Geologic History of Yellowstone

(Modified from Yellowstone Resources and Issues Handbook, 2017)

The landscape of the Greater Yellowstone Ecosystem is the result various geological processes over the last 150 million years. Here, the Earth's crust has been compressed, pulled apart, glaciated, eroded, and subjected to volcanism. All of this geologic activity formed the mountains, canyons and plateaus that define the natural wonder that is Yellowstone National Park. While these mountains and canyons may appear to change very little during our lifetime, they are still highly dynamic and variable. Some of the Earth's most active volcanic, hydrothermal (water + heat), and earthquake systems make this national park a priceless treasure. In fact, Yellowstone was established as the world's first national park primarily because of its extraordinary geysers, hot springs, mudpots and steam vents, as well as other wonders such as the Grand Canyon of the Yellowstone River. Yellowstone's geologic story provides examples of how geologic processes work on a planetary scale. The foundation to understanding this story begins with the structure of the Earth and how this structure shapes the planet's surface.

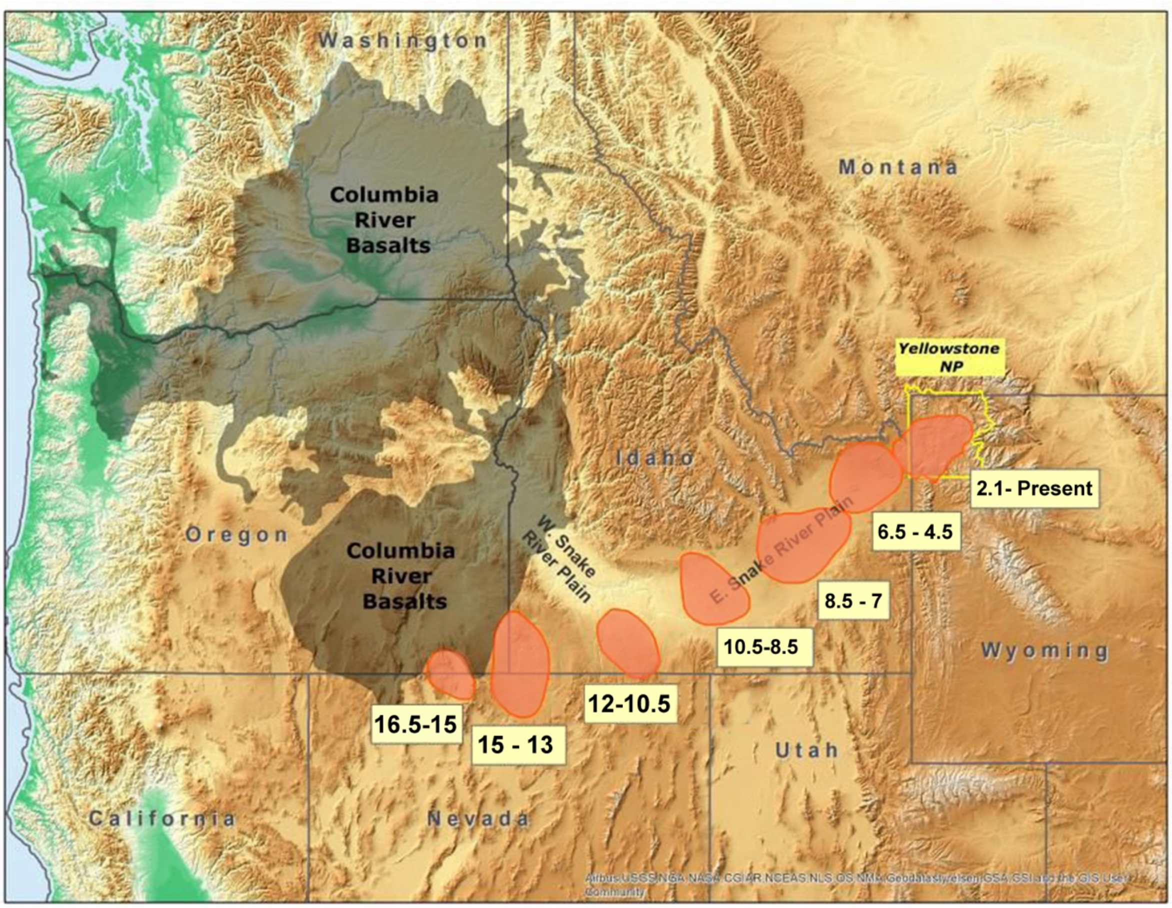
Most of Earth's history (from the formation of the earth 4.6 billion years ago to approximately 541 million years ago) is known as the Precambrian time. Rocks of this age are found in northern Yellowstone and in the hearts of the nearby Teton, Beartooth, Wind River, and Gros Ventre mountain ranges. During the Precambrian and the subsequent Paleozoic and Mesozoic eras (541 to 66 million years ago), the western United States was covered at times by oceans, sand dunes, tidal flats, and vast plains. From the end of the Mesozoic through the early Cenozoic, mountain-building processes formed the Rocky Mountains.

