

California Geological Survey - 150th Anniversary

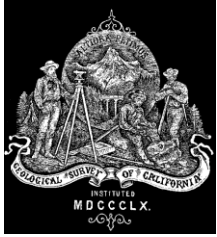
150 Geologic Facts about California



California's geology is varied and complex. The high mountains and broad valleys we see today were created over long periods of time by geologic processes such as fault movement, volcanism, sea level change, erosion and sedimentation. Below are 150 facts about the geology of California and the California Geological Survey (CGS).

General Geology and Landforms

- 1 California has more than 800 different geologic units that provide a variety of rock types, mineral resources, geologic structures and spectacular scenery.
- 2 Both the highest and lowest elevations in the 48 contiguous states are in California, only 80 miles apart. The tallest mountain peak is Mt. Whitney at 14,496 feet; the lowest elevation in California and North America is in Death Valley at 282 feet below sea level.
- 3 California's state mineral is gold. The Gold Rush of 1849 caused an influx of settlers and led to California becoming the 31st state in 1850.
- 4 California's state rock is serpentine. It is apple-green to black in color and is often mottled with light and dark colors, similar to a snake. It is a metamorphic rock typically derived from iron- and magnesium-rich igneous rocks from the Earth's mantle (the layer below the Earth's crust). It is sometimes associated with fault zones and often has a greasy or silky luster and a soapy feel.
- 5 California's state fossil is the saber-toothed cat. In California, the most abundant fossils of the saber-toothed cat are found at the La Brea Tar Pits in Los Angeles.
- 6 California state gem, benitoite, was discovered in 1907 in San Benito County. Crystals are typically light to sapphire blue, but can also form in a wide range of colors. Although benitoite is found in several places worldwide, large gem quality crystals are found only in California.
- 7 The Mendocino Triple Junction is located off the coast of northern California, where three tectonic plates (Pacific Plate, Gorda Plate, and North American Plate) meet.
- 8 The San Andreas Fault forms a transform plate boundary where the Pacific Plate meets the North American Plate south of the Mendocino Triple Junction.
- 9 Geologic hazards in California can consist of earthquake shaking and fault movement, tsunamis, landslides, volcanic eruptions, floods, and exposure to hazardous minerals.
- 10 Floods in California occur along the flood plains of streams and rivers, and also in desert washes and alluvial fans. Alluvial fans form at the mouths of canyons in California's deserts and semi-arid environments from floodwaters depositing sediment as the water velocity decreases.
- 11 The Salton Sea was created in 1905 when several floods inundated a bypass in irrigation canals and diverted the entire Colorado River for nearly two years. Currently, the Salton Sea is maintained by water diversions from the Colorado River.
- 12 Salts are found throughout California's desert areas in basins that have periodically filled with water that subsequently dried up or evaporated. Evaporation of freshwater in Mono Lake, thought to be the oldest lake on the North American Continent, has left behind salts and minerals making the water three times saltier than sea water.



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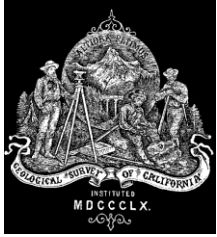
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- 13 During the ice ages 15,000 years ago, Death Valley contained a lake more than 100 miles long and 600 feet deep.
- 14 Marine terraces along California's coastline represent former sea level surfaces and can be used to measure uplift rates. A 125,000 year old marine terrace found in many of California's coastal areas represents the last time global sea level was high. Twenty-five marine terraces can be found on San Clemente Island, dating back as far as approximately 2.8 million years.
- 15 Fossils of mammoths, dogs, bears, cats, horses, camels, antelope, bison, sheep, turtles, shellfish, flamingos and palm trees have been found in sedimentary rocks in southern California near Barstow. A variety of other fossils such as oysters, snails, clams and vertebrates have also been found in northern California.

