State of Oregon
Department of Geology and Mineral Industries
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Open File Report

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UPPER GRANDE RONDE RIVER BASIN GEOLOGY WORKSHOP FIELD TRIP GUIDE — SEPTEMBER 5 AND 6, 2001

By

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NOTICE

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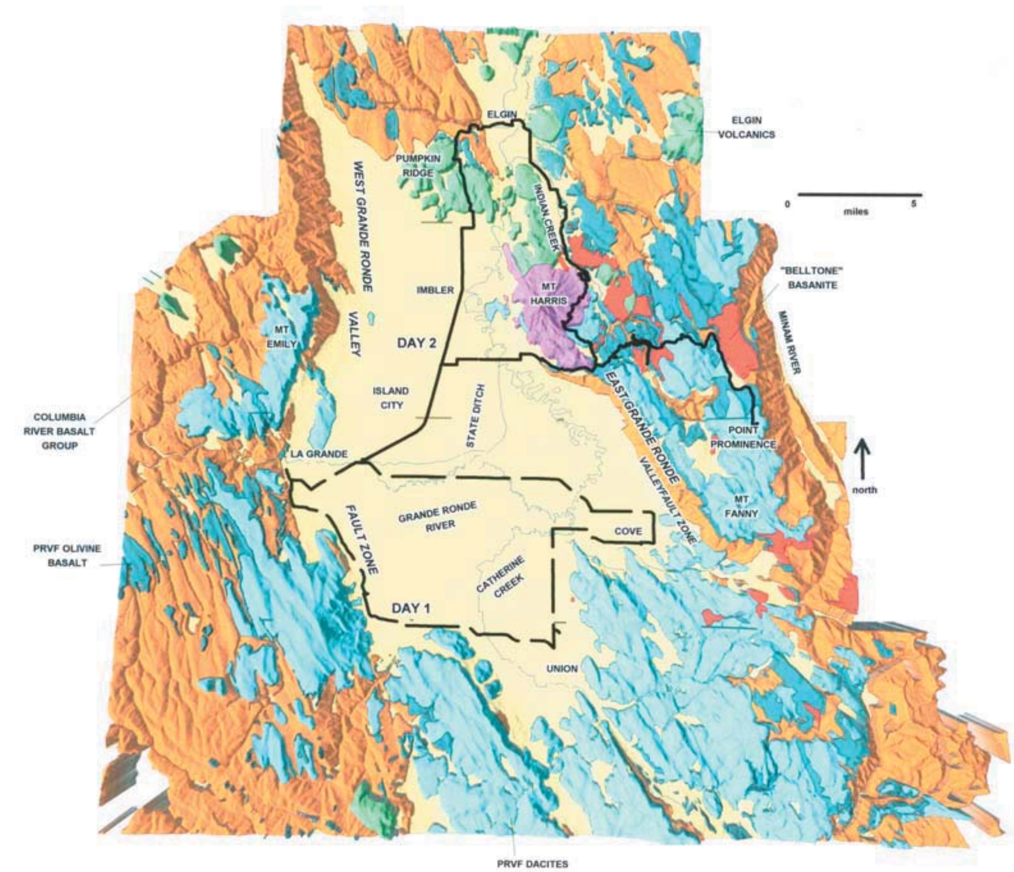
SHADED RELIEF MAP OF THE FIELD TRIP AREA SHOWING THE GENERALIZED GEOLOGY



Field Trip Guide

Day 1
Western and Southern Margin of the Grande Ronde Valley

Day 2
Northern and Eastern Margin of the Grande Ronde Valley and the Indian Creek Drainage

Western and Southern Margin of the Grande Ronde Valley

Quaternary faults, landslides and mass wasting, and other surficial geologic features along the southern and western margins of the Grande Ronde Valley are the focus for the DAY 1 field trip. The first three stops are along the valley's well-defined, fault-bounded western margin. The last two stops are along the valley's more ill-defined southern margin. Figure 1 shows the location of roads and field trip stops 1 through 3 and Figure 6. shows field trip stops 3 through 5.

ROADLOG

Day 1 Field Trip Guide

Miles

0.0 The field trip begins in Island City at the intersection of Oregon State Highway 82 and Oregon State Highway 237. Proceed west on Oregon State Highway 82, into La Grande. The road follows the gently rising surface of the Grande Ronde River fan-delta.

1.0 The Grande Ronde River enters the Grande Ronde Valley through a canyon at 1:00 that has been cut through an uplifted block of older volcanic rocks. The uplifted block is bounded by the West Grande Ronde Valley Fault Zone (WGRVFZ) forming a warped escarpment that rises to both the north and south. At 2:00, the northern segment is capped by Mt Emily, a 13.4 million year old flow of dacitic lava.

2.2 The WGRVFZ is a complex structural feature that is made up of many smaller paralleling and intersecting faults. Some of the structural blocks between fault strands have been tilted toward the valley. Note the steep eastward dip of the andesite flow at 12:00.

The andesite flow is part of the Powder River Volcanic Field (PRVF) and overlies olivine basalt flows that nearly everywhere mark the base of the PRVF. The unstable contact between the olivine basalt flows and underlying Grande Ronde Basalt Formation flows is highly susceptible to mass wasting by landslides. Note the timbered hummocky ground at 10:00 that denotes a landslide deposit.

2.3 Cross under railroad bridge. The first two deep artesian wells at La Grande were drilled by the Union Pacific Railroad. Both wells penetrated about 200 ft of coarse gravels before entering a 600+ ft thick section of older lake sediments. Our interpretations of the driller's logs indicate that both wells penetrated about 500 ft of PRVF flows before encountering productive artesian flow in the underlying Grande Ronde Basalt Formation.

These water wells are presently a source of concern. They have apparently acted as entry points into the regional groundwater table for diesel spillage from the rail yards and adjoining facilities.

2.4 Turn right at traffic light onto Oregon State Highway 30, and drive through downtown La Grande. Many of the older brick and stone buildings would probably not fare well in a sizable earthquake. Much of the brick came from a local brick plant that operated in the 1920's.

3.0 Follow Highway 30 as it turns to the left and heads toward the western escarpment. WGRVFZ crosses between here and escarpment at 12:00.

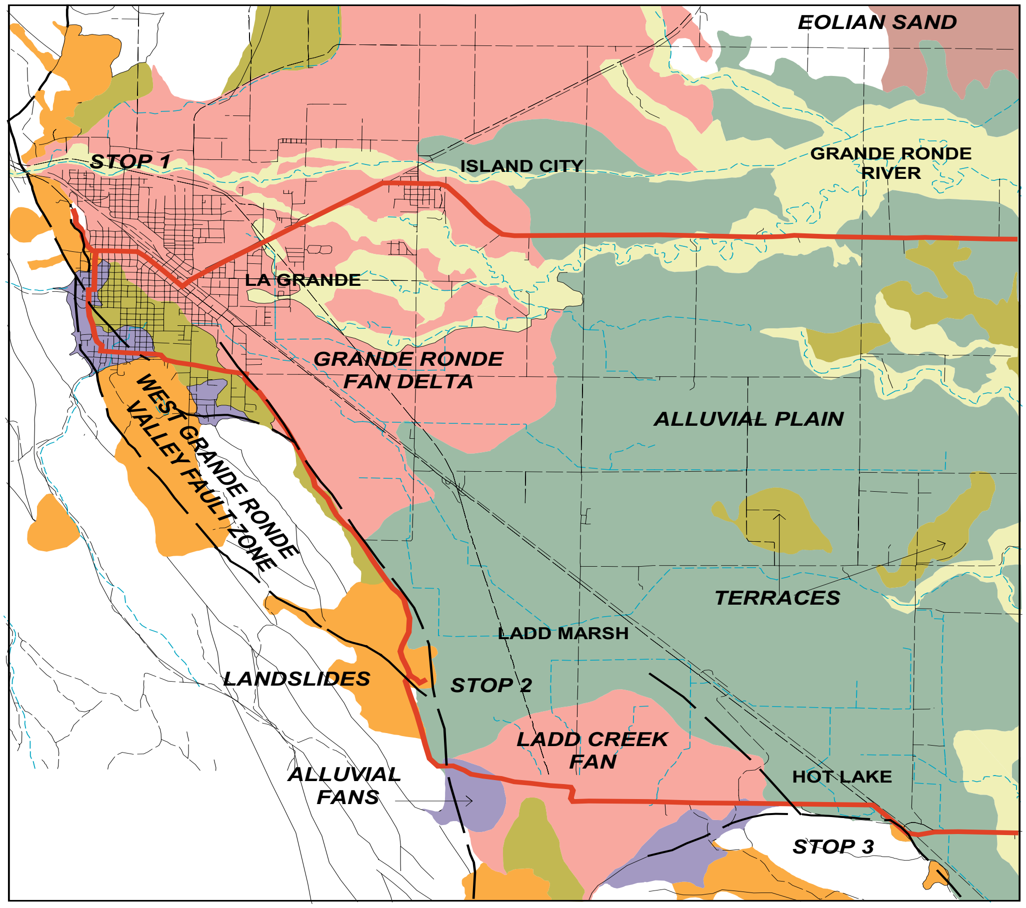


Figure 1. Surficial geologic map of the La Grande area showing Field Trip Stops 1, 2, and 3.

