

Index

Note: Page numbers in *italics* denote figures, while those in **bold** denote tables.

- ablation 88, 263
- accumulation area ratio 88
- adfreeze 58–59, 97
- aggradation 199, 212–214
- alluvial fan, paraglacial 74
- alluvial fill 199
- alveolar weathering 19
- angle of friction 181, 191–195
- anthropogenic forcing 2

- basal adfreezing 58–59
- basal ice 57–69, 58, 91
 - characteristics 65
 - debris content 57
 - debris entrainment 58–59, 62–63
 - dynamic response 58
 - facies 58
 - formation 57–59, 61–63, 63–64
 - isotopic signature 57–58
 - permafrost environment 61–63
 - shearing hypothesis 58–59, 62
 - types 64
- biochemical processes 44
- biogeochemical cycling 1
- biological weathering 14–15, 17, 18, 29, 45
- blockfields 12, 19, 85, 91, 92
 - age estimates 91
 - interpretation 91
- British Columbia 199–218
 - geomorphology 201–202
 - glacier advances 211
 - lithostratigraphy 206, 207, 208, 209–211, 209, 210
 - moraines 202
 - Nostetuko River 199–200, 201, **205**, 213
 - Quaternary volcanic landscapes 219–233
 - radiocarbon ages 211
 - sediment chronology 211–212, 213
 - sedimentology 204–209
 - study area 199–200, 200, 220–222, 221
 - terraces 203, 204
- brunification 15
- buried glacier ice 60–61, 64

- Cheekye basin, paraglacial sediment
 - budget 225–227, **226**, 227
- Cheekye fan 222–225, 223
 - glacier terminus 225
 - ice-contact sediments 226
 - radiocarbon dating **224**
- chemical erosion 43
 - rates 29, **43**
 - solute runoff 34–36
- chemical weathering 14–15, 16, 29, 44, 46
- Clapeyron equation 63
- climate
 - regions 6
 - Würmian bioclimatic zones 6
- climate change
 - effects 1
 - timescale of landform response 263
- climate forcing 2
 - external 258
- climate sensitivity 257–265
 - definition 257, 258
 - feedbacks 258, 260
 - and geomorphology 260–261
 - glacial regions 260
 - Last Glacial Maximum 259–260
 - modelling 260
 - not a constant 259–260
 - periglacial regions 260
 - regional variation 263
 - volcanic eruptions 259
- climatic geomorphology 5–28
- climatic variability
 - altitudinal 85
 - spatial 85
- cold-climate
 - geomorphology 15–19, 18, 24
 - processes 165
- corrie widening 121
 - rock slope failure 113, 115
- cosmogenic isotope surface exposure dating 133, 135, 139
- cryoplanation 7, 12
- cryosol 15
- cryoturbation 10

- dating 19, 20
 - controls on 152
 - see also* cosmogenic isotope surface exposure dating; radiocarbon dating; tree ring series
- debris flows 183
- debuttressing 238
- decarbonization 15
- deglaciation 72
 - paraglacial response 261
- delta formation 159
- denudation **10**, 251–252
 - measurement 33
 - total denudation rate 44
- discrete debris accumulations 85–102, 92
 - and climate 91
 - interpretation 85–86, **98–99**
 - see also* landslides; rock avalanche; rock slope failure; talus slopes
- disturbance regimes 248–249, 252
 - landscapes 235–255
- dynamic geomorphology 80–82

- England, Milfield Basin 145–164
- Equilibrium Line Altitude 87–88, 238
- erosion
 - rates 40–44
 - rock slope failure 103
 - wind 19
 - see also* chemical erosion; glacial erosion

- firn field 140–141
- floodplain stability 199, 212–214
- fluvial deposits
 - dating 145–147, 150
 - response to climate change 215
- fluvial downcutting
 - sediment yield 145
 - valley incision 145
- fluvial systems 219
 - climate change indicators 199
 - glacial catchment 145
 - glacier fluctuations 199–218
 - landslide interrupted 247, 252
 - paraglacial adjustment 145–164
 - response to climate change 145
 - sediment yield 219
- fluvial terraces 145
- fracture enlargement 29, 30, 36, **37**, 38, 40, 46
 - measurement 33
 - process 46
 - rate 46
 - and surface lowering 46
- fractures, and weathering rind 46
- freeze thaw 12, 13, 71, 72, 133, 135, 238
 - experiments 10–12, 13
 - mechanisms 14
- frost bursting 12
- frost heave 10, 11, 12, 63–64
 - models 63
 - tests 51
- frost mounds 21
- frost shattering 7, 12, 13
- frost wedging 12

