Asteroids

Relics of Ancient Time

The world was stunned when an undetected asteroid catastrophically exploded over the city of Chelyabinsk in February 2013, injuring over 1000 people. Luckily, such events are very rare. More commonly, asteroids skim the Earth without impact, as in March 2014, when three asteroids hurtled past our planet within a few days.

Where do asteroids come from and what are they made of? What clues do they hold about the evolution of the solar system? Asteroids are of great interest to planetary scientists because they are relics of shattered protoplanets – time capsules that tell us about the earliest days of the solar system. Scientists have cataloged hundreds of thousands of asteroids. Most of them are found in the asteroid belt between Mars and Jupiter, and many are thought to contain water and amino acids, the building blocks of life.

Michael Shepard tells the fascinating story of their discovery, and what they can tell us about the history of our own planet. He describes how we find and study asteroids, what they look like through the eyes of powerful telescopes and spacecraft, and plans for future sample return missions.

This timely book interweaves accessible scientific explanations with historical background and personal narrative, providing an engaging read for anyone curious about asteroids and what they may mean for our future – both as threats and opportunities.

MICHAEL K. SHEPARD is a Professor of Geosciences at Bloomsburg University in Pennsylvania, specializing in radar asteroid studies. Prior to this, he worked at the Smithsonian Air and Space Museum and the Jet Propulsion Laboratory in Pasadena, California. His latest research involves studying a specific group of asteroids, the M-class, which are thought to be metal cores of ancient protoplanets. He has discovered two asteroid moons, and has also been honored with an asteroid named 20392 Mikeshepard.

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MICHAEL K. SHEPARD
Bloomsburg University

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For Allison

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Preface

20392.

That was all that was written on the note in my university mailbox.

"Did you take this message?" I asked the department secretary.

"Yes. A gentleman on the phone told me to leave that note for you. He didn't leave a name, but said you'd know what it meant."

At first, I was baffled. A phone number? If so, five digits were missing. Area code 203 – I had to look it up – was southwestern Connecticut. I didn't think I knew anyone there.

It had already been a long day, and I was tired and didn't feel like a puzzle just then. But as I went back to my office, a thought struck me. I sat down and opened a web page to the Jet Propulsion Laboratory's Small-Body Database Browser. This is a database of all known asteroids, containing their number, name, and known physical properties. Because there are so many known asteroids, and some have names similar to or identical with other objects in the solar system, asteroids get both a number *and* a name. For example, Jupiter has a moon called Europa, but there is also an asteroid 52 Europa. Prometheus is a moon of Saturn, but 1809 Prometheus is an asteroid.

In the database I typed in 20392 and hit "Enter." It popped up immediately – 20392 Mikeshepard; an asteroid had been named for me. For planetary scientists, and especially for those who study asteroids, this is a common honor. But it's an honor nonetheless – a taste of immortality sanctioned by the International Astronomical Union, the governing body of professional astronomers everywhere with the responsibility, among other things, of assigning names to asteroids, comets, and geological features on the planets and their moons.

This was the culmination of years of work I had begun in 1999. In that year, I took a chance and completely changed my research focus from Mars and Venus to asteroids. The anonymous message was left by my mentor, Steve Ostro, a planetary astronomer at the Jet Propulsion Laboratory who almost single-handedly developed the field of asteroid radar studies. Unlike traditional telescopes, radar telescopes beam a pulse of microwave energy to asteroids and then record and measure their incredibly faint echo. This is an enormously powerful tool, but one of several that I have used in the past decade to study these fascinating objects. Steve died only a few months after that cryptic note, but I am forever grateful to him for his guidance and friendship.

. . .

For three years prior to beginning this project, I wrote a science column for a regional newspaper. People hunger for information about anything space related, and not just the facts and recent news items. They enjoy the stories, the history, and the ups-and-downs of science never fully told in textbooks. They appreciate the broad picture, but rarely have the time or desire to delve into the details. This book is my attempt to address some of that hunger. Unfortunately, space and time are limited – at least for me – so I have had to pick and choose what I consider the high points, and many interesting things were left out. But I have included a number of references at the end to help an interested reader pursue things farther.

