Meteorites, Ice, and Antarctica

Bill Cassidy led meteorite recovery expeditions in the Antarctic for 15 years. His searches resulted in the collection of thousands of meteorite specimens from the ice. This fascinating story is a first hand account of his field experiences on the US Antarctic Search for Meteorites Project, which he carried out as part of an international team of scientists. Cassidy describes this hugely successful field program in Antarctica and its influence on our understanding of the moon, Mars and the asteroid belt. He describes the hardships and dangers of fieldwork in a hostile environment, as well as the appreciation he developed for the beauty of the place. In the final chapters he speculates on the results of the trips and the future research to which they might lead.

BILL CASSIDY was the founder of the US Antarctic Search for Meteorites project (ANSMET). He received the Antarctic Service Medal of the United States in 1979, in recognition of his successful field work on the continent. His name is found attached to a mineral (cassidyite), on the map of Antarctica (Cassidy Glacier) and in the Catalogue of Asteroids (3382 Cassidy). He is currently Emeritus Professor of Geology and Planetary Science at the University of Pittsburgh.

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William A. Cassidy
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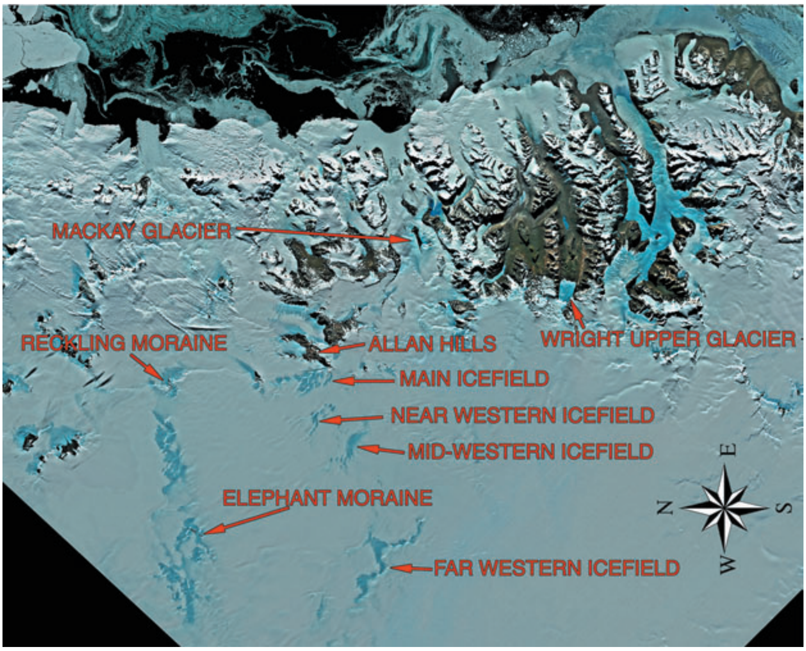

Frontispiece: The illustration shows a digitally enhanced, false-color mosaic of satellite photos of the Allan Hills – Elephant Moraine area. Blue areas are patches of exposed ice. Notice that the Allan Hills Main Icefield stands away from the roughly Y-shaped Allan Hills exposure, due to the presence of a low-lying structural barrier (a subice ridge). Ice flows over this barrier toward Allan Hills. Elephant Moraine is also indicated. The regional linear patches of blue ice, in one of which are found Elephant Moraine and Reckling Moraine, mark the presence of a subice ridge. Ice is spilling over this ridge on its journey northward. The irregular dark area at the top of the photo is open water of the Ross Sea, which is completely frozen during most of the year. Contorted patterns in the water are aggregates of floating ice chunks whose trends reflect eddy currents. Brownish patches in the upper right quadrant are Dry Valleys. (Courtesy of Baerbel Luchitta, USGS Image Processing Facility, Flagstaff, Arizona, USA)

This image can be downloaded in colour from www.cambridge.org/ 9781107403918

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I dedicate this book to my wife, Bev, who ran our home, and our family, for fifteen field seasons while I was in Antarctica, and never once complained.

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Foreword

This wonderful tale of physical and intellectual adventure details the development of the ANSMET (Antarctic Search for Meteorites) program of meteorite collection in Antarctica and its importance for planetary science. Starting from the chance discovery by Japanese glaciologists of several different *types* of meteorites in a limited field area of Antarctica, Cassidy describes the flash of insight that led to his conviction that Antarctica must be a place where many meteorites could be found. His basic idea was that it was wildly improbable to find different meteorites in a limited area *unless there was a concentration mechanism at work*. The subsequent discovery of several hundred meteorite samples by another Japanese team proved the point.

Alas, insights are not always easily shared. The initial rejection of his proposal to test his idea serves as a most useful lesson to young scientists everywhere – don't be discouraged by initial rejection of your new ideas, persist!

Initially undertaken as a joint Japanese–American effort, the national programs eventually diverged. The work directed by Cassidy matured into the highly successful ANSMET program that has become an integral part of the NSF's (National Science Foundation) polar research program.