- gelification 12
- geoarchaeological methods 150–151
- geocryology 18
- geomorphology 3, 7, 81
 - characteristic form time 82
 - and climate sensitivity 260–261
 - cold region 15–19, 18, 24
 - mapping 184
 - reaction time 82
 - relaxation time 82
 - response to climate change 3, 257–265
 - see also* climatic geomorphology; dynamic geomorphology
- Gilgit–Hunza basin 239–244
 - geological setting 239
 - glacial–paraglacial relations 239–244
 - glacier flow patterns 243
 - landslides 244
 - rock avalanches 240, 242, **242**, 243, 246, 248
 - rock slope failures **241**, **242**, 243
- glacial deposits
 - climatic signals 85
 - debris inputs 85
 - formation 85
- glacial erosion
 - debutressing 235
 - oversteepening 235
- glacial ice facies 61
- glacial polish 14
- glacial regions, climate sensitivity 260
 - glacial striations 45
 - glacial systems
 - climate 88, 90
 - debris input 90–91, 90, 93
 - global warming 261
 - water 90
 - glacial trough 121
 - cross section 103
 - overwidening 128–129
 - rock slope failure 103–131
 - size 128–129
 - see also* trough widening
 - glacial–interglacial cycles 81, 177
 - glacial–paraglacial cycle 72, 73, 126, 127, 128, 129
 - evolutionary model 126
 - feedbacks 103, 129
 - frequency 126
 - rock slope failure model 129
 - glacial–paraglacial relations 239–244
 - glacier advance 88, 199
 - and aggradation 214–215
 - fluvial response 199–218, 214–215
 - glacier mass balance 260, 261
 - Holocene 199–218
 - and moraines 86
 - glacier–permafrost interactions 62–63, 66
 - glaciers 57
 - ablation 88
 - accumulation 88
 - alpine 214
 - altitude 95
 - cold based 63
 - debris content 97
 - discrete debris accumulations 85–102
 - distance from the sea 95
 - flow patterns 243
 - glaciation limit 86–88, 87
 - glacier bed 63
 - size 86–87
 - terminus head altitude ratio 88
 - see also* basal ice; plateau glaciers; small glaciers
 - glacigenic sediments
 - paraglacial reworking 181, 182–184
 - quasi stable storage 195
 - glaciodeltaic landform–sediment associations 151
 - glaciodeltaic sediments 145–147
 - glaciodeltaic terraces 151–153, 153
 - glaciofluvial landform–sediment associations 151
 - glaciofluvial terraces 151–153, 153
 - glaciohydraulic supercooling 59
 - glaciolacustrine deposits 151
 - glaciolacustrine landform–sediment associations 151
 - glaciolacustrine sediments 145–147
 - global climate models 258
 - caveats 261–263
 - feedbacks 263
 - hydrological cycle 263
 - global temperature 259
 - global warming 19–24
 - geoindicators 19–21, 21
 - spatial variability 260–261
 - gravitational spread *see* sacking features

