

Index

Note: Page numbers in *italic* denote figures. Page numbers in **bold** denote tables.

- acetaldehyde 156
- acqua alta*, Venice 64, 67
- aesthetic damage 121–125
- air pollution 117–128
 - change in fuel 117–118
 - stone damage 120
- alcohol, anhydrous, as fuel 155–156
- algae 4, 70, 79, 257, 268, 269, 273
- alkyl-alkoxysiloxane, stone treatment 288, **289**, 291–292
- Amarelo de Negrais limestone 99, *100*, 102, 103, 104, 105
- 'Ammonitico rosso' 39, 40
- Anröchte sandstone **141**, 142, *143*, 144, *145*, 146
- Apulia, calcarenite 180
- 'arch mechanism' 29, 30
- Arch-Prison, Lerma, patina 302, *303*
- architecture, Udine 38–39
- ashlar
 - decay 9, 69
 - limestone, Budapest 262, 270, 272, 273
 - rustic 38, 38, 39
 - volcanic tuff, Hungary 251, 252, 253, 256, 258
- attenuation, CT 277–278, 279
- attenuation coefficients 280–281
- Aurisina stone 39, 40
- Azul de Sintra limestone 99, 102, 103

- back-weathering 193–195, *195*
- bacteria 154
- Bad Bentheim Sandstone 201–202
 - petrophysical properties 203–204
 - salt loading 204–208
- Bad Langensalza travertine **141**, *143*
- Basílica da Estrela, Lisbon
 - building materials 102–103
 - stone decay 103–106
 - weathering 99–106
 - granulometry 100–101, 105
- batoliths, granitic, Thailand 45–53
- beam hardening 278, 279
- Belfast, St Matthew's Church, sandstone 3, 5
- biofilms 269, 273
 - see also* weathering, biological
- bitumen, in Dębnik limestone 109, 110
- blackening 121–125
 - and climate change 127–128
 - patterns 124
 - perception 121–123, 124
 - rate 121
- blistering 69, 70
 - Bonamargy Friary 79
 - Budapest limestone 266
- blowouts 69, 70
- Blue Pearl syenite **141**, 142, *143*
- Bollani Arch 38, 38, 39
- Bonamargy Friary 78
 - complex stress history 4
 - conservation treatment **85**
- decay mapping 80–84, *81*
- stone decay 4, 77–85
 - alveolar weathering 78–79
 - biological colonization 4, 79–80
 - connectivity 81–82
 - iron migration 4, 79, 80
 - UAS assessment 84–85
- bowing, marble 237, 238, 243–248
- Bragg diffraction lines, Carrara marble 238–242
- Brazilian test, tensile strength 191, 200
- breccia, Piasentina Stone 39, 39
- bremstrahlung 279
- 3-bromopropyltrimethoxysilane 281–282
- Budapest
 - Citadella Fortress
 - limestone, weathering crust formation 262–274
 - stone decay 69
 - Parliament Building, limestone, weathering crust formation 262–274, 263, 267
 - sulphur dioxide pollution 262, 263–264
- Buntsandstein
 - frost damage 169, 171–176
 - petrophysical properties **168**, 169
 - weathering 169
- Byland Abbey, soft wall capping 310, 311, 313, 314, *315*, 318, 320

- Cabo Ortegal, serpentinite 55–62, 56
- Ca'd'Oro, Venice, Kirmenjak basal course 64, 66
- calcarenite, salt crystallization 179–187
- Calcarenite di Gravina Formation 180–181
 - dry weight loss 183, 184, **184**, **185**, 186
 - porosity 182, 183, 187
 - salt crystallization 183
 - saturation 182
 - uniaxial compressive strength 183, **184**, **185**, 186
- calcário gresoso 89, 96
 - heat-induced laboratory testing 92–96, 93, 94, **95**
- calcite
 - attenuation coefficient 280–281, *281*
 - Dębnik limestone 110, 114
 - Lisbon Cathedral 91, 92, 95
 - recipitation
 - Basílica da Estrela 104, 105
 - Santa Marija Ta' Cwerri 193
 - veins, in serpentinite 55, 57
- calcium, in dust 158
- calcium oxalate, as patina 153, 296, 299, 302, 304
- calcium sulphate 120
- Camaldoli Hill, Piperno 23, 24, 24, 26
- Campanian Ignimbrite 24
- capping *see* wall capping
- carbon
 - elemental, allowable concentration 123
 - organic, air pollution 118
