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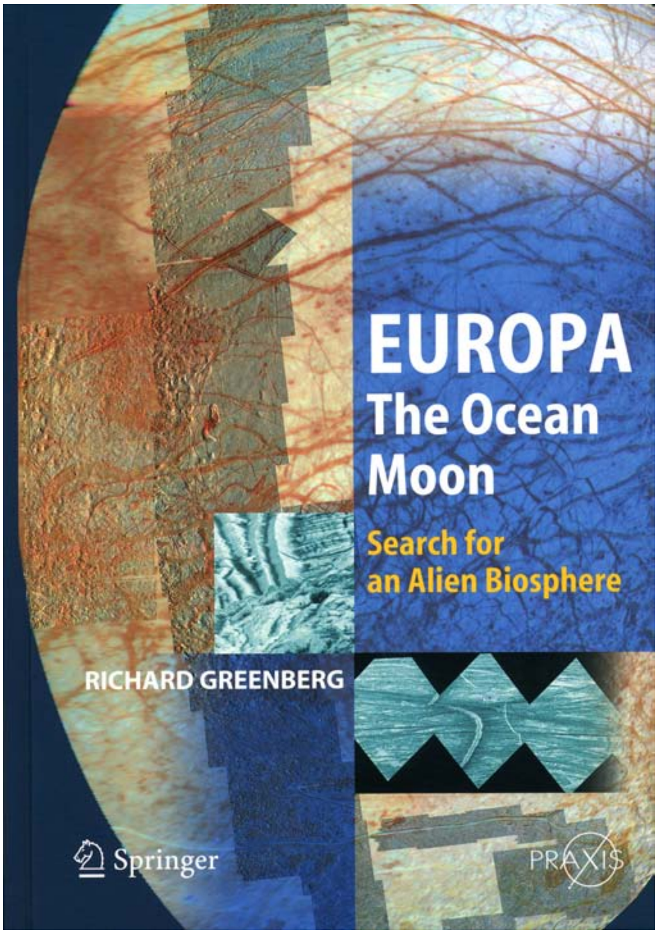
# Book Review

**Europa—The ocean moon: Search for an alien biosphere**, by Richard Greenberg. Springer, 2005, 380 pp., $89.95, hardcover. (ISBN 3-540-22450-5).




There are books that, once opened, because of their fine writing or content just cannot be put down until the last page is turned. There are others that, because of the harshness of the rhetoric, or perhaps the crudeness of content or language, are quickly closed and put on the shelf to simply collect dust. In a way, this book combines these extremes. There were hours when I could not put it down because of the elegance of ideas and interpretations that flowed from the pages. But there were also times when, after turning a page, I found language and concepts so alien to my experiences in dealing with people and institutions that the cover had to be slammed shut and the book literally thrown to the floor.

Richard Greenberg has written a book that lays out an explanation, developed by him and his associates at the University of Arizona, of what the cameras of the Voyager and Galileo missions saw on the surface of Europa. It is an explanation coined in terms of a tidal theory that is forced by the motion of Europa within a Laplace resonance shared by the three inner Galilean satellites. It is a fascinating and controversial story made elegant by the way it leads to explanations of many diverse phenomena in terms of a minimum (two) of geophysical processes—these he calls cracking and melt-through. A geologically young, thin (a few kilometers at most), and, in geological time, mobile ice crust overlying a global ocean is predicted and a significant role for processes such as solid state convection in the ice or cryo-volcanism, which have been discussed by several workers in the field, is denied. It is these predictions, of course, that make the theory scientifically controversial and subject to intense and, in my view, healthy debate in the planetary science community, for, as usual, there are more ways than one to interpret what is seen.

The science story is developed in three sections: a broad overview of what is seen on Europa followed by an explanation of the theory of tides and motion in the Laplace resonance and concluded by a massive section entitled "Understanding Europa." This last section contains fascinating, detailed, and frequently convincing explanations of surface lineaments—both global and local, ridge building, chaotic terrain, surface dilation, the formation of wedges, strike-slip features, cycloids or flexi, impact features, pits and uplifts, the possibilities for non-synchronous rotation, polar wander, global resurfacing, and a mechanism for crustal convergence. It is, except for one aspect of the presentation that I note below, a masterful exposition and a major contribution to the planetary science literature. Part two, the section on tides, is particularly clear and stimulating and this is the part of the book that I could not put down.

Intertwined with this first story, which makes up fully half of the book and is the good part, are two other stories: one concerns the possibility of life on Europa, a topic of considerable current interest in the solar system exploration community, and the other concerns the way in which Greenberg et al. as members and associates of the Galileo imaging team arrived at their interpretations.

