

Newberry Field Trip Guide

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Field Trip Guide - Day 1

Friday, Sept. 15th

Today's trip will be mainly within Newberry Caldera (Figure 1). We will first look at evidence for a flood along Paulina Creek during the late Holocene. Next we will go to the summit of Paulina Peak (7984 feet) for an overview discussion of Newberry. Then there will be two stops along Paulina Lake to look at evidence of caldera floor uplift, underwater paleoterraces and tephra in Paulina Lake, and the archaeology of Newberry. Finally there will be a late optional stop at the Big Obsidian Flow with discussions of rhyolite petrology and a look at giant bubbles within the Big Obsidian Flow. This stop will require hiking up the Big Obsidian Flow trail and then a short off trail walk across the flow. This will require good boots and leather gloves.

- 0.00 --- Turn left on County Rd. 21 from Ogden Group Camp.
Mazama Ash does not cover the wide gravel fan upon which the group camp is located. This is a common feature all along Paulina Creek: gravel terraces 10 to 15 ft (3 to 5 m) above the creek barren of Mazama

Ash. The lack of Mazama Ash in most areas indicates that since the ash-fall about 7600 years ago there was a large flood down Paulina Creek, which removed the ash in all but a few sheltered locations. There are terraces around Paulina Lake, which probably represent the lake level prior to rapid downcutting of the lake's outlet. This downcutting likely provided the water, which stripped out much of the Mazama Ash along Paulina Creek.

- 0.05 --- Cross Paulina Creek.
- 0.30 --- F.S. Rd. 2100 060--Rt. to Prairie Campground.
- 0.35 --- Kuehn Site 97-62 on left exposed the following:
 - Sandy sediments containing reworked tephra - 150 cm
 - Paulina Creek tephra (pyroclastic flow deposit) - more than 180 cm
 - The bottom of the excavation (reached by hand auger) was in Paulina Creek Tephra at 3.33 m. The base of the Paulina Creek tephra was not

