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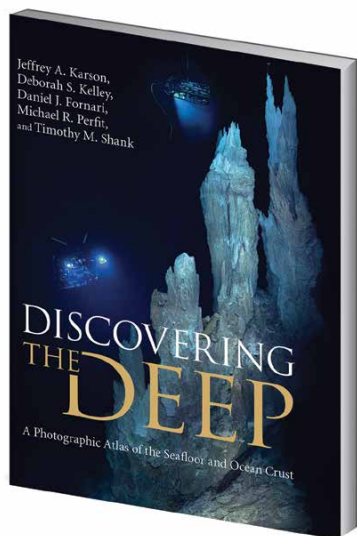
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DISCOVERING THE DEEP: A PHOTOGRAPHIC ATLAS OF THE SEAFLOOR AND THE OCEAN CRUST

By Jeffrey A. Karson, Deborah S. Kelly, Daniel J. Fornari, Michael R. Perfit, and Timothy M. Shank, 2015, Cambridge University Press, 430 pages, ISBN 978-0-521-85718-5, Hardcover: \$99.99 US

Reviewed by William E. Seyfried Jr.

Look no further than the imagery on the dust jacket of *Discovering the Deep: A Photographic Atlas of the Seafloor and the Ocean Crust* to know that something very special lies within. The image of remotely operated vehicle (ROV) *Hercules* and its support vehicle *Argus* approaching the spectacular carbonate edifices of the Lost City Hydrothermal Field (30°N, Mid-Atlantic Ridge) is mesmerizing. At the same time, the image provides clear evidence of technological advances in deep-sea photography made in recent years, especially when high-resolution camera systems are combined with powerful lighting and highly maneuverable deep submergence vehicles. Thus, large features rising from the seafloor (as shown here) can be viewed in totality, while the activities of the very smallest creatures in the ocean realm can be captured and recorded as well. Photography by means of a submerged camera was first attempted by Louis Boutan at the French seaside laboratory of Roscoff in 1893, and one can only imagine his reaction to the spell-binding images in this book. Frankly, this reviewer, who has had the opportunity to view up close many of the deep-sea features shown in the book from the viewpoint of the submersible DSRV *Alvin*, had a reaction probably not too dissimilar to that we can envisage from Boutan! It is, in fact, thrilling to read and/or page through

this impressive book by five of the world's experts in marine science. Indeed, authors Karson, Kelley, Fornari, Perfit, and Shank combine their vast collective knowledge of the processes that are responsible for the origin and evolution of the ocean floor and crust to produce a book that this reviewer believes sets a new standard of excellence in both content and clarity in unraveling the mysteries of the mid-ocean ridge—the largest and most prominent geological feature on Earth.

The first three chapters provide an unusually well illustrated and clear discussion of the history of the tools invented and used in oceanography to study the ocean floor and decipher the meaning and implications of its surface morphology and subsurface configuration. As the authors describe, the deep ocean is unquestionably one of the most extreme environments on Earth, perpetually dark, with pressure imposed by the overlying ocean that can exceed 4,000 pounds per square inch, even along the relatively elevated mid-ocean ridge. The typically cold temperatures of the deep ocean change the physical properties of electrical and mechanical cables, creating unusually challenging conditions that must be overcome to provide images of the deep sea and ocean floor in all their forms. As described in the book's early chapters, the innovative ways early marine scientists overcame these challenges bordered on heroic as they paved the way for more modern approaches that are now routinely used to probe the depths of the ocean floor, image subsurface geological structures, and constrain

the chemical and physical properties of the ocean crust. These chapters brilliantly provide information for the scientist and non-specialist alike on the forces and processes that contribute to the diversity of mid-ocean ridges, the rates of seafloor spreading, the components of spreading systems, and the internal structure of the ocean crust and upper mantle.

