# Index

Note: (ill.) indicates photos and illustrations.

# A

Aa lava, 294 Ablation area, 247 Absolute age, 152-53 Abyssal plains and hills, 347 Accumulation area, 247 Achondrites, 51 Acicular mineral habits, 94 Acid deposition, 187 Acid rain, 180 (ill.), 180-81, 187 Acids, 186-87 Active volcanoes, 296 Adhemar, Joseph. 259 African Rift System, 79 Aftershocks, 267-68, 269 (ill.) Agassiz, Louis, 7, 7 (ill.), 259 Age, 27 Agricola, Georgius, 4, 82, 83, 139, 208, 292 Alaskan volcanoes, 312 Aldebaran, 57 Aldrin, Edwin "Buzz," 49 Aletsch glacier, 408 Allochromatic minerals, 87 Alluvial fans, 221-22 Alpine environment, 242-43, 243 (ill.) Alps, 142, 411–12 a.m., 19-20 Amazon Basin, 433-34 Amber, 151 Amethyst, 101 Amphibole, 121

Anak Krakatau, 430 Ancient insects, 151 Ancient sediments, 196 Andes Mountains, 427 Andesite, 122 Angel Falls, 20, 422 Angle of repose, 191 Angular unconformity, 116 Animals and earthquakes, 279 Annals of the Former World, 455-56 Antarctica, 430-32, 431 (ill.), 432 - 33huge lake beneath ice sheet, 258 ice-free coastal areas and ice shelves, 436 major volcanoes in, 428 mountain ranges in, 215 valley glacier, 432–33 wind erosion, 198 Anthracite coal, 175 Aphelion, 14, 15 Appalachians, 212-13, 377 (ill.), 377–78, 378 (ill.) Aguifer, 231–32 Aral Sea, 419-20 Archipelago, 438–39 Arctic environment, 242, 242 (ill.), 424 Arctic Ocean, 24 Aristotle, 1, 141, 266, 292 Arkansas River, 398 Arkose, 125

Armstrong, Neil, 48 (ill.), 49 Artesian wells, 231–32 Artificial lakes, 229 Asbestos, 100 Ash. 298 Asteroids definition of, 355–56 effect on Earth, 357-58, 359 - 60impacts on Earth since late heavy bombardment, 40 impact on Moon, 361 preventing collision of, 358-59 search for, 360-61 Asthenosphere, 60–61, 69 Astronauts, 49 Astronomical unit (AU), 353 Atlantic Ocean, 24 Atlas Mountains, 412 Atmosphere, 46, 362-64 Australia, gold in, 131–32 Australopithecus afarensis ("Lucy"), 158 Australopithecus africanus ("Taung child"), 158 Avalanches, 191, 248 (ill.), 249 Ayers Rock, 437–38, 438 (ill.) Azizia, Libya, 20

### B

Bacon, Francis, 70 Bailey's beads, 45 Barchan sand dunes, 198 Breccia, 118-19 Carlsbad Caverns, 328, 328 (ill.) Barrier islands, 384 Brookes, R., 155 coral reefs, 324 Basalt, 122 Bryce Canyon, 403-04 definition of, 317 Bascom, Florence, 10 Buckland, William, 147, 155 glacier vs. ice, 324 Basin and Range, 401 Buffon. Comte de Georges Guinness Book of World Batholith, 300 Louis Leclerc, 39 Records, 327 Bathymetric contours, 31 Bullard, Sir Edward, 71 gypsum karst, 323 Bunsen burner, 172 Bays, 381-82 karst regions and. Bunsen, Robert, 172 Beach sand, 339 320-23, 327, 329 Burgess Shale, 159, 411 Bean, Alan, 49 lava, 324-25, 328-29 Burial metamorphism, 119 Beardmore Glacier, 432-33 Lechuguilla Cave, 328 Beaumont, Elie de, 208 limestone, 320, 326-27 Beche, Sir Henry Thomas de C limestone karst, 322 la. 5 primary, 319 Calcite, 85, 95 (ill.) Becquerel, Antoine, 25 records, 329-30 Calcite forms, 326 Bedrock, 223 salt, 322-23 Benioff, Hugo, 78 Caliche, 201 sandstone, 323 Bergschrund crevasses, 248 California and plate tectonsecondary, 319-20 ics. 78 Bertrand, Elie, 266 speleothems, 325–26 Bertrand, Marcel Alexandre, Cambrian Era, 29 spelunker, 317 208-11Canadian earthquakes, 286 stalactites and stalag-Big bang theory, 35–36 Canadian Rockies, 410, 411 mites, 325 (ill.), 326 Big Cypress Swamp, 384 Cannington silver/lead/zinc tectonic, 324 Bingham Canyon copper mine, 133 uniqueness of interior, mine, 130 Canyons, 402 (ill.), 402-04, 318 Biological weathering, 184 403-04 in the United States, 319, Bird fossils, 156–57 Cape Cod, 385 327 Carbon cycle, 111-12 Birthstones, 103, 103 (chart) weather in, 319 Bitumen, 164 Carbon dating techniques, Wind Cave, 329 Bituminous coal, 175 152 (ill.), 153–54 zones, 318-19 Carbon dioxide, 17–18 Black diamonds, 106 Cecchi, Filippo, 274–75 Carbon films, 144–45 Black Hills/Mountains, 213 Cells, 54 Carbonation, 187 Black Sea, 419 Carbonization, 144–45 Cenozoic Era. 29 Black smokers (deep-sea hydrothermal vents), 306, Carlsbad Caverns, 328, 328 Cenozoic orogenies, 210, 307 (ill.), 447–48 210 (chart) Bladed mineral habits, 96 Carrel, Giovanni, 412 Cernan, Eugene, 49 Blocks, 298 Cascade Range, 392–93 Chalk, 125, 150 (ill.) Blowpipe or fusibility test, 91 Caspian Sea, 420 Chamberlin, Thomas Chrow-"Blue Marble," 40 (ill.) Cassini, 58 der. 8-9 Blue Ridge Mountains, 377 Casts, 150 Channeled Scablands, 261, 404 Body fossils, 139 Cataclastic metamorphism, Boltwood, Bertram, 39-40 Channels, 219, 223 Chemical elements in min-Bombs, 298 Catastrophism, 3 Cave and mine tours, 447 erals, 86, 86 (chart) Bonneville Salt Flats, 135 (ill.) (ill.), 447–48 Bouvetova, 437 Chemical mineralogy, 82 Cave system, 317 Chemical sedimentary Bowen, Norman Levi, 10, 84–85, 85 (ill.) Cavendish, Henry, 22 deposits, 115 Bowen's Reaction Series, Caverns, 230 Chemical weathering, 184. 84–85, 85 (ill.) Caves, 54-55, 230, 318 (ill.) 185, 186–88 Braided channels, 223 calcite forms, 326 Chemofossils, 140

