Cycle Oregon 2025 Geology Rocks. High on the Cascades

By Ian Madin

The Rally route will take us on a tour of the southern Oregon Cascade Range, a beautiful and diverse landscape shaped by fire and ice. We will pass ancient and dormant volcanoes, cross active faults and ride through glaciated valleys. The volcanoes of the Cascade Range are part of a volcanic arc, one of the major features of the plate tectonic engine that shapes the surface of the earth.
The outer skin of the earth is a layer of rigid rock, 5-25 miles thick called the crust. Beneath it is the mantle a layer of hot rock under enormous pressure that can flow slowly. The mantle is heated from below by the incandescent core of the earth, and that hot rock rises slowly till it reaches the surface where is spreads out, cooling against the crust. Where this happens, the crust splits, and molten rock fills the crack, cooling to form new crust along an oceanic spreading center. The newly formed crust moves away from the spreading center in both directions. When the moving ocean crust reaches a continent, it slides beneath the edge of the continent in a process called subduction. As the subducting crust sinks it releases water that acts as a flux, causing the mantle above it to melt, feeding a narrow chain of volcanoes called a volcanic are.

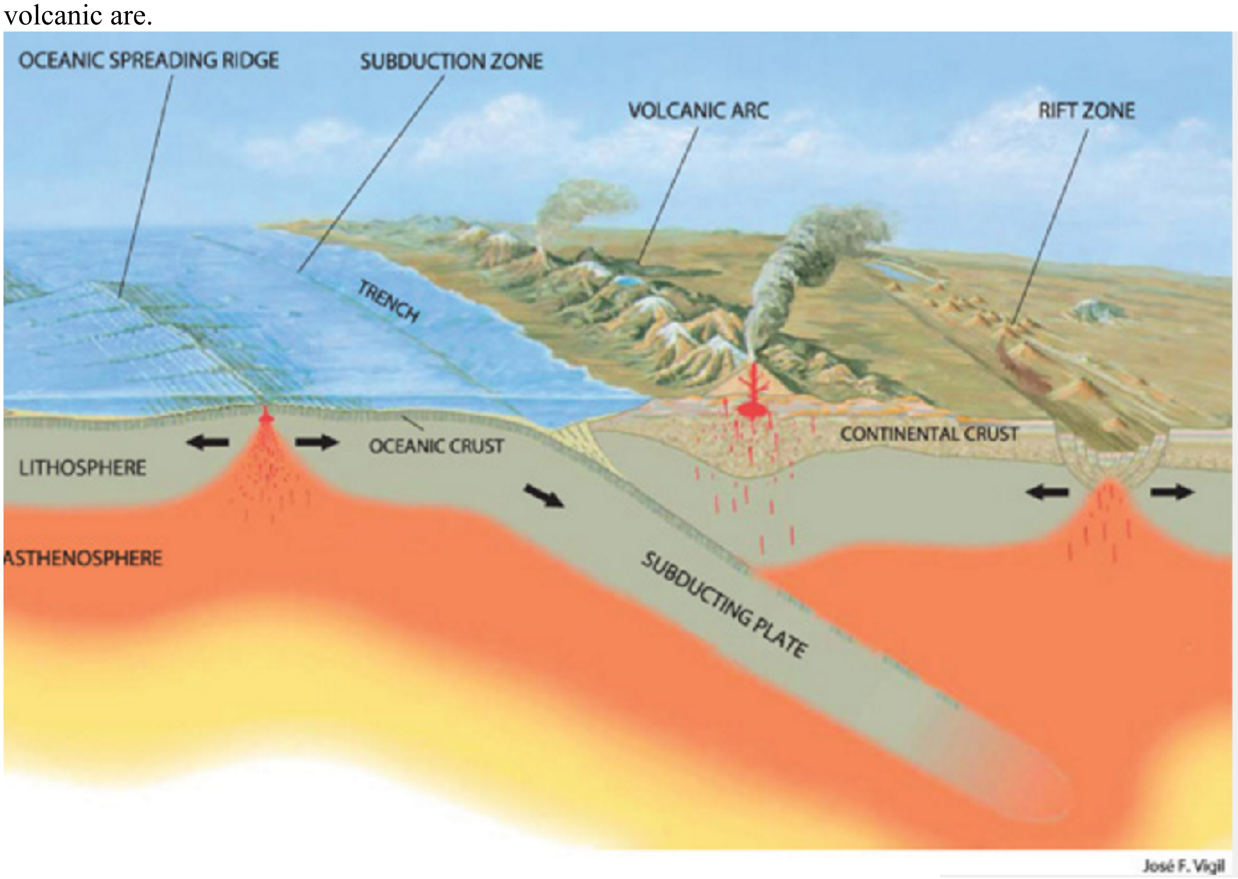
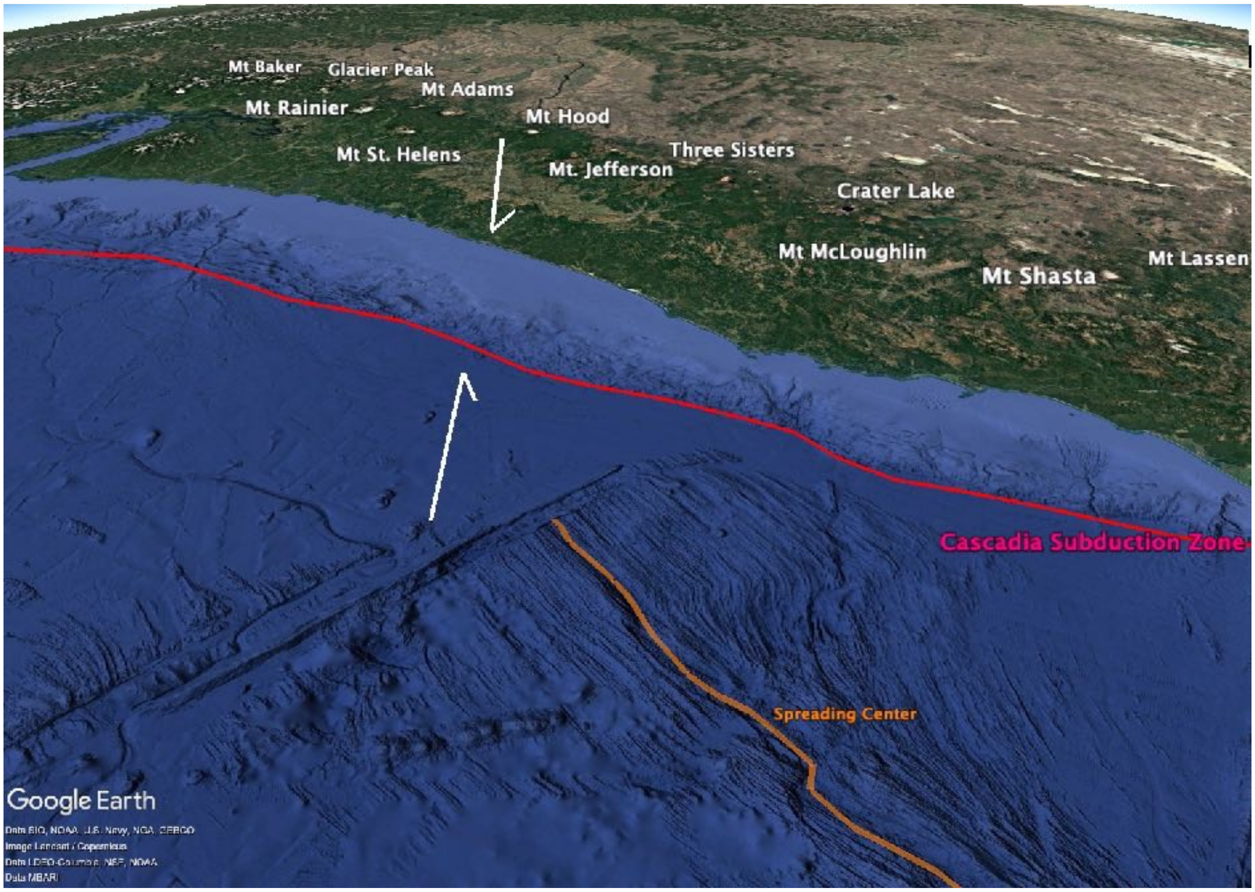


Plate tectonic is the name for the complex movement of the earth's crust, which moves constantly, driven by the upwelling of hot rock in the mantle. Crust is created at oceanic spreading centers and consumed at subduction zones, which produce volcanic arcs.

