The Transantarctic Mountains
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.
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.
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 up to 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.
We are pleased to acknowledge our colleagues, former students, and friends who
 gave us reprints of their papers, permitted us to use their diagrams and photographs,
 or otherwise assisted us in the preparation of this book. Their names are recorded
 here in alphabetical order with our sincere thanks:

  Chris Adams, Richard Alley, Ernie Angino, Rose Askin, Loren Babcock, Enriqueta
  Barrera, Peter Barrett, Charles Bentley, John Behrendt, Paul Berkman, Jane and Phil
  Boger, Scott Borg, Hal Borns, Terry Boroughs, George Botoman, Margaret Bradshaw,
  Henry Brecher, David Bromwich, Colin Bull, Richard Cameron, Bill Cassidy, Eric
  Cherry, Norbert Clauer, Jim Collinson, Charles Corbató, Gary Cotton, Cam Craddock,
  Bert Crarey, Ghizlaine Crozaz, Ian Dalziel, Mary Davis, Georg Delisle, George
  Denton, Don DePaolo, Amy Deventer, Marcia Dixon, George Doumani, Gisela
  Dreschhoff, Rene Eastin, David Elliot, James Elliot, Frank and Carol Faure, Bob
  Felder, Robert Fleck, Ken Foland, Art Ford, Trey and Sarah Fortner, N.H. Fourcade,
  Larry Frakes, Ralph von Frese, Harald Furnes, Harry Gair, Bill Gealey, Chris Gero,
  Dick Goldthwait, John Goodge, Bill Green, Ed Grewe, Pieter Grootes, Anne Grunow,
  Bernie Gunn, John Gunner, Marta Haban, Erik Hagen, Martin Halpern, Warren
  Hamilton, Bill Hammer, Ralph Harvey, David Harwood, Ann Hawthorne, Knut
  Heier, Tim Horner, Terry Hughes, John Isbell, Ken Johnson, Ken Jezek, Lois Jones,
  Barbara Kaelber, Elizabeth Kibler, George Kleinschmidt, Karen Klusmeyer, Chris
  Koeberl, Jack Kovach, Larry Krissek, Phil Kyle, Leo Laporte and the TwiT Army,
  Dan Larsen, Brenda and David Lasorsa, Wesley LeMasurier, John Lindsay, Bill
  Long, Barry Lyons, Ursula Marvin, Paul Mayewski, M.K. McClintock, Bill McIntosh,
  Barry McKelvey, Garry and Dianne McKenzie, Beverly McMahon, Eileen and Maury
  McSaveney, John Mercer, Velon (Tex) Minshew, Art Mirsky, Michael Mohlzaun,
  Dee Molenaar, Joe Montello, Raymond Montigny, Ellen Mosley-Thompson, Sam
  Mukasa, LeeAnn Munk, John Murtaugh, Dirk Neethling, Kuni Nishizumi, Robin
  Oliver, Olav Orheim, Larry Owen, Julie Palais, Robert Pankhurst, Matt Place, Mike
  Prentice, Doug Pride, Phil Ray, Peggy Rees, Bert Rowell, Peter Rowley, Bob Rutford,
  Dwight Schmidt, Jim Schopf, Emil Schulthess, Chuck Schultz, Roberta Score, Mary
  Siders, Andy Sipp, John Spletstoesser, John Sutter, Bernard Stonehouse, Mike
  Strobel, Ed Stump, Chuck Summerson, Paul Tasch, Karen Taylor, Tom and Edie
  Taylor, Jim Teller, Franz Tessensohn, Lonnie Thompson, Sam Treves, Fiorenzo
  Ugolini, Chuck Vavra, Bob Walker, Peter Wäslewska, Gerald Webers, Peter Webb,
  Ian Whillans, J.D.L. White, Shawn Wight, Bob Wilkinson, Terry Wilson, Rebecca
Most of all we thank our mountaineering friends who guided us in the field and helped us to work safely in the Transantarctic Mountains and on the polar plateau: David Buchanan, David Reed, John W. Schutt, and Courtney Skinner.

We also owe a debt of gratitude to the administrators of the National Science Foundation of the USA for the financial and logistical support that enabled us to work in Antarctica. We thank them all but mention especially: David Bresnahan, Erick Chiang, Shaun Everett, Helen Gerasimou, Margaret Lanyon, Ann Peoples, Winnifred Reuning, Phil Smith, Mort Turner, Jack Twiss, Jill Vereyken, and Peter Wilkniss.

We also thank the staff of the Byrd Polar Research Center (formerly the Institute of Polar Studies) of The Ohio State University who supported our efforts in many ways: Peter Anderson, Kathleen Doddroe, David Lape, Arthur Mirsky, Rae Mercier, and Lynn Everett.

Our efforts to write this book were greatly facilitated by the assistance we received from Lynn Lay, librarian of the Byrd Polar Research Center, and from Mary Scott and Patty Ditto of the Orton Memorial Library of the School of Earth Sciences at The Ohio State University. We also thank Betty Heath for transforming a very messy manuscript into a neatly typed manuscript.

We gratefully acknowledge the financial support of The Ohio State University at Marion with special thanks to Dr. Greg Rose, Dean and Director of The Ohio State University at Marion. We also thank Petra van Steenbergen, Senior Publishing Editor of Springer, and her assistant, Cynthia de Jonge, for their friendly cooperation during the writing and production of this book.

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 I Exploration and Characterization

