

Contents

| | | |
|----------|--|-----------|
| 1 | Antarctica: Geomorphology and Climate Trends | 1 |
| 1.1 | Introduction | 1 |
| 1.2 | Physical Characteristics | 2 |
| 1.3 | Geology and Mineral Resources | 5 |
| 1.3.1 | Geology | 5 |
| 1.3.2 | Geochemical Anomalies and Mineral Resources | 9 |
| 1.4 | The Antarctic Climate and Its Role in the Global Climate System | 11 |
| 1.4.1 | The Antarctic Climate | 11 |
| 1.4.2 | Solar Radiation | 14 |
| 1.4.3 | Temperature | 17 |
| 1.4.4 | Clouds and Precipitation | 19 |
| 1.4.5 | Wind Regime | 22 |
| 1.4.6 | Atmospheric Interactions of Antarctica with Lower Latitudes | 24 |
| 1.5 | Global Warming and Climate Variations in Antarctica | 26 |
| 1.5.1 | Climate Variability and Changes Due to Human Activities | 26 |
| 1.5.2 | Trends of Surface Air Temperature in Antarctica | 31 |
| 1.5.3 | Extending Spatio-Temporal Temperature Trends | 34 |
| 1.5.4 | Moisture and Precipitation Trend | 36 |
| 1.6 | Summary | 40 |
| | | |
| 2 | Glacial, Terrestrial and Freshwater Ecosystems | 43 |
| 2.1 | Introduction | 43 |
| 2.2 | Glacial Systems | 44 |
| 2.2.1 | Antarctic Ice Sheets | 47 |
| 2.2.2 | Ice Core Records of Climate and Environmental Change | 53 |

| | | |
|----------|--|------------|
| 2.2.3 | Ice Shelves | 56 |
| 2.3 | Life in Snow and Ice | 58 |
| 2.4 | Ice-Free Areas and Terrestrial Habitats | 60 |
| 2.4.1 | Antarctic Soils | 64 |
| 2.4.2 | Terrestrial Ecosystems | 66 |
| 2.4.3 | Freshwater Ecosystems | 70 |
| 2.5 | Antarctic Ecosystems as Indicators of Change | 75 |
| 2.5.1 | Climate-Change Indications | 76 |
| 2.6 | Future Research in Antarctic Periglacial Areas | 79 |
| 2.7 | Summary | 80 |
| | | |
| 3 | The Southern Ocean Environment: Anthropogenic Impact and Climate Change | 83 |
| | | |
| 3.1 | Introduction | 83 |
| 3.2 | The Southern Ocean | 85 |
| 3.2.1 | Water Masses and Circulation Patterns | 86 |
| 3.2.2 | Air–Sea Exchanges | 89 |
| 3.2.3 | Sea Ice | 91 |
| 3.2.4 | Antarctic Sea Ice and the Global Climate System | 94 |
| 3.2.5 | Biogeochemical Cycles of C, Fe, S and Other Elements in the Southern Ocean | 97 |
| 3.3 | Pelagic Ecosystems | 102 |
| 3.3.1 | Primary Productivity | 104 |
| 3.3.2 | Effects of UV-B on Phytoplankton and Primary Production | 106 |
| 3.3.3 | The Ecological Role of Sea Ice | 108 |
| 3.3.4 | Ice-Edge Processes and Communities | 110 |
| 3.3.5 | Krill and Pelagic Food Webs | 112 |
| 3.4 | Benthic and Epibenthic Organisms | 116 |
| 3.5 | Antarctic Marine Food Webs and the Impact of Human Activity | 120 |
| 3.6 | Summary | 122 |
| | | |
| 4 | Persistent Contaminants in the Antarctic Atmosphere | 125 |
| | | |
| 4.1 | Introduction | 125 |
| 4.2 | The Atmosphere of the Southern Hemisphere | 127 |
| 4.2.1 | Trace Gases | 129 |
| 4.2.2 | The Impact of Biomass Burning | 132 |
| 4.2.3 | Aerosols | 133 |
| 4.2.4 | Volcanic Emissions | 137 |

