

# Index

- Acid rain (*see* Sulphate precipitation)  
*Actinia*, 186  
Activated complex, 5  
Adirondack mountains, USA, 21, 215  
Aerodynamic sizing, 140  
Aerosol, 36, 144, 399  
Africa, 69, 88, 228, 409–14  
African rivers, 228  
Akansk-Achinsk, USSR, 155  
Alberta, Canada, 140–1, 144, 154–5, 204, 247–8, 274–5, 278, 280, 284 (Fig.), 303, 309–31  
Algae, 285, 289  
Algal mats, 370, 382  
Algoma, Canada, 199  
Algonquin Provincial Park, Canada, 214  
Altai, 88  
Amazon river, 224  
Amino acids, 268  
Amu-Daria syncline, 111, 244  
Analyses  
  aerodynamic sizing, 140, 317  
  Kiba reagent, 184  
  O-isotopes, 55–9  
  sample pretreatment, 43–8  
  scanning electron microscopy, 141, 142 (Fig.), 316  
  sulphur  
    atmosphere, 137–41, 312, 344–5  
    coal, 47  
    H<sub>2</sub>S in water, 344–5  
    petroleum, 47  
    soil, 268–9  
    trace-S, 184  
    volcanic fluxes, 117  
Animals, 185–8, 299–303  
Antarctica, 152  
Aquatic organisms, 183–9  
Arabia, 99  
Archean, 14  
Arctic, 151, 167, 300  
Argonne, Illinois, 34  
Armavir, West Caucasus, 103  
Asia, 69  
Asse salt dome, Germany, 237  
Astrakhan gas-condensate deposits, 112  
Athabasca oil sands, 102  
Atlantic Ocean, 152  
Atmosphere, 34–7, 133–76, 383–97, 312–18, 331–43  
  aerodynamic sizing, 140  
  aerosols, 36, 144  
  anthropogenic-S, 147–9, 358–60, 383–97  
  biogenic sulphur, 144–7, 163–7, 242–51, 344–7  
  carbon disulphide, CS<sub>2</sub>, 133–4, 165  
  carbonyl sulphide, COS, 133–4, 165  
  dimethyl sulphide, DMS, 17, 133–4, 165  
  dimethyl disulphide, DMDS, 133–4  
  dispersion, 168–71  
  dustfall, 400–1  
  electron microscopy, 142 (Fig.)  
  emissions, power plant, 331–339, 400–2  
  geothermal areas, 246–8  
  gypsum dust, 68  
  high volume sampling arrays, 140  
  hydrogen sulphide, 17, 133–5, 154–5, 165, 344–7  
  methyl mercaptan, 133–4  
  monitoring with vegetation, 142  
  O-isotopes  
    sulphate, 34–7, 157–58