1 The Exploration of Antarctica ................................................................. 3
  1.1 Brave Men in Wooden Sailing Ships ............................................... 3
  1.2 Search for the Magnetic Pole in Antarctica ..................................... 6
  1.3 Surviving the Antarctic Winter ....................................................... 8
  1.4 The Race to the Geographic South Pole ......................................... 10
    1.4.1 Scott’s First (Discovery) Expedition, 1901–1904 ............... 11
    1.4.2 Shackleton’s First (Nimrod) Expedition, 1907–1909 ...... 13
    1.4.3 Scott’s Second (Terra Nova) Expedition of 1910–1913..... 15
    1.4.4 Amundsen’s (Fram) Expedition of 1910–1912............... 19
    1.4.5 Shackleton’s Second (Endurance) Expedition, 1914–1917.... 22
  1.5 The Modern Era Begins ................................................................... 24
    1.5.1 Byrd’s Little America Expedition, 1928–1930 ................... 24
    1.5.2 Byrd’s Second Expedition, 1933–1935 ............................... 25
    1.5.3 International Geophysical Year (IGY), 1957–1958 ............ 25
    1.5.4 Commonwealth Trans-Antarctic Expedition, 1955–1958.......... 26
  1.6 Antarctic Treaty ............................................................................... 27
  1.7 Scientific Meetings and Publications ............................................... 29
  1.8 Popular Books About Antarctica ..................................................... 29
  1.9 Summary ....................................................................................... 30
  1.10 Appendices...................................................................................... 31
    1.10.1 Exploration of Antarctica Following Byrd’s Second Expedition (Stonehouse 2002) ....................... 31
    1.10.2 Principal Research Stations in Antarctica (Stonehouse 2002) ......................................................... 32
    1.10.3 Member Nations of the Scientific Committee on Antarctic Research (SCAR) (Stonehouse 2002)............. 34
    1.10.4 International Symposia of Antarctic Research Organized by SCAR (Ford 2006) .................................................. 34
    1.10.5 Gondwana Conferences and Their Proceedings Volumes.... 35
    1.10.6 Selected Volumes of the Antarctic Research Series of the American Geophysical Union (AGU) of Washington, DC (All Publications Listed Here Are Also Included in Section 1.10) ..................................................... 35
1.10.7 Memoirs, Special Papers, and Maps of the Geological Society of America (GSA) Relevant to Antarctica ...................... 36
References ................................................................. 37

2 Antarctica: The Continent .............................................. 41
  2.1 Topography .......................................................... 41
  2.2 Volcanoes ............................................................ 43
  2.3 Climate ............................................................... 44
  2.4 Cold-Weather Injuries ............................................. 45
  2.5 The Ozone Hole .................................................... 47
  2.6 McMurdo Station .................................................. 49
  2.7 Amundsen-Scott South-Pole Station ....................... 52
  2.8 Fieldwork in Antarctica ......................................... 54
  2.9 Preservation of the Environment ............................. 56
  2.10 Summary ............................................................ 57
  2.11 Appendices .......................................................... 57
    2.11.1 Exploration of Antarctica by Tractor Train ........... 57
    2.11.2 Structure of the Atmosphere ............................ 60
    2.11.3 Energy Spectrum of UV Radiation .................... 60
    2.11.4 Formation and Destruction of Ozone ................. 61
    2.11.5 Effect of UV Radiation on the Biosphere ............ 62
References ................................................................. 62

Part II The Basement Rocks

3 Southern Victoria Land; Basement Rocks ......................... 67
  3.1 Ice-Free Valleys .................................................. 71
    3.1.1 Topography .................................................... 71
    3.1.2 Geology ........................................................ 72
  3.2 Koettlitz and Skelton Groups .................................... 77
  3.3 Brown Hills ........................................................ 79
  3.4 Age Determinations ................................................. 81
    3.4.1 K-Ar Dates .................................................... 81
    3.4.2 Rb-Sr Dates ................................................... 81
    3.4.3 $^{40}$Ar/$^{39}$Ar Dates ....................................... 85
    3.4.4 U-Pb Dates ..................................................... 86
    3.4.5 Sm-Nd Dates .................................................. 87
  3.5 Geologic History of Southern Victoria Land ................. 88
  3.6 Appendices .......................................................... 89
    3.6.1 Classification of Plutonic Rocks 
of Granitic Composition .............................................. 89
    3.6.2 K-Ar Method .................................................. 89
    3.6.3 Rb-Sr Method ................................................ 90
    3.6.4 $^{40}$Ar/$^{39}$Ar Partial-Release Dates .................... 91
    3.6.5 U-Pb Methods ............................................... 92
    3.6.6 Sm-Nd Method ............................................... 93
References ................................................................. 94

4 Northern Victoria Land ................................................. 99
  4.1 Exploration ........................................................ 99
  4.2 Terra Nova Bay .................................................... 103
4.3 Wilson Terrane ................................................................. 107
  4.3.1 Berg Group, Oates Land .......................................... 107
  4.3.2 Rennick Schist ......................................................... 108
  4.3.3 Daniels Range and Wilson Hills ............................... 110
  4.3.4 Morozumi Range ...................................................... 112
  4.3.5 Lanterman and Salamander Ranges ........................... 115
4.4 Bowers Terrane ............................................................. 116
  4.4.1 Sledgers Group ........................................................ 117
  4.4.2 Mariner Group ........................................................ 119
  4.4.3 Leap Year Group .................................................... 119
4.5 Robertson Bay Terrane .................................................. 120
  4.5.1 The Handler Formation ............................................. 120
  4.5.2 Millen Schist .......................................................... 121
  4.5.3 Admiralty Intrusives ............................................... 121
  4.5.4 Gallipoli Porphyries and Carboniferous Volcanics ....... 125
4.6 Tectonics ............................................................................. 126
  4.6.1 Subduction Model .................................................... 126
  4.6.2 Tectonics of the Wilson Terrane ............................... 128
  4.6.3 Accreted-Terrane Model ......................................... 130
4.7 Summary ........................................................................... 131
4.8 Appendices ......................................................................... 132
  4.8.1 Age Determinations of Basement Rocks of the Terra-Nova-Bay Area .................................................. 132
  4.8.3 Age Determinations of Basement Rocks of the Lazarev Mountains, Daniels, Morozumi, and Lanterman Ranges, Wilson Terrane ........................................... 134
  4.8.4 Age Determinations of the Basement Rocks in the Bowers Terrane .................................................. 136
  4.8.5 Age Determinations of the Robertson Bay Group and Admiralty Intrusives, Robertson Bay Terrane ................................. 137
  4.8.6 Additional Photographs of the Geology of Northern Victoria Land .......................................................... 140
References ................................................................................ 140

