## *Geology of the San Francisco Bay Region*, by Doris Sloan University of California Press/California Natural History Guides, 2005

Abbotts Lagoon, 92 accretion, 31 accretionary wedges, 30 (figure), 31 actinolite, 269 Alameda Creek, 218, 224, 225 Albany Hill, 231 Alcatraz Island, 125, 151–152, 152 (plate), 153 (plate) Alcatraz Terrane, 65 (table), 104, 124 (map), 125-126, 152, 153 (plate), 233 Alexander Valley, 273 alluvial deposits East Bay, 218, 219, 225, 231, 248 North Bay, 255, 264, 283 San Francisco Bay floor, 142, 143, 143 (figure) San Francisco Bay shore, 146-147, 218, 225, 255 South Bay, 192, 205-206, 206-207 See also geologic maps Almaden Quicksilver County Park, 66, 200, 211-215 Almaden Reservoir, 201, 203 Alpine Lake, 96, 107 Altamont Hills, 233, 234, 234 (plate), 238-239 Alum Rock, 210, 211 (plate) Alum Rock Block, 196-197 (map), 198, 199 (table), 202 Alum Rock Park, 97, 204, 209-210, 209 (plate), 210 (plate), 211 (plate) Alum Rock Rhyolite, 210 ammonites, 126 Anchor Bay, 68 Anderson Reservoir, 203, 203 (plate), 207 andesite, 49 (table), 72, 207, 277 Angel Island, 66 (plate), 95, 132-133, 145, 151, 152 (plate) Annadel State Park, 277 Año Nuevo Beach, 156-157 Año Nuevo, Point, 167, 170 anticlines, 40, 41 (figure), 199-200 Antioch, 224 aquifers, 192-193, 192 (figure), 225 Arched Rock, 285, 286 (plate), 287 Arroyo Aguaque Fault, 196–197 (map) Arroyo Mocho Creek, 238 (plate), 239 artificial fill. See fill ash deposits. See volcanic ash deposits asthenosphere, 26, 26 (figure), 29 (figures) Atascadero Formation, 170 Atlas Peak, 276 Avalon Canyon landslide, 166, 166 (plate) baked contacts, 251, 277, 279 (plate) Bakers Beach, 22 (plate), 23, 24-25, 120, 130 Bald Peak Basalt, 248 (figure), 251 basalt, 49 (table), 50 (plate), 64, 72 East Bay, 240 (map), 242, 250-251 Marin County, 100 (map), 106 North Bay, 267, 271, 277 Peninsula, 178-179 San Francisco, 114–115 (map) South Bay, 207–208

See also pillow basalt

basement rocks, 49, 55-70 See also Franciscan Complex; Great Valley Complex; Salinian Complex; specific regions and types of rock basins fore-arc basins, 30 (figure), 64 formed by transpression, 42–43, 42 (figure) landslide basins. Mount Tamalpais. 107 sag ponds, 36 (figure), 37, 84, 167, 194, 262 (plate), 263 See also lakes; San Francisco Bay; specific lakes and valleys Bay Block. See San Francisco Bay Block beach pebbles, 57, 58 (plate), 102, 271 beach sands, 19–23, 20 (plate), 21 (figure) Bodega Head, 22 (plate), 266 Marin Headlands, 102 San Francisco, 22 (plate), 122–123 Bean Hollow State Beach, 60 (plate), 170 Bear Creek, 273 Berkeley, 37, 38 (plate), 230, 249 (plate) Berkeley Hills, 219 (plate), 251 See also East Bay Hills Berrocal Fault, 196–197 (map) Berryessa Formation, 210 Berryessa-Knoxville Road, 271–272 Berryessa, Lake, 67, 254, 271–272, 272 (plate), 273 Berryessa Peak, 254 Bethel Island, 224 Bielawski, Mount, 158 Big Break, 224 Big Rock Ridge, 95 Big Sulphur Creek, 282 Bird Rock, 104 Bishop Tuff, 72 Black Diamond Mines Regional Preserve, 244–247, 245 (plate), 246 (plate), 273, 283 Black Mountain, 93-94, 95 Black Point, 96, 98 (plate), 273 Blackhawk Ranch, 236, 243 blocks, 33 (map), 43-44, 44 (figure) See also specific blocks by name blueschist, 46-47, 61, 94, 201, 269, 271 Bodega Head basement rocks, 68, 69 (plate), 70 beach and dune sands, 20, 22 (plate), 266 Hole in the Head, 264–265, 265 (plate) movement of, 44 Bolinas, 85 Bolinas Lagoon, 21 (plate), 76-77, 84, 93, 121 Bolinas Ridge, 84, 93, 95 Bon Tempe Lake, 107 Bonita, Point, 95, 99, 101 (plate) **Briones Formation** East Bay, 235, 235 (plate), 236 (plate), 242, 243 (plate) South Bay, 204, 210 Brooks Island, 151

Brothers and Sisters, 151, 154-155 Burdell Mountain, 98, 208, 279 Burnt Hills Terrane, 65 (table), 199 (table), 201 Butano Sandstone, 39 (figure), 40, 176, 177, 204 Cache Creek Valley, 273 Calamagrostis ophitidis, 105 Calaveras Fault, 32–33, 33 (map) East Bay, 222–223 (map), 226–227(map) South Bay, 37, 194, 195, 196-197 (map), 198, 200 (map), 207, 210 Calaveras Fault Zone, 203 Calaveras Reservoir, 194, 194 (plate) Caldecott Tunnel, 247–248, 247 (plate), 248 (plate) Calera Limestone, 172-173, 172 (plate) Calero Fault, 196–197 (map) Calero Reservoir, 66, 201, 203 Calistoga, 276 Calochortus tiburonensis, 105 Calochortus umbellatus, 105 Cañada College, 174 Carmet-by-the-Sea, 260, 261 (plate) carnelian, 103-104 Carneros Fault, 258–259 (map) Carquinez Strait, 135, 145, 239 Carquinez Strait Regional Shoreline, 233 Cascade Range, 32 Castilleja neglecta, 105 Castle Rock State Park, 175-176, 177 (plate), 204 Cazadero, 62 Cazadero Terrane, 65 (table), 269, 270 (map), 271 Cedars, The, 272 Cenozoic era, 3, 8 (figure) Central Valley, drainage history, 145-146 chalcopyrite, 233 chemical weathering, 13 chert, 70, 271 See also Claremont Formation; Monterey Formation; radiolarian chert Chesbro Reservoir, 203 China Camp State Park, 93, 95 Chitactac-Adams Heritage County Park, 204-205, 205 (plate) cinnabar, 212-213, 213 (plate), 215 City College mélange, 124 (map), 125, 129-130 clams, 170-171, 171 (plate) fossils, 178, 179 (plate), 242 Claremont Formation, 52 (plate), 71 East Bay, 248, 248 (figure), 249 (plate) South Bay, 204, 209, 209 (plate) Clayton Fault, 196–197 (map) Clear Lake Volcanics, 73–74, 275, 280–282 Cloverdale, 280 coal, 244 See also Black Diamond Mines Coast Range Ophiolite, 54 (figure), 64, 66 Angel Island, 151 East Bay, 233, 242 Marin County, 96 North Bay, 271-272 South Bay, 202, 202 (plate), 210 See also geologic maps; serpentinite Coast Range Province, 10, 11 (map) Coast Ranges, 10 Franciscan Complex belts, 269, 270 (map)

