Reviews

Coordinated by Patrick Taylor

Gravity and Magnetic Methods in Mineral and Oil and Gas Exploration and Production, by Yaoguo Li and Richard Krahenbuhl, ISBN 978-9-462-82159-0, 2015, EAGE, 155 p., US $77.

Inverse theory is being used in several geophysical disciplines (e.g., seismology), and those individuals working with inverse theory, at an advanced level, will gain the most from this volume. Others would be better equipped to make the most of this EAGE book if they are familiar with terms such as L-curve criterion, Green's tensor Γ, or Tikhonov regularization; if not, I suggest that they first read an inverse-theory volume (e.g., Minke, Gubbins, or Parker).

Chapter 1, "Introduction," is just that, whereas Chapter 2 presents the fundamentals of gravity and magnetic data. In Chapter 3, equivalent source techniques of Dampney (1969) are discussed using a regularized inverse method and are preferred by the authors (both Colorado School of Mines) over the fast Fourier transform algorithm. Chapter sections on processing data on uneven surfaces; low latitude reduction to the pole; and denoising of multiple-component gravity gradiometry data are addressed using the equivalent source method to solve these important geopotential field applications.

In Chapter 4, "Fundamentals of 3D potential-field inversion for physical properties," the authors state, "the availability of generalized inversion has been steadily expanding the use to regional-, continental-, and even global-scale problems." In *Geological Interpretation of Aeromagnetic Data*, D. J. Isles and L. R. Rankin, however, have a different take on inversion. They state, "It is unwise to expect that an inversion will be able to provide realistic geometry over broad areas with complex assemblages of magnetic rock units. Inversion schemes are well suited to modeling single magnetic anomalies or local anomaly complexes at depth to provide guidance for drill testing."

Binary inversion is discussed in Chapter 5. This method is applicable when, at a given location, physical properties can have only two possible values. This procedure has special application or salt imaging and reservoir monitoring. A pitfall of binary inversion occurs when the initial assumed topography has undetected irregularities.

In Chapter 6, two methods of estimating the direction of magnetization — Helbig's moment and crosscorrelation — are compared (they also are evaluated once more in Chapter 7.3). Interpreting reduced-to-the-pole magnetic data in the presence of not only susceptibility (high and low) but also remanence and self-demagnetization are also described and well illustrated.

In Chapter 7, five case histories are described using the methods of the earlier chapters: Raglan, Quebec, Ontario (ultramafics with nickel mineralization); iron ore from Ferrifero, Brazil; kimberlites (Northwest Territories, Canada); iron-oxide copper-gold deposits, Carajás, Brazil; and inverting magnetic amplitude data for gas exploration in sedimentary basins. In this section, the authors state, "the primary objective of geophysics is to image and map subsurface geology, not necessarily physical property distributions."

Chapter 8 ("Time-lapse gravity monitoring") and Chapter 9 ("Case studies in time-lapse gravity") are, in my opinion, the most important chapters because they describe a new dimension for geopotential studies. Details are presented on how to establish base stations and make time-interval measurements. Pitfalls are described, e.g., tidal effects, instrument drift, changes in atmospheric pressure, and groundwater variations. In some regions, changes (Arctic) in topography and terrain variations are a concern. This chapter (Chapter 8) is followed by an equally important presentation of several case histories (Chapter 9), viz., North Sea CO_2 injection, gas-cap water injection Prudhoe Bay; monitoring aquifer storage and recovery; geothermal resource monitoring; and several others.

This volume, part of the EAGE Education Tour Series, presents powerful and new methods of processing and interpreting geopotential data. Despite the high level of presentation, it should be within reach of every geophysicist working with gravity and magnetic data. This is a well-produced volume with many black-and-white and color figures and diagrams; unfortunately some of the legends are difficult to read. Not only does this volume lack a list of acronyms but an index as well.

— Patrick Taylor
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A Guided Tour of Mathematical Methods for the Physical Sciences, third edition, by Roel Snieder and Kasper van Wijk, ISBN 978-1-107-08496-4 (hardback), ISBN 978-1-107-64160 (paperback), 2015, Cambridge University Press, 560 p., $130 (hardback), $65 (paperback), $52 (eBook).

The first and second editions of this gem of a volume were received with praise such as "a delight of a book," "a fantastic set of physical problems that opens the gate to the understanding of mathematical physics," and "a refreshing alternative approach," among many others. It is difficult to find better words to describe the third edition, which bears the name of not only Roel Snieder but also that of his new coauthor, Kasper van Wijk. Fresh material has been added to the existing chapters, along with two new ones, the first dealing with probability and statistics, the other with the geophysical inverse problem.

Although any physicist or applied mathematician can benefit from this book, either for study or for reference, it is directed particularly at a geophysical audience. It is student-friendly not only in its clarity and elegance of style, but also because the prices of the paperback and Adobe eBook editions are affordable by many students. This is more than one can say about most technical books nowadays and is a feather in Cambridge University Press's hat.

