The Transantarctic Mountains

View north over Hut Point Peninsula to Mount Erebus

Scott's *Discovery* and hut at Winter Quarters Bay

Future site of McMurdo Station is above opposite shore, Crater Hill on left, The Gap, and Observation Hill on right.

Emperor penguins and rookery at Cape Crozier

Beyond is the margin of frozen Ross Sea and "The Barrier", the ice-cliff terminus of the Ross Ice Shelf.

These watercolor paintings by Dee Molenaar were originally published in 1985 with his map of the McMurdo Sound area of Antarctica. We are pleased to republish these paintings with the permission of the artist who owns the copyright.

Gunter Faure · Teresa M. Mensing

The Transantarctic Mountains

Rocks, Ice, Meteorites and Water

Springer

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Cover illustration: A tent camp in the Mesa Range of northern Victoria Land at the foot of Mt. Masley.

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We dedicate this book to Lois M. Jones, Eileen McSaveny, Terry Tickhill, and Kay Lindsay who were the first team of women to conduct fieldwork in the Transantarctic Mountains during the 1969/1970 field season.

Prolog

Antarctica! The very word brings to mind images of fierce winds, bone-chilling cold, and utter desolation. Antarctica has the reputation of being a hostile place unfit for human habitation where only foolhardy explorers go to satisfy their craving for adventure. Those of us who have worked there have a very different impression of Antarctica. To us it is a place of unsurpassed beauty where the isolation from the "world" permits time for contemplation and creative thought, where loneliness is transformed into solitude, and where life depends on respectful submission to the weather. Antarctic field-geologists learn to live in harmony with the land because they have come not to test their survival skills, but to discover the geologic history of this place and to learn how geological and biological processes work in this unique environment.

Antarctica is also a continent without borders where scientists from many nations come to work in peace, constrained only by the terms of the Antarctic Treaty. In Antarctica, people of different nationalities and cultures support each other in times of need and enjoy each other's fellowship when they meet on the trail. The spirit of Antarctica has evolved because of the absence of economic competition which has been deliberately excluded by the Treaty. A similar spirit of cooperation is now manifesting itself in the exploration of the solar system because the harsh environment of space and the great effort that is required to survive there demand it. Success in the scientific exploration of Antarctica and of the solar system depends both on international cooperation and on our willingness to respect the natural environmental conditions that exist in these places.

Preface

This book presents an integrated overview of all aspects of the geology of the Transantarctic Mountains in easily readable form. The book can also be used to look up specific information about the geology of this mountain range and it records the names of many of the Earth Scientists who have contributed to the understanding we now have of the origin of the Transantarctic Mountains. In spite of the remote location of Antarctica, tens of thousands of men and women have already been there and many more will visit the continent in the future in order to participate in scientific research or to support the research programs that are undertaken by the nations that have joined the Antarctic Treaty. In addition, hundreds of tourists visit Antarctica annually in order to enjoy its natural beauty and to gain an appreciation of their own good fortune for living in the more hospitable regions of the Earth. Antarctica can teach all of us to respect the natural environment that sustains us on the Earth. This book is therefore intended for the men and women who have already visited Antarctica and for those who may visit this continent in the future in order to work there or to be inspired by its natural beauty.

We confine our attention in this book to the Transantarctic Mountains where geologists of many nations have been working since the International Geophysical Year (1957–1958) and where we have also conducted fieldwork between 1964 and 1995. The Transantarctic Mountains are unusual because, for most of their length, they consist of an uplifted and deeply dissected plateau of flat-lying sedimentary and volcanic rocks that were deposited in Phanerozoic time. These rocks are underlain by a basement consisting of a folded and variably metamorphosed volcano-sedimentary complex that was intruded by granitic rocks in the course of the Ross Orogeny during the early Paleozoic Era. Our objectives in writing this book are to summarize the relevant facts about each of the major rock units in the Transantarctic Mountains, to present the hypotheses that have been proposed to explain their origin, and to make our readers aware of issues that are still unsettled. In this way, we hope to encourage further work on geological problems and to identify areas in the Transantarctic Mountains where additional research may be needed. The information we present is derived primarily from the relevant literature supported, when appropriate, by the results of our own work and that of our students. We assume that our readers have a working knowledge of the technical aspects of Earth science and we encourage them to make up their own minds concerning the hypotheses we present.

Antarctica is important not only because of the rocks that form its crust, but also because of the large ice sheet that covers most of the continent. The glaciation of East Antarctica started during the Neogene and has formed an ice sheet that is more than

3 km thick and contains most of the world's fresh water. The stratigraphy of the ice and its isotopic composition of oxygen and hydrogen record variations of the climate extending upto 800,000 years into the past. The history of the East Antarctic ice sheet is also recorded by the geomorphology of the Transantarctic Mountains and by the deposits of till, gravel, and sand the ice sheet has left behind. The ice of the East Antarctic ice sheet adjacent to the Transantarctic Mountains does not melt, except locally on rare occasions. Instead, it ablates directly into the air. Consequently, terrestrial rock debris and extraterrestrial meteorite fragments that are transported by the ice sheet accumulate on the blue-ice surfaces of its ablation zones. Outlet glaciers, that flow from the polar plateau through valleys in the Transantarctic Mountains to the coast of Victoria Land and into the Ross Ice Shelf, descend to the low elevations of the coast where the ice does melt during the austral summer. In the dry (or ice-free) valleys of southern Victoria Land the resulting meltwater collects in lakes and ponds on the valley floors.

In spite of the harsh climate that characterizes the Transantarctic Mountains, bacteria, algae, lichens, and moss grow in sheltered places in the soil and some plants have adapted by becoming endolithic. Even mites and nematodes have been discovered in the ice-free valleys and algal mats thrive in the warm brines that occur at the bottom of the largest and deepest lakes.

These attributes of the Transantarctic Mountains are reflected by the title of this book because a complete description of this mountain range must address not only the rocks, but must also include the ice, the meteorites, and the water. The study of the Transantarctic Mountains is a multi-disciplinary enterprise including aspects of geology, glaciology, meteoritics, aqueous geochemistry, botany, and zoology.

The relevance of Antarctica to the populated areas of the Earth may become more apparent in case global warming causes the Antarctic ice sheet to start melting, thereby raising sea level and flooding coastal areas worldwide. The resulting loss of living space will require the human population to adjust on an unprecedented scale exceeding the increase of sealevel at the end of the Pleistocene Epoch when the population of the Earth was much smaller than it is today.

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Last but not least, we freely admit that all errors of omission and commission in this book are entirely our responsibility and do not reflect on the Office of Polar Programs of the National Science Foundation or on The Ohio State University.

Gunter Faure and Teresa M. Mensing

Contents

Part IV Fire and Ice

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