Figure 2. View of West Grande Ronde Valley Fault Zone (WGRVFZ) looking from above the railroad yards. Dashed line marks a fault that separates landslide deposits from Columbia River Basalt bedrock.

3.4 Continue on Highway 30 as it swings right and climbs off the Grande Ronde fan-delta up onto an old terrace. Subtle inflections in the terrace surface immediately to the left have been suggested as evidence for Recent surface ruptures. The evidence is somewhat questionable due to the mantling effects of the overlying landslide deposits.

STOP 1

3.8 Pull off of Highway 30 into the Gangloff Park overlook. You are standing on a terrace that extends south from here, past Eastern Oregon University, and along Foothills Road. This site provides an excellent vantage point to look at several types of geologic processes that present challenges to the City of La Grande. An exceptionally well-developed debris flow lobe enters the valley to the north across the Grande Ronde River. More subtle landslides bury the upslope side of the terrace to the west. Although these slides obscure the trace(s) of the West Grande Ronde Valley Fault Zone here, "Z" shaped steps along fault traces to the north and south strongly suggest surface rupturing events during the past 10,000 years. Cursory studies to date, based on strike lengths and possible vertical offsets, indicate that the WGRVFZ should be considered capable of generating a magnitude 7.0 earthquake.

Figure 3. View of WGRVFZ where it cuts through behind the Grande Ronde Hospital. Note the block of PVRF andesite tilting toward the valley on the skyline to the right.

Turn left onto Highway 30 and proceed back down the hill toward La Grande.

4.1 Look for subtle break in the terrace surface to the right; this may be evidence of surface rupture.

4.4 Turn right off of Highway 30 onto Walnut Street, following the signs toward the hospital.

4.8 Turn right onto "N" Street. Note the small canyon at 12:00. Although the canyon drains only a small area, historic heavy rains have generated small flash floods and debris flows.

4.9 Turn left onto Alder Street, and proceed south past the hospital. Note the topographic contrast between the steep escarpment behind the hospital, the hummocky surfaced landslide deposits and alluvial fan deposits that the hospital sets on, and the flat terrace to the east. Also, note the steeply dipping andesite flow upslope.

5.3 Turn left onto "C" Street. Note the toe of a major landslide that is visible to the right. Published maps showing the extent of landslide hazards in La Grande have been publicly available since 1971. Note the large, recently excavated landslide boulders in the landscaping on the right. "C" Street continues east to merge into Gekeler Lane as it skirts the toe of the slide.

6.7 Turn right off of Gekeler Lane onto Foothill Road. Foothill Road drops off the terrace onto the edge of the Grande Ronde River fan-delta. The terrace surface is marked by linear topographic inflections that may indicate an active fault. It is not clear just how old the terrace is; a mammoth tooth recovered from loess atop the terrace at the Eastern Oregon University campus yielded a radiocarbon date of about 15,000 years BP.

7.2 The terrace gravels are exposed in the gravel quarry to the right. Lava flows in the hill behind the terrace dip steeply into the valley.

The valley-fill sedimentary section is thicker in the valley just to the east of here than it is in La Grande. The municipal well drilled by the City of La Grande 0.7 miles to the east penetrated 530 ft of gravel and sand. We consider these sediments to be part of an ancient Grande Ronde River fan-delta.

7.6 Foothill Road climbs onto a series of small alluvial fans that here appear to mantle an older terrace surface. The small alluvial fans lap onto the alluvial fan-delta gravels. The line of springs here likely marks the trace of WGRVFZ faults.

9.0 Here the fringing fans overlap the fine-grained silt, clay, and sand that mark the modern alluvial plain facies. These are lacustrine and marsh deposits exposed after the valley had been drained by the State Line Ditch. Ladd Marsh, to the south, is about all that remains of these once extensive shallow lakes and marshes.

9.9 Coarse blocks along the road here are part of a large debris flow deposit.

10.5 Turn left into the Ladd Marsh overlook. Coarse blocks are part of an old debris flow.

STOP 2

10.7 Ladd Marsh overlook

The overlook lies on the partially eroded

Figure 4. View to the west of the pipeline corridor that runs through a large landslide and debris flow complex. This is the route for natural gas, telephone, and fiber optic lines. The landslide buries the southern trace of what appears to be one of the more active faults in the area (dashed line).

remains of an extensive debris flow. Note the large black boulders of basaltic andesite. They are from a series of flows that mark the top of the PRVF in this area. Debris flow and landslide deposits obscure the trace of what appears to be an active fault that enters the valley south of here. The landslides may have been generated by earthquakes.

Alluvial fans, landslide and debris flow deposits, and tilted and faulted bedrock make for complex landforms to the south. The large, well-formed fan at the mouth of Ladd Creek wraps around a slightly elevated terrace.

Ladd Marsh is visible to the southeast. Although the marsh is part of the modern alluvial plain, water well drill logs indicate that the marsh may be underlain at shallow depth by alluvial fan-delta facies gravels and sands. The alluvial plain is bounded on the south by east-northeast trending faults.

10.9 Turn left and head south on Foothill Road.

11.2 Note rounded appearance of coarse fan gravels where Foothill Road crosses onto a small alluvial fan

12.2 Large angular clasts appear on the surface of the fan here. These may be the downstream remnants of an old debris flow deposit.

Figure 5. View of Ladd Marsh with the Hot Lake fault in the background.

12.6 The low terrace riser that comes into view in the foreground at 2:00 is one of the more poorly understood geomorphic features in the valley. It appears to be an erosional remnant of an older, once more extensive terrace. The top of the terrace, at an elevation of slightly over 2,900 ft is only slightly higher in elevation than the terraces at La Grande. It is unclear whether these terraces are all about the same age and mark the high stand of an old lake system; or whether they are of different ages and have been disrupted by movement along the WGRVFZ.

12.8 Continue east on Foothill Road across the I-84 overpass.

13.0 Turn right onto Pierce Road.

13.1 Turn left onto Hot Lake Road. The road crosses the Ladd Canyon alluvial fan.

13.5 Coarse fan gravels are well exposed in the gravel pit to the left.

14.2 At least two major faults form the escarpment to the right. The thick PRVF dacite flows sandwiched between the two faults are tilted toward the valley. The faults are obscured by landslide, debris flow, and alluvial fan deposits. Disrupted topography here has been interpreted in the past as a jumbled block “mega-breccia”. The mega-breccia may be a surface feature formed by downslope movement of large block landslides or a more deeply seated feature formed by valley-side rotation of bedrock slices between closely spaced faults.

15.0 Hot Lake Road drops abruptly off of the

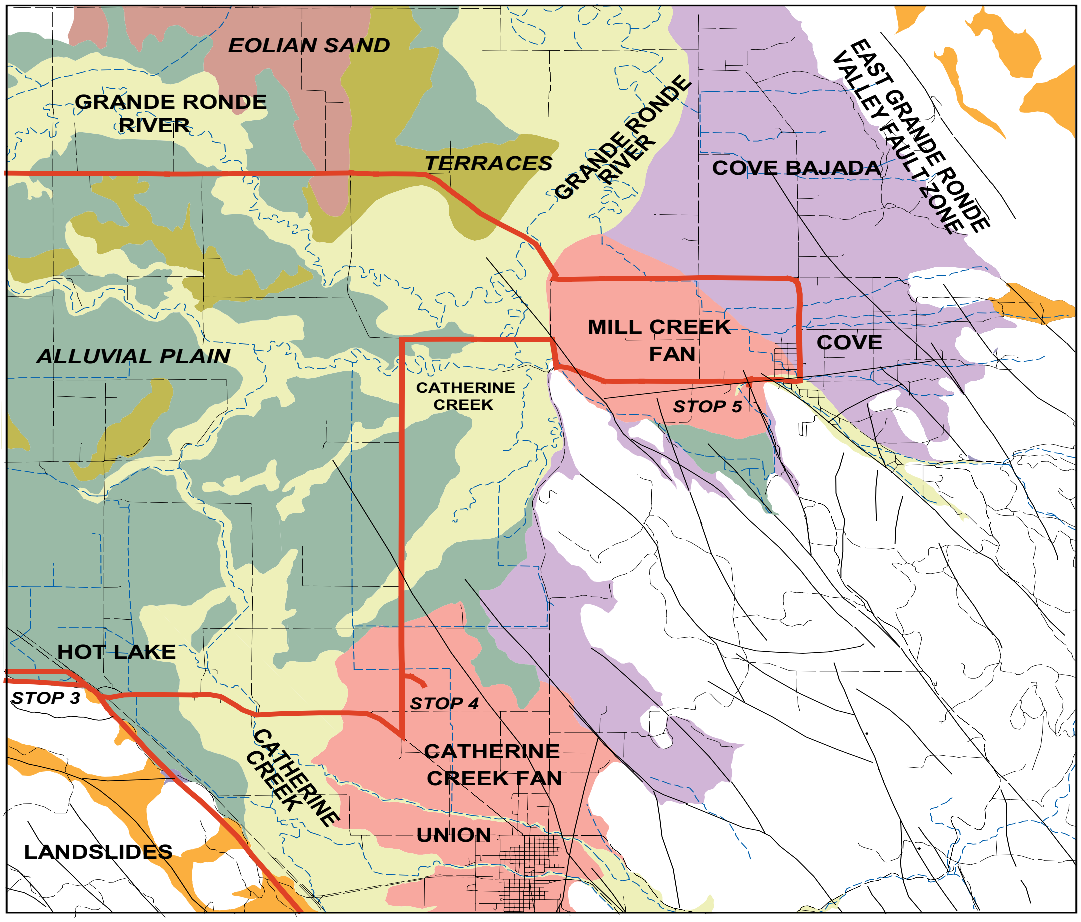


Figure 6. Surficial geologic map of the La Grande area showing Field Trip Stops 3, 4, and 5.

fan surface onto the alluvial plain sediments. Abrupt break in the surface here may mark the trace of an active fault that trends out into the valley.