Each chapter contains a large set of problems that the authors urge the reader to work out since, as they say, a subject cannot be learned by simply reading a textbook — or, as they put it so nicely, "true learning can only take place by active exploration." The book contains a variety of chapters dealing with more routine topics of mathematical physics, such as the divergence and curl of vector fields, linear algebra, Fourier analysis, and potential-field theory. Yet one also finds chapters covering material not usually found in textbooks of this kind. For example, there are lucid chapters dealing with dimensional analysis and scale analysis (the latter is a means to study the relative importance of given terms in an equation). The authors' sense of humor appears often and makes the material even more enjoyable to comb through. Thus the chapter on the calculus of variations begins with the problem of designing an "optimal" can, which turns out to be a circular cylinder, should anybody have been wondering. Other attractive features of the third edition include a Web site from which one can download illustrations appearing in the text as well as updates to the text since, as the authors remark, "This book is evolving."

The volume is both a finely honed learning tool and a good reference for most of the mathematics that a geophysicist might encounter in practice. An exception, at least in my opinion, is a missing chapter dealing with time- and frequency-domain seismic signal processing, which I hope the authors will include in a fourth edition, if not earlier on their Web site. The book concludes with a short but delightful epilogue in which the authors, following the example set by Nobelist E. P. Wigner, speculate just why mathematics has such remarkable predictive power for such a wealth of observed physical processes. In short, here is a book that no practicing geophysicist (or even a retired one!) should be without.

— Sven Treitel
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Treatise on Geophysics, second edition, edited by Gerald Schubert, ISBN 978-0-444-53802-4, 2015, Elsevier, 5604 p., US $4200.

As the sitting SEG President, I have to be somewhat selective accepting new commitments. You might think a book review is the last thing I would step into; after all, I am barely keeping up a few "Seismos" columns per year in *The Leading Edge*.

But this is no ordinary book. *Treatise on Geophysics,* second edition (*TOG2*), is an 11-volume tour de force, a broad and sprawling effort to capture the current state of knowledge in geophysics. From the outset, that presents a problem. Geophysics is a vast collection of disciplines, specialties, topics, methods, and so on. The full scope of geophysics cannot be captured even in 11 thick volumes (length varies from 907-page volume 1 to 302-page volume 9). But it is a majestic undertaking, well worth the effort. To paraphrase Robert A. Heinlein, such a book stitches the patches of the universe together into one garment for us.

The general scope of this laudable Elsevier project can be gathered from the volume titles: (1) "Deep Earth Seismology," (2) "Mineral Physics," (3) "Geodesy," (4) "Earthquake Seismology," (5) "Geomagnetism," (6) "Crustal and Lithosphere Dynamics," (7) "Mantle Dynamics," (8) "Core Dynamics," (9) "Evolution of the Earth," (10) "Physics of Terrestrial Planets and Moons," and (11) "Resources in the Near-Surface Earth."

How does one approach reviewing an 11-volume book? Based on education, I feel qualified to comment on volumes 1, 4, 5, 8, and 10. My entire working life, however, is within the scope of just volume 11. The last individual that is thought to have known all of science was either Thomas Young (d. 1829) or Hermann von Helmholtz (d. 1894), depending on which historian you believe. If we narrow the discussion to just geophysics, someone likely understood it all in the early 1960s, before the subsequent explosion of applied science. It is the nature of a composite science such as modern geophysics that no one person can possibly be an expert in all aspects of the subject.

But that is precisely why magnificent projects like *TOG2* are undertaken with an army of editors and contributors. The editor-in-chief is Gerald Schubert of UCLA, member of the National Academy of Sciences and famous as coauthor with Donald Turcotte of the standard textbook, *Geodynamics*. Each volume has one or two editors and individual chapters have one or more authors, so *TOG2* runs the risk of being science by committee or, worse yet, a tired compilation of previously published papers presented as chapters. Yet *TOG2* compulsively and completely fights this temptation, creating instead a masterful collection of chapters by first-class authors rewarding the reader with a stroll right up to the dizzying height of current knowledge in literally hundreds of subject areas. In volume 1 alone, the list of chapter authors reads like a *Who's Who*, even if you are not in the field of deep-earth seismology: Dziewonski, Virieux, Cormier, Tromp, Levander, Zelt, Symes, and Keller, to name a subjective few.

The typical SEG reader will notice that *TOG2* is not intended to span the applied-geophysical subjects associated with fossil fuel and mineral exploration, although volume 11 ("Resources in the Near-Surface Earth") is a good, self-contained overview. Rather, it deals with the fundamental science behind applied geophysics (particularly seismology) and its application to understanding the earth and planets. To give one example, "Theory and Observations: Forward Modeling: Synthetic Body Wave Seismograms," (volume 1, Chapter 6) is a panoramic discussion of seismic-modeling algorithms, parameterization, and a broad view of heterogeneity, attenuation, and anisotropy. One can easily forgive two colons in the chapter title considering the authoritative depth and breadth of the text. A picky reader might notice that constant-*Q* theory is given as an approximation (that violates causality) without reference to the exact theory of Kjartansson and anisotropy without mention of Thomsen. The former omission is particularly curious since Kjartansson's work appeared the prestigious *Journal of Geophysical Research*. But these are quibbles that detract nothing from a strong authoritative text.

In my opinion, *Treatise on Geophysics,* second edition, is a splendid, ambitious encyclopedia of the fundamental geophysical sciences. As such, it would be a welcome addition to any working library in pure or applied geophysics. Its publisher, editors, and authors are to be commended for undertaking and so finely executing such a task. One wishes that the major applied-scientific societies (SEG, AAPG, and SPE) would collaborate on a similar scale to create a treatise that would as adequately capture the current knowledge of applied geophysics.

— Christopher Liner
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