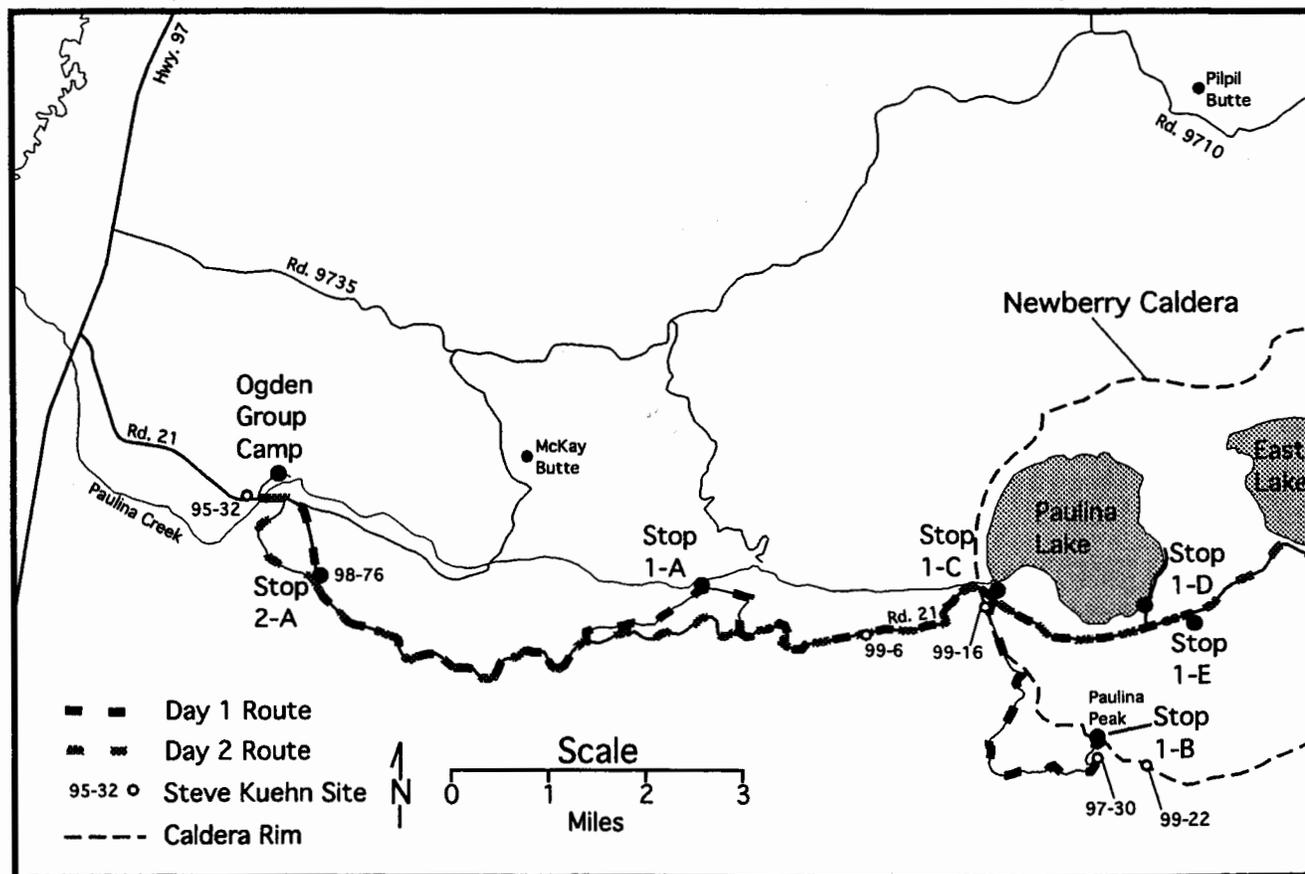


Figure 1 - Field Trip stops for Day 1 and start of Day 2.

reached.

Tomorrow's trip will discuss Steve Kuehn's work in much more detail.

0.40---F.S. Rd. 2120--Lt. to McKay Crossing Campground (2.6 miles). This will be Alternate Stop 1-A if closures due to fire danger prevent us from going to Stop 1-A at Footbridge Falls.

The campground is located on both sides of Paulina Creek. As is common along most of Paulina Creek the Mazama Ash has been striped off most areas as much as 10 to 15 ft (3 to 5 m) above the current creek levels. In a few scattered locations, such as on south side of creek in the campground, Mazama Ash remains near creek level. At this location it appears that the creek was directed to the north side of the valley bottom thus protecting the south side of the valley. McKay Falls is about 500 ft (150 m) downstream.

1.10---Kuehn Site 98-76 on left. See tomorrow's stop 2-A for details.

3.60---F.S. Rd. 9736--Lt. & Rt.

4.35---Enter the McKay Burn. Arson caused fire, which burned 1,150 acres in August 1998.

4.95---Turn left on logging spur at M.P. 7.70. If fire conditions are high we will have gone to McKay Crossing for Alternate Stop 1-A (turn off was at mile 0.40).

5.05---Junction, turn right.

5.10---Note the deep draws to left and right, which are cut into the black lapilli tuff. This is a common feature of the entire west flank of Newberry wherever the black lapilli tuff occurs.

5.25---View of Paulina Peak ahead (Stop 1-B today).

5.50---Leave McKay Burn.

6.05---Turn right on F.S. Rd. 9736-500.

6.45---**STOP 1-A - Footbridge Falls.** Park on both sides of road; do not block road. Hike down trail to Paulina Creek at Footbridge Falls.

Paulina Creek Flood - Larry Chitwood and Bob Jensen.

Until recently an unrecognized feature of the Paulina Creek drainage is the lack of Mazama Ash at most location on the valley floor up to 10 to 15 ft (3 to 5 m) above the current stream level. At this location the full width of the valley floor is exposed bedrock (basalt). The south half of valley is occupied by the existing creek and Footbridge Falls, while the north half of valley contains an abandoned stream

channel with a dry falls. The abandoned channel is also stripped of Mazama Ash indicating that a flood swept over the entire valley floor.

A hike of about three quarters of a mile upstream takes you to Pipeline Falls and associated flood features.

See companion article by Chitwood and Jensen.

6.95---Turn right on F.S. Rd. 9736-550.

7.25---Enter 10-Mile Sno Park.

7.40---Leave 10-Mile Snow Park and turn right on County Road 21 at M.P. 9.55.

8.10---Viewpoint--Rt.

9.10---Newberry Entrance Station (closed).

9.15---Enter Newberry National Volcanic Monument. No collecting without research collecting permit.

10.15---Paulina Creek Falls -- Lt.

