

Contents

List of Contributors	xi	Astronomical Theory of Climate Change	51
Preface	xxv	<i>André Berger</i>	
Acknowledgements	xxvii	Atmospheric Circulation During the Last Glacial Maximum	57
Aerosol (Mineral)	1	<i>David Rind</i>	
<i>Ina Tegen</i>		Atmospheric Evolution, Earth	61
Albedo Feedbacks	2	<i>James Farquhar</i>	
<i>Andrew A. Lacis</i>		Atmospheric Evolution, Mars	66
Alkenones	4	<i>David C. Catling</i>	
<i>Mark Pagani</i>		Atmospheric Evolution, Venus	75
Ancient Cultures and Climate Change	6	<i>Bruce Fegley, Jr.</i>	
<i>Vivien Gornitz</i>		Banded Iron Formations and the Early Atmosphere	85
Animal Proxies, Invertebrates	10	<i>Bruce M. Simonson and Alan J. Kaufman</i>	
<i>Robert R. Gaines and Mary L. Droser</i>		Basal Ice	89
Animal Proxies – Vertebrates	13	<i>Peter G. Knight</i>	
<i>Thomas H. Rich and Patricia Vickers-Rich</i>		Beachrock	89
Antarctic Bottom Water and Climate Change	16	<i>Ian D. Goodwin</i>	
<i>Stan Jacobs</i>		Beetles as Quaternary and Late Tertiary Climate Indicators	90
Antarctic Cold Reversal	22	<i>G. Russell Coope</i>	
<i>Vincent I. Morgan</i>		Beryllium-10	92
Antarctic Glaciation History	24	<i>Jürg Beer</i>	
<i>Kathy Licht</i>		Binge-Purge Cycles of Ice Sheet Dynamics	94
Antarctic Sea Ice History, Late Quaternary	31	<i>Martin J. Siegert</i>	
<i>Xavier Crosta</i>		Bolide Impacts and Climate	96
Archean Environments	34	<i>Michael R. Rampino</i>	
<i>William H. Peck and John W. Valley</i>		Bølling-Allerød Interstadial	100
Arctic Sea Ice	38	<i>Wim Z. Hoek</i>	
<i>Anne de Vernal</i>			
Arid Climates and Indicators	45		
<i>Andrew Goudie</i>			

Borehole Climatology <i>Hugo Beltrami and Daniela Nitoiu</i>	103	Cordilleran Ice Sheet <i>John J. Clague</i>	206
Carbon Cycle <i>Abraham Lerman</i>	107	Cosmogenic Radionuclides <i>Jürg Beer</i>	211
Carbon Dioxide and Methane, Quaternary Variations <i>Bernhard Stauffer</i>	118	Cretaceous Warm Climates <i>Erle G. Kauffman and Claudia C. Johnson</i>	213
Carbon Dioxide, Dissolved (Ocean) <i>Richard E. Zeebe and Dieter A. Wolf-Gladrow</i>	123	Cretaceous/Tertiary (K-T) Boundary Impact, Climate Effects <i>Elisabetta Pierazzo</i>	217
Carbon Isotope Variations Over Geologic Time <i>Ján Veizer</i>	128	Cryosphere <i>Philippe Huybrechts</i>	221
Carbon Isotopes, Stable <i>Steven W. Leavitt</i>	133	Cyclic Sedimentation (Cyclothem) <i>Allen W. Archer</i>	226
Carbonate Compensation Depth <i>Torsten Bickert</i>	136	Dansgaard-Oeschger Cycles <i>Irene A. Mogensén</i>	229
Carbonates, Cool Water <i>Jonathan Clarke</i>	138	Dating, Amino Acid Geochronology <i>Gifford H. Miller</i>	233
Carbonates, Warm Water <i>Dan Bosence</i>	143	Dating, Biostratigraphic Methods <i>Peter M. Sadler</i>	237
Cenozoic Climate Change <i>James D. Wright</i>	148	Dating, Dendrochronology <i>Brendan M. Buckley</i>	239
Cirques <i>Peter G. Knight</i>	155	Dating, Fission-Tracks <i>John I. Garver</i>	247
CLAMP <i>Robert A. Spicer</i>	156	Dating, Luminescence Techniques <i>Glenn W. Berger</i>	249
CLIMAP <i>James D. Hays</i>	158	Dating, Magnetostratigraphy <i>Wout Krijgsman and C. G. Langereis</i>	252
Climate Change, Causes <i>Thomas J. Crowley</i>	164	Dating, Radiometric Methods <i>Chris M. Hall</i>	255
Climate Forcing <i>Andrew A. Lacis</i>	174	Deep Sea Drilling Project (DSDP) <i>William W. Hay</i>	260
Climate Variability and Change, Last 1,000 Years <i>Michael E. Mann</i>	178	Deltaic Sediments, Climate Records <i>Steven L. Goodbred, Jr.</i>	265
Coal Beds, Origin and Climate <i>C. Blaine Cecil and Sandra G. Neuzil</i>	181	Dendroclimatology <i>Brendan M. Buckley</i>	269
Coastal Environments <i>Robert W. Dalrymple and Kyungsik Choi</i>	183	Desert Varnish as a Paleoclimate Proxy <i>Ronald I. Dorn</i>	275
Coccoliths <i>Jeremy R. Young</i>	187	Deuterium, Deuterium Excess <i>Gilles Delaygue</i>	278
COHMAP <i>Thompson Webb III</i>	188	Diamicton <i>John Menzies</i>	278
Continental Sediments <i>Marc S. Hendrix</i>	192	Diatoms <i>Amy Leventer</i>	279
Corals and Coral Reefs <i>John E. N. Veron</i>	198	Dinoflagellates <i>Anne de Vernal</i>	280