## Atmosphere

- O-isotopes (*cont'd*)
  - sulphur dioxide, 37
  - water, 158
  - particle size, 140
  - particulates, 315-17
  - rain and snow, 150-5, 162
  - regional balance 159-62
  - relation to concentrations, 149, 153-7, 314
  - sampling of S-compounds, 44, 137-41
  - sea spray, 17
  - springs, 248-50
  - sulphate, 16, 34-7, 334-6
  - sulphur chemistry, 134-7
  - sulphur compounds, 133-8
  - sulphur dioxide, 37, 133-7, 154-5, 313-16, 333-8, 400
  - sulphur dust, 135, 290
    - incorporation by plants, 290-6
    - incorporation by soil, 290-6
- S-isotopes
  - biogenic-S, 17, 163-7
  - H<sub>2</sub>S, 154-5, 344-7
  - H<sub>2</sub>SO<sub>4</sub>, 143
  - particulates, 141, 316-17, 334-7
  - rain, snow, 150-5, 162, 352-5
  - relation to concentration, 149, 153-7, 314
  - relation to wind direction, 315
  - SO<sub>2</sub>, 139, 141, 154-5, 312-16, 332-8
  - sulphur trioxide, 332
  - sulphuric acid, 143, 299
  - transport, 168-71
  - volcanic emissions, 9, 16, 116-25
- Australia, 69, 88, 99, 271, 303, 385, 371-98
- Azov Sea, 219
- Baikal, USSR, 200
- Balkhash, USSR, 200
- Baltic Sea, 222
- Balzac, Canada, 155
- Barite
  - conversion to AG<sub>2</sub>S, 44
  - conversion to SO<sub>2</sub>, 51
  - O-isotopes, 38, 86, 249
  - radioactive sinter deposits, 38, 249
  - reduction with graphite, 56
  - S-isotopes, 67 (Fig.), 86, 249
- Bark, entrapped sulphur, 325
- Basic sills, S-isotopes, 8 (Fig.)
- Batch process, 6
- Beggiatoa*, 289
- Benthic biomass, 189
- Big Horn basin, USA, 244
- Biogenic emissions
  - ocean, 146-7, 164 (Fig.)
  - springs, 147, 242-51
- Biological sulphur cycle, 9
- Biosphere, 282-311
- Black Sea, 14, 185, 203, 217
- Blood, 300
- Bogs, 95
- Boling, 92
- Boraitotto, Italy, 91
- Brahmaputra, 228
- Brisbane, Australia, 303
- Broken Hill, Australia, 90
- Buggingen deposits, 86
- Calgary, Canada, 154-5
- California, 274, 284 (Fig.)
- Cambrian, 82, 101
- Canada, 82, 147, 154, 248, 274, 286 (*see also* Alberta, Ontario)
- Canberra, Australia, 303
- Cañon Diablo, 65
- Cape Reykjanis, Iceland, 123
- Carbon/sulphur ratio, plants, 282
- Carbon-bonded S, 268
- Carboniferous, 102, 243
- Carbonyl sulphide, COS, 133-4, 146, 165
- Cartagena, Spain, 90
- Caspian Sea, 220
- Casteliano, 88
- Caucasus, 88, 151
- Cenozoic oils, 105
- Central Europe, 88
- Cephalopoda*, 184
- Chemosynthetic autotrophic organisms, 12, 301
- Chesapeake Bay, USA, 147
- China, 91
- Chlamis latiaurata*, 184
- Chlorobium thiosulphatophilum*, 13
- Chlorophyta*, 188
- Chromatium vinosum*, 13
- Chromatium sp.*, 12
- Chvaletice, Czechoslovakia, 147, 155, 399

- Cladophora*, 185  
Claus process, 311  
Closed system, 7  
Coal  
  extraction of sulphur, 47  
  low sulphur, 99  
  S-content, 399  
  S-isotopes, 15 (Fig.), 18, 96–9, 99,  
  (Fig.), 100, 327, 332, 335, 383–7,  
  400  
  S-isotopes, emissions, 147, 154–5,  
  326, 335, 401  
*Codium vermila*, 185  
Coenzyme A, 187  
Colorado River, 227–8  
Connecticut, USA, 199, 203  
Continental seas, 217–24  
Copper–molybdenum deposits, 89  
  (Fig.)  
Copper–nickel deposits, 88 (Fig.),  
  392–4, 398  
Corrosion of monuments, 402–4  
Coverage, 296  
Cretaceous, 82, 245, 274, 318  
Crossfield, Canada, 141, 148  
Crude oil, (*see* petroleum)  
Crust–mantle, 65  
Crustal contamination, 66  
*Cucumis sativus*, 297  
Cyanobacterial mat, 370, 382  
Cysteine, 187  
Cystine, 187, 282, 299–300  
Cystine kidney stones, 300  
Czechoslovakia, 66, 150, 248, 399ff
- Deep sea hydrothermal vents, 301  
*Desulphotomaculum*, 144  
*Desulphovibrio desulphuricans*, 10, 144  
Determination of  $\delta^{18}\text{O}$  of water, 58  
Devonian, 82, 102, 109, 242  
Dimethyl disulphide, DMDS, 133–4,  
  146  
Dimethyl sulphide, DMS, 17, 133–4,  
  146, 165  
Directional array sampling, 315  
Dissolved organic sulphur, 204, 205  
  (Fig.), 318  
Dustfall, 400–1
- East Transbaikal, 89  
East Pacific, 198
- East Siberian platform, 100  
Edmonton, Canada, 154, 312  
Edwards aquifer, Texas, 239  
El-Chichon, Mexico, 117, 125  
Elemental-S  
  atmosphere, 135, 290, 309, 325  
  deposits, 91–5, 411  
  entrapped in bark, 325  
  incorporation by plants, 290–6  
  incorporation by soil, 290–6  
  manufacture, 309–11, 325  
  oxidation, 279, 309–11  
  S-isotope fractionation during  
  oxidation, 279  
  S-isotopes, 67 (Fig.), 91–5, 411  
  springs, 248  
Ellesmere Island, Canada, 38, 199, 203  
Enriched S-isotopes, potential for  
  atmospheric studies, 168  
*Enteromorpha*, 185  
Epiphytic lichens, 142  
Equilibrium isotope effects, 2  
Eschka, 47  
Etna, 118  
Europe, 69  
Evaporites, isotopic composition, 68–87  
  age curves, 82–6, 237 (Fig.)  
  marine, 15, 38, 68–86, 237 (Fig.)  
  non-marine, 86  
  reservoir estimate, 68
- Feathers, 301–3  
Filter packs for atmospheric sampling,  
  44  
Finland, 88  
Fisherman Bay, Australia, 379, 423  
Flue gas, 335, 399  
Fly ash, 328  
Flybye Springs, NWT, Canada, 250  
Flysch waters, 249  
Food webs, 299–303  
Forest soils, 146  
Formation waters, 110 (Fig.), 242–5  
Fossil fuels, 15–16, 15 (Fig.), 95–116,  
  412 (*see also* Coal, Petroleum, Sour  
  gas)  
Fumaroles, 66, 117, 121–4
- Gaurdak deposit, USSR, 94  
Gazli, Middle Asia, 103