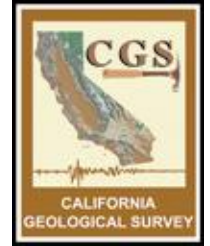
Geomorphic Provinces and Geology

- 16 California is divided into 11 geomorphic provinces: : Basin and Range, Cascades, Coast Ranges, Colorado Desert, Great Valley, Klamath Mountains, Modoc Plateau, Mojave Desert, Peninsular Ranges, Sierra Nevada, and Transverse Ranges.
- 17 The geology and landforms of California were largely created by three episodes of subduction of the oceanic plate under the continental plate from the west, the initiation and growth of the San Andreas fault system, and the extension of the Earth's crust in the Basin and Range area.
- 18 The Sierra Nevada and the Coast Ranges provinces were formed from the collision of tectonic plates, while the Basin and Range and Mojave Desert provinces were formed from the extension of the crust.
- 19 The Salton Trough region of the Colorado Desert province is currently spreading, or undergoing extensional rifting, similar to the plate motion that created Baja California.
- 20 Racetrack Playa, in the Basin and Range province, has grooves etched into the surface of the playa by "moving" rocks that are found at the end of the grooves. It is thought these grooves are formed by rocks entrained in ice being blown across the playa by strong winds.
- 21 Pillow basalts, like those found in the Coast Ranges, were formed when molten lava cooled under the ocean in shapes resembling the size and shape of a pillow.
- 22 Portions of old oceanic crust, called ophiolites, are visible today in the Coast Ranges, the Klamath Mountains, and in the Sierra Nevada.
- 23 Chert is a type of rock in the oceanic crust that formed from silica shells of microscopic organisms deposited on the deep ocean floor. Chert is present throughout California, but especially in the Coast Ranges and the Sierra Nevada.
- 24 Two blocks of granitic rock, known as the Salinian Block of the Coast Ranges, more closely resemble rocks of the Sierra Nevada rather than most of the rocks making up most of the Coast Ranges. One block lies between the Nacimiento and San Andreas Fault Zones in the southern Coast Ranges and west of the San Andreas Fault in the northern Coast Ranges, suggesting large displacement along the San Andreas and Nacimiento Faults.

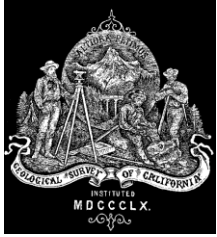


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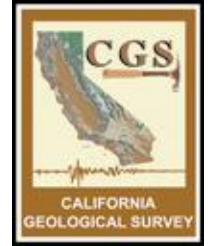


- 25 The Great Valley is an asymmetrical trough that is deeper on the west side of the valley than on the east.
- 26 The surface of the Great Valley consists of recent alluvium eroded from the adjacent Sierra Nevada and Coast Ranges.
- 27 Beneath the recent alluvial deposition in the Great Valley are older sedimentary deposits up to 20,000 meters thick. The older sedimentary deposits are sandstone, shale, and conglomerates that were deposited in an ocean setting, as indicated by the presence of marine fossils.
- 28 Four major types of rock in the Klamath Mountains are similar to those found in the Sierra Nevada and are believed to have once been part of the Sierra Nevada range.
- 29 The Modoc Plateau in northeastern California was a seaway before two main episodes of volcanic activity dominated the area: the older basalt flows and more recent volcanic activity associated with the High Cascades and the formation of the Basin and Ranges.
- 30 Lakes existed on the valley floors of the Modoc Plateau during the last ice age. Most have since dried up. An area of sand dunes, 10 miles long and several miles wide, is related to ephemeral lakes on the Modoc Plateau.
- 31 The Eastern California Shear Zone, located in the central Mojave Desert, consists of several right lateral faults that run parallel to the San Andreas Fault zone to the west.
- 32 The Peninsular Ranges form one of the largest geologic provinces in western North America, extending from the Transverse Ranges south to the tip of Baja California.
- 33 The Peninsular Ranges consist primarily of two phases of plutonic rock formation.
- 34 The older plutonic rocks of the Peninsular Ranges are located on the western side of the range and consist of dark gabbro.
- 35 The younger plutonic rocks of the Peninsular Ranges are located on the eastern side of the range and consist of more silica-rich, lighter colored rocks such as granodiorite and tonalite.
- 36 The Sierra Nevada is known for its granitic batholiths.
- 37 Sierra Nevada also has sedimentary and metamorphic rocks that represent oceanic crust that accreted to the western margin of North America during three episodes of subduction.
- 38 Several caverns present in the Sierra Nevada near Angels Camp and San Andreas were created from groundwater dissolving limestone and marble.
- 39 Glacial processes formed the majority of the current landscape visible today in the higher elevations of the Sierra Nevada, including the steep-sided, U-shaped valleys of Yosemite.
- 40 The Transverse Ranges were formed from compressive forces related to the eastward bending of rocks within the San Andreas Fault Zone.
- 41 The Ventura Basin is the deepest basin in the Transverse Ranges. It contains up to 10,000 meters of sediment, including the thickest section of Pleistocene marine deposits in the world.