- carbonate
 - and air pollution 120
 - in serpentinite 56–57, 57, 58, 59

- Carmelite Quarry, Dębnik limestone 109, 110, 112
- Carrara marble
 bowing 237, 238, 238, 243–248
 strain testing 239–248
 texture 240
 thermal expansion 243–248
- Cassano Spinola Conglomerate 287, 288
- Cava Ortensia marble **141**, 142, 143, 144–145
- cements
 control on permeability and porosity 226, 230–233
 weathering crusts, Budapest limestone 266, 270, 271, 273
- chisels, historical construction techniques, Udine 40–41
- chloride, in dust 158, 159
- chlorite 56
 acid volcanic tuff 256, 258
 Tak batholith granite 50–52
- Cima di Gioia marble **141**, 143, 145
- Citadella fortress, Budapest
 limestone, weathering crust formation 262–274
 stone decay 69
- Cividale del Friuli, stone portals 35
- clay minerals
 in dust 162, 163
 Lisbon Cathedral 96
 swelling 206, 227, 258
- climate change 118–119, 125–128
 biological weathering 79
 flooding 125, 127
 humidity and precipitation 126–127
 pollution 127–128
 temperature 125–126
 wind 127
- coal
 as fuel 117–118
 pollution 119
- Collegiate of San Pedro, Lerma, patina 302
- colour modification
 heat-induced 88
 laboratory testing 92–96
 Lisbon Cathedral 90–91, 90
- Compton scattering 279
- computerized tomography (CT) 277–285
 neutron 283–284
 detectors 283–284
 geological applications 284
 interaction processes 283
 X-ray 278–283
 detectors 280
 geological applications 280–283
 medical 279–280
 microCT 280–283
- condition assessment 4–6, 82–84
 Bonamargy Friary 82–84
- cone beam CT 278, 280
- connectivity analysis 5, 81–82, 83, 84
- conservation treatment
 Bonamargy Friary **85**
 S. Michele Maggiore Basilica, Pavia 288, **289**, 290–294
 soft wall capping 309–322
see also patinas
- consolidant, surface 288, **289**, 290–292
- construction process, pre-emplacement memory 3
- construction techniques, Udine stone portals 40–41
- contour scaling 2, 5, 88, 91, 96
 Igreja Nossa Senhora do Carmo, Rio de Janeiro 156, 157, 159
 St Matthew's Church, Belfast 3
 salt 159
- Cotta Sandstone 202
 petrophysical properties 203–204
 salt loading 204–208
- Cracow, Dębnik limestone 109, 111
- crumbling, acid volcanic tuff 256, 256, 257
- crusts
 acid volcanic tuff 256
 detachment 271, 273
 stone decay 70, 103, 256, 257
 weathering, Budapest limestone 261–262, 265–274
- crystal growth pressure, linear, sandstone 199–208
- crystallization
 salt 178–187, 190, 193
 linear growth pressure, sandstone 199–208
- cyanobacteria 268, 273
- Czech Republic, dimension stone lithotheque 13, 14
- dacite tuff 252, **253**
- damage development model 193–194, 193
- damage mapping, Globigerina Limestone, Malta 192–195
- D'Arconca, Raimondo, work in Udine 34, 38, 39
- Dębnik limestone 109–115
 bleaching 112–113, 115
 chemical analysis **110**
- decay
 Basílica da Estrela 103–106
 Bonamargy Friary 77–85
 connectivity analysis 5, 81–82, 83, 84
 diagnosis 1–6
 holistic approach 2–3, 4–5, 77, 83
 medical analogy 1–6
 TNM staging system 4–5, 77, 83
 Unit Area Spread condition assessment 4, 77, 83–5, 84
- decay mapping 15, 77
 Bonamargy Friary 80–84, 81
 Worcester College, Oxford 69–74
 DMAP 70–74
- decay mapping in Adobe Photoshop (DMAP) 70–74
- delamination 2, 157
- diagenesis
 and cementation 271
 effect on permeability 227
- diagnosis 1–6
 holistic 2–3, 4
 Bonamargy Friary 82–85
- diesel 117–118, 120, 121
- diffraction, neutron 237, 239, 241–243, 247
- dilation, frost damage 167, 170, 171–176
- dimension stones
 lithotheques 13
 Thailand 43, 45–53, 46