Coast Ranges (continued) Great Valley Sequence layers, 67, 67 (plate) coastal processes, 16-23 beach sand deposition, 19-23 marine terrace uplift, 19 See also wave action Coe State Park, 62, 200, 201 College of San Mateo, 174 colliding plates, 28-30, 29 (figure) See also subduction zones Colma Formation Peninsula, 164-165, 183, 183 (plate) San Francisco, 114-115 (map), 122, 130-131 Colma Strait, 146, 146 (figure), 183 complex, defined, 48 See also Franciscan Complex; Great Valley Complex; Salinian Complex Concord Fault, 33 (map), 38 (plate), 222-223 (map), 226-227 (map), 256–257 (map) conglomerates, 49 (table), 52 (plate), 54 (figure) East Bay, 233, 247 (plate), 248-249 Great Valley Complex, San Andreas Fault offsets, 39 (figure), 40 in Great Valley Sequence, 67, 68 Marin County, 89 (map), 90-91, 90 (plates), 96-97, 98 (plate) Marin Islands, 155 North Bay, 266, 268 (plate), 273, 275 Novato Conglomerate, 96-97, 98 (plate), 210, 273 Peninsula, 170, 173 South Bay, 195, 206, 210 convergent plate boundaries, 28-30, 29 (figure) See also subduction zones Copernicus Peak, 10, 186, 254 Coyote Block, 196-197 (map), 198, 199 (table), 202, 203 Coyote Hills Regional Park, 56, 231, 232 (plate) Coyote Reservoir, 74, 194, 203, 204 creep, 36-37, 230 Cronkhite Beach, 56 (plate), 102–104, 103 (plate) Crystal Springs Reservoir, 37, 37 (figure), 167 Cupressus sargentii, 272 cypress, 272 dacite, 207 Daly City earthquake (1957), 164 Daly City landslides, 164–166, 164 (plates), 165 (plates), 166 (plate) dating ages of Bay Area rocks, 3, 8, 10 fault displacement, 38 rocks, 9-10, 48 de Anza, Juan Bautista, 116 debris slides, 14 (figure), 15 Del Puerto Canyon, 202, 202 (plate) Del Puerto Terrane, 65 (table), 68, 199 (table), 234, 270 (map), 273 Delta, 150, 219, 224 levee breaks, 224, 225 (plate) San Francisco Bav interactions, 135, 140 Devils Den Canvon Terrane, 65 (table), 269, 270 (map) Devils Slide, 159, 163, 172, 174, 175 (plate) See also Montara Mountain

diabase, 240 (map), 242

Diablo Fault. See Mount Diablo (Thrust) Fault

Diablo, Mount, 10, 152 (plate), 219, 236 (plate), 238 (plate)

Diablo, Mount (continued) age, 9, 28, 40 cinnabar deposits, 215 exploring, 239–243 fossil vertebrates, 236 Franciscan Complex rocks, 56, 231, 239, 241-242 geologic map, 240 Great Valley Complex rocks, 64, 66, 239, 242, 242 (plate) Tertiary rocks, 239, 242, 243 (plate), 273 uplift processes, 42, 218, 229, 239-240 view from, 216-217, 240-241, 241 (plate) volcanic rocks, 239 Wind Caves, 242-243, 244 (plate) Diablo Range, 40, 186, 219 Alum Rock Park, 97, 204, 209-210 basement rocks, 62, 64, 199-200, 201, 231, 233 faulting/uplift processes, 198, 209 geologic map, 200 Tertiary rocks, 73, 204, 205, 207-208, 279 See also specific peaks diatoms, 71, 248 diorite, 49 (table) divergent plate boundaries. See spreading centers Domengine Formation, 244, 245, 245 (plate), 246 (plate), 273 Doran Park, 20, 22 (plate) Drakes Bay Formation. See Purisima Formation Drakes Beach, 92, 92 (plate) Drakes Estero, 85 Dry Creek, 254 Dry Creek Valley, 254, 271 dunes. See sands Duxbury Reef, 92 Eagle Peak, 242 Eagle Rock, 210 earth, internal structure, 26 (figure) earthflows, 14 (figure), 15-16, 15 (plate), 16 (plate), 282 earthquake preparedness, 39 earthquakes, 28, 35, 35 (figure), 36 Daly City earthquake (1957), 164 Hayward Fault, 229-230 hazards and damage, San Francisco, 117-119, 118 (figure) Loma Prieta earthquake (1989), 33 (map), 35-36, 117, 118–119, 195 North Bay, 264 past, study of, 37, 39 San Francisco earthquake (1906), 33 (map), 35, 36, 84, 117, 167, 262-263 sediment liquefaction during, 16 South Bay, 195 turbidity flows and, 60 See also faults and fault activity; specific faults by name East Bay, 218-251, 220-221 (map) basement rocks, 231-234 creeks and wetlands, 37, 38 (plate), 218, 224-225, 226-227 (map) exploring Black Diamond Mines Regional Preserve, 244-247 exploring Mount Diablo State Park, 239-243 exploring the East Bay Hills, 247-251 gas deposits, 67

East Bay (continued) geologic history, 71, 230-231, 249 geologic map, 222-223 Livermore Valley, 219, 237–239 Tertiary/Quaternary rocks and sediments, 73, 219, 235-236, 246, 247-251, 273 topography, 37, 218-219, 245 volcanics, 73, 233, 246, 250-251 See also East Bay Fault System; East Bay Hills; other specific locations and topographic features East Bay Block, 44 East Bay Fault System, 32-33, 37, 226-227 (map), 228-230 East Bay Hills uplift, 40, 218-219, 229, 249 Mount Diablo uplift, 218, 229, 239-240 North Bay faults and, 263 overview, 228-229 volcanics and, 74, 250 See also specific faults East Bay Hills, 28, 219 (plate), 238-239, 247-251 Franciscan Complex rocks, 233, 249 Great Valley Complex rocks, 64, 233 Tertiary/Quaternary rocks, 247-251 uplift/faulting, 9, 40, 218-219, 229, 247, 249 volcanics, 73, 233, 250-251 See also East Bay; specific locations Eastshore State Park, 231 eclogite, 61, 61 (plate), 104 El Cerrito, 233 El Niño storms, and Peninsula landslides, 164-166 Elder Creek Terrane, 65 (table), 68, 270 (map), 273 electricity generation, The Geysers, 280-281 Elizabeth, Lake, 37 Eriogonum caninum, 105 erosion. 13. 15-16 Peninsula coast, 163-166 tafoni, 170, 171 (plate), 175-176, 204 wave erosion, 17-19 See also landslides; weathering erosion rates, 15, 17 estuarine water circulation, 140 Evergreen Fault, 196–197 (map) Farallon Islands, 68, 142 (figure), 144, 266 Farallon Plate subduction, 31-32, 49, 62, 67, 231 fault maps Bay Area overview, 33 East Bay, 226-227 North Bay, 258-259 Peninsula, 168 South Bay, 196-197 faults and fault activity, 32-40, 84 creep, 36-37, 230 offsets, 37, 38 (plate), 39, 225, 263 overview of Bay Area fault network, 32-33, 33 (map) past movement, analysis of, 39-40 reverse faults, 34 (figure), 195 rock arrangements resulting from, 43-45 strike-slip faults, 31, 33–35, 34 (figure) thrust faults, 34 (figure), 40, 41 (figure), 42, 43 topographic expressions of, 36 (figure), 37, 40-43, 194-195, 229 transpression, 40-43, 41 (figure), 42 (figure) uplift/down-dropping, 42-43, 42 (figure)