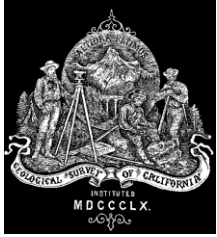
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Faults and Earthquakes

- 42 There are more than 700 named faults in California that are recently active. Many other recently active faults are still unnamed.
- 43 The longest fault in California is the San Andreas Fault system. It has a total known length of 1,600 kilometers (1,000 miles) and incorporates many parallel fault fractures and segments.
- 44 Cumulative displacement along the San Andreas Fault is estimated to be 560 kilometers (350 miles). Rocks on the west side of the fault zone have moved northward in relationship to those on the east side of the fault zone.
- 45 The average rate of slip (lateral or horizontal movement) for the San Andreas Fault is approximately 3.5 centimeters (1.38 inches) per year. Vertical movement also occurs along the fault zone, creating impressive mountain ranges such as the San Gabriel, San Bernardino and San Jacinto Mountains.
- 46 Most earthquakes occurring along the San Andreas Fault Zone are considered shallow, typically originating at depths of less than 10 kilometers (6.2 miles).
- 47 In 1906, the M8.2 San Francisco earthquake caused sudden right-slip movement on the San Andreas Fault up to 6 meters (20 feet). The earthquake also caused a great fire in the City of San Francisco.
- 48 Other important faults in California include: the Rogers Creek, Calaveras and Hayward Faults in the San Francisco Bay Area; the Nacimiento Fault in the southern Coast Ranges; the San Jacinto and Elsinore Faults in the Peninsular Ranges; the Sierra Nevada Fault in eastern California; and the Garlock Fault, which separates the Mojave Desert from the Sierra Nevada and the Basin and Range; and the Elsinore Fault in the Colorado Desert.
- 49 The Garlock Fault is unusual for California because it moves to the left. The majority of California's lateral faults move to the right.
- 50 Approximately 100 earthquakes occur in California daily, though most of them are too small in magnitude to feel.
- 51 The largest earthquake recorded in California was the M7.8 northern California earthquake of 1906. However, the southern California earthquake of 1857 was probably M7.9 and the offshore northern California Cascadia Subduction Zone earthquake of 1700 was probably M9.0.
- 52 Since the advent of CGS in 1860, California has experienced more than 35 earthquakes greater than M6.0.
- 53 The Santa Cruz Mountains, west of the San Andreas Fault, grew 1.2 meters (47.2 inches) higher during the M6.9 Loma Prieta earthquake of 1989, evidence that the Coast Ranges are still rising today due to fault activity.
- 54 During the M6.7 Northridge earthquake of 1994, horizontal accelerations on 1.25g and vertical accelerations of 1.2g were recorded (1g = force of gravity).



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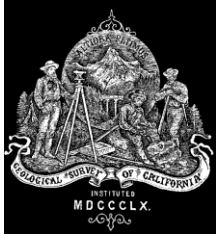


Tsunamis

- 55 Tsunamis that affect California are typically generated by earthquakes and fault movement that occur under the ocean, both off the coast of California and elsewhere in the world.
- 56 In 1700, the M9.0 Cascadia Subduction Zone earthquake caused a tsunami 18 meters (50 feet) high along California's north coast.
- 57 A local earthquake triggered a tsunami near Santa Barbara in 1812. People in coastal villages were so frightened, they moved uphill to the local mission.
- 58 A tsunami generated in the Aleutian Islands in 1946 caused flooding 363 meters (1000 feet) inland at half Moon Bay.
- 59 The M9.2 Alaska earthquake of 1964 caused a tsunami 7.2 meters (20 feet) high that flooded 29 city blocks in Crescent City and killed 12 people statewide.
- 60 Strong water currents generated by a tsunami from the Kuril Islands caused \$20 million of damage in Crescent City's small boat harbor.