5 Central Transantarctic Mountains ............................................ 145
  5.1 Nimrod Group, Miller Range ........................................... 146
    5.1.1 Geology of the Miller Range ...................................... 146
    5.1.2 Age Determinations ................................................ 148
  5.2 Beardmore Group, Queen Elizabeth Range ....................... 153
    5.2.1 Conventional Stratigraphy ...................................... 153
    5.2.2 Revision of the Goldie Formation ............................. 154
  5.3 Byrd Group, Churchill Mountains ..................................... 156
    5.3.1 Conventional Stratigraphy ...................................... 157
    5.3.2 Revision of the Stratigraphy .................................... 158
    5.3.3 Pegmatite, Mt. Madison ........................................ 160
  5.4 Petrogenesis of the Hope Granite ..................................... 162
  5.5 Beardmore to Shackleton Glaciers ................................... 165
    5.5.1 Beardmore to Ramsey Glaciers ................................ 165
    5.5.2 Shackleton Glacier Area .......................................... 166
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5.3</td>
<td>Age of the Taylor Formation</td>
<td>168</td>
</tr>
<tr>
<td>5.5.4</td>
<td>Queen Maud Batholith</td>
<td>169</td>
</tr>
<tr>
<td>5.6</td>
<td>Summary</td>
<td>169</td>
</tr>
<tr>
<td>References</td>
<td></td>
<td>170</td>
</tr>
</tbody>
</table>

6 The Queen Maud Mountains ............................................................. 173
6.1 Duncan Mountains ........................................................................ 174
6.2 O’Brien Peak ............................................................................. 176
6.3 Nilsen Plateau ........................................................................... 177
6.3.1 Granite Harbor Intrusives (Southern Nilsen Plateau) .......... 177
6.3.2 Volcano-Sedimentary Complex (Northern Nilsen Plateau) .... 178
6.3.3 Age Determinations ............................................................ 180
6.4 Scott Glacier Area ................................................................. 182
6.4.1 La Gorce Mountains ............................................................ 183
6.4.2 Age Determinations ............................................................ 186
6.4.3 Queen Maud Batholith ........................................................ 187
6.5 Leverett Glacier Area ............................................................... 188
6.5.1 History of Exploration ......................................................... 188
6.5.2 Stratigraphy ......................................................................... 190
6.5.3 Granite Harbor Intrusives .................................................... 192
6.5.4 Isotopic Age Determinations ............................................... 192
6.6 Summary .................................................................................. 193
6.7 Appendices ............................................................................... 194
6.7.1 Rb-Sr Systematics, Nilsen Plateau (Eastin 1970; Fig. 6.5) .... 194
6.7.2 Bouma Cycles ...................................................................... 195
6.7.3 Modal and Chemical Compositions and Rb-Sr Systematics of the Wyatt Formation, Scott-Glacier Area and Wisconsin Range, Transantarctic Mountains ...... 195
6.7.4 Leverett Formation, Mt. Webster, Harold Byrd Mountains ............................................................................ 196
References ....................................................................................... 197

7 Horlick Mountains ......................................................................... 201
7.1 Exploration of the Wisconsin Range ........................................... 201
7.2 Basement Rocks, Wisconsin Range ........................................... 203
7.2.1 LaGorce Formation ................................................................ 203
7.2.2 Wyatt Formation ................................................................... 204
7.2.3 Southern Nunataks .............................................................. 205
7.2.4 Wisconsin Range Batholith .................................................. 207
7.3 Age Determinations, Wisconsin Range ....................................... 209
7.3.1 Age of the LaGorce Formation ........................................... 209
7.3.2 Age of the Wyatt Formation ................................................. 210
7.3.3 Age of the Wisconsin Range Batholith .................................. 211
7.3.4 Age of Aplite and Pegmatite Dikes ..................................... 212
7.4 Geologic History, Wisconsin Range Basement .................................. 213
7.5 Long Hills ................................................................................ 213
7.5.1 Todd Ridge Pyroclastics, Chemical Composition ............... 215
7.5.2 Age of the Todd Ridge Pyroclastic Rocks ............................ 215
7.6 Ohio Range ................................................................................ 216
7.6.1 Geology of the Ohio Range ................................................ 217
Contents

7.6.2 Granitic Basement ............................................................... 217
7.7 Summary .......................................................................................... 218
7.8 Appendices ....................................................................................... 219
7.8.1 Chemical Composition of Metavolcanic Rocks, Wyatt Formation, Scott Glacier Area and Wisconsin Range in Weight Percent (Faure unpublished; Minshew 1967) .................................................................... 219
7.8.2 Rb-Sr Data, Basement Rocks, Wisconsin Range (Montigny and Faure 1969; Ray 1973; Faure unpublished) .............................................................. 219
7.8.2.1 LaGorce Formation, Ford Nunataks, Wisconsin Range 219
7.8.2.2 Wyatt Formation, Metavolcanic Mountain, Wisconsin Range ................................................... 220
7.8.2.3 Granitic Gneiss, Olentangy Glacier, Wisconsin Range ................................................... 220
7.8.2.4 Unfoliated Porphyritic Granitic Rocks, Gratton Nunatak and Olentangy Glacier ...................... 220
7.8.2.5 Aplite Dikes, Mims, Polygon, Tillite Spurs, Wisconsin Range ................................................... 220
7.8.2.6 Mineral Concentrates, Granitic Rocks and Pegmatites, Mims Spur ........................................ 221
7.8.2.7 Mineral Concentrates, Pegmatites, Mims Spur, Wisconsin Range ................................................... 221
7.8.3 Chemical Analyses of Felsic Pyroclastic Rocks on Todd Ridge, Long Hills, and on Mt. Webster, Harold Byrd Mountains, in Weight Percent (Faure unpublished; Minshew 1967) .................................................................... 221
7.8.4 Rb-Sr Data, Felsic Pyroclastic Rocks, Todd Ridge, Long Hills .............................................................. 222
7.8.5 Modal Compositions of the Granitic Basement Rocks, Ohio Range (Long 1961; Treves 1965) ........................................................................ 222
References ....................................................................................... 223