faults and fault activity (continued) volcanic activity and, 74, 250, 275 See also East Bay Fault System; plate tectonics; San Andreas Fault System; specific faults by name; specific regions fauna fossil vertebrates, 205-206, 236 rock-burrowing mollusks, 178, 179 (plate), 267, 268 (plate) feldspar. 91, 122 fill, 147, 154, 233 city of San Francisco, 110-111, 116-119, 116 (figure), 118 (figure) San Francisco Bay, 147, 149 (figure) See also geologic maps Fitzgerald Marine Reserve, 18 (plate), 19, 162, 163 (plate) flora. See plants folding, 40, 41 (figure), 42-43 Claremont Formation chert, 209, 209 (plate) radiolarian chert, 56, 57 (plate), 99, 101 (plate), 127 (plate), 201 See also transpression foraminifers, 71, 248 fore-arc basins, 30 (figure), 64 formation, defined, 48 Fort Funston, 122, 180, 182 (plate) Fort Point, 130 Fort Point-Hunters Point mélange, 124 (map), 125, 129-130 Fort Ross, 262-263, 262 (plates), 275 Fort Ross Creek, 263 fossils, 3, 71, 91, 126 East Bay, 235, 235 (plate), 242, 243 (plate), 246 North Bay, 279 Peninsula, 172-173, 178, 179 (plates), 180 San Francisco, 180 South Bay, 204, 210 vertebrates, 205-206, 236, 279 Franciscan chert. See radiolarian chert Franciscan Complex, 3, 49, 55-64 assemblage of, 62-64 beach sands and pebbles, 57, 58 (plate), 102 East Bay, 231-233, 239, 241-242, 249 Marin County, 78, 93-95, 104 North Bay, 249, 267–271, 273, 282, 282 (plate) Peninsula, 169–170, 169 (table) rock types, 54 (figure), 55-62 San Francisco, 123–130 South Bay, 199–201, 199 (table) west of the San Andreas Fault, 170 See also Franciscan mélanges; Franciscan terranes; geologic maps; specific terranes and types of rockFranciscan mélanges, 54 (figure), 63 characteristic topography, 63, 63 (figure), 94, 201 East Bay, 231, 233, 241 Marin County, 63 (plate), 94-95, 94 (plate), 95, 104 North Bay, 255, 260, 261 (plate), 269, 271 Peninsula, 169 (table), 173-174 San Francisco, 125, 129–130 South Bay, 199 (table), 201, 212 See also geologic maps Franciscan terranes, 63–64, 65 (table) East Bay, 65 (table), 231, 233 Marin County, 65 (table), 95, 96 (map)

Franciscan terranes (continued) North Bay, 65 (table), 269, 270 (map), 271 Peninsula, 65 (table), 169 (table), 172-173 San Francisco, 65 (table), 124 (map), 125-129 South Bay, 199 (table), 201 See also specific terranes by name Franklin Fault, 226–227 (map) Franks Tract State Recreation Area, 224, 225 (plate) Fremont Havward Fault offsets, 43, 230 Irvington Gravels, 205 salt plant, 150 (plate), 151 Fremont, John C., 134 fumaroles, 280-281 Gabilan Range, 207 garnets, 61, 61 (plate), 104, 122 gas deposits, 67 geologic maps about, xvi-xvii Bay Area overview, 6-7 California geomorphic provinces, 11 chart listing maps by rock type, 306-307 Diablo Range, 200 East Bay, 222-223 Marin County, 82-83 Marin Headlands, 100 Mount Diablo State Park, 240 North Bay, 258-259, 270 Peninsula, 161 Point Reyes, 89 San Francisco, 114-115, 124 South Bay, 190-191 tectonic plates, 27 (figure) See also fault maps geologic processes, 10-23 coastal processes, 16-23 glacial activity, 85 overview, 10-12 plate tectonics overview, 26-30 time scale, 2, 3, 8–10, 8 (figure) weathering and erosion, 13–16 See also plate tectonics geomorphic provinces, 10, 11 (map) Gerstle Cove, 266, 268 (plate) Geysers, The, 271, 280-282, 280 (plate), 281 (plate), 282 (plate) Gilbert, G. K., 142 glacial activity Marin County, 85 sea level changes and, 142, 144, 192 Sierra Nevada, 103, 120-122 Glass Mountain, 277, 278 (plate) glaucophane, 104, 269 gneiss, 49 (table) Goat Rock, 285, 285 (plate), 287 Goat Rock State Beach, 260, 284-287, 284 (plate), 285 (plate), 286 (plates) gold mining, 142, 211-212, 214 Golden Gate, 126, 128, 134, 135 geologic history, 145–146, 146 (figure) shoals and sandbars, 103, 121, 121 (figure) Golden Gate National Recreation Area. See specific locations and beaches Golden Gate Park, 116, 121-122

granite, 49 (table) granitic dikes, 88 granitic rocks, 30-31, 49 (table), 54 (figure), 68-69 Bodega Head, 68, 69 (plate), 266 Peninsula, 13 (plate), 171–172 Point Reyes, 10, 68, 78, 86, 87 (plate), 90, 91 (plate) Sierra Nevada sands, 103, 120–122 South Bay, 199, 199 (table) granodiorite, 49 (table) Grant County Park, 194, 200 gravels East Bay, 225, 237–239 South Bay, 192, 192 (figure), 205-206 See also alluvial deposits graywacke, 51 (plate) in beach sands and pebbles, 102 East Bay, 59, 231, 232 (plate), 233 formation, 49 (table), 54 (figure), 58-60, 62 Franciscan Complex, 58-60, 61, 63-64, 63 (figure) Great Valley Sequence, 203, 203 (plate) Marin County, 93, 93 (plate), 94, 95, 99, 100 (map), 104, 106 metamorphics formed from, 61 North Bay, 269, 271, 273, 287 Peninsula, 172, 173 San Francisco, 59 (plate), 60, 114-115 (map), 123, 123 (plate), 125-126, 128 (plate), 129-130, 130 (plate), 131 San Francisco Bay islands, 151–152, 153 (plate), 154, 154 (plate), 155 South Bay, 201, 203, 203 (plate) See also turbidite deposits Great Valley Complex, 8, 49, 64-68 conglomerates, San Andreas Fault offsets, 39 (figure), 40 East Bay, 233-234, 234 (plates), 239, 242 Great Valley Sequence (Great Valley Group), 64, 67-68, 67 (plate) Marin County, 96-97 North Bay, 64, 67, 266, 267-268, 271-273 Peninsula, 169-170, 169 (table), 170-171, 172, 173 rock types and formation processes, 54 (figure), 64-68 South Bay, 199-200, 199 (table), 202-203 See also Coast Range Ophiolite; geologic maps; Great Valley Sequence; Great Valley terranes; specific terranes and types of rock Great Valley Sequence (Great Valley Group), 64, 67-68, 67 (plate) cinnabar formation, 213 East Bay, 233, 242, 242 (plate) Monterey County, 170 North Bay, 271, 272–273, 272 (plate), 274 Great Valley terranes, 65 (table) East Bay, 65 (table) Marin County, 65 (table), 96, 96 (map) North Bay, 65 (table), 270 (map), 273 South Bay, 199 (table) See also specific terranes by name Green Valley Fault, 33, 33 (map), 256-257 (map), 258-259 (map), 263-264 greenstone, 55-56, 56 (plate), 104, 114-115 (map), 201 Greenville Fault, 33 (map), 196–197 (map), 200 (map), 222–223 (map), 226–227 (map) Grizzly Bay, 273

