

## Preface to the Special Issue on “The 19th Electromagnetic Induction Workshop”

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Electromagnetic 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, U.K., 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 invited review presentations on themes selected by the program committee. These themes vary from workshop to workshop; usually they highlight recent advances in rapidly evolving fields of electromagnetic induction, to introduce important new directions of research as well as to 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; the review papers from the few first workshops were published in *Phys. Earth Planet. Int.* and *Acta Geodaet. Geophys. and Montanist. Acad. Sci. Hung.* All in all these volumes contain 124 review papers and tutorials, including the papers in this present Special Issue. They constitute a very valuable resource for researchers and students, and, in the longer term, record the advances and developments of electromagnetic induction methods and studies.

This Special Issue of *Surveys in Geophysics* contains five expanded articles from the six review papers presented at the 19th Workshop on Electromagnetic Induction in the Earth.

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The workshop was held from 23 to 29 October, 2008, in the Jiuhua Convention Centre, XiaoTangShan, ChangPing district 30 km to the North of the Forbidden City in Beijing, China. It was organised by the Working Group I-2 of the International Association of Geomagnetism and Aeronomy and the Geo-electromagnetic Committee of the Chinese Geophysical Society. The scientific programme of the Workshop was divided into nine themes, for which six had a review presentation:

1. EM and integrated geophysical studies of the Earth, Part I: Near surface applications, including environmental and engineering studies, and Part II: Crustal and mantle studies, including regions with seismic and volcanic activity. Review: Martyn Unsworth, Magnetotelluric Studies of Continent–Continent Collisions.
2. Laboratory studies of electrical properties of rock activity. Review: Takashi Yoshino, Laboratory Electrical Conductivity Measurement of Mantle Minerals.
3. Special session on EM exploration in China. Review: Peizhen Zhang and Guoze Zhao, Contemporary Deformation of the Tibetan Plateau and the 2008 Wenchuan Earthquake of Ms 8.0, Sichuan, China.
4. Applied EM methods for hydrocarbon, geothermal and mineral exploration. Review: Zhanxiang He, Weibin Sun and Weibin Dong, New Progress of Petroleum EM Prospecting and Case Studies in China.
5. 2D/3D modelling and inversion of EM data, including joint inversion techniques. Review: Ralp-Uwe Börner, Numerical Modelling—Advances and Challenges.
6. Marine EM studies.
7. Theoretical aspects of EM exploration, including data processing, response function analysis and distortion analysis.
8. Global induction studies using satellite and ground EM data.
9. Potpourri Session: instrument development, natural source field studies, and new projects. Review: Estella Atekwana, Geophysical Signatures of Microbial Activity.

*Martyn Unsworth* (University of Alberta, Canada) tackles continent–continent collisions, which is a very important tectonic process that has played a fundamental role in the evolution of the continents and has influenced, e.g., global weather patterns. The review focuses on the two most active collisions zones, viz. the India-Asia collision that formed the Tibetan Plateau and Himalaya, and the Arabia-Eurasia collision that formed the Anatolian-Iranian plateau. In addition, the collision zones at a later stage of evolution, such as the European Alps and Pyrenees are discussed. Finally, the high Altiplano-Puna plateau in the Central Andes with many similarities to the Tibetan Plateau is briefly discussed to note that several tectonic processes can build a high elevation plateau.

*Takashi Yoshino* (Institute for the Study of the Earth's Interior, Japan) reviews laboratory measurements of the electrical conductivity of mantle minerals. The interpretation of conductivity models in terms of physical state, composition, deformation, dynamics and evolutionary history largely depends on the physical properties of minerals obtained from laboratory determinations. Thus, proper data on the electrical conductivity of crustal and mantle rocks can provide valuable information on the chemical state, pressure, temperature and the presence of an electrically conductive phase such as a fluid and/or a partial melt. Dr Yoshino, after acknowledging that minor conductive phases such as a fluid or partial melt are important to explain the electrical conductivity values obtained from the geophysical observations, focuses on the electrical conductivity of the mantle minerals. First, he describes the dominant electric conduction mechanisms in silicate minerals and the methods used in high pressure conductivity measurements, paying attention to how to monitor proton conduction due to the migration of hydrogen in nominally anhydrous

minerals. He then examines experimental results for each main mantle mineral, which provide material finally to discuss some important topics such as electrical conductivity at the top of the asthenosphere or water in the mantle transition zone.

In their review, *Zhanxiang He, Weibin Sun and Weibin Dong* (BGP, China National Petroleum Corporation, China) describe recent progress in data acquisition, processing and interpretation techniques for hydrocarbon exploration in China. These authors first review instrument developments and continue by depicting several EM methods embracing, e.g., controlled source and borehole EM methods applied to data processing and interpretation. The authors illustrate the use of electromagnetic methods in hydrocarbon exploration with several examples. Their review gives information on the current status of the use of EM methods in hydrocarbon detection in China. The case histories show that EM methods are useful and effective in petroleum exploration, especially in seismically challenging areas.