15.5 Note abrupt change in slope along the north side of the Hot Lake escarpment. The escarpment here is very steep and is in direct contact with the alluvial plain sediments. Alluvial fan and terrace deposits are noticeably absent.

15.9 Turn right at intersection and head southeast on Highway 203.

STOP 3

16.6 Hot Lake Overlook Hot Lake is fed by artesian thermal springs that reportedly flow between 170 and 1,700 gallons/minute at a temperature of 180°F. The hot water appears to be coming up along the Hot Lake fault. The sharp westward bend in the mountain front behind Hot Lake suggests that the springs may be coming up in a zone of intersecting faults.

Hot Lake has been the focus for geothermal studies in the past. A 2,929 ft deep hole was drilled about one mile south of here by Magma Energy in 1974. At that time, thermal waters in the valley were thought to mark upwelling zones of deeply circulated water along major faults. The Magma well intersected the Hot Lake fault at a depth of about 1,700 feet. Bottom hole

Figure 7. Catherine Creek valley immediately upstream of Union as viewed from the Union water tower. The flat-bottomed valley here is about one half mile wide and filled with gravels. Catherine Creek runs along the foot of this steep escarpment.

temperature was reportedly 130oF. Interestingly enough, the well passed through about 850 ft of PRVF flows and 150 ft of underlying Grande Ronde Basalt before passing through the fault zone and encountering greenstone basement rocks.

The fault zone along which Catherine Creek enters the Grande Ronde Valley at Union is visible at 12:00.

19.5 Turn sharply left just past the electrical substation and proceed north on Godley Road.

STOP 4

20.2 Union County gravel pit

The gravel pit is situated near the distal edge of the Catherine Creek fan-delta. The upper end of the fan-delta begins where Catherine Creek flows around the edge of northwest-trending fault block at Union.

Irrigation wells in the southern part of the valley draw largely from the distal fan-delta facies gravels. The City of Union municipal wells are the only ones that currently draw from the Grande Ronde Basalt.

Phys Point lies at the northern terminus of the northward plunging ridge to the east. This provides a good vantage point of the ragged, southern margin to the Grande

Figure 8. View of the City of Union and the upper part of the Catherine Creek fan-delta looking northwest from the water tower. Mt Emily forms the skyline in the distance.

Ronde Valley. Phys Point, like many of the other north plunging ridges in this area, is a west-ward tilted fault block that is marked by gently sloping west flank and steep east face.

Continue north on Godley Road.

20.8 Continue north on Godley Road across Woodruff Lane. In 1998, we ran an east-west seismic line across the southern end of the valley along Woodruff Lane. Seismic data indicate that here the valley is underlain by a fault-cut, westward-tilted block of volcanic rock. The depth from the volcanic basement increases from about 450 ft to more than 900 ft where the seismic line ended just north of Hot Lake. Drill logs for a water well on the northeast side of the intersection provided a stratigraphic control point for the study. This well is reportedly 720 ft deep and can produce at 1,800 gallon/minute from bedrock. Lacking geochemical analyses, it is impossible to tell whether the well is producing from the PRVF or underlying Grande Ronde Basalt.

21.3 Continue north on Godley Road across an abandoned channel to Catherine Creek. This old channel continues to the northeast to form Phys Slough.

22.0 Godley Road crosses the projected northern extension of the Little Creek fault near here. The Little Creek fault runs along the east side of the first ridge north of Union and appears to continue into the valley where it truncates the east edge of the Catherine Creek fan-delta.

24.0 Continue north on Godley Road across active Catherine Creek channel. Note the small oxbow pond just to the north. Oxbows, cutoff meanders, and "drunken" meanders are typical features of slow-

Figure 9. View of the Cove bajada and East Grande Ronde Valley Fault Zone (EGRVFZ). Note the gently dipping surface of the coalescing fans than form the bajada.

moving, low gradient streams.

24.3 Turn right on Gekeler Lane; proceeding east toward Cove. The high point to the east is 7,153 ft high Mt Fanny, which is capped by 11.8 million year old PRVF dacite flows. On the west side of the Mt Fanny escarpment dacite flows are underlain by PRVF olivine basalt flows, which support well-timbered hillsides. Changes in vegetation closely correspond to the contact with the underlying Grande Ronde Basalt flows, which form bare grassy hillsides. The contact between the olivine basalt flows and underlying Grande Ronde Basalt flows is in many places unstable and often forms landslides. Small, ice-carved cirques or nivation hollows visible on the south face of Mt Fanny are part of the glacial complex that provided stream flow to Mill Creek.

25.8 Turn right (south) on Phys Point Road. Here the road follows the edge of the Mill Creek fan. Note the sharp east face of Phys Point. Many of the ridgelines along the valley's southern margin have an asymmetric form. The ridges are tilted fault blocks with a steep east face on the faulted side and a more gently dipping west slope on the tilted side.

26.2 Take the sharp left turn onto Oregon State Highway 237, head east toward Cove.

Note the asymmetric ridge between here and Cove.

28.2 Turn right onto Hidden Valley Road.

STOP 5

28.3 Overview of Mill Creek fan. Modern Mill Creek has incised a channel into the coarse boulder gravels that make up the Mill Creek fan. The present-day stream does not appear to have sufficient energy to move these large boulders

Return to Highway 237

28.4 Turn right on Highway 237, proceeding into Cove. Most of Cove sits on a coarse, thick apron of alluvial fan gravels that have been draped around faulted bedrock highs.

Turn left into the Ladd Marsh overlook. Coarse blocks are part of an old debris flow.

28.9 Follow Highway 237 as it makes a sharp left hand turn to the north. The Cove warm springs are located just south of this point. The thermal waters appear to be coming up along a northwest-trending fault.

30.0 Highway 237 crosses onto on the Cove bajada. A bajada is a sloping surface made up of coalescing alluvial fans. Here they are forming off the East Grande Ronde Valley Fault Zone (EGRVFZ). It is very difficult to tell where one fan begins and another ends.

30.1 Bear to the left at the intersection and proceed west toward Island City.

32.6 Bear right and continue westward toward Island City.

32.9 Highway 237 crosses the Grande Ronde River. Note fine-grained nature of sediments exposed in the channel. The confluence of the Grande Ronde River and Catherine Creek is about 0.6 air miles upstream (1.2 miles of channel).

33.6 Highway 237 crosses onto a small terrace that stands above the modern alluvial plain. Similar terraces to the southwest are capped by sand and fine gravel. They are apparently remnants of older, higher level of the valley floor that existed before the Grande Ronde River cut into the andesite rim at the northern outlet to the valley.

35.2 Rolling hills here are interpreted as wind-blown silt and sand deposits.

36.0 Highway 237 crosses the Grande Ronde River. This is part of the last meandering channel. Again note the fine-grained alluvial plain sediments exposed in the river channel. Much of the water in the river is diverted north of here through the State Ditch, an eight-mile-long canal that aids in draining the water from a large area north of Hot Lake. The ditch bypasses about 40 miles of meandering channel.

38.6 Road crosses the Spring Slough, one of the old meander channels to the Grande Ronde River.

41.9 Highway enters Island City. The highway crosses onto the distal edge of the Grande Ronde River fan-delta. Before the State Ditch was dug, floodwaters would back up the old channels, forming a large shallow lake and isolate Island City. The increased gradient that the State Ditch provides has converted this reach of the Grande Ronde River from a slow moving meandering stream to a channel cutting, headward-eroding stream.

Northern and Eastern margin of the Grande Ronde Valley and the Indian Creek drainage

Day 2's field trip focuses on two different geologic themes: 1) Constructional landforms related to the formation of the Powder River Volcanic Field (PRVF) and the Columbia River Basalt GROUP (CRBG) and 2) Destructional landforms produced by periglaciation and glaciation of the Mt Fanny plateau. The north and east highlands of the Upper Grande Ronde River Watershed Basin are composed primarily of Miocene aged and younger volcanic rocks that issued from vents and volcanoes located in northeast Oregon. The CRBG lavas erupted onto a landscape of deeply incised valleys in granite and metamorphosed oceanic volcanic rocks and sediment. The younger PRVF lavas were erupted onto the only slightly eroded and weathered CRBG after a hiatus of volcanic activity of only 1 to 1.5 million years.