Grizzly Island Wildlife Area, 150, 284 Guadalupe River, 214-215 Half Moon Bay, 159, 162, 167 Halls Valley, 194 Hamilton, Mount, 10, 186 Hayward, fault offsets, 37, 230 (plate) Hayward Fault, 32-33, 228, 228 (plate), 229-230, 233, 250 Cazadero Terrane movement, 271 creep. 36-37, 230 earthquakes, 229-230 maps, 33, 222-223, 226-227 offsets, 37, 38 (plate), 43, 225, 229, 230, 230 (plate), 279 Healdsburg Fault, 33, 33 (map), 256-257 (map), 258-259 (map), 263 Healdsburg Terrane, 65 (table), 68 Marin County, 96, 96 (map) North Bay, 270 (map), 273 South Bay, 199 (table) Henry Coe State Park, 62, 200, 201 high-grade metamorphism, 61 Highway 1 Marin/Sonoma Coast, 260-261, 275 Peninsula, 163-164, 171-172, 174, 177, 178 (plate) Highway 12, 274 Highway 24, 247-248, 251 Highway 280, 174, 174 (plate) Hill, Mary, 103 honeycomb weathering (tafoni), 170, 171 (plate), 175-176, 204 hornblende, 104 hot springs, 209-210, 280, 282 (plate) Ice Age. See glacial activity Ice Age dune sands, 103, 120–122 igneous rocks, 48, 49 (table) See also specific types Inverness Ridge, 84, 85, 86, 88 iron copper sulfide, 233 iron oxidation, 13, 251, 277, 279 (plate) iron sulfide, 233 Irvington Gravels, 205 Iversen Basalt, 179 James V. Fitzgerald Marine Reserve, 18 (plate), 19, 162, 163 (plate) Jamieson Canyon, 274 jasper, 106, 271 Jenner, 260, 273 Joseph Grant County Park, 194, 200 Kehoe Beach, 71 (plate), 86, 87 (plate), 91, 91 (plate), 92 Kensington, 233 Kirby Cove, 58 (plate), 99, 101 (plate), 102 La Honda Block, 167, 168 (map), 169, 169 (table), 171-172 Lafavette, 249 Laguna de los Dolores, 111 Laguna Salada, 162 Lagunitas, Lake, 107 Laird Sandstone, 89 (map), 91–92, 91 (plate) Lake Ranch Reservoir, 194 Lake Sonoma Terrane, 65 (table), 269, 270 (map)

lakes Central Valley, 145 Marin County, 85, 107 San Francisco, 111, 116 See also specific lakes Lands End, 126, 128 (plate) landslides, 14 (figure), 15-16 East Bay, 15 (plate), 16 (plate), 251 Marin County, 85, 95, 98, 107 North Bay, 260-261, 261 (plate), 282 Peninsula, 164-166, 164 (plates), 165 (plates), 166 (plate) San Francisco, 122, 125–126 turbidity currents, 59-60, 60 (figure) See also geologic maps Las Trampas Regional Wilderness, 16 (plate), 235, 236 (plate) lavas, 49 (table), 54 baked contacts, 251, 277, 279 (plate) East Bay Hills, 250-251 North Bay, 276, 277 See also basalt; greenstone; pillow basalt; volcanic rocks Leona Rhyolite, 233 Lick Observatory, 186, 201 Limantour Spit, 20, 84 limestone, 49 (table), 69 Calera Limestone, 172-173, 172 (plate) South Bay, 190–191 (map) Lincoln Park, 126 liquefaction, 16 lithosphere, 26, 26 (figure), 29 (figures) Little Yosemite, 233 Livermore Gravels, 237, 238 (plates) Livermore Valley, 219, 237-239 Lobos Creek, 111 Lobos, Point, 123 (plate), 128-129, 130 (plate), 266 Loma Prieta, 43, 158, 186, 195, 195 (plate) Loma Prieta earthquake (1989), 33 (map), 35-36, 117, 118-119, 195 longshore drift, 20, 21 (figure) Los Capitancillos Ridge, 212, 212 (plate) Los Trancos Open Space Preserve, 195, 195 (plate), 200 Maacama Fault, 33, 33 (map), 256-257 (map), 258-259 (map), 263 Madrone Springs Fault, 196-197 (map), 200 (map) magma, 28, 30, 49 (table), 54 (figure) magnetite, 122-123 manganese mine, Red Rock, 154 mantle, 26, 26 (figure) maps. See fault maps; geologic maps marble, 49 (table), 69, 86, 172 Marin County, 78–107, 80–81 (map) basement rocks, east of the San Andreas Fault, 78, 93-97 exploring Mount Tamalpais, 105-107 exploring Ring Mountain, 104-105 exploring the Marin Headlands, 99-104 geologic maps, 82-83, 96 geologic overview, 78, 84 rainfall, 106-107 tectonics/faulting, 34-35, 44, 78, 84, 86, 92 Tertiary rocks, east of the San Andreas Fault, 97-98 topography, 78, 79 (plate), 84, 94

Marin County (continued) volcanic rocks, 93-94, 97-98, 208, 279 west of the San Andreas Fault, 78, 84-92 See also Marin Headlands; Reyes, Point; Tamalpais, Mount; other specific locations and topographic features Marin Headlands, 99–104, 103 (plate) geologic maps, 82-83, 96, 100 gravwacke and shale, 93 (plate), 99, 100 greenstone, 56, 56 (plate), 104 pillow basalt, 93, 99, 100, 101 (plate), 102, 104 radiolarian chert, 56-57, 57 (plate), 93, 99, 100, 101 (plate) Marin Headlands Terrane, 65 (table), 201 East Bay, 231, 241–242 Marin County, 95, 96 (map), 99, 100, 126, 128 North Bay, 269, 270 (map), 271 Red Rock, 154 San Francisco, 124 (map), 125, 126, 128 South Bay, 199 (table), 201 Marin Islands, 151, 154-155 marine processes longshore drift, 20, 21 (figure) turbidity currents, 59–60, 60 (figure) See also coastal processes; wave action marine sediments/sedimentary rocks, 31, 54 (figure), 62, 67, 70-71 East Bay, 233-235, 242, 244 Marin County, 89-92, 98 North Bay, 255, 266-267, 273-275 Peninsula, 174-178 San Francisco, 130-131 See also geologic maps; Great Valley Sequence; turbidite deposits; specific rock types and formations marine terraces, 18 (figure), 19 Marin County, 85, 89 (map) Peninsula, 159, 159 (plate), 162, 162 (plate) Sonoma Coast, 254, 260, 262, 262 (plate), 266, 267, 267 (plate), 284 (plate), 285 marine-terrestrial transition, 70-71, 204, 230-231, 235, 247 Markley Canyon, 246 Markley Formation, 246, 273-274 Marsh Creek Road, 233-234, 234 (plate) marshes. See wetlands Mayacamas Mountains, 276 McClures Beach, 87 (plate), 88 McNears Quarry, 93 mechanical weathering, 13 mélanges. See Franciscan mélanges melted ice cream topography, 15-16, 16 (plate), 94, 201, 260, 261 (plate) Mendocino County, 40, 179 Point Arena Terrane, 65 (table), 68 Merced Formation Peninsula, 164-165, 180-182, 181 (plate), 183 Point Reyes, 89 (map) San Francisco, 122, 180, 182 (plate) mercury deposits, 203, 207, 213 mercury mines, 211-212, 213-215, 281-282 mercury sulfide. See cinnabar Mesozoic Era, 3, 8 (figure) Mesozoic rocks, 31 See also Franciscan Complex; Great Valley Complex; Salinian Complex

