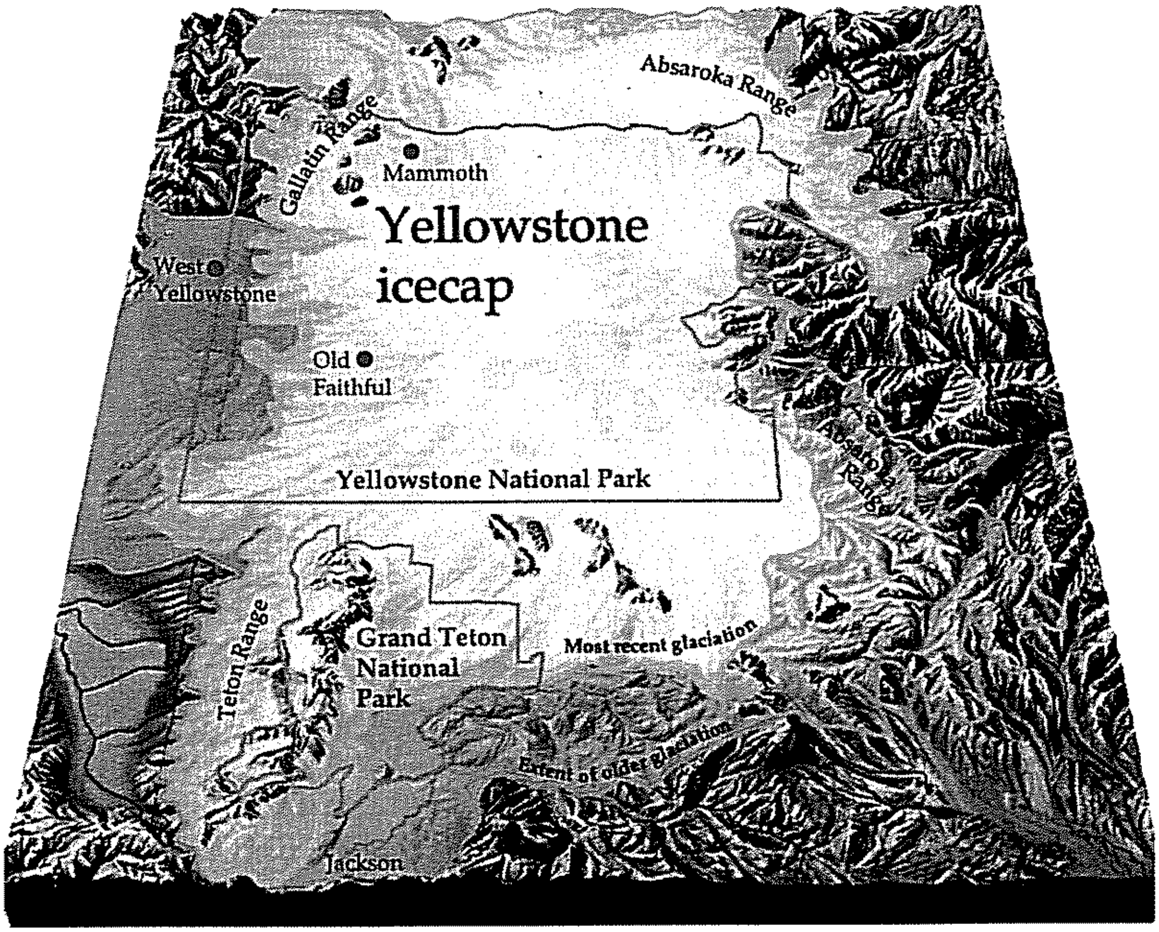
3

Glaciers



The extent of two major glaciations are shown on this map:
Bull Lake—orange outline
Pinedale—blue outline

Scientific understanding of glacier dates, sequence, and extent continues to evolve, and varying information appears in different references (including previous editions of this book). The information here is considered current by Yellowstone's geologist as of March 2006.

Glaciers

Glaciers result when, for a period of years, more snow falls in an area than melts. Once the snow reaches a certain depth, it turns into ice and begins to move under the the force of gravity or the pressure of its own weight. During this movement, rocks are picked up and carried in the ice, and these rocks grind Earth's surface, eroding and carrying material away. Glaciers also deposit materials. Large U-shaped valleys, ridges of debris (moraines), and out-of-place boulders (erratics) are evidence of a glacier's passing.

Yellowstone and much of North America have experienced numerous periods of glaciation during the last two million years. Succeeding periods of glaciation have destroyed most surface evidence of previous glacial periods, but scientists have found evidence of them in sediment cores taken on land and in the ocean.

The Bull Lake Period glaciers covered the region about 140,000 years ago. Evidence exists that this glacial episode extended farther south and west of Yellowstone than the subsequent Pinedale Glaciation *(described in the next paragraph)*, but no evidence of it is found to the north and east. This indicates that the Pinedale Glaciation destroyed surface evidence of Bull Lake Glaciation in these areas.

In the Yellowstone region, the last (and most studied) major glaciation, the Pinedale, may have begun as early as 70,000 years ago. It ended more than 14,000 years ago. At the peak of the Pinedale Glaciation—25,000 years ago—nearly all of today's Yellowstone National Park was covered by a huge ice cap 4,000 feet thick (at a point above present-day Yellowstone Lake, *see above)*. Mount Washburn and Mount Sheridan were both completely covered by ice. This ice field was not part of the continental ice sheet extending south from Canada. The ice field occurred here, in part, because the hotspot beneath Yellowstone had pushed up the area to a higher elevation with colder temperatures and more precipitation than the surrounding land.