The volcanoes that built the Oregon Cascades are the result of subduction, one of the main elements of the plate tectonic processes that shape the Earth. In Oregon the sea floor of the Pacific Ocean has been subducting beneath the edge of the North American continent for almost 50 million years,. The subduction has been feeding a volcanic arc for that entire time, forming the Cascade Range. The twelve major volcanoes along the arc are evidence that the process continues today.



An Oceanic spreading center off the coast of Oregon produces new crust which then subducts beneath Oregon and Washington along a 600-mile-long fault called the Cascadia Subduction Zone. The subducted crust feeds a volcanic arc, the chain of active volcanoes that sits at the crest of the Cascades.

Day 1. Mt Mazama's eruption

For most of the route on the first day, the geology is muted. There are few places where rocks are exposed along the route, and the forested terrain doesn't show any distinctive geologic features. There is one very significant bit of geology in the first 5 miles, setting the stage for the next few days. About 3.3 miles out of Prospect, the route crosses the canyon of the West Fork of the Rogue River. After you cross the river and start to climb out of the canyon, you will see white volcanic ash and pumice in the roadcuts. This is fallout from the cataclysmic eruption that created Crater Lake.

Crater Lake formed during an enormous eruption of Mt. Mazama, one of the many large volcanoes the make up the Cascade volcanic arc. Mt. Mazama had a long eruptive history, and before the eruption probably looked like Mt. Hood or Mt. Rainier; a snow-capped cone carved by deep glacial valleys. Simply projecting the lower slopes of the mountain upwards suggests that Mt. Mazama was 12,000 to 14,000 feet tall.

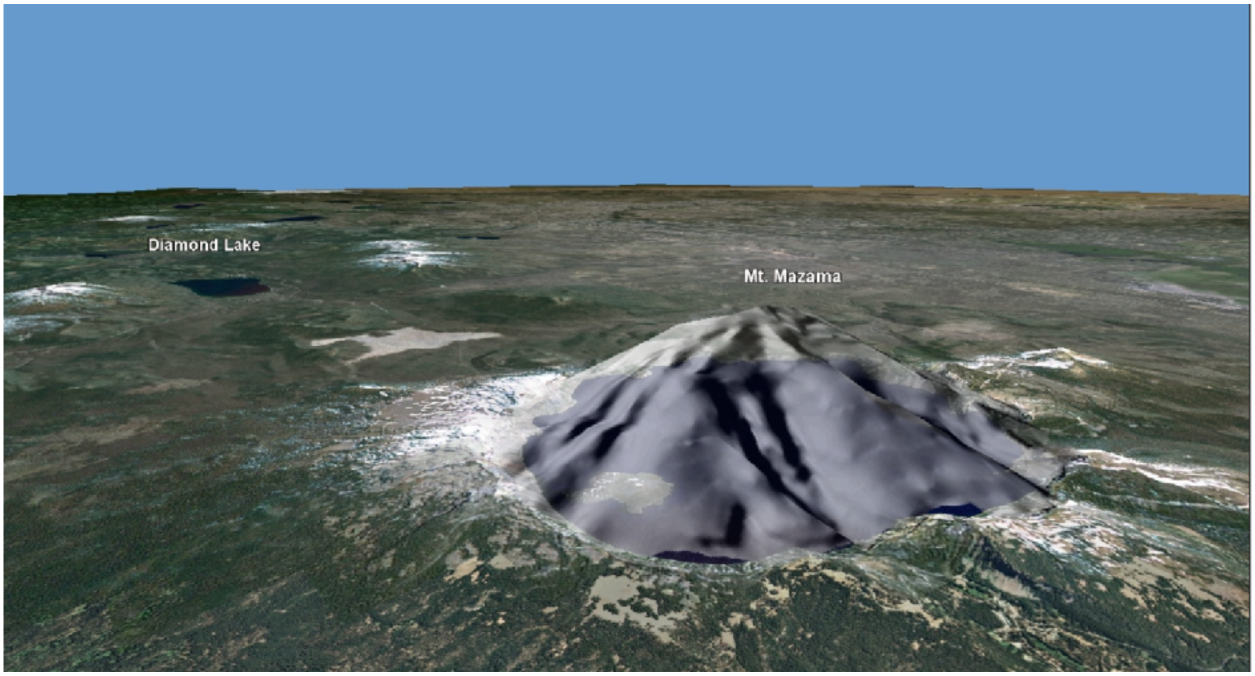
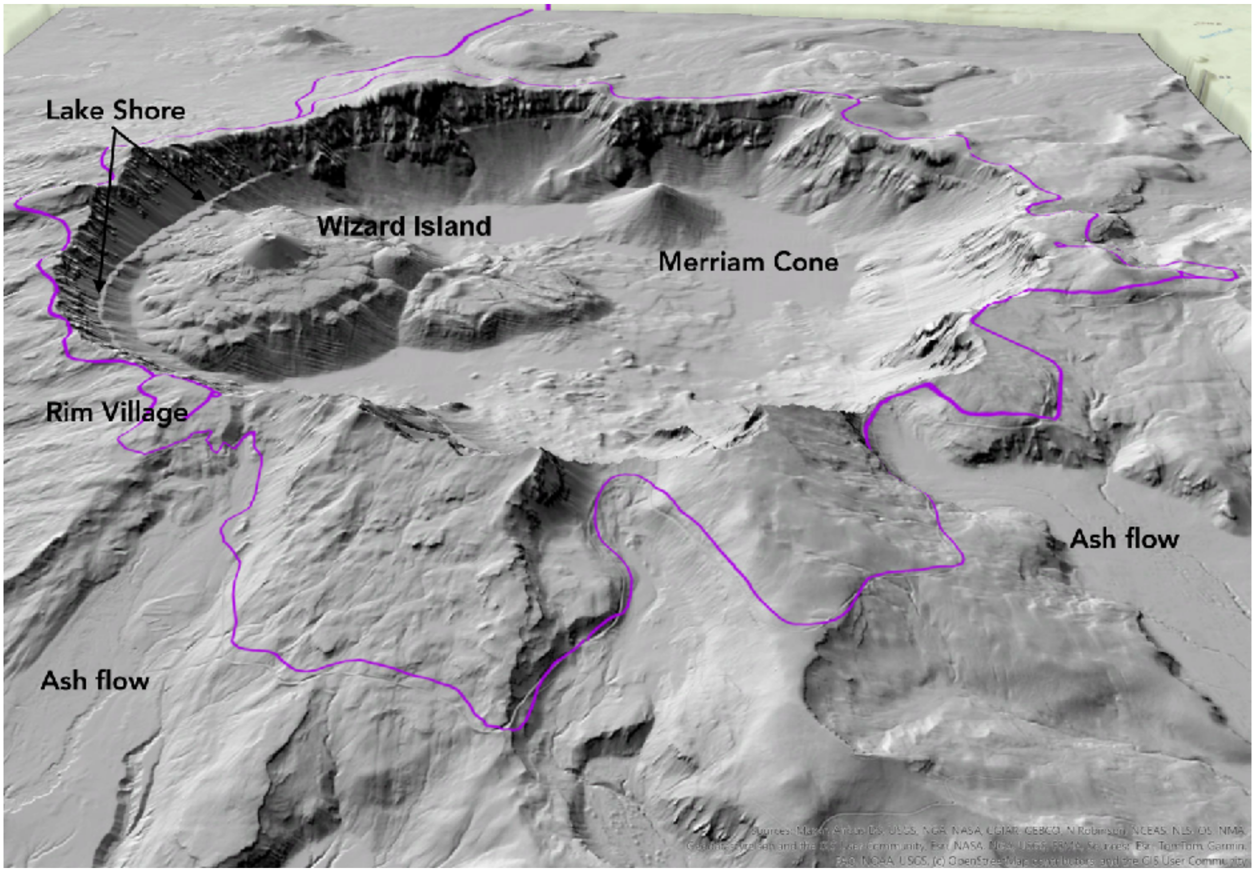


Figure 2 *The Ghost of Mt Mazama. This image shows a reconstruction of the Mazama volcano before the Crater Lake eruption. Extending the remaining slopes and valleys upwards points to a mountain 12,000-14,000 feet high, which would have been laced with large glaciers. All of the "ghost" mountain was blasted into the sky or collapsed into the empty magma chamber during the cataclysmic eruption 7,700 years ago.*

About 7,700 years ago, the depths of Mt. Mazama were filled with huge amounts of hot silica-rich lava. As more magma filled the underground chamber, the pressure increased and started to slowly lift the top of the mountain, cracking it. At some point, a crack broke through to the surface during an earthquake, suddenly releasing the built-up pressure. Like a warm bottle of soda suddenly uncorked, the gas-rich magma expanded into red-hot foam. The explosive increase in volume caused the foaming magma to be ejected as cloud of expanding shattered pumice fragments and ash. The eruption decompressed deeper levels of magma, causing the foaming to accelerate and resulting in a massive column of hot gas, pumice and ash, which rose into the stratosphere. Larger fragments of pumice rained down for miles around the volcano, while ash was transported as much as 800 miles away. In the most intense part of the multi-day eruption, the ash and pumice were falling so thick around the vent that it coalesced into flowing rivers of red-hot fragments and gas; called a glowing avalanche or ash flow. These flows swept down the canyons leading from the mountains at highway speeds, obliterating everything in their path and filling the canyons. So much magma erupted that the top mountain collapsed into the empty magma chamber, leaving a hole nearly 4,000 feet deep. In the years that followed, rain and snow slowly filled the lake, and two small volcanos, Wizard Island and Merriam Cone, grew up from the floor.