Mesozoic Subduction. See Farallon Plate subduction metamorphic rocks, 48, 49 (table), 61-62, 69-70 East Bay, 231, 233 Marin County, 86, 87 (plate), 88, 104, 105 (plate) North Bay, 269 Peninsula, 172 South Bay, 201 See also specific types mica, 104, 269 mica schist, 106 (plate) microfossils. See fossils Miller Creek Fault, 226-227 (map) Mindego Basalt, 178-179 mines, mining Black Diamond Mines Regional Preserve, 244-247, 245 (plate), 246 (plate) gold-mining debris, San Francisco Bay, 142 mercury mines, 211-212, 213-215, 281-282 North Bay and Clear Lake, 281–282 Red Rock, 154 See also quarries Mines Road, 238 (plate), 239 Mission Creek, 111, 117 Mission Dolores, 111 Mission Fault, 43, 226–227 (map) Mission Peak, 15 (plate), 43, 235 Mojave Desert, 207 mollusks fossils and burrows, 178, 179 (plate), 235, 235 (plate), 267, 268 (plate) rock-burrowing clams, 170-171, 171 (plate) Montara Mountain, 158, 159, 176 (plate) granitic rocks, 13 (plate), 68, 171-172, 266 metamorphic rocks, 70 sedimentary rocks, 174 See also Devils Slide Monterey Formation (Monterey Shale), 70-71, 71 (plate), 248 Point Reyes, 89 (map), 91-92 Monterey Peninsula, Bay Area rock matches, 92, 177-178, 266 Montezuma Formation, 283 Montezuma Hills, 283, 283 (plate) Moraga Fault, 226–227 (map) Moraga Formation, 50 (plate), 247 (plate), 248 (figure), 250-251, 250 (plate), 279 Morgan Hill earthquake (1984), 195 Mount Diablo (Thrust) Fault, 226-227 (map), 229, 240, 240 (map) Mount Hamilton Block, 196-197 (map), 198, 199 (table), 201 Mountain Lake, 111 mud San Francisco Bay sediments, 73, 74, 141-143, 143 (figure), 145 See also alluvial deposits Mussel Rock, 162, 166, 180, 181 Napa County, 67, 276-277 See also North Bay Napa Valley, 276 Nassella pulchra, 105 Native Americans, 204–205, 213 mortar rocks, 204, 205 (plate) obsidian quarrying, 277

Neenach Volcanics, 39–40, 39 (figure) Neroly Formation, 246 New Almaden, 201, 203 New Almaden Block, 196-197 (map), 198, 199 (table), 201 New Almaden Quicksilver District, 207, 211-215, 281-282 New Idria Mine, 215 Nicasio Reservoir, 55 (plate), 56, 63 (plate), 94 Nicasio Reservoir Terrane, 65 (table), 95, 96 (map) Niles Canvon, 97, 224, 225 Niles Cone, 225 North American Plate, 26, 27 (figure), 28, 31 See also Farallon Plate subduction; plate tectonics North Bay, 254–287, 256–257 (map) basement rocks, 62, 64, 67, 266-273 baylands, 283-284 cinnabar deposits, 215 faults, 33, 256-257 (map), 258-259 (map), 263-264, 268-269 gas deposits, 67 geologic maps, 258-259, 270 geologic overview, 265 The Geysers, 280-282, 280 (plate), 281 (plate), 282 (plate) mélange landscapes, 63, 63 (plate), 95 Tertiary/Quaternary rocks, 265, 273-279 topography, 254-255, 263, 268, 276, 283 volcanics, 72 (plate), 73 (plate), 265, 275-282 See also Marin County; San Pablo Bay; Sonoma Coast; Sonoma County; Suisun Bay; other specific locations and topographic features Nortonville Shale, 245, 246, 246 (plate), 273 Novato Conglomerate, 96-97, 98 (plate), 210, 273 Novato Quarry Terrane, 65 (table) East Bay, 231, 232 (plate) Marin County, 95, 96 (map) North Bay, 269, 270 (map) San Francisco Bay islands, 155 Oakland, 37, 233 Oakland Conglomerate, 233 Oakland star tulip, 105 obsidian, 49 (table), 277, 278 (plates), 279 (plate) Ocean Beach, 102, 119, 122-123, 123 (plate), 181 ocean crust rocks, 54 (figure), 68, 104, 267 See also Coast Range Ophiolite; pillow basalt Ocean Shore Railroad, 163, 176 (plate) Ohlsen Ranch Formation, 275 Olema, 36, 84 Olema Creek, 84 ophiolite. See Coast Range Ophiolite Orinda, 236, 249 Orinda Formation, 204, 247 (plate), 248-249, 248 (figure), 269, 271 rock examples, 51 (plate), 52 (plate) oxidation, iron-bearing rock, 13, 277, 279 (plate) Pacheco Creek, 224 Pacific Plate, 26, 27 (figure), 28, 31, 68-69 See also plate tectonics Pacifica Quarry, 172–173, 172 (plate) Packwood Gravels, 205 Page Mill Basalt, 179 Paleozoic Era, 3, 8 (figure) Paleozoic rocks, Point Reyes, 86, 88, 89 (map) Palisades, the, 276, 276 (plate)

Palo Alto Baylands, 137 (plate), 150 Palomares Fault, 226–227 (map) Pebble Beach, 170, 171 (plate) Peninsula, 158–183, 160 (map) basement rocks, 60 (plate), 66, 167, 169-174, 169 (table) coastal landscape, 158, 160-166 faults/fault activity, 37, 37 (plate), 158-159, 161 (map), 166–167, 168 (map), 169, 170, 172, 178 geologic map, 161 geologic overview, 158 Point Reyes rock matches, 92, 177-178 Quaternary rocks, 131, 180–183 Sacramento-San Joaquin River reorientation, 145, 182 Tertiary rocks, 40, 174–179 topography, 37, 158, 176 See also Santa Cruz Mountains; other specific locations and topographic features Penitencia Creek, 209 Permanente Terrane, 65 (table) Marin County, 95, 96 (map), 99 Peninsula, 169 (table), 172-173, 173-174 South Bay, 199 (table), 201 Pescadero State Beach, 170 Petaluma, 263 Petaluma Formation, 274, 275, 279 Petaluma River, 254 Petrified Forest, 276, 277 (plate) petroglyphs, 204 petroleum source rock, 70-71 PG&E, Bodega Head nuclear reactor project, 264-265, 265 (plate) Phoenix Lake, 107 pholads, 170-171, 171 (plate) Piedmont, 231 Pigeon Point Block, 167, 168 (map), 169 (table), 170-171 Pigeon Point Formation, 60 (plate), 169 (table), 170-171, 171 (plate) Pilarcitos Block, 167, 168 (map), 169 (table), 170, 172-173 Pilarcitos Fault, 161 (map), 166, 167, 168 (map) pillow basalt, 50 (plate), 54 (figure), 55–56, 62, 63 (figure) Angel Island, 151 beach sands and pebbles, 102 East Bay, 240 (map) Marin County, 55 (plate), 56, 95, 99, 100, 100 (map), 101 (plate), 102, 104 Mount Diablo, 56, 241 North Bay, 269, 271 Peninsula, 172 San Francisco, 114-115 (map), 123 South Bay, 201, 212 Pine Gulch Creek, 84 Pinehurst Road, 233 Pinnacles, 39-40, 39 (figure), 207, 207 (plate) Pinole Fault, 226–227 (map) plants East Bay Hills, 219, 219 (plate) Petrified Forest trees, 276, 276 (plate) on serpentinite soils, 66, 105, 212, 272 South Bay, 186, 205, 212 plate tectonics, 2-3, 48 Bay Area rocks and, 43–45, 48–49, 54 (figure) Farallon Plate subduction, 31-32, 49, 62, 67, 231