Dole Effect <i>Georg Hoffmann</i>	282	Glacial Isostasy <i>Kurt Lambeck</i>	374
Drumlins <i>Peter G. Knight</i>	284	Glacial Megalakes <i>Victor R. Baker</i>	380
Duricrusts <i>David J. Nash</i>	284	Glacial Sediments <i>Douglas I. Benn</i>	382
Dust Transport, Quaternary <i>Karen E. Kohfeld and Ina Tegen</i>	286	Glaciations, Pre-Quaternary <i>Emmanuelle Arnaud and I. Peter Martini</i>	384
Early Paleozoic Climates (Cambrian-Devonian) <i>Arthur J. Boucot</i>	291	Glaciations, Quaternary <i>Shawn J. Marshall</i>	389
Earth Laws and Paleoclimatology <i>Rhodes W. Fairbridge (deceased)</i> <i>and Vivien Gornitz</i>	294	Glaciofluvial Sediments <i>Douglas I. Benn</i>	394
Eccentricity <i>Marie-France Loutre</i>	301	Glaciomarine Sediments <i>Kathy Licht</i>	395
Eemian (Sangamonian) Interglacial <i>Ulrich C. Müller</i>	302	Glendonite/Ikaite <i>Ian P. Swainson</i>	396
Electrical Conductivity <i>Kendrick Taylor</i>	308	"Greenhouse" (Warm) Climates <i>Darren R. Gröcke</i>	397
Eolian Dust, Marine Sediments <i>David K. Rea</i>	308	Heat Transport, Oceanic and Atmospheric <i>Dan Seidov</i>	407
Eolian Sediments and Processes <i>Daniel R. Muhs</i>	312	Heinrich Events <i>Sidney Hemming</i>	409
Eolianite <i>David B. Loope</i>	319	History of Paleoclimatology <i>Rhodes W. Fairbridge (deceased)</i>	414
Eskers <i>Peter G. Knight</i>	320	History of Paleoclimatology – Biographies <i>Rhodes W. Fairbridge (deceased)</i> <i>and Vivien Gornitz</i>	428
Evaporites <i>Stefano Lugli</i>	321	Holocene Climates <i>Neil Roberts</i>	438
Evolution and Climate Change <i>David A. T. Harper</i>	325	Holocene Treeline Fluctuations <i>Mel A. Reasoner and Willy Tinner</i>	442
Faint Young Sun Paradox <i>James Farquhar</i>	333	Human Evolution and Climate Change <i>Gail M. Ashley</i>	446
Flood Basalts: Climatic Implications <i>Andrew D. Saunders</i>	335	Hypsithermal <i>Rhodes W. Fairbridge (deceased)</i>	451
Foraminifera <i>Harry J. Dowsett</i>	338	Ice Cores, Antarctica and Greenland <i>Dominique Raynaud and Frédéric Parrenin</i>	453
Geochemical Proxies (Non-Isotopic) <i>Matthew J. Higginson</i>	341	Ice Cores, Mountain Glaciers <i>Lonnie G. Thompson</i>	457
Glacial Erratics <i>Patrick M. Colgan</i>	354	"Icehouse" (Cold) Climates <i>Paul K. Link</i>	463
Glacial Eustasy <i>Stephen F. Pekar</i>	354	Ice-Rafted Debris (IRD) <i>Julian A. Dowdeswell</i>	471
Glacial Geomorphology <i>John Menzies</i>	361		

