

# Geologic Evolution of Arizona

J. P. Jenney and S. J. Reynolds, *Editors*



Arizona Geological Society Digest 17

1989



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## PREFACE AND ACKNOWLEDGMENTS

This volume is intended to be a summary of current knowledge of the geology of Arizona, including key advances, promising lines of research, and research priorities. The book was first conceived in 1983 and is the result of years of continued effort. The editors constructed an outline of possible chapters, providing coverage of most aspects of Arizona geology. This outline was distributed to numerous geologists in Arizona for their recommendations for potential authors. These recommendations were used by an Arizona Geological Society (AGS) ad hoc committee to decide on a final list of invited papers. Thanks are especially extended to Richard Lundin and William D. Payne for their input at the outline stage. The papers contained within this book are, with few exceptions, those initially solicited. Several originally planned chapters were never received, and several others were written, for a variety of reasons, by authors different from those initially intended. One of the planned chapters is represented in this book by two chapters because of irreconcilable scientific differences between the two authors. Several chapters were added during completion of the book to provide more extensive coverage of certain subjects.

To highlight the geologic evolution of Arizona, authors were asked to emphasize a given period of geologic time rather than a specific area. Authors were requested to synthesize previous work for their assigned time period with new data, ideas, and concepts and to indicate where unresolved problems remain for future workers. Accordingly, most chapters blend past work with the most pertinent new data. Some chapters cover subjects with little previous work and mostly consist of new data, ideas, and syntheses.

The first manuscript was received in 1984. This award goes to J. Lawford Anderson, whom we thank for his patience with us and less punctual authors. All papers were subjected to at least two peer reviews and were also reviewed for content, grammar, and style by the editors. To make the papers as accurate, clear, and concise as possible, some papers were reviewed and returned for authors' revisions several times. Authors were instructed to observe writing guidelines of the U.S. Geological Survey. The very perceptive reader will note variations between papers in some stylistic conventions; the effort has been toward accuracy and internal consistency, with special emphasis on complete and correct referencing.

This volume marks AGS's first excursion into quasi-desktop publishing. After revision, final drafts of most manuscripts were submitted by the authors on floppy disks so that the typesetter could use the original author-prepared text files. These original files were received in various word-processing formats and had to be converted by the editors via a variety of computer software utilities and countless hours into a format usable by the typesetter. The entire process of peer review, multiple revision of some manuscripts, computer manipulation by the editors, and typesetting made the production process much longer than anticipated. The extra effort, time, and expense were deemed worthwhile as the price of producing a comprehensive summary of the geology of Arizona. Because some chapters in the book were completed as early as 1985 and 1986, however, they may not reflect the current ideas of the authors.

The length of the chapters varies, mostly by design. Some of the shorter chapters summarize knowledge about a relatively restricted subject or restricted period of geologic time. Other papers are short because their authors were more successful than their colleagues in emphasizing cogent information and eliminating less important details. The longest papers cover broad subjects and contain much new data. For example, the longest paper, by Phillip Anderson, presents a wealth of new observations and really consists of four separate papers that were combined into one at the request of the editors. Practical length limitations were imposed where possible but not at the expense of forcing deletion of previously unpublished information.

For the benefit of readers trying to obtain copies of publications cited in this book, we point out that the Arizona Geological *Survey* was previously known as the Arizona Bureau of Geology and Mineral Technology (1977 to 1988) and as the Arizona Bureau of Mines (prior to 1977); the agency was part of the University of Arizona until July 1988. The address of the Arizona Geological Survey is 845 N. Park Avenue, Suite 100, Tucson, Arizona 85719. The Geologic Map of Arizona, included in the back pocket of this digest, is Arizona Geological Survey Map 26 and should be cited as such.