- dimethylpolysiloxane, stone treatment 288, **289**, 291–292
- disaggregation 2

- disintegration, granular 88, 90, 91, 96, 103
dispersion aerosols 154
dolomite 56, 58
 and air pollution 120
 see also marble, dolomite
dressing, pre-emplacement memory 3
Dumfries Sandstone
 complex weathering 212, **213**, 215–217, **218**,
 219–221, 222
 permeability 229, **230**, 231–232
dunite, serpentinization 56
durability testing 215–223, **218**
dust 154
 Budapest limestone 273
 Igreja Nossa Senhora do Carmo, Rio de Janeiro
 154, 155
 element analysis 157–163
 modification 158
 sampling 156–157
- earth scientists, role in pre-restoration research 9–17
earthquake, Lisbon (1755) 88
Eastern pluton, Tak batholith 46, 47
Eger Castle, Hungary, acid volcanic tuff 251–259
Eger-Demjén quarry, acid volcanic tuff 252, 253
Eger-Tihamér quarry, acid volcanic tuff 252, 253
Eibelsstadt limestone **141**, 143, 145, 146, 147, 149
elastomers, stone treatment 288, **289**, 291–292
electrophoresis 154
Encarnação de Negrais limestone 99, 102, 103
enstatite 58, 59
epidote, Tak batholith granite 50–52
epsomite 195
extraction, selective 155
- Fair Head, Carboniferous sandstone 78, 80–81
 alveolar weathering 78, 79, 81, 82
 biological growth 79, 81, 82
 iron crusts 78, 79, 80, 81, 82
fan beam CT 278, 280
fiamme 24, 25
fire damage 87–88, 139–150
 carbonate rock 142, 144–146, 148–150
 silicate rock 141, 142, 144, 150
 sulphate rock 146
flaking 2, 79, 80, 103, 257, 266
 acid volcanic tuff 256
 fire induced 88, 91
flooding, and climate change 125, 127
fluoroelastomer copolymer, stone treatment 288,
289, 291
fluoroelastomer terpolymer, stone treatment 288,
289, 291
formaldehyde 156
forsterite 58, 59
fractures 97
 control on porosity 226
Franka, Globigerina Limestone, Malta 191
freeze–thaw 3, 4
 cycles 119, 125
 Budapest limestone 273
 dilation of materials 171–176
 interaction with salt weathering 4, 211–223
Fribourg Cathedral, Villarlod molasses 168, 170
- Friuli *see* Cividale del Friuli
frost damage 119, 125, 167–176
 Buntsandstein 169, 171–176
 dilation of building material 167, 170, 171–176
 mechanisms 167
 Ohya tuff 168–169, 171–176
 and pore size 167
 Usui brick 167–168, 171–176
 Villarlod molasses 170, 171–176
‘fruchtschiefer’, Theuma **141**, 143
fuel, air pollution 117
fungi 70, 268, 273
- Giovanni da Udine (1487–1564), work in Udine 34, 38
GIS (Geographical Information System), decay
 mapping 69
Globigerina Limestone, Malta 189–197
 damage mapping 192–195
 physical properties 191, 192, **192**
 salt weathering 190, 195–197
Göttingen University Library, bowing of marble
 237, 238
Gradisca d’Isonzo, stone portals 35
granite
 and air pollution 120
 Igreja Nossa Senhora do Carmo, Rio de Janeiro,
 element analysis 157–163
 Kösseine **141**, 142, 143, 144, 146, 147, 148, 149
 Leinster
 complex weathering 212, **213**, 215–218,
 219, 220
 permeability 229, **230**, 231, 232, 233
 Thailand 45
 Tak batholith 45–53, 47
 epidote–chlorite mineralization 50–52, 51
 geochemistry 50, **50**
 mining 52–53
 orange granite 48, 49, 50–52
 petrography 48–50, 49
 physical properties 50, **51**
 production economics 48, 53
granulometry, limestone, Basilica da Estrela
 100–101, 105
Gravina calcarenite 180–181, 180, 181
guanine 91, 96
gypsum
 attenuation coefficient 280, 281
 black 2, 120
 Lisbon Cathedral 96
 St Matthew’s Church, Belfast 3
 sulphation 131–137
 Worcester College, Oxford 70
Budapest limestone 261, 266, 268, 273
Dębnik limestone 112–113, 115
fire damage 149
Lisbon Cathedral 91
in patina 299
 Uhrde **141**, 142, 143, 146