Looking North. *This combined lidar and sonar image looks northwest across the stump of Mt. Mazama and Crater Lake, showing the shape of the land features as well as the lake floor. The faint bench around the crater marks the current lake shore and the purple line is the route. The bottom of the lake is very flat in many parts, but Merriam Cone and the Wizard Island volcano rise above it. The valleys in the foreground were filled with the ash flows and have flat wide floors. The steep sharp edged gullies have been eroded into the relatively soft fresh tuff in the last 7,700 years.*

Climbing out of the West Fork Rogue canyon, you can see thick layers of fine white ash studded with fragments of pumice. You may notice layers in the ash, formed as the eruption changed in intensity. When you reach the top of the short climb, there is an excellent view of the Mazama ash in the roadcut on the left. The shoulder is wide so take a break and have a closer look. This is a good place to pick up some pumice to take home. If you look at it closely you will see that it is like a sponge made of volcanic glass. The ash is simply pumice that has been shattered into bits.

Layers of ash from Mt Mazama that buried the land here 7,700 years ago. The layers result from changes in the intensity of eruption and wind direction over the course of several days.

The next roadcut past the top of the climb slices through an old volcanic vent. Red cinders and rubble surround a core of blocky lava. This vent was probably active 4-5 million years ago.

On the left, red cinders and rubble that piled up around a small volcanic vent, on the right is blocky lava that remained in the throat of the vent.

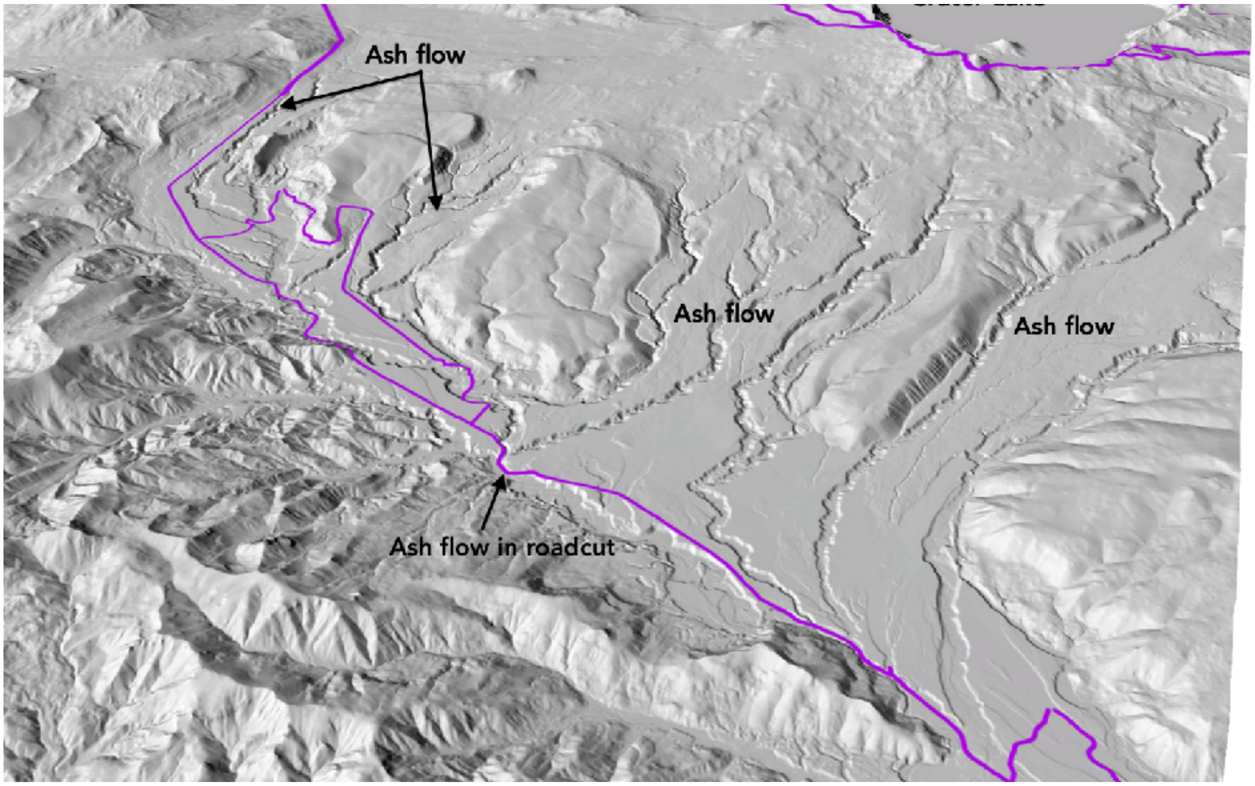
Directly across the road the red lava and rubble is buried beneath the Mazama ash giving us a glimpse of where the land surface was before the eruption.

White Mazama ash 7,700 years old covers red lava, 4-5 million years old.

For the remainder of the ride, on both the main route, long route and gravel you will be travelling through more lava flows from an earlier generation of Cascade volcanoes that were active from about 5 to 2 million years ago. You will see bits of lava in roadcuts, some will be broken into blocks or columns, others will break into thin plates.

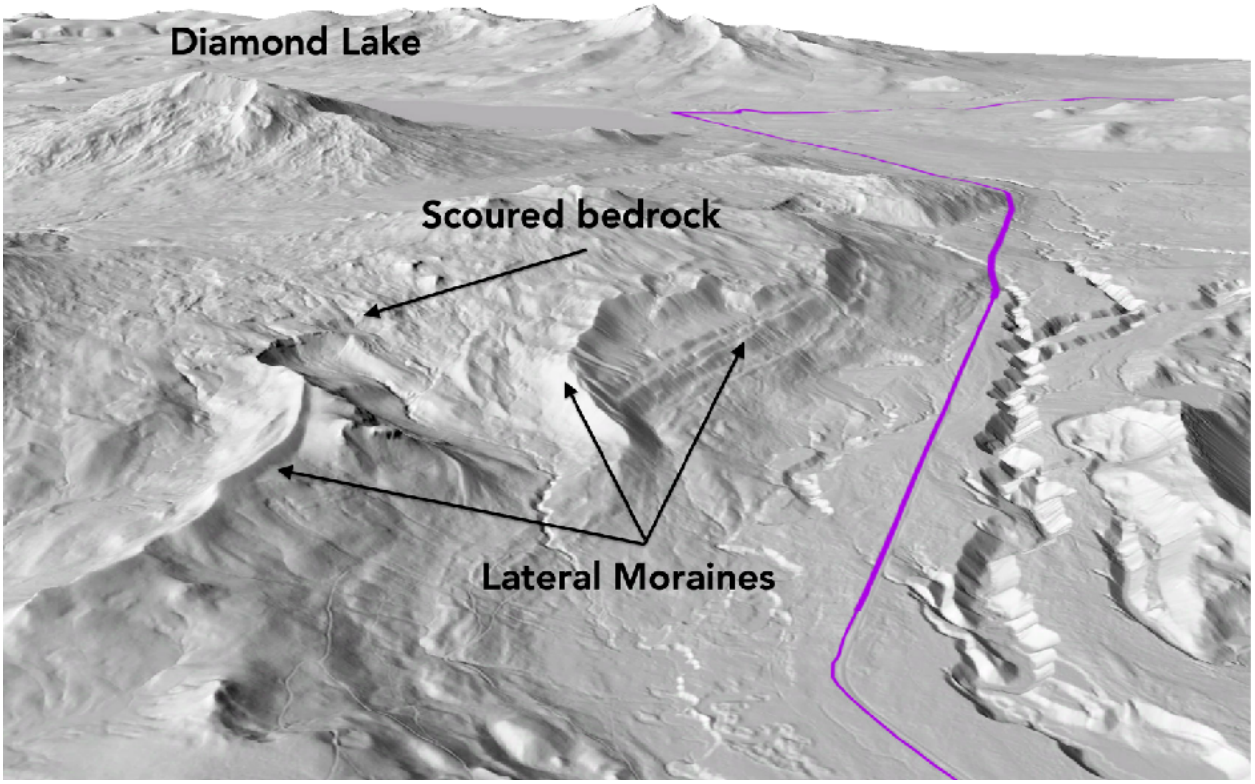
Day 2 Ash flows, Ice Flows and earthquakes.