3

Sedimentation & Erosion

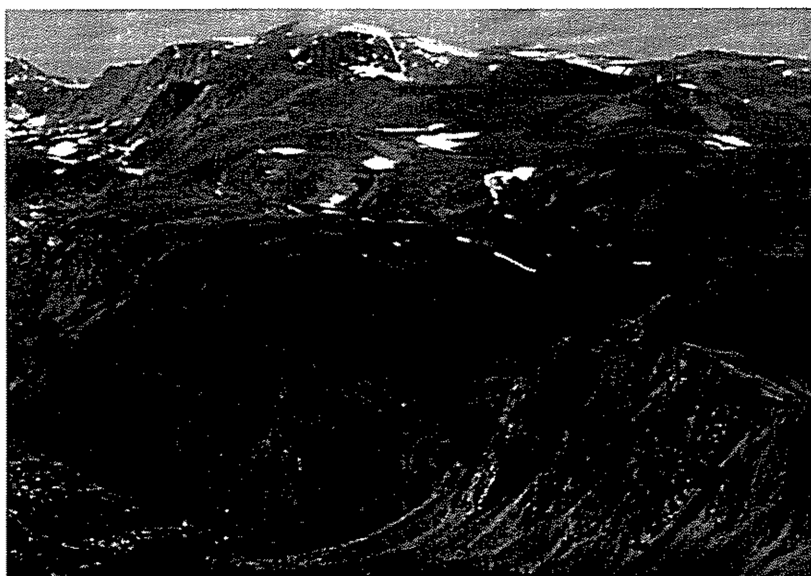
Sedimentation & Erosion

Not all the rocks in Yellowstone are of "recent" volcanic origin. Precambrian igneous and metamorphic rock in the northeastern portion of the park and Beartooth Mountains are at least 2.7 billion years old. These rocks are very hard and erode slowly.

Sedimentary sandstones and shales, deposited by seas during the Paleozoic and Mesozoic eras (570 million to 66 million years ago) can be seen in the Gallatin Range and Mount Everts. Sedimentary rocks in Yellowstone tend to erode more easily than the Precambrian rocks.

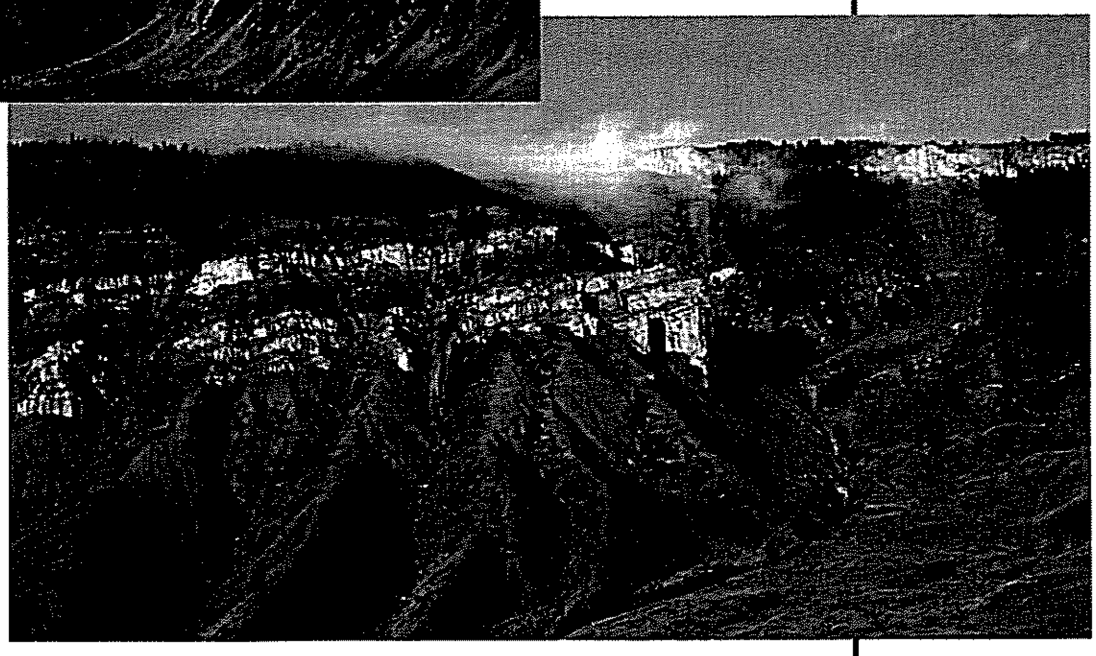
Weathering breaks down earth materials from large sizes to small particles, and happens in place. The freeze/thaw action of ice is one type of weathering common in Yellowstone. Agents of erosion—wind, water, ice, and waves—move weathered materials from one place to another.

When erosion takes place, sedimentation—the deposition of material—also eventually occurs. Through time, sediments are buried by more sediments and the material hardens into rock. This rock is eventually exposed (through erosion, uplift, and/or faulting), and the cycle repeats itself. Sedimentation and erosion are "reshapers" and "refiners" of the landscape—and they also expose Yellowstone's past life as seen in fossils like the petrified trees *(see next page)*.



The Beartooth Mountains northeast of Yellowstone (left) are actually an uplifted block of Precambrian rock.

Mt. Everts, near Mammoth, (below) exposes sedimentary rock, which erodes easily and often tumbles into Gardner Canyon.



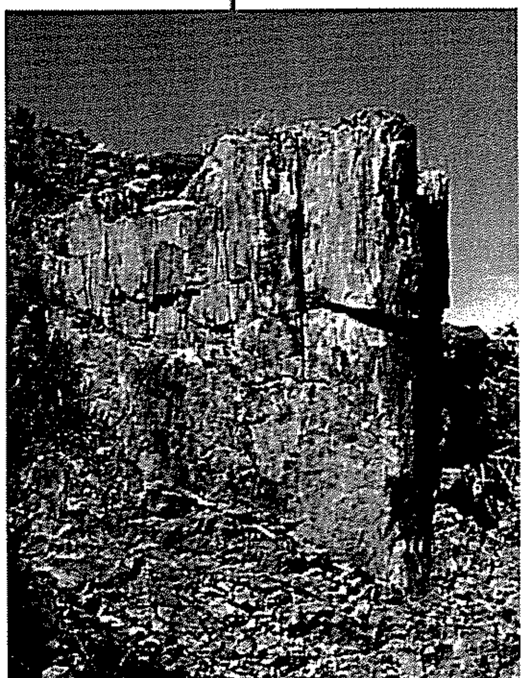
3

Fossils

Fossils

Paleobotany

Nearly 150 species of fossil plants (exclusive of fossil pollen specimens) from Yellowstone have been described, including ferns, horsetail rushes, conifers and deciduous plants such as sycamores, walnuts, oaks, chestnuts, maples, and hickories. Sequoia is abundant, and other species such as spruce and fir are also present.