8 The Far-Eastern Mountains ............................................................... 225
8.1 Thiel Mountains ........................................................................... 225
8.1.1 Geology ............................................................................... 227
8.1.2 Age Determinations ............................................................ 229
8.1.3 Ellsworth-Whitmore Mountains ........................................... 231
8.1.4 Summary ............................................................................. 232
8.2 Pensacola Mountains ..................................................................... 233
8.2.1 Discovery and Exploration .................................................. 233
8.2.2 Topography .......................................................................... 233
8.2.3 Stratigraphy .......................................................................... 234
8.2.4 Age Determinations (Rb-Sr Method) ................................... 237
8.2.5 Age Determinations (U-Pb Method) ................................... 242
8.2.6 Revised Stratigraphy ........................................................... 243
8.2.7 Summary ............................................................................. 245
8.3 Argentina Range .............................................................................. 245
8.4 Shackleton Range and Theron Mountains ....................................... 246
  8.4.1 Discovery and Mapping ..................................................... 247
  8.4.2 Geology .............................................................................. 248
  8.4.3 Age Determinations ........................................................... 250
  8.4.4 Tectonics ............................................................................ 253
  8.4.5 Glaciation ........................................................................... 256
  8.4.6 Summary ............................................................................ 257
8.5 Appendices ....................................................................................... 258
  8.5.1 Chemical Analyses of Whole-Rock Samples of the Thiel
        Mountain Porphyry and of Xenocrysts of Cordierite
        and Hypersthene (Ford and Himmelberg 1976) .............. 258
  8.5.2 Chemical Analyses of the Reed Ridge Granite
        (A and B) and of the Thiel Mountains Pophrpy
        (C and D) in Percent by Weight and Parts Per Million
        (ppm) as Indicated (Vennum and Storey 1987) ............... 259
  8.5.3 Rubidium-Strontium Systematics of the Thiel
        Mountains Porphyry and Reed Ridge Granite
        (Data from Eastin 1970) .................................................... 259
  8.5.4 Summary of Isotopic Age Determinations
        of the Basement Rocks of the Thiel Mountains
        (Schmidt and Ford 1969; Eastin 1970;
        Pankhurst et al. 1988) ....................................................... 260
  8.5.5 Isotopic Age Determinations of Granitic Rocks
        in Whitmore Mountains and Other Nunataks
        of the Ellsworth-Whitmore Mountains Block ................. 261
  8.5.6 Patuxent Formation in the Patuxent Range
        (Data by Eastin (1970)) .................................................... 262
  8.5.7 Patuxent Formation: Description of Samples
        from the Patuxent Range.................................................... 262
  8.5.8 Patuxent Formation Samples of Felsic Flows
        and Plugs (Data by Eastin 1970) ...................................... 262
  8.5.9 Felsites of the Patuxent Formation, Schmidt
        and Williams Hills ............................................................. 263
  8.5.10 Patuxent Formation: Samples of Diabase
        and Basalt (Data by Eastin 1970) ..................................... 263
  8.5.11 Patuxent Formation: Description of Diabase
        and Basalt Samples from the Neptune Range.................... 263
  8.5.12 Gambacorta Formation: Felsic Volcanic Rocks
        of the Hawkes Porphyry Member of the Pensacola
        Mountains (Data by Eastin 1970) ..................................... 264
  8.5.13 Gambacorta Formation and Hawkes Porphyry
        in the Neptune Range (Rock Descriptions
        by D.L. Schmidt) ............................................................... 264
  8.5.14 Chemical Compositions of Rock Samples
        from the Hawkes-Porphyry Member
        of the Gambacorta Formation Provided
        by D.L. Schmidt to R. Eastin, in Weight Percent .............. 265
  8.5.15 Serpan Granite and Gneiss: Rb and Sr Concentrations
        and $^{87}$Sr/$^{86}$Sr Ratios (Measured by Eastin 1970)........ 265
8.5.16 Serpan Granite and Gneiss from Serpan Peak in the Neptune Range of the Pensacola Mountains
(Data by Eastin 1970) ........................................................ 266
8.5.17 Chemical Compositions of Rock Samples from the Serpan Granite and Serpan Gneiss on Serpan Peak, Northern Neptune Range, Pensacola Mountains, in Weight Percent ............................................................... 266
8.5.18 Selected Isotopic Age Determinations of Rocks and Minerals in the Pensacola Mountains in Units of 10^6 Years (Ma) ................................................. 267
8.5.19 Summary of Isotopic Age Determinations of Rocks and Minerals in the Principal Mountain Ranges of the Shackleton Range Expressed in Ma ................................................................ 268
References........................................................................................ 269

9 From Rodinia to Gondwana ............................................................ 275
  9.1 Continental Drift ................................................................................ 275
  9.2 The SWEAT Hypothesis .................................................................... 278
  9.3 Coats Land ......................................................................................... 280
  9.4 Summary ............................................................................................ 283
References ................................................................................................... 284

Part III Gondwana: Growth and Disintegration

10 The Beacon Supergroup ........................................................................ 289
  10.1 Southern Victoria Land .................................................................... 290
  10.1.1 Ice-Free Valleys ........................................................................... 290
  10.1.2 Expanded Stratigraphy ................................................................. 293
  10.1.3 Darwin Mountains ....................................................................... 297
  10.2 Northern Victoria Land .................................................................... 301
  10.2.1 Glacial Diamictite ......................................................................... 302
  10.2.2 Takrouna Formation ..................................................................... 303
  10.2.3 Section Peak Formation ............................................................... 304
  10.3 Central Transantarctic Mountains .................................................... 305
  10.3.1 Alexandra Formation .................................................................... 306
  10.3.2 Pagoda Tillite ................................................................................. 307
  10.3.3 Mackellar Formation .................................................................... 308
  10.3.4 Fairchild Formation ..................................................................... 309
  10.3.5 Buckley Coal Measures ............................................................... 309
  10.3.6 Fremouw Formation ..................................................................... 311
  10.3.7 Falla Formation ............................................................................. 312
  10.3.8 Age Determinations, Falla Formation ........................................... 313
  10.4 Queen Maud Mountains ................................................................. 315
  10.4.1 Cumulus Hills, Shackleton Glacier ............................................... 315
  10.4.2 Mt. Weaver, Scott Glacier ............................................................ 317
  10.5 Horlick Mountains ........................................................................... 318
  10.5.1 Wisconsin Range .......................................................................... 318
  10.5.2 Ohio Range ................................................................................... 319
  10.6 The Far Eastern Mountains .............................................................. 325
  10.7 Summary .......................................................................................... 325
References................................................................................................... 325
11 Beacon Supergroup; Special topics ......................................................... 331
11.1 Isotopic Studies of Carbonate Rocks ............................................... 331
11.1.1 Strontium............................................................................ 331
11.1.2 Oxygen............................................................................. 334
11.1.3 Carbon................................................................................ 337
11.1.4 Calcite Cleats in Coal......................................................... 337
11.2 The Glaciation of Gondwana ........................................................... 339
11.3 Tetrapod Fauna................................................................................. 344
11.3.1 Graphite Peak ..................................................................... 344
11.3.2 Coalsack Bluff.................................................................... 345
11.3.3 Cumulus Hills, Shackleton Glacier .................................... 346
11.3.4 Gordon Valley and Mt. Kirkpatrick ................................... 347
11.3.5 Lystrosaurus ....................................................................... 347
11.3.6 Permo-Triassic Extinction Event ....................................... 347
11.4 Plant Fossils ..................................................................................... 348
11.4.1 Glossopteris........................................................................ 349
11.4.2 Dicroidium ......................................................................... 350
11.4.3 Cycads and Other Gymnosperms....................................... 351
11.4.4 Palynomorphs .................................................................... 353
11.4.5 Permo-Triassic Climate...................................................... 353
11.5 Mineral Deposits .............................................................................. 354
11.5.1 CRAMRA .......................................................................... 354
11.5.2 Inventory of Mineral Deposits ........................................... 355
11.5.3 Radioactivity Surveys ........................................................ 356
11.5.4 Bituminous Coal ................................................................ 358
11.6 Summary .......................................................................................... 359
11.7 Appendix .......................................................................................... 360
11.7.1 List of Publications Concerning Metallic Mineral Deposits in Different Regions of Antarctica by Year of Publication ........................................................ 360
References ................................................................................................... 363