plate tectonics (continued) marine terrace formation, 19, 159, 162 overview, 26-30 Pacific Plate-North American Plate dynamics, 32, 40, 44, 68-69, 70, 73, 273, 275 tectonic history overview, 31-32 tectonic plates mapped, 27 (figure) time scale, 9 types of plate dynamics, 28-31, 29 (figures), 30 (figure) uplift mechanisms, 28, 30, 40-43 See also earthquakes; faults and fault activity; specific regions and faults Pleasants Valley Road, 274 plutonic rocks, 48, 49 (table), 68 See also specific types Point Arena Terrane, 65 (table), 68, 266, 270 (map) Point of Rocks Sandstone, 39 (figure), 40, 177 Point Pinole Regional Shoreline, 228 Point Reyes. See Reyes, Point Point Reyes Conglomerate, 89 (map), 90–91, 90 (plates) Point Reyes National Seashore, earthquake trail, 84, 85 (plate) poison oak, 94 Portolá expedition, 134 Portola State Park, 177 Potatopatch Shoal, 103, 121, 121 (figure) Potrero Hills, 283 prisms. See accretionary wedges Purisima Formation Peninsula, 162, 177-178, 178 (plate), 179 (plate) Point Reyes, 89 (map), 92, 92 (plate) purple needle grass, 105 Putah Creek, 254 pyrite, 233 quarries East Bay, 225, 233, 237 North Bay, 266-267, 268 (plate), 277 Quarry Lakes Regional Recreation Area, 225 quartz, 86, 87 (plate), 122, 287 quartzite, 69, 86, 90 Quaternary Period, 8, 8 (figure) Quaternary rocks and sediments, 8, 74 See also geologic maps; specific regions Quien Sabe Volcanics, 73, 207-208, 279 Raccoon Strait, 135, 145, 151 radiolaria, 56, 57 (figure) radiolarian chert, 49 (table), 53 (plate), 63 (plate) beach pebbles and sands, 57, 58 (plate), 102, 122, 271 East Bay, 56, 231, 232 (plate), 240 (map), 241 folding, 56, 57 (plate), 99, 101 (plate), 127 (plate), 201, 241 formation processes, 49 (table), 54 (figure), 56-57, 62 Marin County, 56-57, 57 (plate), 58 (plates), 95, 99, 100, 101 (plate), 104, 106 North Bay, 269, 271 Peninsula, 172 San Francisco, 56, 114-115 (map), 123, 126, 127 (plates), 131 San Francisco Bay islands, 151, 152, 154, 155 South Bay, 201

radiometric dating, 9-10 rainfall, Marin County, 106-107 Rancho Olompali, 98 Red Rock, 151, 154, 155 (plate) red zones, 251 Redwood Road, 233 redwoods, petrified, 276, 277 (plate) reverse faults, 34 (figure), 195 Reves, Point, 78, 79 (plate), 80-81 (map), 84-92, 88 (map) basement rocks, 10, 68, 78, 86-88 geologic maps, 82-83, 89, 96 Limantour Spit, 20, 84 movement of, 44, 86, 92 outer beach, 20, 23, 84, 86 (plate), 102 overview, 84-85 rock matches to other locations, 92, 177-178 Tertiary rocks, 71 (plate), 89-92 volcanics, 90-91, 90 (plate) rhyolite, 49 (table), 72, 207 Richmond. See Richmond-San Rafael Bridge; San Pablo, Point Richmond-San Rafael Bridge, 59, 231 Red Rock, 151, 154, 155 (plate) Ring Mountain, 62, 94, 104-105, 105 (plate) Robert Sibley Volcanic Regional Preserve, 250, 250 (plate) Rockaway Beach, 172–173, 172 (plate) rockfalls, 14 (figure), 15, 16 Rockland Ash, 72, 143 (figure), 145-146, 182 (plate), 206 Rodeo Lagoon, 102, 103-104 Rodgers Creek Fault, 33, 263-264, 271, 279 maps, 33, 256-257, 258-259 Russian River, 10-11, 254, 273 Sacramento-San Joaquin River system, 135, 138 (figure) geologic history, 145, 182 sediment deposition, 73, 74 See also Delta sag ponds, 36 (figure), 37, 84, 167, 194, 262 (plate), 263 Salinia Terrane, 65 (table), 68 See also geologic maps; Salinian Complex Salinian Block, 44, 86, 170 Sonoma County, 266-267, 275 South Bay, 196-197 (map), 198, 199 See also Bodega Head; Reyes, Point Salinian Complex, 3, 49, 54 (figure), 68-70 Marin County, 78, 86, 88 North Bay, 68, 70, 266-267 Peninsula, 169, 169 (table), 171-172 South Bay, 199, 199 (table) See also geologic maps; Salinia Terrane; specific types of rock salt, 49 (table) South Bay salt production, 150–151, 150 (plate) Salt Point State Park, 266, 267 (plate), 268 (plate) San Andreas Fault, 11 (map), 32, 33 (map) creep along, 37 folding along, 42-43, 42 (figure) Marin County, 78, 79 (plate), 80-81 (map), 82-83 (map), 84, 86 offsets, 39-40, 39 (figure), 84, 85 (plate), 92, 207, 208, 262-263, 266 Peninsula, 37, 37 (plate), 158, 161 (map), 166, 168 (map), 179 Sacramento-San Joaquin River reorientation and, 145 San Andreas fault (continued) Sonoma County, 256-257 (map), 258-259 (map), 260, 262, 263, 264 South Bay, 194, 195, 196-197 (map), 198, 206, 207 San Andreas Fault System, 31, 32-35, 33 (map), 235 North Bay, 263–264, 273, 275 Peninsula, 166, 168 (map), 169 See also San Andreas Fault; other specific faults San Andreas Fault vallev Marin County, 78, 79 (plate), 84, 93 Peninsula, 37, 37 (plate), 167 South Bay, 194 San Andreas Lake, 37, 167 San Benito County New Idria Mine, 215 Pinnacles, 39-40, 39 (figure), 207, 207 (plate) San Bruno Mountain, 128, 173, 173 (plate) San Bruno Mountain Terrane, 65 (table), 173 Marin County, 95, 96 (map) Peninsula, 169 (table), 173 San Francisco, 123 (plate), 124 (map), 125, 128-129, 129 (plate), 130 (plate) San Francisco, 110-131, 112-113 (map) basement rocks, 123-130 earthquake hazards and damage, 117-119, 118 (figure) filled areas, 110-111, 116-119, 116 (figure), 118 (figure) geologic map, 114-115 geologic overview, 110-111 Quaternary rocks, 130–131, 180–182, 182 (plate) sand dunes, 119-123, 119 (plate), 130 streams and lakes, 111, 116, 116 (figure) topography, 110-111 See also specific locations and topographic features San Francisco bar, 121, 121 (figure) San Francisco Bay, 2, 134-151, 136-137 (map), 187, 249 bay floor sediments, 73, 74, 141-143, 143 (figure), 145 East Bay alluvial plains, 218, 225 East Bay creek inflows, 224, 225, 226-227 (map) fill, 147, 149 (figure) flows, circulation, and tides, 135, 138, 140-141, 140 (figure), 141 (figure) geologic history, 134, 142-146 liquefaction hazard, 16 mercury in, 214-215 salinities, 140-141 sea level changes, 120, 134, 142, 142 (figure), 143-145, 192 water depths, 135, 139 (figure) watershed extent, 135, 138 (figure) wetlands and alluvial plains, 146-147, 148 (figure), 149 (figure) wetlands, North Bay, 150, 255, 284 wetlands, South Bay, 150-151 See also San Francisco Bay islands San Francisco Bay Block, 44, 167, 168 (map), 169-170, 169 (table), 173-174 San Francisco Bay islands, 150-155 Alcatraz, 125, 151–152, 152 (plate), 153 (plate) Angel Island, 66 (plate), 95, 145, 151, 152 (plate) Yerba Buena Island, 125, 151, 152, 153 (plate), 154, 154 (plate)

