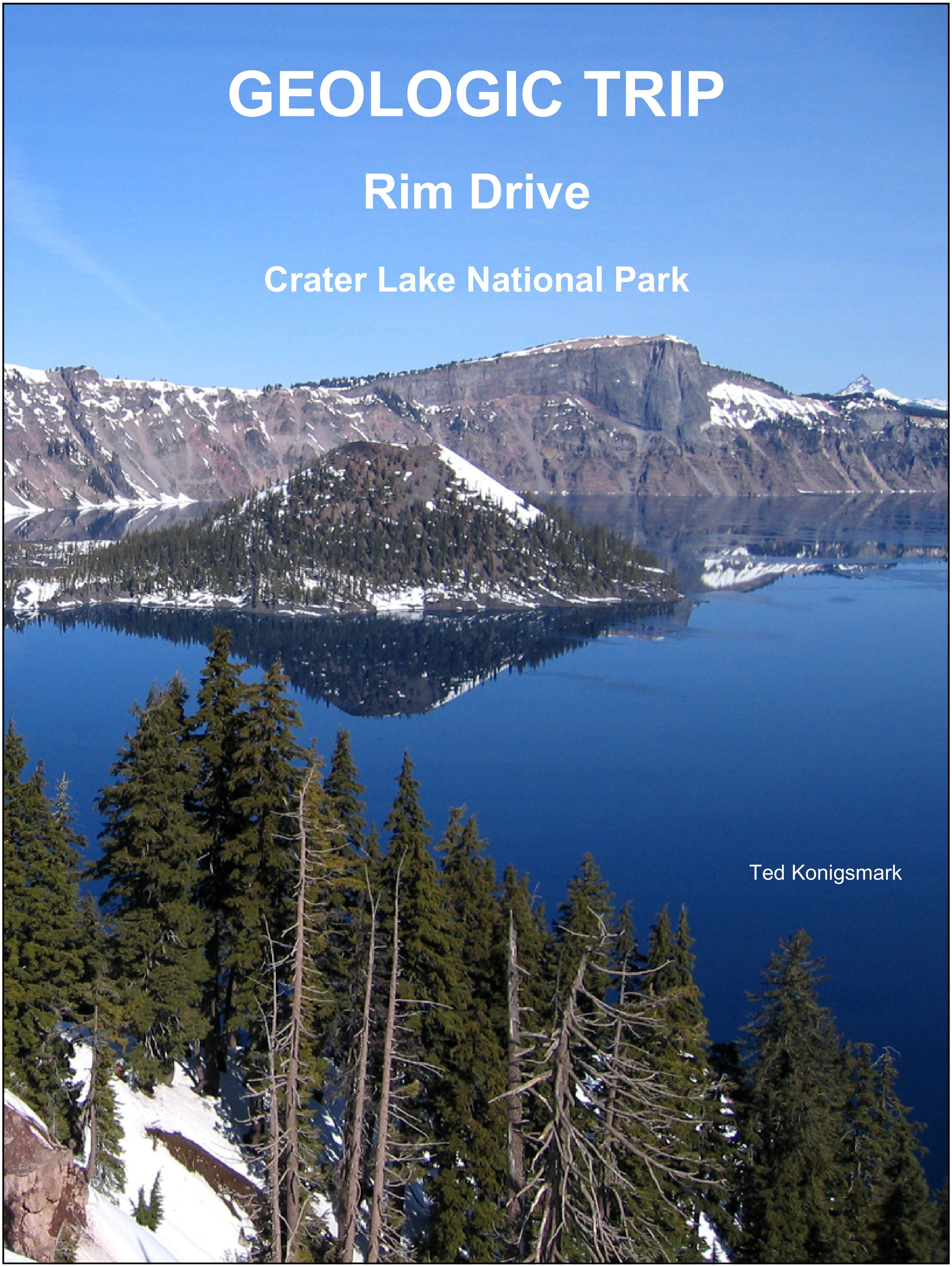
GEOLOGIC TRIP

Rim Drive

Crater Lake National Park



Ted Konigsmark

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GeoPress
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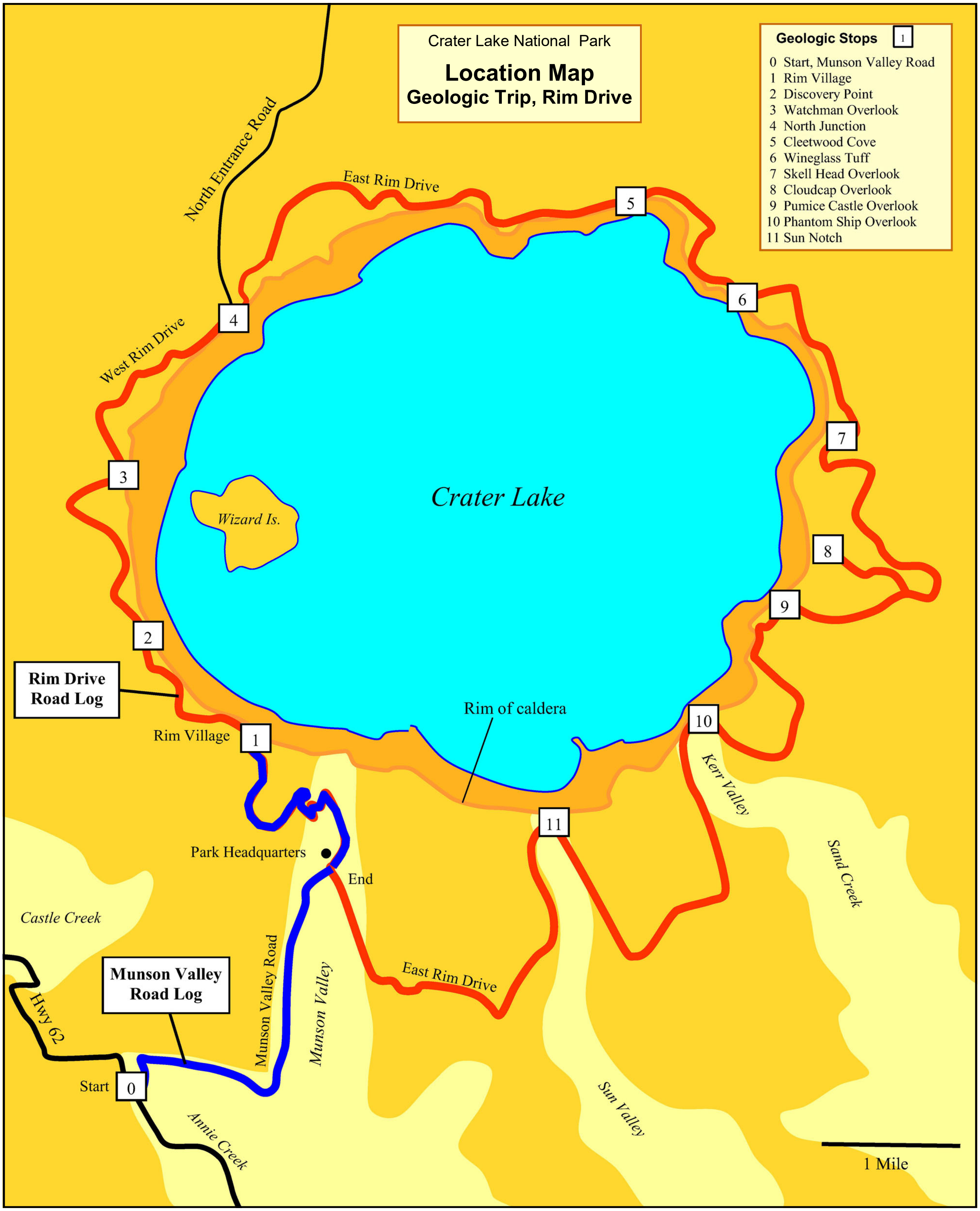
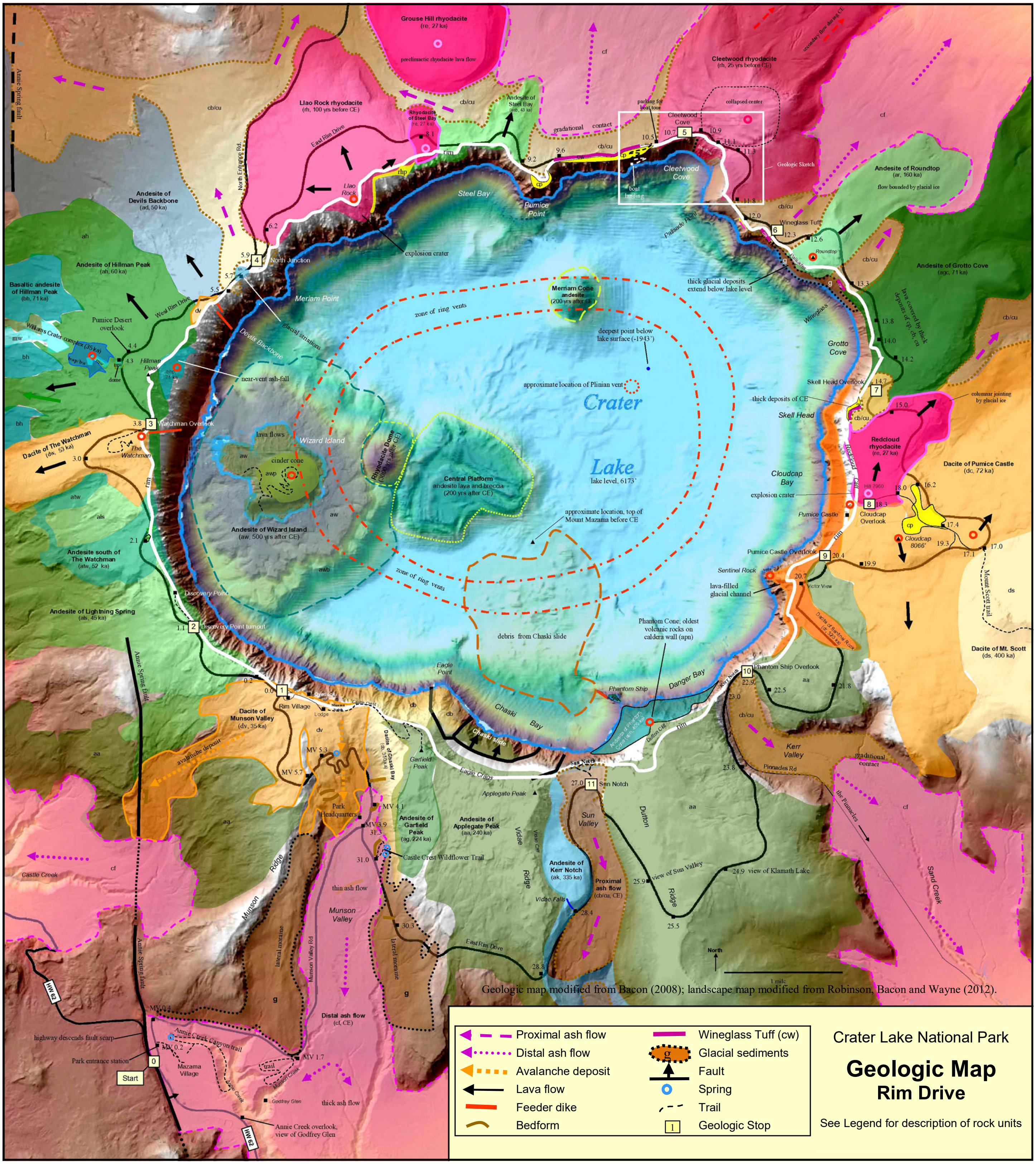
About the Geologic Trip

For well over a hundred years there have been dozens of geologic studies of Mount Mazama and the Crater Lake caldera, and through this work we have a good understanding of how, when, and why the volcano was formed and what might happen in the future. This geologic trip is mainly based on this earlier work, and especially on two recent U.S. Geological Survey reports: *Geologic Map of Mount Mazama and Crater Lake Caldera* (Bacon, 2008) and *Geologic Field-Trip to Mount Mazama and Crater Lake Caldera, Oregon* (Bacon and Wright, 2017). For a good summary of the geologic growth of Mount Mazama, the climactic eruption, and the development of the Crater Lake caldera, see USGS Fact Sheet 092-02. Other reports and web links of special interest are: the National Park Service website for information on roads and park activities; the Crater Lake Institute, a non-profit organization that supports Crater Lake National Park with reports, maps and other information; and a glossary of volcanic terms by the U. S. Geological Survey.

The road from the south entrance to Rim Village is open year round, weather permitting. Rim Drive is closed by snow seasonally, so check road conditions at the Crater Lake National Park website before taking the trip. Collecting or disturbing rock or other natural specimens is prohibited in Crater Lake National Park, except by special permit.



Location Map. The Munson Valley road log begins at the intersection of Highway 62 and Munson Valley Road and ends at Rim Village. You will reset your odometer to 0.0 at Rim Village for the Rim Drive Road Log. This road log travels clockwise around the caldera and ends at the intersection of Rim Drive and Munson Valley Road.



Geologic Map. This map based on and modified from the geologic maps of Bacon (2008) and uses the landscape map from Robinson, Bacon and Wayne (2012) as an underlay to show roads and topography. Surficial deposits of the climactic eruption are not shown except where thick or of special interest.

Legend

Geologic Map, Rim Drive

(ka, thousands of years before present; ya, years ago; CE, climactic eruption)

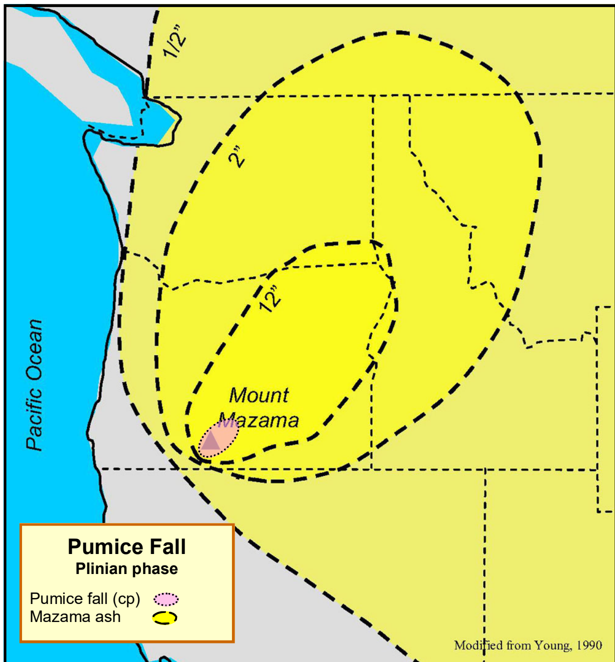
Name and Symbol	Description	Location	~Age
	Crater Lake		
Andesite of Wizard Island (aw, awp, awb)	Andesite cinder cone (awp); andesite lava flows (aw) at base of cinder cone; pillow lavas (aw) in shallow water; glassy breccia (awb) in deeper water.	Stop 3	500 yrs after CE
	Climactic eruption of Mount Mazama		
Proximal ash flow (cu) lithic ash (cb) lithic breccia Distal ash flow (cf)	**Ring-vent phase:** pyroclastic ash flow deposits from ring vents during collapse of Mount Mazama and formation of the caldera. <ins>Proximal ash flow</ins> deposits typically occur within a few miles of caldera. Lithic ash (cu) is light gray fine-to medium-grained crystal and lithic fragments. Lithic breccia (cb) is mainly coarse mafic-rich rocks and andesite scoria in matrix of lithic ash. <ins>Distal ash flow</ins> deposits (cf) occur in mid- and lower sections of glacial valleys; mainly rhyodacite pumice and ash, white to medium gray; deposits up to 300 feet thick. Proximal ash flows grade laterally and downward to distal ash flows.		7,700 ya
Wineglass Welded Tuff (cw)	**Wineglass Welded Tuff** (cw) occurs as pinkish to yellow-brown ledge of welded rhyolite pumice up to 30’ thick in topographic lows on the N and E walls of caldera. The pumice was deposited from pyroclastic flows at the end of Plinian phase of CE and marks end of Plinian phase, beginning of ring-vent phase and the collapse of Mount Mazama. Stop 6		
Pumice fall (cp)	**Plinian phase:** rhyodacite pumice deposited from Plinian cloud during first phase of CE; pink to light orange; bedded with alternating layers of ash fall and ash flow; deposits up to 200’ thick on north and east walls of caldera. Stop 5		
	Mount Mazama		
Cleetwood rhyodacite (rh)	Rhyodacite lava flow (rh); leaked from climactic magma chamber shortly before CE; magma in thick center of flow still molten during CE and “backflow” of this magma into caldera at end of CE.	Stop 5	25 yrs before CE
Llao Rock rhyodacite (rh, rhp)	Rhyodacite lava flow (rh) and ash fall (rhp); early leak from climactic magma chamber; lava fills deep explosion crater below Llao Rock.	Stop 4	100 yrs before CE
Redcloud, Steel Bay, and Grouse Hill rhyodacite (re)	Rhyodacite lava flows from three separate vents— Steel Bay, Grouse Hill, and Redcloud; lava erupted from climactic reservoir before climactic magma fully evolved. Oldest rhyodacite lavas of Mount Mazama.	RD 8.1 Stop 9	27 ka
Williams Crater complex: (bwp/bw) (mw)	Williams Crater complex includes regional cinder cone of basaltic andesite (bwp), lava flows of basaltic andesite (bw), and lava flows and a small dome of mingled dacite and andesite (mw). Mingled dacite and andesite was formed during intrusion of regional dike of (bw) into a local dacite reservoir of Mount Mazama.	RD 4.3	35 ka
Dacite of Munson Valley (dv)	Unconsolidated blocks of medium to dark gray porphyritic dacite in matrix of fine to coarse lithic fragments; rock unit is avalanche deposit from col-lapsed lava dome on upper SW slope of Mount Mazama, accompanied by pyroclastic flows; includes blocks altered to white, yellow, or brown.	MV 5.3 Stop 1	35 ka