The Day two route takes you up the Rogue River valley to its headwaters. There is not much to see along the route in the way of rocks, and the forest obscures much of the landscape, but you will be riding through geologic features with dramatic origins. The floor of the valley is very flat, because it was filled with the same ash flows from Mt. Mazama that you saw on Day 1. Four large valleys channeled the ash flowing down the west side of the erupting mountain into the Rogue valley, filling it with a thick layer of hot ash which compacted into a rock called tuff, leaving a smooth flat surface. Since the eruption, the Rogue and its tributaries have cut narrow gullies through the soft tuff. After the snack stop at Farewell Bend, the route leaves the Rogue River to climb up on top of the ash flow surface for 8.5 miles, the swiftly descends from the top of the ash flow back to river level, with big roadcuts exposing the white ash and pumice. The ash flow is at least 220 feet thick here.



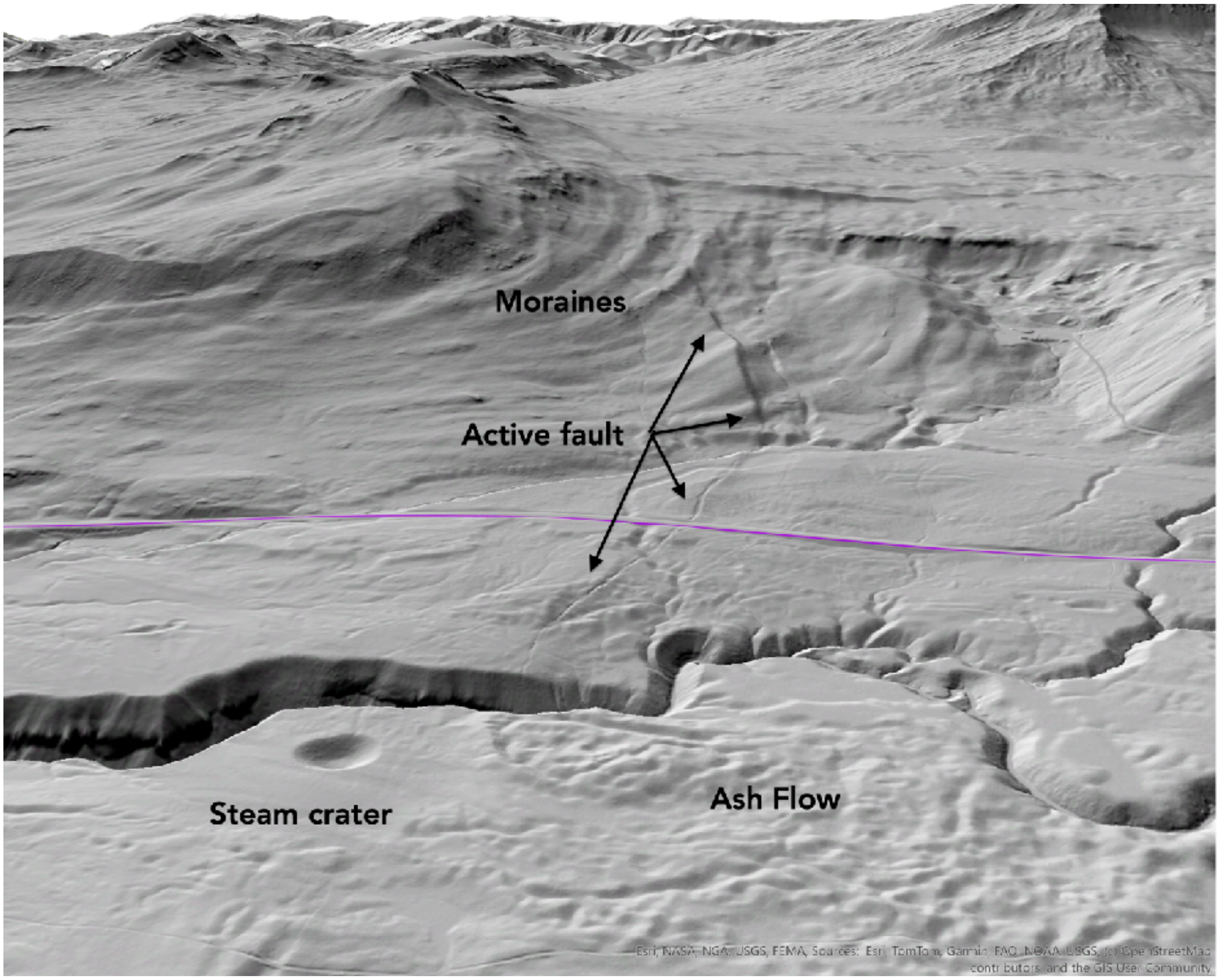
Looking East. The upper reaches of the Rogue River and its eastern tributaries are filled with hundreds of feet of ash flow from the Mt. Mazama eruption.

From this point on, the valley was carved by rivers of ice that originated on Mt. Mazama before its eruption. When the last great ice age peaked about 18,000 years ago, the upper Rogue valley was filled with a glacier 1,300 feet thick. An ice cap covered the High Cascades, sending tongues of flowing ice down all of the canyons around its edge. Those rivers of ice scoured the bedrock, scraping off all of the loose rock, which was then carried with the ice. At the edges and ends of the glacier, the ice melted away, and the rock it was carrying piled up in long thin ridges called lateral moraines. Although not visible from the road, there are many beautifully preserved moraines in the upper part of the valley.



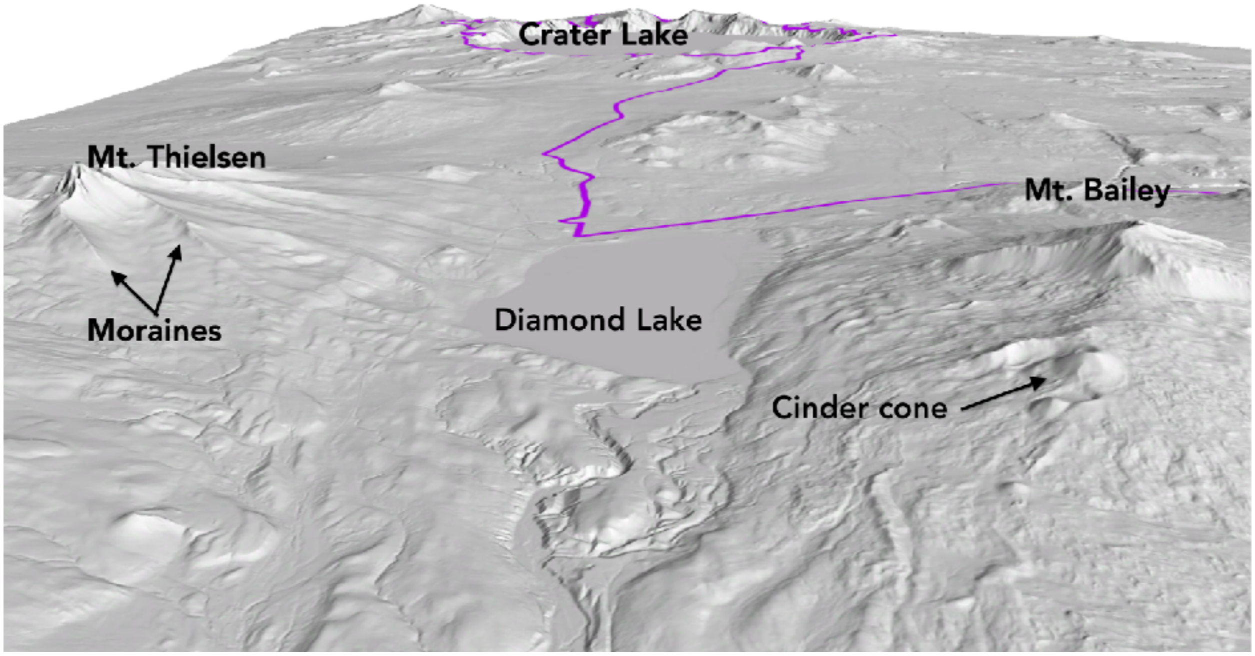
Looking Northeast. Long thin ridges of rock called lateral moraines formed along the edges of the thick glacier that filled the upper Rogue valley. The sinuous moraines on top of the mountain were formed when the glacier was at its greatest extent. The succession of lateral moraines that wrap around the mountain were formed as the glacier receded.