- Great Britain
 rockfall talus slopes 133–144
see also England; Scottish Highlands
 grèzes litées 5, 6
 ground ice, two stage development model 65
 ground penetrating radar 138
- Holocene, glacier fluctuations 199–218
- ice *see* basal ice; buried glacier ice; ground ice; intrasedimental ice; massive ice; pore ice; segregation ice
- ice classification schemes 57
- ice core record 81
- ice dykes 60
- ice extent, debris flux 90–91
- ice lens formation 51–52
- ice sediment classification 57, 65, 66
- ice stream dynamics 63–64
 water supply 64
- ice volumes 86
- ice wedge polygons 10, 21, 156, 160
- ice-contact sediments 226
- ice-dammed lake 145
- interglacials 2
- intrasedimental ice 64, 65
- Ireland
 Ballintra West 171, 171, 172
 Ballycreeen Strand 168–171, 170
 Cnoc na nAcraí 172–174, 173
 Knockadoon Head 168, 169
 Quaternary lithostratigraphy 165–180, 167
 regional stratigraphic framework 166–168
 stratigraphic interpretation 175–177, 176
 study sites 167
 talus slopes 133–144
 White Strand 174–175, 174
- lacustrine deposits 246
 interpretation 247–248
- landslide dams 244–247, 246, 247
 sediment delivery 249
- landslide–interruption complexes 244–247, 246
- landslides 227–229
 controls on 235
 frequency–magnitude model 229, 230
 glacially conditioned 229–230, 231, 235–255
 interpretation 247–251
 paraglacial adjustment 237–239
 post glacial denudation 251–252
 temporal distribution 238
 trigger event 238
see also discrete debris accumulations; rock avalanche; rock slope failure
- Light Detection and Ranging (LiDAR) 151
- lithalsas *see* palsas
- lithosol 15
- lithostratigraphy
 interpretation 165, 175–177, 176
 limitations 177–178
 relative age tool 166
 transition count matrix 177
- marine isotope stage 165
- Markov chain analysis 178
- mass movement, magnitude–frequency 235
- massive ice 57–69, 60, 61
 origin 60–61, 64–65
- mean surface temperature 257–258
- mechanical weathering 29
- microweathering
 data 37
 moisture 29
 processes 29–49
 rates 29–49, 47
- Milankovich forcing 2
- Milfield Basin 145–164, 146
 age-elevation of active channel 160
 delta formation 159
 fluvial sequences 153–159, 158
 geomorphological map 154
 landform assemblages 148, 149
 landform interpretation 159–162
 model of lake drainage 159–161
 paraglacial systems 159
 Quaternary history 147–150
 river long profile 150, 153
 sediment core logs 155, 157
 sediment dating 152
 study area 147–150
 Till–Tweed Geoarchaeology Project 147
 valley floor cross profile 157, 158
 valley floor incision phases 159–160
- moraines 85
 bulk density 185
 dating 88
 dry densities 188, 188
 evolution 184
 formation 182, 195
 frozen sediment 62, 63
 geotechnical properties 182, 195
 glacier mass balance 86
 interpretation 86, 90, 93
 morphology 184
 oversteepening 181
 particle shape 189, 191, 192–194
 particle size 184, 188, 189, 194
 proxy records 215
 record sensitivity 215
 sediment storage 195
 slope angles 184
 slope gradient dispersal diagrams 187
 slope profile 186, 187, 188
 surface lowering rates 194–195
see also steep lateral moraines
- morphodynamics 12
- Mount Garibaldi 222–225, 223
 deglaciation 222–225, 227
 glacier terminus 225
 post glacial phase 225
 sediment deposits 222–225, 227
 volcano growth 222
- Mount Meager
 landforms 228
 landslide frequency–magnitude model 229, 230
 landslides 227–229
 sediment pulsing 227–229
 sediment yield curve 229

- nivation 12–14
 northern hemisphere temperature anomaly 260–261,
 262, **263**
 Norway
 annual temperature 31
 erosion rates 40–44, **43**
 geomorphic environment 30–33
 landscape 31
 lithology 31
 microweathering 29–49, **37**
 precipitation 31
 rock slope failure 108–114, **110**, 116–117
 soil development 31
 solite data **35**, 36, 36
 study locations 30, 31–33, 32
 vegetation 31
 weathering rates 34–36, 40–44
 Nostetuko River 199–200
 aerial photos 201
 aggradation history 200
 radiocarbon ages **205**
 sediment chronology 213
 stratigraphic logs 200
 topographic maps 200

