Cellular Origin, Life in Extreme Habitats and Astrobiology 18

Vinod Tewari
Joseph Seckbach
Editors

STROMATOLITES: Interaction of Microbes with Sediments

Springer

STROMATOLITES: INTERACTION OF MICROBES WITH SEDIMENTS

Cellular Origin, Life in Extreme Habitats and Astrobiology

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Joseph Seckbach
The Hebrew University of Jerusalem, Israel

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Stromatolites: Interaction of Microbes with Sediments

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INTRODUCTION TO STROMATOLITES[1]

Stromatolites, layered sedimentary structures produced by mat-building phototrophic organisms (usually cyanobacteria), are considered the most ancient biological record and the earliest evidence of the emergence of life on Earth. The early stromatolites are the major constituent of the fossil record for billions of years, beginning around 3.5 bya. In the Precambrian era, the “primitive” environments of Earth were too hostile to support life as we know it, and the stromatolites could thrive without competition. They declined in the Phanerozoic as victims of grazing animals.

Today, stromatolites continue to form, although they are nearly extinct in normal marine environments and live a precarious existence in only a few localities worldwide. Modern stromatolites exist in areas that most other life forms consider less desirable, in extreme environments containing hypersaline water, high alkalinity, and high or low temperatures zones. Such places exclude grazing snails and other animals which consume the cyanobacteria. Recent formations of stromatolites were discovered in Shark Bay (Australia) as well as throughout Western Australia, the Bahamas (such as Exuma Cays), the Indian Ocean, various places in the USA (such as in Yellowstone National Park), Laguna Salgada (Brazil), the Mexican Desert, Glacier National Park (Montana and Canada), and the Solar Lake in Sinai, which is heliothermally heated and contains hypersaline water. The study of modern stromatolites assists in the interpretation of ecology and environment of ancient stromatolites as well as possible life on extraterrestrial planets or moons.

Eighty four authors contributed the 34 chapters to this volume. They are from 27 countries (Argentina, Australia, Belgium, Brazil, Canada, China, Croatia, Germany, France, Israel, India, Italy, Japan, Mexico, New Zealand, Norway, Poland, Portugal, Russia, Slovenia, South Korea, Spain, Sweden, Switzerland, Taiwan, UK, USA). We divided this book into seven sections, covering Achaean and modern stromatolites and Astrobiology. We hope that this book will enrich our readers by making a wide range of data on stromatolites accessible.

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December 16, 2010

[1] I thank Fern Seckbach and Professors David Chapman (UCSB) and Maud Walsh (LSU) for proofreading the introduction.

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FOREWORD

Stromatolites: The Present as a Key to the Past

"Everybody will agree that these are very basic points that 'stromatologists' should know at first: they will provide us with the necessary and fundamental botanical background to neatly investigate the algal mats that we find on our tidal flats. Moreover if, by understanding and deciphering the dynamics of recent freshwater structures, we can thoroughly account for the mode of growth, of formation, for the leading ecological requirements and environmental responses of fossil freshwater stromatolites…, then the field is open to **sound**, **natural** and **realistic** understanding of Paleozoic and Precambrian stromatolites…; even if [those] stromatolites originated in different chemical environments, they appear to me not only as analogous but furthermore as **homologous** structures, the growth form and building up of which was in equilibrium with homologous general environmental factors" (Monty, 1972).

These words can be found in an account of the recent algal stromatolitic deposits, Andros Island, Bahamas, by the late Claude Monty (1937–1999). The modern stromatolites in the Bahamas were extensively studied ever since and became a popular model for studies aiming at an understanding of the microbial processes that led to the formation of those Paleozoic and Precambrian stromatolites mentioned by Monty, many of which feature in the chapters in this volume.

Stromatolites (from Greek στρώμα, *strōma*, mattress, bed, stratum, and λιθος, *lithos*, rock) can be defined as layered accretionary structures formed in shallow water by the trapping, binding and cementation of sedimentary grains by biofilms of microorganisms, especially cyanobacteria (http://en.wikipedia.org/wiki/Stromatolites). Extensive information on the nature of stromatolites can be found in the chapters in the current volume and in an earlier volume in this book series (Seckbach and Walsh, 2009).

I first learned about the connection between ancient stromatolites and modern microbial mat structures when I first visited Solar Lake (Sinai Peninsula, now in Egypt) in the beginning of 1975. The layered structure of the microbial mat dominated by cyanobacteria in this small hypersaline heliothermally heated lake and the calcification processes of the mat show how a stromatolite-like geological record is generated before our eyes, a record that extends for more than two thousand years (Krumbein and Cohen, 1974; Cohen et al., 1977).

Other modern "living" stromatolites are found in Western Australia while the most famous site is of course Hamelin Pool. A visit to Western Australia brought me in September 2005 to the no less interesting site of Lake Clifton (Yalgorup National Park) with its thrombolites 'living rocks', microbialites that grow in brackish water. In comparison with the Hamelin Pool stromatolites, the Lake Clifton thrombolites have been very little explored (Friedman, 1995).

Sites such as Solar Lake in Sinai, Andros Island in the Bahamas and Hamelin Pool and Lake Clifton in Western Australia can be studied as model systems towards understanding of the processes that in the past led to the formation of the extensive stromatolites found in the fossil record. This book contains many excellent examples of such studies. However, it should be stressed that extrapolation of the phenomena occurring at such sites in the present to obtain an understanding of events that happened in the Precambrian is not always simple and straightforward. The problems were formulated very clearly by Claude Monty, and therefore the final paragraph from his 1972 paper deserves to be quoted here in full:

"All the small scale processes and factors responsible for the given features and behaviour of a stromatolitic flat, as well as the complex flow of biological, social, chemical…phenomena within a single algal dome or mat have always frightened me when I consider the simple (too simple!) resulting laminated structures that the palaeontologist has to study; I wonder then how much of the natural history of a stromatolite is left in the thin compacted residual laminae found in the base of a Recent deposit; how much then in a fossil stromatolite? Well, very little most probably. But we shall miss or misunderstand this "very little message" if we do not know the rules of the game, if we do not know where the message might come from, if we do not analyse it in full detail, if we do not sharpen our concepts. To this purpose, the Present may be a key to the Past provided:

(1) We have a good critical knowledge of the present processes at every single level of organization
(2) We dig out from the **right** present the **right** key to the **right**, **analogous** or **homologous** Past."

These words are as true today as they were when they were written, nearly 40 years ago. I am convinced that the chapters in this book fulfil these two provisions set by Monty, so that a proper understanding of the true nature of ancient stromatolites can be achieved.

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