Continued on next page

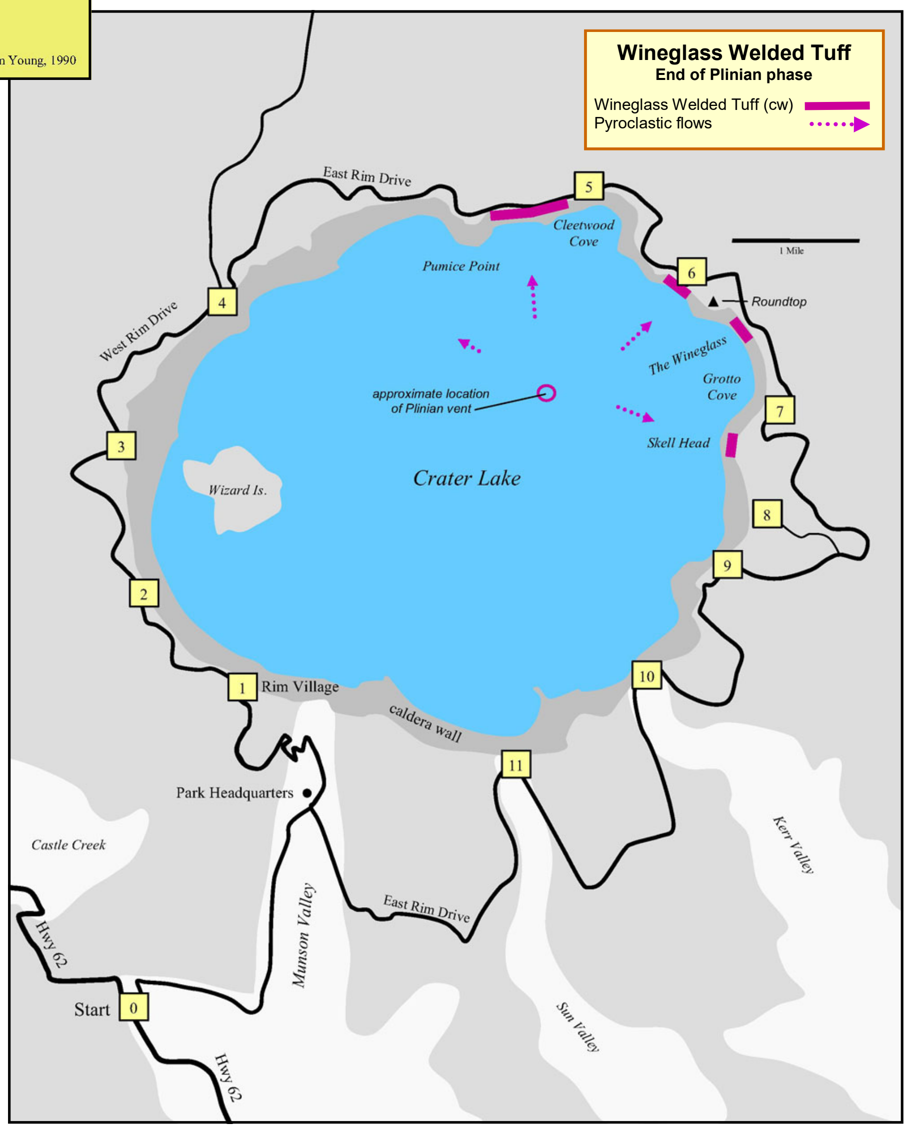
Andesite of Steel Bay (asb)	Youngest andesite lava flows on N flank of caldera; medium to dark gray. Climactic magma chamber was formed after this eruption.	RD 9.2	43 ka
Andesite of Lightning Spring (als)	Andesite lava flows on SW flank of caldera; medium to dark gray; some flows deposited under glacial ice and some have glacial striations and polish.	Stop 2	45 ka
Andesite of Devils Backbone (ad)	Devils Backbone andesite dike on W wall of caldera and associated andesite lava flows on NW flank of caldera.	RD 5.5	50 ka
Andesite south of The Watchman (atw)	Andesite lava flows on W side of caldera; medium to light gray; some lava flows encountered glacial ice during emplacement.	RD 2.1	52 ka
Dacite of The Watchman (dw)	Thick, stubby, blocky, medium to light gray dacite lava flow; vent below The Watchman; extends one and a half miles W of The Watchman.	RD 3.0 Stop 3	53 ka
Andesite of Hillman Peak (ah)	Multiple andesite lava flows at top of Hillman Peak and on W side of caldera; sourced from vent E of rim.	Stop 3	60 ka
Andesite of Grotto Cove (agc)	Two thick andesite lava flows form 300 foot cliff along E rim of caldera above Grotto Cove; also exposed on caldera wall at Cleetwood Cove; some flows in contact with glacial ice during eruption.	Stop 7	71 ka
Basaltic andesite of Hillman Peak (bh, bhp)	Basaltic andesite lava flows (bh) extend up to 3 miles W of caldera; glacial striations on lava flows near Merriam Point; ash cone of near-vent pyroclastic rocks (bhp) on caldera wall below Hillman Peak.	Stop 3	71 ka
Dacite of Pumice Castle (dc, dcp)	Thick dacite lava flows (dc) cover much of Cloudcap and form south section of Redcloud Cliff; Pumice Castle is altered dacite pumice (dcp) from initial phase of eruption; main vent at Cloudcap.	Stop 9	72 ka
Andesite of the west wall (aww)	Thick unit of multiple andesite lava flows on W wall of caldera below The Watchman and Hillman Peak.	Stop 3	73 ka
Andesite of Roundtop (ar)	Andesite lava flow forms Palisades cliff on NE wall of caldera; vent below Roundtop; during eruption, lava was covered and bounded by glacial ice and lava flow lies on thick deposits of glacial till that extend below lake level.	RD 12.6	160 ka
Andesite of Garfield Peak (ag)	Small andesite lava flows and breccia at top of Garfield Peak, lava flows extend one mile down south flank of caldera.	Stop 10	224 ka
Andesite of Applegate Peak (aa)	Multiple, thick, hard andesite and dacite lava flows cover much of S flank of Mount Mazama; lavas exposed on caldera wall from Discovery Point to the Wineglass; lavas form Dutton Cliff, Dutton Ridge; Applegate Peak, Vidae Ridge; Eagle Crags, and Garfield Peak; many flows encountered glacial ice.	Stop 10 RD 25.9 RD 28.8	240 ka
Dacite of Sentinel Rock (dr)	Thick, hard, dacite lava flows on E wall of caldera; these lava flows form upper part of Sentinel Rock and lower part of Skell Head.	RD 20.7	320 ka
Andesite of Kerr Notch (ak)	Porphyritic andesite and dacite lava flows on SE caldera wall and in Kerr Valley and Sun Valley; Vidae Falls flows over glaciated ledge of ak lava.	RD 28.4	335 ka
Dacite of Chaski Bay (db)	Thick unit of multiple andesite and dacite lava flows on S caldera wall from Kerr Notch to Rim Village; forms Castle Crest on trail to Garfield Peak.	Stop 10	350 ka
Dacite of Mount Scott (ds)	Mount Scott is satellite of Mount Mazama formed of near-vent agglutinated volcanic bombs and pyroclastic breccia; changes to medium gray lava flows away from vent; flows extend up to five miles E of Mount Scott.	RD 17.4	400 ka
Andesite of Phantom Cone (apn)	Oldest volcanic rocks on caldera wall; vent is at Phantom Cone on S wall of caldera below Dutton Cliff; near vent deposits include silica-rich pyroclastic breccias, dikes, ash fall and intrusions; Phantom Ship is altered apn lava.	Stop 10 Stop 11	400 ka

Legend. **Names and symbols of rock units are based on the Geologic Map of Bacon, 2008. Rock ages also based on Bacon, but are approximated for simplification. Many of these approximations represent a wide range of rock ages.**

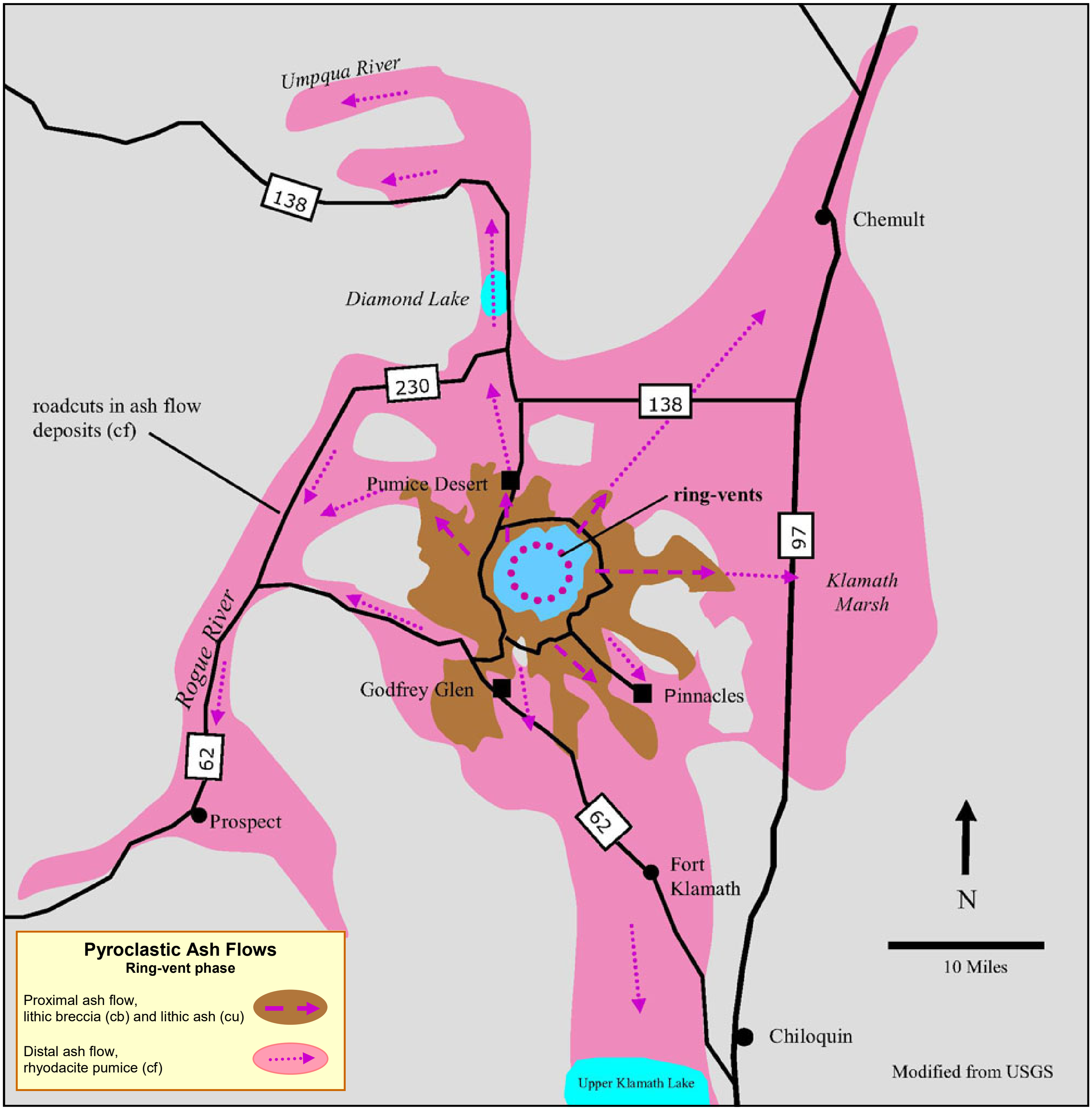
Deposits of the Climactic Eruption



<u>Pumice fall (cp).</u> **The climactic eruption began with a huge explosion from a single vent on the northeast side of Mount Mazama and was accompanied with a Plinian cloud of rhyodacite pumice and ash that reached a height of 30 miles over the volcano. Prevailing winds carried the ash northeast, where it was deposited as a white blanket that covered much of the Pacific Northwest. This bed of "Mazama ash" is used as a time-marker for dating geological and archaeological sites throughout this area. Most of the pumice was deposited near Mount Mazama and is mapped as "pumice fall" (cp) by Bacon (2008). Deposits of the pumice fall are well exposed in many places on the upper wall of the caldera from Llao Rock to the Pumice Castle Overlook.**



<u>Wineglass Welded Tuff (cw).</u> **After several days, the Plinian phase of the eruption ended abruptly and the Plinian cloud collapsed, raining hot, gaseous pumice onto the northeast slope of Mount Mazama. From there, large pyroclastic flows raced down topographic lows on this side of the mountain, leaving deposits of hot pumice along the way. Locally, where deposits were thick and hot, the pumice fused into a hard bed of welded tuff. This welded tuff is exposed in many topographic lows on the northeast wall of the caldera, with thicknesses up to 30 feet. The Wineglass Tuff typically overlies Plinian pumice fall (cp) and is overlain by pyroclastic ash flows of the ring-vent phase of the CE.**



<u>Pyroclastic ash flows.</u> **At the end of the Plinian phase of the climactic eruption, Mount Mazama began to collapse along a series of fractures around the base of the mountain. As the mountain dropped into its magma chamber, pyroclastic flows poured out from multiple "ring-vents" in the fractured zone. At first, the ash flows were rhyodacite pumice (cf), similar to the Plinian phase, and these ash flows traveled down Mount Mazama's glacial valleys as far as 50 miles from the caldera. Thick deposits of these "distal ash flows" occur in the mid– and lower sections of all of Mount Mazama's glacial valleys. Later ash flows included scoria and other heavy rocks that were deposited closer to the caldera. Coarse deposits of these "proximal ash flows" are mapped as lithic breccia (cb) and fine deposits as lithic ash (cu).**

Volcanic Rocks of Mount Mazama % volume*			
Silica content	Rock type	*Increasing water content of magma* →	
		Non-explosive eruptions	Explosive eruptions
High	Rhyolite	none	none
↑ *Increasing viscosity of magma*	Rhyodacite	minor	43% Climactic eruption
	Dacite	15% Before climactic eruption	minor
	Andesite	42% Before climactic eruption	minor
	Basaltic andesite	minor	minor
Low	Basalt	none	none

Volcanic Rocks of Mount Mazama. For most of its 400,000-year life, Mount Mazama was a typical Cascade volcano, formed mainly of andesite and dacite lava flows. However, around 30,000 years ago there was a dramatic change, and rhyodacite magma began to accumulate in a large reservoir below Mount Mazama. Over time, this reservoir grew until it was roughly three miles across and several thousands of feet thick. The water and silica content of the rhyodacite magma also increased, and the magma became increasingly viscous and explosive. The climactic eruption took place 7,700 years ago, and nearly all of the rhyodacite was ejected from the magma chamber over a period of perhaps a week or so. Bacon and Wright (2017) estimate that this very large rhyodacite reservoir contained about 43% of the total volcanic rocks of the Mount Mazama volcano. Five post-caldera eruptions took place within a few hundred years after the climactic eruption, and all occurred on the floor of the caldera. Four were andesite, and one was rhyodacite.