Paulina Creek drains Paulina Lake, 1300 ft (400 m) to the east. The rocks that form the cliffs of the falls are agglutinated andesitic pyroclastic deposits formed of many thin to thick units. Similar rocks occur along the caldera wall for about a mile and a half north of the creek. They grade to the west into ash and represent very near-vent deposits from a ring fracture bordering the west side of the caldera. The rocks below the cliffs are formed of poorly sorted and crudely bedded ash, lapilli, and blocks with abundant accidental lithic fragments. The contact between the lower and upper unit is gradational. Probably the eruptions first deposited relatively cold material, perhaps from phreatic eruptions, and temperatures increased to the point where all fragments were agglutinated at time of deposition. Lapilli tuffs like those at mile 9.00 occur at creek level only a few hundred feet downstream from the falls. (MacLeod and others, 1981)

10.40---Cross low west rim of Newberry Caldera.

10.45---Turn right toward Paulina Peak.

11.00---Kuehn Site 99-16 on right exposed the following:

Mazama tephra - 68 cm

Paulina Creek tephra (primarily flow/surge deposits; soil in upper part) - 342 cm

The bottom of the excavation was in Paulina Creek tephra at 4.10 m.

11.40---Paulina Peak Trailhead parking--Rt.

12.35---View to west of Cascades from Diamond Peak to Mt. Hood.

13.40--- View to south of Crater Buttes, Indian Butte, Fort Rock, Bald Mountain, Wart Peak, Walker Mountain, numerous cinder cones on south flank, and the long narrow Surveryor Flow.

14.10--- Road makes sharp left turn with borrow area on right.

The borrow area was partially filled during reconstruction of the road in 1998. Kuehn Site 97-30 was in the borrow area and exposed the following:

Gray ash - 8 cm

Reworked Paulina Creek tephra - 70 cm

Inplace Paulina Creek tephra (primarily flow/surge deposits; possibly some airfall) - more than 729 cm

The bottom of the excavation was in Paulina Creek Tephra at 8.07 m.

Tomorrow's trip will discuss Steve Kuehn's work in much more detail.

14.35--- Exposure of Paulina Creek Tephra--Lt.

14.65--- **STOP 1-B -- Summit of Paulina Peak.**
Park in parking area and along road.

Newberry Volcano Overview - Larry Chitwood and Bob Jensen.

The edifice of Newberry covers an oval area in excess of 500 mi² (1300 km²). Lavas from Newberry extend northward from the edifice for more than 40 mi (65 km). The oval shape of Newberry results from the distribution of vents and lava flows of basaltic andesite and basalt along the length of the volcano. More than 400 cinder cones and fissure vents have been identified on the flanks of Newberry. In contrast, dacitic to rhyolitic volcanism has been focused in the central part. Pyroclastic flow deposits are most widely exposed on the east and west flanks of the volcano, as are nearly all the dacitic to rhyolitic domes and lava flows.

Here at the summit of Paulina Peak, you are standing on the highest point of the rim of Newberry Crater, a 17 mi² (44 km²) caldera. The floor of the caldera includes East and Paulina Lakes and a wide variety of late Pleistocene and Holocene volcanic features. Between Paulina and East Lakes are Little Crater (basaltic tuff cone), Central Pumice Cone, and the Interlake Obsidian Flow. South of these is the Big Obsidian Flow. Young rhyolitic flows, pumice cones, rings and other tephra deposits are widespread around East Lake. Dating indicates that the East Lake

Obsidian Flows are about 3,500 years old and that many of the other obsidian flows and pumice cones (Interlake Flow, Game Hut Flow, Central Pumice Cone) are about 7,100 years old. The youngest volcanism, 1,250 years ago, was associated with the vent for the Big Obsidian Flow. Eruptions began with a widespread pumice fall. Later eruptions produced the Paulina Lake Ashflow and finally the Big Obsidian Flow itself.

From Paulina Peak there is a 360 degree view, which includes the Cascade peaks from Mt. Adams (168 mi, 270 km) in Washington to Mt. Shasta (164 miles, 265 km) in California and eastward to Steens Mtn (154 miles, 248 km). Paulina Peak is a dome, which extends about 3 mi (5 km) southwest down the flank and is about 1 mi (1.6 km) wide.

See companion article by Jensen and Chitwood.

Return to County Road 21.

18.55--- Turn left on County Road 21.

18.80--- Turn right into Paulina Lake Day Use Area

18.85--- **STOP 1-C -- Paulina Lake Day Use Area.**
Park in Paulina Day Use area.

Paulina Creek Flood (cont) - Larry Chitwood and Bob Jensen.

Evidence suggests that the outlet of Paulina Lake failed in a rapid downcutting event which left a well-developed wave-cut terrace around portions of the lake. Failure likely resulted from the upstream migration of a 5 to 8 ft (1.5 to 2.4 m) waterfall that reached the lake. The andesitic tuff at the lake's outlet is irregularly stratified with wide-ranging degrees of welding. Erosion of weak layers in the tuff undercuts more resistant layers to form waterfalls.