Three quarters of a mile before the second snack stop, the route crosses an active fault. Faults like this are common in the High Cascades, and they typically have earthquakes of magnitude 6 to 6.5 every few thousand years. During each earthquake, the land surface on one side of the fault rises abruptly, producing a scarp across the landscape. The scarp here is visible cutting across moraine ridges, which are offset by about 15 feet. The fault is also visible crossing the ash flow surface, so at least one earthquake must have happened since the eruption 7,700 years ago. There is also a circular crater on the ash flow surface here, caused by a steam explosion when groundwater came in contact with some of the hot ash.



Looking North. The active fault crossing the route makes a clear scarp where it cuts across the 18,000-year-old moraines, and a subtle fissure where it crosses the young Mazama ash flow. It is not visible from the road. The steam crater is 430 feet wide and 200 feet deep.

After the second snack stop the route leaves the Rogue River basin and descends into the basin holding Diamond Lake, which is in the headwaters of the North Umpqua River. The basin that holds Diamond Lake was carved out by a huge glacier fed by streams of ice from Mt Thielsen, Mt. Bailey and Mt. Mazama. The ice age had been over for 4000 years when Mazama erupted, so Diamond Lake was partially filled with ash flow. Diamond Lake is flanked by two volcanoes, Mt. Thielsen to the east is about 300,000 years old and Mt. Bailey is about 100,000 years old. Both have been heavily eroded by glaciers.



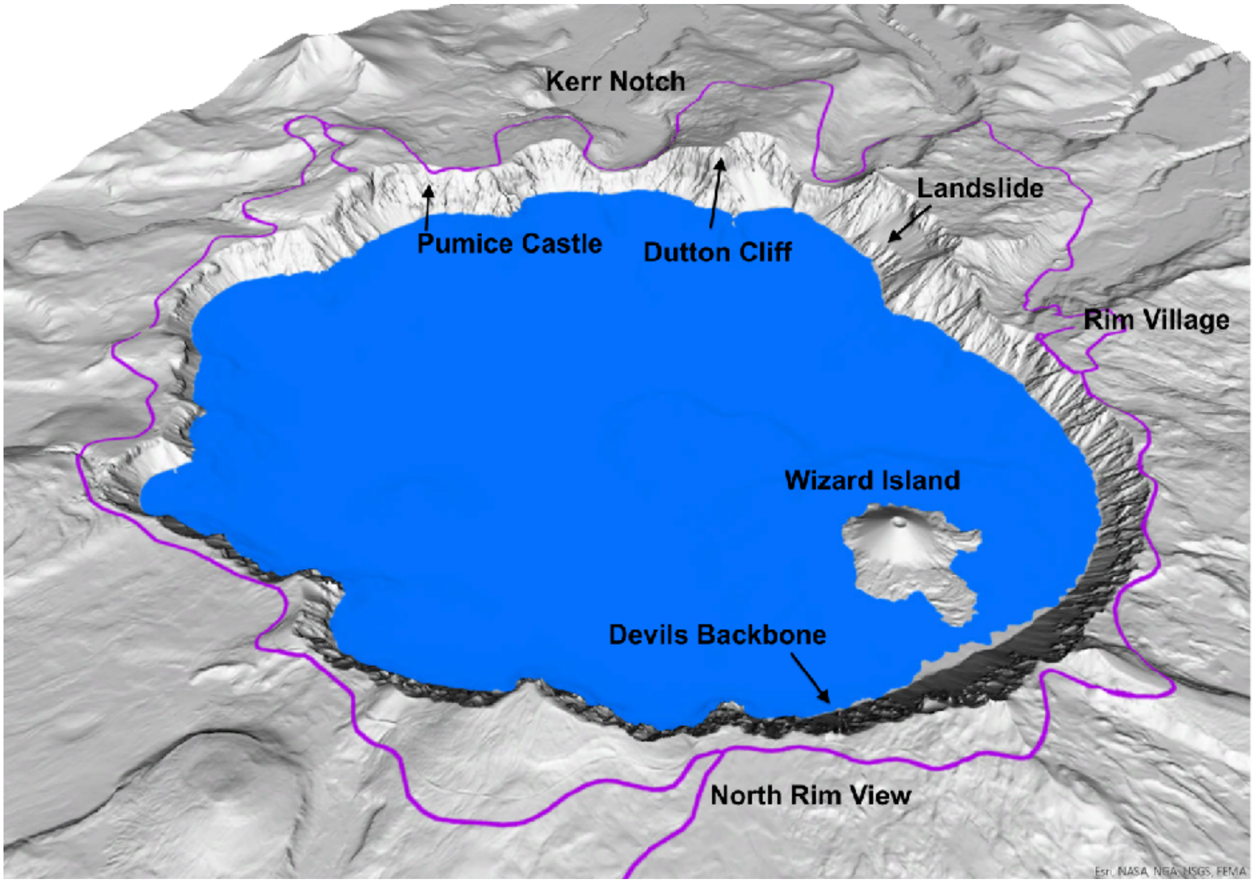
Looking South. The valley that holds Diamond Lake was carved out by glaciers from the three mountains that surround it. There are well developed lateral moraines preserved on Mt. Thielsen. There is a well-preserved cinder cone on the flank of Mt. Bailey.

Day 3. The main attraction.

Crater Lake is a fantastic place, unique and breathtakingly beautiful, and the ride around it is a true classic. Although the scenery is spectacular from any vantage, the geology can be harder to see because of the steepness of slopes and the distance to the opposite rim. This guide will touch on a few of the more easily visible features.

The approach to the rim from the park entrance starts in a sparse forest of lodgepole pine but eventually breaks out onto the Pumice Desert, a broad slope covered with thin grass and a few hardy trees. The pumice from the big eruption is thick here, and is very porous, so rainfall and snowmelt quickly seep in, leaving the upper layers too dry to support much plant life.

At the north rim viewpoint you get your first glimpse of the hollowed-out volcano and the unbelievably blue lake that fills it.



Looking Southeast. This image shows the location of the features described in the following sections.

Mt. Mazama was a stratovolcano, which means it was built up from hundreds of layers of lava, ash and tuff that piled up over hundreds of thousands of years around the central vent. This layering is easiest to see from lake level. The sequence of layers varies as you circle the crater, and few covered the entire mountain. At Dutton Cliff you can see a series of thin dark basalt lava flows capped by thick grey andesite lava flows separated by bands of red rubble.

Looking Southeast. Lava layers at Dutton Cliff, probably visible from Sun Notch. Thin dark grey basalt flows on the right side are covered by thick grey andesite flows on the left, separated by bands of red lava rubble. The light green color on the layers is lichen.