Chemolithoautotrophic organisms, 55	Compositional layering, 61 Conglomerate, 118–19, 125	Earthquakes and faults; Layers (Earth); Mantle;
Chengjiang mud beds, 159	Connecticut River Valley, 381	Moving continents; Plate
Chesapeake Bay, 381–82	• •	tectonics
Chicxulub impact, 415	Conrad, Pete, 49	major minerals in, 63
	Conrad, Timothy, 259	Mohorovičić discontinu-
Chondrites, 51	Contact/thermal metamor-	ity, 63
Chron, 27	phism, 119	oceanic vs. continental,
Chronostratographic units, 29–30	Continental crust, 62–63	62–63
	Continental	P- and S-waves, 68-69
Cichlids, 432	displacement/drift, 4, 72, 142	percentage of, in Earth, 60
Cirques, 252	Continental margins, 341,	Crystal lattice, 92–93
Clastic rocks, 186	342	Crystalline core range,
Clastic sedimentary deposits, 115	Continental rise, 344–45	205-06
Clay, 85, 126	Continental shelves, 341,	Crystalline forms, 93
	342, 343 (ill.)	Crystalline upthrust range,
Cleanatur 103	Continental slopes, 342	205
Cleopatra, 103	Contour lines, 30–31	Crystallography, 82
Cloud, Preston, 11	Convergent boundaries, 75	Crystals, 27. See also Gem-
Coal. See also Fossil fuels;	Coprolites, 147	stones; Minerals
Natural gas; Oil (petroleum) coke, 177	Coral reefs, 324	crystal lattice, 92–93
definition of, 174–75	Corals, 435	crystalline forms, 93
deposits, 176, 178	"Core-rigidity zones," 67	definition of, 92
electricity, 178	Cores, 59–60, 60 (ill.). See	mineral habits, 94, 96
first mention of, 162	also Crust; Earth; Earth-	seven common systems,
gasification and liquefac-	quakes and faults; Layers	85 (ill.), 94
tion, 177	(Earth); Mantle; Moving	small specimens, 93
mining of, 176–77, 177	continents; Plate tectonics	softest, 96
(ill.)	"core-rigidity zones," 67	talc, 96
peat, 176	discoverers of, 65-66	Cubic crystal system, 94, 95
types of, 175–76	Gutenberg discontinuity,	(ill.)
use of, 177–78	65	Cullinan I diamond, 107
Coast Mountains, 212	magnetic field, 66–67	Currents, 345–46
Coastal Ranges, 214, 390	percentage of, in Earth, 60	Cuvier, Baron Georges
Coastlines, 338–39	solid inner, 65–66	Leopold Chretien Frederic
Coelacanth, 153 (ill.), 154	Coronal mass ejections	Dagobert, 141–42
Coke, 177	(CMEs), 36, 42	_
Colorado Plateau, 400	Corrie or cirque glaciers, 245	D
Colorado River, 398, 398 (ill.)	Country rocks, 113	Dams, 224 (ill.), 225, 236
Columbia Plateau, 400	Crater Lake, 393–94	Dana, James Dwight, 7, 99
Columbia River. 397	Crater lakes, 228	Danakil Depression, 428
	Craters, 401–02, 403	Dark zone, 318–19
Comets, 42 (ill.), 357 (ill.) definition of, 356	Craters of the Moon, 401–02	Darwin, George H., 47
effect on Earth, 357–58,	Creep, 191, 269	Dating methods of fossils,
359–60	Crevasses, 248, 249, 250-51	152–53
impacts on Earth since	Cross-bedding, 199	Davis, William Morris, 10
late heavy bombard-	Cross-cutting relationships, 3	Dawson, George Mercer, 8
ment, 40	Crude oil, 164, 165–66	Dead Sea, 20, 420–21, 421
preventing collision of,	Cruithne, 49	(ill.)
358–59	Crust, 39, 59, 60 (ill.). See	Death Valley, 400–01, 401
search for, 360-61	also Cores; Crust; Earth;	(ill.)

Debris avalanche, 195 Drumlins, 254 statistics on geologic fea-Debris fall, 193 tures, 20 Dunes, 198, 199 sun's effect on, 42 Debris flows, 195 Dutton, Clarence Edward, temperature, 15 Debris slide, 193-94 7-8, 212 temperature, highest and Deccan Traps. 414–15 Dynamic metamorphism, lowest, 20 Deep ocean floor (basin), 347 119 temperature statistics, 21 Deep sea channels, 346 Dziewonski, Adam, 70 (chart) Deflation lakes, 229 temperature, varving, Deitz, Robert, 76-77 20 - 21F Delta, 221-22 Van Allen radiation belts. Denali (Mt. McKinley), 393, Earth. 1. See also Cores: 14 - 15394 (ill.) Crust; Layers (Earth); Man-Earthflows, 195 Dendritic drainage pattern, tle; Moon; Moving conti-Earthquakes and faults, 71 224 nents: Planets: Plate tec-(ill.), 271 (ill.), See also Dendritic mineral habits, 96 tonics; Sun; Universe and Cores; Crust; Earth; Layers Desert pavement, 198 solar system (Earth); Mantle; Moving age of, 25, 39-40 Desert water, 231 continents: Plate tectonics a.m. and p.m., 19-20 Deserts, 400, 423-24. See ancient, 286, 286 (chart) also Sand; Wind-blown aphelion, 14, 15 ancient explanations for. sands and deserts asteroids and comets, 40 265 - 66Diagenesis, 116-17 average density, 21–22 animals and, 279 Diamond mines, 128, 129 "Blue Marble," 40 (ill.) average duration of, (ill.) carbon dioxide, 18 280 - 82Diamonds, 83-84, 105 (ill.), circumference of, 17, 24 Canadian, 286 105 - 08dangers to, 36 damage from, 283 Dichroism, 87–88 development of life on, 54 definition of, 267 Dieng Volcano Complex, 301 detection devices, 273-75 elements found in atmos-Dietz, Michael, 168 phere, 17-18 door frames during, 280 Differential weathering, 190 existence of life without elastic rebound, 271 Dikes, 113, 301 sun. 54-55 epicenter, 272 Dinosaurs, 141, 155–57 first living cells on, 54 faults, 269-70 Diorite, 122 late heavy bombardment, feel of, 280 Dip-slip faults, 270 40 first, 265 Disappearing (or loosing) location in solar system, first use of seismic data, stream, 323 68 Disconformit, 116 longitude and latitude, focus (hypocenter), 272 18 - 19Discontinuities, 64 foreshocks, mainshocks, Dissolution/replacement. major statistics, 17 and aftershocks, 144, 186–87 oldest rocks on, 25, 27 267-68, 269 (ill.) Diurnal tides, 334 orbit speed around the graben and horst, 270 Divergent plate boundaries, sun, 16 Hayward fault, 406 perihelion, 14 high death tolls, 285. Dogtooth spar, 326 position in solar system, 287–89, 287–89 (chart) Dokuchaev, Vasily 54 high-risk areas, 282–83 Vasilievich, 9 Prime Meridian, 19 importance of, 265 Dolomite, 383 relation to universe, 35 Internet resources, 465 Door frames, 280 relationship to other Japanese, 281, 417–18 Dormant volcanoes, 296 planets, 16 Kobe, 418 Double planetary system, 48 rotation speed, 16–17 landslides, 285 Drake, Edwin, 170 seasons, 13-14, 14 (ill.) largest, 286-87, 287 Dreikanters, 199 solidification of crust, 39 (chart)

liquefaction, 283–84	Economic geology, 2	Fault block mountain range,
lithosphere and asthenos-	Edgewood-Kuiper Belt	206
phere, 69	Objects (KBOs), 354–55	Faults, 269–70
Loch Ness, 417	Effervescence, 91	Favre, Alphonse, 208
low-magnitude, 289	Elastic rebound, 271	Feldspar, 95 (ill.), 99, 121
magnitude, 276	Electricity, 178	Felsic igneous rocks, 114–15
maps, 275–76	Electron spin resonance,	Fibrous mineral habits, 96
Milne, John, 267	152–53	A Field Guide to Geology:
Mitchell, John, 266–67	Emeralds, 103-04	Eastern North America,
modern study of, 266	Empedocles, 61	Peterson Field Guides, 457
Modified Mercalli Intensi-	Entrance (cave), 318	A Field Guide to Rocks and
ty Scale, 276–77,	Environmental geology, 2	Minerals, Peterson Field
276–77 (chart)	Eocene Period, 351–52	Guides, 457
vs. moonquakes, 47	Eon, 27	Field guides, 456–57
New Madrid Fault Sys-	EOS, 455	Filomarino, Ascanio, 273
tem, 386	Ephemeral stream, 224	Finger Lakes, 261–62,
new measurements of,	Epicenter, 272	373–74
277–78		Firn, 247
New York City, 385–86	Epoch, 27	Fisher Towers, 398 (ill.)
number of, 268, 268	Equant/equidimensional	Fjords, 252, 252 (ill.)
(chart)	mineral habits, 96	Flash floods, 235
Owens Valley, 405–06	Equilibrium line, 247	Flood basalts, 297
P- and S-waves, 68–69	Era, 27	Floodplain, 222
and plate tectonics,	Erathem, 29	Floods. See also Groundwa-
73–74	Eratosthenes, 24	ter; Lakes; Oceans; Rivers;
prediction of, 278–80	Erosion, 183, 185, 222, 223,	Water
Richter scale, 277, 278	251–52	dam breaks, 236
(ill.)	Erratics, 253	destruction from, 235
San Andreas fault, 270,	Esmark, Jens, 259	flash, 235
404-05	Eukaryotes, 54	glaciers, 249
seismic tomography,	Europa, 56, 369	ice jam, 236
69–70	European Alpine system, 412	leading cause of natural
seismic waves, 272	European Alps, 142, 411–12	disasters, 233
seismograms, 273	Everglades, 384	occurrence of, 234, 234
seismographs, 273-75,	Evolution, 11	(ill.)
274 (ill.)	Ewing, James, 275	100-year, 234–35
seismometers, 273	Ewing, Maurice, 342	significant, 236–37, 237
seismoscope, 273	Excelsior diamond, 107	(chart)
strongest, 285	Exfoliation, 188 (ill.), 188–89	storm surge, 236
surface waves, 272-73	Exosphere, 46	Susquehanna River,
"swallowing people"	Extinct volcanoes, 296	380–81
myth, 280	Extra-heavy oil, 164-65	Flows, 191, 194–95
tsunamis, 284 (ill.),	Extrusive igneous rocks, 113	Flowstone, 327
284–85		Fluorescence, 91
Turkey, 418	F	Focus (hypocenter), 272
underwater landslides, 268	•	Foliated rocks, 120
waves, 67, 69	Facies, 112	Folklore, 62, 101-02
"World Series" earth-	Fall/autumn, 13	Foreland, 204
quake, 405	"Falling rock" zones, 193,	Foreshocks, 267-68
East African Rift Valley, 79,	194 (ill.)	Fossil fuels. See also Coal;
428, 429 (ill.)	Falls, 191, 193–94	Natural gas; Oil (petroleum)

