BOOKS: PLANETARY SCIENCE

Fragmented Formative Story

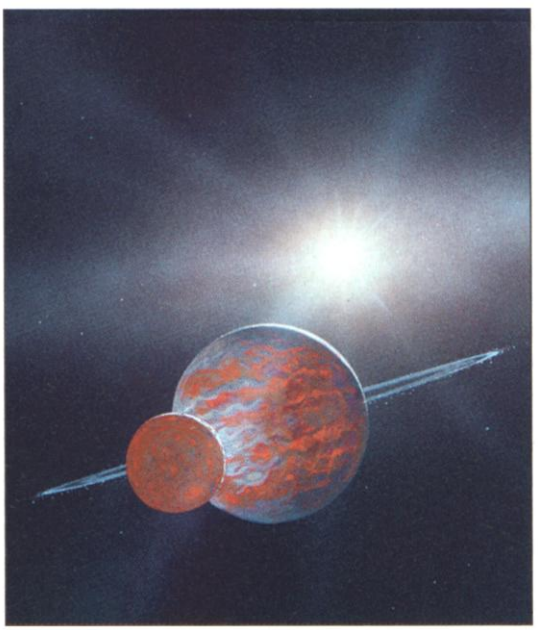
Hugh O'Neill

Origin of the Earth and Moon
R. M. Canup and K. Righter, Eds.
University of Arizona Press, Tucson, in collaboration with Lunar and Planetary Institute, Houston, 2000. 571 pp. $50. ISBN 0-8165-2073-9.

The last quarter century has seen considerable progress in our understanding of the formation of the planet we live on and its satellite. *Origin of the Earth and Moon* offers a comprehensive overview of recent studies into the processes and events that shaped the early history of the Earth-Moon system. The volume effectively summarizes current thinking in the field and suggests avenues for future research.

The volume grew out of an eponymous December 1998 conference organized by Michael Drake and Alex Halliday in Monterey, California. It is not, however, the proceedings of the conference, which are available on the Web (*1*). Instead, the editors, Robin Canup and Kevin Righter, invited the conference attendees to contribute articles—an arrangement similar to that adopted successfully by two antecedent conferences. The first of these (held in Kona, Hawaii, in 1984) was a happily timed meeting that enabled the thinking of many scientists to coalesce around a new model for lunar origins, namely the "giant impact" hypothesis. In this scenario, the Moon formed by the accretion of debris from a collision between Earth and a second protoplanet the size of Mars or larger. The subsequent book, *Origin of the Moon* (*2*), established this class of model as the dominant paradigm and relegated fission and capture models, which had long been recognized as inadequate on many grounds, to positions of historical interest only (*3*). At the second conference, "Origin of the Earth" (held in Berkeley, California, in 1988), participants explored the implications of the hypothetical giant impact for the early Earth (*4*).

A decade later, the 1998 conference found the giant impact well established. It dominates the present volume and provides the theoretical context in which many of the contributors frame their assumptions. No one in the book actively promotes an alternative model, although an appropriate note of caution—occasionally even of skepticism—persists in many of the articles. Glen Stewart devotes his chapter to highlighting potential problems with the physics of the giant impact hypothesis, and the contribution by John Jones and Herbert Palme reviews the problems of reconciling the hypothesis with the Moon's geochemistry. Many authors appropriately place their discussions in the context of the formation of the whole solar system. I would suggest that any fourth conference (and book) in the series should take "the origin of the terrestrial planets" as its unifying theme.



Created by collision. Some years to a century after the hypothesized giant impact, much of the resulting debris had aggregated into the proto-Moon but Earth was still surrounded by a remnant ring.

CREDIT: WILLIAM K. HARTMANN

The book consists of 29 contributions from 66 authors. The chapters vary from summaries of the authors' own research to fairly comprehensive reviews of particular fields. As in the earlier two books, the coverage is fairly evenly divided between physical and chemical perspectives, and just about every aspect of recent research on the formation of Earth and the Moon gets some sort of mention. Readers with a background in the Earth sciences will find most of what they need to bring them up to speed with current thinking on a still-developing story. The organization and presentation of this information is quite an achievement.

