Index

Note: Page numbers in *italic* refer to figures, those in **bold** refer to tables.

abiogenic hydrocarbons 1–2, 10, 151–173
bulk gas compositions 154–155, **156–159**
carbon number ratios **168**
fluid inclusions 154, 163
generation 168–170
istopic data for fluids **160**
occurrences 152–154, **152**
alkaline igneous rocks 151, **152**, 153, 154
basic/ultrabasic rocks 153–154
origin in igneous rocks 155–165, 170
late magmatic origin 162–164, 170
mantle origin 153, 161, 162
models 165–168
post-magmatic origin 164–165, 170
source **152**
stable isotope characteristics 155, **160**
accidental discovery of oilfields 90
accumulation of hydrocarbons, model 70–75, 75
Algeria, hydrocarbon occurrence 49
alkaline igneous rocks, abiogenic hydrocarbons 151, **152**, 153, 154
alteration see hydrothermal alteration; kaolinization;
mineralization; serpentinization
Antarctica, hydrocarbon occurrence 54
Argentina, hydrocarbon occurrence **45**
attribute analysis, fractures 109–124
Australia, hydrocarbon occurrence 53
Azerbaijan, hydrocarbon occurrence 46
basalt lava flows 8, 9, 9, 21, 22, 98
basement see crystalline basement
basement reservoirs
Indonesia 83–84, 84, 85–87
oil and gas recovery 90–92
United States 84–87, 88–89, 90
Venezuela 89–90, 91
basic rocks, abiogenic hydrocarbons 153–154
basins
beneath volcanic rocks 8, 9, 9
brine incursions 188, 191
faulted 228
Mesozoic sedimentary 175, 187, **188**
Paraná Basin, Brazil 3, 13, 15, 22
sedimentary basin evolution 189–191
volcanic-filled trap 9, 9
biogenic hydrocarbons 155–161, **161**
boreholes
discontinuity analysis 201–202
flow zone identification 203–204, 205
groundwater monitoring 198
Potential Flowing Features 211–213
Borrowdale Volcanic Group, UK 197–219
effective properties 214–217, **216**
geology and hydrology 198–201, **199**
groundwater flow model 211–213
investigative techniques 201–208
Brazil, hydrocarbon occurrence **45**
bulk gas compositions, abiogenic hydrocarbons 154–155, **156–159**
buried volcano traps 15–16, 17
see also volcanic reservoir rocks
California, basement reservoirs 87–89, 89
Canada, hydrocarbon occurrence 2, **42–43**
Canadian Shield, bulk gas analyses **158**
carbon number ratios **168**
Chile, hydrocarbon occurrence **45**
China, hydrocarbon occurrence **50–51**
Colombia, hydrocarbon occurrence **46**
columnar joints, volcanic rocks 98, 99
commercial significance of igneous reservoirs 8
cooling joints 223–224, 223
modelling 225, 232
plutonic rocks 93, 100, 102, 143
Cornubian batholith, unroofing 188–189
Costa Rica, hydrocarbon occurrence **43**
crystalline basement
crustal permeability 94–95, 94
definitions 1, 83
discrete fracture networks 225–226
inorganic hydrocarbons 1–2, 10
organic hydrocarbons 2–3
properties 93
strain analysis 228–232
SW Vietnam 221–236
tectonic fractures 226–228
see also basement reservoirs
crystalline volcanic rocks, porosity 96–98, **96, 97**
Cuba, hydrocarbon occurrence **43–44**
Czech Republic, hydrocarbon occurrence **46**
database, hydrocarbon occurrence 37–58
deformation
footwall 227–228, 231–232, 231
hanging wall 227, 231–232, 230
seismic faulting 226–227
strain analysis 228–232
tectonic faults 226–228, 233
diffusive porosity 96
plutonic rocks 100–102, 104–105, 104
volcanic rocks 97, 99, 104–105, 104
digital optical imaging, rough-walled fractures 128–129, **130, 132, 136–137, 136**
discontinuities, Borrowdale Volcanic Group 201–202
domes
reservoirs, Niigata district, Japan 69–75, 71, 73, 74, 75
volcanic-carbonate platforms 16, **18**
