



*Michael Carroll
Rosaly Lopes Editors*

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Oceans in Space

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ISBN 978-1-4614-7472-2 ISBN 978-1-4614-7473-9 (eBook)
DOI 10.1007/978-1-4614-7473-9
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2013939590

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Printed on acid-free paper

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*This book is dedicated to our fathers, Patrick Colin Carroll
and Walmir Croce Lopes, who still inspire us to reach for the stars.*

Foreword

As I stared out the nine-inch-thick viewport at the unnaturally flat and unblemished plain, I was struck by the sheer remoteness of this place. It was as far from the human world of air and sunlight as one could get, without leaving our planet completely. I had left the warm surface waters of the Pacific, south west of Guam, and journeyed almost 7 miles straight down, into the depths of the Challenger Deep, the deepest place in our world's oceans. After free falling through blackness for two and a half hours, I arrived at this austere, lunar plain—the flat “ponded sediments” at the center of the trench's floor. My vehicle, the Deepsea Challenger, landed in a cloud of silt blown up by its thrusters like a spacecraft settling on the surface of an alien world. And indeed it was an inner-space ship, designed to explore the deepest and remote places in the Earth's oceans. It was functioning well as I took my first sediment sample and began to explore horizontally in a transect to the north, across the seafloor.

But something was bothering me. I had come all this way, not just the vertical 7 miles, but the years of design and construction of the sub, and the months at sea diving deeper and deeper as we refined our hardware and honed our skills prior to this ultimate dive. And now that I was here, I was viewing the world just outside my tiny steel sphere through the eyes of multiple HD cameras. But not with my own eyes. So I unshipped the 5K camera mounted in the viewport, and laboriously moved all the gear, the joysticks, and scrubber canisters and bags of warm clothing that were packed in around me. I moved forward, ducking under the HD monitors and bending painfully so that I could look out the viewport with my own eyes—to bear witness to this landscape that had never known the eyes or lights of Man. Ah, I thought, I'm really here. My breath caught in my throat at the realization of where I was, of how many tens of thousands of feet of water lay above my head, separating me from my wife, my children, the world I knew. I felt a sudden sense of loneliness, of disconnection from my kind and the world I knew. And with that followed the thrill that comes with being in a new and strange place, and knowing that no one else, of the seven billion on our world, had been here before. This is what some future astronaut will feel, looking out across the plains of Mars, the ice of Europa, or the hydrocarbon seas of Titan, having journeyed far to be the witnessing eyes for humanity.

As I stared at that stygian plain, I felt a sense of the vastness of time and space. There was a strong feeling of Deep Time here, of slow tectonic processes grinding relentlessly on through the eons, unwitnessed. It was a place seemingly hostile to life, as there was not a single animal large enough to see, nor even the tracks of creatures who might have wandered blindly across the sediment in decades or centuries past. I had never seen this, despite having dived over 80 times to abyssal depths. There were always at least tracks, if not animals themselves, plying their humble trade on the seafloor ooze. But here—nothing.

I knew intellectually that many species of pressure-adapted bacteria lived in the sediment, hopefully some new to science that would be revealed by the core sample I had just taken. But the impression of being *beyond life* was profound. I felt I was in an extreme place, a place I didn't belong. On prior expeditions, I had seen the seemingly infinite adaptability of life. I'd seen millions of blind albino shrimp swimming inches from geysers of water hot enough to melt lead, swarming happily through clouds of deadly hydrogen sulfide, and in fact living off of those toxic chemicals. I'd seen the scarlet fronds of tube worms six-feet long, swaying in the hot boil from hydrothermal vents while, inside them, long sacks of bacteria made their food for

them. I'd seen giant mushroom caps 7 m across formed by the interaction of minerals and bacteria, with upside-down lakes of hot water on their undersides, the terraced pools shimmering like mercury. Nature's imagination is so much richer than our own, and life's ability to adapt is seemingly boundless. But here, on this darkling plain, I felt that life had found a limit. And maybe that's what I was there to witness.

I was struck by the enormity of what we don't know. How limited the headlights of our inquiry are, and how vast the darkness beyond the edge of those lights. Even in this "post-exploration age" on planet Earth, a time when Google Maps allows one to access satellite images of any place on the land surface of our world, there are still so many unseen places, in the depths of the hadal trenches, that all combined they would equal the area of Australia. An unexplored continent waiting down there.

And that is just in the oceans of our own world. What about the oceans of other worlds? Our robotic emissaries have brought us just enough tantalizing information to scientifically imagine those alien seas. And so our minds can voyage there now, but it will be many years before humans can physically venture to those remote shores and bear witness, bringing back the tale of their experience for the rest of us. In the intervening decades, our robotic avatars will send us more pictures and data, perhaps even bring back samples, and that will have to satisfy our relentless monkey curiosity. But eventually, we will have to set foot on those worlds ourselves. Men and women, their breath catching in their throats at the enormity of where they are standing and what they are seeing, must go to those alien shores and push back the boundaries of the unknown.

Imagine standing on the shore of a cryogenic ocean of methane under the dusky orange sky of Titan. Perhaps a hint of the parent planet Saturn, with its ring system blazing diamond-bright in the sunlight, will be visible through a gap in the clouds. A more beautiful, serene, and utterly alien place is hard to conceive.

Imagine standing on the ice of Europa (in your massive radiation-proof hard-suit) as Jupiter's baleful countenance glowers down from above. Water boils up through fissures in the ice nearby, water that might contain life energized by chemosynthesis in the ocean far below.

Imagine standing next to a cryo-volcano on Enceladus, as the ethereal plume of ice crystals towers above you 200 km into the black sky, drifting across the untwinkling stars like ectoplasm. A fairy dust of snow falls around you, sparkling on a plain of ice so cold it's harder than steel. Like an ant next to Old Faithful, you are dwarfed by a manifestation of power and beauty that has gone unwitnessed until your arrival. Now you will bring the images back, halfway across the solar system, for the rest of us.

Imagine standing on the ancient shoreline of the boreal ocean of Mars, leaving bootprints in the dust where the long-vanished surface water once lapped a rocky beach. Was there life in this ocean as well, adapted to the dense brine? Did some creature leave its tracks on this wet sand as it ventured out, bravely, onto that doomed land? Or were those ancient shores trackless and sterile? Is Earth, alone, the only living world? Is there a limit to life? The only way to know is to go.

This book will take you, with words and stunning images, on a voyage of the mind. You will journey far from our blue planet, to the alien seas we now know exist, or once existed, out there on the planets and moons of the solar system. Just as the ocean of our own world mesmerizes us, drawing us to its shores, or to venture forth upon its treacherously fickle surface, and even far beneath it, these alien oceans will compel us to explore and understand them. Their beauty beckons and their danger challenges us. Voyage now, in the pages of this book, just as we will voyage later, with our machine eyes and, someday, our own.

James Cameron

Acknowledgments

Our thanks to Springer editor Maury Solomon, who first saw the potential for this subject and then patiently helped us navigate it to safe harbor. Thanks to Alan Gould for Kepler data and concepts. Our appreciation to NSF, the Mount Erebus Volcano Observatory, and Jeffrey Johnson for the spectacular shots of extremophile-infested ice towers. Dale Andersen of the Carl Sagan Center for the Study of Life in the Universe (SETI Institute) supplied us with some very gooey algal mats. Thanks, too, to all the wonderful artists who shared their visions of cosmic seas in our gallery at the back of the book.

