Guidebook to the Geology of Barringer

Meteorite Crater, Arizona

(a.k.a. Meteor Crater)

Second Edition

Prepared by

David A. Kring

for the

80th Annual Meeting

of the

Meteoritical Society

July 2017

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Note about the Cover Art

The cover is designed to illuminate the world’s best preserved impact crater, our efforts to use this world-class geologic site for training and research programs, and data relevant to the analysis of the crater. The background image was taken by the author. The picture of students in the Field Training and Research Program at Meteor Crater was taken by teaching assistant Josh Garber. The series of images showing different perspectives of the crater are, from left to right,

LPI’s colorized version of Gene Shoemaker’s geologic map
(http://www.lpi.usra.edu/publications/books/barringer_crater_guidebook/craterMap/)

an image of the crater taken by astronauts on International Space Station Expedition 38 for a training exercise (http://www.lpi.usra.edu/exploration/training/resources/measuring_meteor_crater/),

the topography of the crater as seen on a USGS 7.5’ Meteor Crater Quadrangle,

an overlay of thermal imaging of the crater produced by Oleg Abramov,

a hillshade digital elevation map of the crater, and a slope map produced by Marisa Palucis from 25 cm resolution LiDAR data (http://www.lpi.usra.edu/publications/books/barringer_crater_guidebook/LiDAR/).

These and other Barringer Meteorite Crater resources are available at

http://www.lpi.usra.edu/publications/books/barringer_crater_guidebook/

Impact cratering resources for students and educators are available at

http://www.lpi.usra.edu/exploration/training/resources/

LPI Contribution Number 2040
Barringer Meteorite Crater (a.k.a. Meteor Crater) is located in the southwestern United States, North America; 35.026° N, 111.024° W.
# Table of Contents

Title Page           i
Frontispiece           iv
Table of Contents          v
Preface and Acknowledgments       vii

Chapter 1  Introduction                  1
Chapter 2  Target Stratigraphy           7
Chapter 3  Pre-impact Structure          27
Chapter 4  Barringer Meteorite Impact Crater  35
Chapter 5  Shock Metamorphism and Impact Melting  53
Chapter 6  Crater Rim Uplift and Crater Wall Collapse   69
Chapter 7  Overturned Rim Sequence       79
Chapter 8  Distribution of Ejecta        85
Chapter 9  Projectile                  103
Chapter 10  Trajectory                 115
Chapter 11  Energy of Impact            119
Chapter 12  Age of the Crater               121
Chapter 13  Environmental Effects of the Impact  125
Chapter 14  Post-Impact Lake and Volcanic Ash Deposits  131
Chapter 15  Post-Impact Erosion and Sedimentation   151
Chapter 16  Modern Atmospheric Conditions at the Crater  165

Trail Guides                          171
Chapter 17  Crater Rim East Trail Guide  175
Chapter 18  Crater Rim West Trail Guide  201
Chapter 19  Crater Floor Trail Guide     223

Bibliography                          251
Preface and Acknowledgments

The geological guidebook that follows has been prepared for the occasion of the 80th Annual Meeting of The Meteoritical Society in Santa Fe, New Mexico, and a Society field trip to the crater. The guidebook is an expanded version of the first edition, which was prepared for the 70th Annual Meeting of The Meteoritical Society in Tucson, Arizona. While both guidebooks provide a trail-oriented geological tour of the crater, they are also designed to introduce readers to the geological processes that shaped the crater.

The geological processes involved in the formation of the crater have been broken down into a series of discrete topics. The goal is to illustrate how our understanding of those topics has evolved over the past 100+ years of study at the crater and how observations at the crater have influenced them. While our understanding of the processes involved in the crater’s formation have grown, there are also a great number of topics that still need further research. In each section of the guidebook, I try to identify those unresolved issues with the hope that those comments will spawn new studies.

