

Preface

Surface conditions on the Early Archean (and Hadean) Earth were critical to the origin of life. This is not a recent realization, and origin-of-life considerations have long figured prominently in geological analyses of Earth's earliest history. Several detailed treatments over the past century have discussed prebiotic processes based on assumed conditions, analyzed the (sparse) geologic data from earliest times, quantitatively explored chemical processes on and in the Earth and in its atmosphere, and attempted theoretical reconstructions of processes responsible for the formation and early evolution of the planet. Some of these efforts have also been applied to the other terrestrial planets and/or have been informed by knowledge of conditions throughout the solar system. In many of these efforts the analysis may not have given sufficient weight to one or more factors marginal to the expertise of the analyst, though in general there is a good awareness that the problems are complex and rely on information and constraints from a very broad range of disciplines. A recent spate of books discussing the origin of life suggests both a renewed interest in the topic, and perhaps no need for yet another. That a geologist feels an inclination to add to the discussion may seem misdirected. After all, isn't this a biological problem? On the contrary, I suggest that a careful consideration of the (essentially) geologic conditions leading up to life's origins can lead to a better understanding of where and how life began, and I am not the first (Rutten 1962). This book will cover such considerations in some detail and will also explore some essentially biochemical aspects which I don't believe have been previously discussed.

I will not suggest that my expertise across disciplinary boundaries is necessarily superior to those who have attempted an understanding of early Earth and the origin of life, and especially not as detailed in particular fields. However, as one who has a long-standing interest in astronomy, an abandoned goal of becoming a biochemist, degrees in chemistry and geology, research experience in geophysics and geophysical modeling, and a tendency to approach problems as a generalist, I may be better able to appreciate the range of constraints that help define the problem. A previous attempt at describing the origin and evolution of Earth's atmosphere (Shaw 2008) was somewhat limited by publication constraints, though it contains some of the ideas explored herein. In addition, even in the last few years, there have been de-

velopments/discoveries that have affected my thinking, even as I have given more thought to particular aspects of the problem.

This book will not be a critique of past efforts, though it will use and discuss them. There are several aspects of the problem that have been covered in great detail by others, and I make ready reference to those works without repeating previous expositions. I agree with the substance of the vast majority of what has been uncovered and parsed by previous work, and brief expositions of these results will often serve as starting points for my own interpretations. On the other hand, there are many points where I depart from the conventional wisdom, as well as a number of ideas that, if not completely novel, are essential to understanding the origin of conditions conducive to the emergence of life.

The book is divided into three parts. First I discuss the processes and results of the degassing and early processing of Earth's volatile inventory. Next I discuss various aspects of life processes, focusing on the requirements for the earliest emergence of life, including a possible pathway to the generation of the essential complex feedback processes thought to be characteristic of life. The third part examines processes of atmospheric evolution following the emergence of life, especially the development and consequences of photosynthesis, oxygenic photosynthesis in particular. There is a final chapter which examines the implications of the first three parts for understanding the geological and planetological record in terms of atmospheric and surface evolution.

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