

Preface to the Special Issue on “The 20th Electromagnetic Induction Workshop”

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Electromagnetic (EM) induction methods are used and continue to be developed for a wide range of applications, ranging from exploration near the Earth’s surface to investigations of the deep mantle. In this research, important scientific and societal challenges, such as to search for hydrocarbons and other Earth resources, to probe the structure and dynamics of the lithosphere, to study environmental issues and to monitor and mitigate natural hazards, are addressed.

The Working Group I-2 of the International Association of Geomagnetism and Aeronomy on “Electromagnetic Induction in the Earth” has held, since the Edinburgh, United Kingdom, Workshop of 1972, biennial workshops. Here, selected topics are extensively explored by the participants, in the form of oral and poster presentations and discussion sessions. An essential and important part of the EM Induction Workshops (EMIWs) has been the invited review presentations on themes selected by the program committee. These themes vary from workshop to workshop; usually, they highlight recent advances in the rapidly evolving fields of electromagnetic induction and introduce important new directions of research as well as highlight and review results focusing on certain geological targets. The review papers presented at the workshops have traditionally been published as Special Issues of Surveys in Geophysics/Geophysical Surveys since the 1978 workshop in Murnau, Germany.

This Special Issue of Surveys in Geophysics contains expanded articles from six review papers presented at the 20th Workshop on Electromagnetic Induction in the Earth (http://mtnet.dias.ie/workshops/2010_Giza/website/index.html). The Workshop was held

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from September 18 to September 24, 2010, in Giza, Egypt. It was organized by the Working Group I-2 of the International Association of Geomagnetism and Aeronomy and the National Research Institute of Astronomy and Geophysics (NRIAG). The scientific programme of the Workshop was divided into nine themes, for which six had a review presentation:

1. Data Processing, Current Channeling and Distortion.
2. Modeling and Inversion.
Review: Weerachai Siripunvaraporn, Three-Dimensional Magnetotelluric Inversion: An Introductory Guide for Developers and Users.
3. New Hardware and Software Infrastructure.
4. Rock Measurements.
5. Near-Surface and Resource Engineering.
Review: Mark Everett, Theoretical Developments in Electromagnetic Induction Geophysics with Selected Applications in the Near Surface.
6. Seismology and Volcanology.
Review: Michael Becken, MT Studies at the San Andreas Fault Zone: Implications for the Role of Fluids.
7. Tectonic Studies.
Review: Ute Weckmann, Making and Breaking of a Continent—Following the Scent of Geodynamical Imprints on the African Continent Using Electromagnetics.
8. Ocean Studies.
Review: Kerry Key, Marine Electromagnetic Studies of Seafloor Resources and Tectonics.
9. Global Induction Including Satellite Data.
Review: Alexei Kuvshinov, Deep Electromagnetic Studies from Land, Sea and Space. Progress Status in the Past 10 Years.

Weerachai Siripunvaraporn (Mahidol University, Thailand) summarizes and lists all the work that has and is being done in 3-D magnetotelluric (MT) data inversion techniques. His review is very comprehensive in its referencing of the literature. It provides a good comparison of various optimization methods that are used, such as Newton and Gauss–Newton. The review is thorough in its treatment of the topic, including clear descriptions of the technical details that can significantly affect the performance of inversion programs. Finally, the review provides useful practical advice for the users of 3-D MT inversion programs.

Mark Everett (Texas A&M University, USA) gives an excellent review about the state of the art in the near-surface EM covering the years 2007–2010, focusing on the developments in the diffusive domain. The paper discusses the traditional topics such as modeling, inversion, heterogeneity, anisotropy, target recognition, logging and airborne EM. Similarly, several new or emerging techniques are introduced including landmine detection, biogeophysics, interferometry, shallow-water electromagnetics, radiomagnetotellurics and airborne UXO discrimination. Representative case histories describe some of the most notable recent advances in traditional topics and have introduced a few newly emergent techniques and exciting geosciences applications. The paper should be a source of inspiration and references for the near-surface community.