San Francisco Bay National Wildlife Refuge, 150 San Francisco earthquake (1906), 33 (map), 35, 36, 84, 117, 167, 262–263 San Gregorio Fault, 32, 92, 166, 167, 177, 178, 179 maps, 33, 161, 168 See also Seal Cove Fault San Gregorio State Beach, 167, 178, 179 (plate), 180 (plate) San Joaquin River. See Delta; Sacramento-San Joaquin River system San Leandro Creek, 218 San Lorenzo Creek, 218 San Pablo Bay, 136-137 (map), 138, 140, 141, 142, 224, 255 San Pablo Creek, 224 San Pablo, Point, 231, 232 San Pedro, Point, 93, 162, 175, 176 (plates) Sanborn County Park, 194, 200 sands Alameda Creek aquifers, 225 Black Diamond sand mines, 245 Bodega Head dunes, 266 Golden Gate shoals, 103, 120–122 Livermore Valley, 237-239 San Francisco Bay sediments, 143, 143 (figure) in San Francisco Bay sediments, 143, 143 (figure) San Francisco dunes, 119-123, 119 (plate), 130 Santa Clara Valley, 192, 192 (figure) See also beach sands; geologic maps sandstone, 49 (table), 51 (plate), 54 (figure), 67 East Bay, 234 (plate), 244, 245, 245 (plate), 246, 246 (plate), 247 (plate), 273 Marin County, 90 (plate), 91-92, 91 (plate), 98 metamorphics formed from, 69, 86, 88 North Bay, 273-275, 274 (plate), 279 Peninsula, 170-171, 174-178, 175 (plate), 176 (plate), 177 (plate), 180-183 South Bay, 204, 205 (plate), 210, 212 (plate) See also shale; turbidite deposits; specific formations by name Santa Clara Formation, 180, 206, 206 (plate) Santa Clara Valley, 187, 187 (plate), 192-193, 200, 204 Santa Cruz Mountains, 28, 40, 158, 186 basement rocks, 199, 201 deposits eroded from, 205, 206 Point Reyes rock matches, 92 Tertiary rocks, 204 uplift processes, 42, 43, 44, 195, 198 Santa Cruz Mudstone (Santa Cruz Formation), 92, 177 Point Reyes, 89 (map) Santa Margarita Sandstone (Santa Margarita Formation), 89 (map), 92 Santa Rosa, 264, 277 Santa Rosa Valley, 263, 264, 274 Santa Teresa County Park, 203 Santa Teresa Hills, 203, 204 Sargent Fault, 196–197 (map) schist, 49 (table), 69, 86, 104, 106 (plate) See also blueschist Schooner Gulch State Beach, 267, 268 (plate) sea level changes, 19, 70–71, 131, 144 (figure) Black Diamond Mines, 244-245, 246 Marin County, 85, 98 North Bay/Solano County, 273-274 Peninsula/San Francisco, 159, 180-181

San Francisco Bay, 120, 134, 142, 142 (figure), 143-145, 192 See also marine terraces Sea Ranch, 267 sea stacks, 17, 260 Marin Headlands, 104 Point Lobos, 128-129 Sonoma Coast, 17 (plate), 255, 260, 266-267, 268 (plate), 284 (plate), 285, 285 (plate) Seal Cove Bluff, 167, 169 (plate) Seal Cove Fault, 162, 167, 168 (map), 169 (plate) See also San Gregorio Fault sediment flows. See landslides; specific types sediment liquefaction, 16 sedimentary rocks, 48, 49 (table), 54 (figure), 64, 67-68, 70 - 71East Bay, 219, 233-236, 242-243, 244-245, 246, 247 Marin County, 89-92, 90 (plates), 91 (plate) Mendocino Coast, 40 North Bay, 273-275 Peninsula, 174-178 San Francisco, 130-131 South Bay, 202, 203, 204-207 See also geologic maps; marine sediments/sedimentary rocks; specific types and formations sediments, sediment deposition, 8, 13, 15, 74 San Francisco Bay floor sediments, 73, 74, 141–143, 143 (figure), 145 South Bay, 187, 192–193, 192 (figure), 198 See also alluvial deposits; beach sands; gravels; marine sediments/sedimentary rocks; sands Sequoia langsorfii, 276 serpentine reedgrass, 105 serpentinite, 2, 37, 49 (table), 53 (plate), 62, 64, 66 Angel Island, 66 (plate), 151 in beach sands, 122 East Bay, 66, 233, 240 (map), 242 Marin County, 66, 66 (plate), 95, 96, 97 (plate), 104-105, 106 mercury deposits, 203, 212, 213 North Bay, 271–272, 285–286, 286 (plate) Peninsula, 174, 174 (plate) San Francisco, 24-25, 114-115 (map), 123, 129-130, 131 slickensides in, 126, 212, 286-287 soils and flora, 66, 66 (plate), 105, 202, 212, 272 South Bay, 66, 202–203, 202 (plate), 212, 213, 214 (plate) See also geologic maps serpentinite mélange, Fort Point-Hunters Point, 124 (map), 125, 129-130 Shadow Cliffs Regional Recreation Area, 237, 238 (plate) shale, 49 (table), 54 (figure), 59, 67 East Bay, 231, 232 (plate), 233, 234, 234 (plate), 242, 245, 246 Marin County, 71 (plate), 90 (plates), 91-92, 93 (plate), 99, 100, 100 (map), 104 metamorphics formed from, 69, 86, 88 North Bay, 266–267, 269, 274 (plate) Peninsula, 173, 174-175, 175 (plate), 176 (plate) San Francisco Bay islands, 154, 154 (plate), 155 South Bay, 204 See also turbidite deposits; specific formations Shannon Fault, 196-197 (map)

Shell Beach, 271 shutter ridges, 36 (figure), 84 Sibley Volcanic Regional Preserve, 250, 250 (plate) Sierra Azul Block, 196-197 (map), 198, 199 (table), 202, 203 Sierra Nevada gold-mining waste from, 142 Salinian Complex granitics and, 68-69 sands/sediments from, 103, 120-122, 145, 182 Siesta Formation, 248 (figure), 251 silica, 68, 72, 103-104, 276 silica-carbonate rock, 213, 214 (plate) silica sand, Black Diamond Mines, 245 Silver Creek Block, 196-197 (map), 198, 199 (table), 202 Silver Creek Fault, 196–197 (map) silver mining, 211 Silverado Trail, 277, 279 (plate) Sisters. See Brothers and Sisters Skaggs Springs Road, 269, 272 Skinner Ranch, 84 Skyline Boulevard (East Bay), 233, 248 Skyline Boulevard (Peninsula), 173, 175, 177, 204 slate, 49 (table) slickensides, 126, 127 (plate), 212, 286-287 slides. See landslides sliding plate boundaries, 29 (figure), 31, 32 slumps, 14 (figure), 15 Snow Mountain, 67 (plate) soil-building processes, 13 soils, serpentinite, 66, 66 (plate), 105, 202, 272 Solano County, 67, 273-274 See also North Bay; Vaca Mountains Somersville, 245 Sonoma Coast, 254, 255, 260-263 Franciscan rocks, 271 Great Valley rocks, 266 sea stacks, 17 (plate), 255, 260, 266-267, 268 (plate), 284 (plate), 285, 285 (plate) See also Bodega Head; Sonoma Coast State Beach; specific beaches Sonoma Coast State Beach, 17 (plate) Goat Rock State Beach, 260, 284–287, 284 (plate), 285 (plate), 286 (plates) Shell Beach, 271 Sonoma County, 73 (plate), 249 See also Bodega Head; North Bay; Sonoma Coast; other specific locations and topographic features Sonoma, Lake, 254 Sonoma Valley, 276 Sonoma Volcanics, 72 (plate), 73, 97-98, 239, 274, 275-279, 281 South Bay, 186-215, 188-189 (map) basement rocks, 62, 66, 97, 199-203 blocks and terranes, 196-197 (map), 198-199, 199 (table), 201 exploring Almaden Quicksilver County Park, 211-215 exploring Alum Rock Park, 209-210 faults and fault activity, 194, 196-197 (map), 198-199, 206, 207, 210 flora, 186 geologic map, 190-191 geologic overview, 186

