A guide to Long Valley and Mono Basin geology

Restless caldera, labyrinthine fault lines, 500 million years of history

Catherine Billey, Mammoth Times, 12-2-09

Mono County can't boast the tallest mountain (Whitney) or the lowest elevation (Badwater) as does its sister county, Inyo, to the south. But thanks to a restless caldera and a labyrinthine fault system, it does have some of the most fascinating geology in North America.

"It's got the volcanoes and the volcanic history and all the aspects of that. And then it's got the mountains, which are basically the result of faulting," said Terry Wright, an emeritus professor of geology at Sonoma State University who lives on a 10-acre spread in Benton six months of the year.

"Then, within the mountains, the rocks have an extended history that goes back 500 million years, which are a record of mountain building. There are rocks that first had to be formed to be built into the mountains."

The main rocks of the Sierra Nevada stretch all the way in bits and pieces across to the White Mountains, which are the same geology as the Sierra Nevada, except the Sierra are more highly "scrunched," to use Wright's word, meaning metamorphosed (subject to heat and pressure) and deformed (folds and faults).

As if volcanic and faulting influences were not enough to create a sufficiently mixed bag, the Eastern Sierra from Bishop to Bridgeport is also marked by glacial moraines – visual evidence of streams of ice dating back tens of thousands of years.

Two terrific examples exist near Convict Lake (where, in addition, marine fossils have been found thousands of feet above today's sea level) and Conway Summit near Bridgeport, where one of the oldest moraines sits on top of granite.

The geologic drama begins at the Mono County Line just south of Tom's Place on U.S. 395. There, one drives up along the Bishop Tuff (which sits on top of the Sherwin Till, one of the area's oldest glacial deposits). The Bishop Tuff is a pink slope formed 760,000 years ago by glowing hot magma that erupted out from 4 miles beneath the earth in a cataclysmic volcanic eruption.

What's left today is the Long Valley Caldera, a 10-mile-wide by 20-mile-long area that can be seen nearly in its entirety at the Crowley Lake Overlook farther north.

Driving a bit farther north, Mammoth Mountain comes into view. On the edge of the resurgent dome, it was formed when magma leaked out after the main explosion and marks the western periphery of the caldera.

Several miles to the east, across Long Valley, east is Glass Mountain, made of obsidian.

But faults are what down dropped the whole area, Wright emphasizes. "Where the magma blew out, there was nothing left to hold the surface up, so it collapsed along faults."

Airborne ash from the eruption, which was more than 2,000 times that of Mt. St. Helens in 1980, blew as far away as present-day Nebraska.
Scientists have been monitoring geologic unrest in the Long Valley Caldera since a cluster of four earthquakes measuring 6.0 rocked Mammoth Lakes in 1980. At that time, they discovered that the core of the caldera was rising.

“Earthquakes are of two types,” Wright explained. “One is that they are related to faults, which is plate movement, and the front of the Sierra Nevada is sculptured along a series of faults.”

A spectacular example of Eastern Sierra faulting can be seen near McGee Creek near Crowley Lake, which was the epicenter of the 1980 quakes.

“The other thing that causes earthquakes is magma moving,” Wright continued. “That’s been the perennial question in Mammoth: Are we listening to moving magma or are we listening to faults moving?”

A visible geologic remnant from the 1980 quakes can reached along U.S. 395 just before the geothermal plant and turn-off into Mammoth Lakes.

“Look over to the right beyond the hatchery and there’s a ridge. Down the front of this ridge as you look carefully, there’s a path, at the bottom of the path there’s a big boulder. This came down – was shaken awake – by the earthquakes in 1980,” Wright explains.

“Basically, it was a perched boulder. When it shakes, these guys are ready to go. This boulder is something that everybody sees if they look hard enough for it.”

The formerly perched boulder is in the area of numerous local hot springs (Whitmore, Hot Creek, and Little Hot Creek) – underground water heated by magma that still underlies the caldera – as well as natural steam vents, which drive the three geothermal power plants nearby that produce about 40 megawatts of electricity each year.

“The water actually descends along some faults, and ascends along other faults,” Wright clarified. “What happens is water will percolate down, heat up, and come up through other faults. That whole system is on a series of faults that continue to the north as the Mono Craters. They are basically eruptions of magma that have come up through faults.”

Thousands of feet up to the west, several places at Mammoth Mountain were discovered in the 1990s to be emitting CO2 gas, including Horseshoe Lake, the site of a large tree kill. This is the southwest edge of the Long Valley Caldera.

The gas comes from liquefied rock, or magma, most of which is carbon dioxide and fatally poisonous if breathed in high concentrations. Tragically, in 2006, three members of the Mammoth Mountain Ski Patrol died on the slopes of the dormant volcano while trying to rope off a geothermal vent (called a fumarole) there.

All of these circumstances indicate the presence of a restless caldera and increase the chances of an eruption, but at the same time, this type of unrest could endure for decades or even centuries.

According to a U.S. Geological Survey, an eruption is more likely to occur along the Mono-Inyo Craters chain (north of the Long Valley Caldera) that extends all the way to Mono Lake in the Mono Basin. Volcanic domes there (Mono Domes) can be seen along U.S. 395 north of the June Lake turnoff.

These domes, however, are not very explosive because most of the gas in the system erupted with the caldera long ago, making them gas poor. And they are geologic youngsters at some 10,000 years, barely a second’s tick on the geological time scale of 4.6 billion years.

The Panum Dome off U.S. 395 provides an especially good example of a combined rhyolite dome and cinder cone. A hike allows visitors straight into the crater where lava ooze can be seen.

The most recent eruption in the Mono-Inyo system occurred at the northern end at Mono Lake’s Paoha

Island about 350 years ago.

Mono Lake, which comes into view near the Highway 120 turnoff to Yosemite, is a terminal lake in the Mono Basin, a watershed area fed by melting runoff from the Sierra Nevada. It has no outlet to the sea and remains geologically active because of faulting at the base of the Sierra as well as crustal stretching of the Basin and Range Province to the east.

Some scientists have said Mono Lake dates to the caldera eruption 760,000 years ago, but sedimentary evidence indicates that it could be the remnant of a larger, more ancient lake that once covered parts of Nevada and Utah, making it one of the oldest lakes in North America.

Wright agrees with this view. “The lake was being formed and was accumulating sediment as the Bishop Tuff took place. So that eruption doesn’t have to do with the formation of the lake, but it did erupt into the lake.” Those interested in knowing more about the Eastern Sierra in its greater geologic context should check out two books by John McPhee, a Pulitzer-Prize winning geologist: “Basin and Range,” which explores the terrain from Utah to eastern California, and “Assembling California,” which explores the state’s fault lines from the Sierra Nevada through the central Valley to the coastal ranges and San Francisco.

Also, an easy-to read guide that includes eight stops in Mono County is “Geology Underfoot in Death Valley and Owens Valley” by Robert P. Sharp and Allen F. Glazner.