The life story, really little more than a sideline, seems primarily designed to make the significant point that the implication of his tidal theory of Europan surface phenomena is that the ice lid to the ocean is not tightly closed and that,

over relatively short geological timescales, one can expect physical and chemical connections between the ocean and the surface to be opened that may provide a pathway for sustenance of Europan life. This brief section also includes Greenberg's view on planetary protection and an analysis of current policy and practice. In it he calls for increased care in the matter of forward protection in the case of Europa, which I applaud.

The descriptions of how Greenberg developed, promoted, and defended his ideas is another significant part of the book and one that I find at times to be absurd, generally irreverent, and, in professional terms, possibly approaching suicidal. For example, on page 332 he provides a description of how he believes the National Research Council operates: "When NASA contracts with the NRC for advice regarding planetary exploration, it gets the prestige of the National Academy, but it does not get its members. Instead, NRC puts together ad hoc committees, selected by power-brokers of the planetary science community, which produce the reports that NASA pays for. Everyone wins. NASA gets the policy guidelines it wants, with nominally gold-plated credentials, the scientists who serve on the committees for free get to influence policy and get the prestige of having been tapped by an arm of the Academy for their supposed expertise. At the same time, the Academy does a public service, while bringing in some cash." Why this inaccurate and negatively posed description is essential to a book about the surface of Europa or the development of research ideas is beyond me. In my experience, relevant members of the academy are, in fact, deeply involved in the process, usually at the stage of providing detailed and insightful reviews of NRC reports prior to finalization. I find it absurd that part of the motivation is the acquisition of cash.

Paranoia is not a word to be used lightly, but there is much that I am certain is delusional in this aspect of the book. We see this even in the preface (though there similar instances throughout the book): "I never felt welcomed by the team… Then, when it became clear that my field was the key to understanding what we saw at Europa and evident how significant those discoveries were, attempts to keep me marginalized were driven by transparent social, political, and financial motives." This is absurd. The book is filled with words and phrases like: "professional gladiators," "powerful infighters," "perverted definition of 'team'," "sycophantic," "hustlers," "enforcers," "malignity, envy, and ignorance," "locked out," "pontificating," "jealousy," and "animosity." Nowhere, as far as I can see, do the concepts on which the everyday world of our profession is based, that is, integrity, trust, and skeptical inquiry, get a fair shake. Even the players who are mentioned by name are stereotyped. Those who worked with the author are uniformly brilliant and insightful; those who question or raise opposing ideas are to one degree or another vilified. As I noted before: this is absurd.

The book is beautifully produced and edited by Springer and is well illustrated and indexed. An entire section is given to reference, which greatly increases the value of the book. Both color and black-and-white pictures are of acceptable quality, although I found myself resorting to a magnifying glass at times. For science and scientific insight I highly recommend the book; but as an example of how to accomplish science—to use one of Greenberg's idioms—go figure.

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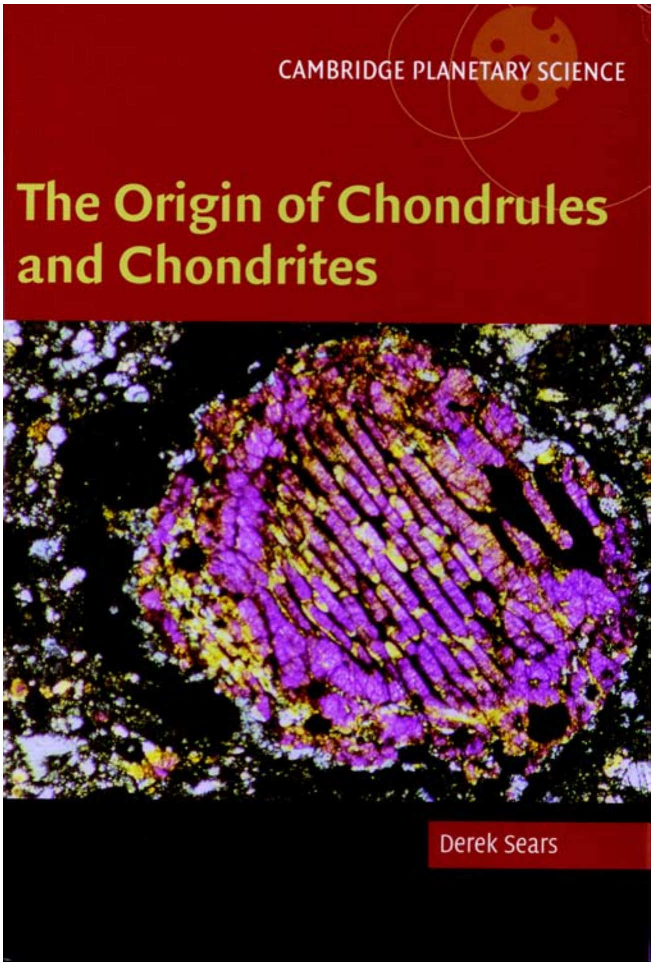
# Book Review

**The origin of chondrules and chondrites**, by Derek Sears. Cambridge University Press, 2004, 209 pp., $110.00, hardcover. (ISBN 0-521-83603-4).




