Microbial Sediments

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This book provides an intriguing look into the world dominated by a diverse 'army' of unicellular organisms quietly but persistently shaping and reshaping the world through their metabolic processes. Microbes, which include bacteria, small algae, fungi, and protozoans, have left significant evidence of their presence and activities in sediments as fossils, fabrics and chemical signatures. Contributions from 52 authors in 34 well written articles document how many carbonates, evaporites, stratiform ore deposits, cherts, and even some siliciclastic sediments from the Archaean through the Recent have been shaped by the efforts of these microorganisms as they simply go about making their living. Of particular note is the fact that many fine-grained carbonate micrites and mudstones and even some cements owe their origin to the metabolic processes of a variety of microbes rather than strict chemical precipitation.

Several chapters document recent technological advances that provided researchers with new tools to identify the various types of diverse microbes and to visualize this fascinating world too small to be seen with the petrographic microscope. Many excellent illustrations show the connection between ultrahigh magnification imaging and how these same features appear at the lower magnifications one more commonly views in hand specimens and thin sections. This will enable those geologists who are not specialists to identify microbial features. Many articles in this volume demonstrate how laboratory analysis for biomarkers and stable-isotope analysis enables researchers to recognize the microbial origin of these deposits even where direct preservation of the microbial bodies has not occurred. A persistent theme through the various chapters is to document what has been discovered in the Recent and demonstrate how this can be identified in the Ancient.

Articles in this volume document microbes living in virtually all modern depositional environments, including subaerial, lacustrine, humid, arid, fresh-water, marine, hypersaline, and hydrothermal. They thrive in various chemical conditions ranging from acidic to alkaline, oxygenated to anoxic, and in various water depths and salinities. Some microbes are photosynthetic, whereas other forms live without light and feed on the metabolic byproducts of others. Some microbes live subaerially in soils, and others stabilize sediments on tidal flats. Still others make their homes on rocks, building stones, statues and monuments where they dissolve and discolor the substrates they colonize. Studies in recent sediments show that microbial assemblages typically change horizontally and vertically as chemical gradients vary in the sediments. Some microbes are extremely hearty, and become dormant for very long periods of time during extreme environmental stress such as high temperatures, desiccation, or lack of nutrients. Recent advances in petroleum technology have taken advantage of this ability in certain ultramicrobacteria to form biobarriers in reservoirs to shut off high-permeability thief zones.

Papers in this book explain the range of chemical and biochemical reactions involved in the various constructive and destructive processes that result from microbial

metabolism. Through their biologic functions, microbes alter the chemistry of their environment, and are involved in both rock-building and rock-destroying processes. Their direct preservation depends on the precipitation of various minerals, some of which are precipitated by microbes as a means of eliminating toxic waste products from the living cells. Many tables and diagrams summarize this, and aid greatly in understanding the complex chemical and metabolic processes that result in mineral precipitation and dissolution.

Some microbes, such as diatoms and coccoliths, directly precipitate minerals such as silica and calcite, which result in diatomites, chalks, micrites and mudstones. Whitings in some modern lacustrine settings in New York have been demonstrated to be bacterially mediated, while those in the marine waters of the Bahamas are more complex, and the role of microbes is not completely understood. Other microbes produce biofilms that bind sedimentary particles and alter the chemistry of the sedimentary environment, which may result in mineral precipitation. The resulting fabrics include stromatolites, oncolites, fenestral fabrics, intraclasts, micritized grains, clotted micrites, peloidal cements, tufa, travertines, and speleothems. Two papers in this volume document the role of microbes in the stabilization of siliciclastic sediments and the formation of irregular non-current-generated stromatolitic laminations in siliciclastics. Through their various metabolic processes, some microbes also are responsible for source rocks and the generation of hydrocarbons, CO_2, and H_2S under a variety of chemical and thermal conditions in the subsurface. Other microbes have resulted in economic deposits of various authigenic metals including phosphate, iron, manganese and uranium.

Microbes were the first forms of life on this planet, and they dominated the biosphere during most of the Precambrian. Several paleontological systems have been devised to classify stromatolites, which have the potential for useful correlations within the limits of particular stromatolite provinces. Interprovincial correlations have lower reliability and time-resolution because of variations in the time-equivalent stromatolite assemblages. Unfortunately, the number of relatively short-ranging but laterally widespread interprovincial taxa are limited in the Precambrian. They do, however, provide paleontological characterization of units that have been already defined by other means, and therefore can contribute to correlation within a particular stromatolite province. The taxonomic classification schemes used for Precambrian stromatolites, however, differ fundamentally from those of the higher plants and animals, because typically the stromatolite-building organisms themselves are not preserved, but only the morphologies of the resulting structures.

The quality of production of this volume is excellent overall. The text is well edited with few typographical errors. Individual chapters are concisely written, focused, and typically less than 10 pages in length. This adds to the ease of reading and prevents “getting lost” in unnecessary detail. The illustrations are abundant, clear and informative. The subject index could be more detailed, but the formatting style makes it easy to read and use. Chapter titles are concise and descriptive so that the reader can readily identify subjects of particular interest. The articles were well chosen to provide diversity in time and geographic settings. Each of the chapters offers something new, so that the reader does not feel that articles are repetitious with only minor variations of the same basic studies. This volume is of interest not only to microbial specialists, but also to any geologist interested in the various conditions under which carbonates, cherts, evaporites,

stratiform ore deposits, and hydrocarbons are deposited. The book also provides invaluable information on the biochemical mechanisms by which these minerals are precipitated and dissolved. It also gives excellent guides to the interpretation of stable isotopes and biomarkers in sedimentary rocks.

At the end of this volume, I was left with a strong feeling of satisfaction that answers to some important geologic questions have been discovered. Through meticulous research, the various authors have persisted in identifying and understanding many of the processes and products that for years had been below the detection limits of our technology, particularly the apparently featureless or vaguely textured carbonate mudstones. Various articles show the benefits of integrating different types of information to solve complex problems. In addition, I felt a profound sense of wonder and humility at the realization of how these simple creatures have had such a significant impact on the world around them by merely going about their daily business of living, growing, surviving and thriving. They do this not only in fairly usual environments, but also under some amazingly hostile conditions.

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