- HADCM3 model 125, 126, 127
Hailes Abbey, soft wall capping 313, 315
halite 199, 200, 201
harzburgite, serpentinization 55, 56
heating–cooling cycles 119

- Heiwa-kannon Temple, Ohya Tuff 168–169, 168
 Howbury Moated Site, soft wall capping 313, 315
 humidity, relative, and climate change 126–127
 Hungary, acid volcanic tuff 251–259
 hydrocarbon
 in Dębnik limestone 109, 110–112
 as fuel 117, 156
- ignimbrite, Rochlitz **141**, 143, 144
 Igreja Nossa Senhora do Carmo, Rio de Janeiro
 see dust, Igreja Nossa Senhora do Carmo,
 Rio de Janeiro
- illite 96, 162, 163
 image analysis 11, 12, 100
 imbibition, calcarenite 183, 186
 Indochina block, Thailand 44
 induration 2, 80
 surface 153
- iron
 Dębnik limestone 112
 in dust 159, 162–164
 exogenic 153–154
 outward migration 2, 4, 79, 80, 153
- iron minerals, Lisbon Cathedral 96
 isotopes, stable, in serpentinites 58, 59–60
 Istria Stone *see* Kirmenjāk
- kaolinite 96, 162, 163, 258
 Karst, Aurisina Stone 40
 Khorat Plateau, Thailand 44
 Kirkham Priory, soft wall capping 310, 311, 312,
 314–315, 319, 320
- Kirmenjāk 39, 39, 40
 geology 65
 porosity 65–66, **65**
 Venice 63–68
 as basal damp-proof course 64, 66–68
 history 63–65
- Kirmenjāk Unit 65
 Kösseine granite **141**, 142, 143, 144, 146, 147,
 148, 149
- Lambert-Beer Law 277–278, 281
 Leinster Granite
 complex weathering 212, **213**, 215–218, 219, 220
 permeability 229, **230**, 231, 232, 233
- Lerma, Burgos, patinas 302, 303
 lichen 4, 79, 257, 268
 in patina 295, 296
- lightning strikes 119
- limestone
 Aurisina stone 39, 40
 Basílica da Estrela
 chemical analysis 102–103
 granulometry 100–101
 petrography 102
 physical properties 103
 stone decay 103–106
 weathering 99–106
 Budapest 264–265
 weathering crusts 261–262, 265–274
 calcário gresoso 89, 96
 Dębnik ‘marble’ 109–115
 dissolution 2
 dolomitic 39, 40
 Eibelstadt **141**, 143, 145, 146, 147, 149
 Kirmenjāk (Istria Stone) 40, 63–68
 Parisian Lutetian limestone 131
 Portland
 complex weathering 212, **213**, 215–217,
 218, 219, 220, 222
 permeability 229, **230**, 231, 232, 233
 sulphation 131–137
 Thailand 45, 46
 Thüste **141**, 142, 143
 Travesio stone 39, 39, 40
 Turonian Richemont limestone 131
- limewash 298
 Lioz limestone 99, 102, 103
 Lisbon, Basílica da Estrela, weathering 99–106
 Lisbon Cathedral
 fire damage 88–97
 decay forms 90–91, **91**
 chromatic modification 90–91, 90, **91**
 granular disintegration 88, 90, 91, 96
 ultrasound tests 89, 91, 92, 96
- lithotheques, dimension stone 13
 Little Ice Age 4, 77, 118
 lizardite 58
 Löbejün rhyolite **141**, 143, 144, 146, 147, 148, 149
 Loei Foldbelt, Thailand 44
 Lutetian limestone, Parisian, sulphation 131–137
- Macaél, serpentinite 56
 Mae Salit pluton, Tak batholith 46, 47, 48
 magnesium, in dust 158, 162–163
 magnesium sulphate 120
 salt loading experiments 195, 196, 197
- Maltese Globigerina Limestone Formation 189–197
 manganese 153–154
- marble
 black ‘marble’, Dębnik 109–115
 bowing 237, 238, 243–248
 calcitic
 Cava Ortensia **141**, 142, 143, 144–145
 Cima de Gioia **141**, 143, 145
 Carrara 237, 238
 residual strain 241–248, 244, **244**, 245
 strain testing 239–248
 texture 240
 thermal expansion 243–248
 dolomite, Thassos **141**, 142, 143, 145
 green 55, 62
 internal stress 237–248
 Thailand 45, 46
- marine aerosols 3, 4, 77, 159
 climate change 127
 Malta 191
- Massafra calcarenite 180–181, 180, 181
 Massari, Giorgio (1687–1766), work in Udine 34
 Masseria del Monte 26
 see also Pianura underground quarry
- medical analogy 1–6