- Geothermal areas, 245–7  
 Glacial tills, 233  
 Glutathione, 187  
 Gracefield, New Zealand, 157  
 Granite, S-concentration, 65  
 Great Salt Lake, 147, 154  
 Great Lakes, 151, 161 (Fig.), 199, 204, 212–15  
 Great Slave Lake, Canada, 247  
 Green Lake, Fayetteville, USA, 199  
 Greenhow, England, 90  
 Ground waters, 38, 177, 229–42, 277, 422–3  
 Groundwater, 229–42, 360–71  
   sulphate  
     O-isotope composition, 232–42, 366–71  
     S-isotope composition, 232–42, 366–71  
 Gulf Coast oils, 108  
 Gypsum, 68, 149, 379  
  
 Hair, 300  
 Harz Mountains, 95  
 Helmstedt, Germany, 96  
 Heron Island, Great Barrier Reef, 300, 303  
 HI-reducible S, 268–9  
 High-volume sampler, 140, 337  
 Higher animals, 299–303  
 Huang He, 228  
 Hubbard Brook, New Hampshire, USA, 147  
 Humic acids, lake sediments, 213–14  
 Hydrogen sulphide  
   abiogenic, in sediments, 198  
   atmosphere, 17, 133–4, 137, 344–7  
   biogenic, 15, 17, 144–7, 163–5, 250, 344–7  
   Black sea, 218  
   emission rates, 17, 345  
   geothermal, 245–6  
   oxidation, 134–5, 143, 347  
   sour gas deposits  
     Astrakhan, 113  
     Orenburg, 111, 113  
     Western Canada, 112 (Fig.)  
   S-isotopes, 154–5  
     biogenic, 15, 17, 144–7, 163–5  
     geothermal, 245–7  
     hydrocarbon deposits, 109–16  
     volcanic, 122–4  
     tidal flats, 344–7  
     volcanic, 122–4  
 Hydrology (*see* Hydrosphere)  
 Hydrosphere, 37, 177–266 (*see also* Continental seas, Groundwater, Lakes, Rivers)  
   bogs, 95  
   dissolved organic-S, 318  
   formation waters, 110 (Fig.), 242–5  
   geothermal waters, 245–7  
   Kuwait, 360–71  
 Hydrothermal vents, 301  
  