acid rain, 180 (ill.), 180–81 cleanest burning, 178–79 development of, 162–63 effect on environment, 179 first mentions of, 161–62 greenhouse gases, 179–80 ozone layer, 181 Polo, Marco, 162 Strategic Petroleum Reserve, 179 U.S. energy from, 162 Fossils, 7, 143 (ill.), 145 (ill.)	most common, 150–51 oldest, 140 origin of, 141 paleontology, 141–42 petrified wood, 144 preservation of remains, 149 pseudofossils, 150 records, 145–46 soft parts, 148, 148 (ill.) taphomony, 142 trace, 140 types of, 139–40 U.S. parks, 159–60	red spinel, 104 synthetic, 108–9 types of, 109 Geochemistry, 2 Geologic divisions, 28–29 Geologic maps, 6, 32 Geologic time scales, 29 Geological sites cave/mine tours, 447–48, 447 (ill.) gem and mineral shows, 446–47 tours and expeditions, 448–50
absolute age, 152 (ill.), 152–53 in the Alps, 142 amber, 151 ancient insects, 151	Fractures, 89 Franklin, North Carolina, mines, 448 Freshwater lake, 226 Frost action, 185	Geological Survey in Britain, 5 Geologists Agassiz, Louis, 7, 7 (ill.) Agricola, Georgius, 4
Arctic, 424 bird, 156–57 carbon dating tech- niques, 153–54 carbonization and carbon	Frost heave, 185–86, 241–42 Frostwork, 326 Frozen regions, 195 Fumarole, 302	Bascom, Florence, 10 Beche, Sir Henry Thomas de la, 5 Bowen, Norman Levi, 10
films, 144–45 categorization of, 146–47 continental drift, 142 coprolites, 147	<b>G</b> Gabbro, 122 Galapagos Islands, 428–29	Chamberlin, Thomas Chrowder, 8–9 Cloud, Preston, 11 Dana, James Dwight, 7 Davis, William Morris, 10
dating methods of, 152–53 definition, 139 determination of age of, 151	Galilei, Galileo, 45 Gamma ray burst, 38 Ganymede, 369 Garnet, 101 Gasification, 177	Dawson, George Mercer, 8 Dokuchaev, Vasily Vasilievich, 9 Dutton, Clarence Edward, 7–8
dinosaur, 141, 155–57 discovery of, 145 famous, 158–59 formation of, 143 gastroliths, 147	Gasoline, 169, 170 Gastroliths, 147 Gem and mineral shows, 446–47 Gemstones. See also Crys-	Gilbert, Grove Karl, 8 Gilbert, William, 8 Gutenberg, Beno, 11 Hall, James, 6–7 Horton, Robert Elmer,
hominid, 157  Homo neandertalensis, 157  Homo sapiens, 158, 158 (chart)	tals; Minerals birthstones, 103, 103 (chart) black diamonds, 106	9–10 Hutton, James, 5 Lyell, Charles, 5 (ill.), 5–6 Maclure, William, 6
importance of, 140 index, 152 Internet resources, 465 La Brea tar pits, 149 "living," 154–55	classification of, 101 collection of, 101 diamonds, 105–08 emeralds, 103–04 folklore surrounding, 101–02	Maury, Matthew Fontaine, 9 Murchison, Sir Roderick Impey, 6 Penck, Albrecht and Walther, 9
on Mars, 159 mineralization, 144 molds and casts, 150	organic, 104 precious vs. semi-pre- cious, 108	Playfair, John, 6 Powell, John Wesley, 9, 9 (ill.)

Sedgwick, Adam, 6 Smith, William, 6 Steno, Nicolaus, 4–5	videos/DVDs, 460–61 Geology Today, 454 Geology Underfoot Series,	"Grand Canyon of the East" (Letchworth Gorge), 374
Werner, Abraham Gott-	456–57	great drumlin field, 374
lob, 5	Geomorphology, 2, 10	Greenland, 407
Geology. See also Geological	Geophysics, 2	highest free-falling water-
sites; Geologists	Geothermal energy, 300	fall in northeastern
age of the science of, 1	Geothermal vents, 55	United States resulting from, 373
best places to collect rock specimens, 443	Geotimes, 454	Humboldt glacier, 408
books, 455–56	Gesner, Abraham, 168	ice-falls, 248
careers in, 452–53, 453	Geysers, 298 (ill.), 299,	Iceland, 408
(ill.), 454	394–95	importance to climate
cataloging and storing	Giant's Causeway, 415	studies, 254–55
collections, 446	Gilbert, Grove Karl, 8	Lambert Glacier, 432
catastrophism, 3	Gilbert, William, 8	last ice age in eastern
children's publications, 457	Glacial advances and	United States, 371
clothing and equipment	retreats, 250	location of, 245
needed for field work,	Glacial drift, 253	major areas of, 247
443 (ill.), 443–45	Glacial flour, 254	measurement of, 247
collection tips, 441–46	Glacial geology, 2, 8–9	Mer de Glace, 408
continental drift, 4	Glaciated valleys, 251	moraines, 251 movement of, 250
cross-cutting relation-	Glacier caves, 324	New England, 371–72
ships, 3	Glaciers, 245 (ill.), 373 (ill.).	North Atlantic shipping,
definition of, 1	See also Ice; Ice ages	407
degrees in, 453–54	Aletsch glacier, 408	Southern Patagonia Ice-
field guides, 456–57	Antarctica, 430–32, 431 (ill.), 432–33, 436	field, 432
getting started in, 441	Beardmore Glacier,	striations, 252
identification of rocks, minerals, and fossils,	432–33	thickest temperate, 249
441, 443	Cape Cod, 385	till and tillite, 253
Internet resources,	common glacial deposits,	types of, 244–45
462–67	252–53	umlaufbergs, 374
law of superposition, 2–3	coverage on Earth's sur-	Vatnajokull glacier,
magazines, 454–55	face, 246, 246 (chart)	408–09
maps, 445–46	crevasses, 248, 250–51	Wisconsin Glaciation, 374–75
museums, 457–60	dangers from, 249	
neptunism, 3	definition of, 244 drumlins, 254	Global climate, 308
organizations and soci- eties, 450–51	economic importance of,	Global earthquake potential
outdoor precautions,	253	map, 282–83
441–42	erosional features from,	Global warming, 255, 349–52, 350 (ill.)
plutonism, 4	251–52	Gneiss, 127
stamps representing, 462	Finger Lakes gorges,	
subdivisions, 2	373–74	Gold, 130–32, 133
supply companies,	firn, 247	Gondwana/Gondwanaland,
461–62	formation of, 246–47	70, 74, 437
television shows, 460	glacial advances and	Gould, Stephen J., 146
tools used for rock and	retreats, 250	Graben, 270
fossil collecting, 444	glacial drift, 253	Grand Canyon, 9, 402 (ill.),
uniformitarianism, 3	glacial flour, 254	402-04, 403-04