Dating of a variety of deposits associated with the flood and terrace indicates that the flood probably occurred between 1730 and 4860 calendar years B.P.

See companion article by Chitwood and Jensen.

Newberry Caldera Floor Uplift - Bob Jensen and Larry Chitwood.

The sudden drop of the lake's surface due to rapid downcutting of the outlet associated with the flood along Paulina Creek resulted in the abandonment of a lake terrace around Paulina Lake. The terrace is well preserved along the east

and southwest shorelines but is not evident along the south, north and northwest shorelines. Along the south shore the terrace has been covered and obliterated by the Paulina Lake ash flow. Here at Paulina Lake Campground the terrace is 4 ft (1.2 m) above natural lake level (the dam at the outlet raises the lake about 4 ft). Following the shoreline from here to the Newberry Group Camp the terrace gradually rises to a height of 11 ft (3.4 m) above natural lake level.

See companion article by Jensen and Chitwood.

Break for Lunch.

Archaeology of Newberry Crater - Tom Connolly.

Archaeological investigations were conducted from 1990 to 1992 within Newberry caldera, in connection with the reconstruction of the highway from just west of Paulina Creek Falls to East Lake Resort. The work involved testing at 14 sites plus formal data recovery excavations at four sites. The cultural deposits encountered during this work fall primarily in Early Holocene (pre-Mazama) and Late Holocene (within the last 3,500 to 4,000 years). There was no strong evidence found for human use of the caldera from the time of the Mazama eruption (7600 years B.P.) to about 4000 B.P.

The Early Holocene (pre-Mazama) caldera occupation appears to be primarily focused on hunting and gathering and retooling in preparation. In contrast all evidence suggests that in the Late Holocene the primary focus of visits to the caldera was for obsidian quarrying.

See companion article by Connolly.

- 18.90--- Turn left on County Road 21.
- 20.15--- Chief Paulina Horse Camp--Rt. Newberry Group Camp--Lt.
- 20.70--- Turn left to Little Crater Campground.
- 20.90--- **STOP 1-D - Little Crater Day Use Area.**
Park in Little Crater Day Use Area.

Newberry Caldera Floor Uplift (cont) - Bob Jensen and Larry Chitwood.

Here at Little Crater Campground the terrace reaches its highest level at 18 ft (5.5 m) above natural lake level. Following the shoreline from here to the northeast

corner of the lake the terrace gradually drops to 7 ft (1.8) above natural lake level. Along this eastern shoreline there are a series of narrow remnants of an older terrace that average about 5 ft (1.5 m) above the main terrace.

See companion article by Jensen and Chitwood.

Tool-Stone Production at Obsidian Flows - Paul Claeysens.

From the middle Holocene to proto-historic times, the caldera functioned as a prehistoric mining district, where obsidian tool-stone was quarried, and bifacial blanks and tools were produced for use and trade outside the immediate area. Some trade ranged far and wide throughout the interior and coastal Pacific Northwest.

Access to the caldera was via three corridors: Paulina Creek, North Rim, and East Rim. These corridors seem to have served groups from different regions around Newberry, thus several cultural groups may have utilized the vast lithic tool stone resources of Newberry Caldera.

See companion article by Claeysens.

Paulina Lake Basin Studies - Bob Reynolds.

The lake shore adjacent to the Little Crater Campground (LCC) provides excellent subaerial exposure of silicified sediment and unconsolidated tephra similar to that found at numerous underwater locations in Paulina Lake. The silicified sediment includes the large platy blocks exposed along this shoreline. The blocks are composed of a mix of rounded pebbles and sand sized pieces of pumice, scoria and obsidian which have been silicified into distinct layers 2-4 cm thick. The plates combine to form open-tiered blocks. The composite thickness of the blocks at this location is at least 3 meters. A similar exposure is located in 1-4 m water depth along the northeast shore of the lake. Both deposits occur at locations of present day hydrothermal thermal activity. This shoreline is interpreted to have developed by a combination of wave action and hydrothermal processes. No other subaerial portion of the Paulina Lake shore has these silicified plates.

