. We would like to thank the editor, Lluís Cabrera, and the editorial staff of Geologica Acta, for the opportunity to publish this special volume. Thanks also to Colin Farquharson, Xavier García, Adele Manzella, Manoj C. Nair, Yasuo Ogawa, Prasanta Patro, Josef Pek and other anonymous reviewers for their valuable work and patience that have made this publication possible. Thanks also to Cynthia Voelker who kindly revised the English writing.

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