In Yellowstone, many petrified trees can be seen. Resulting from volcanic eruptions about 50 million years ago, they present questions that scientists continue to ponder: Were the trees petrified in place and thus represent layers of forest? Or were they scattered before and after petrification, which means the number of forests cannot be determined?

Most petrified wood and other plant fossils come from Eocene deposits about 50 million years old, which occur in many northern parts of the park, including the Gallatin Range, Specimen Creek, Tower, Crescent Hill, Elk Creek, Specimen Ridge, Bison Peak, Barronette Peak, Abiathar Peak, Mount Norris, Cache Creek, and Miller Creek. Petrified wood is also found along streams in areas east of Yellowstone Lake. The most accessible petrified tree site is on Specimen Ridge.

The first fossil plants from Yellowstone were collected by the early Hayden Survey parties. In his 1878 report, Holmes made the first reference to Yellowstone's fossil "forests." The report identified the petrified trees on the north slope of Amethyst Mountain opposite the mouth of Soda Butte Creek, about eight miles southeast of Junction Butte.

Around 1900, F.H. Knowlton identified 147 species of fossil plants from Yellowstone, 81 of them new to science. He also proposed the theory that the petrified trees on the northwest end of Specimen Ridge were forests petrified in place.

Another theory proposes that the trees were uprooted by volcanic debris flows and transported to lower elevations. The 1980 eruption of Mount St. Helens supported this idea. Mud flows not only transported trees to lower elevations, they also deposited the trees upright.

Cretaceous marine and nonmarine sediments are exposed on Mount Everts. The area is under study; fossil leaves, ferns, clam-like fossils, shark teeth, and several species of vertebrates have been found. In 1994 fossil plants were discovered in Yellowstone during the East Entrance road construction project, which uncovered areas containing fossil sycamore leaves and petrified wood.

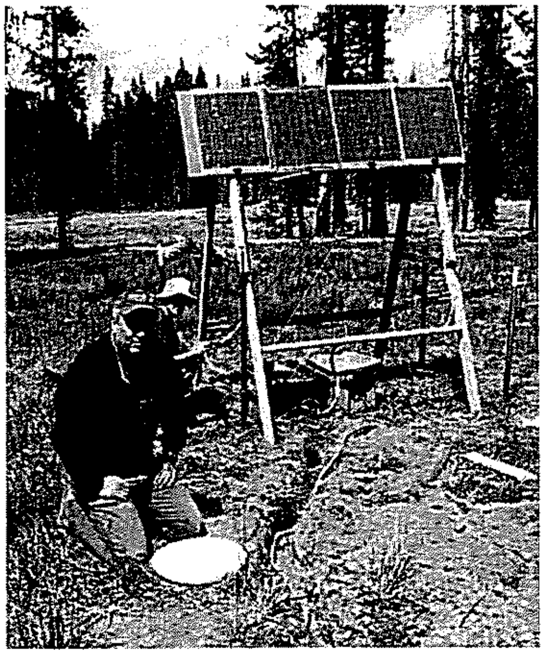
Fossil Invertebrates

Fossil invertebrates are abundant in Paleozoic rocks, especially the limestones associated with the Madison Group in the northern and south-central parts of the park. They include corals, bryozoans, brachiopods, trilobites, gastropods, and crinoids. Trace fossils, such as channeling and burrowing of worms, are found in some petrified tree bark.

Fossil Vertebrates

Fossil remains of vertebrates are rare, but perhaps only because of insufficient field research. A one-day survey led by paleontologist Jack Horner, of the Museum of the Rockies, Bozeman, Montana, resulted in the discovery of the skeleton of a Cretaceous vertebrate. Other vertebrate fossils found in Yellowstone include:

- Fish: crushing tooth plate; phosphatized fish bones; fish scales; fish teeth.
- Horse: possible Pleistocene horse, Equus nebraskensis, reported in 1939.
- Other mammals: Holocene mammals recovered from Lamar Cave; Titanothere (type of rhinocerus) tooth and mandible found on Mt. Hornaday in 1999.



Dr. Robert Smith and assistant set up a temporary seismographic station. It is one of dozens throughout the Greater Yellowstone Ecosystem sending seismic data to researchers at the University of Utah.

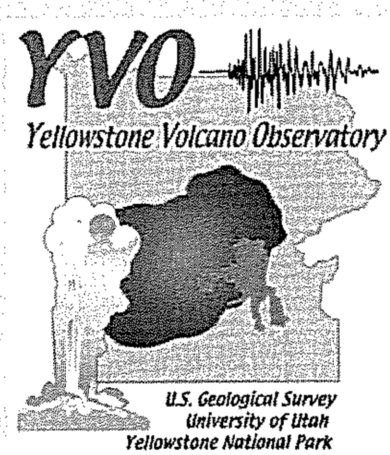
Yellowstone As a Geologic Laboratory

Yellowstone is a unique outdoor laboratory for research scientists. Many of these scientific studies have ramifications far beyond Yellowstone National Park. Current research examples:

- Earthquake monitoring stations detect the numerous daily tremors occurring in the Yellowstone region, and the patterns are studied to develop an understanding of the geodynamics of Yellowstone's hotspot.
- Studies on the location of previously unmapped geologic structures should help us understand what controls subsurface fluid flow and recharge in geothermal systems.
- Baseline geochemical studies help distinguish between human and natural influences on the underground water network in the region.
- Underwater studies in Yellowstone Lake have identified hydrothermal vents where organisms have been found that survive on sulphur emissions and that resemble life found under the ocean near similar hydrothermal vents; comparison studies continue.
- The deposition of sinter around hydrothermal springs is being studied to understand how early life developed on Earth and to look for similarities on other planets, particularly Mars.
- Thermophiles—microorganisms that can live in extreme environments—are being collected from the park's hydrothermal features, identified, and their heat-resistant enzymes are being studied. Some already are being used in a variety of medical and forensic processes. *(See Chapters 4 & 9.)*

All scientists in Yellowstone work under special permits and are closely supervised by National Park Service staff.