I had the good fortune to participate in two ANSMET field seasons and believe that ANSMET is organized in just the right way. It need not have been thus. I suspect that most of us faced with the problem of collecting meteorites in the hostile Antarctic environment would have opted to send in teams of vigorous young male adventurers. And one would have been tempted to use the specimens so collected for one's personal research. But Cassidy had the wisdom to do things differently. The ANSMET field teams consist of a mixture of young and old, professors and students, male and female, Americans and citizens of other countries, with a sprinkling (mostly John Schutt) of experienced field people termed "crevasse experts". They share a common love for, and knowledge of, the scientific study of meteorites. The inclusion of lab scientists in the field teams has led to a much better understanding of the nature of the samples – it is impossible to speak of "pristine" samples when one has seen a black meteorite sitting in a puddle of melt water!

The meteorites are initially handled at NASA's Johnson Spacecraft Center in Houston, and scientists from all countries are invited to request samples. As with the lunar samples before them, the meteorites are considered as the heritage of the human race as a whole. This is as it should be.

The book shows why meteorites are scientifically interesting and the "intellectually curious general reader" addressed by Cassidy will learn much. A foreword is no place to delve into scientific particulars. Suffice to say that almost everything we *know* (as opposed to hypothesize) about the formation and early history of the Solar System is derived from studies of meteorites.

Most, but not all, meteorites are fragments of asteroids. Two important exceptions are those (rare) meteorites that come from the Moon and from the planet Mars. A major part of the NASA Planetary Science program is the continued exploration of Mars with the goal of one day returning samples of the planet to earth. The total cost will run into many billions of dollars. The continued collection of Martian meteorites from Antarctica, at a tiny fraction of the cost of a sample return mission, is clearly warranted. Cassidy also makes a convincing case of continuing the search for new lunar meteorites.

Museum collections have now been greatly surpassed by the thousands of Antarctic finds. A natural question is whether we really need more meteorites. Cassidy shows why the answer is a resounding yes! As luck would have it, the rate of return of interesting specimens just about matches the rate at which they can be properly studied.

There is thus every reason to continue the existing collection effort at about the same level.

Like most meteoriticists, Cassidy emphasizes the planetary insights gleaned from meteorites. He shows explicitly how the sampling of asteroidal fragments permits the study of the melting and differentiation of small planets leading to a better understanding of the processes that operated on the early earth.

Although not discussed by Cassidy, the reader might be interested to learn that meteorites also provide unique information about the larger universe beyond the planets. Relatively recently, researchers have shown that meteorites contain small grains of interstellar dust that formed around different stars at different times prior to the formation of our sun. The detailed study of these grains, some of which formed in the atmospheres of dying stars similar to our own, and others in supernova explosions, provide new insights into stellar evolution and the processes of element formation. Meteorites also provide unique information about the nature and history of galactic cosmic rays.

Cassidy's discussion of the meteorite concentration mechanism and its possible implications for future studies of past and present Antarctic ice movements is both original and important. In collaboration with the late glaciologist, Ian Whillans, he developed a basic model for "meteorite stranding surfaces." These are envisioned as backwaters of ice flows around natural barriers where wind ablation (wind is a near constant presence in Antarctica) serves to build up the surface concentration of meteorites originally trapped in the volume of the incoming ice. He surmises that measurements of the distribution of terrestrial ages of meteorites on different stranding surfaces, coupled with careful glaciological measurements of current ice flow patterns and sub-surface topography, could give new information on the history of the ice flows. He also signals the potential importance of dust bands in the ice for providing "horizontal ice cores" which, if they could be properly dated, would add to our overall understanding. His ideas deserve to be further exploited.

The book treats grandiose phenomena such as the nature of the Antarctic ice sheet and the march of the ice from the polar plateau to the sea. But it is also a highly personal and intimate account. The reader will see clearly the thought patterns and passions that characterize the natural scientist.

I also trust that the reader will understand why other ANSMET veterans and I find Cassidy to be such a splendid expedition companion. His wonderful sense of humor breaks out repeatedly (and mostly unexpectedly) throughout the narrative. I cite just one example. In trying to understand why the meteorite concentrations were not discovered earlier he realizes the dog teams do very poorly on ice fields and such places were thus avoided. This leads him to speculate on equipping dogs with crampons – a thought quickly dismissed as he imagines the consequences of a crampon-equipped dog scratching its ear! I invite the reader to find and enjoy the many other examples sprinkled throughout the text.

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January 2003

Acknowledgments

I hope, and intend, that this book will appeal to the intellectually curious general reader, as well as those who do research on meteorites and field work in Antarctica. In seeking to write such a book, I have prevailed upon the good natures of a number of friends and colleagues to read early drafts, criticize, and suggest. The following persons have done much to influence the final form of the book. I thank them all, very sincerely.

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Parts I and II of this book were reviewed by Roger Hewins and Part III was reviewed by Phil Bland. These were very constructive reviews, containing excellent suggestions. I followed many suggestions but declined others, for one reason or another. If the book is less than it could be because I have not accepted all these suggestions I accept full responsibility.