The Mt Fanny plateau is an informal name that we have given to the broad, north-sloping uplands that form the eastern boundary to the Grande Ronde Valley. The plateau is bordered on the east by the deep Minam River canyon and on the west by the escarpments of the Eastern Grande Ronde Valley Fault Zone (EGRVFZ). The plateau is capped by lava flows of the PRVF and it encompasses the north-flowing Indian Creek drainage basin. As the field trip travels up Indian Creek, it provides a view of a glacial outwash plain up through a landslide-scarred, stream-cut canyon, proceeding past active boulder streams and landslides, and finally up onto an ice-carved plateau. Figure 1 shows the location of roads and field trip stops 1 through 8.

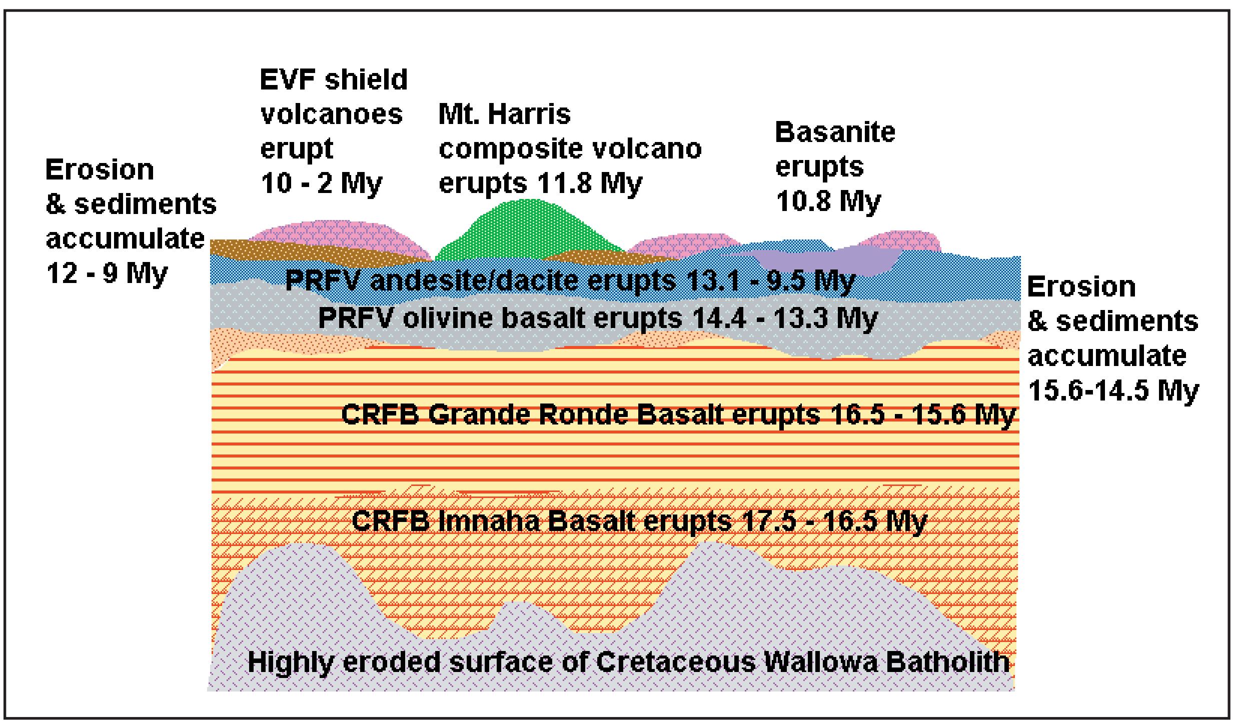


Figure 10. Stylized view of the geologic history of the field trip area over a period from approximately 18 to 2 million years.

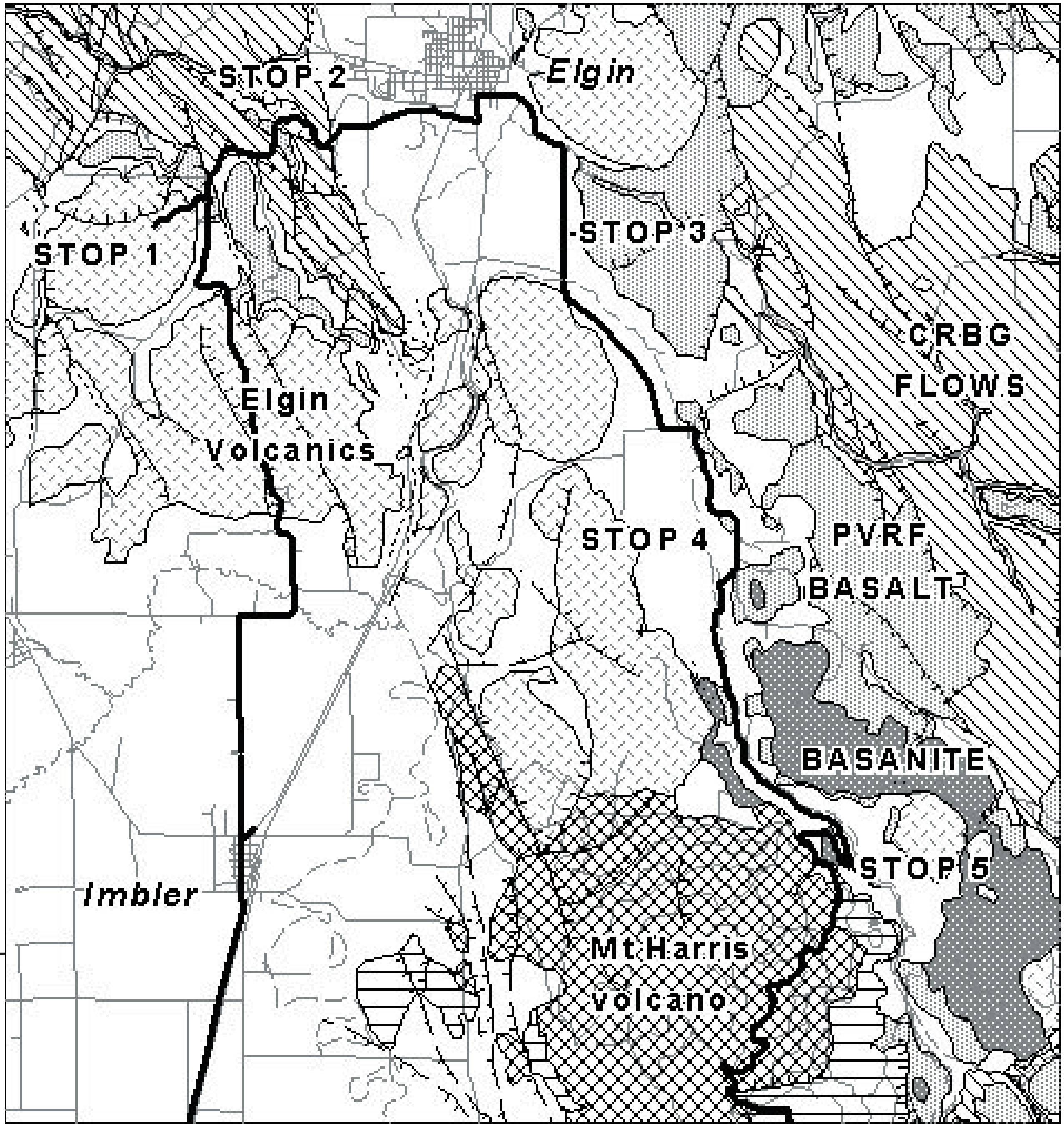


Figure 2. Geologic map of northern Grande Ronde Valley and eastern Highlands. Map also shows location for Field Trip Stops 1, 2,3,4, and 5.

ROADLOG

Day 2 Field Trip Guide

Miles

0.0 Trip begins at Island City, intersection of OR State Highways 82 and 237

The Field Trip begins by driving north from Island City on Oregon State Highway 82. The highway crosses the Grande Ronde River and turns to the northeast at the edge of town. The road follows the gently eastward sloping surface of the Grande Ronde River fan-delta. The coarse and well-washed gravels and sand at the distal edge of the fan are both an important shallow aquifer and rock material resource.

1.0 The EGRVFZ separates Quaternary surficial deposits from the Miocene lava flows that form the steep escarpment in the distance. The high point along the escarpment at 11:00 is Mt Harris, whose summit stands at 5,357 ft elevation. Mt Harris is an 11.8 million-year-old composite volcano that sits atop a northwest dipping surface of Grande Ronde Basalt.

3.2 The highway swings to the north and climbs onto Sand Ridge. The shallow rolling hills that make up the Sand Ridge are old sand dunes that stand above the modern alluvial plain of the Grande Ronde River.

Much of Sand Ridge is irrigated by deep wells that tap a deep artesian aquifer in the buried Grande Ronde Basalt Formation. Well cuttings recovered from recently drilled wells provide important information about which geologic units are the source of the water. Distinctive rock chemistries enable us to "fingerprint" different flows and correlate them with chemically similar lavas in the adjoining highlands.