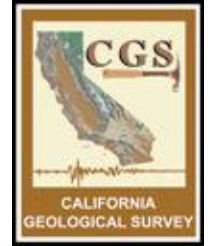
Landslides

- 61 Landslides occur on steep slopes and on slopes underlain by weak rock materials throughout California. They are triggered by earthquakes, storms, weak bedrock, fire damage, wave action, natural erosion, and human activities.
- 62 Landslides are highly prevalent in the Coast Ranges of northern California and in the Transverse Ranges of southern California. These areas are subject to devastating landslides and flooding, particularly when seasonal wildfires are followed by heavy rainfall.
- 63 During the 1998 El Nino storm events, more than \$250 million damage and 25 storm-related deaths occurred in California. Large landslides failed in the Coast Ranges both north and south of San Francisco, as well as in the Los Angeles area in southern California.
- 64 In less developed areas of the Coast Ranges, landslides may cause more sedimentation and downslope transport than stream erosion, thereby impacting water quality and wildlife habitat.
- 65 Clear Lake was formed when a large landslide blocked its outlet to Cold Creek. It is the largest natural freshwater lake in the Coast Ranges.
- 66 The prehistoric Blackhawk slide, located on the north slope of the San Bernardino Mountains, is the largest slide in the Transverse Ranges and one of the largest known in North America. It is 8 kilometers (5 miles) long, 3.2 kilometers (2 miles) wide, and 10 to 30 meters (30 to 100 feet) thick.
- 67 Since 1956, repeated movement on landslides near Portuguese Bend, on the Palos Verdes Peninsula, has caused millions of dollars of damage to homes built on top of them.
- 68 Repeated movement on the La Conchita landslide in 1995 and 2005 has resulted in the loss of both lives and property.



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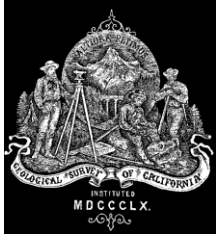
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- 69 Large landslides in the Sierra Nevada blocked Highway 50 both in 1983 and 1997 and dammed the American River, causing significant damage to nearby homes and cottages. During the 75 days Highway 50 was closed in 1983, South Lake Tahoe businesses lost over \$20 million in revenue.

Volcanoes

- 70 Evidence of recent volcanic activity is present at several locations in California including: Lassen Volcanic National Park; the Long Valley Caldera, Mono Craters, and the Coso Volcanic Field; Mt. Shasta and the Modoc Plateau; The Geysers and geothermal hot springs area near Clear Lake; and the Salton Sea.
- 71 California's most recent volcanic eruptions occurred at Lassen Peak between 1914 and 1921.
- 72 Fumaroles (vents of volcanic gas and steam) found near Lassen Peak are evidence of recent and ongoing volcanic activity.
- 73 Present day Lassen Peak is located on the eastern edge of an older and much larger volcano named Mt. Tehama that was nearly destroyed in a large volcanic eruption about 200,000 years ago. Mt. Tehama formed in the remains of an even older and larger volcano named Maidu.
- 74 The Long Valley Caldera was formed approximately 760,000 years ago when the roof of the Long Valley magma chamber ruptured and collapsed. Volcanic ash from the Long Valley Caldera eruption 760,000 years ago has been found as far away as Missouri.
- 75 A swarm of earthquake activity between 1980 and 1986, the continued rise of land forming a dome, and a carbon dioxide gas release that killed large stands of trees in 1995 are evidence of continuing volcanic activity in the Long Valley Caldera.
- 76 Devils Postpile National Monument, near Mammoth Mountain, is a display of the polygonal fracture pattern typical of basalt flows as they crystallize and cool into columns.
- 77 Other centers of recent activity in the southern Sierra Nevada occur at Mono Lake, Sherwin Hill, the volcanic fields of Owens Valley and Toowa Valley, Mammoth Mountain, and Mono and Inyo craters. The Coso Volcanic Field also contains numerous basaltic flows and cinder cones.
- 78 In north-central California, Mt. Shasta lies only 50 kilometers (31 miles) from the recently active Medicine Lake shield volcano. A molten magma chamber still exists beneath Mt. Shasta.
- 79 In northeastern California, lava flows 1200 to 1500 meters (4000 to 5000 feet) high form the Modoc Plateau. The Modoc Plateau is part of the much larger Columbia Plateau, which covers 518,000 square kilometers (200,000 square miles) in eastern Oregon and Washington, southern Idaho, northern Nevada and Utah, and western Wyoming.
- 80 Lava tubes found on the Modoc Plateau were formed from numerous lava flows occurring during the last 700,000 years. Obsidian found on the Modoc Plateau, and near Mono Lake, is volcanic glass formed from the rapid cooling of lava flows.
- 81 The Sutter Buttes, in the Sacramento Valley, were created by volcanic activity that occurred between 1.6 million and 1.3 million years ago. A thick layer of sediments in the center of Sutter