THE YELLOWSTONE VOLCANO OBSERVATORY



Increased scientific surveillance of Yellowstone in the past 30 years has detected unmistakable changes in its vast underground volcanic system, similar to historical changes observed at many other large calderas (volcanic depressions) in the world. To strengthen the capabilities of scientists to track and respond to changes in Yellowstone's activity, a fifth U.S. volcano observatory was created in 2001, complementing existing ones for Hawaii, Alaska, the Cascades, and Long Valley, California. The Yellowstone Volcano Observatory (YVO) is supported jointly by the U.S. Geological Survey, the University of Utah, and Yellowstone National Park.

The principal goals of YVO include:

* *Strengthening the monitoring system for tracking earthquake activity, uplift and subsidence, and changes in the hydrothermal (hot water) system;*
* *Assessing the long-term potential hazards of volcanism, earthquakes, and explosive hydrothermal activity in the Yellowstone region;*
* *Enhancing scientific understanding of active geologic and hydrologic processes occurring beneath Yellowstone and in the surrounding region of the Earth's crust; and*
* *Communicating new scientific results, the current status of Yellowstone's activity, and forecasts of potential hazardous hydrothermal explosions or volcanic eruptions to Yellowstone National Park staff, the public, and local, State, and Federal officials.*

Current real-time-monitoring data are online at volcanoes.usgs.gov/yvo/monitoring.html.

This text from a YVO pamphlet, "Steam Explosions, Earthquakes, and Volcanic Eruptions—What's in Yellowstone's Future?," sold by the Yellowstone Association.

Table 39.1 Generalized Geologic Column, Yellowstone National Park.

Time Units: Era	Time Units: Period		Time Units: Epoch	Rock Units		Geologic Events
Cenozoic	Quaternary		Holocene	Alluvial, landslide, glacial, and hot spring deposits		Earthquakes; landsliding Geothermal activity, hot springs, geysers Neoglaciation Regional uplift; doming in center of Yellowstone Plateau Erosion of Grand Canyon of Yellowstone River
			Pleistocene	*Yellowstone Group (about 20 formations and members)	(Plateau rhyolites and basalts) (Lava Creek Tuff) (Mesa Falls Tuff not exposed in park) (Huckleberry Ridge Tuff)	Pinedale glaciation Post-caldera lava flows; Obsidian Cliff Bull Lake glaciation Pre-Bull Lake glaciation Climactic eruptions and caldera collapse of third volcanic cycle; rhyolitic ash falls, mudflows, welded tuff, breccias, etc. Second volcanic cycle; Island Park caldera and western part of Yellowstone Plateau First volcanic cycle; caldera collapse in Island Park area, ash falls, pyroclastics, breccias, etc ; rhyolitic eruptions
	Tertiary	Neogene	Pliocene Miocene			Erosion of ranges, canyon cutting, sedimentation in basins
		Paleogene	Oligocene			Regional uplift; block-faulting
			Eocene	*Absaroka Volcanic Supergroup (9 formations)		Repeated eruptions of andesitic pyroclastics and lavas; burial of fossil forests Basaltic breccias and flows
			Paleocene			Post-orogenic faulting, uplift and erosion
Paleozoic/ Mesozoic	(Cretaceous)			*Over 40 formations, some in northern and some in southern sections of park		Laramide orogeny; intense folding and thrust faulting, uplifting of Rocky Mountains Extensive deposition of marine and nonmarine sedimentary rocks as seas advanced and retreated over downwarped area
						Major angular unconformity
Precambrian				Gneisses and schists		Orogenic cycles, intrusions, metamorphism, sedimentation and erosion

*For details of the stratigraphic record, see Keefer (1971, pp. 9–11), Parsons (1978, p. 214), Christiansen and Blank (1972, p. B6), Love and Keefer (1975, p. D9), Ruppel (1972, p. A8), Smedes and Prostka (1972, p. C7).

VOLCANO HAZARDS FACT SHEET

U.S. Department of the Interior
U. S. Geological Survey

Yellowstone: Restless Volcanic Giant

Three million visitors each year marvel at Yellowstone's Rocky Mountain splendor, including its thousands of steaming geysers, shimmering thermal pools, and bubbling mudpots. But the greatest wonder of all goes mostly unnoticed. Hidden underground, powerful volcanic, tectonic, and hydrothermal forces are continually reshaping the landscape of America's first and foremost national park. Symptoms of the underground turmoil include numerous earthquakes (most too small to be felt), uplift and subsidence of the ground surface, and persistent but ever-changing hydrothermal activity. Eventually, the unrest will culminate in another large earthquake or volcanic eruption, both of which have occurred many times before in Yellowstone's geologic past. Scientists from the U.S. Geological Survey and the University of Utah are studying the Yellowstone region to assess the potential hazards from future earthquakes and eruptions and to provide warning if the current level of unrest should intensify.

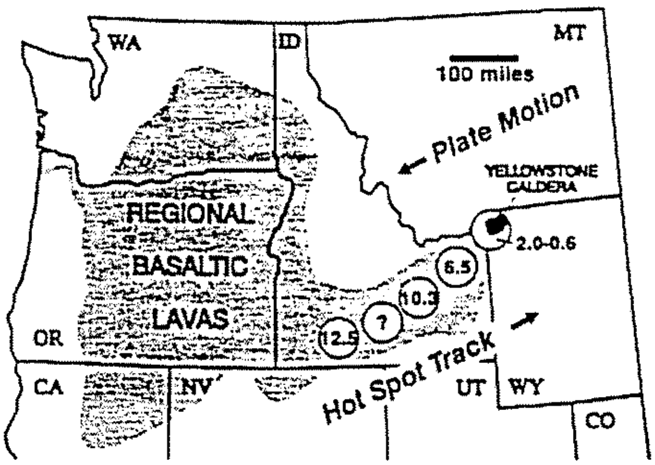


Figure 1. Regional basaltic lavas (stippling) and chain of rhyolitic caldera groups (circles), with ages in millions of years, along track of Yellowstone hot spot.