 Iceland, 123  
 Igneous rock S-isotopes, 8 (Fig.)  
 India, 247, 405–8  
 Indian Ocean, 185  
 Indus, 228  
 Iran, 99  
 Iraq, 91–2, 99  
 Isotope effects (*see also* Oxygen-isotope fractionation, Sulphur-isotope fractionation)  
   equilibrium, 2  
   equilibrium constant, 3  
   fractionation factor, 6  
   kinetic, 5  
   partition functions, 3  
 Israel, 150, 161  
 Italy, 91  
  
 Japan, 88, 162, 246, 287, 343–61  
 Jarosite, 250, 299  
 Jordan Rift Valley, 150  
 Jurassic, 82  
  
 Karelia, 88  
 Karst lakes, 20  
 Kazakhstan, 89, 151  
 Kazalehstan steppe, USSR, 20  
 Keystone, USA, 155  
 Kiba reagent, 46  
 Kidney stones, 300  
 Kilauea, 118, 120, 245  
 Kinetic isotope effects, 5  
 Kirgizia mountains, USSR, 151  
 Kola Peninsula, USSR, 151  
 Krafla, 245  
 Krakatoa, 125  
 Kunashir Island, 123

- Kurume, 150  
Kuwait, 99, 360–71
- Labadie, USA, 155  
Lacq, France, 110  
Ladoga, USSR, 200  
Lagoons, 146  
Lake Tanganyika, 200  
Lake Vanda, Antarctica, 38, 203  
Lake Chernyi Kichiyer, USSR, 203  
Lake Sakovo, USSR, 203  
Lake Bolshoi Kichiyer, USSR, 203  
Lake Kuznechikha, USSR, 203  
Lake Kinneret, 200  
Lake Creteil, 200  
Lake Kononyer, USSR, 203  
Lakes, 20, 38, 198–217  
    eutrophic, 205–8  
    humic acid, 213–15  
    karst, 20  
    meromictic, 208–11  
    oligotrophic, 204–5  
    oxygen isotope composition of  
        sulphate, 205  
    sediments, 211–17  
    water column, 198, 203  
Lead sulphide ores, (*see* Ore deposits)  
Lena River, USSR, 283  
Li-Al-H<sub>4</sub>, 46  
Lichens, 320, 323  
Lignite, 95  
Linsley Pond, USA, 199  
Lithosphere, 38, 65–132  
Lone Pine Sanctuary, Queensland,  
    Australia, 300  
Long Island, USA, 155  
Lublin, Poland, 150, 157
- Mackenzie River, 20, 246, 317  
Madison formation, 111  
Mafic rocks S-concentration, 65  
Mambray Creek, South Australia, 190,  
    379  
Mangrove, 185  
Marine sulphate, (*see* Evaporites,  
    Ocean)  
Marine animals, 185–8  
Marine sedimentary cycle, 14  
Marsh sediments, 180–93  
Mass spectrometry  
    memory effects, 54  
    oxygen isotopes, 59  
    sulphur isotopes, 54  
Meggen, 88  
Mekong, 228  
Mendeleev volcano, 123  
Meteorites, 65  
Methionine, 280, 297  
Methyl mercaptan, CH<sub>3</sub>SH, 133–4, 146  
Mexico, 91  
Microbial biomass, 269  
Middle East, 69, 100  
Mikawa Bay, Japan, 147  
Miocene, 82  
Mishrak, Iraq, 92  
Mississippi River, 228  
Mississippian, 244  
Miziiskaya platform, 102  
Modelling of uptake of industrial S,  
    320  
Mollusc, 184  
Mongolia, 89  
Monkeoppi formation, 82  
Montana, 102  
Monuments, corrosion, 402–4  
Moscow, 151  
Moss Bluff, USA, 91  
Mosses, 142  
Mt Ontake, 347  
Mt Tom Pond, USA, 199, 203  
Mt Agung, 147  
Mt St Helens, USA, 118, 121
- Nagoya, 150, 353–7  
Nails, 300  
Nairne, Australia, 88  
Native sulphur, 18, 91–5 (*see also*  
    Elemental-S)  
Natural oil seeps, 108  
New Zealand, 151, 245, 279, 284  
    (Fig.), 285–6  
New Haven, USA, 154  
New York City, USA, 155  
Newport, California, USA, 190  
Nigeria, 410–16  
Nitrogen/sulphur ratio, plants, 282  
Norlinger Ries, Germany, 96  
Norman Range, Canada, 38  
North America, 69, 91 (*see also*  
    Canada, United States of America)  
North Dakota, 102  
Northport, USA, 155