It is important to use this incredible impact crater to learn about the planet-shaping processes associated with asteroid and comet collisions. It is also important to use such a perfectly preserved site to train planetary scientists, many of whom are no longer emerging from the ranks of field-based geology programs and, thus, lack any other field experience. For that reason, we were very fortunate to receive funds from the NASA Lunar Science Institute and the NASA Solar System Exploration Research Virtual Institute for a Field Training and Research Program at Meteor Crater. We have, since the Society’s last field trip to the crater, trained ~70 graduate students at the crater through that program. Those young investigators and the institutions they represented are responsible for a tremendous amount of new research reported in this edition of the guidebook and I thank them: Corwin Atwood-Stone (University of Arizona), Jeffrey Balcerski (Case Western Reserve University), David Blair (Purdue University), Samuele Boschi (Lund University), Aaron Boyd (Arizona State University), Jessie Brown (University of New Brunswick), Christy Caudill (University of Western Ontario), Mitali Chandnani (University of Alaska Fairbanks), Matthew Chojnacki (University of Tennessee), Shoshanna Cole (Cornell University), Laura Corley (University of Hawaii at Manoa), Kathleen Craft (Virginia Tech University), Sarah Crites (University of Hawaii), Natalie Curran (University of Manchester), Connor Davis (Western University), Patrick Donohue (University of Notre Dame), Sarah Drummond (University of Tennessee-Knoxville), Nicholas DiFrancesco (Stony Brook University), Joshua Garber (University of California-Davis), Tienelle Gaither (Northern Arizona University), Shannon Hibbard (Temple University), Michelle Hopkins (University of Colorado-Boulder), Matthew Huber (University of Vienna), Kynan Hughson (University of California Los Angeles), Steven Jaret (Harvard University), Christine Jilly (University of Hawaii), Mallory Kincyzyk (North Carolina State University), Katrina Korman (Temple University), Myriam Lemelin (Université de Sherbrooke), Anna Losiak (University of Vienna), Analisa Maier (University of Colorado), Aviva Maine (Northern Arizona University), Audrey Martin (University of Tennessee), Ellinor Martin (Lund University), Mélissa Martinot (Vrije Universiteit Amsterdam), Cameron McCarty (University of Tennessee), Francesca McDonald (University of Manchester), Julie Mitchell (University of Houston-Clear Lake), Stephanie Montalvo Delgado (University of Puerto Rico at Mayaguez), Raquel Nuno (Arizona State University), Lissa Ong (University of Arizona), Lillian Ostrach (Arizona State University), Katie O’Sullivan (University of Notre Dame), Seda Oezdemir (University of Vienna), Ross Potter (Imperial College London), Kathryn Powell (Washington University), Kathryn Rathbun (University of Iowa), Nisa Rhodes (University of Texas at El Paso), Stuart Robbins (University of Colorado-Boulder), Margaret Rosenberg (California Institute of Technology), Adam Sarafian (Massachusetts Institute of Technology), Douglas Schaub (Stony Brook University), Laura Seward
We supplemented that formal program with additional training and/or research opportunities for nearly two dozen students and postdoctoral researchers at the crater: Oleg Abramov (LPI), Denise Anders (LPI), Katherine Bermingham (University of Maryland), Ana Cernok (LPI), Adeene Denton (LPI), Amy Fagan (LPI), Miriam Galenas (University of Maryland), Justine Grabiec (LPI), Connor Hilton (University of Maryland), Debra Hurwitz (LPI), Katherine Joy (LPI), Georgiana Kramer (LPI), Celestine Mercer (LPI), Amanda Nahm (LPI), Takafumi Niihara (LPI), Teemu Öhman (LPI), Jennifer Rapp (JSC), Martin Schmieder (LPI), Barry Shaulis (LPI), Samuel Simmons (University of Houston), Matt Weller (Rice University), Oliver White (LPI), and Emily Worsham (University of Maryland).

Finally, with additional support from the Barringer Family Fund for Meteorite Impact Research, students Marisa Palucis (University of California Berkeley) and Ankit Verma (Trinity College) have been able to conduct detailed research at the crater. Their efforts and the insights they are providing are gratefully acknowledged.

Because members of The Meteoritical Society formed the core of the principal investigators in the original Apollo sample program, the Society might also appreciate the important role geologic sites like Barringer Meteorite Crater can have in training astronauts who may, at some future point in time, be asked to collect samples from the Moon, an asteroid, or even Mars. Fortunately, since the Society last met at the crater, I have had an opportunity to use the wonderfully exposed geology at the crater to train three groups of NASA astronauts, along with astronauts from the Canadian Space Agency (CSA) and Japan Aerospace Exploration Agency (JAXA). It has been a thoroughly rewarding experience to work with such gifted people who absorb the lessons to be learned at the crater with considerable zeal.

In parallel with those training and research programs, several independent research projects were initiated to study structural elements of the crater, the distribution of ejecta both on the surface and in the subsurface, gully formation in the crater walls, the general breakdown of rock exposed by the impact, and modern meteorological attributes. That work produced several new insights about the crater that will be described in the chapters that follow. I thank each of those teams for their research and am happy to report that several additional projects are in development, so credible research at the crater will continue.

The goal of those activities is to bring the crater and the processes that shaped it alive for our community, affiliated scientific disciplines, and the general public. That endeavor is only possible because of the tremendous support of Drew Barringer, President of the Barringer Crater Company, and Brad Andes, President of Meteor Crater Enterprises. I thank the entire Barringer family for its stewardship of the crater and its interest in preserving the site for education and scientific research. The field training and research activities at the crater have also been facilitated by Lanah Butterfield, Vice President of Meteor Crater Enterprises, and the incredibly helpful MCE staff. Some of our recent research was conducted on the surrounding Bar T Bar Ranch, which was made possible with the gracious
support of Judy Chilson Prosser, an owner and operator of the ranch. I thank Carleton Moore for his insights about the crater and Canyon Diablo meteorites. I might add that he repeatedly provided presentations about Canyon Diablo meteorites to students in our Field Training and Research Program at Meteor Crater, which greatly enriched the students’ experiences. I also thank Martin Schmieder for kindly assisting this field trip by providing a tour of the crater rim while I lead a tour of the crater walls and crater floor.

For the production of this guidebook, I thank Linda Chappell, Sandra Cherry, and David Bigwood at the Lunar and Planetary Institute (LPI) for helping me obtain copies of some of the older publications about the crater; Jennifer Steil for converting first edition files into a more modern format; John Blackwell and Ronna Hurd for their assistance with some of the illustrations in the guidebook; and Delia Enriquez for printing and binding the document you now hold in your hands. I thank Linda Garcia in the LPI Meeting Planning Services department and Beth Ha and Shannon Clark at the University of New Mexico for their help organizing the field trip. Likewise, I thank Karen Ziegler and the organizing committee of the 80th Annual Meeting of The Meteoritical Society for promoting the field trip.

To all who participate in the field trip, I thank you for your interest.

David A. Kring
Houston
...the consequences of an asteroid impact.