During the Cenozoic era (approximately the last 66 million years of Earth's history), widespread mountain-building, volcanism, faulting, and glaciation sculpted the Yellowstone area. The Absaroka Range along the park's north and east sides was formed by numerous volcanic eruptions about 50 million years ago. This period of volcanism is not related to the present Yellowstone volcano. Approximately 30 million years ago, vast expanses of today's West began stretching apart along an east–west axis. This ongoing stretching process increased about 17 million years ago and created the modern basin and range topography (north–south mountain ranges with long north–south valleys) which characterizes much of the West, including the Yellowstone area. About 16.5 million years ago, an intense period of volcanism initiated near the borders of present-day Nevada, Oregon, and Idaho.

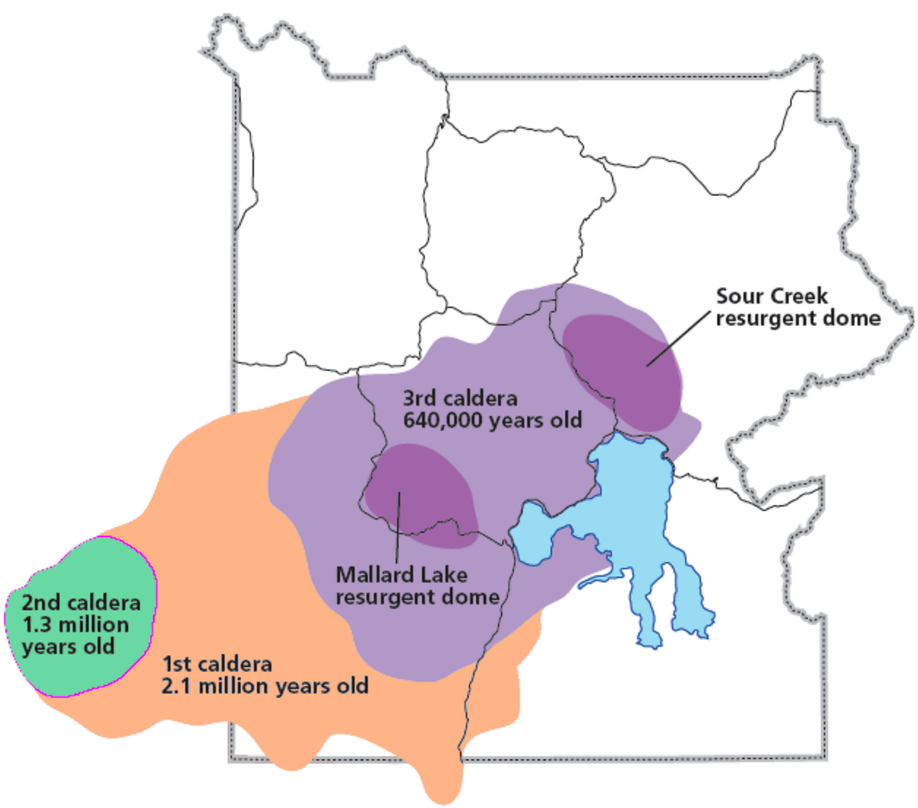
Subsequent volcanic eruptions can be traced across southern Idaho towards Yellowstone. This 500-mile trail of more than 100 calderas was created as the North American plate moved in a southwestern direction over a shallow body of magma. About 2.1 million years ago, the movement of the North American plate brought the Yellowstone area closer to the shallow magma body. This volcanism remains a driving force in Yellowstone today.