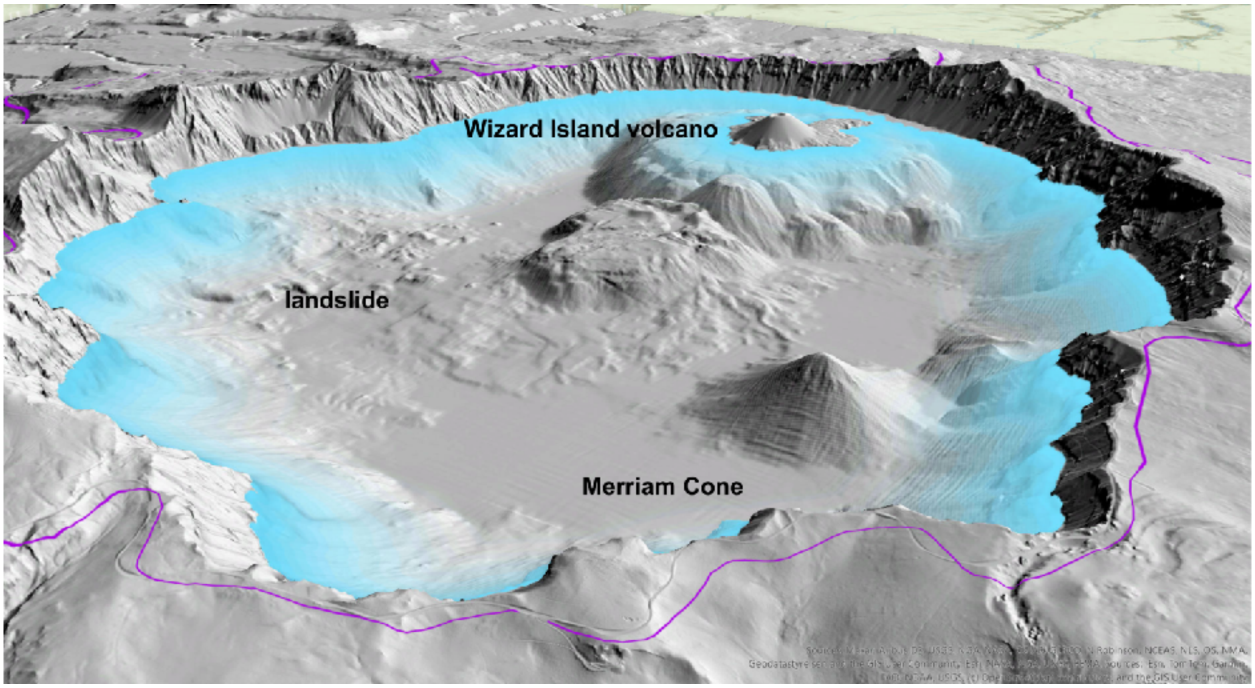
In addition to the lava flows that built up the mountain, there were earlier eruptions of ash and pumice that covered much more of the mountain. A distinctive band of orange tuff is visible around the southeast side of the crater, high on the rim, and is responsible for the feature called Pumice Castle. This tuff is visible at the top of the Cleetwood Cove trail if you decide to make the hike to the lake.

Pumice Castle is the name for this eroded remnant of tuff. The black and white layers are part of the same tuff body, the orange color is the result of iron deposited in parts of the layer by mineral rich groundwater. Above the tuff there is a thick layer of andesite lava and the top of the rim has a layer of pumice from the eruption that formed the crater. Visible from Cloudcap Viewpoint.

As the mountain grew layer by layer, the molten rock feeding later eruptions had to force its way through the previous layers to reach the surface. Lava remained in these fissures after the eruption, cooling to form a dike, a thin sheet of lava that cuts vertically across the older horizontal layers. The Devils Backbone on the southwest side of the lake is one of the most impressive dikes visible in the rim.

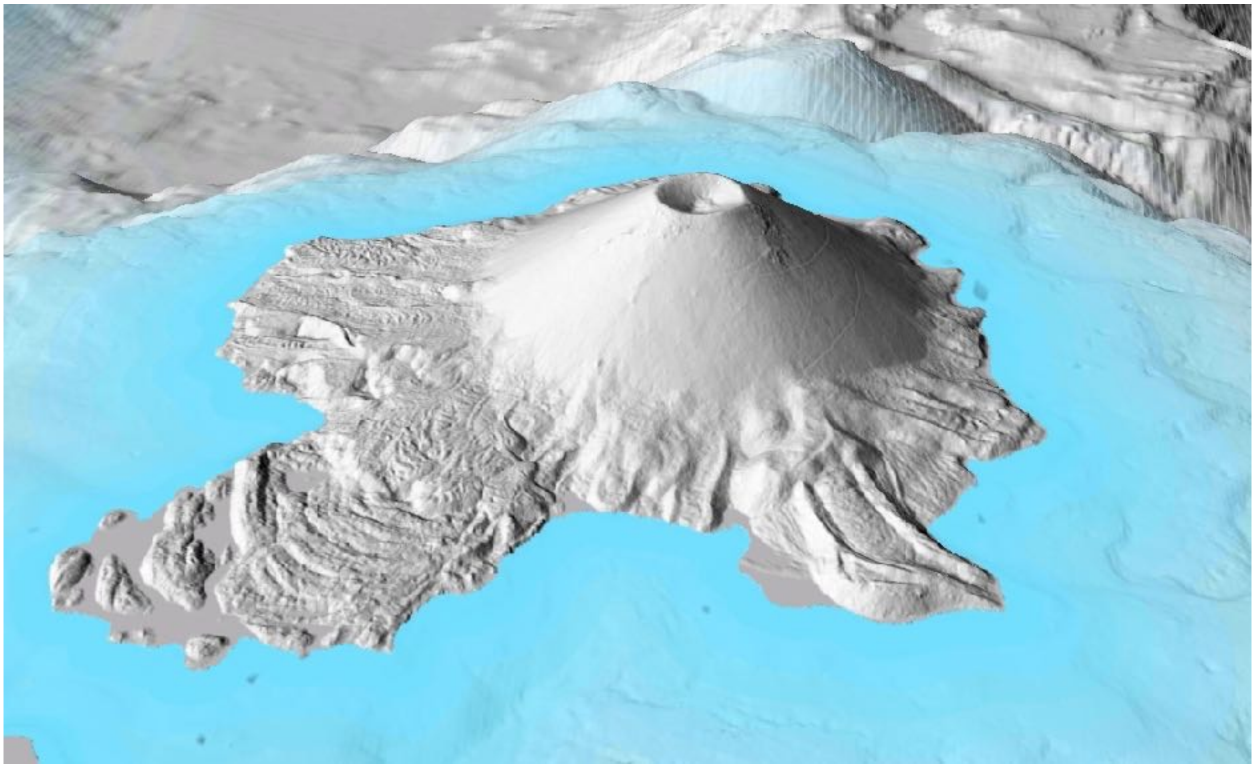
The Devils backbone is a dike, a vertical sheet of lava that formed when molten rock forced its way to the surface through earlier layers of lava.

After the great eruption, two small volcanos grew from the floor of the crater. Merriam Cone sits 600 feet below the surface, a perfect cone that rises 1300 feet above the flat floor of the crater.



Looking southwest across Crater Lake at underwater features on the floor of the crater. Merriam Cone and the Wizard Island volcano grew after the collapse of the mountain. Debris from a giant landslide can be seen on the lake floor at the left.

The small perfect cinder cone of Wizard Island sits on top of a massive underwater pile of lava, and is surrounded by a chaotic flow of andesite lava. Cinder cones form when the molten rock reaching the surface is charged with dissolved gas, causing it to foam and fountain. The spray of lava thrown into the air freezes into cinders and falls back to earth to build a cone of loose material around the vent. Eventually the gas pressure is relieved, and the liquid lava can flow away from the cone.



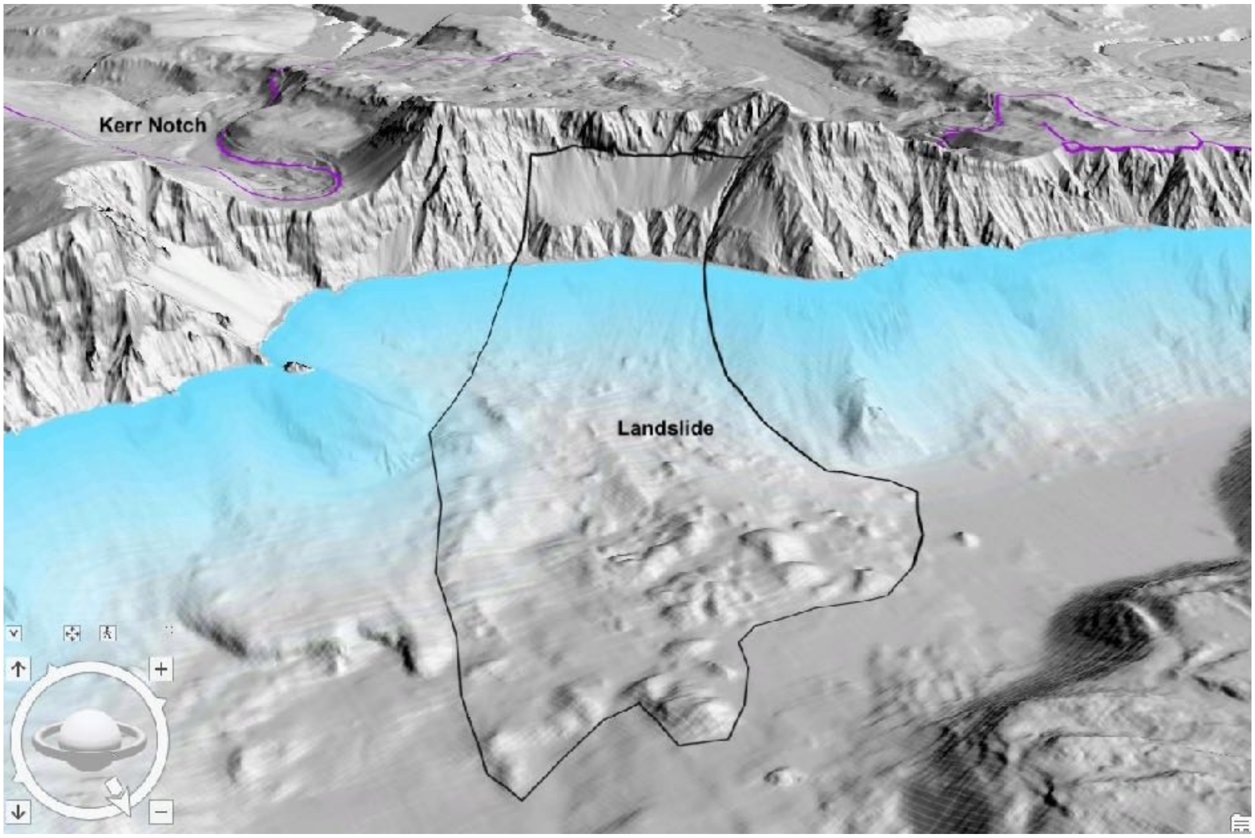
Looking Northwest. Wizard Island is the tip of a much larger underwater volcano, and consists of a cinder cone surrounded by A'a lava flows. The thick slowly moving flows have wrinkled surfaces, and two flows on the right-hand side of the Island have natural levees.