"Grand Canyon of the East" (Letchworth Gorge), 374 Grand Tetons, 391 Granite, 121–22 Granular flows, 195 Graphite, 83–84 Gravel, 130, 137 Graywacke, 125–26 Great Barrier Reef, 434–35, 436 (ill.) Great drumlin field, 374 Great Lakes, 382 Great Salt Lake, 397 Green Mountains, 379 Greenhouse effect, 18, 365 Greenhouse gases, 179–80, 253	H Half Dome (Yosemite National Park), 188 (ill.), 389–90 Halite, 95 (ill.) Hall, Sir James, 6–7, 293 Halophilic organisms, 55 Hand of Faith, 132 Hanging glaciers, 244 Hanging valleys, 251–52 Hardness, 89–91 Harrison, George, 132 Hart, William A., 172 Hawaiian Islands, 305–06 Hawaiian Ridge, 206–07 Hayden Planetarium, 458 (ill.)	Hortonian overland flow, 218 Hot spot, 304–06 Hot springs, 55, 394–95 Howe Caverns, 447 Hudson Bay, 421, 422 Hudson River, 379–80 Humboldt glacier, 408 Hurricane Agnes, 381 Hurricane Camille, 340 Hurricane winds, 340 Hutton, James, 3, 4, 5, 259 Hydration, 186 Hydrology, 2 Hydrothermal metamorphism, 119 Hydrothermal minerals, 133–34
Greenland, 20, 407	Hayward fault, 406	Hyperthermophilic organ-
Greensand, 125	Heezen, Bruce, 342	isms, 55
Greenwich, England, 19	Helictite bushes, 326	
Groins, 341	Hennepin, Louis, 384	I
Ground ice, 241	Herkimer Diamond Mines,	Ice. See also Glaciers; Ice ages
Ground moraines, 251	448	alpine environment,
Ground shaking, 283	Herodotus, 1, 141	242–43, 243 (ill.)
Groundwater. See also	Hess, Harry, 72, 76–77	Antarctic lake, 258
Floods; Lakes; Oceans; Rivers; Water	Hessel, Johann Friedrick Christian, 82	arctic environment, 242,
amount of water under-	Hexagonal crystal system,	242 (ill.)
ground, 230	94, 95 (ill.)	frost heave, 241–42
aquifer, 231–32	High velocity events, 191	ice caps, 257–58 ice domes, 257
caves and caverns, 230	Highlands, 45	ice sheets, 255–56, 258
definition of, 229	Hillary, Sir Edmund, 204	ice shelves, 256–57
under deserts, 231	Himalayas, 211, 409-10	icebergs, 257
fluctuation of, 229–30,	Hinterland, 204	icefields, 257–58
230 (ill.) pollution, 232–33	Hoba, 52	ground, 241
problems, 232–33	Holmes, Arthur, 79	melting, 258
supplies, 230–31	Hominid, 157	patterned ground,
well, 232	Homo erectus ("Java Man"),	239–40
Guettard, Jean-Etienne,	157 Homo neandertalensis, 157	periglacial regions,
292–93	Homo sapiens, 157, 158, 158	239–40
Guilin Hills of China, 425	(chart)	permafrost, 240–41 rime, 243–44
Guinness Book of World	Hoodoos, 404	Ice ages. See also Glaciers;
Records, 327	Hoover Dam, 224 (ill.)	Ice ages. See also Glaciers,
Gulf of Aden Rift, 79	Hope Diamond, 107 (ill.),	Agassiz, Louis, 7, 259
Gulf of Mexico, 385	107–8	cause of, 259
Gutenberg, Beno, 11, 65, 277	Hope, Henry Philip, 108	Channeled Scablands,
Gutenberg discontinuity, 65	Horn, 252	261
Gypsum dunes, 118 (ill.)	Horst, 270	coverage on Earth, 262
Gypsum karst caves, 323	Horton, Robert Elmer, 9–10	definition of, 259

Finger Lakes, 261–62	K	Lapidary Journal, 455
first proposal of idea of,	179, 400	Late heavy bombardment, 40
259	K2, 409	Lateral moraines, 251
glacial and interglacial	Kames, 253	Laterites, 201
periods, 260, 261	Kanchenjunga, 409	Latitude, 18 (ill.), 18–19
(chart)	Karst regions and caves, 320–23, 327, 329	Laurasia, 74
Lake Bonneville, 261		Laurentia, 376
last, 260	Kelvin, Lord, 39	Lava, 294, 324–25, 328–29,
"Little Ice Age," 262–63	Kerosene, 168	414–15
major and minor, 260	Kettle lake, 253	Lava field, 401–02
Ice caps, 257–58	Kimberlite, 105	Lava pillars, 306–07
Ice caves, 324	Kobe, 418	Law of superposition, 2–3,
Ice domes, 257	Koh-I-Noor diamond, 108	4–5
Ice jam floods, 236	Krakatau, 313	Law of the Sea Treaty, 134
Ice sheets, 255–56, 258, 351,		Layers (Earth). See also
371	L	Cores; Crust; Earth; Earth-
Ice shelves, 256–57		quakes and faults; Mantle;
Icebergs, 249, 257	La Brea tar pits, 149	Moving continents; Plate tectonics
Ice-falls, 248	Laccolith, 300	compositional and
Icefields, 257–58	Lackawanna Coal Mine Tour,	mechanical, 61
Iceland, 408	448	earthquake waves, 69
Idiochromatic minerals, 87	Lahars, 301–02	folklore about, 62
Igneous minerals, 84	Lake Baikal, 228, 420	importance of, 61–62
Igneous rocks, 112–13,	Lake Bonneville, 261	interior, 60–61
114–15, 121–22	Lake Missoula, 261	major, 59–60
Impact craters, 355, 358, 358	Lake Superior, 20	scientific explanation of,
(ill.)	Lake Tahoe, 398–99	61
Index fossils, 152	Lake Victoria, 432, 433	seismic tomography,
Indian Ocean, 24	Lake Vostok, 56	69–70
Inner core, 59–60	Lakes. <i>See also</i> Floods; Groundwater; Oceans;	Leaded gasoline, 169
Insects, 151	Rivers; Water	Lechuguilla Cave, 328
Interglacial periods, 260, 261	deepest, 227–28, 228	Lehmann, Inge, 65–66
(chart)	(chart)	Leonardo da Vinci, 142, 266
Intermittent stream, 224	definition of, 226	LePichon, Xavier, 73
Internal (density) waves, 340	freshwater vs. saline	Letchworth Gorge, 374
Interplanetary dust, 53	(salt), 226–27	Lightfoot, John, 25
Intraplate ocean tectonics,	Great Salt Lake, 397	Lignite, 175–76
80	Lake Baikal, 228, 420	Limestone caves, 320,
Intrusive igneous rocks, 113	Lake Tahoe, 398–99	326–27
Irwin, James, 49	Lake Victoria, 432, 433	Limestone karst caves, 322
Isostasy, 7–8, 212, 375	largest, 227, 227 (chart)	Limestones, 123, 125, 126
Isostatic rebound, 61	Mono Lake, 399	Limnogeology, 2
	pond, 226	Linnaeus, Carolus, 82
J	types of, 228–29	Liquefaction, 177, 283–84
	Lamarck, Jean-Baptiste, 25	Lithosphere, 60, 61, 69
Jade, 101	Lambert Glacier, 432	Lithospheric plate bound-
Japan and earthquakes, 281,	Landforms, 9-10, 299-300,	aries, 74–76
417–18	404	Lithospheric plates, 77–78,
Jupiter, 54, 56, 336, 363,	Landslides, 191, 192, 192	79–80
367, 369	(ill.), 283, 285	Lithostratigraphic units, 30