Magma, Hot Spots, and the Yellowstone Supervolcano

Magma (molten rock from below the Earth's crust) is close to the surface in the greater Yellowstone area. This shallow body of magma is caused by heat convection in the mantle. Plumes of magma rise through the mantle, melting rocks in the crust, and creating magma reservoirs of partially molten, partially solid rock. Mantle plumes transport heat from deep in the mantle to the crust and create what we call "hot spot" volcanism. Hot spots leave a trail of volcanic activity as tectonic plates drift over them. As the North American Plate drifted to the southwest over the last 16.5 million years, the hot spot that now resides under the greater Yellowstone area left a swath of volcanic deposits across Idaho's Snake River Plain.



Heat from the mantle plume has melted rocks in the crust, and created two magma chambers of partially molten, partially solid rock near Yellowstone's surface. Heat from the shallowest magma chamber caused an area of the crust above it to expand and rise. Stress on the overlying crust resulted in increased earthquake activity along newly formed faults. Eventually, these faults reached the magma chamber and magma oozed through the cracks. Escaping magma released pressure within the chamber, which also allowed volcanic gasses to escape and expand explosively in a massive volcanic eruption. The eruption spewed copious volcanic ash and gas into the atmosphere and produced fast, super-hot debris flows (pyroclastic flows) over the existing landscape. As the underground magma chamber emptied, the ground above it collapsed and created the first of Yellowstone's three calderas. This eruption 2.1 million years ago—among the largest volcanic eruptions known to man—coated 5,790 square miles with ash, as far away as Missouri. The total volcanic material ejected is estimated to have been 6,000 times the volume of material ejected during the 1980 eruption of Mt. St. Helens, in Washington.



3 Caldera Cycles in the past 2.1 Ma

A second significant, though smaller, volcanic eruption occurred within the western edge of the first caldera approximately 1.3 million years ago. The third and most recent massive volcanic eruption 630,000 years ago created the present 30 by 45-mile-wide Yellowstone Caldera. Since then, 80 smaller eruptions have occurred. Approximately 174,000 years ago, one of these created what is now the West Thumb of Yellowstone Lake. During and after these explosive eruptions huge lava flows of viscous rhyolitic lava and less voluminous basalt lava flows partially filled the caldera floor and surrounding terrain. The youngest of these lava flows is the 70,000 year old Pitchstone rhyolite flow in the south-west corner of Yellowstone National Park.

Since the last of three caldera-forming eruptions, pressure from the shallow magma body has formed two resurgent domes inside the Yellowstone Caldera. Magma may be as little as 3–8 miles beneath Sour Creek Dome and 8–12 miles beneath Mallard Lake Dome, and both domes inflate and subside as the volume of magma or hydrothermal fluids changes beneath them. The entire caldera floor lifts up or subsides, too, but not as much as the two domes. In the past century, the net inflation has tilted the caldera floor toward the south. As a result, Yellowstone Lake's southern shores have subsided and trees now stand in water, and the north end of the lake has risen into a sandy beach at Fishing Bridge.

Visit the link below to download the complete Geology section from the Yellowstone Resources and Issues Handbook.

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