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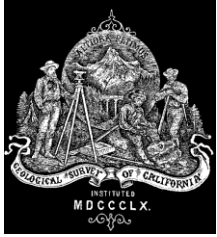


Buttes indicates a crater lake was once present.

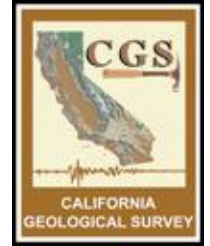
- 82 Table Mountain (east of Oroville) was formed by lava flowing into the valley out of the Sierra Nevada.
- 83 Significant volcanism also occurred in the Coast Ranges south of Clear Lake, covering an area of more than 900 square kilometers (350 square miles). Recent volcanic activity persists as hot springs and steam vents on the southeast shore of Clear Lake and at The Geysers.
- 84 Mount Konocti is a prominent 1280 meter (4200 feet) high volcanic cone on the southwest shore of Clear Lake.
- 85 The Petrified Forest west of Calistoga contains petrified wood that was buried in volcanic ash.
- 86 Morro Rock, along the south central coast of California, is part of an old volcanic chain that extends 25.6 kilometers (18 miles) from Morro Bay to San Luis Obispo.
- 87 Lake Tahoe formed when a volcanic eruption flowed across the valley, creating a natural dam.

Mining and Minerals

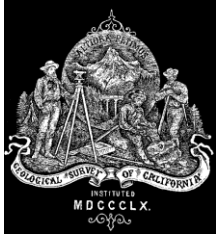
- 88 Long before the arrival of Europeans, native Americans in California mined a variety of minerals and rocks including: obsidian and chert for knives, arrowheads and other tools; soapstone for bowls, pipes, and beads; clay for pottery; hematite, cinnabar, manganese and graphite for various colors; and asphalt for waterproofing and use as an adhesive.
- 89 Historically, California has been a significant producer of the following metals: gold, mercury, and tungsten. It has also produced copper, iron, lead, zinc, antimony, chromite, manganese, titanium, silver, platinum and molybdenum.
- 90 California also produces industrial minerals including: sand and gravel, crushed stone, limestone (for cement), clays, borates, rare-earth elements, and saline compounds (salt).
- 91 The first known discover of gold in California was in the 1770s at the Potholes in Imperial County.
- 92 Gold was discovered at Coloma in 1848. The Gold Rush of 1848 and the subsequent influx of settlers led to California becoming the 31st state of the Union in 1850.
- 93 Since 1848, California has produced about 120 million ounces (more than 8 million pounds) of gold. This would make a cube about 19 feet on a side.
- 94 The largest placer gold "nugget" found in California was discovered in 1854. It weighed 54 pounds troy (648 ounces).
- 95 The most productive gold mine in California was the Empire Mine, which produced nearly six million ounces. The McLaughlin Mine, southeast of Clear Lake, produced over 3 million ounces of gold.
- 96 In 2000, CGS published a poster showing 13,500 historic gold mines throughout the state.
- 97 Since the early 1900's, the value of California's annual industrial mineral production has exceeded the value of its annual metal production.



