current state of this particular field of study is apparent in many of the articles, and an effort to reduce this confusion would certainly have been worthwhile to the reader. Nevertheless, the material that has been included is of high quality, and well worth the attention of all scientists who wish to learn important things about this fundamental problem of geology.

REFERENCE

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Physics and Chemistry of Comets. Edited by Walter F. Huebner. Springer-Verlag, New York, 1990. 376 pp., $59.00

The last 6 years have provided us with a tremendous information explosion regarding our knowledge about the physical state and composition of comets. The flybys of Comets Giacobini-Zinner and Halley by various spacecraft have given us the first close-up views of a comet's nucleus and the first direct samplings of cometary coma material. In addition to these *in situ* measurements, remote observations from ground-based, airborne, and spacecraft-based observatories explored the variations of the cometary comae with time. Modern CCD and infrared detectors have proved to be quite important and achieved numbers of discoveries. In the future scientists will look back on this period as one of the great leaps forward in our understanding of comets. In the 17th century Halley recognized that comets were orbiting members of the Solar System, and in the early 1950s Whipple deduced the nature of comet nuclei as small dirty water-ice bodies and Oort recognized their origin and important connection to the origin of the Solar System. The next great leap forward will hopefully happen after extensive study via rendezvous and sample return missions to comets during the early part of the next century.

This book, edited by Walter Huebner, contains contributions by himself and 10 other distinguished scientists and is aimed at providing "a comprehensive review of our understanding of comets." The book is self-described as being designed primarily as a textbook for advanced undergraduate and graduate students and (but less so) as a reference text for researchers in the field. It concentrates mainly on the advances learned from the Halley/Giacobini-Zinner experience. A forward by Fred L. Whipple places our current view of comets in historical context. The text of the book itself is divided into eight chapters, each written by one or two authors, covering as separate topics the nucleus, the neutral coma, dust, plasma, the orbital distribution of comets, and comet formation and evolution. These topics are bracketed by an overall introduction as well as a summary chapter on the implications of comet research for the future.

Most of the individual chapters are written in the textbook style rather than the review article style which makes them quite readable. The book does a comprehensive job of extracting and condensing the essence and the most important contributions of almost 800 technical papers into a very readable length without becoming too watered-down. A book such as this would have been a welcome sight during my first year of graduate school. At that time the only review book available was the (by then) dated "The Moon, Meteorites and Comets" volume of "The Solar System" by Middlehurst and Kuiper.

The shortcomings of the book in general are few and relatively minor. A short chapter at the beginning or a several page addition to the introduction summarizing the history of cometary knowledge from Brahe and Halley through Whipple through 1985 would have made the book much more useful for technically trained students or scientists without a particular background in planetary science. Most of the authors include statements about what we will learn from future spacecraft missions; this is fine. However, some of the pro-CRAF/Rosetta cheerleading sounds more like a proposal justification than a textbook explanation; this is especially true in the introduction. Few of the likely readers of this book will need to be convinced of the importance of spacecraft missions to comets.

With regard to the individual chapters there are a few minor (and perhaps picky) criticisms. The nucleus chapter concentrates too much on the dust jets and flows in the innermost coma as seen by the Giotto Multicolor camera rather than on the nucleus as such, although admittedly, there is much to be learned about the nucleus by looking at the coma. The coma chapter says that hydrodynamic modeling of the coma began with Marconi and Mendis (1982, *Astrophys. J.* **260,** 386) whereas it began at least as early as the late 1960s by Shul'man, as reviewed by Mendis and Ip in 1975 (*Astrophys. Space Sci.* **39,** 335). Curiously, the 3.4-μm C–H stretch emission is mentioned in neither the dust nor the coma chapters. Remote observations of cometary ion phenomena, despite having many decades of history before the 1985–1986 flybys, receive little attention in the plasma chapter except for a short discussion of disconnection events. Most of the other chapters present a brief pre-Halley/Giacobini-Zinner history. Since this is a textbook, a short summary of the early material could have been included to make a more complete story. However, the authors did present a list of review papers for background so as not to leave the reader completely in the dark.

There is one scientific point that is not stressed enough in the book. The study of comets by the analysis of remote observations is an absolute necessity for achieving the complete understanding of comets as discussed in the book. There is a tendency for the book to put all of the proverbial eggs of future comet science in the CRAF and Rosetta baskets. CRAF, if it survives as a continuing mission, and Rosetta will provide incredibly thorough insight into two comets. However, many of the important scientific questions elucidated in the introduction and in the final chapter can only be answered by knowing something about comets as a class of objects. After all, since *in situ* spacecraft studies will only be made for a very few comets over the next few decades at best, it is of the utmost importance to use the spacecraft data as the ground-truth to calibrate both future and past work which must rely exclusively on remote observations. In fact many of the new and exciting findings of the Halley/Giacobini-Zinner period came not just from spacecraft instruments, but also from the tremendous efforts by many observers with Earth-based and space-based telescopes.

After examining this book one should be impressed by the advances in our knowledge about comets brought about by the spacecraft data and the huge amount of coordinated remote observational data from Comets Giacobini-Zinner and Halley. In addition, I also was personally struck by how the spacecraft measurements largely substantiated the basic physical properties of comets which had already been inferred from over 100 years of traditional remote astronomical observations and their analyses.

In conclusion, this is a very good book encompassing the very diverse field of the study of comets in the aftermath of the Halley and Giacobini-Zinner experience, and I recommend it for both students and scientists studying the field for the first time or trying to learn more about other subdisciplines in the field.

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