method, summarized in Pauli's small book *Meson Theory* (Interscience, 1946). After the war, back again in Zurich, Pauli and his students made major contributions to the renormalization theory, a modification of quantum electrodynamics, which he and Heisenberg had initiated as a modern theory in 1929, and with which the letters deal at great length.

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Introduction to the Physics of Rocks

Yves Gueguen and Victor Palciauskas
Princeton U. P., Princeton, N. J., 1994. 294 pp. $49.50 hc
ISBN 0-691-03452-4

Rocks! Nations go to war over the fluids they contain; faults rupturing through them destroy entire cities; nuclear waste isolation and remediation of subsurface contamination, among society's more intractable problems, depend crucially on their properties. Rocks, so easily taken for granted underfoot, also contain many of our critical resources: oil, gas, minerals and, most valuable of all, potable water.

Yet rock properties continue to challenge the most advanced methods of experimental and theoretical physics. There are issues of scale as well as complexity. What is measured in the laboratory may not be easily applicable to the 10^2–10^6-meter length scales or the 10^3–10^8-year time scales relevant in nature. And rock properties depend on complex, time-dependent microstructures, including fracture linkages and tortuosity of pores. Even these purely geometrical characteristics—let alone the ways in which they govern the dynamics of and transport through rock—are poorly understood despite years of study motivated by enormous economic incentives. Clearly, rock physics is ripe for major breakthroughs.

Yves Gueguen and Victor Palciauskas's *Introduction to the Physics of Rocks* offers a superb entree to this field at the interfaces of physics, geology and engineering. No other book I know of gives such a broad introduction to the discipline.

Each chapter begins with a physical overview, making it easy to follow the authors as they discuss systematically the wide variety of properties relevant to rock physics. Chapters on the elasticity, fracture, flow and acoustics of rock are followed by summaries of transport (fluid, electrical and thermal) and magnetic properties. A good selection of problems amplifies the discussion in each chapter; no solutions are given.

This text is suitable for junior and senior undergraduate majors in physics or geology, as little more than the introductory courses in each of these subjects is presumed. Indeed, the authors have cut through much of the geological terminology, simplifying the usual classification of rocks and focusing on a subset of the most important minerals. A background of two years of college mathematics should suffice: Vector calculus appears and the authors briefly introduce cartesian tensors, but there is no calculus of complex functions.

The main flaws in this book are minor irritants, including awkward wording and specialized terms that go undefined; also, units are not used uniformly (GPa vs. Mbar, for example) and, after carefully defining one sign convention for stress, the authors use an alternative convention without warning. These potential sources of confusion may limit the book's usefulness for self-study but should be easy to clean up in a new edition.

Introduction to the Physics of Rocks can be particularly effective as a text for a lecture course. Gueguen and Palciauskas provide clear physical descriptions of the concepts, tending toward intuitive explanations or simplified derivations rather than actual proofs. This stripped-down approach, with results sometimes given as foregone conclusions, may present difficulties for students wanting to learn the material on their own. However, the details can be clarified through lectures, which should also serve to counter any minor confusions arising from the text.

In summary, Gueguen and Palciauskas have written an excellent textbook. They successfully communicate the applications as well as the intellectual challenges of rock physics. My sense is that most students of the physical sciences can learn much from this book—and enjoy themselves while doing so.

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Atmospheric Convection

Kerry A. Emanuel
Oxford U. P., New York, 1994. 570 pp. $59.95 hc
ISBN 0-19-506630-8

Thermal conduction, radiation and convection are the three general processes by which heat can be transferred from place to place, as we are taught in our elementary physics classes. Radiation alone operates in a vacuum and only radiation and conduction in a solid, but convection can occur in a fluid (liquid or gas), giving rise to the possibility of convective heat transfer, which often dominates over the other processes. In the Earth's atmosphere, conduction is utterly negligible in the response of the atmosphere to differential solar heating; the average temperature contrast between tropical and polar regions is maintained, rather, by convective heat transfer associated with large-scale flow at about one-third of the "radiative equilibrium" value.

Atmospheric Convection, an excellent monograph by a leading atmospheric scientist, is not about convection in its broadest sense as understood by physicists and engineers. Meteorologists, for reasons hard to discover, restrict the use of the term "convection" to the comparatively small-scale, fluid-dynamical processes that occur in the lower reaches of the atmosphere, where they are largely responsible for transferring heat upwards from the underlying surface, four-fifths of which is ocean. The thermodynamics and hydrodynamics of these processes are complex, for they involve considerations of multiphase systems comprising air together with water in all its forms (vapor, liquid and solid.)

Kerry Emanuel's monograph is aimed largely at research meteorologists, many of whom nowadays are obliged to ride on the "global warming" and "climate change" bandwagon, where it is necessary to justify activities on the basis of their direct relevance to improving global numerical models of the atmosphere used in weather and climate prediction. In these models convection, being a small-scale process, is not represented explicitly. Rather it is "parameterized"—that is, its effects on large-scale motions (which *are* represented explicitly) are expressed in terms of relationships involving transfer coefficients and other empirical quantities. And it is probably fair to say that deficiencies in parameterization schemes for convection in these global numerical models produce some of the most serious prediction errors. So it is likely that many meteorological readers of *Atmospheric Convection* will jump straight to the final two chapters, in which the interaction of convection with large-scale flows and the representation of cumulus clouds in numerical models are discussed.

Emanuel leads up to these final