A fundamental contribution of this book involves the clarity in the way the authors establish linkages between seafloor volcanism, largely at mid-ocean ridges, and underlying hydrothermal systems. Heat and mass transfer between subsurface magmatic bodies and seawater produce hydrothermal fluids with temperatures in excess of 400°C. The authors clearly and effectively describe this process, not just from a geological or geochemical perspective, but also from a biological one, because the chemical transformation of seawater to “black smoker” vent fluid includes the addition of chemical components that fuel microbial metabolism through chemosynthesis. The recognition of chemosynthesis at seafloor vents represents one of the great scientific discoveries of the twentieth century. As emphasized by the authors of this book, chemosynthetic ecosystems at deep-sea vents provide the closest analogs to life on the early Earth and offer insight into conditions permissible for life as we know it elsewhere in the solar system.

Chapter 4 provides the clearest, most comprehensive, and best illustrated discussion of marine hydrothermal systems that exists anywhere. The authors take the reader on a written and pictorial tour

of some of the most important marine hydrothermal systems on planet Earth, carefully pointing out the different process-controlling variables active at each and then placing each in a three-dimensional context within the ocean crust. Although many of these systems are associated with clearly recognizable linkages between hydrothermal activity and volcanic/magmatic processes, this is not always the case. For example, the now famous Lost City Hydrothermal Field, where co-authors Kelley and Karson, in particular, played key roles in both discovery and interpretation, provides one such example. Here, tectonic forces expose ultramafic rocks on the seafloor that were once beneath the Mid-Atlantic Ridge. Serpentinization of the ultramafic lithologies by seawater-derived fluids results in a very different type of hydrothermal activity that contrasts sharply with the more magmatically robust black smoker systems. Lost City hydrothermal fluids are characterized by high pH, highly reducing conditions, and an abundance of abiotically derived organic molecules. Geological and geochemical data reviewed in the book make clear that this system is perhaps the longest-lived venting system currently known in the global ocean, with continuous activity for at least 150,000 years.

Subsequent chapters in the book take the reader from the seafloor at deep-sea vents into the underlying ocean crust, offering enlightening discussion of submarine volcanism and volcanic processes that fuel seafloor eruptions and also providing clues to the physical and chemical conditions responsible for generating mid-ocean ridge basalt magma. Moving still further and deeper into the ocean crust, there are cogent discussions of intrusive rocks, dike complexes, gabbro, and peridotite based on the experiences of authors who have contributed so much over many years to leading-edge, fundamental research on these and related topics. As with earlier chapters, important research papers delineating key concepts

are cited throughout, facilitating location of original work for readers who may seek further documentation. This referencing is often lacking in similar books, and the effort of the authors in this regard should be acknowledged. As with all the chapters in this book, powerful images and supporting schematic illustrations are incredibly useful as a means of clarifying key concepts.

Discovering the Deep: A Photographic Atlas of the Seafloor and Ocean Crust is a game changer in the way complex processes that contribute to the formation and evolution of ocean floor and crust are described. Documentation of these systems along with inclusion of amazingly clear illustrations goes well beyond simply explaining cause and effect. Indeed, the power of the images encourages the reader to want to learn more about a subject that until now has not taken full advantage of the transformational advances in ocean science technology that have occurred in recent years. The authors use this approach throughout, but end their “story” with a very hopeful message of continuing exploration and discovery in the ocean sciences, driven not only by curiosity but also by the availability of ever more sophisticated new tools linked through cabled networks that can provide information on changes in the deep ocean realm in real time and over great spatial scales.

I strongly recommend this book to researchers, students, and teachers in the marine sciences, either as a primary or a supporting text for upper division undergraduate and graduate courses in marine geology. A suite of online resources, PowerPoint files, and videos accompanying the book provide a novel and unusually effective learning experience that will definitely enhance understanding of the spectacular inner workings of planet Earth. 📷

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**American Meteorological Society
96th Annual Meeting**
January 10–14, 2016, New Orleans, LA, USA
<http://annual.ametsoc.org/2016>

2016 Ocean Sciences Meeting
February 21–26, 2016, New Orleans, LA, USA
<http://meetings.agu.org/meetings/os16>

Ocean Optics XXIII
October 23–28, 2016, Victoria, BC, Canada
<http://www.oceanopticsconference.org>