Michael Becken (University of Münster, Germany) addresses the impact of fluid networks of electrical conductivity. The author presents a comprehensive review about the MT studies carried out until present in the San Andreas Fault Zone in central California and their relation with other geophysical, geological and geochemical data as well as the

constraints from the SAFOD borehole. Explanations about the source of the fluids, fluid pressure and mechanisms generating the pathways of interconnected pores lead to significant constraints that explain within the geodynamic context of the area the variations appearing in the seismic behavior of the San Andreas Fault Zone.

Ute Weckmann (German Research Centre for Geosciences GFZ, Germany) provides in her review a very comprehensive, interesting and valuable summary of current and early magnetotelluric experiments across Africa. After briefly outlining the evolution of the African continent, Weckmann goes on to review the pioneering electromagnetic work as the early results significantly shaped our understanding of the conductivity characteristics of cratons and mobile belts. Through imaging the subsurface electrical resistivity structure at crustal and lithospheric-mantle scales from various recent experiments, she provides important constraints on the geological processes, collision/convergence (“Making a continent”) and extension/divergence (“Breaking a continent”), which have contributed to the formation of the African continent throughout time. The paper will certainly benefit those interested in the applications of the MT method itself, such as the search for natural resources, those interested in the African geology in particular and those interested in understanding the processes of continental accretion and destruction elsewhere.

Kerry Key (University of California, USA) discusses recent advances in marine EM methods, which have been widely adopted during the last decade, predominantly due to the industrial demand and promotion of EM as a valuable tool for characterizing offshore hydrocarbon reservoirs. The author presents an overview of these recent developments, covering the industrial and academic use of marine EM for resource exploration and tectonic investigations, ranging from acquisition technology and modeling approaches to new physical and geological insights learned from recent data sets.

Deep electromagnetic studies providing information on the electrical conductivity of the mantle have experienced rapid progress in the last decade due to, e.g., the increased amount of satellite data, methodological improvements facilitating numerical modeling in 3-D spherical geometry and the understanding that deep EM studies yield information on the Earth’s interior that is independent of and complementary to seismic tomography data and models. *Alexei Kuvshinov* (ETH, Switzerland) gives an excellent review of recent advances in global EM studies. His viewpoint comes from the EM community but does not miss the context of deep Earth geophysics by providing the comparison of the conductivity models (1-D and 3-D) with seismic models as well as interpreting the results with the help of laboratory data. He has grouped the contributions over the last decade according to scale (regional, semi-global, global), domain (frequency or time) and primary data source (observatories, submarine cables, satellites). He finally gives an outlook for future studies, interesting and important for those already in the field but, in particular, to students entering the field and looking for interesting and significant research topics in the rapidly evolving field.

The 20th EM Induction Workshop in Giza attracted 252 scientists, representing universities, research institutes and the industrial sector, from 29 countries from all major continents of the world. In addition to six review papers, 262 abstracts were contributed. A total of 32 contributions, including the reviews, were presented in nine oral sessions in the mornings, and 228 posters were presented throughout the workshop. Four discussion sessions were held in the afternoons, on the themes of the day.

On September 21, our traditional excursion took us to the pyramids and tombs of the Giza and Saqqara and to downtown Cairo to explore the oriental bazaars of Khan El Khalili. While admiring the beautiful articles created several thousands of years ago, it may have occurred in someone’s mind to think what might remain from our days after

thousands of years. The excursion day ended with a workshop dinner in the boat restaurant on the Nile River with a magnificent view of the lights of downtown Cairo as well as with dance performances given by talented professional artists. Apart from the excursion, many of the workshop participants after the sessions took a short taxi drive to the Giza pyramids to follow the Sound and Light Show describing the history of the pyramids. However, perhaps the most attractive target was the pool of the Cataract Pyramid Resort, where it was possible to get some relief from the sun while having fierce water polo matches.

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The Working Group thanks most warmly the Local Organizing Committee for a very well-organized workshop. Future workshops are planned for Darwin, Australia, July 25–31, 2012, and Weimar, Germany, August 24–30, 2014.

Finally, we, as Guest Editors, thank twelve referees for their careful and constructive reviews as well as the Springer Editorial Office, and in particular Michael Rycroft, Editor in Chief and Joanne Cabato and Priya Sambandam, Springer Editorial Office Assistants, for their help and advice during the editorial process.