"Little Ice Age," 262–63 Littoral drift, 341	Layers (Earth); Moving continents; Plate tectonics	major factors of, 192 oceans, 195–96
"Living," 154–55	discontinuities in, 64	regolith, 190
Loch Ness, 417	lack of samples in, 64	sediment flows, 194
Loihi Seamount, 304	major minerals in, 65	slumps, 194, 194 (ill.)
Loma Prieta earthquake, 405	Mohorovičić discontinu-	slurry flows, 194–95
Long Valley, California,	ity, 63	talus slope, 191
395–96	percentage of, in Earth, 60	types of, 191
Longitude, 18–19	upper and lower, 63–64	water, 193
Longitudinal sand dunes, 198	upper mantle rocks,	Mathilde, 52 (ill.)
Longshore current, 340–41	64–65	Matterhorn, 412
Lopolith, 300	The Map That Changed the	Matthews, Drummond, 77
Love, Augustus Edward	World: William Smith and	Mauna Loa, 305, 393
Hough, 68, 272	the Birth of Modern Geolo-	Maury, Matthew Fontaine, 9
Love waves, 69, 272	gy, 455	McMurdo Dry Valleys, 439
Low velocity events, 191	Maps earthquake, 275–76	Mechanical layering, 61
Lowell, Percival, 368	geological, 6, 445–46	Medial moraines, 251
Lower mantle, 63–64	ocean, 342	Mediterranean Sea, 419
Low-magnitude earthquakes,	topographic, 33	Megalosaurus, 155
289	Marble, 128	Mer de Glace, 408
"Lucy" (Australopithecus	Mare, 45	Mercalli, Giuseppe, 276–77
afarensis human fossil), 158	Marginal crevasses, 248	Mercaptan, 173
Lunar eclipse, 44 (ill.), 44–45	Mariana Trench, 20, 24, 75, 78	Mercury, 362, 365
Luray Caverns, 327	Marine geology, 2, 331–32	Meridian, 19–20
Luster, 88	Marine-based ice sheets,	Mesozoic Era, 29
Luzon, Philippines, 313	255–56	Mesozoic orogenies, 210,
Lyell, Charles, 3, 5 (ill.), 5–6	Mars, 50–51	210 (chart)
	atmosphere, 363	Metamorphic minerals, 84
M	fossils on, 159	Metamorphic rocks, 112,
Maars, 299	meteorite, 56–58	120, 127 Metamorphism, 119–20
Maclure, William, 6	relationship to Earth, 364	Meteor Crater, 403
Madagascar, 436–37	(ill.), 364–65, 365–67	Meteorites
Mafic igneous rocks, 114	Mars Global Surveyor, 58	contact with Earth, 50
Magma, 112, 114, 294	Mars Odyssey, 58	falling, 52–53
Magnesio-wüstite, 65	Mass wasting. See also Soils;	lack of signs of life in, 55
Magnetic field, 66–67	Weathering; Wind-blown sands and deserts	largest to land on Earth,
Magnetism, 8, 91	ancient sediments, 196	52
Magnetite, 86	angle of repose, 191	from Mars, 56–58
Magnitude, 276	definition of, 190	from planets, 50–51
Mahogany obsidian, 123	"falling rock" zones, 193,	types of, 51
Maine, 372	194 (ill.)	Meteoroids, 50
Mainshocks, 267-68	falls vs. slides, 193-94,	Meteors, 50, 51 (ill.), 360 (ill.)
Mallet, Robert, 266, 275–76	194 (ill.)	Mica, 99–100, 121
"Man in the Moon," 45	frozen regions, 195	Michell, Rev. John, 22
Manganese nodules, 134	granular flows, 195	Micromounts, 93
Mantell, Gideon, 155	human contribution to,	Mid-Cretaceous Period, 351
Mantle, 46, 59, 60 (ill.). See	196	Middle zone, 318
also Cores; Crust; Earth;	importance of, 191	Mid-ocean islands, 304
Earthquakes and faults;	landslides, 192, 192 (ill.)	Mid-ocean ridges, 348

Migration theory, 38	gravel, 137	relationship to Earth,
Milky Way Galaxy, 41	Internet resources,	361–62
Milne, John, 267, 275	466–67	search for more moons,
Mineral habits, 94, 96	largest hole drug, 130	50
Mineralization, 144	native elements, 129	second moon of Earth, 49
Mineralogy, 4, 81–82, 83	salt, 136–37	surface of, 45 (ill.)
Minerals. See also Crystals;	sand, 137	tidal pull, 335 (ill.), 336
Gemstones	silver, 132–33	Moonquakes, 47
blowpipe or fusibility test,	tours, 447–48	Moons, 369
91	uranium, 134–35	Moraines, 251
Bowen's Reaction Series,	Mississippi River, 380	Morgan, William Jason, 73
84–85, 85 (ill.)	Mitchell, Edgar, 49	Moro, Lazzaro, 208
chemical elements in, 86,	Mitchell, John, 266-67	Morrison Formation, 155
86 (chart)	Mixed tides, 334	Mt. Erebus, 428
cleavage of, 88–89	Modified Mercalli Intensity	Mt. Etna, 313–14, 314 (ill.),
color of, 86–88	Scale, 276–77, 276–77	413–14, 414 (ill.)
definition of, 81	(chart)	Mt. Everest, 20, 204, 205
diamond mines, 128	Moho Project, 64	(ill.), 409
economic importance of, 92	Mohorovičić, Andrija, 63	Mt. Fuji, 51 (ill.), 309 (ill.),
feldspar, 99	Mohorovičić discontinuity,	410
formation of, 84	63, 64	Mt. Kilimanjaro, 428, 429 (ill.)
fractures in, 89	Mohs' Scale of hardness,	Mt. Olga, 437
hardness of, 89–91	89–90, 90 (charts)	Mt. Pinatubo, 416–17
history of, 82–83	Molds, 150	Mt. Rakaposhi, 410
identification of, 91	Mollie Kathleen Gold Mine,	Mt. Rushmore, 213
Internet resources,	448	Mt. St. Helens, 310–11, 311
464–65	Molten rock crystallization,	(ill.), 312
luster of, 88	293	Mt. Vesuvius, 412–13
main groups, 92	Mono Lake, 399	Mt. Washington, 377 (ill.)
mica, 99–100	Monoclinic crystal system,	Mountain building, 6–7, 211
Mohs' Scale of hardness,	94, 95 (ill.)	Mountain evolution, 211
89–90, 90 (charts)	Monogenetic fields, 297	Mountain glaciers, 244
names of, 84	Moon. See also Earth; Plan-	Mountains
polymorphs, 83–84	ets; Sun; Universe and	Andes Mountains, 427
quartz, 97–98, 98 (ill.)	solar system	Antarctica, 215
rock-forming, 85–86	asteroid collision on, 361	Appalachians, 212–13,
salt, 100–01	astronauts on, 49	377 (ill.), 377–78 Atlas Mountains, 412
"salt" and "salary," 100	atmosphere, 46	Black Hills/Mountains,
serpentine, 100	composition of, 46	213
silica, 97	effect on Earth, 49	Canadian Rockies, 410,
softness of, 90	exosphere, 46	411
streak of, 89	impact craters, 355, 356	Cascade Range, 392–93
value to humans, 91–92	(ill.)	Coast Mountains, 212
Mines and mining. See also	layers, 46–47	Coastal Ranges, 214, 390
Rocks	"Man in the Moon," 45	Crater Lake, 393–94
coal, 176–77, 177 (ill.)	moonquakes, 47	definition of, 203
deepest, 128	origins of, 47–48	Denali (Mt. McKinley),
deepest holes drilled,	part of a double planetary	393, 394 (ill.)
128–29	system, 48	disappearance of ancient
gold, 130–32, 133	phases, 48	ranges, 210

early beliefs and theories guakes and faults; Layers Nile River, 20, 219-20, 220 about, 207-08 (Earth); Mantle; Plate tec-(ill.) European Alpine system, tonics Nitrogen cycle, 111 idea of, 70-71 412 Non-clastic rocks, 186 magnetism in rocks, 72 European Alps, 411–12 Nonconformity, 116 past appearance of, 74 Grand Tetons, 391 Nonfoliated rocks, 120 physical evidence of, 71 Green Mountains, 379 Norgay, Tenzig, 204 Mudflows, 194-95 Half Dome, 389-90 North Atlantic shipping, 407 Mudstone, 126 highest, 204, 204 (chart) Northcott, Col. Theodore Clay, 319 highest peaks in eastern Mughal emeralds, 104 Nunavut, 286 Murchison, Sir Roderick United States, 376 Impey, 6 Himalayas, 409–10 hinterland and foreland. 0 204 N Oasis, 231 isostasy, 212 Native elements, 129 Oblique-slip faults, 270 Laurentia, 376 Obsidian, 123, 294 Natural acids, 186-87 Matterhorn, 412 Ocean tides. See also Oceans Natural bridges, 323 models of mountain causes of, 333 building and evolution, Natural gas. See also Coal: effects of Moon's tidal 211 Fossil fuels: Oil (petroleum) definition of, 171-72 pull on Earth, 336 Mt. Everest, 204, 205 (ill.) first mention of, 162 geological importance of, Mt. Fuii, 410 334 formation of, 172 Mt. Washington, 377 (ill.) high and low, 334 (ill.), Olympic Mountains, Internet resources, 334-35 466 - 67391-92 lowest and highest. liquids, 172 Olympic Peninsula rain 336-37, 337 (ill.) location of, 163 forest, 392 spring and neap tides, pipelines, 173–74 orogenies, 208-11, 209 333 (charts), 210 (charts) plant, 173 (ill.) sun and other planets sour gas, 174 Ozark Mountains, 379 and, 335 usage of, 172 plate tectonics, 203–04 tidal wave, 337 well blowout, 164 ranges and systems. types of, 334 204-07, 207 (chart) wells, 163-64, 172, 174 Oceanic crust, 62-63 Rocky Mountains, 390–91 Natural gemstones, 109 Oceans. See also Floods; San Juan Mountains, 391 Neanderthal skeleton, 156 Groundwater; Lakes; Ocean Shawangunk Mountains, (ill.) tides; Rivers; Seas; Water 378 Neap tides, 333 abyssal plains and hills, Shenandoah National Near-Earth Comets, 357 347 Park, 378-79 Near-Earth objects, 356–57, amount of water in, Sierra Madre, 214 358-59 23 - 24Smoky Mountains, 213 Neptune, 363, 367–68, 369 average depth of, 24 (ill.) Neptunism, 3 average temperature of. Southern Alps, 427 Nevado del Ruiz, 312-13 23 stages of development, 212 New England, 371–72 beach sand, 339 Swiss Alps, 206 (ill.) New Madrid Fault System, coastlines, 338–39 White Mountains, 214, 386 color of, 23 379 New York City, 385–86 coverage on Earth, 331 worst weather in, 214 Ngorongoro crater, 430 currents, 345-46 Yosemite Valley, 389–90 Niagara Falls, 382-84, 383 deep ocean floor (basin), Moving continents. See also (ill.) 347 Cores; Crust; Earth; Earth-Niche glaciers, 245 deep sea channels, 346