South Bay (continued) San Francisco Bay/wetlands, 137 (plate), 140-141, 143, 150-151 Santa Clara Valley, 187, 187 (plate), 192-193, 200, 204 Tertiary/Quaternary rocks, 186, 198, 204-208 topography, 186, 194-195, 198, 201 volcanics, 74, 207-208 See also Diablo Range: Santa Cruz Mountains: other specific locations and topographic features spreading centers (tectonic plates), 28, 29 (figures), 54 (figure) springs, 36 (figure), 229 See also hot springs St. Helena, Mount, 10, 250-251, 254, 276 Stevens Creek County Park, 206 Stevens Creek Reservoir, 206, 206 (plate) Stewarts Point-Skaggs Springs Road, 269, 272 storms coastal effects of, 103, 164-166, 260 effects on San Francisco Bay, 140 Mount Tamalpais' influence, 106-107 See also wave action Strawberry Creek, 37, 38 (plate) streams East Bay, 37, 38 (plate), 218, 224-225, 226-227 (map) offsets due to fault movement, 36 (figure), 37, 38 (plate), 225, 263 San Francisco, 111, 116, 116 (figure) sediment carriage, 237 Streetcar to Subduction (Wahrhaftig), 131 strike-slip faults, 31, 34 (figure), 40, 42–43, 42 (figure) East Bay, 228 Peninsula, 166, 167, 169 South Bay, 194, 196–197 (map) See also San Andreas Fault System; specific faults by name Stump Beach, 266 subduction zones (convergent plate boundaries), 28, 29 (figure), 30–31, 30 (figure) North Bay, 265, 269 Pacific Northwest, 32 rock formation in, 54 (figure), 61-62 See also Farallon Plate subduction subsidence San Francisco, 117-119 Santa Clara Valley, 193, 193 (figure) Suisun Bay, 136-137 (map), 141, 142, 150, 224, 255, 284 Suisun Marsh, 284 sulfur, 233 Sunol Regional Wilderness, 46-47, 62, 233 Sycamore Formation, 237 Sydney Flat Shale, 246 synclines, 40, 41 (figure) East Bay Hills, 247-248, 248 (figure), 250-251 Livermore Valley, 239 Peninsula shore, 162, 163 (plate) tafoni, 170, 171 (plate), 175-176, 204 Tamalpais, Mount, 10, 40, 105-107 rocks, 66, 93, 95, 96, 105-106 uplift processes, 42 Tassajara-Green Valley Formation, 237

Tassajara Hills, 224, 237 Teachers Beach, 86, 88 tectonics, tectonic processes. See plate tectonics Telegraph Hill, 59 (plate), 60, 125-126 Temblor Sandstone, 204, 205 (plate), 212 (plate) Temescal, Lake, 37 terranes, 43, 63 Bay Area overview, 65 (table) Franciscan, 63-64, 65 (table), 95, 96 (map) Great Valley, 65 (table), 68 Marin County, 95, 96 (map) Salinian, 65 (table) San Francisco, 123, 124 (map), 125-129 San Francisco Bay islands, 151, 152, 154, 155 South Bay, 199 (table), 201 See also specific terranes by name Tertiary Period, 8, 8 (figure) Tertiary rocks, 3, 8, 70-74 See also geologic maps; specific regions, types, and formations Thornton Beach, 164-165, 164 (plates), 181 (plate), 183 (plate) thrust faults, 34 (figure), 40, 41 (figure), 42, 43 East Bay, 229, 240, 240 (map) Marin Headlands, 56 Peninsula, 166-167 South Bay, 194, 195, 196-197 (map), 198 Tiburon buckwheat, 105 Tiburon mariposa lily, 105 Tiburon paintbrush, 105 Tiburon Peninsula, 95, 132-133, 151 Ring Mountain, 62, 94, 104–105, 105 (plate) tides, San Francisco Bay, 135, 138, 139 (figure) time, geologic, 8 (figure) Tomales Bay, 84, 86, 88 Tomales Point, 88, 91, 266 topography of the Bay Area, 10-11, 67 mélange landscapes, 63, 63 (plate), 94, 201 satellite photos, xviii-1, 12 (plate) topographic results of faulting, 36 (figure), 37, 40-43, 194-195, 229 See also specific regions Toxicodendron diversilobum, 94 transform plate boundaries. See sliding plate boundaries transpression, 40, 195, 198, 263-264 Treasure Island, 154 tuff, 49 (table), 72, 73 (plate), 178, 180 (plate), 239 See also volcanic ash deposits turbidite deposits, 59-60, 67, 68 Cache Creek Valley, 273 East Bay, 233–234, 234 (plates) North Bay, 266-267, 267 (plate), 269, 272-273, 272 (plate) Peninsula, 170-171, 171 (plate) Point Reyes, 89-91, 90 (plate) See also graywacke; Great Valley Sequence; San Bruno Mountain Terrane; shale turbidity currents, 59, 60 (figure) See also turbidite deposits Twin Peaks, 56, 126 Umunhum, Mount, 43, 158, 186, 201 Upper Stevens Creek County Park, 194, 200

Upper Stevens Creek County Park, 194, 200 U.S. Geological Survey Web site, 39 Uvas Creek, 204 Uvas Reservoir, 201 Vaca Mountains, 254-255, 272-273, 274 Valley Ford, 274 (plate), 275 valleys, 36 (figure), 37, 43 See also basins; specific valleys by name Vaqueros Sandstone, 175-176, 177 (plate), 204 Veeder Mountain, 276 vertebrate fossils, 205-206, 236 volcanic arcs. 30, 30 (figure) volcanic ash deposits, 72-73 Peninsula, 146, 178, 180 (plate), 181-182, 182 (plate) San Francisco Bay, 143 (figure), 145-146 South Bay, 206 volcanic rocks, 48, 49 (table), 71-74 East Bay, 73, 233, 239, 246, 247-248, 248 (figure), 250-251 Marin County, 93-94, 97-98, 208, 279 North Bay, 72 (plate), 73 (plate), 275, 276, 278 (plates), 279, 279 (plate) Peninsula, 174, 178-179 Pinnacles, 39-40, 39 (figure), 207, 207 (plate), 208 (plate) South Bay, 207-208, 210, 211 (plate) See also geologic maps; specific types volcanoes, volcanic activity Cascade Range, 32 Clear Lake Volcanics, 73-74, 275, 280-282 East Bay, 250-251 eastern California, 9, 31, 72, 182 Northern California, 72, 144, 182 Quien Sabe Volcanics, 73, 207-208, 279 Sonoma Volcanics, 72 (plate), 73, 97-98, 239, 274, 275-279.281 volcano formation, 28, 30-31 Wahrhaftig, Clyde, 131 Walnut Creek (city), 249 Walnut Creek (stream), 224 Warm Springs Fault, 196–197 (map), 226–227 (map) wave action, 17-19, 101-102, 159 beach sand movement and, 19-20, 23, 102-103 sea cliff erosion, 165-166, 165 (plates), 260, 261 (plate) See also sea stacks wave-cut platforms, 18 (figure), 18 (plate), 19, 260 Peninsula, 159, 162, 163 (plate) weather. See storms weathering, 13 honeycomb weathering (tafoni), 170, 171 (plate), 175-176, 204 Wind Caves, Mount Diablo, 242–243, 244 (plate) West Napa Fault, 33 (map), 258-259 (map) Westlake Palisades, 165–166, 165 (plates) wetlands Delta, 150, 224 San Francisco Bay, 146-147, 148 (figure), 149 (figure), 150-151, 255, 284 Whiskey Hill Formation, 176-177 Wildcat Creek, 224 wildlife. See fauna Wilson Grove Formation, 98, 274-275, 274 (plate), 279 Wind Caves, 242–243, 244 (plate)

Yerba Buena Island, 125, 151, 152, 153 (plate), 154, 154 (plate)
Yolla Bolly Terrane, 65 (table)

Angel Island, 151
East Bay, 233
Marin County, 95, 96 (map)
North Bay, 269, 270 (map), 271
South Bay, 199 (table), 201

Yolo County, Cache Creek Valley, 273