Vesta and Ceres: Insights from the Dawn Mission for the Origin of the Solar System

The NASA Dawn mission, launched in 2007, aimed to visit two of the most massive protoplanets of the main asteroid belt: Vesta and Ceres. The aim was to further our understanding of the earliest days of the Solar System, and compare the two bodies to better understand their formation and evolution. This book summarizes state-of-the-art results from the mission, and discusses the implications for our understanding not only of the asteroid belt but of the entire Solar System. It comprises of three parts: Part I provides an overview of the Main Belt asteroids and provides an introduction to the Dawn mission; Part II presents key findings from the mission; and Part III discusses how these findings provide insights into the formation and evolution of the Solar System. This is a definitive reference for academic researchers and professionals of planetary science, asteroid science, and space exploration.

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    978-1-108-47973-8

† Reissued as a paperback

VESTA AND CERES

Insights from the Dawn Mission for the Origin of the Solar System

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CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India

103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781108479738
DOI: 10.1017/9781108856324

First published 2022

Printed in the United Kingdom by TJ Books Limited, Padstow Cornwall

A catalogue record for this publication is available from the British Library.

ISBN 978-1-108-47973-8 Hardback

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PREFACE

The NASA Dawn spacecraft took off from Cape Canaveral in September 2007 atop a Delta II rocket starting an ambitious journey to Vesta and Ceres, the two most massive worlds in the largest reservoir of asteroids in the Solar System, the Main Belt. The mission's name was chosen to testify to a bold intent: execute a journey in space and time toward the dawn of the Solar System.

Prior to the Dawn launch, Earth-bound observations of Vesta and Ceres revealed intriguing features – from Vesta's rugged shape to Ceres' tenuous water exosphere – but these objects remained fuzzy speckles of light, even through the lenses of the most powerful telescopes. What we knew, however, was enough to justify a dedicated space mission to explore Vesta and Ceres. Yet our preexisting knowledge turned out to be only the tip of the iceberg of what Dawn discovered.

Since 2007, the science of Main Belt asteroids has considerably evolved. Remote telescopic observations have increased in spatial resolution, leading to detailed views of large Main Belt asteroids, including Vesta and Ceres. These new developments, along with an historical recount of how Dawn came to be, are discussed in Part I of the book.

With Dawn's exploration of Vesta (2011–2012) and Ceres (2015–2018), these two worlds came into focus. Breathtaking details emerged of how large collisions sculpted Vesta, liberating massive amounts of material in the inner Main Belt and providing the source of an important family of meteorites recovered on Earth. Ceres' complex geology, which may rival that of the Earth and Mars, showed recent cryovolcanic activity. Part II of this book is dedicated to these highlights and many more discoveries of the Dawn mission. The outstanding collection of papers presented in this part, led by members of the Dawn Science Team, follows a strong tradition of books showcasing the findings of space missions. But the present book is more than that.

By the time Dawn completed its mission in 2018, our understanding of the formation of the Solar System had greatly evolved thanks to new theoretical models and to a new trove of meteorite geochemical data, and Dawn observations of Vesta and Ceres provide new, vital constraints to synergistically interpret models and data. The broader implications of the Dawn legacy are discussed by prominent scientists from various disciplines in Part III of this book.

The idea for this book was born in the aftermath of the international workshop "The Main Belt: A Gateway to the Formation and Early Evolution of the Solar System" held in Sardinia, Italy, 2019 June 4–7. Many of the chapters' authors attended the meeting and embraced lively discussions about Dawn, Vesta, and Ceres, with the Mediterranean Sea in the background, less than 300 miles away from Palermo Observatory, where Ceres was discovered in 1801.

The editors hope this book will serve as a solid reference for the younger generations as well as for more seasoned researchers to successfully pursue future exploration of the Main Belt. We certainly have learned a lot thanks to Dawn, and yet we know that we have barely scratched the surface of what Main Belt asteroids can tell us about the dawn of our Solar System.