12 The Ferrar Group: Kirkpatrick Basalt .................................................. 373
12.1 Wisanger Basalt, South Australia .................................................... 373
12.2 Tasmanian Dolerite .......................................................................... 373
12.3 Diamictites, Transantarctic Mountains ............................................ 375
12.3.1 Mawson Formation ............................................................ 375
12.3.2 Prebble Formation .............................................................. 378
12.3.3 Exposure Hill Formation.................................................... 379
12.4 Kirkpatrick Basalt, Northern Victoria Land..................................... 380
12.4.1 Mesa Range........................................................................ 380
12.4.2 Tobin Mesa......................................................................... 382
12.4.3 Pain Mesa........................................................................... 384
12.4.4 Solo Nunatak...................................................................... 389
12.5 Brimstone Peak, Prince Albert Mountains....................................... 392
12.6 Kirkpatrick Basalt, Queen Alexandra Range ................................... 392
12.6.1 Stratigraphy and Chemical Composition ........................... 393
12.6.2 Fossils Among the Lava Flows .......................................... 395
12.6.3 K-Ar Dates ......................................................................... 396
12.6.4 40Ar/39Ar Dates ................................................................... 397
12.6.5 Rb-Sr Dates........................................................................ 399
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.6.6</td>
<td>Initial $^{87}$Sr/$^{86}$Sr Ratios</td>
<td>400</td>
</tr>
<tr>
<td>12.6.7</td>
<td>Magma Mixing</td>
<td>401</td>
</tr>
<tr>
<td>12.7</td>
<td>Petrogenesis: Isotopic Evidence</td>
<td>403</td>
</tr>
<tr>
<td>12.7.1</td>
<td>Tasmanian Dolerite</td>
<td>403</td>
</tr>
<tr>
<td>12.7.2</td>
<td>Kirkpatrick Basalt, Mesa Range</td>
<td>405</td>
</tr>
<tr>
<td>12.8</td>
<td>Continental Tectonics</td>
<td>405</td>
</tr>
<tr>
<td>12.9</td>
<td>Virtual Geomagnetic Poles</td>
<td>406</td>
</tr>
<tr>
<td>12.10</td>
<td>Summary</td>
<td>408</td>
</tr>
<tr>
<td>References</td>
<td></td>
<td>408</td>
</tr>
</tbody>
</table>

| 13      | Ferrar Group: Dolerite Sills and the Dufek Intrusion                | 415  |
| 13.1    | Southern Victoria Land                                              | 415  |
| 13.1.1  | Isotopic Dating                                                      | 418  |
| 13.1.2  | Chemical Compositions                                               | 420  |
| 13.1.3  | Mineral Stratigraphy                                                | 420  |
| 13.1.4  | Trace Elements                                                       | 422  |
| 13.1.5  | Flowage Differentiation                                              | 424  |
| 13.1.6  | Magma Transport                                                     | 425  |
| 13.1.7  | Petrogenesis                                                         | 426  |
| 13.2    | Roadend Nunatak, Touchdown Glacier                                  | 427  |
| 13.2.1  | Stratigraphy                                                         | 427  |
| 13.2.2  | Chemical Compositions                                               | 428  |
| 13.2.3  | Rb-Sr Dating                                                         | 430  |
| 13.2.4  | Oxygen                                                               | 431  |
| 13.3    | Central Transantarctic Mountains                                    | 432  |
| 13.3.1  | Mt. Achernar, MacAlpine Hills                                       | 432  |
| 13.3.2  | Portal Rock, Queen Alexandra Range                                  | 436  |
| 13.4    | Dufek Intrusion                                                      | 440  |
| 13.4.1  | Topography                                                           | 441  |
| 13.4.2  | Stratigraphy                                                         | 443  |
| 13.4.3  | Chemical Composition and Mineralogy                                 | 447  |
| 13.4.4  | Age and Petrogenesis                                                | 449  |
| 13.4.5  | Natural Resources                                                    | 452  |
| 13.5    | Summary                                                              | 456  |
| 13.6    | Appendices                                                           | 456  |
| 13.6.1  | Mineralogical Types of Ferrar Dolerite Sills in Southern Victoria Land | 456  |
| 13.6.2  | Chemical Analyses of Dolerite Sills on Roadend Nunatak, South        | 457  |
| 13.6.3  | Rb-Sr Systematics of the Dolerite Sills on Roadend Nunatak at the    | 457  |
| 13.6.4  | Major-Element Analyses of Whole-Rock Samples, Ferrar Dolerite Sills  | 458  |
| 13.6.5  | Rb-Sr Systematics of the Sills of Ferrar Dolerite on Mt. Achernar,   | 459  |
| 13.6.6  | $\delta^{18}$O Values of Plagioclase and Pyroxene in Dolerite        | 460  |