In this case the lava was fairly thick, and formed an A'a flow. A'a lava flows slowly and develops a thick frozen crust. As it continues to move, the crust breaks up into a jumble of jagged lava boulders, leaving the flow covered with a chaotic mass of loose rock. At Wizard Island, one part of the flow had the liquid core drain away, causing the inside of the flow to subside, leaving sharp lava levees on either side.

The A'a lava flow that makes up Wizard Island. Solid rock is present beneath this covering of broken lava.

On the Southeast side of the lake, just West of Kerr Notch, there is a big scoop out of the rim, and beneath the water a massive fan of rock rubble. The rock of the canyon rim here was weakened by hot acidic spring water until it eventually collapsed, leaving behind the gap in the rim and spreading debris 2 miles out into the lake.

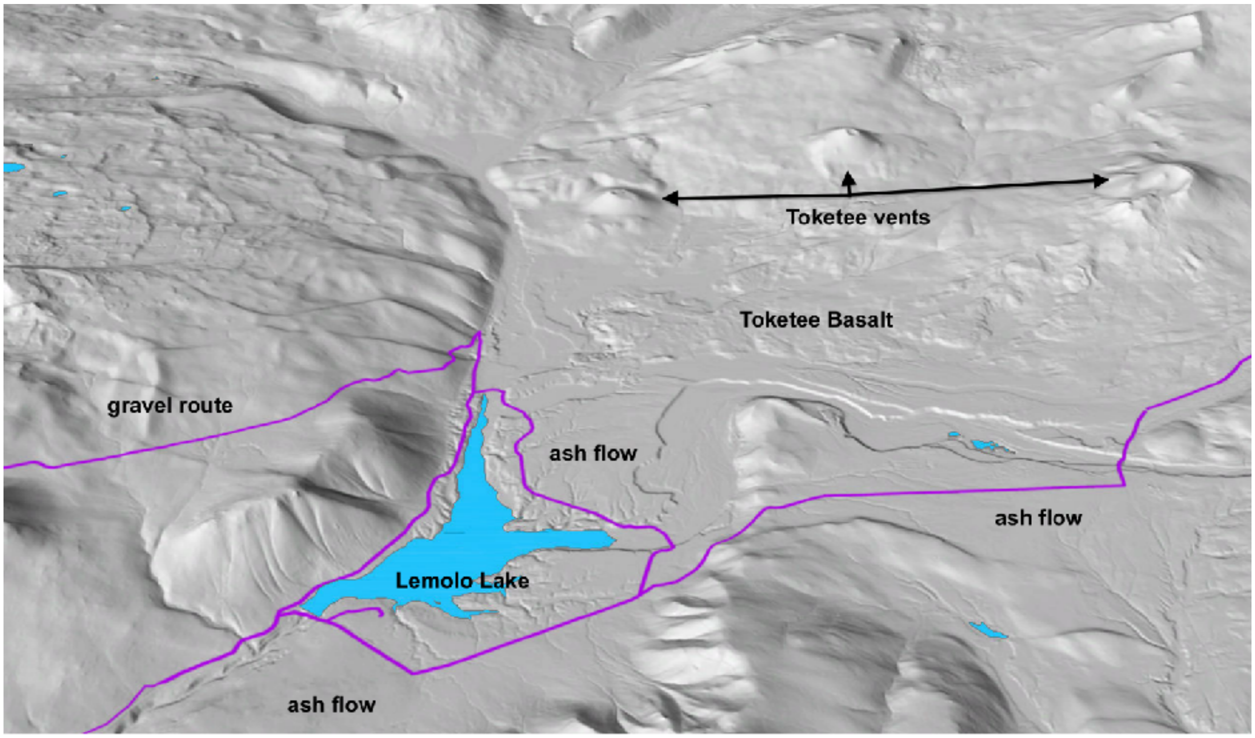
Kerr Notch is the remains of one of the many valleys gouged out of the top of Mt. Mazama by glaciers. When the mountain collapsed, the upper reaches of the valley went with it. Now you can see the characteristic "u" shaped profile of a glacier valley where Kerr notch meets the rim.



Looking Southeast. The large gap in the upper crater wall is the source of a huge landslide that spread debris across the lake floor. Kerr notch is the remnant of a glacial valley that extended far up the mountain before the great eruption.

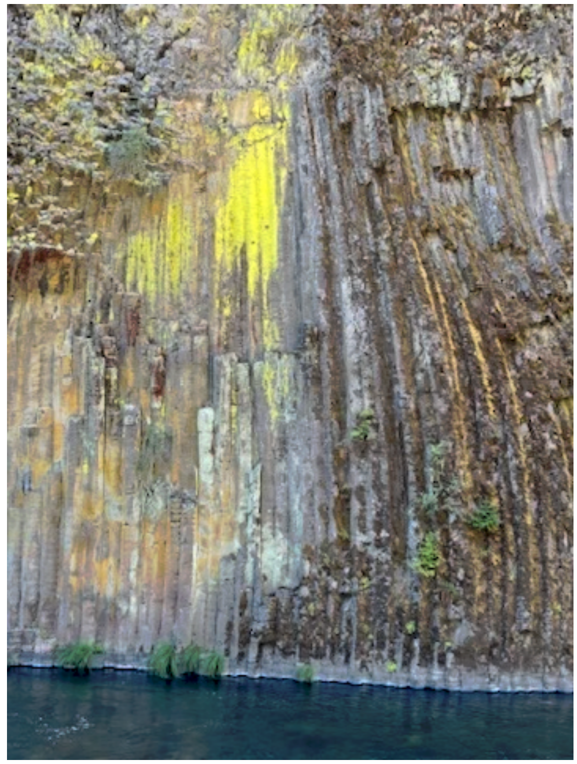
Day 4. Glacial Cirques and canyon-filling flows.

The route on Day 4 continues with the earlier themes of Cascade volcanic eruptions, glaciers and earthquake faults and the effect they have on the landscape. Leaving camp the route goes along the shore of Diamond Lake then across the floor of the broad glacial valley that holds the lake. After crossing Thielsen Creek, the route climbs onto a broad flat surface covered with Mazama ash flow. Coming up the Rogue on Day two, the valley floor was flat because the ash flow had filled it completely. Here the ash flow is a thin layer on top of an older lava flow that filled the canyon 750,000 years ago. This is called the Toketee Basalt, named for the famous Toketee Falls, which erupted from vents east of Lemolo Lake and flowed 30 miles down the canyon of the North Fork of the Umpqua, filling it to a depth of 300-400 feet, and leaving a broad barren lava plain in place of a glacier carved valley.



Looking East. Lemolo Lake sits on a flat surface formed when the Toketee basalt erupted 750,000 years ago, filling the canyon of the North Umpqua River.