drilling techniques 23–25
Ecuador, hydrocarbon occurrence 46
Effective Elastic Thickness (EET), lithosphere 227–228, 228
Egypt, hydrocarbon occurrence 49
El Salvador, hydrocarbon occurrence 44
Environmental Pressure Measurement tests (EPMs) 207, 215–217
Evaporites, intrusions into 15
Exhumation fractures
  crystalline basement, SW Vietnam 222
  modelling 225, 226–228
  exploration methods 19–21, 55–58, 197–198
Extenstional crystalline basement
  fault basin 228
  fracture systems 221–236

Faeroe Islands, hydrocarbon occurrence 46
Faults
  Borrowdale Volcanic Group 199, 199, 201
  modelling 225–228, 232–234, 233
  see also fracture systems
Fields 37–58
Fischer–Tropsch synthesis, abiogenic hydrocarbons 153, 167–169, 170
Flood basalts
  exploration 21, 22
  hydrocarbons beneath 8, 9, 9
  flow see fluids; groundwater flow
  flow foliation in plutonic rocks 100–102, 102, 103
  flow porosity 96
  plutonic rocks 102, 104–105, 104
  volcanic rocks 97–98, 98, 99, 99, 104–105, 104
Fluids
  calibration in rough-walled fractures 129–130, 130
  fluid-pressure profiles, Niigata district, Japan 75, 77–78
  inclusions in alkaline igneous complexes 154, 163
  transport in igneous rocks 95–96, 125, 139
  see also groundwater flow...; hydrothermal alteration; kaolinization; water
  foliation, magmatic flow 100–102, 102, 103
  footwall deformation, modelling 227–228, 231–232, 231
Fracture attribute analysis 109–124
  data set locations 113–115, 114
  fracture data sets 115–118
  sampling methods 110, 111–113, 112
  size and spacing 118–120, 119
  vein formation 120–121
Fracture systems
  basement reservoirs 83–104
  Borrowdale Volcanic Group 197–218
  borehole discontinuity analysis 201–202
  flow zone identification 203–204, 205
  surface mapping 202–203
  wireline measurements 204, 210
Cornish granite 113

definitions 111, 201
extensional crystalline basement 221–236
  granites 223
  primary 223–224, 224, 226, 233
  secondary 224, 225, 226–228, 233–234, 233
  porosity 18–19
  thermally induced in granite plutons 143–150, 148
  see also joints; primary porosity; rough-walled fractures
  fracture-dominated flow 197–219
  see also Borrowdale Volcanic Group
France, hydrocarbon occurrence 46
Gas fields and reservoirs 37–58, 83–92
Abiogenic origin 151
Suban field, Sumatra 83–84, 84
Geographical distribution 36
Geological exploration methods 19
Geological modelling 22–23
Geometry
  fracture network 209–214
  plutons and joint formation 143–149, 148
Geopressures 24
Georgia, hydrocarbon occurrence 47
Geothermal gradients, Japan oil fields 75–79
Germany, hydrocarbon occurrence 47
Granites
  basement reservoir 83
  basinal brine incursions 188, 191
  Cornubian batholith 176, 188–189
  fractured 113, 223
  kaolinization 175–195
  porphyritic 100, 101
  St Austell pluton, Cornwall 176–177, 176, 189–191, 190
  thermally induced fractures 143–150, 148
  granular volcanic rocks, porosity 98–99
  gravity exploration methods 19–20
Greece, hydrocarbon occurrence 47
Greenland
  hydrocarbon occurrence 44
  Ilulissat complex
    abiogenic hydrocarbons 152, 162, 165
    bulk gas analyses 157, 159
    fluid inclusions 154
  groundwater flow in the Borrowdale Volcanic Group 197–219
  conceptual model 211–214
  effective properties 214–217, 216
  flow zone identification 203–204, 205
  hanging wall deformation, modelling 227, 229, 231–232, 230
  heat flow values, maturation modelling 12, 12
  high fidelity polymer model (HFPM), rough-walled fractures 127–128, 128, 129, 132
horst blocks
