# McArthur-Burney Falls Memorial State Park

National Natural Landmark 1984

## From Lava Flows to Waterfalls

Burney Falls is in the eastern part of the Cascade Range geomorphic province near the boundary with the Modoc Plateau geomorphic province. Lava flows superficially blanket both provinces. The falls are at the north end of a west-northwest oriented basin in a region of several faults that run north-northwest. Most of the rocks in the vicinity of the falls are basaltic lava flows. Basalt rocks underlying the higher areas west of the park are Pliocene in age (5.3 to 1.8 million years old) and those underlying the park itself are Pleistocene in age (1.8 million years old or younger).

**Features/Process:**

Volcanic hydrogeology of waterfalls, and lava flows

The lava flows repeatedly covered the ground surface and built up the plateau layer by layer. Hot gases within the fresh lava bubbled to the top of some layers to form a froth that quickly solidified in the cooler environment of the ground surface conditions. The frothy sponge-like layer is called scoria and is easily broken apart into small fragments. As the lava flowed, the surface margins cooled while the inside remained molten, flowing out to create interior channels known as lava tubes. As flows cooled throughout, extensive cracks formed due to thermal contraction. Earthquakes were common and fractured the solidified lava rocks. These features provide abundant pathways and storage spaces for groundwater and are key factors underlying the voluminous spring-fed water flows that emerge at the falls. With time, the minerals of the basalt gradually break down into clay particles which will eventually clog the spaces and pathways. Such is the case with the older Pliocene lava beds to the west.

## Sources of the Water

The ultimate source of the water in Burney Falls is the rain and snow that falls over the Pit River watershed. The water either flows directly into the creek or soaks into the sponge-like rocks. During times of high water, the creek flows continuously all the way to Burney Falls. During drier times, Burney Creek commonly sinks into its bed, disappearing well upstream of Burney Falls, only to reappear as seepage into the creek bed above the falls and as springs in the rock face of the falls.

In the summer, the farthest upstream spring is about ¾ mile from the lip of the falls. The Burney creekbed is usually dry from that point on upstream.

**What you can see:** The highlight is Burney Falls, a 129-foot tall thundering waterfalls fed both by a spring-fed stream (Burney Creek) flowing over the top of basalt cliffs and by springs that issue directly from the basaltic cliff face. The springs are reported to discharge approximately 100 million gallons per day.

The 1¼-mile long gorge downstream of the waterfalls was carved by progressive stream down-cutting and undercutting of weak rocks that underlie the durable basalt flow.

Around the south side of Lake Britton are exposures of a soft white rock (diatomite) also found in the gorge downstream of the falls.

*Photo: Dennis Heiman, Sacramento River Watershed Program*

**Why it's important:** Burney Falls is an outstanding example of a waterfall and stream fed by large springs that are commonly associated with areas covered by recent lava flows, and also of a waterfall formed by the undercutting of horizontal rock layers.

The soft white rock is diatomite. Its presence is evidence that a very large lake once filled the region and supported abundant tiny freshwater plankton called diatoms.

## Permeability (a measure of how efficiently water can transmit through rock)

Pleistocene and Holocene lavas flows exhibit moderate to very high permeability. They contain open joints and fractures that serve as passageways for the downward migration of water. Water also migrates through various rock units: 1) highly permeable volcanic-rock rubble, and/or 2) scoria at the surface and base of the layers, and 3) stream gravels in drainages down which the lava may have flowed.

The basalts have been locally disrupted and fractured by earthquakes along faults. A number of faults immediately south and southeast of Lake Britton are considered still active in that they exhibit movement in Holocene (11,000 years old or younger) time. The movement along the faults offsets the basalts into tilted blocks. The blocks are separated by nearly vertical scarps ranging in height from 10 to 100 feet or more. The rock is sheared along these faults, producing highly permeable pathways for the infiltration (downward movement) of groundwater.

In the park, surface streams are relatively rare since water soaks readily into the highly permeable Pleistocene lava flows. Once subsurface, the water (groundwater) flows laterally along the permeable tops and bottoms of the lava flows and in sediments between lava layers. Groundwater commonly resurfaces as large springs, such as those that feed Burney Falls, Hat Creek to the southeast, the Fall River at Thousand Springs, and Big Lake a few miles northeast of Burney Falls.

In contrast, the older, more-weathered Pliocene lava flows exhibit less permeability because the clays formed by weathering of the lava seal the porous voids within the lava flows.

## Differential Erosion

The gorge below Burney Falls was formed by erosion of the softer layers beneath the Pleistocene basalt flow. The continual erosion of these softer strata by the relentless pounding forces of the waterfall undermines (removes support for) the overlying lava flow, causing it to periodically collapse into the developing gorge. By this process, the waterfall migrates upstream. So far, it has migrated more than a mile from the confluence of Burney Creek and the Pit River (which is now impounded behind the hydroelectric Pit No. 3 Dam as Lake Britton).

## Diatomite

In the park and especially to the north, 1.8 to 5.3 million-year-old rocks that consist largely of a chalky white substance (diatomite) underlie the younger lava. The diatomite consists of skeletal remains of microscopic single-celled plankton that were abundant in an ancient lake, died, and sank to the bottom. The lake likely filled behind a natural dam or dams formed by movements along faults. The local diatomite is a small example of the much more widespread deposits in the region. Their broad distribution suggests that the lake in which they formed may have been quite large. How large? That remains unknown.

Diatomite has commercial applications including use as a filtering agent, as filler for paints and spackle, as an addition to cement, and as a mild abrasive. It has been mined at the large Dicalite Mine just west of Lake Britton—outside of the park.

The younger Pleistocene lava flows erupted, flowed over, and covered the diatomite.

## Final Thoughts

The past landscape has been covered and obscured by lava flows and modified by erosion to its current incarnation. But the landscape continues to change as it is subjected to geological processes, and eventually it will be destroyed and re-constructed to a fresh, new look.

*Written by Michael Wopat, California Geological Survey*
*Photos: Michael Wopat (except where noted)*



Geological Gems of California State Parks, Special Report 230 – Fuller, M., Brown, S., Wills, C. and Short, W., editors, 2015 Geological Gems of California, California Geological Survey under Interagency Agreement C01718011 with California State Parks.