- Northwest Territories, Canada, 286  
 Novgorod, 151  
 Novodimitrovskaya, USSR, 91
- Ocean (*see also* Evaporites, Sulphate)  
 aerosols, 144–5  
 atmosphere, 144–147, 152 (Fig.)  
 biogenic sulphide, 145–6, 164 (Fig.)  
 carbonate, isotope composition, 251  
 emissions, 17  
 littorals, 17, 146  
 precipitation, 152  
 sediments, modern, 189–98  
 spray, 17, 152  
 sulphate, 14, 37, 178–183
- Ochoan, 82  
 Oder, 228  
 Oil shales, 391, 416  
 Oil, (*see* Petroleum)  
 Oligocene, 82  
 Onega, USSR, 200  
 Ontake, Japan, 120  
 Ontario, Canada, 21, 102, 143, 155,  
 198–9, 202, 212–15, 274, 320  
 Open system, 7  
 Ordovician, 82  
 Ore deposits, 18, 87–91  
 Australia, 80, 391–7  
 India, 405–8  
 S-isotopes, 67 (Fig.)  
 Cu-Mo, 89 (Fig.), 392–4  
 Native-S, 91–5, 411  
 Pb-Zn, 15, 90 (Fig.), 392–6  
 Orenburg gas-condensate deposit, 111  
 Organic-S, S-isotopes, 67 (Fig.)  
 Oxygen-isotope fractionation  
 exchange during sulphate reduction,  
 239–42  
 exchange reactions, 28–32  
 SO<sub>2</sub>-water, 28–32  
 sulphate crystallization, 33  
 sulphate reduction, 33  
 sulphate-water, 28  
 sulphide oxidation, 32  
 Oxygen-isotopes (*see also* Sulphate)  
 O<sub>2</sub>, atmosphere  
 water, 34–5, 365–9  
 urine, 301
- Pacific Ocean, 152  
 Paige Mountain, NWT, Canada, 147,  
 154, 248
- Parr bomb, 45, 47  
 Particulate sulphur, 138, (*see also*  
 Elemental sulphur, Atmosphere)  
 Peat, 16, 95 (*see also* Coal)  
 Pedosphere, (*see* Soil)  
 Pennsylvania, USA, 332  
 Pennsylvanian, 102, 244  
 Perch Lake basin, 232  
 Permian, 82, 102, 243  
 Persian Gulf, 378  
 Peru, 89  
 Petroleum  
 contamination in sediments, 108  
 extraction of sulphur, 47  
 mean S-isotope composition, 107  
 S-isotopes, 15 (Fig.), 18, 100–108,  
 332–43, 387–91  
 Phaeophyta, 189  
 Phanerozoic, 68  
 Phosphoria formation, 111  
 Photosynthetic organisms, 12  
 Phytobenthos, 188  
 Phytoplankton, 146, 188  
 Pisa, 150, 160  
 Plants (*see* Vegetation)  
 Plastic Lake watershed, 232  
 Pleistocene, 82  
 Poland, 91, 150  
 Polar bears, 187, 300  
 Polychaeta, 184  
 Polysaccharide sulphate, 45  
*Polysiphonia subilifera*, 185  
 Pore water sulphate, 193, 203  
 Power plants  
 Chwaletice, Czechoslovakia, 399  
 coal, 147, 155, 332, 342, 401  
 emissions, S-isotopes, 400–1  
 Kansk-Achinsk, USSR, 326–8  
 Northeastern USA, 331–43  
 Prague, 154  
 Proterozoic, 100  
 Prudhoe Bay, Alaska, USA, 108  
 Pyrite  
 abiogenic, 198  
 coal, 399–400  
 lake sediments, 254  
 ocean sediments, 197–8  
 oxidation, 12–13, 33  
 S-isotopes, 67 (Fig.), 88 (Fig.)  
 volcanic ash, 247
- Queechy Lake, USA, 199, 203