Another set of flat-lying silicified plates has recently been discovered beneath the lake

at 12-18 m (40 to 60 ft) water depth. The submerged plates are remarkably similar to the subaerial shoreline deposits exposed at this site. These submerged plates have a near ubiquitous occurrence about the perimeter of the lake. The composite thickness of the underwater plates is less than 10 cm at most locations. Matted grasses and wood fragments were recovered from some of the plates and a radiocarbon age of 6750 +/- 350 yr was obtained from one site. The extensive lateral occurrence of these silicified plates, together with entrained wave modified pebbles and plant material supports a shoreline origin for the plates. The silicification of ancient shoreline sediment about the entire perimeter of the lake indicates an episode of significantly greater hydrothermal input to the lake basin than currently exists. The restricted depth of occurrence suggests a relatively rapid lake level change.

Several different tephtras have been recovered from Paulina Lake. Three of the oldest tephtras are found beneath the paleoshoreline plates and range in composition from basaltic andesite to rhyolite. None have been correlated to any known eruption. The youngest tephtra in the lake is the 1300 yr old Paulina Lake ash flow, which entered the south shore of the lake and continued across the lake for at least 100 m.

See companion article by Reynolds.

There are exposures of the base of Paulina Lake ash flow to the west of the boat ramp along the south shore of Paulina Lake.

21.10--- Return to County Road 21 and turn right to return to Ogden Group Camp or turn left for Optional Stop 1-E (for those interested in making the optional stop at the Big Obsidian Flow).

21.50--- Turn right to Big Obsidian Flow.

21.60--- Optional Stop 1-E – Big Obsidian Flow.
Park in Big Obsidian Flow Parking Lot and hike trail to upper viewpoint.

There is a Magma Chamber, Isn't There?
- Scott Linneman.

What better setting to discuss the existence of an upper crustal magma chamber than on Newberry's Big Obsidian Flow? What do the four episodes of rhyolitic volcanism in the Holocene tell us about the magmatic

system beneath Newberry Volcano? We will observe and discuss some of the evidence that suggests that the bimodal volcanism at Newberry formed by a combination of repeated, small volume, mafic magma injections into the crust and subsequent crustal melting.

See companion article by Linneman.

Explosion Craters and Giant Gas Bubbles - Bob Jensen.

At least 42 explosion craters pockmark the surface of the Big Obsidian in Newberry Caldera. The craters range from 40 to 200 ft (12 to 60 m) in diameter and from 15 to 45 ft (5 to 14 m) in depth. Discontinuous rings of rubble form rims around the craters. At the bottom of four of the crater are parts of spherical cavities or giant gas bubbles that are up to 50 ft (15 m) in diameter and filled to varying degrees with rubble that has collapsed from the crater walls above.

Craters of similar morphology have been observed on the Interlake Obsidian Flow (Newberry), Rock Mesa Flow (South Sister), Glass Mountain (Medicine Lake), and Little Glass Mountain (Medicine Lake), but no evidence of large spherical cavities has been observed below the floors of craters that have been examined.

Rhyolite flows are believed to develop layers as gases exsolve from the flow. The surface layer is finely vesicular pumice; beneath this is a layer of obsidian underlain by coarsely vesicular pumice. Giant gas bubbles in the Big Obsidian flow probably form and grow beneath or within the coarsely vesicular pumice and rise upward to the base of the obsidian layer within several meters of the surface, where they burst explosively. The blast creates a steep-walled crater rimmed with blocks of pumice and obsidian. Debris from the explosion falls back into the crater, partially or completely obscuring the giant bubble.

See companion article by Jensen.

Giant Gas Cavities and Flow Structure - Jon Castro.

Mesoscopic structures in four large gas cavities were mapped on the Big Obsidian Flow as a means of determining possible links between large scale surface folding and hazardous explosive activity originating from within the flow. A large gas cavity located in the northern flow lobe

(near the foot path) contains a host of structures including lineations and striations, and small scale folds that suggest a structural mechanism for cavity growth. Stereographic analyses of flow banding, stretched bubble lineation, striations, and mesoscopic fold axes indicate that three cavities are near cylindrical folds while one can be described as a noncylindrical fold. Cavity fold axes are oriented parallel to large scale compressional flow ridge axes, suggesting that cavities form in response to shortening during flow advance. Folds develop as the upper 10-20 m of obsidian

buckles due to both cooling compression of the flow front topographic barriers (e.g., talus ap Void space is created in fold hing obsidian layers shear past each other pull apart. The resultant cavities serve as reservoirs for exsolved vol and potentially vent explosively to explosion craters on the flow surface
See companion article by Castro Olmstead, and Joslin.

- 21.70--- Return to County Road 21 and turn left to return to Ogden Group Camp.
- 33.80--- Turn right to Ogden Group Camp.