YELLOWSTONE'S ROOTS

Scientists have traced Yellowstone's origin to a *hot spot* in the mantle, one of a few dozen such hot spots on Earth. Buoyant material from a hot spot rises through the upper mantle, bringing heat from the Earth's interior closer to the surface. The Yellowstone hot spot impinges on the base of the North American plate, one of several rigid plates that make up the Earth's crust. These plates move a few inches per year with respect to the stationary hot spots and each other, sometimes causing great earthquakes as the plates collide, grind past one another, or split apart.

The Yellowstone hot spot has interacted with the North American plate for perhaps as long as 17 million years, causing widespread outpourings of basalt that bury about 200,000 square miles in Washington, Oregon, California, Nevada, and Idaho under stacks of lava flows half a mile or more thick. Some of the basaltic melt, or *magma*, produced by the hot spot accumulates near the base of the plate, where its heat melts rocks from the Earth's lower crust. These melts, in turn, rise closer to the surface to form large reservoirs of potentially explosive rhyolite magma. Catastrophic eruptions have partly emptied some of these reservoirs, causing their roofs to collapse. The resulting craters, some of which are more than 30 miles (50 kilometers) across, are known as volcanic *calderas*. Because the plate was moving an inch or so per year southwestward over the hot spot for millions of years as the calderas formed, groups of calderas are strung out like beads on a string across parts of Idaho and Wyoming (fig. 1).

THE YELLOWSTONE CALDERA

The most recent caldera-forming eruption about 650,000 years ago produced a caldera 53 x 28 miles (85 x 45 kilometers) across in what is now Yellowstone National Park (fig. 2). During that eruption, ground-hugging flows of hot volcanic ash, pumice, and gases swept across an area of more than 3,000 square miles. When these enormous *pyroclastic flows* finally stopped, they solidified to form a layer of rock called the *Lava Creek Tuff*. Its volume was about 240 cubic miles (1,000 cubic kilometers), enough material to cover Wyoming with a layer 13 feet thick or the entire conterminous United States with a layer 5 inches thick. The Lava Creek Tuff has been exposed by erosion at Tuff Cliff, a popular Yellowstone attraction along the lower Gibbon River.

The eruption also shot a column of volcanic ash and gases high into Earth's stratosphere. This volcanic cloud circled the globe many times and affected Earth's climate by reducing the intensity of solar radiation reaching the lower atmosphere and surface. Fine volcanic ash that fell downwind from the eruption site blanketed much of North America. This ash layer is still preserved in deposits as far away as Iowa, where it is a few inches thick, and the Gulf of Mexico, where it is recognizable in drill cores from the sea floor.

Lava flows have since buried and obscured most of the caldera, but the underlying processes responsible for Yellowstone's tremendous volcanic eruptions are still at work. Eventually, another "bead" may be added to Yellowstone's 300-mile-long string of calderas, with global consequences that are beyond human experience and impossible to anticipate fully.

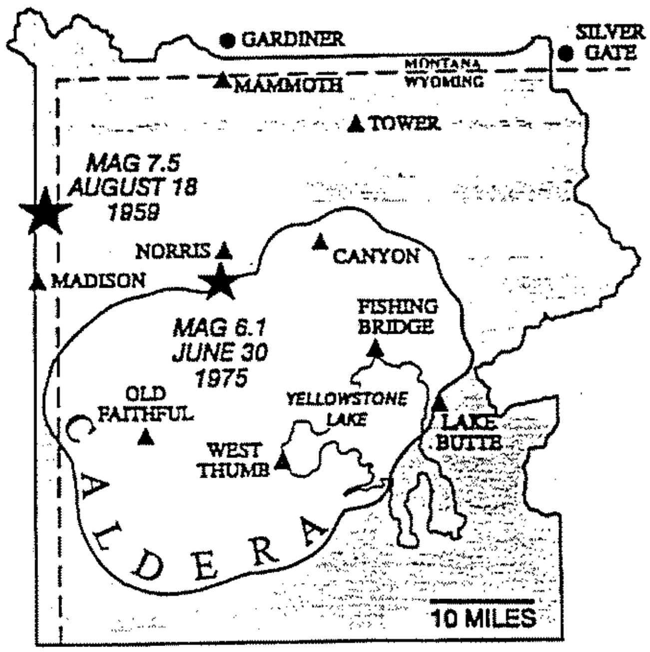


Figure 2. Yellowstone National Park and the 630,000-year-old Yellowstone caldera, with locations of two recent large earthquakes (stars).

CONTEMPORARY UNREST

In the meantime, the giant is restless. Thousands of small earthquakes rattle the Yellowstone region each year. Most of these are too small to be noticed except by sensitive seismometers, but a few are large enough to cause substantial damage. At least eight magnitude-6 or greater earthquakes have occurred in the Yellowstone region during historical time. The largest of these was the magnitude-7.5 Hebgen Lake earthquake on August 18, 1959, which cost 28 lives and $11 million in damage. The most recent was a magnitude-6.1 earthquake near the Norris geyser basin on June 30, 1975.

Earthquakes are not the only symptom of unrest. Yellowstone's famous hydrothermal system releases heat energy at an average rate of about 4,500 megawatts — about 50 times the planetary average. In addition, repeated surveys show that the ground surface near the center of the Yellowstone caldera rose more than 3 feet from 1923 to 1985, then subsided about 6 inches from 1985 to 1992 (fig. 3). Studies of shorelines near the outlet of Yellowstone Lake show that the caldera's center has risen and fallen 3 times during the past 10,000 years. The total vertical change during each "breath" of the caldera is estimated to be about 65 feet (20 meters).

REASON TO WORRY?

The current rates of seismicity, ground deformation, and hydrothermal activity at Yellowstone, although high by most geologic standards, are probably typical of long time periods between eruptions and therefore not a reason for immediate concern. Potentially damaging earthquakes are likely to continue occurring every few decades, as they have in the recent past. Eventually Yellowstone will erupt again, but there is no indication that an eruption is imminent or what kind of eruption may come next. For the foreseeable future, the same powerful forces that created Yellowstone will continue to animate this slumbering, but restless, volcanic giant.