5.9 Old town site of Alicel. A 3,050 ft deep well drilled 0.6 miles northeast of Alicel reached the top of the volcanic basement at a depth of 1132 ft. The well penetrated nearly 1300 ft of lava flows of the PRVF before reaching the top of the Grande Ronde Basalt. Upon completion, the well was reportedly flowing at a rate of 300 gal/min. Water temperature was reportedly 104ºF.
At 3138 ft, Oregon's deepest water well is located on the west shoulder of Sand Ridge, about 1.6 miles to the west of Alicel. This well, drilled in 1998-1999, penetrated 1916 ft of sedimentary fill before reaching the top of the PRVF lavas. The well penetrated about 800 ft of PRVF lava before reaching the top of the Grande Ronde Basalt at a depth of 2700 ft. Upon completion, the well was reportedly flowing 101ºF water at a rate of about 350 gal/minute. The bottom of the well stands at an elevation of about 390 ft below sea level. From a scientific standpoint, this is perhaps the most important well in the valley and has provided a wealth of geologic data on the valley's sedimentary history. A 7.5 million year old ash recovered from 1553 ft depth provides us with the first direct evidence of when the Grande Ronde Valley started to form.

9.4 Mt Emily, at an elevation of 6,110 ft, caps the high escarpment to the west at 10:00. The prominent cliff faces at the summit are formed by a 13.4 million-year-old PRVF dacite lava. The contact between the Grande Ronde Basalt and overlying PRVF units is marked by changes in vegetation and landforms. The Grande Ronde Basalt forms steep, barren ridges where trees are clustered in linear bands indicating the more porous and water-rich flow tops. The top of the Grande Ronde Basalt stands at an elevation of about 5,400 ft. The tree-covered toe of the escarpment is a series of alluvial fans. The WGRVFZ separates the more-gently sloping fan surface from the steep escarpment of Grande Ronde Basalt.

10.4 Town of Imbler. A third scientifically important well is located about 0.6 miles west of Imbler on Hull Road. Drilled in 2000, the well penetrated 412 ft of sediments before reaching a 1,220 ft thick section of PRVF lavas. Upon completion at a depth of 1,905 ft, the well was reportedly

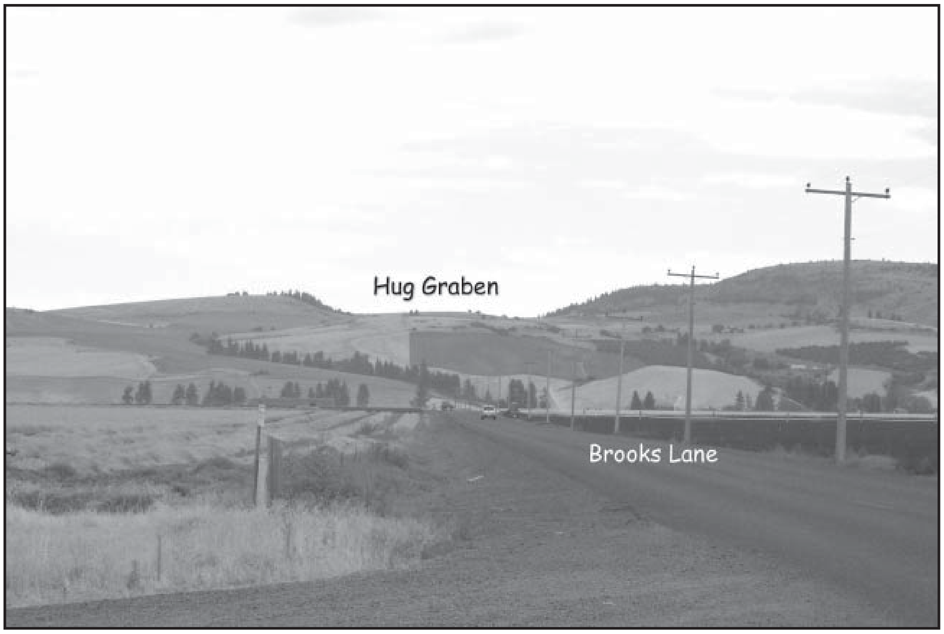


Figure 3. Hug graben as seen looking north from Brooks Road.

flowing at a rate of about 2,000 gal/minute. Pliocene aged ish fossils recovered from a depth of about 450 ft are providing important information regarding the valley's paleoenvironment.

10.6 Leave Highway 82 on north side of Imbler and continue straight north onto Brooks Road. The low hills to the north are some of the small shield volcanoes in what we are calling the Elgin Volcanic Field (EVF). Although part of the larger PRVF, flows from these volcanoes are generally separated from the older, more extensive PRVF flows by poorly consolidated sand and silt.

12.3 Turn right at the "T" intersection onto Courtney Lane, then follow Courtney Lane across Willow Creek and turn left off of the pavement onto the graveled Hug Road. Hug Road climbs onto the silt-covered south side of the EVF. These brown silts are interpreted as wind-blown silt (loess) that was swept up off of the old alluvial plain by north-blowing winds.

Hug Road continues north through a small valley. This is the Hug graben, a small down-dropped block that is flanked by relatively small, northwest-trending faults.

15.5 The low, broad hill in the foreground is the Pumpkin Ridge Volcano, the most distinctive and unusual volcano in the EVF. Although chemical analyses clearly show the lava is a basalt, it contains abundant black amphibole crystals. This mineral is usually associated with more silica rich andesite and dacite lavas.

16.2 At the 3-way intersection turn right onto Pumpkin Ridge Road and continue north through Missouri Hollow. Although the hollow is now largely buried by wind-blown silt, older sediments and lava flows have been penetrated by water wells and are locally exposed in road drainage ditches and dug wells. Some of the sediments that immediately underlie the Pumpkin Ridge volcano are granitic (arkosic) sands. The ridge to the northeast is an upfaulted block of older rock that is capped by an olivine basalt flow that underlies the granitic sands.

17.1 Turn left on the dirt lane, and enter the GROWISER property. We will proceed west through the gate and follow the road to the top of the Pumpkin Ridge volcano.

STOP 1

17.7 Top of Pumpkin Ridge Volcano.

Dr. Andrew Huber, will give a short explanation of the GROWISER project. The highland formed by the volcano acts as a catchment for the eolian material that forms the soil on the hillside. This is a good place to see how the physical geology/geomorphology of an area can determine soil types in other ways than just mechanical and chemical weathering of the substrate.

This is also a good place to begin describing the various parts of the Powder River Volcanic Field. In the northern part of the field, we have small, scattered volcanoes, such as this one at Pumpkin Ridge that, no matter what their chemistry, usually contain black amphibole crystals. These small volcanoes overlie the olivine basalt unit that defines the base of the PRVF. They also lap onto the margin of older and larger volcanoes, such as the one that forms Mt Harris to the south.

Return to intersection of Huber Lane and Pumpkin Ridge Road; turn left onto Pumpkin Ridge Road.

18.8 Bear right at the intersection and continue on Pumpkin Ridge Road (which becomes an unimproved road). Pumpkin Ridge Road emerges from the timbered slope (underlain by unconsolidated sediments) and crosses onto a rocky ridge of Grande Ronde Basalt flows. As we continue east, the Pumpkin Ridge Road crosses two west-northwest-trending faults. The heavily vegetated slope is a deeply weathered and poorly exposed olivine basalt flow that overlies the sedimentary unit between the PRVF and the older Grande Ronde Basalt lavas of the CRBG.

STOP 2

19.4 The sedimentary unit between Grande Ronde Basalt and the PRVF only rarely forms outcrops. Here a lithic ash-flow tuff is exposed in the road cut. It was produced by a large explosive eruption of high silica ash and debris from a rhyolitic vent whose location remains unknown.

We will walk down the road and look at the granitic sands and gravels that apparently underlie the volcanic sediments. “Outcrops” of the intervening sedimentary unit are poor at best and apparent only in road cuts or disturbed ground. To make matters worse, the sediments typically support a lush vegetation and can only be confidently identified by the glitter of mica in the soil.

The unconsolidated nature of the sediments, if overlain by competent lava flows, often leads to impressive landslides. South of this location, along Highway 82 by Rhinehart Lane, eastward dipping EVF andesite lava flows overlie the sediments. The entire ridge is a landslide which requires almost constant road maintenance.

20.0 The Pumpkin Ridge Road descends down across the faulted escarpment of Grande Ronde Basalt that marks the west side of Indian Valley. Low hills lying immediately to the east of Elgin are more of the small shield volcanoes that make up the Elgin volcanic field (EVF). Stubblefield Mountain, which forms the skyline at 12:00, is both the largest and northernmost of these volcanoes. The prominent small butte at the northwest end of Indian Valley to the left is Jones Butte, a Pliocene dacite plug that, at about 2 million years old, is apparently one of the youngest volcanic features in the Upper Grande Ronde River Watershed Basin.

20.9 Turn left onto Hemlock St and continue east past the gravel pit at mile post 21.1. The gravels are part of an older terrace deposit that is now being dissected by the Grande Ronde River and Phillips Creek.

21.9 Turn left (north) onto Highway 82 into Elgin. The highway crosses Phillips Creek, which is normally dry at this time of year.

