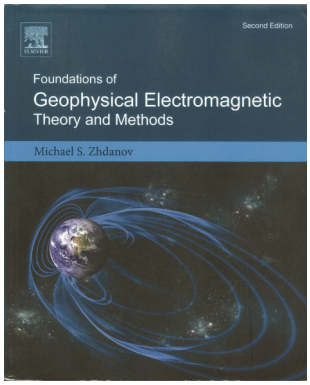


Foundations of Geophysical Electromagnetic Theory and Methods. Second edition. Michael S. Zhdanov. Elsevier, Radarweg 29, PO Box 211, 1000 AE Amsterdam, The Netherlands. 2018. xxxiii + 770 pages. Price: US$ 300.

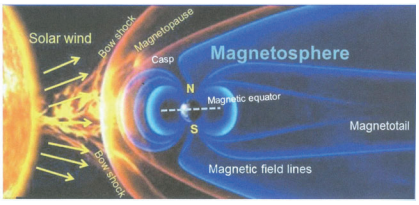
Exploration of Earth's subsurface has diverse practical applications: in the search for minerals and hydrocarbons; in groundwater, geothermal and environmental studies, and in investigations of regional tectonics. Electromagnetic (EM) methods of subsurface exploration, involving measurements of electric and magnetic fields from various platforms to obtain information about the distribution of electrical conductivity within the Earth, have made rapid strides in the last few decades. In geophysical exploration, electrical conductivity is considered to be more useful than other physical properties of the medium because it varies by several orders of magnitude in the subsurface, while other parameters vary over relatively limited ranges. This book, in its second edition, covers the entire gamut, ranging from basics of EM theory to complexities involved in the analysis and interpretation of data using different EM methods, and recent developments in improving reliability of the results based on more rigorous theoretical models.

The book is divided into four parts. The first part, consisting of two chapters, is devoted to a discussion of differential calculus of vector fields. As pointed out by the author in the Preface, some readers may not find the discussions on differential forms in chapters 1 and 2 to be particularly useful. In Part 2, after a detailed discussion of Maxwell's equations in chapter 3, basic equations for the three main groups of EM methods, used in geophysical exploration, are introduced in chapter 4. In the direct-current (DC) methods, currents driven through source electrodes on the surface of the Earth, which flow entirely within the Earth, are measured by electrodes at different distances from the source electrodes, to carry out vertical electric sounding of the subsurface. This method, which assumes that temporal variation of the currents is slow enough that induced currents are negligible, is widely used. In the other two groups of methods discussed in the book – natural-field EM methods and controlled-source EM methods (CSEM) – time-varying external magnetic fields give rise to induced currents within the Earth, and subsurface electrical conductivity distribution is computed from estimates of induced currents. There are natural sources of time-varying magnetic fields in the Earth's ionosphere and magnetosphere, which are discussed briefly in chapter 13. In CSEM methods, a transient EM field is generated over the Earth using a source with specified parameters.

Starting with a theoretical description of EM induction in a homogenous conductive medium in chapter 4, the next level of complexity is introduced in chapter 5, where EM fields in horizontally stratified media are discussed. While this provides the first approximation for a regional model consisting of Earth's crust and upper mantle, it also serves as the background on which compact anomalous regions are considered to exist in more complex models. Such models are then amenable to EM forward modelling using an integral equation approach, discussed in chapter 6. An important new addition in the second edition of the book is the discussion of the contraction integral equation method developed in recent years, where preconditioning is introduced in order to improve the convergence rate of successive iterations. Differential equation methods are also discussed in chapter 6, with new sections on contraction preconditioner and an edge-based finite element method, where the choice of basis functions ensures that divergence-free conditions are satisfied automatically.

Part 3 of the book deals with inversion of the EM field data for imaging subsurface geo-electric structures. In chapter 7, the author dwells on the problem of non-uniqueness that is faced in inversion of EM field data. Tikhonov regularization theory is presented as a guide to minimize the problem of unstable and unrealistic models that are obtained from a solution of an ill-posed geophysical inverse problem. In chapter 8, an efficient method is introduced for calculation of the Fréchet derivatives of the forward modelling operator, which are used to estimate the sensitivity of EM data to 3D geo-electrical model parameters, an important aspect of EM inverse problems. Chapter 9 on EM migration, reviews the theoretical aspects of an alternative approach for reconstruction of a subsurface 3D geo-electric structure, which makes use of recorded amplitudes and phases of the EM field scattered by the structure, and the concept of holography. Utility of this approach in reducing computational requirements has been demonstrated in several publications by the author, who has developed this alternative method.

The first nine chapters of the book are devoted to EM field theory as applied to the problem of reconstruction of subsurface geo-electric structures using EM methods. However, the reader is reminded that these methods are applied in the real world, by detailed discussions in part 4 of the book, on practical aspects of the application of EM methods. Chapter 10 provides information about the electrical properties of various rock-forming minerals. It also discusses the dependence of electrical conductivity of water-bearing rocks on their porosity, for different types of rocks. The phenomenon of induced polarization (IP) is introduced in this chapter, and further discussed in chapter 12 on IP methods. An effective medium theory is described in chapters 10 and 12, to deal with complex rock formations, including their matrix composition, porosity, anisotropy and polarizability. Electrical properties of important large-scale geo-electrical structures such as sedimentary basins and oceans are also included in chapter 10. Chapter 11 deals with practical considerations for generation of EM fields in the CSEM methods and acquisition of high-quality EM data in the field. Methods for measurement of electric fields and various types of magnetometers used to measure



Magnetosphere of the Earth

magnetic fields are also discussed. Chapter 11 concludes with various aspects of pre-processing the acquired data.