The broad field of numerical modelling for electromagnetic applications is among the most rapidly evolving fields in EM induction studies today, as a result of increased industrial needs, in particular in the hydrocarbon and ore exploration industries, and as a result of improved reliability and accuracy of data acquisition techniques. *Ralp-Uwe Börner* (TU Bergakademie Freiberg, Germany) summarizes the main achievements in the numerical solution of direct 3D electromagnetic problems during the last decade. Emphasising the latest results and trends in the field, Dr Börner centres his review on Finite Difference (FD) and Finite Element (FE) spatial discretization methods, which have become the mainstream approaches in forward modelling of the electromagnetic field. After a brief introduction, he describes spatial discretization and time integration methods, the latter being significant in electromagnetic exploration in particular. He then goes through some numerical methods available for the solution of the large equation systems arising from the spatial discretization of the partial differential equations. Dr Börner finishes his review by addressing several challenges in reducing the computing costs, e.g., in terms of code efficiency and speed.

Micro-organisms participate in a variety of geologic processes that alter the chemical and physical properties of their environment and which therefore have a significant impact on near-surface geophysical investigations. Attempts to understand the role of micro-organisms acting in geological systems have resulted in the development of a new sub-discipline in geophysics called “biogeophysics”. Thus the review by *Estella Atekwana and Eliot Atekwana* (Oklahoma State University, U.S.A.) on geophysical signatures of microbial activity is very timely. Geophysical techniques, with the advantage of rapid deployment, the ability to cover extensive areas at high spatial sampling density, and the ability to repeat the observations in short time intervals, can complement biological and geochemical studies at contaminated sites. Their review focuses primarily on biogeophysical signatures of sites contaminated by light, non-aqueous phase liquids (LNAPL). It examines the geophysical responses over short time periods of weeks to months when the alteration of the LNAPL by microbial activity has not occurred to a significant degree and over long periods of several years to decades, when significant microbial degradation of the LNAPL has occurred.

The 19th EM Induction Workshop in Beijing attracted 480 scientists, which is the overwhelming record in the history of these induction workshops. The number of Chinese delegates was the largest, with 255 scientists and students. Other delegates, representing universities, research institutes and the industrial sector, came from 43 countries from all the major continents of the world (and from all the major lithospheric plates). In addition to the six review papers, there were 371 contributed abstracts. A total of 57 contributions, including the reviews, were presented in ten oral sessions in the mornings and 320 posters

were presented throughout the workshop. Four discussion sessions were held in the afternoons, on the themes of the day.

Besides the main workshop, a Pre-Workshop and Post-Workshop were organized. The Pre-EMIW took place in the Long-Ge Hotel in Beijing from 20 to 22 October, 2009. It consisted of five tutorial courses given by Igor Rokityansky (The MV—Basic Concept of Magnetic Variation Methods and Their Use), Weerachai Siripunvaraporn (3-D MT Forward Modelling and Inversion), George Jiracek (Digital Processing with Application to Geoelectromagnetics), Ivan Varentsov (MT/MV Data Processing: Multi-Site Techniques and Case Histories with Noise Problems), and Saurabh Verma (New development of MT data analysis and interpretation). About 80 people, including 32 from outside China, attended this pre-workshop. The Post-Workshop on Deep Structure and Dynamics of Himalaya-Tibet and the Wenchuan Strong Earthquake was held in Chengdu University of Technology in Sichuan province, from 31 October to 3 November, 2008. About 50 people attended this meeting. A number of the post-workshop participants joined a trip to visit the Wenchuan earthquake area.

In addition to the scientific program, there were a number of social events during the workshop. On 26 October, nine buses took participants and accompanying persons either to the Forbidden City or to the Great Wall, where it was possible to select the “Sunday walk” or the physically more demanding “Monday walk”. On the return trip, the buses stopped at the new Olympic village for a quick look at the Bird’s nest, Water cube, etc. This Sunday ended with a workshop dinner in the “Restaurant City in Shengtaiyuan Garden”, where even the restaurant personnel could not name the dozens of dishes served in a traditional Chinese way. A dance performance was given on the next evening; a talented group of professional artists from the Art College of Yangtze University in Hubei Province came to Beijing just for this event. A ping-pong (table tennis) friendship match was held between the international and Chinese teams on 28 October. In order to encourage interactions between the delegates, the activities mentioned above were free.

The Working Group I-2 is most grateful for their generous financial and logistical support to many Chinese and international organisations, institutions and universities (26) and enterprises (18), among them the China Earthquake Administration (CEA), the China National Petroleum Corporation (CNPC), the National Science Foundation of China (NSFC), the China Petroleum and Chemical Corporation (SINOPEC), the China Geological Survey, the Beijing Ouhualian Science and Technology Ltd. (BOST), and NSF, IAGA, Phoenix, KMS Technologies and Metronix from outside China. Applications for financial support to attend were received from 146 people, and a total of 74 people from 22 different countries were allocated support to attend this most worthwhile event. Most of the support was given to students or postdoctoral fellows/junior scientists.

The Working Group is grateful to the Local Organizing Committee for a very well organized workshop, in spite of unforeseen complications caused by the Olympic Games held in August 2008 in Beijing, and the devastating 2008 Wenchuan MS 8.0 Earthquake. Future workshops are planned for Giza, Egypt, in September 2010, and Darwin, Australia, in late July and early August 2012.

Finally, we, as Guest Editors, thank the twelve referees for their careful and constructive reviews as well as the Springer Editorial Office, and in particular Michael Rycroft, Editor in Chief, Petra van Steenbergen, Senior Publishing Editor, Earth Sciences, and Joanne Cabato, Springer Editorial Office Assistant, for their help and advice during the editorial process using the EM (i.e. Editorial Management) system.