BOOKS: GEOSCIENCES

Making Sense of Deformed Rocks

Steven Wojtal

The deformation of rock generates individual macroscopic structures like fractures, faults, and folds as well as mappable patterns of structures that indicate the relative motion of tectonic plates. Deformation also produces distinctive features that pervade rocks at mesoscopic and microscopic scales. These fabrics are defined by distorted sedimentary or igneous features or by preferred orientations of mineral grains or reshaped rock fragments. Over the past 50 years, geologists have developed increasingly precise three-dimensional characterizations of rock structures and fabrics in different geologic settings. During the same interval, they have used a growing body of experimental data, better mathematical descriptions of displacement and velocity fields associated with rock structures, and theoretical analyses of the mechanics of deformable materials to interpret structures and fabrics and, in some cases, to determine the dynamics of rock deformation. The mathematical approach of continuum mechanics is the thread that weaves together studies of processes at different spatial and temporal scales: from individual mineral grains to regional deformation to tectonic plates, and from instantaneous displacements like earthquake slip to movements taking millions of years. For this reason, the third volume of *Techniques of Modern Structural Geology* will interest all researchers and students in the fields of structural geology and tectonics.

The Techniques of Modern Structural Geology
Vol. 3: Applications of Continuum Mechanics in Structural Geology
by John G. Ramsay and Richard J. Lisle

Academic Press, San Diego, 2000. 372 pp. Paper, $65, £43.95. ISBN 0-12-576923-7.

John Ramsay, an emeritus professor at the University of Zurich and the Swiss Federal Institute of Technology (ETH), is perhaps the most renowned living structural geologist. Few individuals have had as strong an impact on modern structural geology. His co-author Richard Lisle, who is at Cardiff University, Wales, has also earned significant respect and acclaim for thoughtful and thorough research papers and monographs. Because of the authors' expertise, the importance of the topic, and the success of the earlier volumes, *Applications of Continuum Mechanics in Structural Geology* has been anticipated by the community for some time. *Volume 1: Strain Analysis*, by Ramsay and Martin I. Huber, was published in 1982; *Volume 2: Folds and Fractures*, also by Ramsay and Huber, appeared in 1987. Despite the long hiatus, *Volume 3* shares many features with its predecessors and has a surprisingly similar overall feel.

Like the earlier volumes, *Continuum Mechanics* is grounded in thorough analytical descriptions of structures and fabrics found in naturally deformed rocks. The authors depict sample structures and their analyses in numerous line drawings and black-and-white photographs, the artistic design and clean layout of which add substantially to the presentation. Those familiar with the first two volumes will find the figures here are equally successful at presenting concepts. Readers unfamiliar with structural geology but interested in continuum mechanics will find in these illustrations striking and convincing evidence that relates individual rock structures and fabrics to features of strain or stress distributions.

Ramsay and Lisle have also preserved the expository tone of the earlier volumes. Individual chapters ("sessions") address topics through a combination of descriptive text, worked examples, and questions for the reader. Given the topics covered and the level of the approach taken by the authors, the likely audience is (at least in North America) graduate students and researchers, not undergraduates. For this reason, I find this question-answer organization a curious rhetorical choice. In those cases where the authors defer the answers to the ends of the chapters, the questions disrupt an otherwise smooth expository flow.

The authors have chosen, with a few exceptions, to relegate citations to annotated lists of key references at the ends of chapters rather than link particular ideas to specific sources. And there is a slight bias toward the work of European scientists. Nonetheless, the lists should lead any interested reader well into each of the topics addressed.

Computer methods are required to solve many of the particular problems that the authors discuss. To introduce them, the volume includes listings of Quickbasic programs written by Lisle, and all of these programs are provided (in Windows 3.1 and Macintosh versions) on a CD-ROM. The programs that I tried (on a Windows-compatible computer) ran smoothly and generated usable and, as far as I could ascertain, accurate output.

The book covers a broad range of general continuum mechanics topics and techniques, including heterogeneous stress, Lagrangian and Eulerian specifications of displacement and velocity fields, heterogeneous strains in two and three dimensions, finite-element and finite-difference modeling of elastic and viscous deformation, and the use of stream functions to analyze viscous flows. The authors present the topics and techniques briskly and clearly, underscoring general principles. They then outline how the material is relevant to geologists who seek to understand the development of rock structures. Ramsay and Lisle employ the effective strategy of introducing general classes of problems, such as sheet flow or channel flow, that they then exploit to investigate distinctive geological settings, such as the flow of glacial ice or lava. The coverage of finite-element and finite-difference methods, which sets this volume apart from other structural geology texts, is especially clear and should stimulate more workers to undertake these methodologies. The book also provides thorough coverage of several topics of interest mainly to Earth scientists, such as fault-slip analysis (paleostress analysis), the development of shear zones and band structures, and the folding of rock layers.

Spectacular structures. The west face of the Dent de Morcles in the Swiss Alps exposes these folds in Cretaceous and Tertiary sedimentary rocks. They are a striking example of rock structures in mountain belts, one of several settings where mappable patterns reveal the character of rock deformation.