Integrated Ocean Drilling Program (IODP) <i>Manik Talwani</i>	473	Maunder Minimum <i>Drew T. Shindell</i>	550
Interstadials <i>Wim Z. Hoek</i>	477	Medieval Warm Period <i>Rhodes W. Fairbridge</i> (deceased)	551
Iron and Climate Change <i>David Archer</i>	478	Mesozoic Climates <i>Gregory D. Price</i>	554
Isotope Fractionation <i>Dieter A. Wolf-Gladrow and Richard E. Zeebe</i>	479	Messinian Salinity Crisis <i>Stefano Lugli</i>	559
Kames <i>Peter G. Knight</i>	483	Methane Hydrates, Carbon Cycling, and Environmental Change <i>Gerard R. Dickens and Clayton Forswall</i>	560
Kettles <i>Peter G. Knight</i>	483	Mid-Pliocene Warming <i>Mark A. Chandler</i>	566
Lacustrine Sediments <i>Bernd Zolitschka and Dirk Enters</i>	485	Millennial Climate Variability <i>Gerard Bond (deceased)</i>	568
Lake-Level Fluctuations <i>Mark B. Abbott and Lesleigh Anderson</i>	489	Mineral Indicators of Past Climates <i>Vivien Gornitz</i>	573
Last Glacial Maximum <i>David Q. Bowen</i>	493	Monsoons: Pre-Quaternary <i>Pinxian Wang and Qianyu Li</i>	583
Last Glacial Termination <i>Didier Paillard</i>	495	Monsoons, Quaternary <i>Anil K. Gupta</i>	589
Late Paleozoic Paleoclimates <i>Anne Raymond and Christopher R. Scotese</i>	498	Moraines <i>Peter G. Knight</i>	594
Late Quaternary Megafloods <i>Victor R. Baker</i>	504	Mountain Glaciers <i>Lonnie G. Thompson</i>	595
Late Quaternary-Holocene Vegetation Modeling <i>Jed O. Kaplan</i>	507	Mountain Uplift and Climate Change <i>Douglas W. Burbank</i>	596
Laterite <i>Michael Widdowson</i>	514	Nearest-Living-Relative Method <i>Volker Mosbrugger</i>	607
Laurentide Ice Sheet <i>Arthur S. Dyke</i>	517	Neogene Climates <i>Carin Andersson</i>	609
Little Ice Age <i>Drew T. Shindell</i>	520	Nitrogen Isotopes <i>Julian P. Sachs</i>	612
Loess Deposits <i>Konstantin G. Dlussky</i>	522	North Atlantic Deep Water and Climate Change <i>Thomas M. Marchitto, Jr.</i>	614
Marine Biogenic Sediments <i>Wolfgang H. Berger and Gerold Wefer</i>	525	North Atlantic Oscillation (NAO) Records <i>Heidi M. Cullen</i>	619
Marine Carbon Geochemistry <i>David Archer</i>	533	Obliquity <i>Marie-France Loutre</i>	625
Marine Clay Minerals <i>Alastair Ruffell</i>	539	Ocean Anoxic Events <i>Bradley Sageman</i>	626
Mars: Water and Past Climates <i>Phillip R. Christensen</i>	540	Ocean Drilling Program (ODP) <i>Joanne C. Reuss</i>	630
Mass Extinctions: Role of Climate <i>Garland R. Upchurch, Jr.</i>	547		