Three main groups of EM methods used in geophysical exploration: DC and IP methods, natural-field EM methods, and CSEM methods, are discussed in detail in chapters 12–14 respectively. In chapter 12, the new edition has introduced a generalized effective medium theory of the IP effect (GEMTIP), which includes elliptical inclusions in a model of the multiphase medium. A new section in this edition discusses 3D inversion of the magnetotelluric (MT) phase tensor, as the phase relationship between electric and horizontal magnetic field vectors is not significantly affected by near-surface heterogeneity, unlike the observed electric field amplitude. The only flaw that I found in this otherwise comprehensive book is in the description of the natural EM field of external origin provided by currents flowing in the Earth's magnetosphere and ionosphere, which the author may have included for the sake of completeness. For currents flowing in the ionosphere at an altitude of about 100 km above the surface of the Earth, effects of non-uniformity of the source field are not discussed in the book. In MT and magnetovariational methods, currents flowing in the magnetosphere are often considered as the external sources of plane EM waves incident normally on Earth's surface. Frequency bands used in these methods are such that the displacement current may be neglected. These frequency bands are considered to arise from complex interactions between Earth's magnetic field and flow of plasma from the sun. However, the statement (p. 503) that magnetic storms are associated with solar flares, and the suggested mechanism of a storm, are incorrect. Earth-directed coronal mass ejections (CMEs) from the sun generally cause major magnetic storms, when the interplanetary magnetic field accompanying the CMEs has a southward component allowing reconnection with the Earth's magnetic field. This finds no mention in the book. High-speed solar streams from coronal holes, which give rise to co-rotating interaction regions are generally associated with weaker magnetic storms. This lacuna may be skipped by readers as in natural-field EM methods, unlike the CSEM methods, parameters of the source of the external field are not specified.

Scientists and technologists involved in two important areas of geophysical exploration: offshore hydrocarbon exploration using EM methods and exploration of mineral deposits using airborne electromagnetic (AEM) methods should find the inclusion of recent developments in these two areas to be useful. The new approach to 3D inversion of AEM data may lead to improved reliability of the results of such exploration. Finally, a separate chapter devoted to specific case studies involving the use of different EM methods in tectonic and crustal studies, mineral and hydrocarbon exploration should be highly instructive.

This book is a complete treatise on the subject by an authority in this field, which should be included in the library of a university, institute, or organization involved in teaching or using EM methods of geophysical exploration. In the exposition of the theoretical foundation of these methods, the level of complexity of subsurface geological structures has been increased in steps. The first few chapters provide excellent material for an introductory course on EM methods for postgraduate geophysics students. For those engaged in research in this area, the book offers deep insights into many aspects of EM methods. It would enable researchers to explore how they can develop their own tools to extract reliable and useful information from EM data obtained in different settings.

ARCHANA BHATTACHARYYA

Upper Atmospheric Studies Division,
Indian Institute of Geomagnetism,
New Panvel Campus,
Navi Mumbai 410 218, India
e-mail: abh@iigs.iigm.res.in

Annual Review of Phytopathology, 2017. Jan E. Leach and Steven E. Lindow (eds). Annual Reviews, 4139 El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, USA. Vol. 55. x + 610 pages. ISBN: 978-0-8243-1355-5. Price: US$ 107.

This volume includes 25 authoritative reviews. The main subjects dealt with are emerging themes, plant immunity, ecological and epidemiological issues, pathophysiology, pathogen biology and disease management. The opening chapter is an autobiographical sketch of a molecular plant pathologist, Nickolas J. Panopoulos. His research career bloomed in USA during the period when the era of molecular plant pathology sprouted from developments in recombinant DNA. The personal reflection of his accomplishments along with the growth of molecular phytobacteriology have been admirably described. Youngsters can derive inspiration from this presentation.

Toxin–antitoxin (TA) systems widely present in the prokaryotic kingdom are ancient sets of closely linked self-killing or suicide genes consisting of a toxin gene and its cognate antitoxin gene. The bacterial genomes harbour several of them with diverse structure, and these move between genomes through horizontal gene transfer. They encode a proteinaceous toxin capable of killing the host and a labile antitoxin which are either small proteins or small RNAs (sRNAs) directly inhibiting the toxin or controlling toxin production. It is now clear that these gene modules are present in plasmids as well as in chromosomes. The past 34 years, since the discovery of a TA system involved in plasmid stability in host bacterium[1], have widened our knowledge, more particularly with bacterial pathosystems in animals revealing their multiple cellular functions, including persistence or bacterial stress tolerance, pathogenicity and virulence, phage defence and biofilm formation. However, the functions of chromosomally encoded systems still remain an enigma. TA systems are prevalent in plant-associated pathogenic and symbiotic bacteria. Shidore and Triplett mine the TA systems in host–microbe interactions and examine their role in bacterial lifestyles with the plant which would trigger a new theme for expanding our understanding of plant–microbe interactions. This review attempts to project TA systems offering opportunities for development of novel strategies to manage plant diseases, similar to the approaches in biomedical field towards applications for clinical infections.

The host microbiota presents opportunities for pathogens interacting with other microorganisms of varied ecological lifestyles of commensalism, symbiotic and pathogenic forms in their biotic environment resulting in the cause of disease or altering the disease manifestations either directly or indirectly. Knowledge gained on this in recent years has led to the evolution of a new concept of