- Radioactive-S, 190  
Rain, 18–19, 365, 399  
Ram River, Canada, 320  
Rammelsberg, 88  
Rayleigh distillation equation, 210  
Reactions  
  first order, 12  
  multi-step, 6, 12  
  unidirectional, 12  
Red Sea, 198, 223  
Red Deer, Canada, 154  
Regional balances of atmospheric sulphur, 159–62  
Rhine, 228  
*Rhodophyta*, 189  
*Rhodopseudomonas sp.*, 13  
Rice-fields, 146  
River Niger, 227  
River basins, 228  
Rivers, 20, 224–9  
  O-isotopes, 25  
  sulphate concentration, 227–9  
  S-isotope variations, 38, 225–9, (Fig.), 283  
Rock–water interactions, 230  
Rot event, 85  
Rotleigend salt deposits, 86  
Russian platform, 100  
  
Sabkhas, 369  
Sakhalin, 150  
Salmon, 186  
Salt marshes, 146  
Salt crystals on leaves, 298  
Salt Lake City, Utah, USA, 158  
Salt domes, 92  
Santa Lucia, 88  
Satsuma Iwo-Jima group, 122  
Scanning electron microscopy, 142 (Fig.), 316  
Sea spray, 144–6  
Seals, 187, 300  
Sediments  
  distribution of sulphur compounds, 193  
  lake  
    anthropogenic influence, 211–17  
    S-isotope composition, 211–17  
  marsh, 190  
  ocean, modern, 189–8  
  pore water sulphate, 193, 203  
  sulphide mineral formation, 197–8  
  sulphur-isotope balance, 195–7  
  sulphur-mass balance, 196–7  
  sulphur-isotope composition, 193  
Selenium/sulphur ratio, 296, 302, 325  
Serchio River, Italy, 38  
Sernoye (reservoir), USSR, 200  
Shark Bay, Western Australia, 372, 423  
Shatt al Arab, 228  
Shikote Alin, 65  
Shimodava (Japan), 88  
Showashinzan volcano, Hokkaido, 122  
Shrimp, 187  
Siberia, 150  
Siberian platform, 89  
Sicily, 93  
Silurian, 102  
Skyreholme, England, 90  
Slotted cascade impactor, 140  
Soil, 267–82  
  horizons, 323–4  
  O-isotopes, 277  
  sources of S, 271–2  
  S-forms, 267–71  
    C-bonded, 268  
    HI-reducible, 268  
    inorganic, 267  
    organic, 268–71  
  transformations of S, 271  
  transfer of S to, 280–2  
  sulphate, 267  
  S-isotopes, 272–82, 291 (Fig.)  
    318–24, 326–71  
Solar Lake, 200, 203  
Solfatara, 117, 121–4  
Sour gas  
  Alberta, 16, 122 (Fig.), 309–11  
  Astrakhan, 112–13  
  emissions, 312–26  
  Orenburg, 111, 113  
  processing, 309–11  
  S-isotopes, 109–16, 309–11  
Souris River formation, Canada, 82  
South America, 69, 91  
Soviet Union (*see* USSR)  
Soxhlet extraction, 46  
Spencer Gulf, South Australia, 372, 422  
Spindleton, 92  
Springs, 146, 247–50, 289 (Fig.), 298  
  barite sinter, 249