Ocean Paleocirculation <i>Roger Francois</i>	634	Paleosols, Quaternary <i>Tatiana D. Morozova and Andrei A. Velichko</i>	752
Ocean Paleoproductivity <i>Adina Paytan</i>	644	Paleotemperatures and Proxy Reconstructions <i>Thomas M. Cronin</i>	757
Ocean Paleotemperatures <i>Mara Weinelt</i>	651	Paleotempestology, the Sedimentary Record of Intense Hurricanes <i>Jeffrey P. Donnelly</i>	763
Organic Geochemical Proxies <i>Philip A. Meyers</i>	659	Palynology <i>Margaret Kneller and Sarah Fowell</i>	766
Ostracodes <i>Thomas M. Cronin</i>	663	Patterned Ground <i>Matthew R. Bennett</i>	768
Outwash Plains <i>Peter G. Knight</i>	665	Periglacial Geomorphology <i>Brigitte Van Vliet-Lanoë</i>	770
Oxygen Isotopes <i>Gilles Delaygue</i>	666	Phosphorite <i>Yehoshua Kolodny</i>	775
PAGES <i>Keith Alverson and Christoph Kull</i>	675	Phosphorus Cycle <i>Gabriel M. Filippelli</i>	780
Paleobotany <i>Elizabeth A. Kowalski and David L. Dilcher</i>	679	Pingos <i>Matthew R. Bennett</i>	783
Paleocean Modeling <i>Matthew Huber</i>	683	Plate Tectonics and Climate Change <i>Robert M. DeConto</i>	784
Paleoceanography <i>Katrin J. Meissner, Alvaro Montenegro, and Chris Avis</i>	690	Pleistocene Climates <i>David Q. Bowen</i>	798
Paleocene-Eocene Thermal Maximum <i>Gavin A. Schmidt</i>	696	Pliocene Climates <i>Alan M. Haywood</i>	804
Paleoclimate Modeling, Pre-Quaternary <i>Christopher J. Poulsen</i>	700	PMIP <i>Vivien Gornitz</i>	813
Paleoclimate Modeling, Quaternary <i>Robert J. Oglesby and Kirk A. Maasch</i>	709	Pollen Analysis <i>Margaret Kneller</i>	815
Paleoclimate Proxies, an Introduction <i>Vivien Gornitz</i>	716	Potassium-Argon/Argon-Argon Dating <i>Chris M. Hall</i>	823
Paleo-El Niño-Southern Oscillation (ENSO) Records <i>Michael K. Gagan</i>	721	Precession, Climatic <i>Marie-France Loutre</i>	825
Paleogene Climates <i>Donald R. Prothero</i>	728	Pre-Quaternary Milankovitch Cycles and Climate Variability <i>Paul E. Olsen and Jessica H. Whiteside</i>	826
Paleohydrology <i>Françoise Gasse</i>	733	Proglacial Lacustrine Sediments <i>Wibjörn Karlén</i>	835
Paleolimnology <i>Philip Barker</i>	738	Proterozoic Climates <i>Grant M. Young</i>	836
Paleo-Ocean pH <i>Martin R. Palmer</i>	743	Quaternary Climate Transitions and Cycles <i>Mark Maslin</i>	841
Paleo-Precipitation Indicators <i>Paul A. Baker</i>	746	Quaternary Vegetation Distribution <i>John Jack W. Williams</i>	856
Paleosols, Pre-Quaternary <i>Steven G. Driese</i>	748	Radiocarbon Dating <i>R. Ervin Taylor</i>	863

Radiolaria <i>Adolfo Molina-Cruz (deceased) and Kjell R. Bjørklund</i>	869	Sun-Climate Connections <i>Peter F. Almasi and Gerard Bond (deceased)</i>	929
Red Beds <i>Nathan D. Sheldon</i>	871	Tephrochronology <i>Andrew J. Dugmore and Anthony Newton</i>	937
Roches Moutonnées <i>Matthew R. Bennett</i>	873	The 8,200-Year BP Event <i>Allegra N. LeGrande</i>	938
Sapropels <i>Kay-Christian Emeis</i>	875	Thermohaline Circulation <i>Andrew J. Weaver and Oleg A. Saenko</i>	943
Scandinavian Ice Sheet <i>Jan Mangerud</i>	877	Tills and Tillites <i>Douglas I. Benn</i>	948
Sea Level Change, Last 250 Million Years <i>Kenneth G. Miller</i>	879	Time-Series Analysis of Paleoclimate Data <i>David J. Thomson</i>	949
Sea Level Change, Post-Glacial <i>Vivien Gornitz</i>	887	Transfer Functions <i>Stephen Juggins</i>	959
Sea Level Change, Quaternary <i>John M. Chappell</i>	893	Triassic-Jurassic Climates <i>Gregory J. Retallack</i>	962
Sea Level Indicators <i>Michael S. Kearney</i>	899	Uranium-Series Dating <i>Yemane Asmerom</i>	969
Sedimentary Indicators of Climate Change <i>Joseph P. Smoot</i>	902	Varved Sediments <i>Matti Saarnisto and Antti E. K. Ojala</i>	973
Snowball Earth Hypothesis <i>Grant M. Young</i>	907	Volcanic Eruptions and Climate Change <i>Richard B. Stothers</i>	976
SPECMAP <i>Franck C. Bassinot</i>	911	Weathering and Climate <i>Louis A. Derry</i>	981
Speleothems <i>Yemane Asmerom</i>	916	Wisconsinan (Weichselian, Würm) Glaciation <i>John T. Andrews</i>	986
Stable Isotope Analysis <i>Germán Mora</i>	918	Younger Dryas <i>Dorothy M. Peteet</i>	993
Strontium Isotopes <i>Ján Veizer</i>	923	Author Index	997
Sulfur Isotopes <i>Harald Strauss and Ján Veizer</i>	926	Subject Index	999
		Appendix	1049