| | | |
|----------|--|------------|
| Contents | | XIII |
| 4.3 | Persistent Contaminants in the Antarctic Atmosphere | 140 |
| 4.3.1 | The Mercury Cold Trap | 142 |
| 4.3.2 | Trace Elements in Antarctic Aerosol | 146 |
| 4.3.3 | Radionuclides | 151 |
| 4.3.4 | Persistent Organic Pollutants (POPs) | 153 |
| 4.4 | Antarctic Scientific Stations as Sources of Atmospheric Contaminants | 158 |
| 4.5 | Summary | 160 |
| 5 | Persistent Contaminants in Snow, Terrestrial Ecosystems and Inland Waters | 163 |
| 5.1 | Introduction | 163 |
| 5.2 | Atmospheric Contaminant Deposition and Their Incorporation into Ice | 164 |
| 5.2.1 | Dry, Wet and Occult Deposition in Polar Regions | 165 |
| 5.2.2 | Air–Snow Interactions and Post-Depositional Processes | 169 |
| 5.3 | Snow and Ice Core Records of Airborne Trace Metals | 171 |
| 5.3.1 | Lead as a Paradigm of Hemispheric-Scale Anthropogenic Impact | 172 |
| 5.3.2 | Natural and Anthropogenic Inputs of Lead to Antarctic Snow | 175 |
| 5.3.3 | Copper, Cadmium and Zinc | 178 |
| 5.3.4 | Mercury and Other Trace Metals | 183 |
| 5.3.5 | Persistent Organic Contaminants | 186 |
| 5.4 | Monitoring of Persistent Contaminants Around Scientific Stations Through Snow | 189 |
| 5.5 | Contaminants in Antarctic Soils | 191 |
| 5.6 | Cryptogamic Organisms as Biomonitors of Atmospheric Contaminants | 196 |
| 5.6.1 | Accumulation of Persistent Contaminants in Antarctic Lichens | 196 |
| 5.6.2 | The Potential Role of Bryophytes as Biomonitors | 200 |
| 5.7 | Anthropogenic Impact on Lakes and Streams | 203 |
| 5.8 | Summary | 206 |
| 6 | Contaminants in Antarctic Seawater and Sediments | 209 |
| 6.1 | Introduction | 209 |
| 6.2 | Trace Elements in Antarctic Marine Waters | 211 |

| | | |
|-------|--|------------|
| 6.2.1 | Element Input from Atmospheric Dust in the Southern Ocean | 212 |
| 6.2.2 | Biogeochemistry of Cobalt, Copper, Nickel and Zinc | 216 |
| 6.2.3 | The “Cadmium Anomaly” in the Southern Ocean | 219 |
| 6.2.4 | Natural and Anthropogenic Sources of Lead | 221 |
| 6.2.5 | A Neglected Element: Mercury | 224 |
| 6.3 | Particles Fluxes and the Composition of Surface Sediments | 226 |
| 6.4 | Environmental Pollution in Marine Coastal Areas | 231 |
| 6.4.1 | The Impact of Disused Whaling Stations in Peri-Antarctic Islands | 232 |
| 6.4.2 | Accidental Oil Spills | 233 |
| 6.4.3 | The Impact of Coastal Scientific Stations | 237 |
| 6.5 | Effects of Local Environmental Pollution on Benthic Communities | 242 |
| 6.6 | Summary | 246 |
| | | |
| 7 | Persistent Contaminants in Antarctic Marine Food Chains . | 249 |
| 7.1 | Introduction | 249 |
| 7.2 | Trace Elements and POPs in Pelagic Plankton | 251 |
| 7.2.1 | Bioaccumulation of Persistent Contaminants in <i>Euphausia superba</i> (Krill) | 255 |
| 7.3 | Transfer of Contaminants in Pelagic Food Chains | 259 |
| 7.3.1 | The (Hyper)Accumulation of Cd and Hg in Pelagic Seabirds | 261 |
| 7.3.2 | POPs and Heavy Metals in Pelagic Marine Mammals | 266 |
| 7.4 | Contaminants in Coastal Benthic Organisms | 270 |
| 7.4.1 | Metal Accumulation and Homeostasis in Antarctic Molluscs | 273 |
| 7.4.2 | Antarctic Fish and the Transfer of Contaminants to Higher Vertebrates | 276 |
| 7.5 | Contaminants in Birds and Seals Breeding in Antarctica . . | 279 |
| 7.5.1 | Penguins as Biomonitor Organisms | 280 |
| 7.5.2 | Contaminants in Seals and in a Top Predator Bird: the South Polar Skua | 282 |
| 7.6 | Summary | 287 |
| | | |
| 8 | Climate Change, Anthropogenic Impact and Environmental Research in Antarctica: a Synthesis and Perspectives | 291 |
| 8.1 | Introduction | 291 |
| 8.2 | Climate Change and Pathways of Persistent Contaminants . | 294 |
| 8.2.1 | Future Trends in Trace Metal Deposition | 295 |

| | |
|---|------------|
| Contents | XV |
| 8.2.2 The Unpredictable Pathway and Temporal Trend of POPs . . | 297 |
| 8.3 The Development of Large-Scale Monitoring Networks . . . | 299 |
| 8.3.1 Regional Baseline Concentrations of Persistent Contaminants | 301 |
| 8.3.2 Circumpolar Biomonitoring of Coastal Marine Ecosystems . | 304 |
| 8.4 Global Environmental Challenges and the Reduction of Adverse Impacts in Antarctica | 307 |
| 8.5 Science and the Protection of the Antarctic Environment . . | 309 |
| 8.6 Summary | 311 |
| | |
| References | 315 |
| | |
| Geographical Index | 379 |
| | |
| Subject Index | 385 |
| | |
| Taxonomic Index | 393 |

