

# Contents

<b>1</b>	<b>Antarctica: Geomorphology and Climate Trends . . . . .</b>	<b>1</b>
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
<b>2</b>	<b>Glacial, Terrestrial and Freshwater Ecosystems . . . . .</b>	<b>43</b>
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
<b>3</b>	<b>The Southern Ocean Environment: Anthropogenic Impact and Climate Change . . . . .</b>	<b>83</b>
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
<b>4</b>	<b>Persistent Contaminants in the Antarctic Atmosphere . . . . .</b>	<b>125</b>
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
<b>5</b>	<b>Persistent Contaminants in Snow, Terrestrial Ecosystems and Inland Waters . . . . .</b>	<b>163</b>
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 Biomonitor of Atmospheric Contaminants . . . . .	196
5.6.1	Accumulation of Persistent Contaminants in Antarctic Lichens . . . . .	196
5.6.2	The Potential Role of Bryophytes as Biomonitor . . . . .	200
5.7	Anthropogenic Impact on Lakes and Streams . . . . .	203
5.8	Summary . . . . .	206
<b>6</b>	<b>Contaminants in Antarctic Seawater and Sediments . . . .</b>	<b>209</b>
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	 <b>Persistent Contaminants in Antarctic Marine Food Chains .</b>	 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	 <b>Climate Change, Anthropogenic Impact and Environmental Research in Antarctica: a Synthesis and Perspectives . . . .</b>	 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



Antarctic Ecosystems

Environmental Contamination, Climate Change, and  
Human Impact

Bargagli, R.

2005, XX, 398 p., Softcover

ISBN: 978-3-540-74005-6