** % volume from Bacon and Wright, 2017*

Road Log, Munson Valley Road

<u>Munson Valley.</u> From its start at Highway 62, Munson Valley Road travels across the upper end of Annie Creek, then follows Munson Valley north to Rim Village. Munson Valley is a typical glacial valley, carved from Mount Mazama's older volcanic rocks by a series of ice-age glaciers. During the ring-vent phase of the climactic eruption, this glacial valley served as a major pathway for pyroclastic ash flows on the south side of the caldera, and rhyodacite pumice and ash from these flows cover much of valley floor. The thickest deposits are in lower Munson Valley and along Annie Creek, and the deposits thin northward toward Park Headquarters and the rim of the caldera.

MV 0.0 Start.
The Munson Valley road log starts at the intersection of Highway 62 and Munson Valley Road. This intersection is on the downside of the Annie Spring fault, a major boundary fault of the Basin and Range geologic province. Highway 62 travels down this fault scarp a couple of hundred feet west of this intersection. From here, the fault trends north along the west side of the Crater Lake caldera. Set your odometer at 0.0 at this intersection and turn east on Munson Valley Road. **0.2**

MV 0.2 Park entrance station and Mazama Village (café, gift shop, cabins, campground, groceries, and gas). Mazama Village is built on the thick distal ash flows (**cf**) of the CE, and there are good exposures of these ash flows along the Annie Creek Canyon Trail (2.1 mi. RT) next to campground. **0.2**

MV 0.4 Bridge across Annie Creek, near Annie Spring. This spring is in thick ash flow deposits (**cf**) near the head of Annie Creek, and supplies water for Mazama Village. After crossing the bridge, roadcuts on left are the lateral moraine of the Annie Creek glacier. **1.3**

MV 1.7 Turnoff for Godfrey Glen trailhead, right. This short, easy, loop trail (1.2 mi. RT) travels along the rim of Munson Creek with good views of distal ash flows (**cf**) on the steep sides of the incised creek. The trailhead parking area is excavated from the lateral moraine of the Munson Valley glacier, and the trail begins on ash flows (**cf**) that cover the valley floor (photo). Beyond the trailhead, Munson Valley Road turns north and travels along the west side of Munson Valley toward Park Headquarters. **2.2**

MV 3.9 Stop sign at intersection with East Rim Drive. Continue toward Park Headquarters. **0.1**

MV 4.0 Park Headquarters. The Steel Visitor Center (photo) is open year-round, weather permitting, and provides rangers, information, post office, and restrooms. During periods of maximum glaciation, the Munson Valley glacier filled this part of the valley with over 600 feet of glacial ice, and the glacial ice extended across Munson Ridge where it joined the Castle Creek glacier. Average snow depth at Park Headquarters in March is nearly ten feet. **0.1**

MV 4.1 Lithic breccia (**cb**) in roadcut (photo), right, immediately beyond stop sign. This is one of several dune-shaped bedforms of lithic breccia near Park Headquarters that were deposited by ash flows that traveled down Munson Valley during the ring-vent phase of the CE. Bedforms typically occur where the proximal ash flows were impeded by abrupt changes in topography. **1.2**

MV 5.3 Dacite of Munson Valley (**dv**) in long roadcut, right (photos). These unconsolidated volcanic rocks are an avalanche deposit from collapse of a large dacite lava dome on the southwest flank of Mount Mazama about 35,000 years ago. This avalanche deposit fills much of the upper end of Munson Valley and underlies most of Rim Village. Munson Valley Road uses these rocks as a ramp as it climbs up the side of Munson Valley on its way to Rim Village. **0.4**

MV 5.7 Andesite of Applegate Peak (**aa**) in roadcut, right, is northern part of Munson Ridge. **1.0**

MV 6.7 Intersection, turn right for Rim Village and park near the Gift Shop for Stop 1. When leaving Rim Village you will reset your odometer to 0.0 at this intersection to begin the Rim Drive Road Log.

MV 1.7 Godfrey Glen Trail (1.2 mi. loop, easy). The trailhead parking area is excavated from glacial deposits of the lateral moraine of the Munson Valley glacier. The trailhead is at the contact between the glacial moraine and the distal ash flow deposits (cf) that cover the floor of Munson Valley. The trail travels along the west rim of Munson Creek, with good views of colonnades and pinnacles in the distal ash flow deposits (cf) on the steep sides of the creek.

MV 1.7 Godfrey Glen, from viewpoint on Highway 62, one mile south of the Park Entrance Road. In this area, Munson Creek has cut a steep-sided canyon into thick distal ash flows of the CE, exposing colonnades and pinnacles along the sides of the canyon. The Godfrey Glen Trail travels along the west rim of Munson Creek, upper center, with good views of these colonnades and pinnacles. The light colored deposits on the lower canyon wall are mainly rhyodacite pumice from the early ring-vent phase of the eruption, whereas the overlying darker rocks are from the late phase and include andesitic and gabbroic scoria from the lower part of the magma chamber. The colonnades along the upper wall were formed by contraction during cooling of the ash flows, and the pinnacles along the mid-canyon wall developed where ash deposits were cemented by hot fluids and gasses escaping from the ash flows. Godfrey Glen, lower center, is an isolated meadow on lower Munson Creek, surrounded by pinnacles and colonnades.

MV 4.0 Steel Visitor Center at Park Headquarters, with park information, post office and rest rooms.

MV 4.1 Lithic breccia (cb) in roadcut near Park Headquarters was deposited by pyroclastic flows that traveled down Munson Valley during the ring-vent phase of the CE. This small dune-shaped deposit includes boulders of several types of volcanic rocks in a matrix of light-brown sand-sized lithic fragments. Many boulders have been rounded by spalling as the hot rocks cooled. Bedforms like this typically occur where topographic obstacles impeded the pyroclastic flows.

MV 5.3 Upper, dacite of Munson Valley (dv) in long roadcut is an avalanche deposit formed during collapse of a dacite lava dome on the upper slope of Mount Mazama 35,000 years ago. These unconsolidated rocks now fill much of the upper end of Munson Valley and underlie most of Rim Village.

Lower, close-up of roadcut. This unconsolidated avalanche deposit is a mixture of large to small blocks of dacite lava, pumiceous dacite and other lithic blocks in a matrix of fine to coarse lithic fragments. The dacite is medium to dark gray and porphyritic. Some blocks are prismatically jointed and many are altered to yellow, reddish brown, or bleached to white, suggesting the avalanche was accompanied by pyroclastic flows during collapse of the lava dome.

Road Log, Rim Drive

<u>West Rim.</u> All of the lava flows along Rim Drive from Rim Village to Stop 4 are andesite or dacite that erupted from 35,000 to 80,000 years ago. In general, these lava flows become older northward. During the ice ages, this part of the mountain was periodically covered by a thick ice field, and many of these lava flows encountered glacial ice during their eruption and/or were later scratched and polished by glacial ice. Most of the lava flows along this section of Rim Drive are covered by thin, patchy deposits of lithic breccia and lithic ash (cb, cu).

RD 0.0 Stop 1, Rim Village.

RD 0.0a Sinnott Overlook, open observation area.

Park where convenient and go to the Rim Visitor Center. From there, take the stone walk down the upper wall of the caldera to the Sinnott Memorial Overlook (open daily from late June to late September). The open observation area at the overlook has excellent views of the Crater Lake caldera as well as a large relief map of the caldera and surrounding areas. Most of the stops on the road log are on or near the rim of the caldera, and many can be seen from here. Also, take a look at the exhibits in the enclosed room at the back of the observation area. After leaving the overlook, follow the path toward Crater Lake Lodge. After a short distance, look back toward the overlook (photo) and note how well it blends into the unconsolidated avalanche deposits of the dacite of Munson Valley (**dv**, 35 ka). The dv deposits are easily identified by the large loose boulders and light tan matrix, and these rocks can be seen all along the upper wall of the caldera from Rim Village to Crater Lake Lodge. Rim Village and Crater Lake Lodge are built on these rocks, and the trail from Crater Lake Lodge to Garfield Peak travels across these rocks on its way to the peak (photo). The **dv** avalanche deposits were easily graded to provide a large building area for the village, and without these unconsolidated rocks there would be no Rim Village—at least as we know it. The area around Rim Village is mostly covered by a thin layer of proximal ash flows, mainly lithic ash (cu), and these powdery light gray ash deposits are best seen near the Gift Shop and along the upper wall of the caldera at the west end of the village. When leaving Rim Village, reset your odometer to 0.0 at the intersection with Rim Drive and turn right at the gate. **0.2**

After leaving Rim Village, Rim Drive hugs the rim of the caldera for a short distance, with good views of Crater Lake and the west wall of the caldera.

RD 0.2 Rim Drive turns away from the caldera and begins to travel across lava flows of the andesite of Lightning Spring (**als**, 45 ka). These lava flows are well exposed in several roadcuts on the way to Discovery Point and will seen in more detail at Discovery Point. **0.9**

RD 1.1 Park in large turnout, right, for Stop 2, Discovery Point.

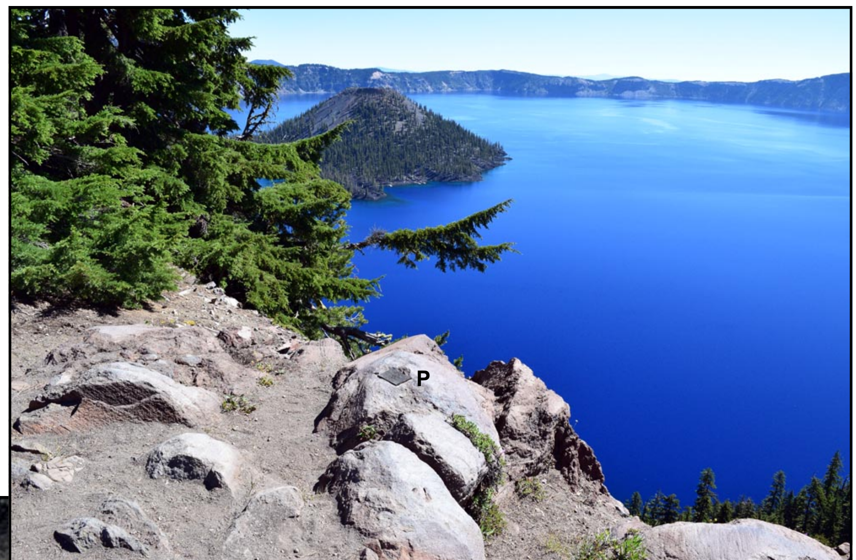
RD 0.0b **The Sinnott Overlook is built into the upper wall of the caldera and is designed to blend in with the wall. Lava flows of the andesite of Applegate Peak (aa, 240 ka) provide a firm foundation for the overlook, and the overlying avalanche deposits (dv) were easily excavated to accommodate the building. View from rim looking northwest.**

RD 0.0c **Crater Lake Lodge (right) is built on the dacite of Munson Valley (dv) and the trail to Garfield Peak (2.4 mi. RT, difficult) travels across these rocks on its way to the peak. The dv avalanche deposits are several hundred feet thick in this area and fill in much of the upper end of Munson Valley. Munson Notch (M), a shallow 30-foot depression in the rim at the head of Munson Valley, lies immediately east of Crater Lake Lodge, but is mostly obscured by trees. View from rim looking east.**

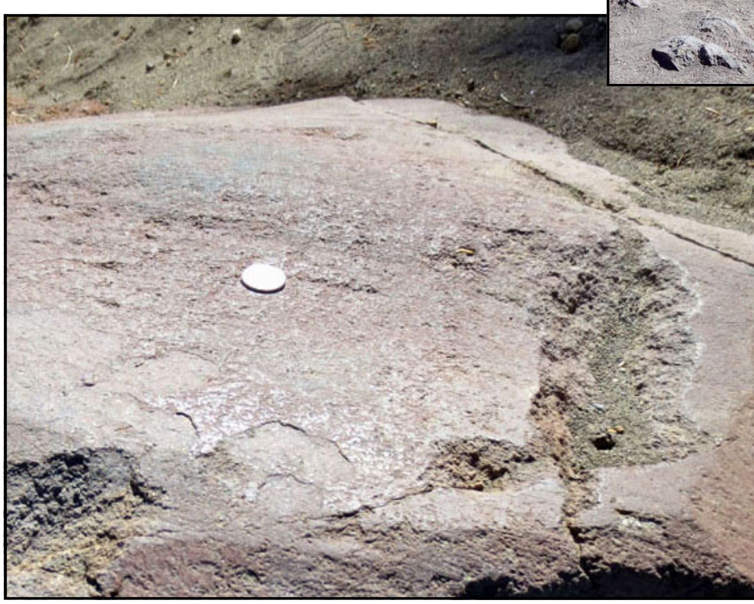
RD 1.1 Stop 2, Discovery Point. Take the trail from the north end of the parking area to Discovery Point (0.5 mi, RT). At Discovery Point you will see an outcrop of hard pinkish and gray lava with a brass plaque commemorating John Hillman's discovery of Crater Lake on June 12, 1853. This smooth, rounded outcrop is a lava flow of the andesite of Lightning Spring (**als**) that has been scratched and polished by glacial ice, and is one of many outcrops of **als** lava at Discovery Point with glacial striations and polish. The **als** lava erupted from a vent east of the present rim during a glacial period ~45,000 years ago, and covers an irregular area that extends up to 2.5 miles southwest of the rim. During the ice ages, this part of Mount Mazama was periodically covered by a thick ice field that fed the Castle Creek and Bybee Creek glaciers on the west slope of Mount Mazama. Mount Mazama was born and grew up during the ice ages and many of Mount Mazama's lava flows were in contact with glacial ice and modified by the glacial ice. You will see several other examples of lava in contact with glacial ice during this trip.

From Discovery Point there are excellent views of the west wall of the caldera from the Watchman Overlook to Llao Rock (photo). Note especially the crags below Hillman Peak, the Devils Backbone dike, and Llao Rock.