Ideas of what happens in a giant impact have evolved considerably since the Kona conference. On the geochemical side, I agree with the opinion of Jones and Palme that the study of the hafnium-tungsten isotopic system has provided the single most important new advance. The chapter by Halliday *et al.* is devoted to this topic, and Snyder *et al.* also discuss it in some detail. Like many avenues of research discussed in this volume, this work is very much science in progress; the final story remains unwritten. But at present, and in agreement with more circumstantial evidence from other isotopic systems such as uranium-thorium-lead or xenon, the ^{182}Hf-^{182}W evidence appears to show that Earth's core formed surprisingly late in the accretion process, some 50 million years after the origin of the solar system. More controversially, the birth of the Moon appears to coincide with or, possibly, even predate the cessation of the core-forming process on Earth. Although important technical issues concerning these lunar data must still be resolved, it seems difficult to accommodate this within the normal scenario for the giant impact. And it is disappointing to find that these chronological constraints and their implications have been ignored in the nearly all the chapters on the physics of the processes.

In fact, the neglect of these constraints is but one example of the main failing in the current work on lunar origins, which is that the science is still compartmentalized into the authors' various specialties. The failure to integrate evidence from multiple disciplines pervades most chapters. Isotope geochemists seem particularly reluctant to consider arguments from other disciplines, even from other branches of chemistry. This reluctance inevitably leads them to use simple mixing models as universal "explanations" of any imaginable process. A hopefully apocryphal attitude, attributed by lunar geochemists to their geophysical colleagues, has the geophysicists seeing little need to constrain their modeling to fit the geochemical evidence because the geochemists cannot agree amongst themselves on this evidence. The unfortunate truth in the excuse should not exculpate this attitude.

From our present understanding (or lack thereof) of the chemistry of Earth and Moon, the formation of terrestrial planets must have been a complicated process involving elements of happenstance. Improving our understanding will require the synthesis of contributions from many disciplines. The key to progress will be critical evaluation of the entire body of evidence. Here I am reminded of A. E. Ringwood's earlier monograph with exactly the same ti-

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tle as the present volume (*5*), one whose author did have the courage to synthesize. Science is not only about what we know, but also how well we know it. Not all of the evidence discussed in this volume's various chapters is of equal value; some of it is very probably misleading or its implications misunderstood, and some may even be just plain wrong. Courage is needed as well to sort through the conflicting data. Perhaps a strength of the book is that it exposes the fractured state of knowledge about planetary origins, and thus forms a good foundation for future endeavors.

Origin of the Earth and Moon is very competently produced and reasonably priced for an academic tome. It goes without saying that it deserves a home in every planetary scientist's library. Unfortunately, this will not result in best-seller status. The exploration of the solar system has been grossly under-appreciated as an intellectual adventure.

Before the era of space travel, our understanding of Earth had been held back by the problem of uniqueness—we had only Earth itself to study. The Apollo program changed this. In particular, exploration of the Moon fostered thinking about Earth from an expanded perspective. One consequence has been the growing awareness of Earth's special qualities and how very rare the circumstances leading to the formation of a habitable planet might be. Could Earth and its life be unique?

I would like to believe that this subject would be central to the intellectual aspirations of all people, whatever their cultural background. But the list of authors who contributed to this volume reveals a sorrier reality. More than 50 of the 66 are from the United States, and most of the others work in Japan and Germany. Although the conference's California location may partially explain this bias, the participation is also a fair reflection of activity in the field. Sadly, there is nothing at all from anyone still practicing science in the former Soviet Union. Maybe current economic woes are to blame there. Yet the science discussed in this volume is not expensive to carry out, and the costs hardly excuse other countries that are conspicuously absent from the list of authors despite their cultural and intellectual pretensions. I hope that the perspectives offered in *Origin of the Earth and Moon* will catalyze more widespread international interest in the subject.