floor of, 77	location of, 163	P
hurricane winds, 340	non-fuel uses of, 168	_
ice sheets, 351	octane, 169	Pacific Ocean, 24
Internet resources, 466	offshore drilling, 171	Pahoehoe lava, 294
littoral drift, 341	oil or tar sands, 166	Painted Desert, 400
longshore current,	oil shale, 166	Paleomagnetism, 72
340–41	origination of U.S., 171	Paleontology, 2, 141–42
maps, 342	products, 167	Paleosols, 201
marine geology, 331–32	refined, 167–68, 168 (ill.)	Paleozoic Era, 29
mass wasting, 195–96	Trans-Alaska Oil Pipeline,	Paleozoic orogenies, 209,
mid-ocean ridges, 348	165 (ill.)	209 (chart)
ores in, 133–34	U.S. energy from, 166-67	Palmieri, Luigi, 274
resources in, 332–33	use of, 170	Pangaea, 70, 74
salt in, 332	well blowout, 164	Panthalassa, 70
seamounts, 349	wells, 163 (ill.), 163-64,	Papua New Guinea, 344, 345
seawater, 332–33	170, 171	(ill.)
sediment, 346–47	Oil shale, 166	Parabolic sand dunes, 198
shores, 338	Old Faithful geyser, 298	Parallel drainage pattern,
storm surges, 340	(ill.), 299, 395	226
submarine landslides,	Oldham, R. D., 65	Patterned ground, 239–40
343–44	Olivine, 121	Peak Ground Acceleration
trenches, 348 (chart),	Olympic Dam mine, 135	(PGA), 282–83
348–49	Olympic Mountains, 391–92	Pearl, 102
turbidity currents, 344	Olympic Peninsula rain for-	Peat, 176
underwater volcanoes,	est, 392	Pedalfer soils, 201
302-03	100-year floods, 234–35	Pedocol soils, 201
waves, 337-38, 339-40	Oozes, 347	Pegmatite, 114
world ocean, 332	Opal, 102	Pelitic rocks, 120–21
Octane, 169	Ophiolite belts, 65	Penck, Albrecht and Walther,
Offshore drilling, 171		9
Ogallala Aquifer, 232	Ordovician Period, 29	Perennial stream, 224
Oil or tar sands, 166	Organic gemstones, 104	Periglacial regions, 239–40
Oil (petroleum). See also	Organic sedimentary	Perihelion, 14
Coal; Fossil fuels; Natural	deposits, 115	Period, 26 (ill.), 27
gas	Orogenies, 208–11, 209	Permafrost, 240–41
barrel capacity, 166	(charts), 210 (charts)	Permineralization, 144
bitumen, 164	Ortelius, Abraham, 70	Perovskite, 65
commercial drilling,	Orthoclase feldspar, 63	Peterson Field Guides, 457
170–71	Orthorhombic crystal sys-	Petrified wood, 144
crude, 164, 165–66	tem, 94, 95 (ill.)	Petroleum geology, 2
definition of, 164	Orthorhombic sulphur, 95	Petrology, 10
drilling, first, 170	(ill.)	Phacolith, 300
extra-heavy, 164–65	Outer core, 59	Phosphorite, 134
first mention of, 161-62	Owen, Richard, 4	Phreatic eruption, 299
future consumption, 171	Owens Valley, 405–06	Phyllite, 127
gasoline price fluctua-	Oxbow lakes, 223, 223 (ill.),	Physical mineralogy, 82
tion, 170	229	Physical weathering, 184,
Internet resources, 466-67	Oxidation, 186	185
kerosene, 168	Oxygen, 17–18, 186	Piedmont, 377–78
leaded vs. unleaded gaso-	Ozark Mountains, 379	Pillow lava, 303
line, 169	Ozone layer, 181	Pinnate drainage pattern, 224

Pioneer crafts, 57	Plate tectonics. See also	Precious gemstones, 108
Pipelines, 173–74	Cores; Crust; Earth; Earth-	Primary caves, 319
Pitman, Walter III, 73	quakes and faults; Layers	Prime Meridian, 19
Piton de la Fournaise, 430	(Earth); Mantle; Moving	Prismatic habits, 96
Planet X, 368–69	continents	Pseudochromatic minerals,
Planetary weathering, 189	African Rift System, 79	87
Planetology, 2	California, 78	Pseudofossils, 150
Planets. See also Earth;	definition of, 72 early work in, 72–73	Pumice, 122, 294
Moon; Sun; Universe and		P-waves, 68–69, 272
solar system	earthquakes, 73–74 lithospheric plate bound-	Pyrite, 86
asteroids, 355–56,	aries, 74–76	Pyroclastic flow, 302
357–58, 358–59,	lithospheric plates,	Pyroxene, 121
359–60, 360 (ill.),	77–78, 79–80	Pythagoras, 141
360–61	Mariana Trench, 78	
astronomical unit (AU),	mountains, 203–04	Q
353	plate collisions, 78	•
atmospheres, 362–64	prediction of earth-	Quaoar, 354–55
comets, 356, 357 (ill.),	quakes, 75	Quartz, 95 (ill.), 97–98, 98
357–58, 358–59, 359–60, 360 (ill.),	rifts, 78–79	(ill.), 121
360–61	seafloor spreading, 76-77	Quartzite, 127
Edgewood-Kuiper Belt	shrinking Earth theory, 73	
Objects (KBOs), 354–55	Wadati-Benioff zone, 78	R
formation of, 39	Plateau uplift, 206	Radial drainage pattern, 225
greenhouse effect, 365	Plateaus, 423	Radiation zones, 14–15
impact craters, 355, 358,	Plato, 292	Radiometric dating, 152, 152
358 (ill.)	Playfair, John, 6	(ill.)
Jupiter, 363, 367	Pleochroism, 87–88	Rainbow obsidian, 123
life on, 58	Plot, Rev. Robert, 155	Rayleigh, Lord John William
Mars, 364 (ill.), 364–65,	Pluto, 336, 353–54, 355,	Strutt, 68, 272
365–67	363–64, 368–69	Rayleigh waves, 68, 272–73
Mercury, 365	Pluton, 300–01	Recrystallization, 144
meteorites from, 50–51	Plutonic rocks, 113	Rectangular drainage pat-
Moon, 361–62	Plutonism, 4	tern, 224
moons, 369	p.m., 19–20	Red Sea, 420
near-Earth objects,	Polar ice caps, 362	Red Sea Rift, 79
356–57, 359	Poles, 16–17	Red spinel gemstones, 104
Neptune, 367–68	Pollen grains, 150–51	Refined oil, 167–68, 168 (ill.)
nine known, 353 Pluto, 353–54, 355,	Polo, Marco, 162	Regional metamorphism, 119
368–69	Polymorphs, 83–84	Regolith, 190
polar ice caps, 362	Pond, 226	Reid, Henri Victor, 271
Potentially Hazardous	Popcorn, 326	Réunion Island, 430
Asteroids (PHAs), 357	Popocatépetl, 416, 416 (ill.)	Reversed polarity, 66–67
relationship to Earth, 16	Poseidon, 266	Rhodonite, 95 (ill.)
Saturn, 367	Potentially Hazardous Asteroids (PHAs), 357	Rhyolite, 122
tides, 335–36	Powell, John Wesley, 9, 9 (ill.)	Rhyolite caldera complexes, 296–97
Venus, 353, 354 (ill.), 365	Practical Geologist, 456	Richter, Charles Francis, 65,
"wobbling," 362	Precambrian Era, 28, 29	277, 278 (ill.)
Plate boundary zones, 76	Precambrian orogenies, 209,	Richter scale, 277, 278 (ill.)
Plate collisions, 78	209 (chart)	Rift valley lakes, 228
•	,	• /

