

es that generate the rocks. Throughout the 1970's new concepts, applications, and terminology were burgeoning, great creativity and energy were devoted to multiple studies of both ancient and modern deposits, and numerous meetings were conducted to keep pace. Several general textbooks on volcanoes and volcanology appeared in the 1970's and early 1980's whose modern treatments of pyroclastic rocks helped document this progress, but such summaries were necessarily brief. Research papers on specific topics helped keep specialists up to date but neglected neophytes. About a decade ago, R. V. Fisher and H.-U. Schmincke, both of whom were deeply involved in research on pyroclastic rocks and processes, recognized the urgent need for a more complete review and conceived the present book. This felicitous volume is the first fully comprehensive treatment covering the whole field of pyroclastic rocks.

The 14 chapters of the book take readers from the broad general principles of volcanoes through the origin of pyroclastic rocks and descriptive details concerning various kinds of pyroclastic rocks to the role of the rocks in stratigraphic and structural processes. Throughout the book, the emphasis is on geologic processes; descriptive material is clear and enlightening but is always presented in a way that will aid the reader to understand a process of origin or change. The early part of the book deals with the tectonic setting and forms of volcanoes, the composition and behavior of magma, and the physical and chemical processes that govern volcanic eruptions, particularly explosive eruptions. The central portion of the book is concerned with pyroclastic deposits, the particles that compose them, and the processes and results of pyroclastic fallout, pyroclastic flow, hydroclastic eruptions (caused by exploding steam), submarine eruptions, and lahars (volcanic debris flows lubricated by water). Post-emplacement and alteration processes are also discussed. The final part of the book shows how pyroclastic rocks are involved in stratigraphic relationships and how they fit into the general scheme of global tectonics.

A vast amount of personal experience and diligent scholarship went into producing this book; the material is reliable, authoritative, and current, and the book is logically organized and clearly written. The authors' own special interests are reflected by particularly fine summaries of subaqueous processes, pyroclastic flows, and hydroclastic eruptions. Throughout the book the treatment of

Prices of Books						
Average per-volume prices of books reviewed in <i>Science</i> 1979–1984. Data are for hard-cover books except where books were available only in paperback; books priced only in foreign currencies and (for 1984) books distributed free of charge were excluded from the calculations. The average prices per page of the technical books in the natural sciences for the years covered were 8.6¢, 9.0¢, 11.3¢, 11.1¢, 11.1¢, and 12.0¢.						
Category	Price (dollars)					
	1979	1980	1981	1982	1983	1984
All books	30.33	35.52	42.22	44.05	41.93	45.38
Technical books in natural sciences	39.18	42.61	52.76	51.70	51.18	55.29

subjects is nicely balanced. I perceived neither significant omissions nor factual errors and spotted only a handful of typographic errors. Each subject has been thoroughly documented; the list of references comprises more than 1000 entries, some of which appeared as recently as this year. Separate subject and locality indexes are provided. The illustrative material is effective in supplementing the text, the line drawings and charts are clear and easy to read, and the photographs are informative and of exceptional quality.

The book will be useful as both a textbook and a research guide; it has applications in the diverse fields of volcanology, igneous petrology, sedimentology, stratigraphy, economic geology, and tectonics. In the end, the reader will have learned a great deal about pyroclastic processes and will have attained a clear idea of how knowledge of pyroclastic deposits can be applied in the solving of many kinds of geologic problems.

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## The Dumping of Wastes at Sea

**Wastes in the Ocean.** IVER W. DUEDALL, DANA R. KESTER, BOSTWICK H. KETCHUM, and P. KILHO PARK, Eds. Wiley-Interscience, New York, 1983. Vol. 1, Industrial and Sewage Wastes in the Ocean. xxiv, 432 pp., illus. \$54.95. Vol. 2, Dredged-Material Disposal in the Ocean. xx, 300 pp., illus. \$39.95. Vol. 3, Radioactive Wastes and the Ocean. xxii, 522 pp., illus. \$85. Environmental Science and Technology.

The object of the volumes reviewed here, which are the first three of a set of six, is "to present a comprehensive overview of the state of our knowledge concerning the disposal of waste in the

ocean and to present new and original contributions to the evaluation of the impact of the disposal of waste materials on human life and well being, on the marine biota, on amenities, and on legitimate use of the ocean."

Volume 1 deals with the physical, chemical, and toxic properties of dumped industrial waste and with the environmental effects of such waste. Special attention is given to stabilized coal waste and to the mid-Atlantic and New York Bight dumpsites in United States waters. Volume 2 deals with the regulation of the disposal of contaminated dredged material in the United States, dredged-material dumpsites in U.S. waters, biological aspects of contaminated sediments, and alternatives to dumping sediments in open waters. Volume 3 deals with practices for the disposal of radioactive waste, physical and biological processes in such wastes, and the feasibility of placing radioactive wastes beneath the sea floor.

Although the first two volumes discuss the international legal structure, they primarily address current practices and regulations in the United States. The experimental results and case studies presented in these two volumes are based mostly on investigations carried out in or near the mid-Atlantic and New York Bight dumpsites.

The dumping of radioactive waste in the deep sea is of necessity more clearly influenced by international and multilateral agreements and by the multilateral collaborative investigations aimed at assessing the feasibility of future disposal of high-level waste in the seabed, and the papers in volume 3 provide a relatively complete summary of existing international practices as well as of their scientific basis.

In general, the volumes reflect rather well the political and regulatory measures that have been taken to control sea dumping. The more technically oriented

papers range from discussions of basic research aimed at elucidating a particular (although not always clearly relevant) environmental problem to descriptions, in relatively nonscientific terms, of aspects of an existing disposal practice. Each volume starts with an overview paper written by the editors, which provides the necessary background for placing the subsequent papers in context. The concluding chapter in each volume, also written by the editors, is less successful in attempting to look ahead to future needs.

Although the readers of these volumes will learn a lot about dumping practices on the continental shelf and in the deep sea, they will no doubt also recognize that the vast majority of the papers come from the community of environmental regulators and scientists who are involved in managing or supporting ocean dumping and who are often proponents of the practice. There is little in these volumes to indicate that some fraction of the scientific community has doubts, whether justified or not, about the merits of continued or enhanced sea disposal. Similarly, little is done to compare and contrast the input and impact of contaminants from sea dumping, river runoff, transport through the atmosphere, or rather massive land outfall which exists in some regions for the discharge of sewage and radioactive wastes. Indeed, the comparison of disposal options, which is required to decide which option provides the least detriment, does not receive the attention it deserves. A variety of sources contribute to the load of a contaminant in the ocean, and any truly comprehensive treatment of waste management and its potential long-term effects on humans and the marine environment must consider all such sources as well as the justification for the use of the marine environment for disposal.

One can also note that for the most part, and especially when dumping on the continental shelves is considered, the papers discuss the ability of the ocean to reduce the concentration of a contaminant through dispersal. Thus the open ocean is often treated as the sink for wastes disposed of on the continental shelves or slopes. There is little acknowledgment in the book that the ocean is a system with a finite capacity for some contaminants. For those contaminants the impact of dumping will often extend far beyond the continental shelves of a single nation, and the problem is truly one of international scope.

All in all, however, the volumes provide the general reader with a useful overview of the dumping of wastes at

sea. In addition, those wishing to become knowledgeable about the scientific aspects of the subject will find enough material to provide both some understanding of the existing basis for sea dumping and some insight into the needs for future research.

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