 TNM Staging System 4–5, 77, 83
- memory
 post-emplacement 3
 Bonmargy Friary 4
 pre-emplacement 3

- 'memory effect' 3, 120
- micrite, weathering crusts, Budapest limestone 266, 273
- microcracks 88, 91, 97
 - Budapest limestone 271, 273
- microCT 277, 280–283
- microfabric, serpentinite 56
- mirabilite 200, 201, 207
- montmorillonite 256
- mortar, hard 3, 4
- moss 70
- mouldings 41
- Mt Arzolo Sandstone
 - Pavia 287–288, 289
 - conservation treatment 288, **289**, 290–294
 - petrophysics 290, **291**, 292
 - weathering 287
- nanoCT 277, 280
- Naples, Piperno 23–31
- Neapolitan Yellow Tuff 23, 27, 29, 30
- neutron diffraction 237, 239, 241–243, 247
- neutron tomography 277, 283–284
- nitrate, in dust 158, 159
- nitric acid 118, 154–155, 156
- nitrogen dioxide 118, 120, 154
- NOAH's ARK project 125, 127
- Norwich Cathedrals, blackening 122
- Obernkirchen sandstone **141**, 143, 144, 145
- Ohya tuff
 - frost damage 168–169, 171–176
 - petrophysical properties 169
 - weathering 169
- orthogneiss, Verde Andeer **141**, 142, 143, 144, 145
- Oxford, Worcester College, decay mapping 69–74
- ozone 118, 120
- Palace-Church of Nuevo Baztán, Madrid, patina 301, 303
- Palladio, Andrea (1508–80)
 - work in Udine 34, 38, 39, 41
 - work in Venice 64
- Palmanova, stone portals 34, 35
- paragenesis, talc-carbonate 55, 59
- parallel beam CT 278
- Paris, Lutetian limestone, sulphation 131–137
- Parliament Building, Budapest limestone, weathering
 - crust formation 262–274, 263, 267
- particulate matter, atmospheric 154–155
- patinas 295–304, 298
 - composition **297**, 299, 302, 304
 - history 295–296, **297**
 - modern reproduction 302, 304
 - role 296
 - Spain 299–302, 303
 - terminology 296–298
- patination 302, 304
- Pavia, Mt Arzolo Sandstone 288
- pellicole ad ossalato* 296
- perfluoropolyether, stone treatment 288, **289**, 291–292
- permeability 225–226
 - controls 227
 - scale 228
 - and weathering 225–234
 - Dumfries Sandstone 229, **230**, 231–232
 - as indicator of durability 216–217, 222–223
 - Leinster Granite 229, **230**, 231, 232, 233
 - Portland Limestone 229, **230**, 231, 232, 233
 - Stanton Moor Sandstone 229, 230–231, 232
- permeametry 226–227
- petrography
 - microscopic 10–11
 - Tak batholith granite 48–50
- petrol 117
- Phlegraean Fields, Piperno Formation 24
- photogrammetry, decay mapping 69
- Pianura underground quarry
 - Piperno 23, 24, 26–30
 - stress simulation 29–30
- Piasentina Stone 35, 38, 39, 39, 41
- Pierre de Courville *see* Lutetian limestone
- Pietra d'Istria *see* Kirmenjak
- Piperno 23–31
 - geology 24, 25
 - history 23–24
 - mineralogy 24–26, 25, **26**, 30
 - Pianura underground quarry 23, 24, 26–30
 - Soccavo quarry 23, 24
- Piperno Formation 24, 25, 27
- pollution
 - atmospheric 117–128
 - and climate change 127–128
 - 'memory effect' 3, 120
 - post-emplacment memory 3
 - Rio de Janeiro 155, 156
 - St Matthew's Church, Belfast 3
- polymer, fluorinated, surface treatment 288, **289**, 291–292
- pore size
 - and frost damage 167
 - and salt crystallization 179
- pore space, and salt weathering 200, 203, 206
- pores, microscopic analysis 11, 13
- porosimetry
 - mercury intrusion
 - calcarenite 183, **185**, **186**, 187
 - Globigerina Limestone 191
 - limestone, Budapest 263, 271
 - Mt Arzolo sandstone 291
- porosity 225
 - acid volcanic tuff 253, 255, 257–259
 - and salt crystallization, calcarenite 179–187, 200, 203, 206
 - and weathering 226
 - weathering crust, Budapest limestone 268–270
- portals, natural stone
 - Udine 33–41