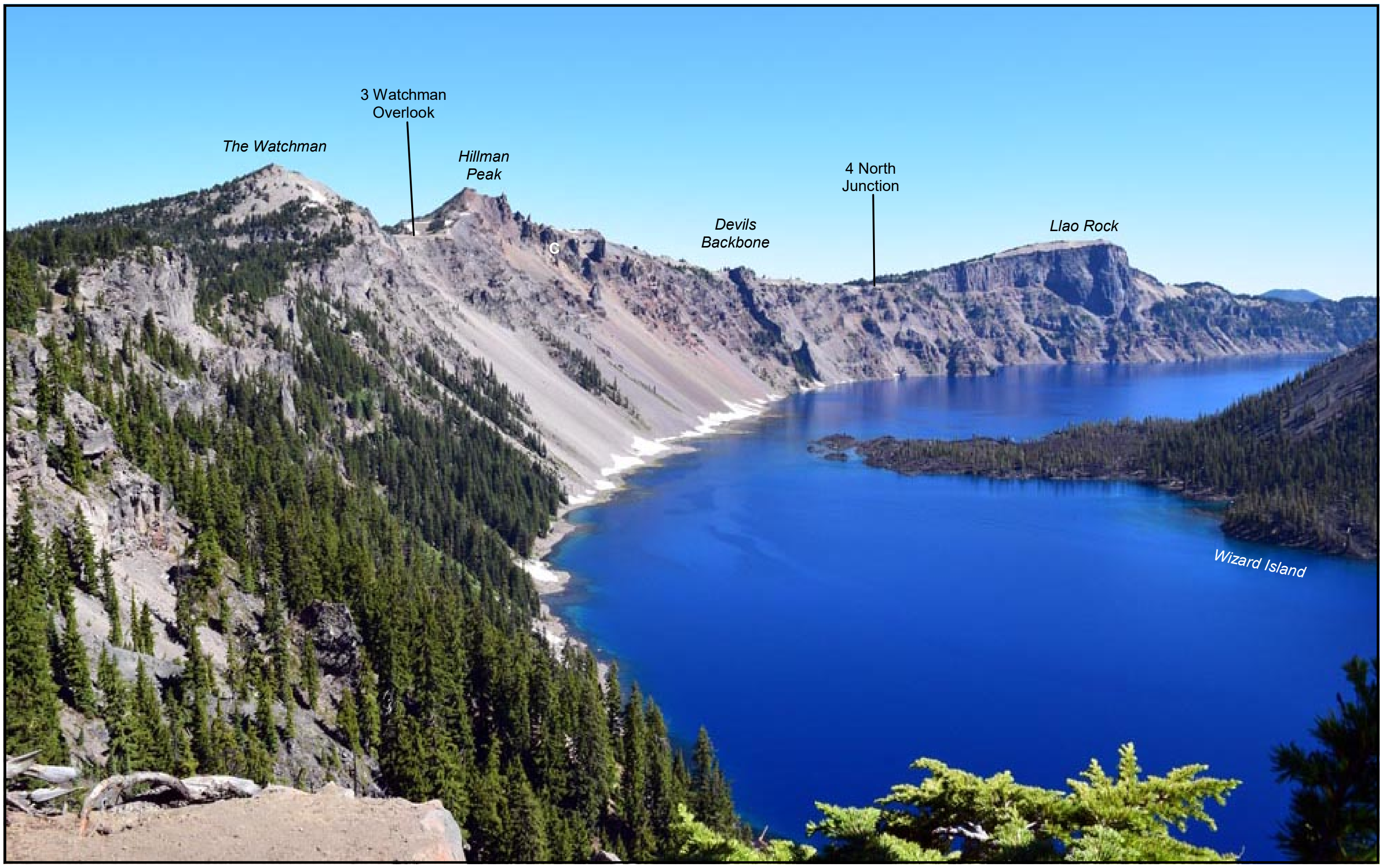
RD 1.1a Discovery Point parking area, looking southeast toward Rim Village. Munson Notch (MN) can be seen as a shallow depression in the rim of the caldera between Rim Village and Garfield Peak.



RD 1.1b Discovery Point, with outcrops of lava (andesite of Lightning Spring, 45 ka) that have been smoothed, polished and striated by glacial ice. The outcrop, center, has a brass plaque (P) commemorating discovery of Crater Lake by John Hillman at this point on June 12, 1853.



RD 1.1c Glacial polish and striations on lava outcrop at Discovery Point.



RD 1.1d West wall of caldera, from Discovery Point, with good view of Devils Backbone and crags (C) on caldera wall below Hillman Peak.

After leaving Stop 2, Rim Drive continues across the **als** lava flows for half a mile, then begins traveling over older lava flows of the andesite south of The Watchman (**atw**, 52 ka). **1.0**

RD 2.1 The medium to light gray **atw** lava flows are well exposed in the long roadcut, right, and the steep cliff at the north end of this roadcut is an isolated remnant of **als** lava that lies on top of **atw** lava (photo). The base of the **als** lava is a layer of dark, glassy, brecciated rocks, and these grade upward into long irregular columns, then into thin platy lava and blocky lava from the interior of the flow. The top of the **als** flow is missing, probably removed by glaciation.

The turnout on the rim just beyond this roadcut has good views of Wizard Island. After leaving the turnout, Rim Drive turns away from the rim and begins to climb across the dacite of The Watchman lava flow (**dw**, 53 ka). The south side of this thick lava flow is well exposed in the long roadcut on right. **0.9**

RD 3.0 The large paved turnout, left, is on the crest of the **dw** lava flow, and there are good exposures of the medium to light gray, blocky dacite lava in the long roadcut opposite the turnout (photo). This thick, pasty, slow-moving lava flow came from a vent below The Watchman and forms a narrow, thick, steep-sided ridge that extends down the west flank of the caldera for about a mile and a half from the vent. At the time of the eruption, the top of the **dw** lava was covered by an outer layer of pumiceous and glassy rocks, but most of these rocks have been removed by ice and pyroclastic ash flows of the CE. After leaving the turnout, Rim Drive turns toward the caldera and continues across the **dw** lava flow until it reaches the Watchman Overlook**. 0.8**

RD 3.8 Park at the Watchman Overlook for Stop 3.

RD 2.1 Remnant of andesite of Lightning Spring lava (als, 45 ka) overlies andesite south of The Watchman (atw, 52 ka), lower right. This remnant is near the north end of a long roadcut in the atw lava.

RD 3.0 Dacite of The Watchman lava flow (53 ka) in roadcut, right. This blocky, medium to light gray, porphyritic lava is several hundred feet thick and came from a vent below The Watchman.

3.8 Stop 3, Watchman Overlook.
The Watchman Overlook is on the west rim of the caldera between Hillman Peak and The Watchman, and Wizard Island is one mile offshore from the overlook. The Watchman is the highpoint of the thick, pasty, light gray, blocky, dacite of The Watchman (**dw**) lava flow. This steep-sided, elongated lava flow erupted from a vent below peak 53,000 years ago and slowly crept down the west slope of Mount Mazama for about 1.5 miles. The **dw** lava flow is about 500 feet thick, half a mile wide, and Rim Drive crosses over this lava flow on its way to the Watchman Overlook (RD 3.0). From the overlook you can see a thick feeder dike for the **dw** lava cutting across older volcanic rocks on it way to the vent below peak (photo). The peak is a glaciated horn, carved by the thick glacial ice that covered this area during the ice ages.

RD 3.8a The Watchman, from Watchman Overlook. A short trail (1.6 mi. RT, moderate) travels across the dw lava flow on its way to the historic fire lookout at the top of the peak.

Hillman Peak is formed from lava flows of the andesite of Hillman Peak (**ah**, 60 ka), and these lava flows extend over much of the west rim of the caldera from the Watchman Overlook to Devils Backbone. The serrated top of the peak is the inclined and truncated edges of **ah** lava flows on the side of a large ash cone. The ash cone and **ah** lava flows are well exposed on the wall of the caldera below the peak (photo). Somewhat surprisingly, the ash cone is not from the **ah** eruption, but is from an older eruption — the basaltic andesite of Hillman Peak (**bh**, 71 ka). The large dark brown crags on the wall of the caldera below Hillman Peak are the altered and indurated volcanic rocks associated with the **bh** ash cone and vent. Lava flows (**bh**) from this vent cover much of the area near Williams Crater and extend up to two miles west of Williams Crater.

Wizard Island, one mile east of the overlook, is a classic andesitic cinder cone capped with a 90-foot-deep crater on top (photo). The Wizard Island eruption began about 500 years after the CE and mostly occurred under water as the lake was filling the caldera. The cone was formed only after the vent rose above lake level and cinders could be thrown into the air.

After leaving the Watchman Overlook, Rim Drive turns away from the caldera and travels across **ah** lava flows for the next 1.5 miles. These lava flows are exposed in several roadcuts along Rim Drive. **0.5**

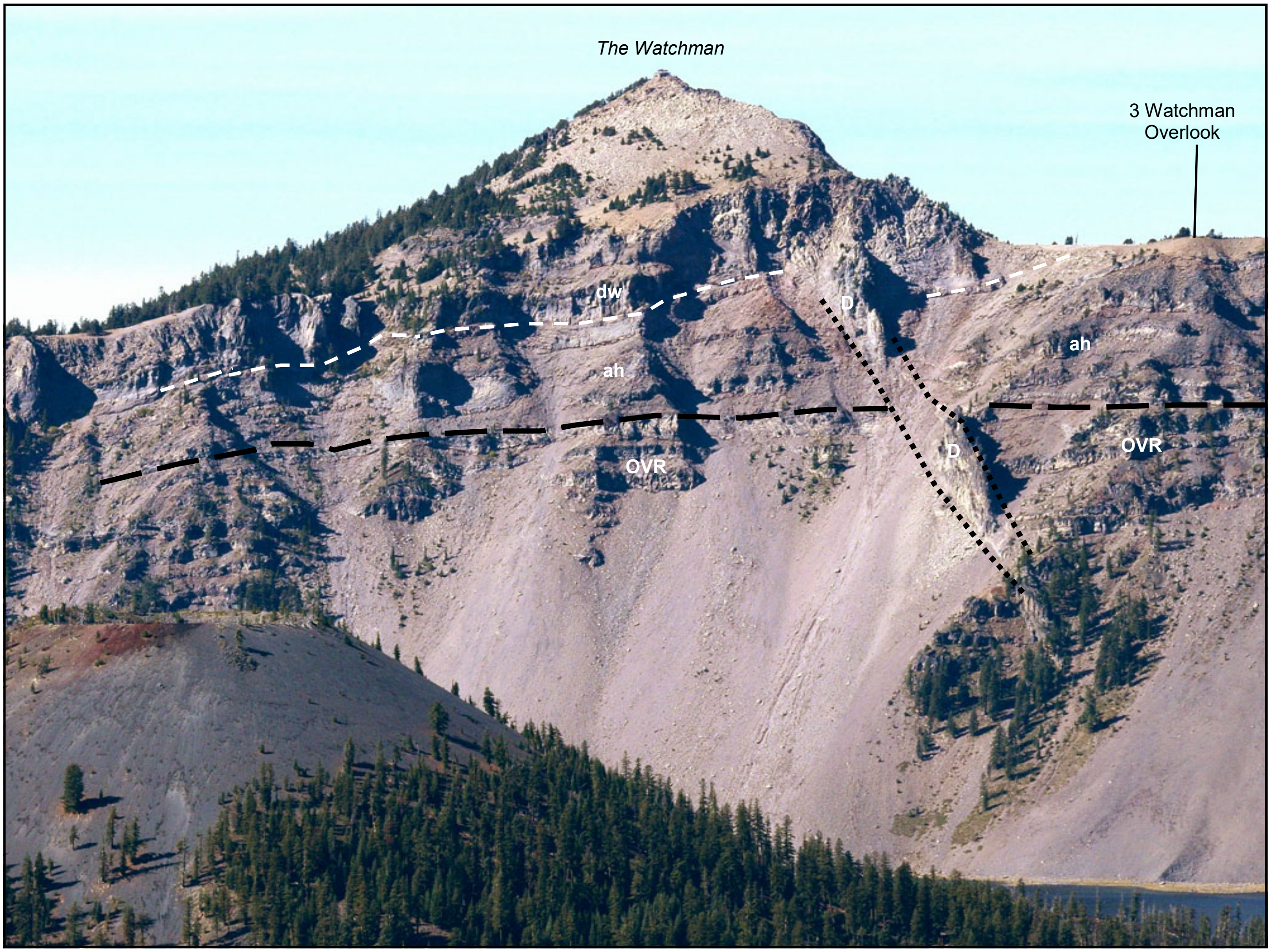
4.3 Williams Crater (photo), left, is part of the Williams Crater complex, which includes a cinder cone and lava flows of basaltic andesite, lava flows of commingled dacite and andesite, and a small dome of commingled lava near Rim Drive. This small group of related igneous rocks resulted from a chance encounter, 35,000 years ago, between a regional dike of basaltic andesite and a local reservoir of dacite magma from Mount Mazama. **0.1**

4.4 Pumice Desert viewpoint, left. This viewpoint provides a good view of the northwest slope of Mount Mazama and a distant view of Pumice Desert, a low, flat, treeless area at the base of the north slope (photo). Williams Crater complex is also accessible from this parking area. The large roadcut opposite the turnout has good exposures of **ah** lava flows. **1.1**

5.5 Devils Backbone is exposed on the caldera wall below the first paved turnout on the rim (photos). The Devils Backbone was a feeder dike to the Devils Backbone andesite lava flow (**ad**, 50 ka), which extends down the northwest slope of the caldera as far as six miles from the rim. Due to erosion, there is no direct connection between the dike and the lava flow, but both have the same composition and age and are considered to be the same eruption. The roadcut adjacent to the turnout is dacite of Munson Valley (**dv**, 35 ka). **0.2**

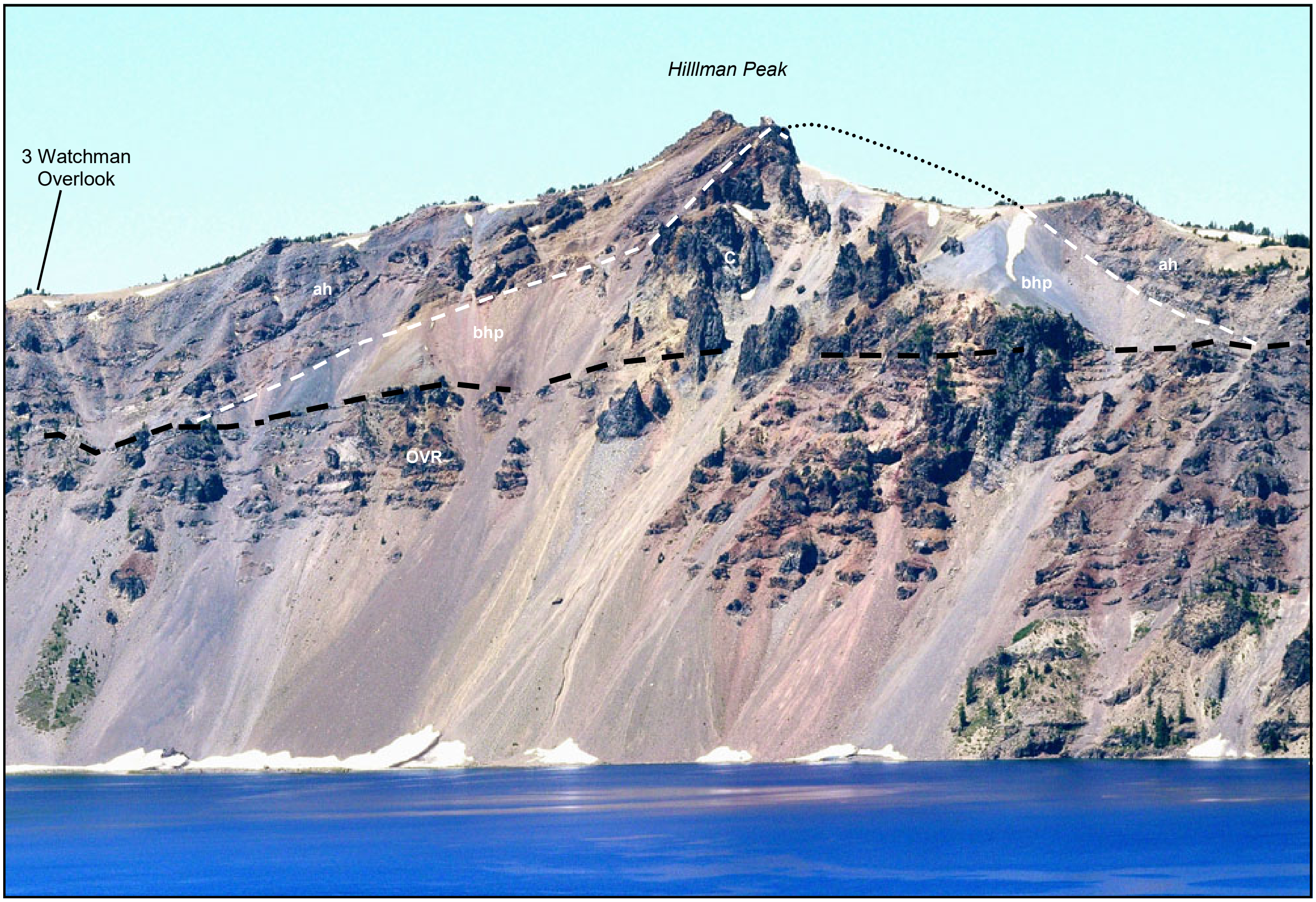
5.7 The lava outcrops at the second paved turnout have excellent examples of glacial striations and polish (photos). The lava is basaltic andesite of Hillman Peak (**bh**, 72 ka). **0.2**

