Holland's Earth

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The Chemical Evolution of the Atmosphere and Oceans.
By Heinrich D. Holland.
Princeton University Press: 1984. Pp.582. Hbk $97.50, £80.70; pbk $24.50, £20.30.

THERE is an almost sensual pleasure to be had from collecting small rare objects, such as stamps, books or rocks. Some modern books on natural history can delight the reader in the same way, but it is unusual for a textbook to elicit this feeling. *The Chemical Evolution of the Atmosphere and Oceans* is an exception.

Professor Holland's view of the evolution of the Earth — where the constancy of climate and composition over geological time is a straightforward consequence of the working of chemical and physical forces — differs sharply from mine that sees in the constancy a homoeostasis maintained for and by the biota. That this difference is mutual is noted courteously but firmly in his closing pages. In no way does this difference of interpretation alter my pleasure from reading the book, nor my admiration of its authoritative excellence — science can benefit from the personal dialectical approach and guesses are needed to start the iterations that may converge towards the unattainable goal of truth. The book is enhanced by clear and comprehensible graphs and tables, and at times reads more like the report of a research project than a textbook.

It begins with four chapters about the origins of the Earth and on what is known of the Hadean. It is easy to forget that this turbulent period occupied nearly one-quarter of the Earth's history, whereas human beings have occupied only the past thousandth of it. Models of the Hadean are thin and rather speculative but here are displayed the few solid facts that are available. It is a source of wonder that one of the most certain of these is the earliest; namely, that much of the material of the Earth came from a supernova explosion 4.55 Gyr ago. The evidence from the distribution of radioactive and stable isotopes, the fall-out of that vast initial nuclear explosion, is used extensively throughout the book. Just as loud and angry voices carry further than quiet conversation, there is a tendency to concentrate on events that are violent and stormy rather than on the calmer periods in between; yet it could have been during a calm spell at the end of the Hadean that life assembled itself. Essential for theories of the origin of life is information on the structure and composition of the prebiotic atmosphere and oceans. It seems that the new orthodoxy is still with us and that the atmosphere at the end of the Hadean was dominated by CO_2 and neutral to slightly reducing. The oceans by contrast were buffered at a low redox potential by an abundance of soluble electron-rich species of elements such as iron and sulphur.

As the book moves on into the Archean, the emergence of life is noted but curiously kept at low key as if the author considered it to be impolite or improper to discuss biological matters too deeply in a book on chemical evolution. Perhaps, though, the reluctance to become involved with the fashionable science of biogeochemistry is wise. There have been numerous attempts

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Atmospheric input — Krakatoa rumbles on, one hundred years after the original eruption.

to put the biota in a box and assign to it inputs and outputs, an operation analogous to that of making a materials and energy balance of a living animal. Something may be learnt from these exercises but they can offer nothing to explain the potential of living systems for homoeostasis nor can they predict the course of their evolution. An interdisciplinary approach to earth science is more in need of contributions from geophysiology than from biogeochemistry.

This beloved data-bank of a book that never considers things beyond the limits of decent speculation also never ceases to present its data in a way that tempts speculation far beyond those limits. To nowhere does this apply more than the chapter on terrestrial environments. The environmental factors that determined the speciation of uranium at the end of the Archean are discussed at length yet there is no word about the strange affair of the natural nuclear reactors at what is now Oklo in Africa. There, 2.35 Gyr ago, uranium was sufficiently concentrated and purified to exceed the critical mass needed for a working nuclear reactor. Did the primitive artifice of dumb prokaryotic miners equal our proud science and technology? And what does the existence of that reactor then tell us of the atmosphere of those times?

The personal character of the book is strongest in the final chapter that deals with the Phanerozoic. The fascinating question of why the composition of the sea has stayed so constant is made significant by the skilful marshalling of the evidence. All is included, even the poetic names of those extraordinary crystalline rocks of the evaporites; such as polyhalite that bears no halogens or sylvite that does. From the constancy of the composition of sea water we move on to the constancy of the abundance of oxygen in the recent atmosphere. I could not help wondering here why the evidence of the presence of charcoal and of fossilized wood in sediments is not mentioned as setting quite sharp limits on the possible range of oxygen. If charcoal is a fossil indicator of fires, the fires can only have occurred when oxygen was within the range 15% to 25%.

The evolution of the Earth as a planet is vastly different from that of the other terrestrial planets. As Anderson has recently observed (*Science* **223**, 347–355; 1984), plate tectonics are unique to the Earth and made possible only by the presence of limestone, which in turn is almost wholly a product of the biota. The geological community is only now beginning to take on the difficult problem of explaining the effects of the presence of the biota on the evolution of the Earth, and it will be some time before the biological presence is considered as a driver rather than a passenger. There are still formidable barriers to interdisciplinary thinking.

As a young scientist I was advised to read original papers rather than textbooks. Times have changed — nowadays too many published papers are either otiose or just plain wrong. How can those who seek information outside their speciality sift the good from the bad? This is where a book such as this is invaluable to a general scientific readership. It is well and clearly written, providing an authoritative summation of information about the Earth from the viewpoint of a geologist and a chemist, and also serves as a guide to the key original sources. But most of all it contains a constant supply of robust but finely tested facts and decent speculations that can be used for building images and models. It will be my companion for many years to come. □

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