Preface

This volume integrates the latest findings on earliest life forms, identified and characterised in some of the oldest sedimentary rocks and seafloor hydrothermal systems on Earth and includes a number of papers from authors with alternate perspectives on the evidence of earliest life. Emphasis is placed on the integration of microanalytical methods with observational techniques and experimental simulations because of the challenges involved in study of organic matter in such ancient rocks. The opening section focuses on submarine vent systems that the majority of researchers postulate served as the cradle of life on Earth. In the following sections evidence for life in strongly metamorphosed rocks such as those in Greenland is evaluated and early ecosystems identified in the well preserved Barberton and Pilbara successions in Southern Africa and Western Australia. This volume will be of great value to graduate students and researchers interested in the origin and record of earliest life on Earth.

The quest for evidence of the earliest life forms on Earth has occupied geologists and palaentologists in earnest for the past 50 years after a somewhat rocky start in the late nineteenth and early twentieth century dogged by controversy surrounding the theory of evolution. It was recognized early that the first forms of life had to be primitive microbial forms with the ability to utilize inorganic compounds and convert them into organic matter and were thus unlikely to leave fossil traces as we know them from geologically younger rocks. Stromatolites are a potential exception to this generalisation and the most abundant biogenic structures identified in Archaean age rocks because of their distinctive morphologies. Unfortunately, laminated sedimentary structures can form in a variety of ways including seafloor precipitation such that the biogenicity of early Archaean stromatolites (>3.0 Ga) is highly debated due to the general lack of biosedimentary fabrics and organic remains of microfossils. In this volume new research on stromatolites and other microbially induced sedimentary structures are presented and evaluated in the context of previous work. Brasier documents the history of the search for Precambrian life and the numerous diversions along the way, which has led to the recognition that morphological complexity can develop abiologically in natural systems. Webb and Kamber show that high precision, high resolution trace element analysis coupled with other geochemical evidence may allow distinction between competing abiogenic and biogenic hypotheses for the origin of sedimentary structures inferred to be stromatolites or other microbialites on the basis of morphology and geological setting. A third contribution by Noffke summarizes her work on microbially induced sedimentary structures that result from the biotic-physical interaction of microbial mats with the sedimentary dynamics in sandy marine environments and are well represented in the 2.9 Ga Pongola Supergroup of South Africa.

Seafloor hydrothermal systems are postulated as the cradle of life on Earth because their chemistry favours the synthesis of reduced carbon compounds and present day thermophilic microbes such as archaea and sulfate reducing bacteria inhabiting deep sea vent environments sit at the base of the tree of life. Evidence of hydrothermal activity is widespread in the well preserved 3.5 to 3.2 Ga rocks of the Pilbara Craton of Western Australia and the Barberton Greenstone Belt in Southern Africa, which comprise a number of volcanic packages overlain in turn by thin units of clastic and chemical sedimentary rocks. This book focuses on such environments and the carbonaceous matter that occurs in both clastic and chemical sedimentary rocks of the Pilbara Craton and Barberton Greenstone Belt, most notably in thin chert units and transgressive bodies (chert dykes) formed by precipitation on the seafloor and replacement of other rock types. Golding et al. review the literature on the multiple sulfur isotope geochemistry of seafloor hydrothermal systems and sediments and present new data for the 3.24 Ga Sulphur Springs massive sulfide deposit and the 3.5 Ga Dresser Formation of the Pilbara Craton, which are respectively the earliest well preserved and documented black smoker and epithermal style seafloor hydrothermal systems on Earth. Hofmann's study of the Barberton Greenstone Belt in South Africa describes the Archean hydrothermal systems and their potential significance as a habitat for early life. Williams and her colleagues report their experimental work on the role of clay minerals particularly the smectite clays in the abiotic synthesis of organic molecules in seafloor hydrothermal systems. This is suggested as a possible mechanism for the beginning of life and the primordial birth of the first replicating cell.

Another group of papers focuses on the remains of organic matter preserved in the least thermally altered early Archean rocks of the Pilbara Craton and Barberton Greenstone Belt and demonstrates a possible relationship between co-existing abiotic and biological carbonaceous materials. Glikson et al. summarize their comprehensive studies of organic matter concentrates from these ancient rocks using sophisticated electron microscopical methodologies and geochemistry, as well as a comparison of this material with the remains of a modern hyperthermophilic microbe cultured under simulated hydrothermal conditions and thermally stressed. In another contribution De Gregorio and colleagues evaluate a variety of nano scale methods for establishing the biogenicity of ancient organic matter and associated putative microfossils and stromatolites. Furthermore, this group of researchers conducted laboratory Fischer-Tropsch-Type (FFT) experiments that produced abiotic carbonaceous matter, which they compared to carbonaceous matter obtained from ancient rocks, enhancing the distinction between biological and abiologically sourced organic matter.

The remaining two chapters in this volume discuss the Archean nitrogen and carbon isotope records and their use as tools in the search for evidence of early life.

Pinti and Hashizume show that nitrogen isotopes can be used for modeling the interplay of changing microbial metabolisms through early Earth history and related broadly to environmental changes including the progressive oxygenation of the Earth. On the other hand McCollom argues that carbon isotopes alone are insufficient to establish a biological origin for ancient organic matter because carbonaceous matter produced in FTT experiments can have similarly ^{13}C-depleted carbon isotopic compositions. The comparison of FTT carbonaceous matter synthesized under simulated hydrothermal conditions with thermally stressed microbial cultures and undisputedly ancient biogenic carbonaceous matter is a common thread of several chapters in this book, and an avenue for future research.

Finally, as editors of this volume, we would like to thank all the authors and co-authors and reviewers for their contributions and Springer Publishing Editor Petra van Steenbergen and her assistant Cynthia de Jonge for initially suggesting the topic for this book and their consistent support during its writing.

Suzanne D. Golding and Miryam Glikson

http://www.springer.com/978-90-481-8793-5

Earliest Life on Earth: Habitats, Environments and
Methods of Detection
Golding, S.D.; Glikson, M. (Eds.)
2011, XVI, 316 p., Hardcover
ISBN: 978-90-481-8793-5