The builders of Elgin used several local rock types as building stone. The more pink blocks in some downtown buildings were quarried from Jones Butte. The general store is built of blocks of palogonitic tuff breccia mined from quarries east of Elgin. These distinctive yellowish gray breccias were most likely formed by the explosive interaction of basalt magma and water. Such hydrovolcanic deposits typically form maar volcanoes.

22.2 Turn right onto Cedar Street and proceed east, across the Grande Ronde River. Here the banks of the present-day flood plain are visible. Low hill in foreground is one of the small EVF shield volcanoes.

23.2 Turn right onto Cemetery Road and proceed south past the cemetery. The road crosses onto the thick deposit of terrace gravels that extend south along Indian Creek.

STOP 3

23.9 The terrace gravels to the east are well exposed in the rock pit. Large clast size suggests a high energy depositional environment. The clasts are all volcanic rocks that could have easily been eroded from lava flows exposed in the headwaters of Indian Creek. We interpret this gravels to be a to be glacial outwash deposited by Indian Creek during one of the last of the glacial periods.

24.5 Turn left back onto the Elgin Cemetery Road and continue south across Indian Creek.

Low hills to east (11:00) are capped by an olivine basalt flow. Bare rounded hill on the skyline is a 200 ft thick mound of welded spatter that marks a vent complex for the last Grande Ronde Basalt flows to be erupted in this area. The hill is flanked by the hydrovolcanic deposits that have been quarried for use as building stone in Elgin.

26.2 Turn left onto Indian Creek Road and cross the outwash plain of Indian Creek. Note the exceptionally coarse gravels deposited in Indian Creek, a result of glacial melting further up the creek during the Pleistocene.

Follow the road to the right (south). The light yellowish gray and brown outcrops along the road are hydrovolcanic deposits. Mafic hydrovolcanic deposits such as these are often described as palagonite breccias due to their yellowish color. Palagonite is altered basaltic glass that forms when the hot magmas are rapidly quenced due to interaction with water or ice. Palagonite is usually a good sign of water-magma interactions.

STOP 4

27.5 Here one of olivine basalt flows that that mark the base of the PRVF is very thin and pillowed. The pillow structure indicates that the lava flowed into water. This is one

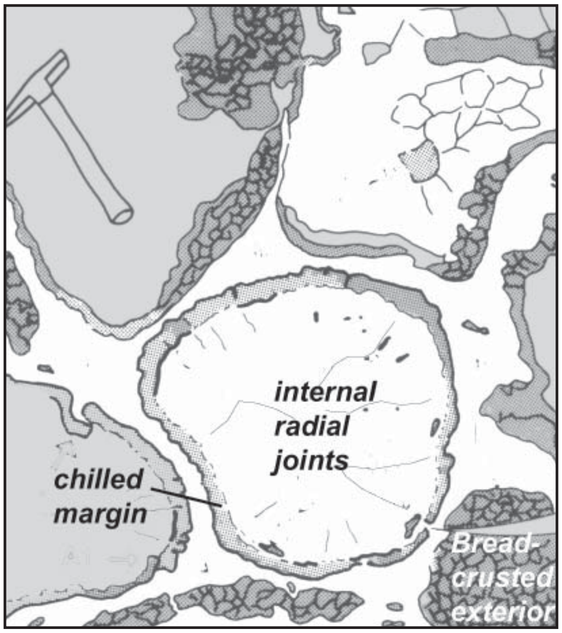


Figure 4. Cross-section of the front of a pillowed basalt flow. As the flow is emplaced in water the exterior rapidly chills to a glass and frequently crazes. The interior must still expand, as volatiles are still degassing from the lava, forming radial joints and a breadcrusted exterior.

of the better examples of a pillow lava to be found anywhere in eastern Oregon.

The pillow basalt flow lies atop the hydroclastic breccia. Both volcanic deposits indicate this area was quite wet during the middle Miocene, about 14 million years ago.
Continue south on Indian Creek Road, bearing right at the intersection of the Shaw Creek Rd. and Indian Creek Rd. at MP 27.9. Note the coarse boulder gravels that form a low outwash terrace along the west side of Indian Creek.

Here Indian Creek has cut down into some hydrovolcanic deposits at the top of the Grande Ronde Basalt. The olivine basalt unit becomes several hundred feet thick to the south. The thickened olivine basalt unit forms a basal platform to the thick andesite and dacite lava flows that make up the bulk of the PRVF to the south.

30.5 Bedrock units in the lower Indian Creek canyon are largely buried by old landslide and talus deposits. The landslides most commonly occur where poorly consolidated sedimentary interbeds at the top of the Grande Ronde Basalt have been exposed in stream canyons and on faces of uplifted fault blocks. Massive landslides are most notable where the interbeds are capped by thick lava flows.

31.2 A basanite lava flow forms the dark cliff faces along the rim at 11:00. The 10.8 million-year-old basanite flow is an exceptionally low silica lava that erupted following the build up of the Mt Harris and other volcanoes in the central part of the PRVF. Here the basanite flow is a classic example of inverted topography. What is now a flat topped ridge was once a canyon. The basanite lava flowed down an old canyon whose walls have been eroded away.

31.9 The same basanite lava flow forms the outcrops at 3:00.

32.1 Turn left onto the more poorly traveled gravel road. Road to the right accesses the north flank of the Mt Harris volcano.

STOP 5

32.6 This is a good place for an overview of the basanite flow to the east. Note the extensive talus apron at the base of the flow. Intercanyon flows can sometimes be traced upstream to their source vents. The mapped out pattern of this flow indicates that it flowed in a northwesterly direction from vent complex(es) located to the south.

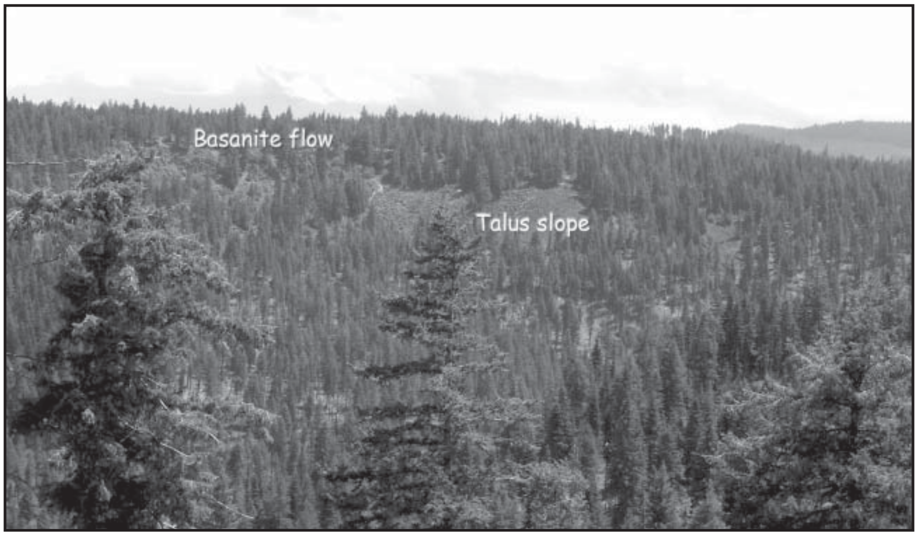


Figure 5. Basanite lava flows form distinctive scarps.

The combination of channel-filling intercanyon lava flows and constructional vent complexes often makes volcanic stratigraphy challenging. There is always the question of whether that high point that you are looking at is a volcano or the eroded remains of an old lava filled stream channel. Volcano stratigraphy can be even more complicated when still younger volcanoes erupt atop the channel-filling flow. The timbered covered high point between the basanite-capped benches is a hornblende-bearing andesite that resembles the shield volcanoes near Elgin. Question, is this an older, small shield volcano that the basanite flowed around, or is it a small shield volcano that erupted onto the basanite flow?

Generally speaking, the more silica poor flows (basalt and basanite) tend to travel further from their source vents and are thus more likely to fill downslope channels. More silica rich lavas (andesite and dacite) tend to mound up at their source vents and form a constructional volcano like Mt Harris. However there are always exceptions to the rules. The platy dacite that we are standing on is part of a large and laterally extensive andesite and dacite lava field that forms a broad platform atop the olivine basalt flow. Rather than mounding up at their source, these lavas were relatively fluid and flowed laterally for many miles.

Continue south to mile post 34.1. The black platy lava that forms the base of the Mt Harris volcano is well exposed in the rock pit to the right. The lava is a high silica andesite.
The Indian Creek Road follows the edge of the Mt Harris Volcano where the typical radial drainage off the composite volcano forms a scalloped topographic pattern.

35.6 Follow the Indian Creek Road as it bears to the left. Right hand fork goes to the top of Mt Harris. A dacite spine at the top of Mt Harris is a remnant of the lava that plugged the vent and the source of the 11.8 My radiometric age.

37.1 The EGRVFZ forms the east flank of the Grande Ronde Valley, visible at 12:00. A flow-on-flow sequence of thick andesite flows forms the plateau of Mt Fanny, the highest point along this eastern escarpment to the Grande Ronde Valley.

37.7 Olivine basalt to the right forms the base of the PRVF. Although we have come up over 1,000 ft in elevation since we entered the Indian Creek valley, we are continuing to closely follow the northward dipping contact between the Grande Ronde Basalt and PRVF.

