work, compilation of data, and perceptive thought about porphyry copper deposits. In addition, Titley emphasizes to good effect what is not known about the deposits and how much of the record of them has been destroyed by late Tertiary Basin and Range structures, erosion, repeated strong supergene alteration, and intense hydrothermal masking of rock relationships and petrographic features of the temporally and genetically related porphyry intrusions. He stresses the importance of fracture-control of the economic hypogene sulfides in a variety of host rocks and places less emphasis on "disseminated" sulfides in intrusive rocks than had previously been placed. This emphasis on the crosscutting, epigenetic nature of the mineralization should help alleviate misconceptions held by some nonporphyry specialists working in "frontier areas," such as the Canadian Shield, about one of the most fundamental features of porphyry-style mineralization. I recommend the classification of joint sets, veins, faults, fault-veins, dikes, and fault-dikes presented in the volume by Heidrick, Rehrig, and Titley. Widespread use of their terms would permit more precise comparison of these important ore-related features in porphyry deposits in many parts of the world.

Einaudi presents a useful overview of skarns and a particularly good summary of the skarns at Bingham, Utah, and their relationship to the porphyry copper deposit and the lead-zinc-silver lode deposits. With limited data he also makes a valiant attempt to relate geological features to copper grades and tonnages. This approach, of course, will have to be pursued more vigorously in the future as higher copper grades are sought and at greater depths. Sphalerite is mentioned as occurring in many deposits, but especially in the peripheral parts of copper-bearing skarns. One cannot help but wonder how much zinc and other valuable metals, such as lead, silver, and even tungsten, at Twin Buttes has been mined but not extracted from the deposits. Perhaps improved knowledge of the distribution of such metals and of the techniques used to extract them could increase the supply of these commodities for industry.

Part 2 includes much basic information on deposits and their surrounding geology, but perhaps the most outstanding contributions are new ones on the important Pima district south of Tucson, Arizona. An overview of the geology of the district is followed by descriptions of the Twin Buttes, Sierrita-Esperanza, Mission, and San Xavier North deposits, which makes for a reasonably complete, concise account of the district.

Titley and other contributors to this volume have helped direct future studies by pointing out what is still not known about the deposits in this region. But here, as well as in other important copper-producing regions, geologists have been preoccupied with the large economic deposits and have virtually ignored subeconomic and almost barren deposits. Little has been published about their abundance, distribution, basic features, and relationship to important economic deposits. When you see only part of the beast, how do you know that you have an elephant? Geologists must learn how to recognize the difference. Einaudi's attempt to relate geological features to grades and tons of copper metal is a step in the right direction for effective exploration for blind and higher-grade deposits.

This is a stimulating book on a fascinating subject. If will be of particular value to exploration geologists searching for porphyry copper deposits, but it is indispensable for any serious student of porphyry deposits. The binding, paper, editing, printing, illustrations, and price are excellent.

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Collision Theory

Atomic and Molecular Collision Theory. Proceedings of an institute, Arezzo, Italy, Sept. 1980. FRANCO A. GIANTURCO, Ed. Plenum, New York, 1982. x, 506 pp., illus. $59.50. NATO Advanced Study Institutes Series B, vol. 71.

Atomic and molecular collision theory is a relatively old field; most of the basic theory and simple models were developed in the early decades of this century. The field has, however, experienced an extraordinary productivity in recent years. There are several causes for this, especially the development of more specific and powerful experimental tools to complement the classic spectroscopy and provide more and more sensitive data and advances in computer science, which make increasingly complex systems amenable to computational attack. Most stimulating of all, however, has been the continuing development of new applications, in fields ranging from astrophysics to laser physics to surface science, which encourage atomic physicists to investigate new classes of problems.

This book consists of the lecture notes from a NATO Advanced Study Institute that present collision theory from both a theoretical and an applied point of view. Most of the papers deal with formal aspects of collision theory, including electron and photon collisions with atoms and molecules, heavy particle collisions, and collisions under special circumstances. The remainder of the papers deal with applications to related fields. No experimental papers are included.