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- 98 Although there are very few active gold mines today, California ranks 5th among the states in non-fuel mineral production, accounting for approximately 5.6% of the United States total.
- 99 In 2008, there were approximately 720 active mines in California. Their production had a market value of \$4.0 billion.
- 100 Construction aggregate (sand and gravel and crushed stone), used in buildings, roads, and other structures, is California's leading industrial mineral with a total value of \$1.1 billion produced in 2008.
- 101 More than 200 million tons of construction aggregate is produced in California each year. This is between 6 and 7 tons per year for each person in the state.
- 102 Mercury has been mined in the Coast Ranges from the Santa Barbara area to Lake County. The three largest mercury producing areas in the Coast Ranges include the New Almaden, New Idria, and Mayacamas mining districts.
- 103 Large crystals and gems formed in pegmatite dikes in the Peninsular Ranges have been mined primarily from three areas in San Diego County: Pala, Rincon, and Mesa Grande districts.
- 104 Brown coal, mined west of Antioch in the Coast Ranges, provided the majority of coal mined in California between 1860 and 1920.
- 105 The Pine Creek Mine in the Tungsten Hills area of the northern Basin and Range Province produced over one-third of the United States' tungsten production for many years. Tungsten is a metal used for electrical purposes and in hardening alloys such as steel.
- 106 The Mountain Pass Mine in San Bernardino County has the highest concentration of rare earth elements in the Western Hemisphere.
- 107 The West Shasta District in the Klamath Mountains has been the largest source of copper in California. Gold, chromite and zinc were also mined in the Klamath Mountains province.
- 108 Borates, typically used in cleaning materials, were first discovered in California in Tehama County in 1856. Large deposits in the southern California desert areas near Boron were found in the late 1800s and early 1900s. For many years, California has produced a significant portion of the world's borates. They have a wide variety of uses in many industries including: agriculture, ceramics, glass and fiberglass manufacture, and the chemical industries.
- 109 Under California's Surface Mining and Reclamation Act of 1975, all active mines must be reclaimed to a second, beneficial use when mining is completed. Examples include reclaiming mining pits to: strawberry fields or other types of crops; grazing lands or wildlife habitats; lakes and recreational areas; and residential or industrial property.
- 110 There are more than 47,000 abandoned mines in California that may present safety and/or environmental hazards. Since 1997, the Abandoned Mine Lands Unit of the Department of Conservation has conducted field inventories, provided preliminary assessment of health and safety hazards observed, and worked with other agencies, including CGS, to remediate hazardous abandoned mine features where feasible.



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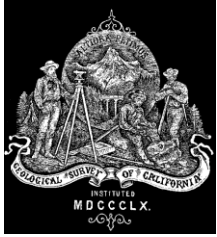


Oil and Natural Gas

- 112 In 2009, California produced approximately 630 thousand barrels of oil per day or 230 million barrels per year. Of these, 195 million barrels were produced onshore and 35 million barrels were produced offshore.
- 113 The Midway-Sunset oil field, southwest of Bakersfield, continues to be the largest producing oil field in California. It has produced a total of about 3 billion barrels of oil; 34 million barrels were produced from this site in 2009.
- 114 Folded rock layers act as natural traps for oil and natural gas in California.
- 115 Oil comes from organic matter, but the primary source is marine organisms.
- 116 Oil in California comes to the ground surface in natural seeps. The La Brea Tar Pits in Los Angeles provide examples of natural oil seeps.
- 117 Oil was discovered in the form of a natural tar pool in California in 1769.
- 118 The first commercial oil well in southern California was completed in 1866 in Ventura County.
- 119 Offshore oil wells were drilled as early as 1896 off the coast of Santa Barbara.
- 120 The deep basins adjacent to the Transverse Ranges near Los Angeles have the ideal combination of rock types and geologic structure for the production of oil.
- 121 The Monterey Formation is also an important oil-producing formation in California.
- 122 Approximately 279 billion cubic feet of natural gas were produced in California in 2009.
- 123 Dry natural gas (primarily methane) was first produced for commercial use in 1933 at the Sutter Buttes.
- 124 The Sacramento Valley produces primarily natural gas and no oil, while the San Joaquin Valley produces both oil and gas.