Rifts, 78–79	Rock of Gibraltar, 424	sedimentary rock parti-
Rime ice, 243–44	Rock slide, 193–94	cles, 117–18, 118 (chart)
Ring of Fire, 308–09, 348	Rock-forming minerals,	shale, 126
Rio Grande River, 397	85–86	siltstone, 126
Rivers. See also Floods;	Rocks. See also Mines and	texture, 113
Groundwater; Lakes;	mining	unconformity, 116
Oceans; Water	Ayers Rock, 437–38, 438	volcanoes, 295–96
Amazon Basin, 433–34	(ill.)	weathering, 188
Arkansas River, 398	chemical solution, 117	xenolith, 123
braided channels, 223	clay, 126	Rocky Mountains, 390-91
channels, 219, 223	composition, 114	Rodinia, 74
Chesapeake Bay, 381–82	conglomerate vs. breccia,	Rogue waves, 339
Colorado River, 398, 398	118–19	Rose Center for Earth and
(ill.)	country, 113	Science, 458 (ill.)
Columbia River, 397	cycle of, 111	Ross Ice Shelf, 436
Connecticut River Valley,	definition of, 111	Rossby waves, 338
381	diagenesis, 116–17	Ruby, 104
dams, 225	diamond mines, 128	Runoff, 218
delta and alluvial fans,	dikes and sills, 113-14	
221–22	erosion, 197	S
drainage patterns,	facies, 112	3
224–26	falls and debris, 193-94,	Sahara Desert, 20, 423–24
erosion of, 222, 223	194 (ill.)	St. Lawrence River, 381
flood disaster, 380–81	Guilin Hills of China, 425	Saline (salt) lake, 227
floodplain, 222	igneous, 112, 113, 114,	Salt, 100–101, 135 (ill.),
Great Lakes, 382	121–22	136–37, 332
Hudson River, 379–80	Internet resources,	"Salt" and "salary," 100
largest, 220, 220 (chart)	464–65	Salt caves, 322–23
longest, 221, 221 (chart) major parts of, 221	intrusive and extrusive igneous, 113	San Andreas Fault, 72–73, 74
meandering, 223	limestones, 125, 126	(ill.), 270, 404–05
Mississippi River, 380	location of unique, 124	San Francisco Volcanic
Niagara Falls, 382–84,		Field, 396
383 (ill.)	magma, 112 major families, 112	San Juan Mountains, 391
Rio Grande River, 397	marble, 128	Sand, 116 (ill.), 117, 118 (ill.), 137
St. Lawrence River, 381		Sandstone, 123, 125–26
source of, 219–20	metamorphic, 120, 127 metamorphism, 119–20	Sandstone caves, 323
submarine canyon, 379	minerals in, 121	Sandwell, David, 342
Susquehanna River,		Sapphire, 102 (ill.)
380–81	mudstone, 126 natural cycles affecting,	Saturn, 363, 367, 369
valleys, 6, 222	111–12	Schist, 127
Verdon Gorge, 421–22	obsidian, 123	Schmitt, Harrison, 49
ways water gets into, 219	pegmatite, 114	Scott, David, 49
Yellow River, 422	pelitic, 120–21	Scott, Robert, 433
Zambezi River, 433 (ill.),	Rock of Gibraltar, 424	Sea cave, 317
434, 434 (ill.)		Sea chasm, 317
Roadside Geology Series,	sand, 116 (ill.), 117, 118 (ill.)	Seafloor spreading, 72, 76–77
456	sandstone, 125–26	Seamounts, 303, 349
Roche moutonnée, 252	sedimentary, 115, 117,	Seas. See also Oceans
Rock & Gem, 455	123, 125	Aral Sea, 419–20

sedimentary deposits, 115

Rock layers, 29-30

Black Sea, 419

Coming Con 420	Chaffor Faul 279 (:11)	Courth Africa 199
Caspian Sea, 420	Shaffer, Earl, 378 (ill.)	South Africa, 128
caves, 317	Shale, 126	Southern Alps, 427
Dead Sea, 20, 420–21,	Shawangunk Mountains, 378	Southern Patagonia Icefield,
421 (ill.)	Sheen obsidian, 123	432
deep sea channels, 346	Sheet erosion, 218	"Space dust," 53
Hudson Bay, 421, 422	Shells, 150–51	Specific gravity, 91
Law of the Sea Treaty,	Shenandoah National Park,	Speleothems, 325–26
134	378–79	Spelunker, 317, 318 (ill.)
Mediterranean Sea, 419	Shepard, Alan, 49	Spring (body of water), 323
Red Sea, 420	Shield volcanoes, 296	Spring (season), 14
Red Sea Rift, 79	Ship Rock, 402	Spring tides, 333
seafloor spreading, 72,	Shoemaker, Eugene, 403	Sprinkle, Leland, 327
76–77	Shores, 338	Stalacpipe Organ, 327
seamounts, 303, 349	Shrinking Earth theory, 73	Stalactites and stalagmites,
seawater, 332–33	Siachen glacier, 410	325 (ill.), 326
Tethys Sea, 412	Sierra Madre, 214	Stamps, geology, 462
Seasons, 13–14, 14 (ill.)	Sierra Nevada, 389	Star dunes, 198
Seat earth, 123	Silica, 63, 97	Steno, Nicolaus, 4–5, 82, 93,
Seawater, 332–33	Sills, 114, 301	208
SeaWIFS satellite, 23	Siltstone, 126	Steno's law, 4–5
Secondary caves, 319–20	Silver, 132–33	Stishov, Sergei, 65
Sedgwick, Adam, 6	Simulants, 109	Stishovite, 65
Sediment, 346–47	Sinkholes, 323	Stony-irons, 51
Sediment flows, 194	Slate, 127	Storm surge floods, 236
Sediment transport, 185	Slides, 193–94	Storm surges, 340
Sedimentary deposits, 115	Slumps, 194, 194 (ill.)	Strabo, 292
Sedimentary minerals, 84	Slurry flows, 194–95	Strategic Petroleum Reserve,
Sedimentary rock particles,	Smith, Walter, 342	179
117–18, 118 (chart)	Smith, William, 6, 455	Stratovolcanoes, 296
Sedimentary rocks, 112, 115,	Smoky Mountains, 213 (ill.)	Streak, 89
117, 123, 125	Snowflake obsidian, 123	Streams, 224
Seismic tomography, 69–70	Softness, 90	Striated mineral habits, 96
Seismic waves, 272	Soil science, 9	Striations, 252
Seismograms, 273	Soils. See also Mass wasting;	Strike and dip, 32–33
Seismographs, 273–75, 274	Weathering; Wind-blown	Strike-slip faults, 270
(ill.)	sands and deserts	Stuart, Leon H., 361
Seismography. See Earth-	definition of, 199	Subbituminous coal, 175
quakes	formation of, 200	Submarine canyons, 342–43,
Seismology, 11	horizons, 200, 200	379
Seismometers, 273	(chart)	Submarine landslides,
Seismoscope, 273	paleosols, 201	343–44
Semidiurnal tides, 334	rivers, 223	Subsidence, 283
Semi-precious gemstones,	types of, 201	Summer, 13
108	Solar eclipse, 43 (ills.), 44	Sun. See also Earth; Moon;
Semyenov, F. N., 170	Solar nebula theory, 36–38	Planets; Universe and solar
Series, 29	Solar system. See Universe	system
Serpentine, 100	and solar system	as average star, 40
Seuss, Edward, 70	Solid inner core, 65–66	distance from center of
"70,000 kilometer-long," 304	Solidiuction, 195	Milky Way Galaxy, 41
Shackleton, Sir Ernest	Solution weathering, 187	effect on Earth, 42
Henry, 70, 433	Sour gas, 174	release of energy, 41