 - construction forms 38–39, 38
 - construction techniques 40–41
 - database 34–35
 - inventory 35–37
 - materials and weathering 39–40
- Portland Limestone
 - complex weathering 212, **213**, 215–217, 218, 219, 220, 222
 - permeability 229, **230**, 231, 232, 233
- portlandite 142, 149
- potassium, in dust 158

- precipitation, and climate change 126–127
pumice 252
pyrite, in Dębnik limestone 110, 111, 112
quarries
 historical
 dimension stone lithotheques 13–15
 replacement stone 16–17
quarrying, pre-emplacement memory 3
quartz, attenuation coefficient 280–281, 281
- rainout 154
rainwater, *Basilica da Estrela* 99, 104–105
Rakowice Cemetery, Dębnik limestone 110, 113, 113
Red Ammonite Stone (*Ammonitico rosso*) 39, 40
relief weathering 193–194, 195, 257
 acid volcanic tuff 256
replacement, stone 16–17
research, pre-restoration, role of earth scientist 9–17
resin, siliconic, surface treatment 288, 289
resin penetration 11, 13
restoration, role of earth scientist 9–17
rhyodacite tuff 252, 253
rhyolite, Löbejün 141, 143, 144, 146, 147, 148, 149
rhyolite tuff 251, 252, 253, 258
Richemont limestone, Turonian, sulphation 131–137
Rievaulx Abbey, soft wall capping 313–314, 313, 315
Rio de Janeiro
 environmental conditions 155
 Igreja Nossa Senhora do Carmo 155
Rochlitz ignimbrite 141, 143, 144
rock fabric, image measurement 11, 12
Rossi, Domenico (1657–1737) 34
ruins, conservation, soft wall capping 309–322
- S. Michele Maggiore Basilica, Pavia
 Mt Arzolo Sandstone 287, 288
 conservation treatment 288, 289, 290–294
Saint Eustache Church, Paris, sulphation
 experiment 131, 132
Saint Gatien Cathedral, Tours, sulphation
 experiment 131, 132
St Matthew's Church, Belfast, sandstone 3, 5
salt, contour scaling 159
salt precipitation, *Basilica da Estrela* 104, 105
salt weathering 16, 119, 125
Apulia 180
 Bonmargy Friary 4, 77, 78–79
 and climate change 125, 126
 crystallization
 acid volcanic tuff 257
 calcarenite 179–187
 sandstone 199–208
 efflorescence 100, 103, 105, 256
 and freeze–thaw cycles 211–223
 Globigerina Limestone, Malta 190, 193, 195–197
 interaction with freeze–thaw 4
 microCT 282
 St Matthew's church, Belfast 3
 sandstone 2
Sammicheli, Michele (1484–1559) 34
sampling 10
 machine-facilitated 10
 manual 10
San Blas Monastery, Lerma, patinas 302, 303
- sandstone
 and air pollution 120
 Anröchte 141, 142, 143, 144, 145, 146
 Bonmargy Friary 78
 stone decay 4, 78–85
 Buntsandstein, frost damage 169
 Dumfries
 complex weathering 212, 213, 215–217,
 218, 219–221, 222
 permeability 229, 230, 231–232
 internal stress 2
 Mt Arzolo, Pavia 287–294
 conservation treatment 288, 289, 290–294
 petrophysics 290, 291, 292
 Obernkirchen 141, 143, 144, 145
 St Matthew's Church, Belfast 3, 5
 salt loading, length change 199–208
 Bad Bentheim Sandstone 201–208
 Cotta Sandstone 202–208
 Schoetmar Sandstone 202–208
 salt weathering 199–208
 Stanton Moor
 complex weathering 212, 213, 215–223, 218–220
 permeability 229, 230–231, 232
 Thailand 45, 46
 Vernadia Stone 39–40
 Villarlod molasses, frost damage 170
 Wesersandstein 141, 142, 143, 144, 145
 Santa Marija Ta'Cwerra, Malta
 Globigerina Limestone 190
 damage mapping 192–195, 194
 salt-loading 195–197
scaling, acid volcanic tuff 256
Scamozzi, Vincenzo (1548–1616) 34, 40
scanning geometry 278
scatter 278
 Compton scattering 279
Schmidt hammer hardness test, acid volcanic tuff 251,
 252, 253, 253, 258
Schoetmar Sandstone 202–203
 petrophysical properties 203–204
 salt loading 204–208
scialbatura 295, 296
scoriae 24, 25, 26
sea-level rise 128