Geothermal

- 125 California is the United States' largest generator of electricity from geothermal energy.
- 126 Geothermal areas are commonly present where magma is close to the Earth's surface. Steam is produced when the magma heats groundwater.
- 127 In 2008, approximately 450 wells in California produced more than 105 billion kilograms of steam. In response to the need for sustainable power and electricity, 32 new high-temperature geothermal wells were drilled compared to 12 new wells drilled in 2007.
- 128 California's geothermal production comes primarily from fields at The Geysers in Sonoma and Lake counties, Casa Diablo in Long Valley, Coso near Lone Pine, and the Imperial Valley.
- 129 California's deepest producing geothermal well is over 3.2 kilometers (2 miles) deep and located in The Geysers Geothermal field, about 96 kilometers (60 miles) northeast of San Francisco.
- 130 One of the largest and hottest geothermal wells in the world is located in southern California's



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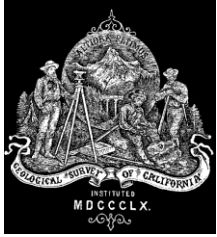


Salton Sea Geothermal field. The “Vonderahe1” can produce nearly 2.2 million pounds of hot water in an hour, enough to power a 30-megawatt power plant.

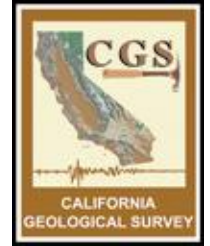
- 131 Hot springs are also formed from geothermal activity.
- 132 Hot springs are present at The Geysers and other geothermal fields, as well as along numerous fault zones including the Surprise Valley fault in the Modoc Plateau.
- 133 Many geothermal resources throughout California are “low-temperature”, and some are being used for non-electrical purposes, such as space-heating. The City of San Bernardino has one of the largest geothermal space-heating systems in the world.

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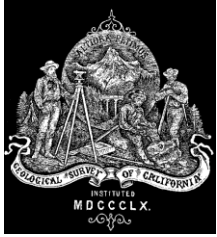
- 134 In 1851, one year after California was admitted to the Union, the California Legislature named John B. Trask, a medical practitioner and active member of the California Academy of Sciences, as Honorary State Geologist. California has had twenty one individuals fill the role of State Geologist or State Mineralogist since 1853 when the Legislature passed a joint resolution for geological information about the state.
- 135 In 1860, Josiah D. Whitney was named State Geologist and director of the first Geological Survey of California when the Legislature passed an act creating the Office of State Geologist and defining the duties thereof. The act directed Whitney to make an accurate and complete geological survey of the state.
- 136 In 1880, the State Mining Bureau was established to provide information on the occurrence, mining and processing of gold in the state. The Bureau published the first geologic map of the state in 1891, showing eight geologic units, along with numerous blanks where information was lacking. Four revisions of the State Geologic Map have been made since: in 1916, 1938, 1977 and 2010.
- 137 The name of the Bureau was changed in 1927 to the Division of Mines within the Department of Natural Resources, and the first staff geologist was hired in 1928. In the following years, two well-defined mining engineering and geology branches were established and the Division began publishing numerous geologic quadrangle maps and reports.
- 138 In 1962, the name was changed to the Division of Mines and Geology (DMG) to reflect the development of new programs and the shift in organization from primarily mining-oriented to one responsible for a wider range of practical applications in geology and earthquake hazards.
- 139 In 1968, the Geologists and Geophysicists Act was passed requiring the licensing of geologists to practice in the state.
- 140 During the 1970s to present, many new environmental and public safety laws were passed, including legislation focusing on DMGs authority in the areas of: assessing earthquakes and fault hazards; monitoring earthquake ground shaking; identifying mineral resources and implementing regulations related to surface mining and reclamation; providing geologic hazard assessment and review; and providing information and advisory services to other agencies, industries and the public involved with public policy decision-making.