38.6 Turn left onto USFS Road 62 and head southeast toward Point Prominence.

39.0 Olivine basalt flows are exposed along the road to the right. This basal unit to the PRVF is as thick as 300 ft in this area. Recall that the olivine basalt flow at STOP 4 was no more than 3 ft thick

Gasset Bluff, a thick accumulation of basaltic andesite and andesite flows, forms a prominent high point to the south of here. As these flows are limited to that area, we suspect that their source lies at or near Gasset Bluff.

39.6 The light colored soil along the road here is probably derived from the sedimentary interbed that separates the olivine basalt from the underlying Grande Ronde Ba-

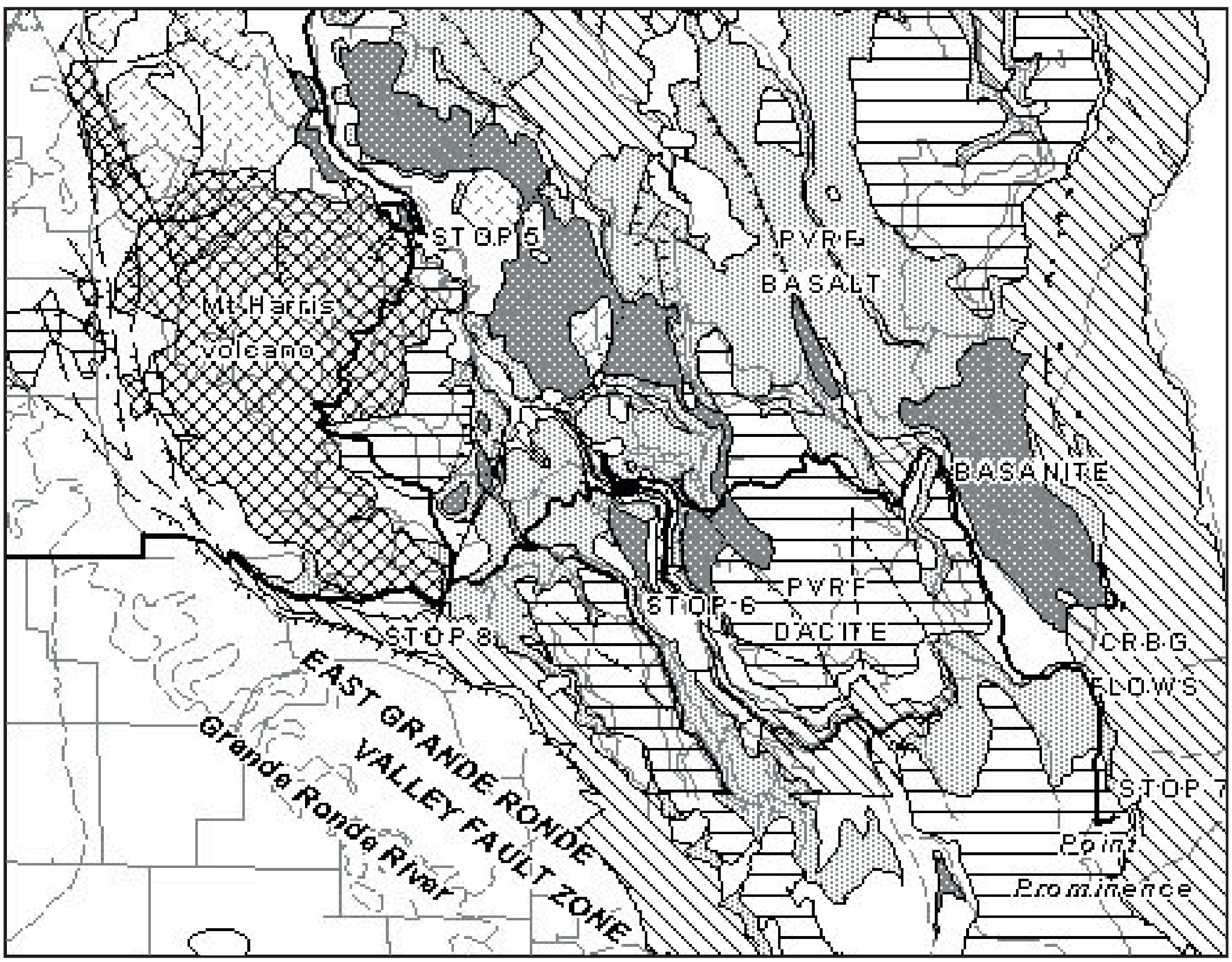


Figure 6. Geologic map of the north Mt. Fanny plateau showing Field Trip Stops 5, 6, 7, and 8.

salt. The low relief, frequently hummocky, topography that we see here is typical of areas that are underlain by sediments.

The unusually thick olivine basalt section suggests that the map unit here includes several olivine basalt flows that are separated by thin sedimentary interbeds. Driller's logs show thin sedimentary interbeds in the olivine basalt unit beneath the Grande Ronde Valley.

39.8 Grande Ronde Basalt flows are exposed along the road to the right. .

39.9 Bear left after crossing the fork of Little Indian Creek. Rounded outcrops in the road cut here are typical of weathered olivine basalt. Note the light colored soils that typically overlie the olivine basalt unit.

41.0 Thick light colored soil in the road bank here appears to be at least partially derived from the sediments that separate the PRVF from the underlying Grande Ronde Basalt.

41.4 Brush and springs here mark the contact between olivine basalt and underlying Grande Ronde Basalt

41.8 Turn right after crossing Indian Creek. The road follows Indian Creek upstream.

42.1 Basanite outcrops above are the source for the prominent talus slope at 2:00. Note the broad valley that Indian Creek forms to the south.

STOP 6

43.0 We will walk from here to look at some periglacial features. Coarse blocks of basanite derived from the shear cliffs above have "flowed" down the hillside to rest here beside a deposit of poorly sorted rock

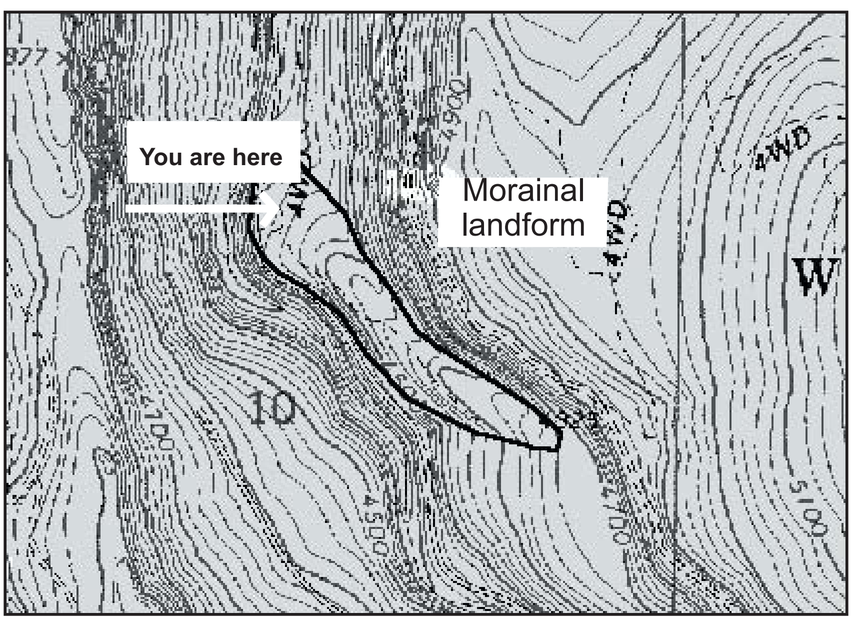


Figure 7. A moraine landform can resemble the linear ridge-like shape above. The landform is characterized by nonsorted and generally unstratified deposit of glacially transported material (drift). This feature is composed of boulders and cobbles of basanite and olivine basalt in a sandy soil matrix. But is this a moraine?

and soil. The boulder stream has detached from the talus slope above. They are generally free of vegetation, possibly due to slight continued movement that prohibits soil buildup or storage of water.

The vegetated linear landform to the right has the topographic features of a lateral moraine (see map insert of Figure 7) but is quite far down the Indian Creek valley and at a low elevation for moraines. It contains very poorly sorted basanite and olivine basalt boulders in a sandy soil matrix. It is best viewed along the road south of the pull-off.

46.1 Red-weathering rocks here are basanite float boulders that are intermixed with light colored, probably sediment-derived, soils. It is quite probable that the basanite buried some stream sediments as it filled the original canyon.

46.7 The edge of the large andesite flow here is typically marked by large, disoriented boulders and blocks. We think the large blocks form where the andesite flow overlies a poorly consolidated sedimentary interbed.

47.5 The platy andesite forms massive outcrops along both sides of the road here. We are still not sure whether this andesite is one of the extensive flood andesite flows that underlie the basanite to the south or whether it is a younger flow that erupted onto the basanite. The broad uplands immediately to the south may mark thickening of the flow around its source vent.

48.2 The dark cliffs and blocky talus at 10:00 are typical of the basanite flow. Road follows the upper part of Clarks Creek and crosses a thick andesite lava flow.