solar eclipse, 43 (ills.), 44,	Titan, 369	black smokers (deep-sea
45	Tombaugh, Clyde William,	hydrothermal vents),
speed of, 41, 42	368	306, 307
Sunset Crater, 396–97	Topographic maps, 33	future, 304
Surface waves, 272–73	bathymetric contours, 31	Hawaiian Islands, 305–06
Susquehanna River, 380–81	contour lines, 30–31	hot spot, 304–06
'Swallowing people" myth,	definition of, 30	importance to oceans,
280	geologic map, 32	302–03
S-waves, 68–69, 272	profile, 32	lava pillars, 306–07
Swiss Alps, 206 (ill.)	scales, 31–32	Mauna Loa, 305
Sykes, Lynn R., 73	strike and dip, 32–33	mid-ocean islands, 304
Synthetic gemstones,	symbols, 33, 33 (chart)	modern volcanic islands,
108-09	Trace fossils, 139, 140	303–04
	Trans-Alaska Oil Pipeline,	pillow lava, 303
Т	165 (ill.)	seamounts, 303
	Transform boundaries, 76	"70,000 kilometer-long,"
Tabular mineral habits, 96	Transverse crevasses, 248	304
Talc, 86, 96	Transverse sand dunes, 198	Unequal tides, 334
Talus slope, 191	Tree rings, 153	Uniformitarianism, 3
Taphomony, 142	Trellis drainage pattern, 225	United States Geological
Tarn lakes, 228	Trench boundaries, 75	Survey (USGS), 450
Taughannock Falls, 373	Trenches, 24, 348 (chart),	Universe and solar system.
"Taung child" (Australop-	348–49	See also Earth; Moon;
ithecus africanus human	Trichroism, 87–88	Planets; Sun age of, 37
fossil), 158	Triclinic crystal system, 94,	big bang theory, 35–36
Гесtonic caves, 324	95 (ill.)	dangers in, 36
Герhra, 297–98	Trigonal/rhombohedral crys-	Earth's location in, 38
Terminal moraines, 251	tal system, 94, 95 (ill.)	Earth's relation to, 35
Terrestrial-based ice sheets,	Trilobites, 159	formation of, 38
255–56	Triton, 369	formation of planets in, 39
Tertiary Period, 27	Tsunamis, 283, 284 (ill.),	gamma ray burst, 38
Tethys Sea, 412	284–85, 339–40, 344	origins of, 36–37
Tetragonal crystal system,	Tuff rings, 299–300	solar nebula theory,
94, 95 (ill.)	Tunnels, 323	36–38
Thales of Milet, 266	Turbidity currents, 344	Unleaded gasoline, 169
Γharp, Marie, 342	Turkey earthquakes, 418	Upper mantle, 63–64
Thermoluminescence,	Turquoise, 102	Upper mantle rocks, 64–65
152–53	Twilight zone, 318	Uranium, 134–35
Гhumbnail specimens, 93 Гibetan Plateau, 423	Tyrannosaurus rex, 147	Uranium-series dating, 152
Fidal wave, 337	igramosaaras rex, 111	(ill.), 153
		Uranus, 363, 367
Fierra del Fuego, 438–39 Fill and tillite, 253	U	U.S. fossil parks, 159–60
Fime	Umlaufbergs, 374	U-shaped valleys, 222
age of Earth, 25	Unconformity, 116	Ussher, James, 25
geologic, 26 (ill.), 27		1301101, 1411100, 40
geologie, 40 (III.), 41	Under-ice lakes, 55–56	

Underwater landslides, 268

Underwater volcanoes. See

activity, amount of,

also Volcanoes

302-03

geologic divisions, 28–29

geologic time scales, 29

Precambrian, 28

29-30

rock layers based on,

# V

Valley and Ridge, 377 Valley and ridge ranges, 205 Valley glaciers, 244 Valleys, 6 gevsers, 298 (ill.), 299 Vostok Station, Antarctica, 20 Valvasor, Janez Vaikard, 321 Giant's Causeway, 415 Voyager crafts, 56 (ill.), 57 Van Allen, James, 15 Internet resources, 466 V-shaped valleys, 222 Van Allen radiation belts. Krakatau, 313, 429-30 14-15 lahars, 301-02 Varves, 153 landforms from contact W Vatnajokull glacier, 408-09 with, 299-300 Wadati, Kiyoo, 78 Venezuela, 173 (ill.) lava, 294 Wadati-Benioff zone, 78 Venus, 353, 354 (ill.), Long Valley, California, 395-96 362-63, 365 Water. See also Floods: Verdon Gorge, 421–22 magma, 294 Groundwater; Lakes; major, 314-15, 314-15 Oceans: Rivers: Seas Vermiculite, 100 cycle around the Earth, (chart) Victoria Falls, 434 218 - 19modern study of, 292-93 Vine, Frederick, 77 distribution on, 217 molten rock crystalliza-Volatile organic compounds importance to the Earth, tion, 293 (VOCs), 179 217, 218 monitoring of, 307-08 Volcanic mountain range, mass wasting, 193 Mt. Etna, 313-14, 314 206 runoff, 218 (ill.), 413–14, 414 (ill.) Volcanic rocks, 113 Water cycle, 111 Mt. Pinatubo, 416–17 Volcanoes, 301 (ill.), See also Waterfalls, 20, 422-23 Underwater volcanoes Mt. St. Helens, 310–11. 311 (ill.), 312 Waves, 337-38, 339-40 active, 296, 311-12 Alaskan, 312 Mt. Vesuvius, 412–13 Weathering, 184 (ill.). See also Mass wasting; Soils; Nevado del Ruiz, 312-13 in Antarctica, 428 Wind-blown sands and casualties from, 297 Ngorongoro crater, 430 deserts characteristics of, 297 observatories, 308 acids, 186-87 Chicxulub impact, 415 origin of word, 294 carbonation, 187 Crater Lake, 393-94 phreatic eruption, 299 caused by humans, danger of, 295 pluton, 300-01 189-90 Deccan Traps, 414–15 Popocatépetl, 416, 416 chemical, 186-88 definition of, 293 (ill.) clastic and non-clastic dormant, 296 pyroclastic flow, 302 rocks, 186 earliest known recorded. Réunion Island, 430 definition of, 183-84 292 Ring of Fire, 308–09 differential, 190 early explanations for, rocks, 295-96 erosion, 183, 185 291 - 92San Francisco Volcanic exfoliation, 188-89 East African Rift, 428, Field, 396 frost action vs. frost 429 (ill.) Sunset Crater, 396-97 heave, 185-86 effect on global climate, tephra, 297-98 hydration, 186 308 twentieth-century, 313 natural acids, 186-87 extinct, 296 types of, 296 oxygen, 186 famous, 309 (ill.), unusual appearances of, planetary, 189 309–10, 309–10 (chart) 296 - 97processes, 184 features of, 298-99 volcanology, 2, 293 rocks, 188 first, 291 Yellowstone region, sediment transport, 185 formation of, 295 394-95 solution, 187 fumarole, 302 Volcanoes (book), 456 Wegener, Alfred, 4, 70-71, 72 Galanagos Islands. 428-29 Volcanology, 2, 293 Welcome Nugget, 132 gases from, 301 Von Humboldt, Alexander, Welcome Stranger Nugget, geothermal energy, 300 266 132

Well blowout, 164 Wells (fossil fuels), 163 (ill.), 163-64, 170, 171, 172, 174 Wells (water), 232 Werner, Abraham Gottlob, 3, 5,83 White cliffs of Dover, 150 (ill.), 151 White Mountains, 214, 379 Whymper, Edward, 412 Wilson, J. Tuzo, 72, 305 Wind-blown sands and deserts. See also Deserts; Sand Antarctica, 198 coverage of, on Earth, 198 cross-bedding, 199

desert pavement, 198 dreikanters, 199 dunes, 198, 199 major, 197, 197 (chart), 197 (ill.) rock erosion, 197 tectonic caves, 324 Wind Cave, 329 Winter, 13 Wisconsin Glaciation, 374-75 Wistar, Caspar, 155 "Wobbling" planets, 362 World ocean, 332 "World Series" earthquake, 405 Wormlike fossils, 159

## X-Y

Xenolith, 123 Xenophanes, 141 Yellow River, 422 Yellowstone region, 394–95 Yosemite Valley, 389–90

#### Z

Zambezi River, 433 (ill.), 434, 434 (ill.) Zheng Heng, 273 Zion Canyon, 403–04 Zircon crystals, 27, 95 (ill.) Zone, 29, 318–19