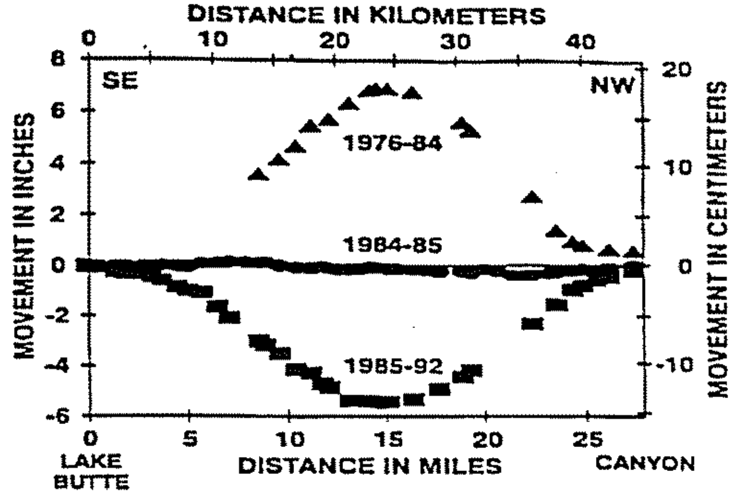


Figure 3. Ground movements between Lake Butte and Canyon (see fig. 2) for the periods 1976-84 (uplift), 1984-85 (quiescence), and 1985-92 (subsidence).

ADDITIONAL READING

Brantley, S.R., 1994, Volcanoes of the United States: General Interest Publications of the U.S. Geological Survey, U.S. Government Printing Office, Jacket 376-846, 44 pages.

Pierce, K.L., and Morgan, L.A., 1992, The track of the Yellowstone hotspot: volcanism, faulting, and uplift: Geological Society of America Memoir 179, pages 1-53.

Smith, R.B., and Christiansen, R.L., 1980, Yellowstone Park as a window on the Earth's interior: Scientific American, volume 242, pages 104-117.

Smith, R.B., and Braile, L.W., 1994, The Yellowstone hotspot: Journal of Volcanology and Geothermal Research, v. 61, pages 121-187.

Daniel Dzurisin, Robert L. Christiansen, and Kenneth L. Pierce

For additional information, contact:

U.S. Geological Survey
Cascades Volcano Observatory
5400 MacArthur Blvd.
Vancouver, Washington 98661

Tel: (360) 696-7693 e-mail: cvo@pwavan.wr.usgs.gov
fax: (360) 696-7866 URL: http://vulcan.wr.usgs.gov/

YELL 264

A GEOLOGY OUTLINE OF YELLOWSTONE NATIONAL PARK

Many events have shaped the Yellowstone we see today, and the land is still changing. The following is an outline of some of the significant geological events which have occurred in the area known as Yellowstone National Park. This will help you to understand what forces have shaped the park's landscape and why there is such an abundance of geothermal activity here.

2.7 BILLION YEARS AGO: The oldest rocks known in Yellowstone were formed. These Precambrian gneisses and schists are exposed in parts of the Gallatin Mountain Range.

570 MILLION YEARS AGO: A 2.1 billion year gap exists between the Precambrian rocks and this time. Probably some uplifting occurred during this period, and a great deal of erosion took place. At this time, the area that is Yellowstone was basically a featureless plain. What rocks are known from this time period may be found on Buffalo Plateau in the north central part of the park.

570 TO 75 MILLION YEARS AGO: For about 500 million years (from Cambrian to the Cretaceous periods), Yellowstone was periodically flooded by shallow seas that covered much of what is the western United States. Many sedimentary rocks found in Yellowstone were formed as deposits in these seas (sandstone, shale, limestone, dolomite, and various "formations" which combine types of rocks). Based on the fossil record, it appears that seas advanced and retreated at least one dozen times in the Yellowstone area. Rocks from this time may be found on Mount Everts, the Gallatin Mountains, and around the Snake River.

75 MILLION YEARS AGO: Tha Laramide Orogeny began about this time, lasting about 20 million years. Major crustal movements took place in Yellowstone and throughout the Rocky Mountain area as mountain building occurred. Anticlines, synclines, and various faults date from this period. The crustal movements probably helped to lead to the volcanic events which came later. Uplifting movements during the orogeny changed stream courses and increased erosion.

55 to 50 MILLION YEARS AGO: Several large volcanoes erupted in and near Yellowstone. Volcanic rocks from eruptions of the Absaroka and Washburn ranges now cover part of the Gallatin Mountains as well as other areas of Yellowstone. Both intrusive and extrusive rocks date from this time, including lava, ash, pumice, rhyolite, andesite, basalt, and breccia. Some eruptions were "quiet" lava flows; others were violent. Heavy rainfall at this time also caused some known mudflows and landslides. The timing of these varied eruptions resulted in the petrified tree specimens found in the park on Specimen Ridge and the Gallatin Mountains. Probably several hundred years passed between eruptions.

50 TO 40 MILLION YEARS AGO: Erupting Absaroka volcanoes buried most of Yellowstone under thousands of feet of lava, breccia, and ash. This extensive deposition turned Yellowstone into a plateau with just a few volcanic peaks towering above it and sluggish streams cutting through it. Yellowstone was probably not as high above sea level then as it is today. Based on the fossil record, Yellowstone's climate was warm, almost subtropical.

40 TO 10 MILLION YEARS AGO: There are no examples in the park from the period between the Absaroka volcanoes and this time. Some rocks dating from this gap can be found south of the park. In Yellowstone, rocks from this time period were probably eroded away.

10 MILLION YEARS AGO: Another period of uplift occurred. The Teton and Gallatin mountain ranges were uplifted thousands of feet, increasing drainage and erosion throughout this area. As the uplift went on, Yellowstone was characterized by sharply defined canyons, mountains, and tablelands.