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1.2</td>
<td>Chemical Compositions</td>
<td>428</td>
</tr>
<tr>
<td>13.2.3</td>
<td>Rb-Sr Dating</td>
<td>430</td>
</tr>
<tr>
<td>13.2.4</td>
<td>Oxygen</td>
<td>431</td>
</tr>
<tr>
<td>13.3.1</td>
<td>Mt. Achernar, MacAlpine Hills</td>
<td>432</td>
</tr>
<tr>
<td>13.3.2</td>
<td>Portal Rock, Queen Alexandra Range</td>
<td>436</td>
</tr>
<tr>
<td>13.4</td>
<td>Dufek Intrusion</td>
<td>440</td>
</tr>
<tr>
<td>13.4.1</td>
<td>Topography</td>
<td>441</td>
</tr>
<tr>
<td>13.4.2</td>
<td>Stratigraphy</td>
<td>443</td>
</tr>
<tr>
<td>13.4.3</td>
<td>Chemical Composition and Mineralogy</td>
<td>447</td>
</tr>
<tr>
<td>13.4.4</td>
<td>Age and Petrogenesis</td>
<td>449</td>
</tr>
<tr>
<td>13.4.5</td>
<td>Natural Resources</td>
<td>452</td>
</tr>
<tr>
<td>13.5</td>
<td>Summary</td>
<td>456</td>
</tr>
<tr>
<td>13.6</td>
<td>Appendices</td>
<td>456</td>
</tr>
<tr>
<td>13.6.1</td>
<td>Mineralogical Types of Ferrar Dolerite Sills in Southern Victoria Land</td>
<td>456</td>
</tr>
<tr>
<td>13.6.2</td>
<td>Chemical Analyses of Dolerite Sills on Roadend Nunatak, South</td>
<td>457</td>
</tr>
<tr>
<td>13.6.3</td>
<td>Rb-Sr Systematics of the Dolerite Sills on Roadend Nunatak at the</td>
<td>457</td>
</tr>
<tr>
<td>13.6.4</td>
<td>Major-Element Analyses of Whole-Rock Samples, Ferrar Dolerite Sills</td>
<td>458</td>
</tr>
<tr>
<td>13.6.5</td>
<td>Rb-Sr Systematics of the Sills of Ferrar Dolerite on Mt. Achernar,</td>
<td>459</td>
</tr>
<tr>
<td>13.6.6</td>
<td>$\delta^{18}$O Values of Plagioclase and Pyroxene in Dolerite</td>
<td>460</td>
</tr>
</tbody>
</table>
13.6.7 Chemical Analyses of Rock Samples from a Measured Section of the Sill of Ferrar Dolerite on Portal Rock, Queen Alexandra Range (J.M. Hergt personal communication to G. Faure, April 27, 1987) ................................................ 460

13.6.8 Average Chemical Analyses of the Lexington Granophyre and Other Felsic Differentiates of the Dufek Intrusion in the Forrestal Range and Dufek Massif, in Weight Percent (Ford 1970; Ford and Kistler 1980) ........................................ 463

13.6.9 Modal Concentrations of Minerals in the Rocks of the Forrestal Range and the Dufek Massif (Data from Ford et al. 1983) ............................................................... 464

13.6.9B Concentrations of Metals in Whole-Rock Samples of the Dufek Intrusion (Ford et al. 1983) ........................................ 464

13.6.10 Concentrations of Vanadium in the Oxide Minerals of the Dufek Intrusion in the Dufek Massif (Ford et al. 1983) ............................................................... 465

References ........................................................................................... 466

14 Kirwan Volcanics, Queen Maud Land .................................................... 471
14.1 Kirwan Escarpment ......................................................................... 472
14.2 Vestfjella .......................................................................................... 476
  14.2.1 Chemical Compositions ...................................................... 477
  14.2.2 Isotopic Age Determinations .............................................. 479
  14.2.3 Petrogenesis ................................................................. 480
  14.2.4 Permian Sedimentary Rocks ............................................. 482
14.3 Plogen and Basen ............................................................................ 483
  14.3.1 Geology and Geochemistry ................................................. 483
  14.3.2 Isotopic Compositions ........................................................ 484
  14.3.3 Petrogenesis ........................................................................ 485
14.4 Summary .......................................................................................... 486
14.5 Appendices ....................................................................................... 487
  14.5.1 K-Ar Age Determinations of Jurassic Basalt Flows and Dikes in Queen Maud Land ........................................ 487

References ................................................................................................... 488

15 Break-up of Gondwana and Assembly of Antarctica ......................... 491
15.1 The Plume Hypothesis ..................................................................... 491
15.2 The Weddell-Sea Triple Junction ..................................................... 494
15.3 Subduction Along the Paleo-Pacific Coast ...................................... 495
15.4 Assembly and Break-Up of Gondwana ........................................... 497
15.5 Uplift of the Transantarctic Mountains ............................................ 500
  15.5.1 Crustal Structure of Antarctica ........................................... 501
  15.5.2 The Transantarctic Fault Zone ........................................... 502
  15.5.3 Marie Byrd Land .................................................................. 504
  15.5.4 The Accreted Terranes of NVL ........................................... 505
  15.5.5 Fission-Track Method of Dating ......................................... 505
  15.5.6 Uplift of the Transantarctic Mountains ............................... 507
15.6 Summary .......................................................................................... 508
15.7 Appendix .......................................................................................... 510
  15.7.1 The Fission-Track Method of Dating..................................... 510

References ................................................................................................... 511
Contents