- Springs (*cont'd*)  
 biogenic emissions, 250  
 cave development, 248  
 jarosite depositing, 249  
 sulphate  
   O-isotopes, 248–9  
   S-isotopes, 247–9  
 sulphide  
   S-isotopes, 248–9  
 travertine depositing, 248
- Sulphate  
 assimilation, 10, 285–8  
 concentration  
   formation waters, 293–6  
   lakes, 199–211  
   rivers, 225–9  
   seas, 217–25  
   sediments, 193–5  
 crystallization, 33  
 geothermal, 245–7  
 marine, 14–15, 68–86  
 ocean (*see* marine)  
 O-isotopes, 37–8, 225  
   aerosol, 36–7  
   evaporites, 84 (Fig.)  
   groundwater, 232–42  
   meromictic lakes, 209  
   rain, snow, 34–7, 150–9, 366–71  
   soil, 277  
   springs, 38, 247–9  
   urine, 301  
 pore water, 193, 203  
 precipitation, 8, 150–67, 352–61, 366, 400–2  
 reduction  
   algal mats, 370  
   assimilatory (*see* sulphate assimilation)  
   bacterial, 10–11, 192  
   chemical laboratory, 5, 32, 50–1  
   dissimilatory, 11  
   intensity in marches, 189–93  
   intensity in sediments, 189  
   light hydrocarbon gases, 113  
   mixture, 44  
   O-isotope fractionation, 33, 239–42  
   S-isotope fractionation, 5, 10–11, 239–42  
   thermochemical, 112–13  
 S-isotopes, 14, 18–20  
   aerosol  
   eutrophic lakes, 205–8  
   evaporites, 5, 68–86, 83, (Fig.), 85 (Fig.), 367  
   formation waters, 242–5  
   geothermal, 245–7  
   groundwater, 231–42, 365–6  
   lakes, 199–217  
   meromictic lakes, 208–11  
   minerals, 367  
   oligotrophic lakes, 203–4  
   rain, snow, 8, 150–67, 352–61, 365, 400–2  
   rivers, 38, 225–9, 282  
   seas, 217–25  
   springs, 247–9  
   terrestrial, 236 (Fig.)  
   volcanic ash, 348
- Stratosphere, 147, 154
- Streams (*see* rivers)
- Sudbury, Canada, 21, 143, 155, 198, 202, 215
- Sulphide (*see also* Hydrogen sulphide)  
 abiogenic, in sediments, 198  
 mineral formation, sediments, 197–8  
 oxidation, 12–13, 33, 309, 348  
 S-isotopes (*see also* Ore deposits)  
   in lignite, 96  
   ocean sediments, 193–6  
   uptake by plants, 289
- Sulphide ores (*see* Ore deposits)
- Sulphur isotope exchange reactions, 4
- Sulphur dioxide, SO<sub>2</sub>  
 atmosphere, 133–41, 154–5, 312–16, 332–8, 403  
 exposure threshold for plants, 290  
 geothermal, 245  
 heterogeneous oxidation, 136  
 homogeneous oxidation, 136  
 oxygen isotope composition, 37  
 preparation for sulphur isotope analyses, 48–53  
 purification, 52
- S-isotopes  
 atmosphere, 139, 141, 154–5, 312–16, 332–8  
 dependence on wind, 138–40, 315–16  
 sour gas processing, 309–11
- Sulphur dust, (*see* Elemental-S, atmosphere)
- Sulphur hexafluoride, SF<sub>6</sub>, 48, 179