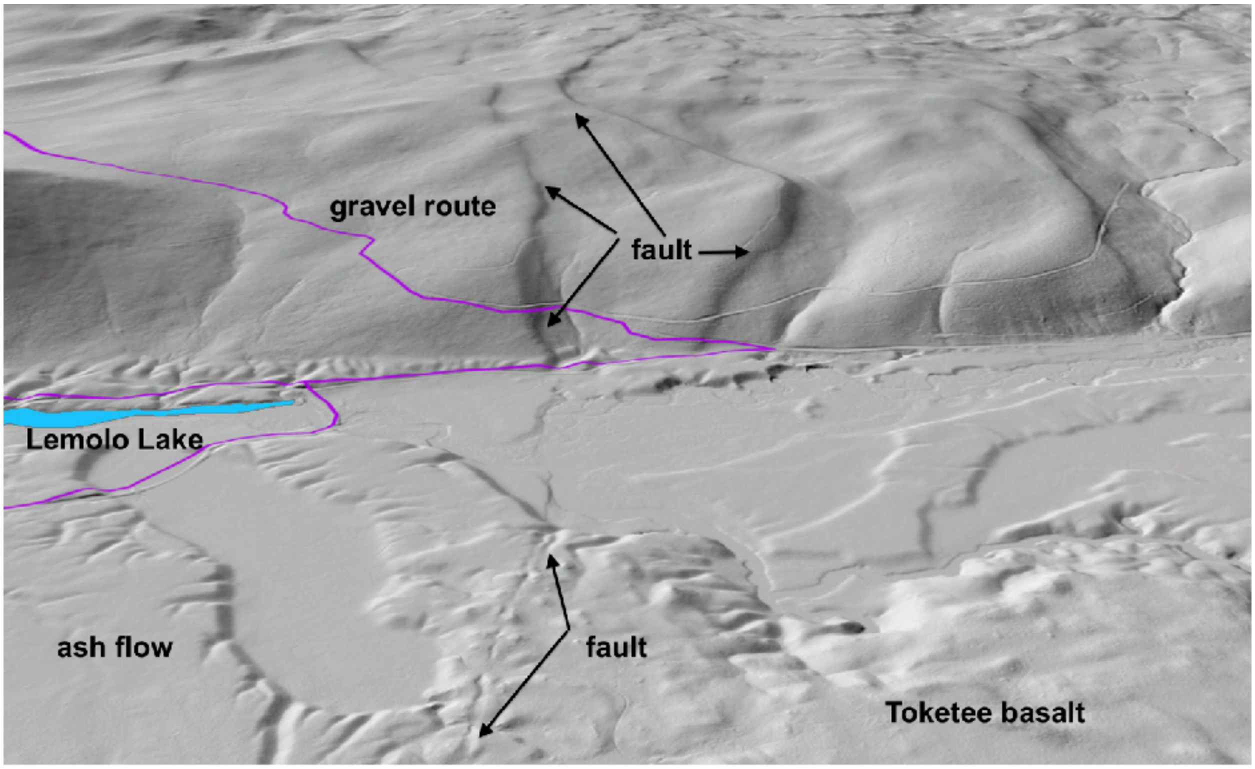
After the lava cooled, the river began to re-establish its course, flowing across the top of the canyon-filling lava until it cascaded down the steep front of the flow. The power of the water cascading down a 300-foot-high falls allowed the river to rapidly carve a new canyon through the lava, leaving the original lava surface high on the new canyon walls. In places, the river is still carving through the basalt, leaving beautiful waterfalls like Toketee Falls and cliffs shaped into fantastic columns as the lava cooled and shrank.



At Toketee Falls, the North Umpqua is still cutting through the 750,00 year old Toketee Basalt. At Soda Springs, the river has carved a vertical cliff showing intricate basalt columns.

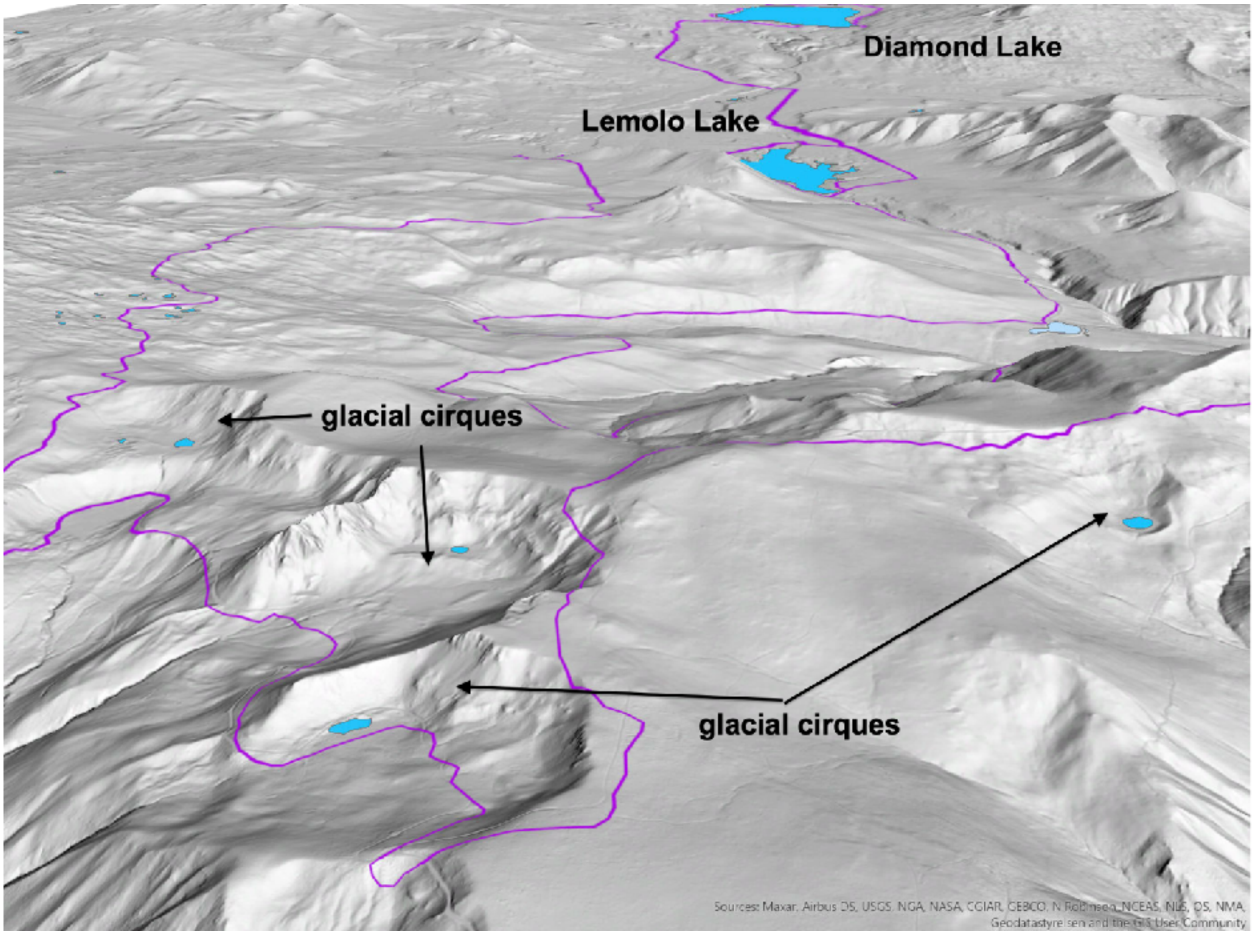
When Mt Mazama erupted the canyon was once again filled, this time with ash flow that travelled 20 miles down the canyon, filling it with 50 to 100 feet of ash and pumice. In the thousands of years since the eruption, the river has quickly carved through the ash flow, re-establishing its course.

Those who go on the long gravel route will start by switchbacking up the hill after leaving the flat ash flow plain around Lemolo Lake. The switchbacks cross a pair of active faults, that make short sharp cliffs, or scarps across the landslide. These scarps were formed during several earthquakes over the past thousands of years, growing a few feet in seconds during each earthquake.



Looking North. The gravel route crosses two active earthquake faults as it leaves the flat valley floor.

Past the Faults, the gravel route climbs a high ridge forming the headwaters of the North Umpqua. At a bit over 6,000 feet, this ridge was high enough for small glaciers to form during the peak of the last ice age, 18,000 years ago. Ice and snow accumulated on the shaded North and East slopes of the ridge, and when the ice became thick enough it started to flow. Over time the flowing ice gouged a bowl-shaped depression out of the ridge, called a cirque. When the ice melted away 11,000 years ago, small glacial lakes remained in the cirques, filling holes carved into bedrock by the moving ice.



Looking South. The high ridge north of Lemolo Lake is scalloped by small glacial cirques, each holding a small lake.

Ian Madin worked as a geologist for the State of Oregon for 34 years before retiring in 2022. He has been riding with Cycle Oregon and sharing his love of Oregon's rocks and landscapes since 2013.