References

1. Abstracts for the Monterey meeting can be found at: www.lpi.usra.edu/meetings/origin98/pdf/program.pdf
2. W. K. Hartmann, R. J. Phillips, G. J. Taylor, Eds., *Origin of the Moon* (Lunar and Planetary Institute, Houston, 1986).
3. A good summary of such models is given by S. G. Brush, *Rev. Mod. Phys.* **62**, 43 (1990).
4. H. E. Newsom, J. H. Jones, Eds., *Origin of the Earth* (Oxford Univ. Press, New York, 1990).
5. A. E. Ringwood, *Origin of the Earth and Moon* (Springer-Verlag, New York, 1979).

NOTA BENE: ENVIRONMENT

Sounds of Silence

The British Antarctic Survey (BAS) has found an inspired way to bring scientific issues to the attention of a wider audience—through music. With the Philharmonia Orchestra, it commissioned a symphony from Peter Maxwell Davies, who traveled to Antarctica in the austral summer of 1997–1998 in preparation for the work. The British composer led the Philharmonia in the premier of the resulting *Antarctic Symphony* at Royal Festival Hall, London, on 6 May; an upcoming performance in Scotland will be broadcast on BBC Radio 3 on 27 June.

Antarctic Symphony
Peter Maxwell Davies
Information on performances is availabe at www.maxopus.com

The work consists of a single movement in which the composer weaves sounds based on his Antarctic experiences (some created with unusual instruments such as a biscuit tin filled with broken glass) into a fabric of classical music that evokes his impressions of the continent. Among Davies's inspirations were the sounds of the ship breaking through sea ice and of an avalanche of snow enveloping those on deck when the ship passed through a narrow channel—which he found "more profoundly quiet than the previous silence."

The symphony also commemorates the 1953 *Sinfonia Antarctica*, which Ralph Vaughan Williams (who never traveled to Antarctica) developed from his own score for the film *Scott in the Antarctic*. I would have liked to have heard the two pieces in succession.

A wealth of beautiful pictures and the composer's diary from his trip have been combined in a book, *Notes from a Cold Climate* (Browns, London, 2001). The BAS and the Philharmonia Orchestra have also collaborated on an accompanying education project, Antarctic Waves (www.antarcticwaves.com). This toolkit will offer Antarctic sounds, images, and scientific data to help high school students create music.

—JULIA UPPENBRINK

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A DAY OUT: PLANT ECOLOGY

Paradise Regained

Sandra Knapp

The garden of Eden in the Bible was the paradise from which humans were banished. At the Eden Project in Cornwall, we are welcomed in to discover how we interact with and influence our environment through our actions and our lack of action. In a reversal of the Biblical creation myth, this garden is conceived with the acquisition of knowledge at its center.

The Eden Project is a world of superlatives: the world's biggest greenhouses, built using the largest free-standing scaffolding; the "compost heap to beat them all," for the making of 85,000 metric tons of soil. It aims to change the way we think about the world we inhabit. To facilitate this goal, the project is enhancing the presentation of the plant collections with commissioned art from a range of media including sculpture, music, animation, and performance. This ambitious and poetic vision has inspired many in a country where another giant dome built to mark the Millennium instead sparked controversy and unseemly bickering. The project opened this spring with a blaze of publicity in the midst of the foot-and-mouth epidemic, and it has far exceeded its visitor targets.

The Eden Project
Bodelva, St. Austell, Cornwall PL24 2 SG, UK.
www.edenproject.org.uk/

But is this Eden really paradise? Does it make places like London's Kew Gardens obsolete and old-fashioned? And most importantly, will its future really be as solid and sustaining as the drama of its creation? We went to Cornwall to see how the

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