seepage water, *Basilica da Estrela* 104–105
serpentine 56, 58
serpentinite
 Cabo Ortegal 55–62
 carbonated 56–57, 57, 58, 59
 geochemistry 58–60, 61
 Macaoel 56, 59, 60
 physical properties 61, 61
 mineralization 56–58, 57
 Moeche 59, 60
 physical properties 60, 61, 61
 physical properties 60–61, 61, 62
 weathering 58–59
serpentinization 55, 56–57, 56, 57
Shan Tai block, Thailand 44
shear, in serpentinite 55, 56, 57
silica, in dust 158–160, 162–164
'silica glaze' 154, 164
sinogram 278

- slate, and air pollution 120
smectite 96, 227, 258
smog, photochemical 118, 120, 155
 Rio de Janeiro 156
smoke 117, 118, 119
SO₂ *see* sulphur dioxide
Soccavo quarry 23, 24, 26
sodium, in dust 158–159
sodium chloride
 St Matthew's Church, Belfast 3
 salt loading experiments 195, 196, 200, 201,
 205–206, 207
sodium sulphate
 complex weathering experiments 212, 214–223
 modified durability test 215–217, 221, 222
 salt crystallization durability test 217, 218, 221
 salt loading experiments 195–196, 200, 201, 204,
 206, 207
soiling *see* blackening
Soll, Globigerina Limestone, Malta 191
soot 118, 120, 121
 see also blackening
Spain, patinas 299–302, 303
spalling 88, 91, 96, 103, 140
spinel 56, 58
Stanton Moor Sandstone
 complex weathering 212, 213, 215–223, 218–220
 permeability 229, 230–231, 232
stone
 properties 225–226
 and weathering 226–227
 replacement 16–17
stone type
 determination 9–15
 macroscopic examination 9–10
 microscopic petrography 10–11
 sampling 10
 sourcing 11–15
strain
 Carrara marble 241–248, 244, 244
 residual 241–248
Strasbourg Cathedral, Bundsandstein 168, 169
stress, Pianura underground quarry 28, 29–30
stress history 3–4
stylolites 226, 227
 Kirmenjak 65–66, 66
Sukhothai Foldbelt, Thailand 44
sulphate, in dust 158, 159
sulphation
 in limestone 96, 131–137
 modelling 133–135
sulphur dioxide 118, 119, 154
 air concentration
 Budapest 262, 263–264
 Paris and Tours 133–137, 133
 stone damage 120
sulphuric acid 154–155
supersaturation 199
surface modification 153
 Igreja Nossa Senhora do Carmo, Rio de Janeiro
 S. Michele Maggiore Basilica, Pavia 288, 289,
 290–294
 see also patinas
syenite, Blue Pearl 141, 142, 143
Tak batholith, Thailand
 granite 45–53
 epidote–chlorite mineralization 50–52, 51
 geochemistry 50, 50
 mining 52–53
 orange granite 48, 49, 50–52
 petrography 48–50, 49
 physical properties 50, 51
 production economics 48, 53
 rock types 48
Tak pluton, Tak batholith 46, 47, 48
talc 56, 58, 59
temperature, and climate change 125–126
Thailand
 dimension stones 43, 45–53, 46
 mining 45
 Tak granitic batholith 45–53
 tectonic framework 43–45, 44
Thassos dolomite marble 141, 142, 143, 145
thenardite 104, 105, 199–200, 201, 207
thermal analysis, differential 140, 141, 142, 143, 145
thermal blanket experiments 314–320, 314
thermal conductivity 150
thermal expansion
 carbonate rock 144–146
 Carrara marble 243–8
 silicate rock 142, 144
 sulphate rock 146
thermogravimetry 140, 142, 143, 145
thermophoresis 154
Theuma 'fruchtschiefer' 141, 143
Thornton Abbey, soft wall capping 310, 312, 312,
 314–315
Thüste limestone 141, 142, 143
TNM (Tumour Node Metastases) Staging System
 4–5, 77, 83
Tolmezzo, stone portals 35
tomography *see* computerized tomography
tools, historical construction techniques, Udine
 40–41
Torriani Palace 38, 40
Tours, Richemont limestone, sulphation 131–137
Tower of London, blackening 122, 124, 128
traffic, air pollution 118
travertine
 Bad Langensalza 141, 143
 Thailand 45, 46
Travesio stone 39, 39, 40
tremolite 58, 59
Trieste, stone portals 35