3 TO 2 MILLION YEARS AGO: Magma had been building up for some time in two chambers under Yellowstone. About two million years ago a first eruption from these chambers occurred. Much of the huge caldera caused by this eruption was obliterated by a later eruption that occurred 600,000 years ago. The removal of so much magma caused the two chambers to collapse around a ring fracture zone, leaving the second caldera several thousand feet deep and many miles in diameter. This caldera was roughly bounded by the Washburn Range, Absaroka Range, Flat Mountain, the Red Mountains, and the Madison Junction bluffs. A third caldera eruption took place between 200,000 and 125,000 years ago in what is now the West Thumb of Yellowstone Lake. This caldera within a caldera measures four miles wide and six miles long. Dust and ash from the caldera eruptions filled Yellowstone's lowlands. Only peaks as high as Bunsen Peak stood above the ash (which settled into a "welded tuff").

Molten lava continued to flow from the two magma chambers, with much of the lava filling in the caldera but some running over the rim. Lava flows of rhyolite now compose some park plateaus, such as the Madison Plateau; a few lava flows were basaltic, such as the columns found along the Yellowstone River near Tower Fall. Obsidian Cliff was also formed at this time, but it derived from a lava flow outside the caldera area. The last of the lava flows took place about 60,000 years ago.

300,000 TO 8,000 YEARS AGO: Three periods of glaciation took place in Yellowstone. The "Pre-Bull Lake" glaciation lasted from about 300,000 to 180,000 years ago; the "Bull Lake" glaciation lasted from 125,000 to 45,000 years ago. As the previous entry indicates, these glaciers were in Yellowstone at the same time lava was flowing in parts of the park.

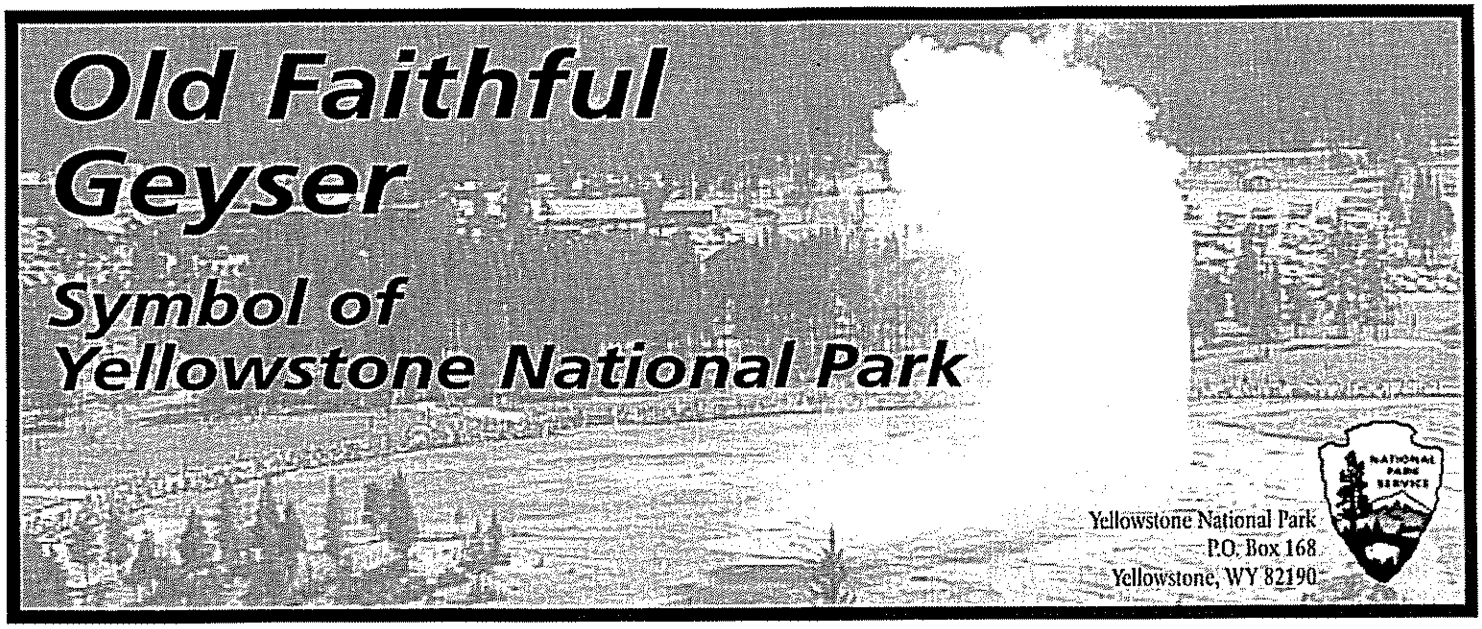
The "Pinedale" glaciation lasted from 25,000 to about 8,000 years ago. This glacial period is better known than the previous two. In fact, it obscured much of the change that the previous two had caused. Icefields from the Absaroka and Gallatin ranges as well as from mountains north of the park contributed to the Pinedale glaciers covering Yellowstone. Glacier ice built up to as much as 3,000 feet thick (over the Lake Basin) within the park. Only the west edge of the park and the highest ridges escaped being glaciated. As ice and rock, the glaciers gouged and smoothed the topography. As they melted, glaciers left behind moraines and boulder erratics, especially in the lower Lamar Valley. Streams and lakes developed from glacial meltwater, causing erosion and redistribution of sediments. Although some snowfields exist year-round in the park, there are presently no glaciers in Yellowstone. A few glaciers can still be found in the Teton and Wind River ranges.

THE PRESENT TIME: Features which probably attract some visitors to Yellowstone-the Grand Canyon of the Yellowstone River, geothermal features, waterfalls, rivers, and lakes-resulted from geological processes still happening today. Yellowstone has more geysers, mud pots, hot springs, and fumaroles than any other place in the world. Long-term erosion is exemplified on a grand scale by the Grand Canyon of the Yellowstone and the park's numerous waterfalls. Because many faults are located in Yellowstone, earthquakes regularly occur here. Most earthquakes are not readily noticeable. However, in 1959 a powerful earthquake (7.8 on the Richter Scale) was centered just outside the park to the west; it triggered landslides and caused radical behavior in geysers within the park.