5.9 Park at North Junction for Stop 4.



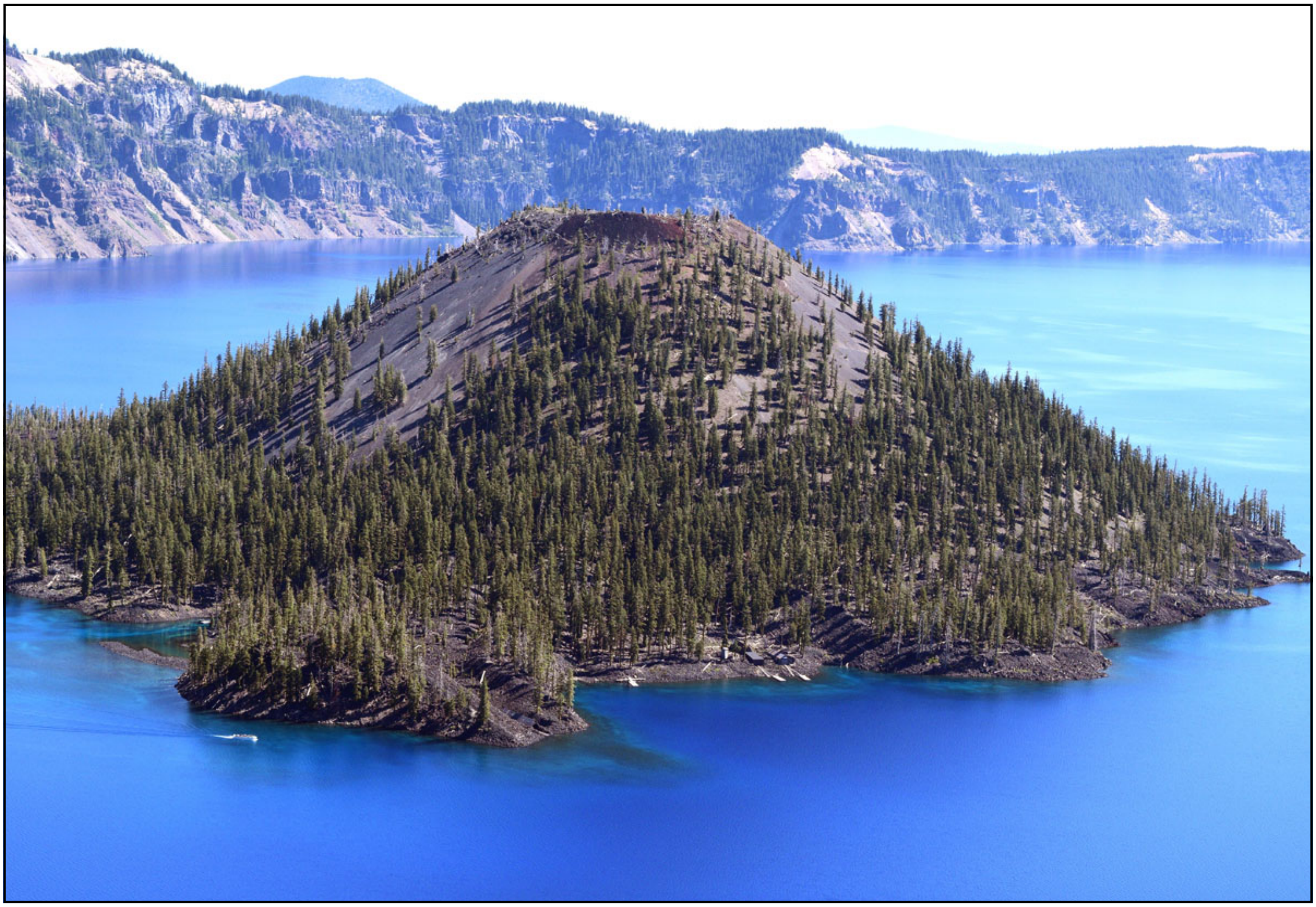
RD 3.8b **The Watchman is the high point a small dacite lava flow (dacite of The Watchman, dw, 53 ka) that erupted from a vent below the peak. A thick feeder dike (D) for the lava flow cuts across older lava flows on its way to the vent. The dw lava overlies andesite of Hillman Peak (ah, 60 ka) and older volcanic rocks (OVR, 70 to 275 ka) down to lake level. Telephoto view from east rim.**

RD 3.8c **Historic fire lookout at the top of The Watchman. Telephoto view looking north from Rim Drive.**



RD 3.8d Hillman Peak is steeply dipping andesite lava flows (andesite of Hillman Peak, ah, 61 ka) that overlie an older ash cone (basaltic andesite of Hillman Peak, bhp, 71 ka). Large crags (C) on caldera wall below the peak are indurated ash, breccia, and intrusives associated with the bhp vent. Older volcanic rocks (OVR) are andesite and dacite lava flows (73-275 ka). Telephoto view from east rim.

RD 3.8e Crags on caldera wall below Hillman Peak. Telephoto view looking north from Watchman Overlook.



RD 3.8f Wizard Island is an andesite cinder cone that erupted within the caldera about 500 years after the climactic eruption. The caldera was filling with water at that time, and the vent and early lava flows were below water. While flows were below water, they built a broad, thick platform of pillow lava and glassy breccia. When the vent reached above water, cinders were thrown into the air, and cinder cone was then built on top of the lava platform. From time to time, lava leaked from the base of the cinder cone, and this lava now forms a narrow rim of dark andesite breccia along the shoreline. Some lava flows continued into the lake and became pillow lavas.

RD 3.8g Telephoto view of Wizard Island crater from Watchman Overlook. Boat tours on Crater Lake are operated in cooperation with the National Park Service. Some tours offer a short stay on the island, giving passengers time to hike, swim, fish, and relax on their own. From the boat dock at Wizard Island there is a trail (2.2 mi. RT, strenuous) to the to the summit and a 0.3 mile path around the crater. Check with the park service for details and arrangements.

RD 4.3 **Williams Crater is a regional cinder cone built from lava flows (bw) and pyroclastic rocks (bwp) of the basaltic andesite of Williams Crater, and is similar to other regional cinder cones near Mount Mazama. However, Williams Crater also has two small light-gray lava flows of mingled dacite and andesite (mw). The Williams Crater eruption occurred 35,000 years ago when a regional dike of bw intruded a local dacite reservoir of Mount Mazama and the two magmas mixed and mingled in the dacite reservoir. Telephoto view looking north from Rim Drive.**

RD 4.4 **Distant view of Pumice Desert (P), looking northeast from turnout. Pumice Desert is a low area with little vegetation at the base of the north slope of Mount Mazama. During the climactic eruption, as much as 200 feet of coarse scoria and lithic fragments accumulated in this depression as pyroclastic flows dropped their heavy rocks at the foot of the mountain. These coarse rocks drain rapidly, so it is difficult for vegetation to survive. North Entrance Road passes through Pumice Desert.**

RD 5.5 Right, view of Devils Backbone from turnout. Below, telephoto view of Devils Backbone from Rim Village. The Devils Backbone dike (ad, 50 ka) ranges in thickness from 25 to 50 feet and cuts through 1200 feet of older volcanic rocks (OVR, 53–150 ka) as it climbs the west wall of the caldera from the lake to the rim. The dike is broken into two segments - a long lower segment and a shorter upper segment, offset to the north. This massive dike fed the Devils Backbone lava flow, and this lava flow covers much of the northwest flank of the caldera. The top of the dike cuts through a small remnant of andesite south of The Watchman (atw, 53 ka), and this remnant is well exposed on the rim of the caldera immediately north of the dike. The OVR are covered with Plinian ash fall (cp) and proximal ash flows (cb, cu).

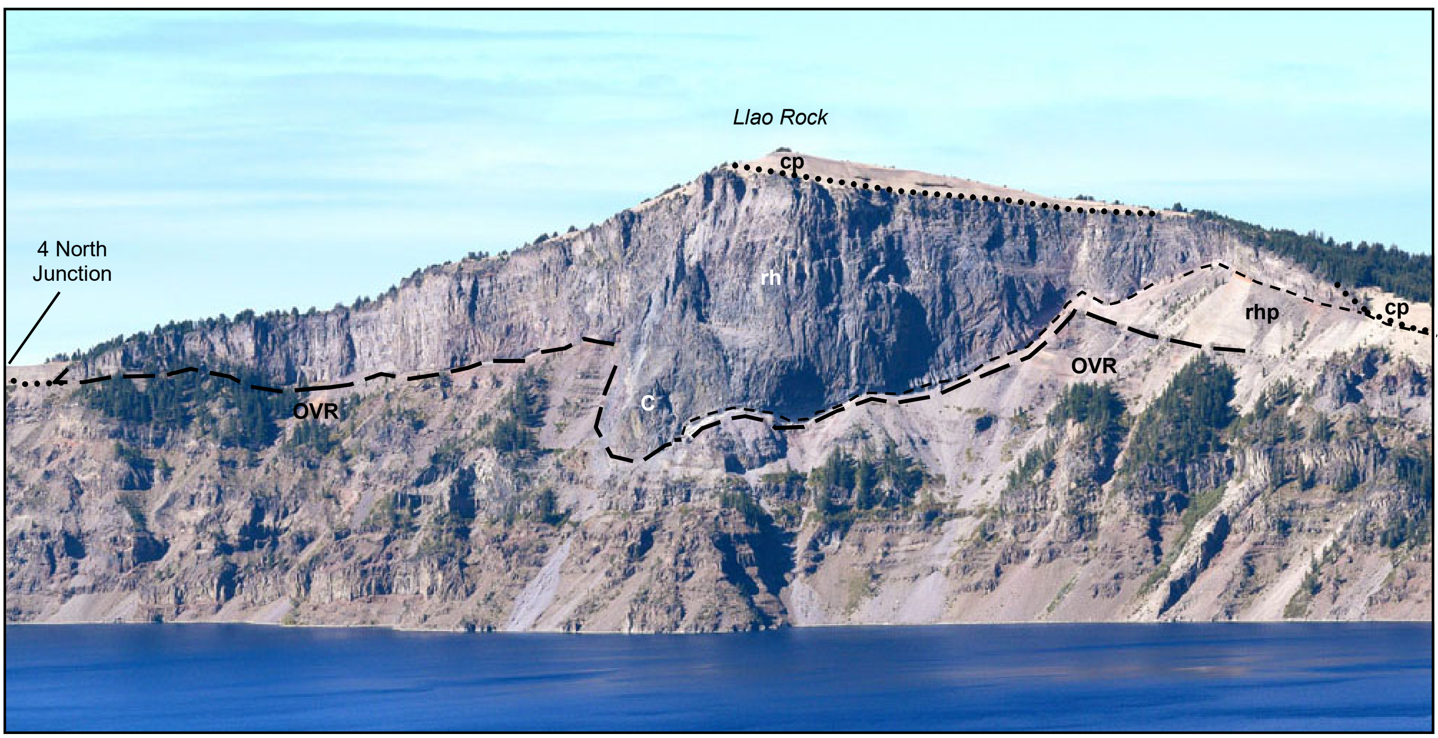
RD 5.7 Glacial polish and striations on lava flow (basaltic andesite of Hillman Peak, 71 ka) on west rim of caldera. View from turnout.

<u>North Rim.</u> With the exception of the andesite of Steel Bay (asb, 43 ka), all of the volcanic rocks along Rim Drive from Stop 4 to Stop 6 are rhyodacite lava flows and pyroclastic rocks from the climactic reservoir. The oldest is the small rhyodacite of Steel Bay lava flow (re), which erupted from an early stage of the climactic reservoir 27,000 years ago. The next eruption was the Llao Rock rhyodacite (rh), a small "leak" from the climactic reservoir about 100 years before the CE. Then, just a few years before the CE, the Cleetwood rhyodacite (rh) also leaked from the climactic reservoir, and the lava was partly molten at the time of the CE. Lastly, during the CE, the north rim was covered with thick Plinian pumice fall (cp) and proximal ash flows (cb, cu), and these deposits are over 400 feet thick at Cleetwood Cove.

RD 5.9 Stop 4, North Junction.

From the parking area, take the short walk to the rim, where you will get a close-up profile of Llao Rock, the massive 1200-foot cliff of rhyodacite lava **(re)** that dominates the northwest wall of the caldera. The Llao Rock eruption occurred about 100 years before the CE and began with an explosion that dug a 500 foot crater into the northwest side of Mount Mazama. The explosion was accompanied by large cloud of pumice and ash that rose high above the volcano. Some of this ash fell back into the crater, some was deposited on the north and east slopes of Mount Mazama, and some was carried into southern Oregon and northern California by prevailing winds. After the explosive phase, rhyodacite lava filled the explosion crater and built a 600-foot-high, two-mile-wide dome over the vent. Llao Rock is the top of this dome, and the viewpoint at Stop 4 is near the west edge of the dome. During the Plinian phase of the CE, the Llao Rock lava was covered with thick deposits of pumice fall (**cp**), but most of this pumice was removed by pyroclastic ash flows of the ring-vent phase. These proximal ash flows (cb, cu) now cover most of the dome.

When leaving the North Junction parking area, turn right on East Rim Drive. After a couple of hundred feet, East Rim Drive turns away from the rim and begins to travel across the northwest side of the Llao Rock rhyodacite lava flow. **0.3**



RD 5.9 Llao Rock rhyodacite (rh) fills a 500 foot explosion crater (C) in older volcanic rocks (OVR, 42-172 ka) and overlies volcanic ash (rhp) from the initial phase of the eruption. After filling the crater, the rhyodacite continued several thousand feet beyond the crater and built a low lava dome over the vent. During the CE, the Llao Rock dome was covered with Plinian pumice fall (cp), but most of this pumice was removed from the mid and lower parts of the lava dome by later proximal ash flows (cb, cu) of the CE.