trona 104, 105
tuff
 acid volcanic
 Hungary 251–259
 mineralogy 252–253, 253, 254
 pore-size distribution 255, 257–258
 porosity 253, 255
 weathering 256–259
Weibern 141, 143
Uclés Monastery, Cuenca, patina 299, 301–302, 303
Udine
 history 33–34
 natural stone portals 33–41

- Udine (*Continued*)
 natural stone portals (*Continued*)
 construction forms 38–39, 38
 construction techniques 40–41
 database 34–35
 inventory 35–37
 materials and weathering 39–40
- Úhrde gypsum **141**, 142, *143*, 146
- ultrasound tests, Lisbon Cathedral 89, 91, 92, 96
- Unit Area Spread condition assessment scheme 4, 77, 83–85, **84**
 Bonamargy Friary 84–85, **85**
- Usui brick
 frost damage 167–168, 171–176
 petrophysical properties 167, **168**
 weathering 168
- vegetation, soft wall capping 309, 315
- veins, calcite, in serpentinite 55
- velatura* 296, **297**
- Venice, Kirmenjak 63–68
 as basal damp-proof course 64, 66–68
acqua alta 64, 67
 history 63–65
- Verde Andeer orthogneiss **141**, 142, *143*, 144, *145*
- Verde Macael 56, 59, **60**
 physical properties 61, **61**
- Verde Pirineos 55, 59, **60**
 physical properties 60, 61, **61**
- Verdolino quarry 24, 26
- Vernadia Stone 39–40, 39
- Villarlod molasses
 frost damage 170, 171–176
 petrophysical properties **168**, 170
 weathering 170
- wall capping
 hard 309, 312
 soft 309–322
 Byland Abbey 310, 311, 313, 314, *315*, 318, 320
 Hailes Abbey 313, 315
 Howbury Moated Site 313, 315
 Kirkham Priory 310, 311, *312*, 314–315, 319, 320
 Rievaulx Abbey 313–314, *313*, 315
 thermal blanket experiments 314–320, *314*
 Thornton Abbey 310, 312, *312*, 314–315
 Whitby Abbey 314, 315
 wooden dowel moisture survey 313, 314, 318, *318*, *319*
- walls, ruined, conservation, soft capping 309–322
- washout 154
- water, chemistry, Basílica da Estrela 104–105
- water-repellent 3, 282, 288, **289**, 290–292
- weathering 15–16, 119
 acid volcanic tuff, Hungary 256–259
 alveolar
 Bonamargy Friary 78–79, 79
 Dębnik limestone 114
 Malta 190, 193, 193–194, *195*
 analytical study 15–16
 back-weathering 193–195
 Basílica da Estrela 99–106
 granulometry 100–101
 biological 4, 5, 79, 128, 257, 268, *269*, 273
 Buntsandstein 169
 chemical, Basílica da Estrela 104, 105
 complex 211–223
 crusts, Budapeste limestone 261–262, 265–274
 dust, Igreja Nossa Senhora do Carmo, Rio de Janeiro 158–164
 effects of climate change 125–127
 identification 15
 Istria Stone 40
 Ohya tuff 169
 and permeability 225–234
 Piasentina Stone 39
 post-emplacment memory 3
 properties of weathered stone 16
 relief 193–194
 salt 16, 119, 125
 Bonamargy Friary 4
 and climate change 125, 126
 crystallization in calcarenite 179–187
 and freeze–thaw cycles 211–223
 Globigerina Limestone, Malta 190, 195–197
 interaction with freeze–thaw 4
 linear crystal growth pressure, sandstone 199–208
 St Matthew's Church, Belfast 3
 serpentinite 58–59
 Udine stone portals 39–40
 Usui brick 168
 Vernadia Stone 40
 Villarlod molasses 170
 volume increase 4, 167, 179, 195, 200
- Weibern tuff **141**, *143*
- Wesersandstein sandstone **141**, 142, *143*, 144, *145*
- Western pluton, Tak batholith 46, *47*, 48
- wetness, time of, and climate change 126, *127*, 128
- wetting–drying cycles 119, 125
- Whitby Abbey, soft wall capping 314, 315
- wind damage 119, 125
 and climate change 127
- wood, as fuel 117–118
- wooden dowel moisture survey 313, 314, 318, *318*, *319*
- Worcester College, Oxford, boundary wall, decay mapping 69–74
- X-ray CT 277, 278–283
- Yunnan Malay mobile belt, Thailand 44