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Preface to the Special Issue on "The 23rd Electromagnetic Induction Workshop, Chiang Mai, Thailand"

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Division VI (formerly Working Group I.2) of the International Association of Geomagnetism and Aeronomy (IAGA) on "Electromagnetic Induction in the Earth and Planetary Bodies" (https://www.emiw.org/) has long played an active role in the field of geophysics. The Electromagnetic Induction Workshop (EMIW) is one of its most important activities and has been held biennially since its inception in 1972 in Edinburgh, UK. Keynote reviews are given by both younger and senior scientists and are summarized in review papers. These review papers describe recent advances in a sub-discipline or topic, and some are regarded as tutorials in the future application of a particular method. These contributions are published as Special Issues of Surveys in Geophysics/Geophysical Surveys.

The 23rd EMIW was held in Chang Mai, Thailand, between the 14th and 20th August 2016, and was attended by 315 participants from 39 countries. More than 350 abstracts were submitted to the eight workshop sessions:

Session 1: Instrumentation, Sources, and Data Processing
Session 2: Theory, Modelling, and Inversion

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Session 3: Exploration, Monitoring, and Hazards
Session 4: Tectonics, Magmatism, and Geodynamics
Session 5: Marine Electromagnetic (EM) Studies
Session 6: Rock and Mineral Resistivity, and Anisotropy
Session 7: Global and Planetary Studies
Session 8: Electromagnetic (EM) Induction Education and Outreach Poster Session

Eight keynote reviews, focusing on sessions 1–6, are summarized within the workshop Special Issue.

Alan D. Chave (Woods Hole Oceanographic Institution, USA) describes the estimation of magnetotelluric (MT) response functions from statistical models, based on very recent related works. Although robust estimation approaches have long been applied in many practical cases, he evaluates the validity of conditions behind these approaches. Stable distributions are introduced as a more appropriate distribution to describe the regression residuals for MT, for which the Gaussian is an end member. Based on the statistical characters of the residual distribution, the optimal maximum likelihood estimator (MLE) is devised. Stable MLE and conventional robust estimates for an exemplar dataset are compared, and the differences and advantages of the MLE approach over the robust estimates are discussed in detail. The paper is instructive for MT practitioners seeking to learn more about the statistical background to MT response estimation methods.

In recent years, three-dimensional (3-D) MT and electromagnetic (EM) data acquisition have increased significantly thanks to the greater availability of 3-D MT and EM inversion codes. Marion Miensopust (Leibniz-Institut für Angewandte Geophysik, Germany) shares her experience through her review, "Application of 3-D EM inversion in practice—Challenges, pitfalls and solution approaches". Her intention is to raise awareness of 3-D data acquisition and 3-D inversion amongst MT and EM researchers, and to assist in obtaining robust interpretations. In particular, her conclusions provide a useful guide to achieving a successful 3-D interpretation.

Integration of EM data with other geophysical data, such as velocity and resistivity, through joint inversion, is crucial to providing better data interpretation. However, such data combinations can sometimes cause bias, which can mislead interpretation. Max Moorkamp (University of Leicester, UK) provides an insightful tutorial, "Integrating electromagnetic data with other geophysical observations for enhanced imaging of the Earth: A tutorial and review". In his review he uses many examples to demonstrate the advantages and disadvantages of joint inversion. This provides a handy tool for both EM practitioners and scholars from other geophysics disciplines interested in using joint interpretation.

Javier Fullea (Dublin Institute for Advanced Studies, Ireland) reviews integrated geophysical–petrological modelling approaches. In particular, he looks at where electrical conductivity and other physical properties of rocks need to be linked by common subsurface thermochemical conditions within a self-consistent thermodynamic framework. Different observables that can contribute to this joint interpretation approach are introduced. In addition, the main components of the supporting algorithm are described and the development of a self-consistent petrological–geophysical thermodynamic framework, where mantle properties are calculated as a function of temperature, pressure, and composition, are illustrated. The potential of this approach is highlighted through a case study from Central Tibet, where seismological and magnetotelluric data are combined with information on topography, surface heat flow, and mantle xenoliths. In this process, differing and complementary sensitivities of the various datasets are analysed and discussed, highlighting the advantages for a holistic understanding of complex tectonic environments based on integrated thermochemical models.

Hydrocarbons and geothermal resources are an important energy source in Asia. While oil exploration, particularly onshore, relies on conventional seismics, there are certain environments where EM methods can add vital information to assist optimal target characterization. The advantage of EM methods is apparent when either insignificant variations or prominent contrasts in seismic velocities in the target region are expected, e.g., due to an overburden shield over the target hydrocarbon source. Geothermal resources constitute a different scenario since the fluids involved, porosities, and geological settings, augur detectable changes in the electrical conductivity imaged by EM methods. Prasanta Patro (CSIR—National Geophysical Research Institute, India) provides several case histories from Asian countries, illustrating the role of MT in this context. He describes the general conditions for applying magnetotellurics and reveals advances in imaging, modelling, and inversion due to developments in numerical approaches, computer power, and inversion strategies.

Letian Zhang (China University of Geosciences, China) provides a review of the lithospheric electrical structure of Asia, the youngest and largest continent on Earth. The review focuses on the continent's continued growth, which is a result of its complex tectonic history and ongoing collisions of several continental blocks and subductions of the oceanic lithosphere. He categorizes the Asian continent into three tectonic systems: major continent blocks, major orogenic systems, and subduction systems, and reviews recent works, providing comparisons of regional structures in each system. He concludes that the conductivity of the continental lithosphere generally increases from the major continent blocks to the orogenic systems, and again to the subduction systems, which corresponds to the transition from most stable to most active tectonic regions. Detailed descriptions of each system are given, providing a useful overview of the relationship between lithospheric structure and regional tectonics.

Takuto Minami (Earthquake Research Institute, The University of Tokyo, Japan) reviews recent studies on motional induction generated by ocean tides, including tsunamis. This field has experienced significant progress in the last decade due to major tsunami events, greater use of magnetic field data gathered by seafloor instruments and satellites, and developments in numerical simulations. The review begins with a brief history of older motional induction studies and then covers recent studies of ocean tides and tsunamis, providing a comprehensive overview of the observations, simulations, and applications for studies of the electrical conductivity of the Earth's interior. The review is a useful gateway to developments in motional induction studies and recent progress in this field.

Hydraulic fracturing, or "fracking" for short, is one of those geoengineering buzzwords that elicits controversy amongst both geoscientists and wider society. It is used in different gas-bearing environments, as well as for carbon storage and sequestration, where it enhances subsurface permeability. These measures seek to maximize fluid and/or gas flow, and fracking operations are often monitored using EM methods. This is because electrical conductivity shows strong variation depending upon subsurface fluid content and is also sensitive to changes in porosity and permeability. Stephan Thiel (Geological Survey of South Australia, Australia) summarizes EM methods employed in this field, which provide an alternative means to detect subsurface fluids as they are pumped. He draws attention to several key considerations, including: (1) surface MT measurements show subtle, yet detectable, changes during fracking, derived from time-lapse MT deployments; (2) modelling studies should be carried out prior to fluid injection, as they are crucial for survey design and monitoring of fracks; and (3) the limitations of surface-based experiments using electrical conductivity images, as injected fluid volume alone often cannot account for changes in resistivity detected at the surface.

Finally, we, as Guest Editors, would like to express our gratitude to the Editor-in-Chief, Michael J. Rycroft, for his help with the editorial process, as well as Amir Khan, Paul Glover, and fifteen anonymous referees, for their constructive reviews.