RD 6.2 The black glassy lava in the long roadcut (photo), right, is from the chilled upper surface of the Llao Rock rhyodacite lava flow. At the time of lava flow, these glassy rocks were covered with an outer shell of blocky pumice, but most of the pumice was removed by the proximal pyroclastic flows (**cb, cu**) of the CE. A thin layer of these ash flows can be seen at the north end of this roadcut. For the next 1.5 miles Rim Drive travels over the Llao Rock lava flow, with intermittent exposures of pumice, glassy rhyodacite, and light gray felsite from the upper part of the lava flow. **1.9**

RD 8.1 The small rhyodacite of Steel Bay lava flow (**re**, 27 ka) is exposed in the roadcut, right. This short, narrow, steep-sided lava flow erupted from a vent near the rim and is well exposed on the wall of the caldera (photo). The lava is the same composition and age as the Grouse Hill and Redcloud rhyodacites. These three lava flows are the first eruptions from the climactic reservoir, and provide a sample of an early stage in the development of the climactic magma. (Bacon, 2008). **1.1**

RD 9.2 Andesite of Steel Bay (**asb**, 45 ka) lava flow is exposed in roadcuts and outcrops at turnout on rim. This is the youngest andesite on the north rim of the caldera, and the climactic reservoir began to develop a few thousand years after its eruption. Just beyond the turnout, Rim Drive turns away from the caldera and travels over thick deposits of the CE on the backside of Pumice Point. These deposits are well exposed at the top of Pumice Point (photo), but cannot be seen from this part of Rim Drive. **0.4**

RD 9.6 The long roadcut beyond the picnic area, left, is in proximal ash flows (**cb, cu**) of the CE. The turn-outs on the right overlie a thick, hard ledge of Wineglass Welded Tuff (**cw**), and this orange ledge can be seen on the caldera wall below the turnouts. Rim Drive travels on top of this ledge from here to the Trailhead for Cleetwood Cove, where the ledge ends. **0.9**

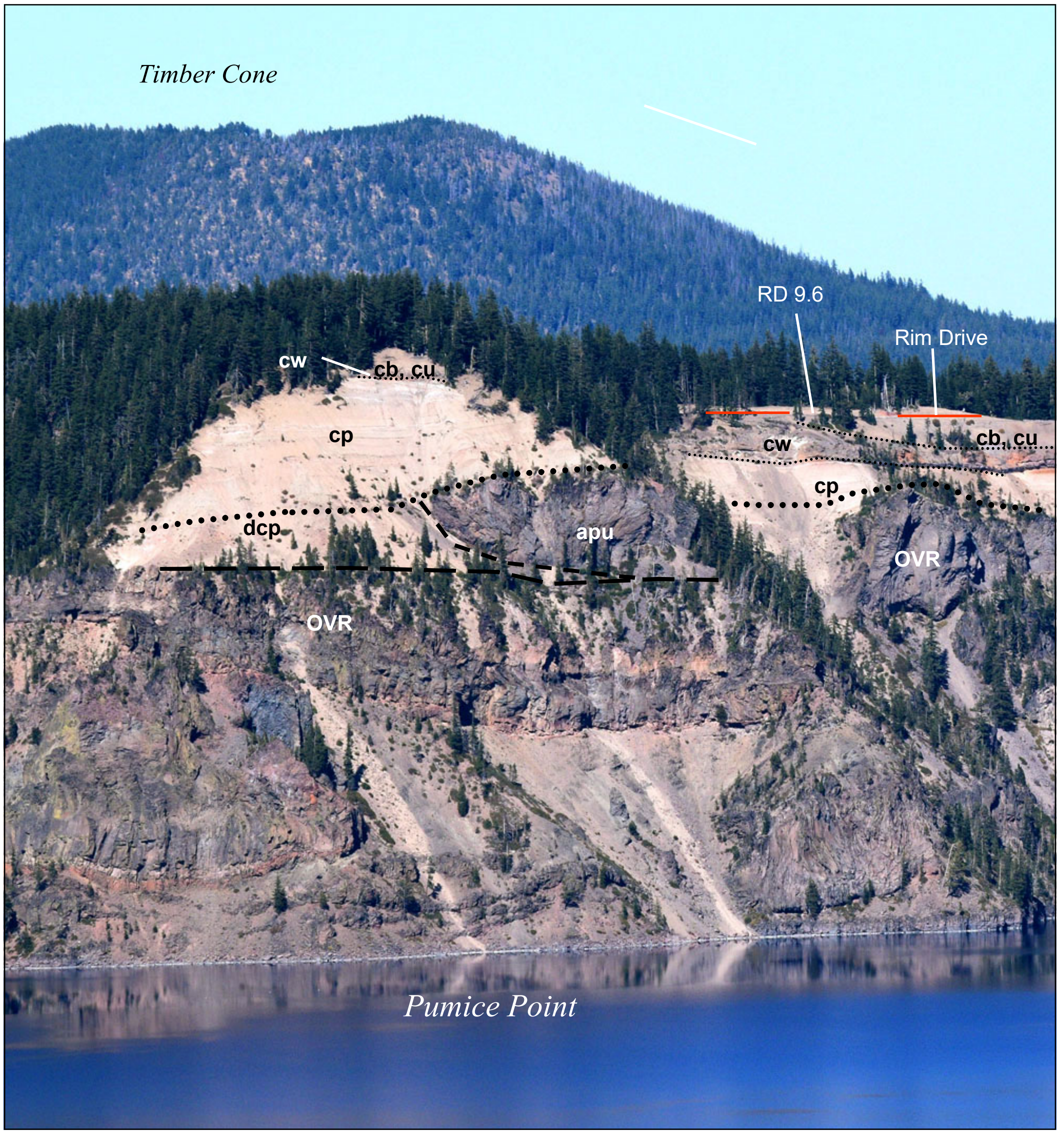
RD 10.5 Trailhead for Cleetwood Cove (2.2 mi. RT, strenuous). This trailhead is at the western edge of the Cleetwood rhyodacite lava flow (**rh**), and the roadcut, left, is pumice fall (**cp**) that was deposited on top of this lava flow. These rocks will be described in more detail at Stop 5. **0.2**

RD 10.7 Park in the turnout opposite the red rocks in the roadcut for Stop 5, Cleetwood Cove.

RD 6.2 Black glassy rhyodacite from chilled upper surface of Llao Rock rhyodacite lava flow.

RD 8.1 Rhyodacite of Steel Bay (re) on upper wall of caldera. The re lava came from a vent below Hill 7358 and is overlain by ash deposits (rhp) from the Llao Rock eruption and Plinian pumice fall (cp) from the CE. The re lava flow overlies an irregular surface of lava flows of the andesite of Steel Bay (asb, 43 ka). Older volcanic rock (OVR) are andesite and dacite lava flows up to 150 ka.

RD 9.2 The upper slope of Pumice Point is covered by ~300 feet of ash and pumice from the dacite of Pumice Castle (dcp) and climactic eruptions (cp, cw, cb, cu). Thin beds of ash and pumice from the Llao Rock and Cleetwood eruptions are also present, but not shown. On the east side of Pumice Point, a lava flow of the andesite of Pumice Point (apu, 47 ka) fills a glacial valley in pumice deposits of the dacite of Pumice Castle (dcp, 72 ka). The far right side of the photo shows the wall of the caldera below the long turnouts at RD 9.6. Note the very thick ledge of Wineglass Welded Tuff (cw) on the wall of the caldera below these turnouts, and also note the roadcuts in proximal ash flow deposits (cb, cu) along Rim Drive. Older volcanic rocks (OVR) are mostly andesite and dacite lava flows (115-125 ka). Telephoto view looking north from Rim Village.



RD 9.6 Turnouts overlie thick ledge of Wineglass Welded Tuff (photo 9.2), which can be seen below the turnouts. Roadcuts are proximal ash flows (cu, cb) of the CE.

10.7 Stop 5, Cleetwood Cove. Park in the turnout on right, opposite the red rocks in the roadcut. For the last 0.2 mi. Rim Drive has been traveling across the Cleetwood rhyodacite lava flow (**rh**), and this turnout is directly on top of the lava flow. The Cleetwood lava is of special interest because it was still hot during the CE and molten lava from the center of the flow spilled down the wall of the caldera at the head of Cleetwood Cove during the final stage of the CE. The following road log and geologic sketch describe the major geologic features of this unusual lava flow.

RD 10.7a The turnout at Stop 5 is on top of a 300 foot cliff of the Cleetwood rhyodacite lava. This lava was still hot at the time of the CE, and the roadcut is Plinian pumice fall (cp) that was deposited directly on top of this hot lava. The red rocks are pumice that was altered by the heat from the lava and fluids trapped within these rocks. The white rocks (W) are stratigraphically higher and were altered by fumarolic gasses escaping from the pumice deposit. The face of the roadcut is littered by large blocks lithic breccia (cb) from the top of the roadcut.

<u>Road Log, Geologic Sketch, Cleetwood Cove.</u>

10.5 The parking area for Cleetwood Cove is the west edge of the Cleetwood rhyodacite lava flow (rh), where the lava is overlain by thick deposits of Plinian pumice fall (cp). These pumice deposits are well exposed in the long roadcut, left, from the parking area to Stop 5.

10.7 Stop 5. This turnout lies directly on top of the Cleetwood lava flow (photo 10.7a). The red rocks in the roadcut are pumice (cp) that was deposited directly on top of the Cleetwood lava and altered and oxidized by heat from the lava and fluids and gasses that were trapped within the pumice. The white rocks in the roadcut are further above the lava and were altered by hot fumarolic fluids and gasses escaping the pumice. The thick cliffs of lava (rh) on the sides of Cleetwood Cove (photo 10.7b) are solidified lava on the sides of the lava flow, and the Cleetwood backflow at the head of Cleetwood Cove is remobilized lava from the center of the flow that spilled down the wall of the caldera.

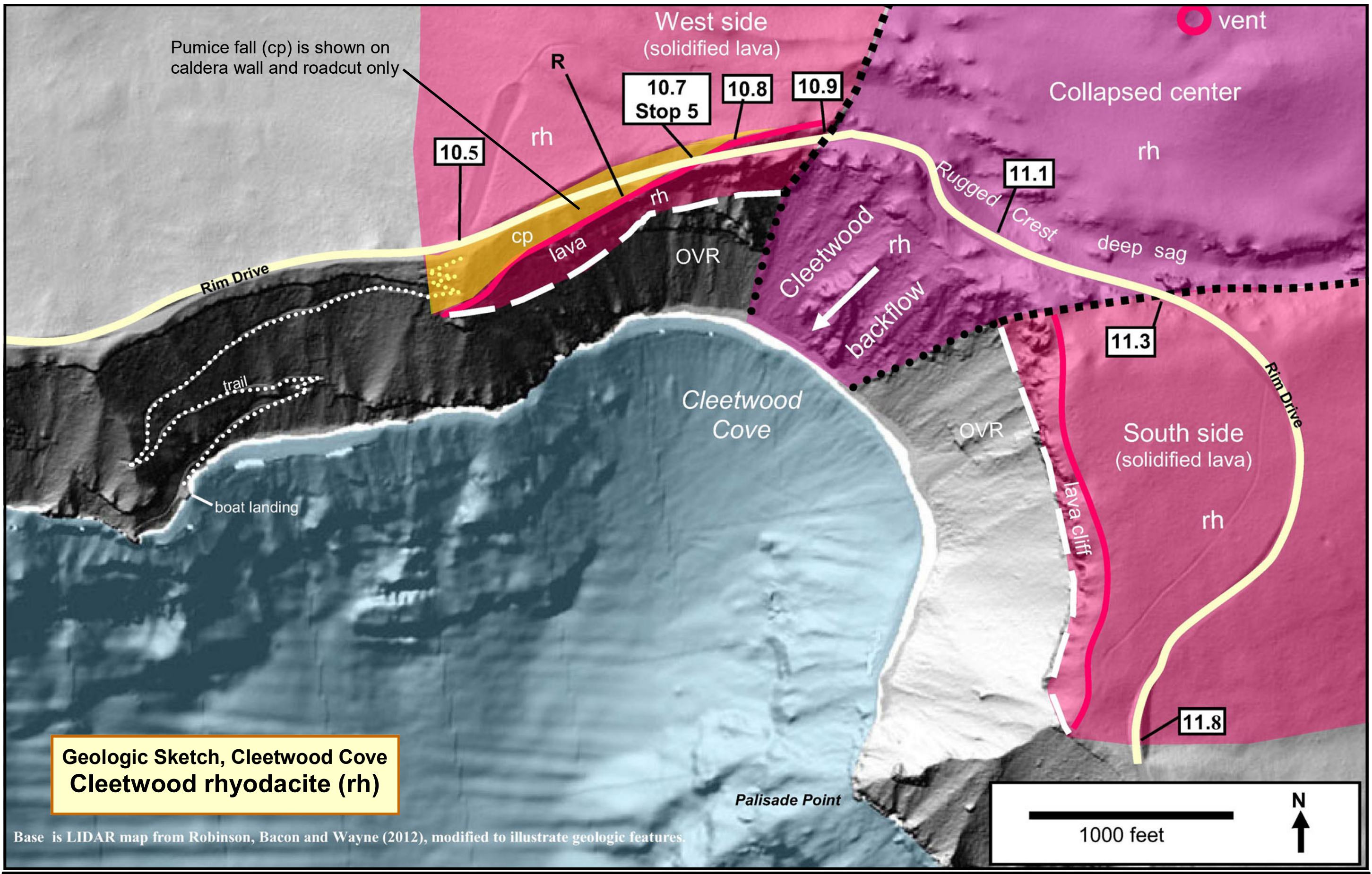
10.8 Roadcut exposes red rocks along the contact between the Cleetwood lava and overlying pumice fall (photo).

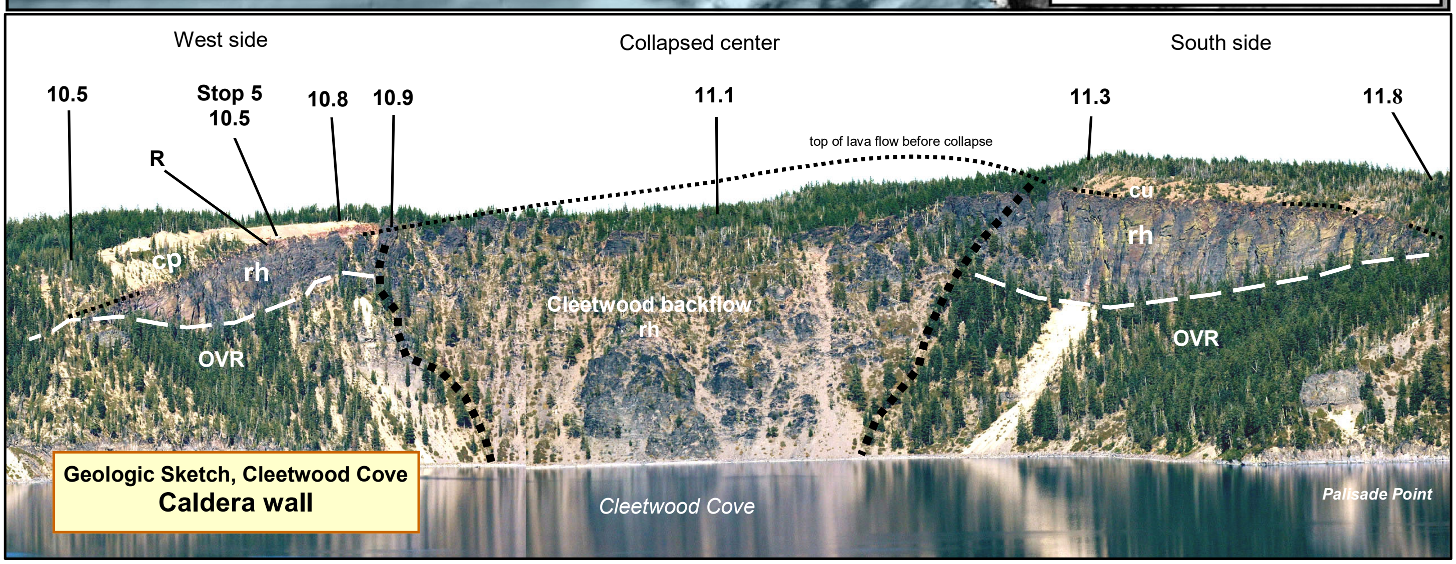
10.9 The large fluted cliff (photo), left, marks the contact between the solidified Cleetwood lava on the west side of the lava flow and the Cleetwood backflow at the head of Cleetwood Cove.