For the aid of the reader, I have also included a brief list of general asteroid and meteorite terms, just prior to Chapter 1. A more detailed glossary is included at the end of the book for any word in bold.

Acknowledgements

In a November 2012 editorial in *Meteorite* magazine, Robert Beauford wrote, "science is a team sport." This book is proof of that. I owe a debt to many friends, colleagues, and new acquaintances. Those who helped directly in this project include Vishnu Reddy (PSI), Lance Benner (JPL), Amy Mainzer (JPL), Mike Nolan and Ellen Howell (NAIC/Arecibo), Peter Brown (University of Western Ontario), Alan Harris and Brian Warner (More Data!), Peter Jenniskens (SETI), Muawia Shaddad (University of Khartoum), Gary Fujihara (Big Kahuna Meteorites), Alan Tokunaga and Bobby Bus (IRTF), Ralph Harvey (ANSMET, Case Western), Ed Cloutis (University of Winnipeg), Steve Arnold (*Meteorite Men*), Randy Korotev (Washington University), Bill Hartmann (PSI), Gareth Williams (MPC), the entire NEO group at JPL but especially Jon Giorgini, Bill Bottke (SWRI), Bill Merline (SWRI), Mark Booth (Pontificia Universidad Catolica de Chile), Beth Clark (Ithaca College), Dan Scheeres (University of Colorado, Boulder), Bob Naeye (*Sky and Telescope*), Mini Wadhwa (Arizona State University), and Chris and Jen Whisner (Bloomsburg University). I am also grateful to the following for allowing me to use images throughout the book: Catalina Sky Survey, H. Edin, J. Kashuba, R. Kempton, P. Mann, University of Palermo, J. Utas, J. Van Gundy, and R. Ratkowski. I apologize to any I may have inadvertently left off this extensive list.

I am grateful to Bloomsburg University for providing an environment where this type of scholarship is encouraged, and to the editors and staff at Cambridge University Press for taking a chance on this book. Finally, none of this would have been possible without the support of my family and especially my wife.

Brief list of asteroid and meteorite terms

SPACECRAFT-VISITED ASTEROID CLASSES

C-class A class of asteroids characterized by low albedos (dark) and flat, featureless spectra. An example is 253 Mathilde.
E-class A class of asteroids characterized by very high albedos (bright) and red-sloping featureless spectra. An example is 2867 Steins.
M-class A class of asteroids characterized by moderate albedos and red-sloping featureless spectra. An example is 21 Lutetia.
S-class A class of asteroids characterized by moderate albedos and red-sloping spectra with modest absorption features. Examples include 433 Eros and 25143 Itokawa.
V-class A class of asteroids characterized by high albedos and spectra consistent with basalt lava compositions. An example is 4 Vesta.

BASIC METEORITE TERMS

Achondrites Meteorites that have undergone melting on their parent asteroid. They do not contain chondrules. Examples include **howardite–eucrite–diogenite** (**HED**), lunar, and Martian meteorites, among others. Most are stony meteorites, but achondrites include the stony-irons and irons in some classification schemes.
Chondrites The dominant type meteorite, so-called because they contain chondrules as a significant component of their composition. The three major types are **ordinary**, **carbonaceous**, and **enstatite** chondrites. They are all stony meteorites.
Iron A meteorite that is composed chiefly of iron–nickel.
Stony A meteorite composed chiefly of silicates, but may possess some metal, chiefly iron and nickel.
Stony-iron A meteorite that is roughly equal parts silicate and metal. A **pallasite** is one type.

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Frontmatter
More information

Fragment of asteroid 2008 TC_3, now known as the meteorite Almahata Sitta, found in the desert of Sudan, near Train Station Six.
Credit: Dr. P. Jenniskens.