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- 141 The official name of the division was changed to the California Geological Survey (CGS) in 2006; CGS is one division within the Department of Conservation (formerly Natural Resources).
- 142 CGS currently operates six programs: Earthquake Engineering, Mineral Resources and Mineral Hazards Mapping, Geologic and Hazards Mapping, Seismic Hazard Assessment, Seismic Hazards Zonation, and Forest and Watershed Geology.
- 143 CGS's Earthquake Engineering Program operates the California Strong Motion Instrumentation Program which records the strong shaking of the ground and in structures during earthquakes for the engineering and scientific communities through a statewide network of strong motion instruments. The first seismic monitor was installed by CGS at Point Arena in 1972. Since 1972, CGS has installed monitoring equipment at more than 1100 stations throughout the state, including 760 ground-response stations, 200 buildings, 25 dams and 70 bridges. Information gathered is used for earthquake engineering and building safety purposes.
- 144 CGS's Mineral Resources and Mineral Hazards Mapping Program (MRMHMP) provides data about California's varied non-fuel mineral resources (such as metals and industrial minerals), naturally occurring mineral hazards (such as asbestos, radon, and mercury), and information about active and historic mining activities throughout the state. Since 1978, CGS has completed 97 mineral land classification projects that cover about 34% of the state. These studies identify mineral resources that may be of economic value, primarily in developing areas. Environmental planners and other decision-makers are required to consider this information when development plans are proposed in their jurisdictions.
- 145 CGS's Regional Geologic and Hazards Mapping Program identifies where significant geologic and seismic hazards exist or are likely to exist so that informed land use and emergency response planning decisions can be made. Geologic maps were published by CGS in 1891, 1916, 1938, 1977 and 2010. Current geologic mapping by CGS shows geologic materials and structures in sufficient detail so the maps of geologic hazards and regulatory zone maps can be prepared. Under this program, CGS also maps Earthquake Fault Zones under the Alquist-Priolo Earthquake Fault Zoning Act, established in 1972 following the 1971 San Fernando earthquake. This law requires the State Geologist to establish regulatory zones around surface traces of active faults to prevent the construction of buildings for human occupancy. Local agencies must consider these maps and require detailed geologic studies for all proposed land subdivisions and most structures for human occupancy within the zones.
- 146 CGS's Seismic Hazards Assessment Program provides hospital and school environmental reviews, earthquake loss estimation, studies of historical earthquakes, and seismic probabilistic hazard assessment. CGS ensures that new construction for schools and hospitals includes consideration of geologic and seismic hazards. Schools are reviewed under provisions of the Field Act, enacted in 1933 following the Long Beach earthquake when 70 school buildings were destroyed, 120 suffered major damage, and 300 had minor damage. Hospitals are reviewed under requirements of the Hospital Facilities Seismic Safety Act, enacted in 1973 following the 1971 San Fernando earthquake when damage to at least three hospital buildings resulted in 47 of the 65 deaths.
- 147 CGS's Seismic Hazards Zonation Program identifies and maps areas prone to liquefaction,



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earthquake-induced landslides and amplified ground shaking. This program was implemented in 1990 under the Seismic Hazards Mapping Act, enacted following the Loma Prieta earthquake of 1989 to address earthquake related hazards that occur in addition to surface fault rupture. Based on the underlying geologic conditions, CGS maps existing landslides and areas prone to liquefaction, and establishes hazards zones around these areas. Local agencies must require detailed geologic investigations with recommended mitigation measures before a work permit is approved to construct buildings within these zones.

- 148 CGS's Forest and Watershed Geology Program (FWGP) provides technical information and advice about landslides, erosion, sedimentation and other geologic hazards to government agencies, industries and the public that make land-use decisions on California's forested lands and in watersheds where proposed activities may contribute to environmental or public safety hazards in the wild land and urban/wild land interface. CGS staff: map landslides in forested terrain; assess post wild land fire geologic hazards; assess and develop mitigation measures to limit erosion from unpaved roads and trails; assess landslide and erosion hazards in proposed timber harvesting plans and restoration projects along rivers and streams that may impact water quality and/or wildlife habitat; and map potential debris flow and flooding hazards on alluvial fans.
- 149 The California Geological Survey Library has been in existence since 1880 and has developed into an extensive collection of over 100,000 scientific and technical books and reports, including CGS publications, various map collections, photographs, U.S. Geological Survey publications and periodicals related to various geological topics.
- 150 CGS has developed the Educational Resources Center for students, teachers, and all others with an interest in the hope of making earth science learning more fun, intriguing, and meaningful. The Teacher Resource Center, which is part of the Educational Resources Center, provides tools and material for classroom instruction related to the earth sciences.

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