fracture systems 221, 222, 225–228
strain analysis 228–232, 229–230
host rock, radioactive waste 197
Hungary, hydrocarbon occurrence 47
hydrogeology of the Borrowdale Volcanic Group
host rock, radioactive waste 197
hydrogen presence in the Borrowdale Volcanic Group
198–201, 199
effective properties 214–217, 216
heterogeneity 213
major unit identification 209–211
testing 207–208, 211, 215–216
hydrothermal alteration
abiogenic hydrocarbons 164–165
maturation effects 11, 13
mid-oceanic ridges 10
petroleum migration 13
St Austell granite migration 13
St Austell granite migration
Seismic, thermal effects 10–11
Seismic imaging 10
Seismic methods 8
Seismic methods
St Austell granite
Iceland, hydrocarbon occurrence 47
igneous intrusions, thermal effects 10–13
igneous reservoirs 7–8, 16–19
commercial significance 8
seals 19
see also volcanic reservoir rocks
igneous rocks see also volcanic reservoir rocks
Ilimaussaq complex, Greenland
abiogenic hydrocarbons 152, 162, 165
bulk gas analyses 157, 159
fluid inclusions 154
impact structures 2–3
India, hydrocarbon occurrence 51
Indonesia
basement reservoirs 83–84, 84, 85–87
hydrocarbon occurrence 53–54
inorganic hydrocarbons see abiogenic hydrocarbons
intrusive rocks see granites; igneous intrusions;
plutonic rocks
Italy, hydrocarbon occurrence 47
Japan
hydrocarbon occurrence 51–52
NW Honshu volcanic reservoir rocks 69–81
oil fields 69, 70, 73–74
joints
columnar joints 98, 99
cooling joints 93, 100, 102, 143
cross joints 143
joint sets 223, 224, 224
plutonic rocks 93, 100, 102, 102
Kalimantan, basement oil field 84, 86–87
Kansas, basement oil production 84, 88
kaolinite in SW England granites 175–195
aqueous fluids 186–187
basin evolution model 186–191
fluid composition 184–185
fluid inclusion petrography 179–181, 180
hydrothermal origin hypothesis 176–177
oxygen isotope composition of quartz 182–183
paragenesis 184
regional implications 189–191
stable isotope composition 181–182, 182, 184–185, 186
thermal evolution 188–189
timing of fluid migration 187–188, 191
vein geology 178, 178
vein petrography and mineralogy 178–179, 179
weathering hypothesis 177
Kazakhstan, hydrocarbon occurrence 52
Kenya, hydrocarbon occurrence 49
Kola Peninsula, Russia
abiogenic hydrocarbons 152, 162, 165
bulk gas analyses 156–157, 159
fluid inclusions 154
laccoliths 16
Christmas tree 14–15, 14
fractured 15
large intrusions, thermal effects 11–12
late magmatic origin, abiogenic hydrocarbons 152,
153, 162–164
laumontite tuff 25
lithosphere
Effective Elastic Thickness 227–228, 229
flexing 228
Madagascar, hydrocarbon occurrence 49
magma
abiogenic hydrocarbons origin 152, 153, 162–164
composition effect on cooling joints 102
flow foliation in plutonic rocks 100–102, 102, 103
re-equilibrium model 165–167
magnetic exploration methods 19–20
magnetotelluric exploration methods 20, 22
mantle origin, abiogenic hydrocarbons 151, 153, 162
marine volcanism, NW Honshu, Japan 69
mariolitic cavities, plutonic rocks 100
maturation of hydrocarbons 10–13, 76
heat flow values 12–13, 12
hydrothermal systems 11, 13
large intrusions 11–12
Mesozoic sedimentary basins 175, 187, 188
metal mineralization 8
metamorphic rocks, basin reservoirs 84, 87–92
meteoric water 186–187, 200
methane
crystalline basement 10
fluid inclusions 154, 155
Mexico, hydrocarbon occurrence 44
migration of hydrocarbons 13–14, 74, 75
mineral–fluid evolution of a basin 175–195
mineralization 8
Borrowdale Volcanic Group 26, 205–209, 207, 208
St Austell granite pluton 176
INDEX

mineralization (cont.)