Few would disagree with Derek Sears' claim that chondrites are the most studied rocks in the solar system and the least understood. To help remedy this, Sears has written a monograph, which is profusely illustrated with black-and-white images, diagrams, and sketches, that reviews the properties and proposed origins of chondrules and chondrites. He carefully guides the reader through the wealth of chemical and isotopic data on chondrules and chondrites, provides an excellent account of the theories of chondrule origins, and offers a coherent, though very controversial, model for their origin.

The first two chapters provide a historical overview of chondrite research and classification and a concise guide to the asteroids, their role as meteorite parent bodies, and the effects of impacts in forming regolith and impact melts. This is followed by a brief review of the chemical and oxygen isotopic compositions of the various groups of chondrites and their ages. Sears then identifies what he considers to be the most important questions about chondrites: how did the chondrules form and how were Fe,Ni metal and silicate fractionated from one another? The last half of the book focuses on the chemical, physical, and isotopic properties of chondrules that bear on these two questions and the various mechanisms that have been proposed to form chondrules.

Chondrites are the end products of nebular processes that operated in the protoplanetary disk and geological processes that operated on asteroids. Disentangling the effects of these two kinds of processes has been a continuing challenge for chondrite researchers for the last 50 years. Sears infers that chondrules did not form in the solar nebula and argues that impact processing on asteroids was much more important. He includes a brief review of Ca-Al-rich inclusions and the possible role of nebular condensation in their formation, but concludes that Ca-Al-rich inclusions are evaporative residues and byproducts of chondrule formation.

In the final chapter, he outlines his preferred origin for chondrules and chondrites: within a few million years after the formation of the oldest solar system solids, massive impacts on the larger, volatile-rich, carbonaceous asteroids produced plumes of melt droplets, gas, dust, and fragments. These plumes enveloped the asteroids, gradually depositing chondrules and Fe,Ni metal grains that had been aerodynamically sorted by size and density. Interestingly, he suggests that most North American researchers favor nebular mechanisms for chondrule formation, whereas most European and Japanese researchers favor an impact origin. However, recent models proposed specifically for CB chondrites by workers in North America resemble Sears' concept.

Sears traces the birth and evolution of diverse models for chondrule origins and includes references to 800 papers on chondrules and chondrites published between 1772 and 2003. His historical approach ensures that this book will be a valuable reference in many libraries. Where else can you discover who first compared the composition of the Sun's surface with that of the chondrites (the famous American astronomer, H. N. Russell in the *Astrophysical Journal* in 1929) or who first published quantitative models for heating asteroids of diverse sizes with $^{26}$Al (J. M. and M. A. Herndon in a *Meteoritics* paper in 1977)?

To test impact and nebular models for the origin of chondrules and relate the spectral properties of asteroid surfaces to those of meteorites, Sears argues that we must bring back asteroid samples for study in laboratories. The only way to disentangle what happened in the nebula from what happened on asteroids is to visit actual outcrops on asteroids, do geological fieldwork, and return samples. The Japanese space agency's Hayabusa spacecraft will attempt these tasks in the fall of 2005 when it visits the S-type asteroid, Itokawa.

To condense chondrite research into a relatively small book that focuses on chondrule origins and metal-silicate fractionation, Sears was forced to omit detailed accounts of several important topics about chondrites. For example, if you want an up-to-date, detailed review of presolar grains, Ca-Al-rich inclusions, organic matter, or early solar system chronology, you should read the chapters by Zinner, MacPherson, Gilmour, and McKeegan and Davis in the *Treatise on geochemistry* (2003). Researchers who need detailed accounts of the minerals present in chondritic components and their compositions should go to the extraordinary 398 page compendium by Brearley and Jones published by the Mineralogical Society of America in 1998, which includes about 1000 references. But the only book that will give you a concise account of the properties and proposed origins of chondrules and chondrites is this monograph. You may not be convinced that Sears has identified the correct model for chondrule formation, but you will learn much about chondrules and chondrites.

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