Suggested reading:
The Roadside Geology of Yellowstone Country by William Fritz
Interpreting the Landscape of Grand Teton and Yellowstone National Parks by John Good and Kenneth Pierce
The Geologic Story of Yellowstone National Park by W.R. Keefer

Old Faithful Geyser

Symbol of Yellowstone National Park



About Old Faithful Geyser

Soon, a towering column of water will surge out of the earth as Old Faithful continues its unbroken series of eruptions. Eruptions occur an average of 17 times per day, every day. Because of changes in circulation that resulted from the 1959 Hebgen Lake and 1983 Borah Peak earthquakes, as well as other local and smaller earthquakes, the average interval between eruptions has been lengthening during the last several decades. In the past, Old Faithful displayed two eruptive modes: short duration eruptions followed by a short interval, and a long duration eruption followed by a long interval. However, after a local earthquake in 1998, Old Faithful's eruptions are more often of the long duration, long interval type.

Other great geysers are dormant for months or years between their periods of activity, yet Old Faithful has not stopped in historic times. Other geysers erupt to greater heights, and a few are more predictable. However, careful observations of each Old Faithful eruption enable interpretive rangers to predict the next eruption.

Old Faithful—Vital Statistics

as of 2004

Height of eruption	106–184 feet (32–56 m) Average = 130 feet (40 m)
Duration of eruption	1.5–5 minutes
Interval between eruptions If eruption lasts less than 2.5 minutes If eruption lasts more than 2.5 minutes	 65 minute interval 92 minute interval
Temperature	203°F (95°C) just prior to an eruption (water boils at 199°F/93°C at this altitude [7,366 ft/2,245 m])
Volume of water in an eruption	3,700–8,400 gallons (14,000–32,000 liters)

Geyser Essentials

In order to exist, geysers need:

Heat

Magma (partially melted rock) is the source of heat for geysers and hot springs. The heat is transmitted through solid rock and fluid substances to water that has seeped to depths as great as 10,000 feet (3 km) below the surface. The water temperature can exceed 400°F (204°C).

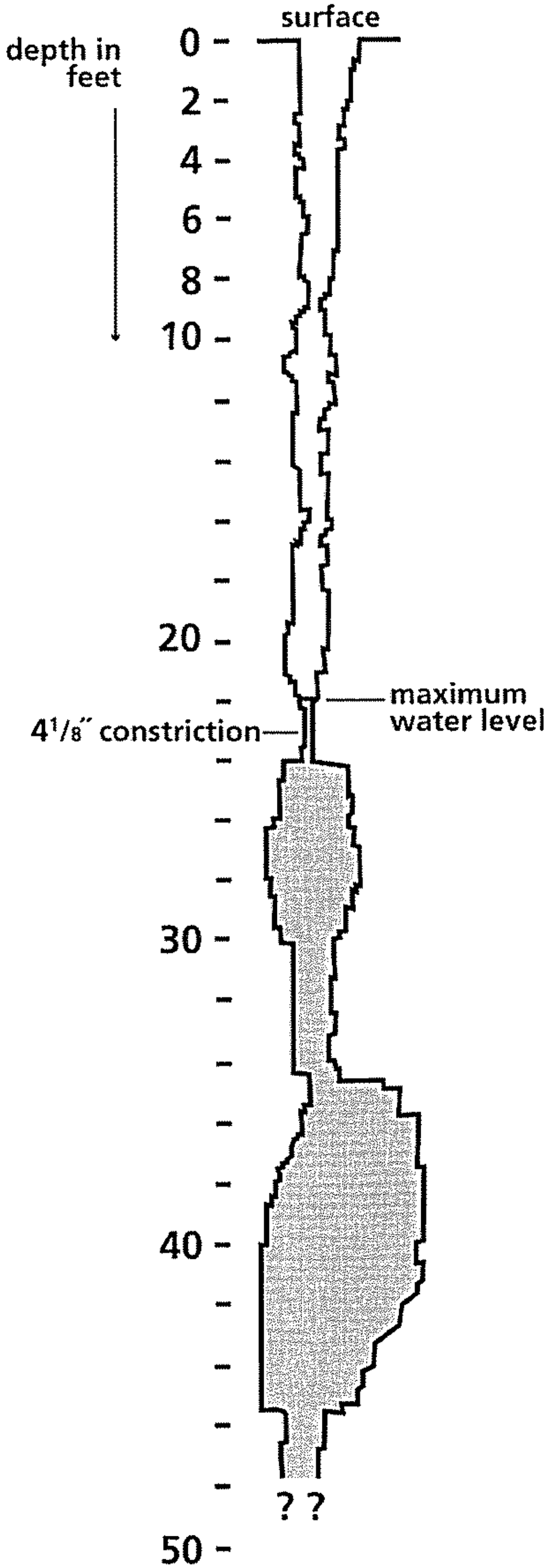
Water

The tremendous amounts of water that erupt from Old Faithful, Giantess, Grand, Echinus, and other major geysers show that large volumes of water move rapidly throughout a geyser's natural "plumbing." The water comes from one or more porous, permeable beds of rock, called aquifers. It is believed that almost all of the water in geysers and hot springs comes from surface water such as rain and snow.

A constricted "plumbing system"

In Yellowstone's hydrothermal areas, the under-lying rocks contain fissures and fractures through which water circulates from deep within the earth. High temperatures dissolve silica and other minerals in the water, which coat the plumbing. If a constriction develops in plumbing, a geyser may result.

Old Faithful's Plumbing



Geyser tubes or "plumbing systems" are not uniform in shape. They are usually crooked or constricted in many places. Measurements of Old Faithful's conduit reveal a constriction at about 22 feet (6.7 m).

No two geysers erupt alike because of variations in heat flow, water movement, and plumbing systems.

Notice the size of the constriction in Old Faithful's plumbing—rocks, sticks, and other objects could easily clog it, thus altering or stopping its eruptions.

It is illegal to throw anything in Yellowstone's hydrothermal features.

Geysers are rare and beautiful. Treasure and preserve them!