see also hydrothermal alteration; kaolinization
modelling
basin evolution in SW England 186–191
fracture systems in extensional crystalline basement 221–236
exhumation fractures 226, 227, 228
faults 226–228, 232–234, 233
tectonic fractures 226–228
geological 22–23
groundwater flow 211–214
high fidelity polymer model 127–128, 128, 129, 132
hydrocarbon accumulation 70–75, 75
hydrocarbon origin 165–168
magmatic re-equilibrium 165–167
maturation of hydrocarbons 12–13
thermally induced fractures 143–149
Mongolia, hydrocarbon occurrence 52
New Caledonia, hydrocarbon occurrence 54
New Zealand, hydrocarbon occurrence 45
Nicaragua, hydrocarbon occurrence 45
Norway
hydrocarbon occurrence 47
occurrence of hydrocarbons 2, 7–33, 35, 36, 37–58
Africa 49–50
Antarctica 54
Asia 46, 50–53
Australasia 53–54
Canada 42–43
Central and South America 43–46
Europe 46–49
Indonesia 53–54
overlying igneous rocks 55–58
Scandinavia 44, 47
United Kingdom 48–49
United States 37–42
oil
characteristics 24–25
genesis 80
maturation and migration 75–79
oil fields and reservoirs 37–58
calculated fluid-pressure profile 77–78
geothermal gradients 75–79
Indonesia 83–84, 84, 85–87
Japan 69–70, 70, 71–74
oil maturation and migration 75–79
stratigraphical column, Niigata district 72
USA 84–87, 88–89, 90
Venezuela 89–90, 91
see also gas fields and reservoirs
Omaha Dome, USA, Christmas tree laccolith 14–15
optical profiles, rough-walled fractures 128–129, 130, 136–137, 136
organic hydrocarbons 2–3
overlying igneous rocks 55–58
oxygen isotope composition, quartz in kaolin veins 182–183, 183
parametrization, rough-walled fractures 132–135, 133
Paraná Basin, Brazil
flood basalts 22
laccolith traps 3, 15
source rock 13
pepèrite reservoir rock 17–18
permeability
Borrowdale Volcanic Group 215–217, 216
crystalline basement 94–95, 94, 96
igneous rocks 105
preservation 105
see also porosity
petroleum see oil
PFFs see Potential Flowing Features
Philippines, hydrocarbon occurrence 54
phonolite ignimbrite, flow porosity 99
plateau basalts see flood basalts
plutonic rocks
diffusive porosity 100–102, 104–105, 104
flow porosity 102, 104–105, 104
jointing 93, 100, 102, 102
magmatic flow foliation 100–102, 102, 103
see also granites
plutons
cooling joints 143
genesis and primary fracture distribution 143–149, 148
St Austell granite 176–177, 176, 189–191, 190
thermal effects 11–12
porosity 16–19
depth relationship, argillaceous sediments 76, 80
fractures 18–19
permeability relationship, volcanic reservoir rocks 74
secondy 18
see also diffusive porosity; flow porosity; primary porosity
porphyritic granite 100, 101
Portugal, hydrocarbon occurrence 47
post-magmatic origin, abiogenic hydrocarbons 164–165
Potential Flowing Features (PFFs), groundwater flow 204–208, 206, 207, 209, 211–217, 212, 214–218
pre-Tertiary basement reservoirs 83–92
Precambrian basement reservoir, Kansas 84, 88
pressure seals, volcanic reservoir rocks 19, 74–75, 79
primary fractures
modelling 225, 232
SW Vietnam 223–224, 224
primary porosity 16, 93–107
classification in igneous rocks 95–103, 96
crystalline volcanic rocks 96–98
granular volcanic rocks 98–99
plutonic rocks 100–103
preservation 105
weathering effects 104
production practices 24–25
profiling, fracture surfaces 126–132
quartz
oxygen isotope composition in kaolin veins 182–183, 183
relationship to kaolin 175, 178, 179, 180, 182
temperature of precipitation 183–184
quartzites, basement reservoir 84, 88
radioactive waste repository 197
Red Sea, hydrocarbon occurrence 49
Republic of the Congo, hydrocarbon occurrence 49
reservoirs
domal 69–75, 71, 73, 74, 75
igneous 7–8, 16–19
pepêrite rock 17–18
rock types 37–54
see also basement reservoirs; gas...; oil...; volcanic reservoir rocks
rough-walled fractures 125–141
digital optical imaging 128–129, 130, 132, 136–137, 136
fluid calibration 129–130, 130
high fidelity polymer model preparation 127–128, 129, 132
parametrization 132–135, 133
real rock apertures 137–139, 137–139
results 136–139
software 126, 132, 133, 134, 135
surface profiling 126–132
synthetic fractures 135–136, 136, 137
technical difficulties 131–132, 131
Russia
hydrocarbon occurrence 47–48