Part IV Fire and Ice

16 Cenozoic Volcanoes ................................................................. 519
  16.1 Erebus Volcanic Province ....................................................... 519
    16.1.1 Petrology ..................................................................... 521
    16.1.2 Chemical Compositions .............................................. 522
    16.1.3 K-Ar Dates ................................................................... 523
    16.1.4 Rb-Sr Systematics ....................................................... 525
    16.1.5 U-Pb Systematics .......................................................... 526
    16.1.6 Oxygen Isotopes .......................................................... 527
    16.1.7 Ultramafic Inclusions .................................................. 527
    16.1.8 Granulite Inclusions .................................................... 528
    16.1.9 Structural Discontinuity of the Deep Crust ...................... 529
  16.2 Ross Island .............................................................................. 530
    16.2.1 Hut Point Peninsula and Petrogenesis ......................... 532
    16.2.2 Mount Erebus, Summit ................................................. 535
    16.2.3 Mount Erebus, Gas and Dust ....................................... 538
    16.2.4 Mt. Erebus, Soil Salts .................................................. 539
    16.2.5 Soil Salts, Coast of Ross Island .................................... 540
  16.3 Melbourne Volcanic Province .................................................. 542
    16.3.1 Mt. Melbourne ............................................................. 543
    16.3.2 Petrogenesis (Mount Melbourne) .................................. 546
    16.3.3 The Pleiades .................................................................. 548
  16.4 Hallett Volcanic Province ......................................................... 550
    16.4.1 Adare Peninsula ............................................................ 550
    16.4.2 Hallett Peninsula .......................................................... 551
    16.4.3 Daniell Peninsula .......................................................... 551
    16.4.4 Coulman Island ............................................................. 552
    16.4.5 Possession Islands ......................................................... 553
  16.5 The Balleny, Scott, and Peter I Islands ........................................ 554
    16.5.1 Balleny Islands ............................................................. 555
    16.5.2 Scott Island ................................................................. 555
    16.5.3 Peter I Island ............................................................... 556
    16.5.4 Petrogenesis (Balleny Islands) ....................................... 556
  16.6 Mount Early and Sheridan Bluff, QMM .................................... 558
  16.7 Summary .................................................................................. 561
  16.8 Appendices .............................................................................. 562
    16.8.1 Average Chemical Compositions of the Granulite Inclusion from the Deep Crust Beneath the Transantarctic Mountains and the Ross Embayment (Kalamarides and Berg1991) .............................................. 562
    16.8.2 Isotopic Compositions of Strontium and Sulfur in Soil Salts on Ross Island Including the Summit of Mt. Erebus (Jones et al.1983; Faure and Jones 1989) ...................................
    16.8.3 Isotopic Compositions of Two-Component Mixtures (Faure and Jones1989) ...................................................... 564
    16.8.4 Isotope Compositions of Strontium and Neodymium of Volcanic Rocks from the Mt. Melbourne Volcanic Field (Wörner et al.1989) .................................................. 565
    16.8.5 Isotope Compositions of Strontium of the Cenozoic Lavas of Northern Victoria Land and Adjacent Islands .......................................................... 565
References .......................................................................................... 565
17 The East Antarctic Ice Sheet ............................................................ 573
  17.1 Dynamics of the Antarctic Ice Sheets ........................................ 573
  17.2 Cenozoic Glaciation of Antarctica ........................................... 576
  17.3 The Elephant Moraine .............................................................. 579
    17.3.1 Physical Dimensions .................................................... 579
    17.3.2 Lithologic Composition of Rock Clasts ............................ 579
    17.3.3 Origin of the Elephant Moraine ................................... 581
    17.3.4 Dating Supraglacial Moraines ....................................... 582
    17.3.5 Micropaleontology of Molded Till Pellets ..................... 583
    17.3.6 Ablation Rates .......................................................... 585
    17.3.7 Subglacial Calcite and Opaline Silica ............................ 586
  17.4 Reckling Moraine and Allan Hills .......................................... 589
    17.4.1 Lithology of Rock Clasts ............................................. 591
    17.4.2 Ablation Rates .......................................................... 591
    17.4.3 Oxygen Isotopes ........................................................ 592
    17.4.4 Bedrock Topography ................................................... 594
  17.5 Accumulation Rates of Snow and Condensation Temperatures ...... 595
    17.5.1 Accumulation Rates .................................................... 595
    17.5.2 Temperature Estimates (Oxygen) .................................. 596
    17.5.3 Temperature Estimates (Hydrogen) ............................... 597
  17.6 Climate Histories from Ice Cores ............................................. 599
    17.6.1 The Vostok Core ......................................................... 600
    17.6.2 Dating Ice ............................................................... 601
    17.6.3 EPICA Core at Dome C .............................................. 601
  17.7 Water Under the Antarctic Ice Sheet ....................................... 605
    17.7.1 Pressure-Melting Point ............................................... 605
    17.7.2 Lake Vostok ................................................................ 607
    17.7.3 Ice Streams ............................................................. 607
    17.7.4 Effect on Sea Level .................................................... 608
  17.8 Cryogenic Brines and Evaporites ............................................. 610
  17.9 Chemical Composition of Antarctic Ice .................................... 612
    17.9.1 Firn at Base Roi Baudouin ......................................... 613
    17.9.2 The Byrd-Station Ice Core .......................................... 613
    17.9.3 Nitrate and Sulfate Concentrations ............................... 614
    17.9.4 Lead in Continental Ice Sheets ................................... 615
  17.10 Dust in the Ice Sheets of Antarctica ..................................... 617
    17.10.1 Stratospheric Dust ................................................... 617
    17.10.2 Tephra Layers in the Ice Sheets of Antarctica ............. 619
    17.10.3 Tephra on the Allan Hills Ice Fields ......................... 621
    17.10.4 Black Spherules, Allan Hills .................................... 622
  17.11 Summary .............................................................................. 624
  17.12 Appendix .............................................................................. 626
    17.12.1 Chemical composition of snow at Base Roi Baudouin, 
    Amundsen-Scott, and Plateau stations 
    (Hanappe et al. 1968) ....................................................... 626
References ....................................................................................... 627