 oxidation 15

 Pakistan
 Upper Indus Basin 235–255, 236
 see also Gilgit–Hunza basin
 palaeogeographical reconstruction 5
 paleic relief 129
 palsa formation 55
 buoyancy 51–56
 model 51–52, 53
 phases 54
 palsas 21, 21
 environmental indicators 55
 force balance 53
 internal structure 52
 paraglacial 71–84
 alluvial fan 74
 definition 71, 73, 134
 environments 1–3
 fluvial response 162
 mass movement 195
 models 80, 145
 processes 23, 24, 76, 181, 183, 235
 and proglacial 76
 rock slope failure 103–131, 133,
 139, 140
 scree 95
 slope adjustment 181–197
 transitional landscapes 79–82
 valley fill 74
 see also zone of paraglacial relaxation
 paraglacial cycle 161, 219, 220
 rock slope failure 126
 paraglacial geomorphology 19, 24
 definition 219
 publications 73
 Quaternary volcanic landscapes 219–233
 paraglacial landforms 23, 76
 classification 159
 scales of 75, 76–77
 transient 71, 79–82
 paraglacial sediment exhaustion model 2, 23, 24,
 77–79, 78, 219, 220, 227, 230, 238
 paraglacial sediment wave model 76–78, 78
 paraglacial sediments 1, 73–75, 219
 extrinsic perturbation 231–232
 pulses 214
 release 79, 80
 yield 76, 78, 78, 145, 214
 paraglacial systems
 evolution 73–76
 global warming 261
 interpretation 159–162
 origin 73–76
 secondary 159
 partitioned landscapes 249–251, 250, 252
 peat
 deposit age 206, 212–214
 deposition of 199, 212–214
 physical properties 51, 53, 55
 periglacial 1–3, 71–84, 238
 definition 71
 equilibrium 72, 73
 erosion cycle 7
 sediments 1
 periglacial geomorphology 5–28
 development of 5, 7–12
 periglacial landforms 1, 72, 133
 evolution 73
 periglacial processes 7, 72, 243
 monitoring 22
 slope dynamics 8–9
 periglacial regions, climate sensitivity
 260, 261
 periglacial–glacial system 72, 73
 periglacial–paraglacial indicators 134–141
 permafrost 51, 57, 71, 72, 133, 243
 active layer 22, 238
 CO₂ degassing 3
 distribution 3
 rock glaciers 97
 spatial changes 21–22
 subaerial aggradation 60
 temporal changes 21–22
 thaw 19–21
 thickness 3
 physical weathering 46
 pingos 10, 11
 plateau glaciers 85, 88–90, 89, 92
 centre of mass 90
 Pleistocene
 deglaciation 145–164
 Europe 5–7
 podolization 15
 polygonal ice wedge casts *see* ice wedge polygons
 pore ice 65
 porewater pressure 60
 porosity 44–45
 precipitation 1
 trends 263
 proglacial 71–84
 definition 71
 equilibrium 73

- fluvial archive 199
- sediment 72–73
- proglacial lakes 162
- proglacial landforms 72–73
 - classification **77**
- proglacial rivers, hydrology 72
- protalus lobes 97
- protalus ramparts 95–96, 96, 133–134, 140–141
 - origin 140–141
- protalus rock glaciers 138–140
 - interpretation 138
- pseudokarren 29, 39, 42, 45

- Quaternary lithostratigraphy 165–180
- Quaternary volcanic landscapes
 - paraglacial geomorphology 219–233
 - study area 220–222, 221

- radiative forcing 257–258
- radiocarbon dating 150, **152**, 199, 201, **205**, 211, 212–214, **224**
- regelation 8, 58–59, 64
- Richter slopes 12
- rim retreats **117**
- river planform 199
- rock avalanche 235, 236, 240, 246
 - as barriers 244–247, 248
 - detachment zone 237, 242
 - emplacement morphologies 237
 - exhaustion model 238
 - lithology 237
 - mechanics 235–236
 - misclassification 237
 - origin 237
- rock glaciers 85, 133–134, 138–140, 139
 - debris proportion 97
 - debris supply 91–95, 94, 95
 - interpretation 93–95
 - origin 93
 - permafrost 97
- rock slope failure 109, 109, 111, 112–113, 114, 115, 116–117, 121, 122, 133, 136
 - ages 104–105
 - breadth 103, 105, 105, **110**
 - catastrophic 235
 - corrie widening 115, 119
 - cumulative impact 126, 127
 - debris 103–104, 106
 - depth of bite 103–104, 105–108, 105, 106, 107, **110**, 114–117, 124–125, 129
 - distribution 251
 - erosion 103
 - geotechnics 104–105
 - glacial trough widening 103–131
 - glacially conditioned 229–230, 231, 235–255
 - glacier exploitation 229
 - incidence 118, 120
 - incipient trough widening 119–124
 - interpretation 105, 236–237
 - long section 104
 - magnitude 106, **241**
 - map based measures 106–108, 107
 - paraglacial 103–131, 139, 140
 - paraglacial cycle 126
 - trough widening 117–124, **117**, 125, 128, 129
 - types 104–105
 - whole valley impact 117–119
 - see also* discrete debris accumulations; landslides; rock avalanche; talus slopes
- rock surface weakening 34, 36–38, **37**, 38
- rockfall talus slopes *see* talus slopes
- rockwall retreat, rates 124–125, 134, 139–140