Kola Peninsula, hydrocarbon-bearing fluid inclusions 154
St Austell granite, Cornwall, UK 176–177, 176, 189–191
sampling methods, fracture attribute analysis 111–113, 112
schists, basement reservoir 87, 90
seals 19, 74–75
secondary fractures 224, 225, 226–228, 233–234, 233
see also shear fractures; tectonic fractures
secondary porosity 18
sedimentary basin evolution 189–191
seeps 37–38, 41–49, 51–54
seismic exploration methods 20–22
processing procedures 21
techniques 20–21
volcanostratigraphy 21–22
seismic faulting, modelling 226–227
Sellafield, UK
Borrowdale Volcanic Group 197–219
geology and hydrology 198–201, 198, 199, 200
mineralization episodes 208
stratigraphy 200
serpentine plugs, Texas 16, 17, 18
serpentinization
abiotic hydrocarbons 10
basic rocks 153, 169
shear fractures 224, 225, 233–234, 232
shows 37–48, 50–51, 53–54
software
fracture networks 225, 233
rough-walled fracture characterization 126, 132, 133, 134, 135
sonic velocities, igneous rocks 20
source rocks 8–10
South Africa, hydrocarbon occurrence 50
stable isotope characteristics
abiotic hydrocarbons 155, 160
kaolin veins 181–182, 182, 184–185, 186
strain analysis
extensional crystalline basement 228–232
thermally induced fractures 144–146, 146, 147
stratigraphic trap, volcanic-filled basin 9, 9
stratigraphy
Niigata district, Japan 72
Sellafield area, UK 200
subaerial volcanic rocks, source rocks 9
Suban gas field, Sumatra 83–84, 84
Sumatra, basement oil fields 83–84, 84, 85
supercritical water 13
surface mapping 19, 202–203
SW Vietnam
extensional crystalline basement 221–236
field studies and fractures 223–225
geology 222–223
modelling of fractures 225–228
strain analysis 228–232
Syria, hydrocarbon occurrence 52
tabular granitic plutons, geometry and primary
fracture distribution 143–149, 148
tectonic fractures, modelling 226–228, 232
themogenic hydrocarbons see organic hydrocarbons
thermal effects of igneous intrusions 10–13
thermally induced fractures in granite plutons 143–150
Tibet, hydrocarbon occurrence 52
traps 14–16, 37–54
buried volcanoes 15–16, 17
fractured sills 15
laccoliths 14–15, 14, 16
stratigraphic 9, 9
Turkey, hydrocarbon occurrence 52
Ukraine, hydrocarbon occurrence 48
ultrabasic rocks, abiogenic hydrocarbons 153–154
United Kingdom
Borrowdale Volcanic Group 197–219
Cornwall
fracture attribute analysis 113, 114, 115–117, 115–116
St Austell granite 176–177, 176
vein formation 120–121
vein thickness and spacing 115–117, 115–116
hydrocarbon occurrence 48–49
United States
basement reservoirs 84–87, 88–89, 90
hydrocarbon occurrence 37–42
unloading, fractures 224, 227–228, 229
upper mantle, abiogenic hydrocarbons 151, 153
veins
Cornwall, UK
formation 121–122
thickness and spacing 115–117, 115–116
kaolin 178–179, 179
stable isotope composition 181–182, 182, 184–185, 186
quartz, oxygen isotope composition 182–183, 183
Venezuela
basement reservoirs 89–90, 91
hydrocarbon occurrence 46
Verran fault plane, Norway (VFP) 114, 115, 121–122, 122
vesicular volcanic rocks
porosity 97, 97
primary porosity 16
VFP see Verran fault plane
Vietnam
fracture systems in extensional crystalline basement
221–236
hydrocarbon occurrence 53
volatiles
petroleum migration 13–14, 15
see also hydrothermal alteration; kaolinitization
volcanic reservoir rocks 2–3, 2, 18
basins beneath 8, 9, 9
crystalline 96–98
granular 98–99
magnetotelluric exploration 22
NW Honshu, Japan 69–81
Niigata district 69–75, 71, 73, 74, 75
porosity 74, 96–99, 97–99, 104–105, 104
pressure seals 74–75
source rocks 9
vesicular 16, 97, 97
see also flood basalts; volcaniclastic rocks
volcanic-carbonate platforms (domes) 16, 18
volcaniclastic rocks 21, 98–99
volcanoes, traps 15–16, 17
volcanostratigraphy, exploration method 21–22
Vung Tau peninsula, Vietnam
fracture attribute analysis 113, 114, 117, 117, 118
lithological variations 121
water
basinal brine incursions 188, 191
meteoric 186–187, 200
supercritical 13
see also fluids; groundwater flow...
weathering
kaolinitization effect 177
porosity and permeability effects 104
see also exhumation
well log analysis 23, 24
wireline measurements, Borrowdale Volcanic Group
204