49.0 Road crosses a series of west-side-down northwest trending faults onto the older Grande Ronde Basalt.

49.2 Look for the change in soil color from rust red (Grande Ronde Basalt) to light brown (olivine basalt) as we cross into the overlying PRVF lava. Even though the olivine basalt contains less silica than the Grande Ronde Basalt lavas, its unique feldspar-rich texture and lower iron content cause the lava to weather to a very light color.

49.8 The basanite flow is well exposed on the ridge at 10:00. The road follows the contact between the olivine basalt and the overlying platy andesite.

50.2 Heavily vegetated areas often develop on light colored soils. Here, it is unclear whether these light colored soils are derived mostly from a) the erosion of sedimentary interbeds, b) represent volcanic ash falls from Recent eruptions of Cascade volcanoes such as Mt Mazama, or c) are fine-grained glacial drift. Our close proximity here to the ice-scoured headwaters of Indian Creek certainly makes the glacial drift hypothesis attractive.

50.9 Turn right and continue on USFS Road 62. Note olivine basalt float along road.

53.2 Turn right onto USFS Road 6220. The road is heavily armored with coarse Grande Ronde Basalt gravel quarried from Mt Moriah to the north.

53.3 USFS Road 6220 crosses onto olivine basalt.

53.9 The road continues across olivine basalt. Here the road skirts the eastern edge of the Mt Fanny Plateau before it drops off into the deep, 3000+ ft, Minam River Canyon.

54.3 The road crosses onto a platy andesite flow that here overlies the olivine basalt flow. This is one of the thick platy andesite flows that extend for many miles to the south. These flows are somewhat of a mystery. Lava of this composition really should mound up around the vent areas to make at least moderate sized volcanoes instead of covering a 100 mi^2 or so of countryside with a thick flat-topped lava flow.

55.0 Turn left onto the road to the lookout at the top of Point Prominence (elevation of 6,745 ft). This is a steep and somewhat rocky road and passengers riding in less than robust vehicles may want to wait to be ferried to the top.

STOP 7

55.3 Point Prominence Lookout. We will walk east from here, past the lookout tower, to the vantage point overlooking the Minam and Little Minam Rivers. The andesite flow here is more than 500 ft thick. Note how the andesite is bare of soil and weathers to small angular fragments.

The east flank of the Mt Fanny plateau is marked by the deep canyons of the Minam and Little Minam Rivers. As much as 2,500 ft of CRBG lavas are exposed in the 3,000+ ft deep canyon. The base of the CRBG is marked by the Imnaha Basalt, which unconformably overlies an eroded surface of much older, pre-Tertiary aged granitic and metamorphic rocks. The Imnaha Basalt is in turn overlain by the Grande Ronde Basalt. Poorly exposed olivine basalt flows and exceptionally well-exposed andesite flows disconformably overlie the Grande Ronde Basalt on the west side of the canyon.

Backbone Ridge is a narrow strip of Imnaha and Grande Ronde basalt flows that separates the Minam and Little Minam

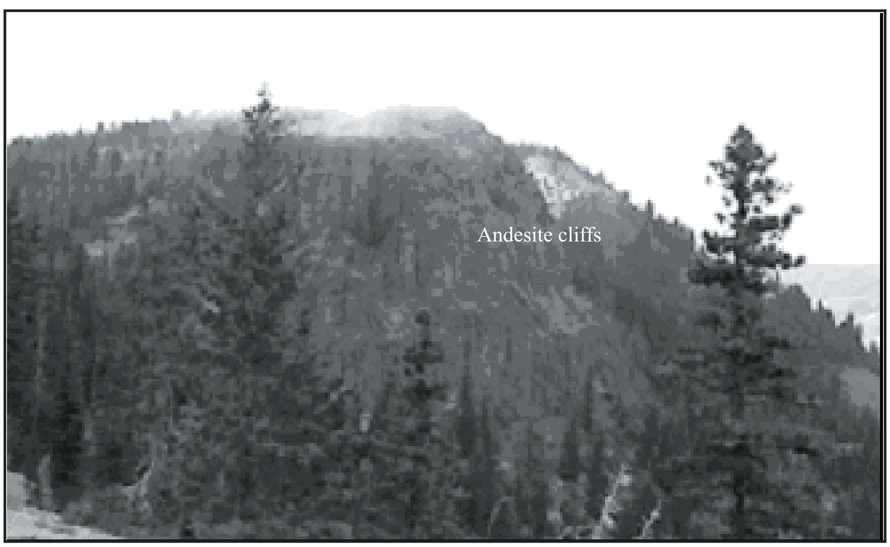


Figure 8. Over 500 ft thick andesite flow forms resistant cliffs at Point Prominence. The andesite sits atop poorly exposed olivine basalt, which in turn sit atop Grande Ronde Basalt. The Imnaha Basalt is exposed in the valley 3000 ft below.

Rivers. The true size of the canyon is apparent when one realizes that Backbone Ridge is more than 1,000 ft high. The base of both the Minam and Little Minam Rivers have been heavily carved by thick valley glaciers. Granitic glacial erratics at the top of the south end of Backbone Ridge indicate that the glaciers were more than 400 ft thick where they merged across the top of the ridge.

Scalloped cliffs to the south in the Big Canyon area mark the headwall cirques. Here precipitous cliffs such as Dunn's Bluff were carved by small alpine glaciers. The high point in the distant to the southwest is Mt Fanny, which stands at an elevation of 7,153 ft. Similar cirques are found hanging above the Grande Ronde Valley along the west side of Mt Fanny.

Note the broad, hummocky tree covered plateau that extends between Point Prominence and Mt Fanny. This is the topographic feature that we refer to as the "Mt Fanny plateau" The rounded bare rock hillocks and intervening boggy swamps provide evidence for ice scouring which indicate that, during the Pleistocene glaciation, the entire plateau was covered with an ice cap that was the source for the Indian Creek glacier.

Retrace steps to the intersection of USFS Rd. 62 and USFS Rd 6220 at mile post 57.4. Turn left onto and proceed toward La Grande.

60.5 Here we can look down onto the summit of Mt Harris to the north. Because the surface of the Mt Fanny plateau dips to the north the summit of Mt. Harris is at an elevation lower than the this site. The road crosses a northeast trending fault that drops down to the northwest.

64.9 Another view of the summit of Mt Harris from the south.

69.3 Continue left at the intersection of USFS Rd 62 and the Mt Harris Loop Road and follow the road as it descends into the Grande Ronde Valley.

69.6 Lava exposed in the rock pit to the right is a basaltic andesite flow that makes up part of the base of the Mt Harris volcano. The lava overlies the olivine basalt flows that mark the base to the PRVF.

69.7 Deeply weathered olivine basalt flows are exposed in the road cuts to the right. The road follows along the top of a broad bench that is underlain by Grande Ronde Basalt. Landslide deposits atop the bench form a hummocky surface marked by springs and large blocks of PRVF lavas.

Topographic benches covered with landslide deposits commonly mark the contact between the Grande Ronde Basalt and overlying PRVF units. The benches are erosional features formed in response to landslides.

70.8 The eastern escarpment to the Grande Ronde Valley comes into view at 8:00. The escarpment is the upthrown side to the EGRVFZ. The abrupt change in slope between the steep faceted spurs and gently slope bajada surface marks the main fault.

STOP 8

71.2 The road has been dropping down into the Grande Ronde Valley atop a westward sloping shelf of Grande Ronde Basalt. Segments of the EGRVFZ separate the shelf from the flat valley floor. The flat valley floor is separated from the fault zone to the south by a southward-rising bajada –a series of coalescing alluvial fans. Hummocky ground atop bajada marks debris flow and landslide deposits.

Note the flow pattern of the Grande Ronde River to the west. The Grande Ronde River enters the valley at La Grande and turns south after reaching the alluvial plain, then east and finally north to circumvent Sand Ridge. At this point, the river forms a complex series of meanders before exiting the valley through the Elgin cut to the north.

71.3 High cliffs to the north are dacite and andesite flows from the Mt Harris volcano. The cliffs have retreated from the bench through headward erosion by landslides.

73.4 An olivine basalt flow is exposed here atop Grande Ronde Basalt flows.

73.5 Underlying Grande Ronde Basalt flows are exposed along the road. Note chaotic land surface formed by the large landslide at 12:00.

73.7 Turn right at intersection onto Grays Corner Road.

74.6 Turn left at the 3-way intersection onto Alicel Lane and head west onto the valley floor.

75.9 The lane crosses the Grande Ronde River. Note fine-grained sediments exposed in the channel. These very fine-grained sediments are typical of the alluvial plain sediments.

76.2 The lane rises up off the alluvial plain sediments onto the wind-blown sands of Sand Ridge.

77.6 Road makes a sharp left hand turn. The Aliscel water well is situated alongside the road to the left. This 3,050 ft deep well reached the top of the PRVF at a depth of 1,132 ft. The contact between the Grande Ronde Basalt and the Powder River Volcanic Field here lies more than 2,400 ft below the land surface at this point.

77.8 Turn right and proceed west through Alicel.

78.4 Turn left at intersection of Alicel Lane and Oregon State Highway 82, proceeding south toward Island City and end of the Field Trip.