11.1 After leaving the fluted cliff, Rim Drive travels across the Cleetwood backflow and descends into the collapsed center of the lava flow. This part of the lava flow is up to 200 feet lower than the sides and is littered with large blocks of lava from the top of the flow. For several hundred feet, Rim Drive travels along the southwest side of a deep linear depression in the collapsed center (photo), then Rim Drive climbs up to the thick solidified lava on the south side of the lava flow.

11.3 Rim Drive is now on the south side of the Cleetwood lava flow, and the lava is covered with thin pumice fall (cp) and proximal ash flows (cb, cu) of the CE.

11.8 Rim Drive leaves the Cleetwood lava flow and travels across thick pumice fall (cp) and proximal ash flows (cb, cu).





<u>Geologic Sketch, Cleetwood Cove.</u> **The Cleetwood lava flow (rh) was still hot at the time of the climactic eruption. The top, bottom, and sides of the flow had solidified, but the thick rhyodacite in the center of the flow was still molten. Plinian pumice fall (cp) that was deposited on top of the Cleetwood lava at the beginning of the climactic eruption was altered and oxidized to red along the contact with the hot lava. These red rocks (R) can be seen along both sides of Cleetwood Cove. When Mount Mazama collapsed during the final phase of the CE, the caldera removed the southwest part of the lava flow and broke into the molten rhyodacite in the center of the flow. The thick cliffs along the sides of Cleetwood Cove are the solidified lava on the sides of the flow, and the dark, blocky "Cleetwood backflow" at the head of Cleetwood Cove is remobilized lava from the center of the flow. As the Cleetwood backflow spilled down the wall of the caldera, the center collapsed, forming a low area littered with broken blocks from the top of the flow. The Cleetwood lava overlies older glacial and volcanic rocks (OVR) up to 190 ka. The accompanying road log describes geologic features along this part of Rim Drive.**

RD 10.7b View toward head of Cleetwood Cove from turnout at Stop 5. This turnout is on top of a thick cliff on Cleetwood lava on the west side of Cleetwood Cove, and a similar lava cliff can be seen on the opposite side of the cove, right center. Note that there is no lava cliff at the head of the cove. Instead, the Cleetwood backflow (CB) covers the wall of the caldera. This is the remobilized rhyodacite that spilled down the wall of the caldera when Mount Mazama collapsed at the end of the CE. The red roadcut, left, is altered rocks along contact between Cleetwood lava and Plinian pumice fall (photo RD 10.8).

RD 10.8 Altered rocks along contact between the Cleetwood lava (rh) and overlying pumice fall (cp). After passing this road cut and the fluted cliff at the end of the roadcut, Rim Drive travels across the Cleetwood backflow and descends into the collapsed center of the lava flow.

RD 10.9 Fluted cliff at north end of the long roadcut marks the contact between the solidified lava on the west side of the Cleetwood lava flow and the Cleetwood backflow at the head of the cove.

RD 11.1 Large chaotic blocks of lava in the collapsed center of Cleetwood lava flow. Multiple polished and striated surfaces (P) within and between the blocks record movement of the lava.

12.0 Turnout on rim with good exposures of pumice fall and proximal ash flows (cp, cw, cb, cu) in roadcut and outcrops (photos). After leaving the turnout, Rim Drive turns away from the caldera for a short distance and continues to travel across ash flow deposits.

12.3 Park in the turnout on the rim, right, for Stop 6, the Wineglass Tuff.

RD 12.0a Turnout, with pumice fall (cp), Wineglass Welded Tuff (cw) and proximal ash flow deposits (cb, cu) of CE.

RD 12.0b Close-up of lithic breccia (cb).

12.3 Stop 6, Wineglass Tuff.

The rim of the caldera at Stop 6 is a hard 30-foot-thick ledge of pinkish Wineglass Welded Tuff (**cw**). This unit is of special interest because it is easily identifiable and marks the end of the Plinian phase of the CE and the beginning of the ring-vent phase and collapse of Mount Mazama. The Wineglass Tuff is mainly rhyodacite pumice deposited by pyroclastic flows during collapse of the Plinian cloud at the end of the Plinian eruption. These pyroclastic flows generally followed topographic lows on the northeast slope of Mount Mazama, and most exposures of the Wineglass Tuff occur in topographic lows along the northeast rim of the caldera from Pumice Point to Skell Head. The Wineglass Tuff is generally thin or absent on the topographic highs along this section of the rim.

In most locations, the Wineglass Tuff overlies thick Plinian pumice fall (**cp**) and is overlain by proximal ash flows (**cb, cu**). However, the Wineglass Tuff at Stop 6 is not covered by these ash flows, providing a rare opportunity to see the top of the Wineglass Tuff (photos). Look for arcuate gashes in the top of the flow, formed by slumping of the hot tuff before it was completely welded. Also look for older volcanic rocks, torn from the vent as it enlarged during the late stage of the Plinian eruption.

After leaving Stop 6, Rim Drive turns away from the caldera and begins to cross the short, steep-sided andesite of Roundtop lava flow (**ar**, 160 ka). **0.3**

RD 12.3a Thick ledge of Wineglass Welded Tuff (cw) at Stop 6 overlies Plinian pumice fall (cp) and thins rapidly toward topographic high, upper left. The cw on the topographic high is overlain by proximal ash flows (cb, cu) of the CE, but these deposits are absent at Stop 6, providing a rare look at the top the Wineglass Tuff. Telephoto view from east rim.

RD 12.3b Upper surface of Wineglass Welded Tuff at Stop 6. Arcuate fractures (F) were formed by slumping of the hot tuff before it solidified.

RD 12.3c Close-up of ledge shows large rock, right center, welded to the top of the ash flow.

<u>East Rim.</u> **Rim Drive crosses four lava flows on the east rim from Stop 6 to Stop 9. Two are andesite, one dacite, and one rhyodacite. All erupted from 27,000 to 160,000 years ago and most were shaped and modified by glaciers during their eruption. Glacial sediments are exposed on the wall of the caldera in several places, and are especially thick from the Palisades to the Wineglass. Most of the east rim is covered with thick pumice fall (cp) and proximal ash flows (cb, cu) of the CE, and the deposits at the top of Skell Head provide an especially complete record of the CE.**

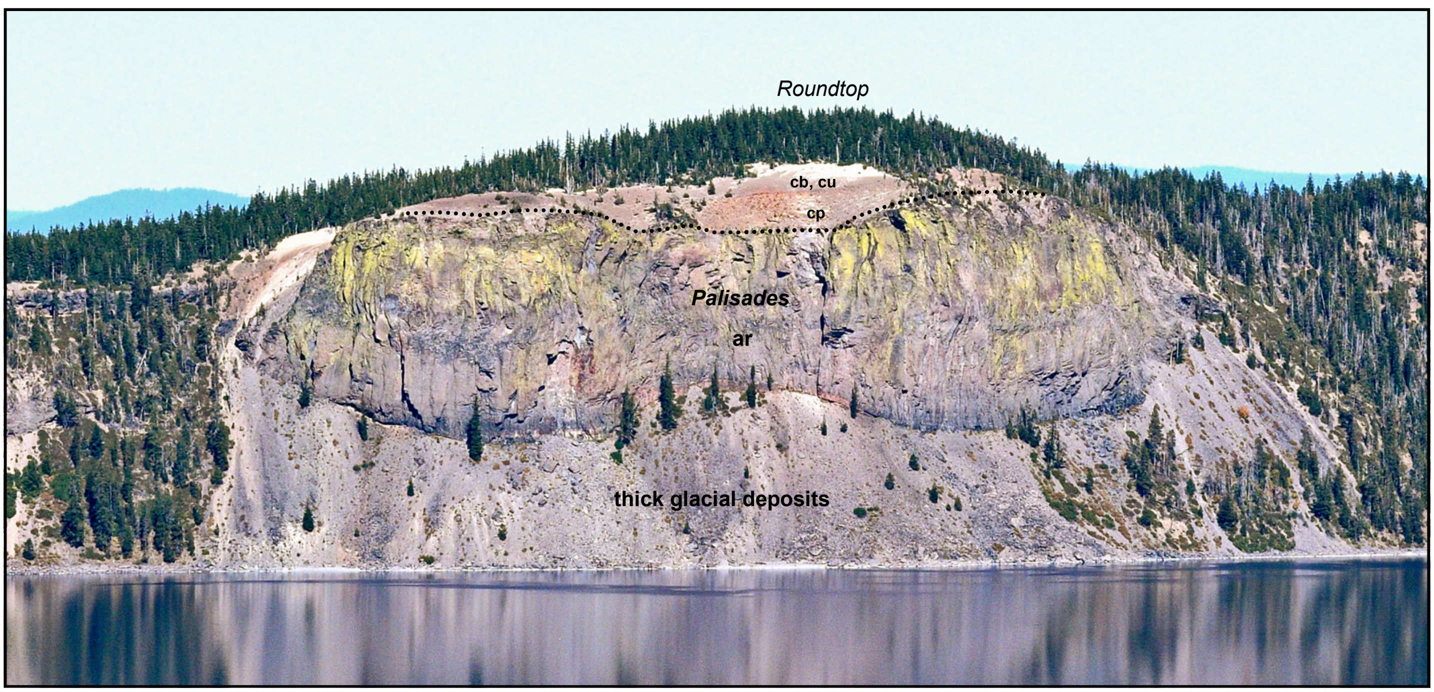
12.6 The roadcut, right, is on the north side of the andesite of Roundtop lava flow (**ar**, 160 ka). The vent for the lava flow is below Roundtop, and the lava flow forms the well-known "Palisades" on the wall of the caldera (photo). This short, steep-sided lava flow overlies thick glacial sediments and was likely bounded and perhaps completely covered by glacial ice during its eruption. **0.7**

13.3 The Wineglass, a well-known feature on the northeast wall of the caldera (photo), lies below this turnout, however it cannot be seen from the turnout. The top of the Wineglass is a thick ledge of Wineglass Welded Tuff that is overlain by lithic breccia. The bowl and stem are pumice fall (**cp**) and light-colored scree from the overlying ash deposits that cover older glacial sediments and lava flows. Beyond the turnout, Rim Drive travels across two thick lava flows of the andesite of Grotto Cove (**agc,** 71 ka) for the next 1.4 miles. These lava flows are covered by Plinian pumice fall (cp) and proximal ash flows (**cb, cu**) of the CE. **0.5**

13.8, 14.0 The two turnouts, right, are on the rim of the caldera above Grotto Cove, and have good views of Grotto Cove, the **agc** lava along the rim of the cove, and the pumice fall (**cp**) and proximal ash flows (**cb, cu**) of the CE. **0.2**

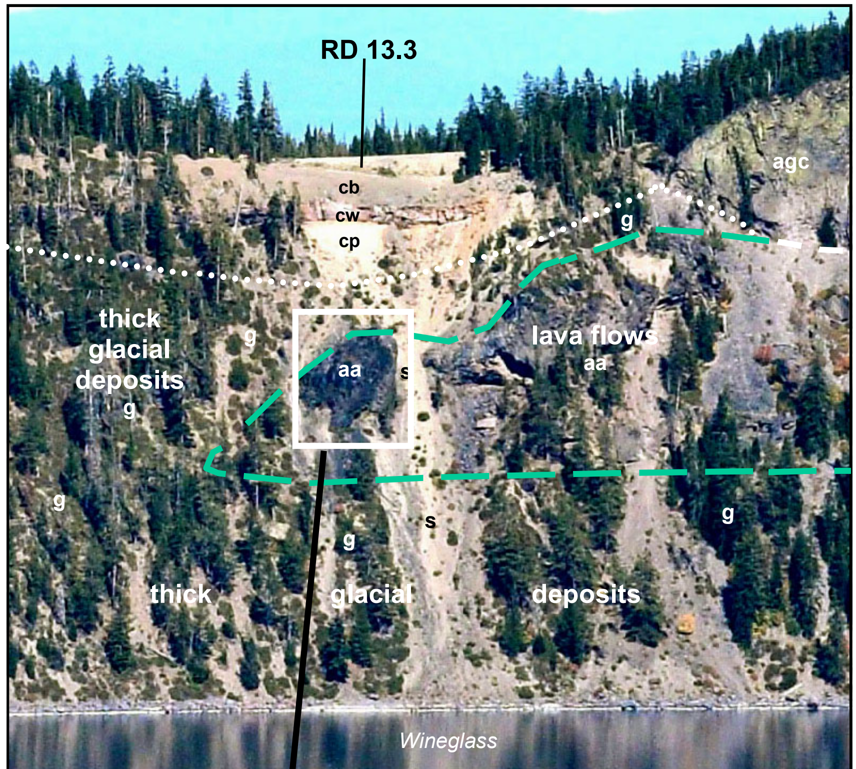
14.2 Roadcut, right, in **agc** lava, one of few roadcuts in these lava flows. **0.5**

14.7 Park at Skell Head Overlook for Stop 7.



RD 12.6 The Palisades. This 400-foot, steep-sided, vertically-jointed cliff is a thick lava flow of the andesite of Roundtop (ar, 160 ka). The ar lava erupted from a vent below Roundtop and was likely covered by thick glacial ice as it traveled down the northeast slope of Mount Mazama for 1.5 miles. The lava flow overlies thick glacial deposits that extend along the lower wall of the caldera for over a mile from Palisade Point to The Wineglass. These porous sediments likely serve as an overflow drain that maintains Crater Lake at constant level.

RD 13.3a The top of the Wineglass is a thick ledge of Wineglass Welded Tuff (cw), and this is overlain by lithic breccia (cb). The bowl is pumice fall (cp) and scree from the overlying ash deposits, and the stem is light-colored scree (s). The scree on the stem covers thick glacial sediments (g) and dark lava (andesite of Applegate Peak, aa, 240 ka) that is overlain and underlain by the glacial deposits. The large black outcrop next to the stem is an outcrop of the aa lava with spectacular columnar jointing (below). Telephoto view from Rim Village.



RD 13.3b The large outcrop of aa lava next to stem of the Wineglass (above) has spectacular columnar jointing. The jointing occurs in multiple rows of long, narrow, glassy columns that radiate in many directions. This outcrop is near the northern limit of the aa lava flow and is overlain and underlain by thick glacial sediments. The columns were likely formed where meltwater from a large glacier penetrated irregular fractures in the lava during cooling. View from Skell Head Overlook.

