The Early Earth: Physical, Chemical and Biological Development

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The Early Earth: Physical, Chemical and Biological Development

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Preface

The early Earth, to borrow from the term used by Queen Elizabeth I to describe the Archaean of Labrador, is Terra Meta Incognita. This is still largely correct as much of its character is still unrecognized. Some of the most interesting problems in geology and biology lie in the study of the planet's early history. This book arose from a Discussion Meeting in February 2000, sponsored by the Royal Astronomical Society and the Geological Society. The meeting was designed to cover a wide range of different aspects of the early Earth. Much was discussed, arguments were detailed, and perhaps some insight was gained.

Though much is published about the Archaean, there are few recent books that offer, in a single volume, a wide-ranging access to the subject. Conference volumes can be little more than random assortments of papers by people who happened to be there, while single-author textbooks have thematic unity but can be very out of date by the time they are published. This book, we hope, bridges that gap to some extent. It stems from the meeting but incorporates more recent work by the speakers, and also some work by authors not presented at the meeting. The intent is to cover a wide range of Archaean topics at research level (and so be useful to graduate students and those seeking an introduction to the subject), while retaining some of the work-in-progress vigour of a discussion meeting.

The papers are divided into three sections:

(1) Geophysical and petrological constraints on archaean lithosphere.
(2) Models of cratonic evolution and modification.
(3) Constraints on the Archaean environment.

The first section contains a series of papers concerned with the differences in overall structure and composition between Archaean and post-Archaean lithosphere, and has contributions from seismologists, petrologists, and geochemists. **James & Fouch** present seismological evidence from southern African, particularly the Kaapvaal craton, for the formation and evolution of cratons: Archaean cratons have relatively thin crust and high velocity mantle roots that extend to depths of at least 200 km, in contrast to younger terrains which have a thicker complex crust and relatively low seismic velocities in the mantle. Then **Kendall *et al.*** turn to North America and present seismic evidence for the evolution of the Archaean Superior province. **Priestley & McKenzie** present seismic and geochemical constraints on the formation of Archaean lithosphere and its current structure. The next three papers cover the geochemical and petrological constraints on the origin and development of Archaean lithosphere. **Pearson *et al.*** consider the time constraints imposed by Re and Os; **Arndt *et al.*** present evidence on the origin of continental lithosphere from studies of high Mg olivine and the residue left beneath continents after eruption of flood basalts; and **Luais & Hawkesworth** discuss the isotopic evolution of Pb in the Archaean. In the final paper in this section, **Musacchio & Mooney** use P-wave and S-wave velocities. to suggest mid-Proterozoic anothosites had a mantle source and that the mid-Proterozoic lower crust is mafic.

The second section contains papers modelling cratonic evolution and accretion. **Sleep *et al.*** present numerical models of cratonic roots in normal mantle flow and in the presence of plumes. Cratons may suffer lateral erosion rather thinning. **Bleeker** reviews the tectonic evolution of Archaean granite–greenstone terrains. Then, taking a rather different approach, **Jelsma & Dirks** provide a geochemical and age database and propose a tectono-magmatic evolution model for the Zimbabwe craton.

The third section contains papers concerned with details of the formation, maintenance and development of the Archaean surface environment, and linkage between the evolution of the surface and the planetary interior. This is a very wide field and the papers deal with matters such as the timing of hydrogen loss from the Earth, the shift to an oxygen-rich atmosphere, carbon dioxide build-up in the atmosphere, the appearance of life, early biogenic controls on the carbon cycle and the origins of photosynthesis. **Marty & Dauphas** discuss rare gases and major volatiles in the Hadaean, followed by **Zahnle & Sleep**, who investigate the climate of the ancient Earth and the role of carbon dioxide cycling. Then **Kramers** considers the rates of formation and destruction of continental crust in the Archaean and the drawdown of a massive CO_2 atmosphere. **Nisbet** discusses the physical and biological controls on the Earth in the late Hadean and Archaean. This paper was the Geological Society's 2000 Fermor Lecture, commemorating Sir Lewis Fermor, of the Geological Survey of India. In keeping with Fermor's wide-ranging interests, the brief for this paper was very broad, and looks back to a meeting in Harare, Zimbabwe 50 years ago when Fermor and A. M. Macgregor explored physical and biological controls on the Earth's evolution. The topic of Archaean life is continued in the following paper by **Grassineau *et al.***, which presents detailed C and S isotopic data from the Belingwe greenstone belt. Finally, **Rollinson** sets out the metamorphic history of the 3.8 Ga Isua Greenstone Belt in Greenland, for which carbon isotope values suggest that some of the sediments may be of biogenic origin.

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Mary Fowler, Cindy Ebinger & Chris Hawkesworth
June 2002