The Arizona Geological *Society* was founded as an organization of professional and student geologists in 1948. It has never been part of the University of Arizona. AGS digests have always been produced irregularly; we therefore



encourage that they be referenced without the use of "v." or "Vol." (e.g., "Arizona Geological Society Digest 17"); the implication that the digest is a serial publication will thereby be avoided. The use of Roman numeration has also been discontinued, and Arabic numbers may be substituted in citations of older digests. Original titles and editors of AGS digests and guidebooks are listed below. All were published in Tucson, Arizona by the society. Listings marked with an asterisk are permanently out of print.

#### Guidebooks

Guide book for field trip excursions in southern Arizona, 1952, 150 p.\*

Heindl, L. A., ed., Southern Arizona Guidebook II (combined with the 2nd Annual Arizona Geological Society Digest), 1959, 290 p.\*

Titley, S. R., ed., Southern Arizona Guidebook III, 1968, 354 p.

#### Digests

Anthony, J. W., ed., Arizona Geological Society Digest [Volume I], 1958, 58 p.\*

Digest II, combined with Guidebook II, 1959.\*

Anthony, J. W., ed., Arizona Geological Society Digest Volume III, 1960, 185 p.\*

Anthony, J. W., ed., Arizona Geological Society Digest Volume IV, 1961, 196 p.\*

Heindl, L. A., ed., Arizona Geological Society Digest Volume V, 1962, 130 p.\*

Gray, St. Ives, ed., Arizona Geological Society Digest Volume VI, 1963, 94 p.\*

McCullough, E. J., ed., Arizona Geological Society Digest Volume VII, 1964, 171 p.

DuBois, R. L., ed., Arizona Geological Society Digest Volume VIII, 1966, 181 p.\*

McCullough, E. J., ed., Arizona Geological Society Digest Volume IX, 1971, 265 p.

Wilt, J. C., and Jenney, J. P., eds., Tectonic digest: Arizona Geological Society Digest Volume X, 1976, 430 p.

Jenney, J. P., and Hauck, H. R., eds., Proceedings of the Porphyry Copper Symposium, Tucson, Arizona, March 18-20, 1976: Arizona Geological Society Digest Volume XI, 1978, 178 p.

Jenney, J. P., and Stone, Claudia, eds., Studies in western Arizona: Arizona Geological Society Digest Volume XII, 1980, 322 p.

Stone, Claudia, and Jenney, J. P., eds., Arizona Geological Society Digest Volume XIII, 1981, 215 p.

Dickinson, W. R., and Payne, W. D., eds., Relations of tectonics to ore deposits in the southern Cordillera: Arizona Geological Society Digest Volume XIV, 1981, 288 p.

Wilkins, Joe Jr., ed., Gold and silver deposits of the Basin and Range province, western U. S. A.: Arizona Geological Society Digest Volume XV, 1984, 233 p.

Beatty, Barbara, and Wilkinson, P. A. K., eds., Frontiers in geology and ore deposits of Arizona and the Southwest: Arizona Geological Society Digest Volume XVI, 1986, 554 p.

Jenney, J. P., and Reynolds, S. J., eds., Geologic evolution of Arizona: Arizona Geological Society Digest 17, 1989 (this volume).

Dickinson, W. R., and Klute, M. A., Mesozoic rocks of southern Arizona and adjacent areas: Arizona Geological Society Digest Volume 18, 1987, 394 p.

AGS has also published the Arizona Highway Geologic Map (M. E. Cooley, compiler, 1967, scale 1:1,000,000) and has issued a number of unpublished field-trip guides. A current publication list is available from the Arizona Geological Society, P. O. Box 40952, Tucson, Arizona 85717.

This book was prepared in cooperation with the Arizona Geological Survey (AZGS), which provided unlimited access to computer equipment and permitted one of us (S. J. R.) to devote large amounts of time to the project. We thank State Geologist Dr. Larry D. Fellows for his support, Evelyn M. VandenDolder for her advice regarding editing, and Pete Corrao for contributing illustrations and drafting assistance..

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J. P. J. and S. J. R.

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