- preparation for sulphur isotope analyses, 53–4
- Sulphur-isotope abundances, 8–21
  - atmosphere, 16, 312–17
  - basic sills, 8 (Fig.)
  - biogenic H<sub>2</sub>S, 17, 163–7
  - coal, 15 (Fig.), 383–5
  - Cu-Ni deposits, 89 (Fig.), 392–4, 398
  - Cu-Mo deposits, 89 (Fig.)
  - Cu-sandstone deposits, 90 (Fig.)
  - emissions, power plant, 400–1
  - evaporites, 5, 68–86, 83 (Fig.), 85 (Fig.)
  - fly ash, 327
  - feathers, 301–3
  - fossil fuels, 15–16, 15 (Fig.), 95–116
  - geothermal areas, 245–7
  - H<sub>2</sub>S in hydrocarbon deposits, 109–16
  - hair, 300–3
  - humans, 302–3
  - igneous rocks, 8 (Fig.)
  - lakes, 20, 199–218
  - native S, 18, 91–5
  - ocean, 14
  - oil shale, 391
  - organic-S, 67 (Fig.)
  - Pb-Zn deposits, 90 (Fig.), 373, 392–8
  - petroleum, 8 (Fig.), 15 (Fig.), 99–108, 331–43, 387–90
  - pyrite-polymetallic deposits, 88 (Fig.), 283, 392
  - rain, 8 (Fig.), 18–19, 150–2, 399
  - relation to metal pollution, 302
  - rivers, 20, 38, 225–9, 283
  - sea spray, 17
  - seas, 218–25
  - sedimentary sulphides, 8 (Fig.)
  - snow, 8 (Fig.) (*see also* rain)
  - sour gas processing emissions, 160 (Fig.)
  - springs, 247–9
  - stratosphere, 147
  - sulphide ores, 87–91, 90 (Fig.)
  - sulphur dioxide, 138–40, 400
  - terrestrial sulphate, 236 (fig.)
  - topographical effects, 295
  - urine, 301
  - volcanogenic, 8 (Fig.), 9, 93, 119–25
- Sulphur-isotope fractionation, during atmospheric transformations, 143
  - exchange reactions, 4, 143
  - oxidation
    - elemental S, 279
    - sulphide, 12–14
  - sulphate reduction
    - assimilatory, 10, 285
    - chemical, 6, 32, 50–1
    - dissimilatory, 11
  - <sup>35</sup>S-labelled sulphate, 190
  - Sulphur trioxide, 32, 49, 137, 332
  - Sulphuric acid from volcanic ash, 347
  - Sweden, 88, 240
  - Switzerland, 212
- Tadzhik depression, USSR, 105
- Tadzhikistan mountains, 151
- Tar sands, 413
- Tarnobzheg, Poland, 92
- Tatarian, 82
- Teepee Creek, Canada, 140
- Tensleep formation, 111
- Texas, 102
- Thiobacilli*, 12
- Thiobacillus denitrificans*, 235
- Thiobacillus concretivorus*, 13
- Thompson, Canada, 274
- Tidal flats, 344–7
- Timano-Pechora, 100
- Tokyo, 150, 353–7
- Topographical factors, 295
- Transition state theory, 5
- Triassic, 102, 244
- Troilite, 65
- Tunisia, 284 (Fig.), 286
- Tuscany, Italy, 38
- Typha latifolia*, 293
- Uinta Basin, Utah, 105
- Unidirectional processes, 5, 12
- United States of America, 88, 91, 102, 105, 108, 121, 146–7, 154–5, 158, 199–203, 215, 244–5, 274, 284, 332
- Upper Silurian, 82
- Urals, 88, 151
- Urine, 300
- Usnea scabrata*, 297
- USSR, 20, 81, 89, 91, 94, 105, 109, 111–13, 155, 200, 203, 217–24, 222, 273, 282–5, 284 (Fig.), 326
- Valleyview, Canada, 275, 280, 320

- Vegetation, 20, 142, 282–99  
  algae, 185–9  
  atmospheric monitoring, 142  
  benthic weeds, 185  
  C/S ratios, 282  
  emission of reduced-S, 297  
  marine, 183  
  salt crystals on leaves, 298  
  sulphide assimilation, 184, 188  
  sulphur dioxide  
    exposure threshold, 290  
    uptake, 288, 290–5  
  sulphur dust incorporation, 325  
  sulphur-forms, 282–3  
  sulphur isotopes, 283–99, 318–19  
    biological factors, 296  
    fractionation during emissions of  
      reduced-S, 297  
    salt crystals on leaves, 298  
    topographical influence, 295  
  *Zostera*, 185, 189  
Venezuela, 14  
Venice, 150, 157, 160  
Vistula, 228  
Vladivostok, 150  
Volcanoes  
  activity classification, 121  
  ash, 120–1, 348  
  emissions, 16, 66  
  gases, 121–4  
  S-flux to atmosphere, 116–19  
  S-isotopes, 8–9, 119–25  
  total volcanic sulphur emitted to  
    atmosphere, 124–5  
Volcanogenic deposits, 93  
Volga, 243  
Volga-Urals, 110  
  
Wawa, Canada, 212, 273  
Whiskers, 300  
Whitecourt, Canada, 140, 155, 204, 319  
Wind River Basin, USA, 102, 110, 244  
Wood Point, Australia, 379  
Wind direction, effect on S-isotopes of  
  SO<sub>2</sub>, 139 (Fig.)  
  
Yakutia, 150  
Yellowstone, 245  
Yudomski Souris event, 85  
  
Zechstein, 82  
Zhosaly Sopka, USSR, 283  
Zinc sulphide ores (*see* Ore deposits)  
Zooplankton, 146  
*Zostera*, 185, 189