18 Meteorites on Ice ............................................................. 635
  18.1 Meteorites in Antarctica ....................................................... 635
  18.2 Classification of Meteorites .................................................. 637
  18.3 Antarctic Meteorites ........................................................... 640
    18.3.1 Physical Properties of Meteorites ................................. 641
    18.3.2 Transport and Exposure .............................................. 643
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.3.3 Meteorite Collections from Antarctica</td>
<td>644</td>
</tr>
<tr>
<td>18.4 Meteorite-Impact Craters</td>
<td>644</td>
</tr>
<tr>
<td>18.4.1 Wilkes Land Impact Basin</td>
<td>645</td>
</tr>
<tr>
<td>18.4.2 Butcher Ridge, Cook Mountains</td>
<td>645</td>
</tr>
<tr>
<td>18.5 Allan Hills Icefields</td>
<td>649</td>
</tr>
<tr>
<td>18.6 Meteorite Chronologies</td>
<td>652</td>
</tr>
<tr>
<td>18.6.1 Cosmic-Ray Exposure Ages</td>
<td>653</td>
</tr>
<tr>
<td>18.6.2 Terrestrial Ages</td>
<td>655</td>
</tr>
<tr>
<td>18.6.3 Old Meteorites at the Allan Hills</td>
<td>656</td>
</tr>
<tr>
<td>18.7 Chemical Weathering of Stony Meteorites</td>
<td>656</td>
</tr>
<tr>
<td>18.7.1 Evaporite Minerals</td>
<td>659</td>
</tr>
<tr>
<td>18.7.2 Clay Minerals</td>
<td>660</td>
</tr>
<tr>
<td>18.7.3 Trace Elements</td>
<td>661</td>
</tr>
<tr>
<td>18.7.4 Iodine Contamination</td>
<td>661</td>
</tr>
<tr>
<td>18.8 Iron Meteorites: Derrick Peak</td>
<td>663</td>
</tr>
<tr>
<td>18.9 Lunar and Martian Meteorites</td>
<td>665</td>
</tr>
<tr>
<td>18.9.1 Lunar Rocks in Antarctica</td>
<td>666</td>
</tr>
<tr>
<td>18.9.2 Martian Rocks in Antarctica</td>
<td>669</td>
</tr>
<tr>
<td>18.9.3 Life on Mars? (ALH 84001)</td>
<td>670</td>
</tr>
<tr>
<td>18.10 Micrometeorites and Cosmic Spherules</td>
<td>672</td>
</tr>
<tr>
<td>18.10.1 Discovery of Micrometeorites</td>
<td>673</td>
</tr>
<tr>
<td>18.10.2 Origin and Composition</td>
<td>673</td>
</tr>
<tr>
<td>18.10.3 Classification</td>
<td>675</td>
</tr>
<tr>
<td>18.10.4 Micrometeorites, Cap Prudhomme</td>
<td>675</td>
</tr>
<tr>
<td>18.10.5 Micrometeorites, South Pole</td>
<td>677</td>
</tr>
<tr>
<td>18.11 Summary</td>
<td>677</td>
</tr>
<tr>
<td>18.12 Appendices</td>
<td>678</td>
</tr>
<tr>
<td>18.12.1 Letter Codes and Locations of Collecting Sites of Meteorite Specimens (Antarctic Meteorite Newsletter, 29(2):3, 2006 and Gazetteer of the Antarctic (Fourth edition))</td>
<td>678</td>
</tr>
<tr>
<td>18.12.2 Calculation of the Terrestrial Age of the LL6 Chondrite ALH 78153 by the Decay of Cosmogenic $^{36}$Cl and $^{26}$Al</td>
<td>679</td>
</tr>
<tr>
<td>18.12.4 Partial List of Martian Meteorites Collected in Antarctica</td>
<td>681</td>
</tr>
<tr>
<td>References</td>
<td>682</td>
</tr>
</tbody>
</table>

19 Glaciation of Southern Victoria Land ........................................... 693
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.1 Neogene Sediment in McMurdo Sound</td>
<td>693</td>
</tr>
<tr>
<td>19.1.1 CIROS-1 and MSSTS</td>
<td>694</td>
</tr>
<tr>
<td>19.1.2 Cape Roberts Project</td>
<td>696</td>
</tr>
<tr>
<td>19.1.3 Ross Ice Shelf Project</td>
<td>697</td>
</tr>
<tr>
<td>19.2 The Sirius Group</td>
<td>697</td>
</tr>
<tr>
<td>19.2.1 Mt. Sirius</td>
<td>698</td>
</tr>
<tr>
<td>19.2.2 Marine Microfossils and Real Wood</td>
<td>700</td>
</tr>
<tr>
<td>19.2.3 Pyrite Grains and Cosmic Spherules</td>
<td>701</td>
</tr>
<tr>
<td>19.3 Dominion Range</td>
<td>702</td>
</tr>
<tr>
<td>19.3.1 Stratigraphy</td>
<td>702</td>
</tr>
</tbody>
</table>
### Contents

19.3.2 Pliocene Nothophagus ........................................................... 704
19.3.3 The Beardmore Fjord ............................................................ 706
19.3.4 History of Glaciation of the Transantarctic Mountains .............. 706
19.3.5 Trouble with Diatoms ............................................................. 707
19.3.6 The Outlet Glaciers ............................................................... 709
19.3.7 Rb-Sr Dating of Feldspar in Till ............................................ 710

19.4 Volcanic Activity, Southern Victoria Land ..................................... 711
19.4.1 Taylor Valley ....................................................................... 714
19.4.2 Wright and Ferrar Valleys .................................................... 715
19.4.3 Koettlitz Glacier .................................................................. 716

19.5 Arena Valley and Western Asgard Range ...................................... 718
19.5.1 Arena Valley ....................................................................... 718
19.5.2 Western Asgard Range ........................................................ 718
19.5.3 Volcanic Ash ....................................................................... 718
19.5.4 Endolithic Plants .................................................................. 720

19.6 Wright Valley ........................................................................... 722
19.6.1 Glaciation ........................................................................... 723
19.6.2 Peleus Till .......................................................................... 724
19.6.3 Wright Fjord ....................................................................... 726
19.6.4 Ross-Sea Glaciation ............................................................. 726

19.7 Lakes of the Ice-Free Valleys ..................................................... 728
19.7.1 Lake Vanda, Wright Valley .................................................. 728
19.7.2 Sources of Salts: Strontium Isotopes ..................................... 737
19.7.3 Don Juan Pond ................................................................. 738
19.7.4 Lake Bonney, Taylor Valley ................................................ 740
19.7.5 Meltwater Streams, Taylor Valley ....................................... 742

19.8 Summary ................................................................................. 746

19.9 Appendices ............................................................................... 748
19.9.1 \(^{40}\)Ar/\(^{39}\)Ar Dates Derived from Volcanic Ash in Arena Valley and from the Western Asgard Range, Southern Victoria Land (Marchant et al. 1993a, b) ........ 748
19.9.2 Names and Locations of 44 Present-Day Lakes and Ponds in southern Victoria Land and on Ross Island (Chinn 1993).............................. 748
19.9.3 Chemical Analyses of Brine in Don Juan Pond of Wright Valley, Southern Victoria Land (Compiled by Jones 1969)............................................. 749
19.9.4 Reports Concerning the Geochemistry of Don Juan Pond in Wright Valley, Southern Victoria Land ........................................ 749
19.9.5 Isotope Compositions of Strontium in the Water of the Principal Tributary Streams in the Three Watersheds of Taylor Valley (Lyons et al. 2002).... 750

References ..................................................................................... 750

20 Antarctica in Retrospect ................................................................ 759

Author Index ................................................................................... 761

Subject Index ................................................................................... 779

Geologic Time Scale ........................................................................ 803
The Transantarctic Mountains
Rocks, Ice, Meteorites and Water
Faure, G.; Mensing, T.M.
2011, X, 600 p., Hardcover