As always in a volume like this, the papers vary considerably in length, style, and quality. Most of the papers on theory stress the formalism used to describe atomic and molecular collisions and briefly explain the methods that have been used to attack a particular class of problems. The clarity of the exposition suffers, however, from the extraordinary complexity of notation employed. This problem is endemic to collision theory, especially as applied to multiparticle systems. Still, the authors would have done better to include more discussion of why each method is unique and when it might be applicable. Few examples or comparisons with experimental results are provided, which adds to the confusion. The reader is left with little sense of which methods are proving to be most successful.

Exceptions are Bardsley's chapter on recombination and Percival's on highly excited atoms. Bardsley's contains very little formalism but a wealth of "working rules" and examples, together with comparisons to experiment. Percival's discussion of classical theory and the correspondence principle contains a clear treatment of regions of validity.

The papers on applications, such as van Regemorter's on astrophysics and Levine's on chemical physics, present quite a different view of atomic and molecular collisions. Here one learns, for example, how information from atomic and molecular physics can be applied to the diagnosis of astrophysical plasmas.

For the specialist in atomic and molecular collision theory, the book is a reasonably compact and up-to-date review of methods. The extensive references compensate for the dearth of examples to a considerable extent. The papers on applications offer an opportunity to look at collision theory from a new perspective and may suggest new problems. For the nonspecialist, the formal chapters would be heavy going indeed, and of dubious usefulness. The papers on applications and the less formal papers on theory offer insight into the calculation of atomic and molecular collision pro-

cesses that impinge on such a wide variety of fields.

The book itself is not particularly well prepared. The typescript with handwritten equations is difficult to read. Several of the papers contain an annoying number of typographical errors and, in one case, transpositions of text. The references have not been updated; papers from 1980 are still listed as "to be published."

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Radio Emissions

Extragalactic Radio Sources. Papers from a symposium, Albuquerque, N.M., Aug. 1981. DAVID S. HEESCHEN and CAMPBELL M. WADE, Eds. Reidel, Boston, 1982 (distributor, Kluwer Boston, Hingham, Mass.). xviii, 490 pp., illus. Cloth, $54.50; paper, $26. International Astronomical Union Symposium no. 97.

In some ways this book is to extragalactic radio astronomers what a detailed field guide to tree identification is to foresters. The 148 papers (27 of which were invited) in the volume are prize specimens. The range of subjects, the depth of research, and especially the amount of activity from related fields described in these proceedings are remarkable.

Ten years ago the material in a book such as this would have consisted mainly of radio continuum and polarization studies of radio galaxies and quasars. No longer. In the past five years the field has broadened explosively, and the book contains optical and x-ray, as well as radio, observations. In addition, the types of objects discussed include the galactic center, SS 433, Seyfert galaxies, and Centaurus A, as well as the usual radio galaxies, quasars, and BL Lacertae objects. Size scales vary from a millisecond of arc to 2π radians; distances from the microscopic, solar-system–like scales of superluminal radio sources to billions of light years; and times from "flickers" of a few hours to cosmological scales.

But the book is more than a field guide. Notable trends of unification at a level, for the first time, beyond the speculative can be found in it. J. Oort's opening lecture summarizes the emerging synthesis found in some detail in other papers. Quasars, radio galaxies, and Seyferts have long been thought to exhibit substantial morphological differences in their radio properties. As radio sources, they have been separated into phyla. Although no grand consensus is evident in the proceedings, a point made repeatedly is that the morphological differences may, in fact, be illusory and attributable to strong observational selection effects as well as to evolutionary changes in the universe on time scales of galaxy evolution. It is especially exciting that the new diversity in extragalactic radio astronomy seems to be leading to synthesis and understanding rather than fragmentation and incohesiveness.

To the active researcher in extragalactic astronomy the book can be the most important addition to a bookshelf in years. Even though its research content will mostly appear in standard journals, the compilation of the material in a single reference is invaluable for expediting the merger of timely observations, speculation, and research strategies into bold new ideas and interpretations. Because the meeting was so well attended, the contents of the book are essentially complete, as any useful field guide must be.

The book does not and was probably never intended to provide a simplified overview of the entire field and all of its most pressing research directions. Therefore it is not a book for the casually interested. What's more, the amount of information is overwhelming if not intimidating. There were times in my reading of the book when I felt like a Martian handed only a field guide to tree identification and given the task of summarizing the latest results in terrestrial forest ecology.

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