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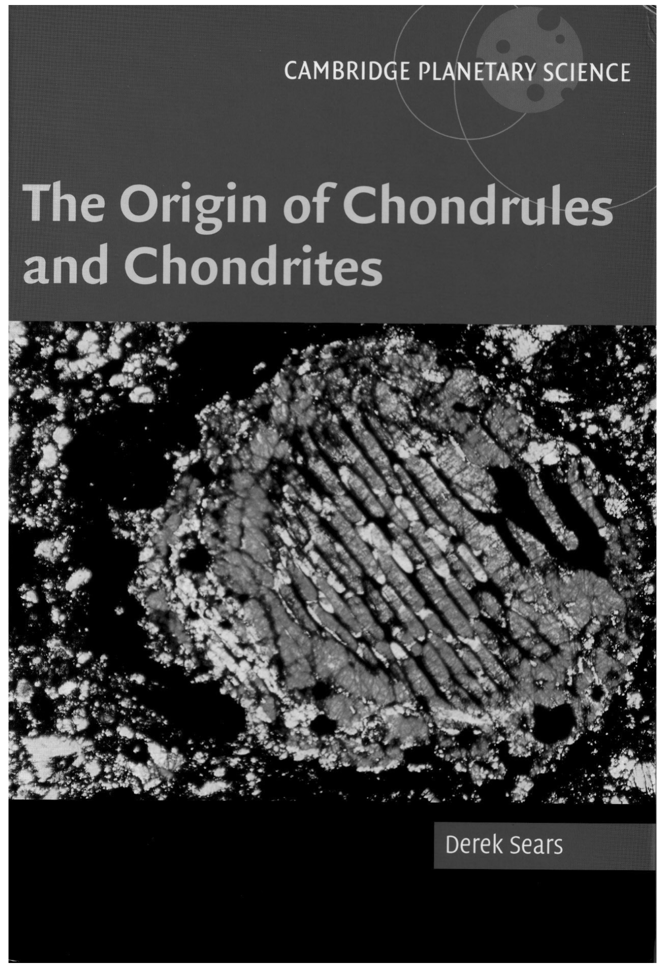
Book Review

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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