- sacking features 235, 238, 241–243, 245
- salinization 15
- salt weathering 12
- sand wedges 5, 6
- sandur 75
- Scottish Highlands
 - rock slope failure 106, 108–117, **110**, 111, 114, 112–113, 115, 118, 121, 122, 129
 - study area 108–111, 109
- scree fans 95
- sediment supply 1
 - changes 199
 - controls on 165
- sediment yield 81, 219
- sediment constant 219
- landslides 219
- paraglacial 76, 78, 78, 145, 214
- sediments
 - cold climate 165
 - core logs 155, 157
 - deposition processes 178
 - diffusion rate 229
 - entrainment 78
 - facies 182
 - interpretation 248
 - see also* glacial sediments; paraglacial sediments
- segregation ice 52, 64, 65
- shear box tests 181, 185–188, **188**, 190–191, 191, 195
- shear stress 97
- slope angle 185
 - measurement 184
 - particle shape 189, 191, 192–194
 - particle size 184, 188, 189, 194
 - stabilizing 194
- slope denudation **10**
- slope dynamics 7, 8–9
- slope processes, controls on 238
- slope stability, post glacial 238
- small glaciers, debris supply 91–95, 94
- snowline 88
 - regional 87
- solifluction 3, 39
- solute flux 30, **35**, 36
- sorted circles 10, 11
- spalling 29, 38, 39, 40, 47
- stable isotope analyses 57
- steep lateral moraines 183
 - geotechnical controls 181–197
 - paraglacial slope adjustment 181–197
 - section 193
 - shear surface 193
 - type of failure 191–195
- stone run pavement formation 20

- stress release processes 135
 sturzstrom *see* rock avalanche
 sublimation 263
 surface hardness
 and surface lowering 44, **44**
 and weathering rind 44–45, **44**
 surface lowering 36, **37**
 and fracture enlargement 46
 post glacial rate 29, 30
 rates 43, **43**, 194–195
 and surface hardness 44, **44**
 Switzerland
 climate 182
 Feegletscher Nord glacier 181, 182–184
 geomorphology 183
 moraines 181–197
 study area 182
 tafoni 29, 39, 41, 45
 talus
 accumulation rates 134
 age determination 135
 composition 138
 modification 133
 origin 134
 periglacial development hypothesis 134
 structure 137–138
 talus foot landforms 133–144, 138–140, 139
 debris ramps 140
 evolution models 133
 formation 133
 interpretation 133
 origin 141
 periglacial–paraglacial indicators 134–141
 talus slopes 133–144, 135–138, 136
 evolution models 133
 formation 133
 interpretation 133
 origin 141
 particle size 135–136, 137, 138
 periglacial–paraglacial indicators 134–141
 scarp edge 137, 138, 140
 thaw ponds 21
 thermal weathering 12, 14, 19
 thermokarst 55
 transitional landscapes 249–251, 250
 tree ring series 201, 212–214
 trough widening
 asymmetric profile 119
 feedback 128–129
 incipient 119–124, 124
 paraglacial 120
 rate 130
 rock slope failure 117–124, **117**, 125, 128, 129
 valley floor
 development 157, 158, 161–162
 incision phases 159–160
 paraglacial fill 74
 weathering 12, 14–15, 16, 17, 46
 alveolar 19
 controls on 29, 44–45
 differential 45
 fractures 45–46
 indices 33–34, 36–38, 46
 morphology 38–40
 processes 5, 18–19, 44–45, **44**
 rates 15, **17**, 30, 33, 34, 40–44
 rock type **17**, 18, 29
 signatures 18
 and water chemistry 33, 34
 see also biological weathering; chemical weathering;
 mechanical weathering; microweathering;
 physical weathering; thermal weathering
 weathering pits 39–40, 41, 45
 weathering rind 44, 47
 development 30
 and fractures 46
 and surface hardness 44–45, **44**
 thickness 29, 33–34, 36, **37**, 38
 Würm glaciation 6
 Würmian bioclimatic zones 6
 zone of paraglacial relaxation 103, 126–128, 128, 129,
 161–162