CREDIT: COURTESY JOHN RAMSAY

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Highlighting the geometries of structures and fabrics, Ramsay and Lisle argue for thorough and careful characterization of naturally deformed rock. They emphasize geometric and kinematic analogies between rock structures and the results of elastic or viscous boundary value problems, and they are conservative in the inferences they draw from their comparisons of continuum mechanics models and natural structures. Their inferences are, in my view, robust and highly general, and their approach is worthy of emulation.

Applications of Continuum Mechanics in Structural Geology offers an excellent conclusion to the series. Like its predecessors, it is thoughtfully conceived and carefully completed. As Ramsay and Lisle state repeatedly, for the foreseeable future structural geology will require thorough characterizations of natural structures along with effective analyses of the stress, displacement, or velocity fields inferred to be responsible for them. Because this volume exemplifies successful ways to accomplish both tasks, it is a fine introduction to modern structural geology.

BROWSINGS

The Living Wild. *Art Wolfe.* Wildlands, Seattle, WA, 2000. 256 pp. $65, C$100. ISBN 0-9675918-0-5.

To promote the preservation of biodiversity, Wolfe presents spectacular photographs of charismatic animals in their natural surroundings—from islands and oceans to mountains and the polar regions to the tropics. He includes brief accounts of the wildlife, their future prospects, and his experiences in recording them on film. Accompanying essays by William Conway, Richard Dawkins, Jane Goodall, John Sawhill, and George Schaller discuss the current status and future prospects of wildlife conservation. These maroon-fronted parrots (*Rhynchopsitta terrisi*) inhabit pine forests of Mexico's Sierra Madre Oriental, where they are threatened by habitat destruction from logging, agriculture, and grazing.

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BOOKS: ENVIRONMENT

Why We Must Worry

Peter Raven

One constantly wonders why books and papers about the global environment and our effects on it are so widely ignored when the arguments are ostensibly so convincing. Perhaps their often alarmist tone, which frequently engenders a feeling of powerlessness, contributes to the problem. Or perhaps, in some instances, a wooden writing style dissuades readers. If such factors are to blame, *The World According to Pimm* should offer a certain cure. Not so much an original treatment of the field as a highly engaging, beautifully presented one, this is an outstanding effort that surveys the relevant facts extremely well.

With passion and grace, Stuart Pimm (a professor of conservation biology at Columbia University) presents a view of the world that is both personal and universal. His informative account draws on his wide travels and extensive scientific studies of the environment, which have taken him to each of the continents. Pimm uses his rich background in evaluating the status of Hawaii's rarest birds as a jumping-off point for considering the fate of the world as whole, its myriad species, and its extraordinary beauty. Offering readers a rare combination of vivid imagery and close attention to detail, Pimm presents our relation to our planet—its forests, drylands, prairies, and oceans—with a precision and clarity that have seldom been approached in other works on this topic. Writing so as to be understood by any intelligent reader, he skillfully reviews the current condition and likely future of our impacts on the land and in the oceans. The book is exceptionally well documented, and it presents the facts of environmental degradation as clearly and forcibly as any work that I have encountered.

The World According to Pimm
A Scientist Audits the Earth
by Stuart L. Pimm
McGraw Hill, New York, 2001. 303 pp. $24.95. ISBN 0-07-137490-6.

The impact of 6.1 billion humans on our planet is staggering and affects every aspect of our lives, whether we realize it or not. Pimm emphasizes the accelerating loss of biological diversity. A few centuries ago, about 10 of the estimated 10 million species on Earth disappeared each year; now perhaps 1000 are lost annually, and the rate is rapidly climbing toward 10,000 per year as human impacts intensify everywhere. In addition, species are not interchangeable. The product of at least 3.8 billion years of evolution, each has its own importance, its own meaning in the function of ecosystems, and its own potential for us. Because extinction is irreversible, it has permanent effects on Earth and on human prospects.

Humans currently consume more than 40 percent of the world's annual biological productivity, and we use and borrow more than half of its accessible global freshwater runoff. Our situation is clearly not sustainable. We are living off the principal, not the interest, and we face the same consequences that such a strategy would have if it were applied to a personal bank account.

In his epilogue, Pimm does an especially good job of highlighting the lack of attention economists and politicians pay the environment, and the grave dangers implicit in such negligence. Earth has only so much to yield, and only at our peril can we assume it can continue to respond to our needs. It is important that we learn about Earth and its biota much more efficiently and rapidly than we currently do, because we need such knowledge to manage our home sustainably. We must address these problems at a global scale, "with at least enough precision to detect a decade of change." In an outstanding imaginary dialogue with an economist, an environmentalist, and someone governed by social and religious values, Pimm presents lively and convincing arguments about what we can do and why we should do it. *The World According to Pimm* is a remarkable testament to the ideas presented in its closing sentences: "Our world is a spectacularly beautiful, interesting, and diverse place. Only by attending to its problems will it remain so."

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