14.7 Stop 7, Skell Head Overlook.

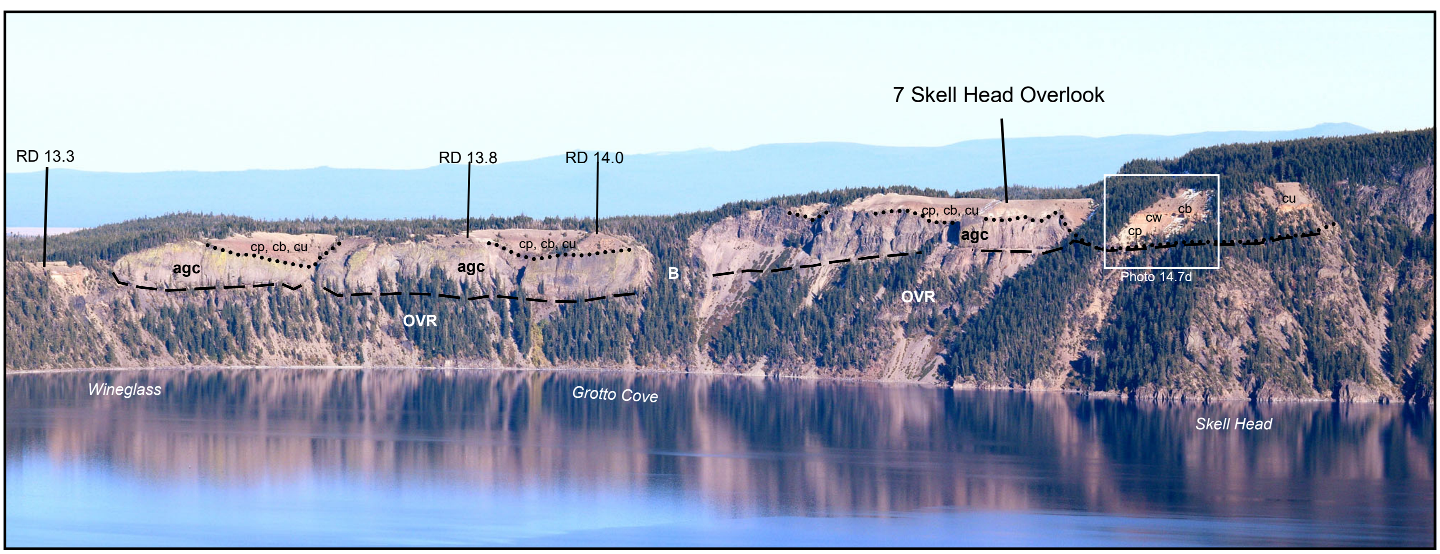
The Skell Head Overlook is at the south end of Grotto Cove, and the mile-long rim above the cove is dominated by two adjacent 300-thick lava flows of the andesite of Grotto Cove (**agc**, 71 ka). These lava flows are separated mid-way along the cove by a zone of blocky lava, and the overlook is on the higher, younger lava flow. Both flows extend down the northeast slope of Mount Mazama for about three miles from the rim. Most of the lava along the rim is covered by thick deposits of the CE (**cp, cb, cu**).

The overlook is about 1000 feet above Crater Lake and has good views of the west and north walls of the caldera. This is a good place to pause and look at some of the geologic features seen so far. Here are some things to look for, clockwise from Rim Village to the Wineglass:

RD 14.7a Skell Head Overlook.

1. Munson Notch on the rim of the caldera between Garfield Peak and Crater Lake Lodge
2. Sinnott Overlook on the upper wall of the caldera at Rim Village
3. Feeder dike for The Watchman lava flow (**dw**)
4. Ash cone (**bhp**) on the wall of the caldera below Hillman Peak
5. Devils Backbone dike (**ad**)
6. Llao Rock pumice fall in the explosion crater below the Llao Rock (**rhp**)
7. Steel Bay rhyodacite lava flow (**re**) east of Llao Rock
8. Ash deposits (**dcp, cp, cw, cb, cu**) at Pumice Point
9. Palisades, Roundtop, and andesite of Roundtop lava flow (**ar**)
10. The Wineglass and the **aa** lava next to the stem of the Wineglass

After leaving Stop 7, Rim Drive continues toward the rim for several hundred feet as it leaves the **agc** lava flow and then begins to travel across thick deposits of the CE (**cp, cw, cb, cu**) at the top of Skell Head (photo). Unfortunately, these rocks cannot be seen from this part of the rim. **0.3**



RD 14.7b The rim of the caldera along Grotto Cove is lava flows of the andesite of Grotto Cove (agc, 71 ka), covered by thick deposits of the climactic eruption (cp, cb, cu). An especially thick and complete section of these deposits is exposed at the top of Skell Head, immediately south of Grotto Cove. The agc lava flows overlie older andesite and dacite volcanic rocks from 240-335 ka (OVR). Telephoto view from west rim.

RD 14.7c Grotto Cove, looking north from Skell Head Overlook. Thick agc lava flows along rim of Grotto Cove are overlain by pumice fall (cp), lithic breccia (cb) and lithic ash (cu). The Wineglass Welded Tuff is mostly thin to absent, but is represented by several feet of light orange altered ashflow deposits between the cp and cb.

RD 14.7d Thick deposits of the CE at the top of Skell Head (cp, cw, cb, cu) overlie glacial sediments (g) and older volcanic rocks (OVR, 240-335 ka). Telephoto view from west rim. According to Bacon (2008), this is the most complete record of the CE on the rim of the caldera.

15.0 Redcloud rhyodacite lava flow (**re**, 27 ka) exposed in roadcut, right. Rim Drive is now climbing the steep north side of the lava flow and in a few hundred feet the road turns south and crosses the crest of the flow. This narrow, thick, lava flow erupted from a vent below Hill 7960 near the Cloudcap Overlook, traveled down the northeast slope of Mount Mazama for about a mile while in contact with glacial ice, and ends in a steep cliff with columnar jointing formed during contact with glacial ice. **1.2**

16.2 Lava flows of the dacite of Pumice Castle (**dc**, 72 ka) in roadcuts (photo). These thick, hard lava flows erupted from a vent at Cloudcap and cover much of the upper surface of Cloudcap. **0.8**

17.0 Trailhead for Mount Scott (8930'), left (5.0 mi. RT, difficult). **0.1**

17.1 Intersection, turn right for Stop 8 at Cloudcap Overlook. **0.3**

17.4 The large turnout, right, is on a broad saddle between Mount Scott and Cloudcap and has good views of both mountains. Looking east, Mount Scott (photo) is a parasitic cone of Mount Mazama and was built from some of Mount Mazama's oldest volcanic rocks (dacite of Mount Scott, **ds**, ~400 ka). The glacial cirque was cut into the soft, altered volcanic rocks near the vent. The **ds** lava is mainly breccia and agglutinate on the upper slopes, and massive lava flows on the lower slopes that extend about five miles down the east slope of the mountain.

From the west end of the turnout there is a good view of the steep east face of Cloudcap. This broad, low-relief mountain was the main vent for lava flows (**dc**) and pumice deposits (**dcp**) of the dacite of Pumice Castle (72 ka). The steep east face of Cloudcap was carved from the soft, altered rocks near the vent, but these rocks are now covered by Plinian pumice fall (**cp**). **0.6**

18.0 The lava in the roadcut, left, is a remnant of the base of the Redcloud rhyodacite lava flow (**re**, 27 ka), and consists of pumiceous rocks at the bottom, grading upward into dark glassy rhyodacite, then into platy rhyodacite (photo). The upper part of the flow is missing. The Redcloud lava came into this area from a vent near Cloudcap Overlook at an early stage of the eruption, stayed long enough for the bottom of the lava flow to solidify, then retreated and joined the main **re** lava flow down the steep northeast slope of Mount Mazama. Rim Drive crosses this lava flow from RD 15.0 to 16.0. This basal remnant of **re** lava overlies light gray pumice fall (**rep**) from the initial phase of the Redcloud eruption and orange dacite pumice fall (**dcp**) from the Pumice Castle eruption (photo), and is overlain by ash deposits of the Llao Rock (**rhp**) and climactic eruptions (**cp, cb**). **0.3**

18.3 Park at Cloudcap Overlook for Stop 8.

RD 16.2 Lava flows of dacite of Pumice Castle (dc, 72 ka) in roadcut. View is from turnout, looking north toward Redcloud rhyodacite lava flow (rh), center.

RD 17.4a Mount Scott (8930'), a parasitic cone with some of the of oldest lava flows of Mazama (dacite of Mount Scott, 400 ka). View looking southeast from turnout. The lava is mainly breccia and agglutinate on the upper slopes of the mountain and massive lava flows on the lower slopes. The large glacial cirque is cut into soft, altered rocks near the vent.

RD 17.4b Steep east face of Cloudcap, looking west from turnout. This was the main vent for lava flows (dc) and pyroclastic rocks (dcp) of the dacite of Pumice Castle (72 ka), and the steep slope is a glacial cirque cut into altered dc near the vent. The older rocks in the cirque are now mostly covered with Plinian pumice fall (cp). Roadcut on left and large block on right are dc lava.

RD 18.0a **Remnant of the base of the Redcloud rhyodacite lava flow (re, 27 ka). The re lava stayed only long enough to leave this "footprint", then changed direction and joined the main re lava flow down the northeast side Cloudcap. This remnant is about 10 feet thick and includes pumiceous rocks at the base, grading upward into dark glassy rhyodacite, then into platy rhyodacite. The remnant is overlain by ash deposits of the Llao Rock (rhp) and climactic eruptions (cp, cb), mostly covered by scree, and overlies light gray pumice (rep) and orange dacite pumice (dcp) from the Pumice Castle eruption (below).**

RD 18.0b **East end of roadcut. Remnant of Redcloud lava (re) overlies light gray pumice fall (rep) from the initial phase of the Redcloud eruption and orange pumice fall (dcp) of the dacite of Pumice Castle eruption. The vent for the Redcloud eruption is below Hill 7960 (right center) next to the Cloudcap Overlook.**

RD 18.3 Stop 8, Cloudcap Overlook.
The Cloudcap Overlook (7800') is the highest point along Rim Drive, and the road to the overlook is the highest paved road in Oregon. The overlook is at the top of Redcloud Cliff, which extends along the rim of the caldera from Skell Head to the Pumice Castle Overlook. This cliff is formed from two overlapping lava flows, and both erupted from vents the overlook — the dacite of Pumice Castle from a vent at Cloudcap, half a mile southeast of the overlook, and the Redcloud rhyodacite from a vent a immediately north of the overlook (Hill 7960). The broad upper surface of Cloudcap is covered with Plinian pumice fall (**cp**) and proximal ash flows (**cb, cu**) of the CE, and these deposits are well exposed below the overlook. In places, these deposits have been scoured and cleaned by powerful seasonal winds along the top of the cliff.

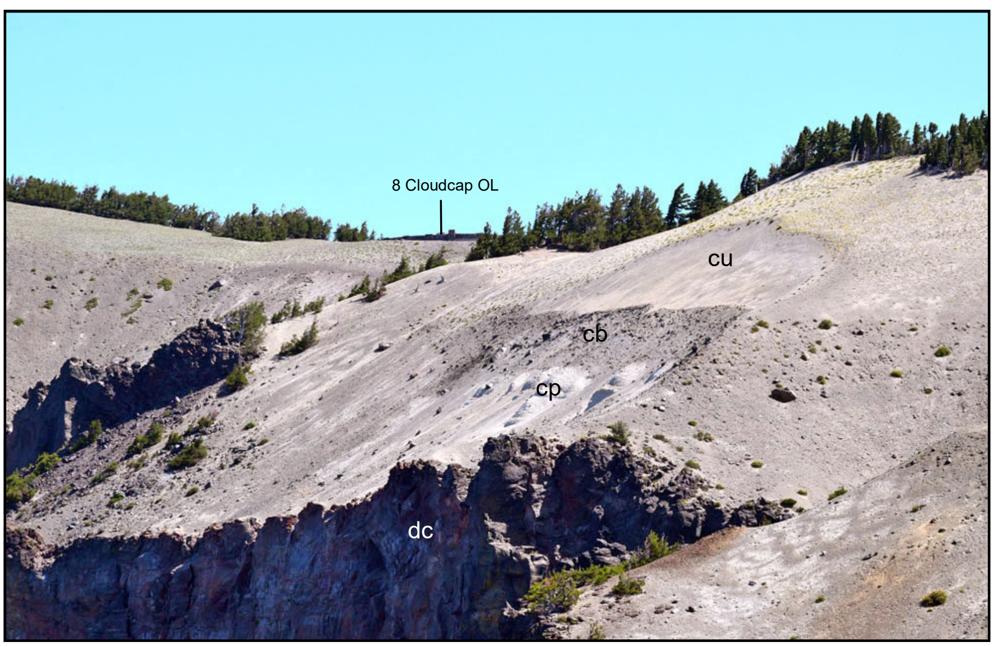
Return to Rim Drive. **1.0**

RD 19.3 Turn right on Rim Drive. Rim Drive is now traveling along the south side of Cloudcap, and the roadcuts are lava flows (**dc**) and pumice (**dcp**) of the dacite of Pumice Castle, locally covered by talus, Plinian pumice fall (**cp**) and proximal ash flows (**cb, cu**) of the CE. **0.6**

RD 19.9 Roadcut, right, lava flows of dacite of Pumice Castle. **0.5**

RD 20.4 Park in turnout, right, for Pumice Castle Overlook, Stop 9.

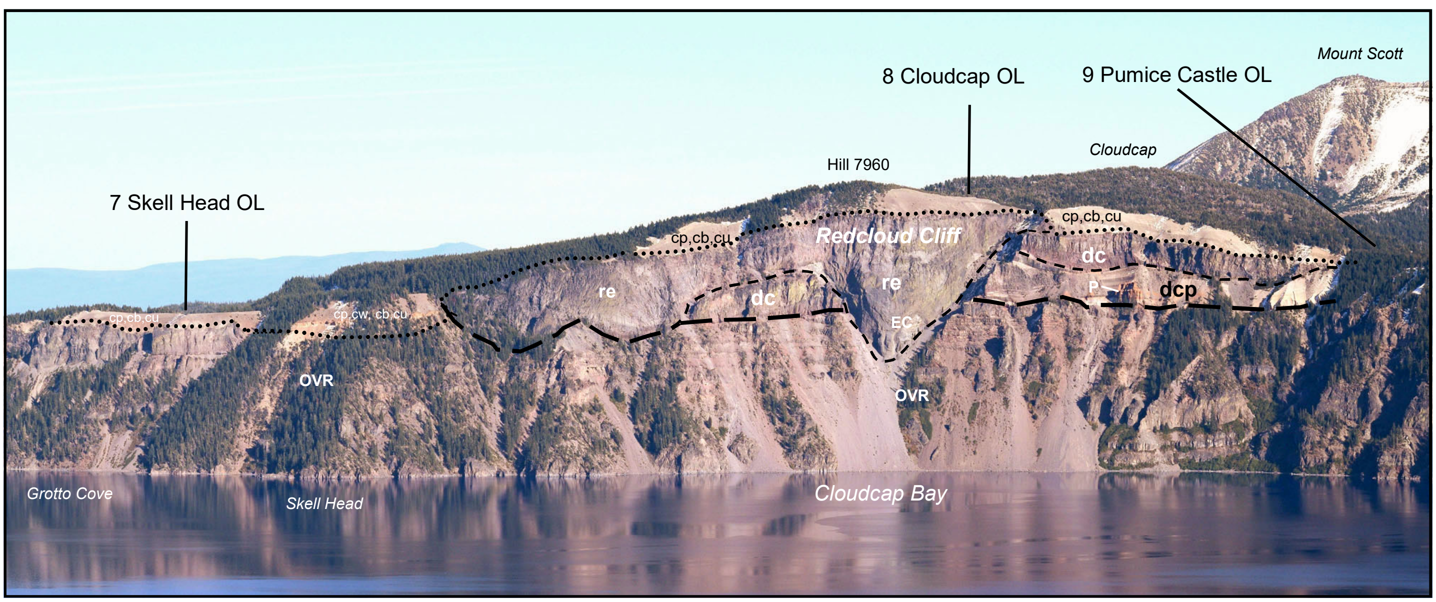
RD 18.3a Cloudcap Overlook, with view of southwest wall of caldera.



RD 18.3a Thick deposits of Plinian pumice fall (cp), lithic breccia (cb), and lithic ash (cu) at the top of Redcloud Cliff, locally scoured by strong seasonal winds. These deposits overlie thick lava flow of dacite of Pumice Castle (dc) along the south section of Redcloud Cliff. Telephoto view from Pumice Castle Overlook.

RD 20.4 Stop 9, Pumice Castle Overlook. High, massive Redcloud Cliff extends along east rim of the caldera for over a mile from Skell Head to the Pumice Castle Overlook. This imposing cliff is formed from two overlapping lava flows. The south section, near the Pumice Castle Overlook, is lava flows of the dacite of Pumice Castle (**dc**, 72 ka), and this lava overlies several hundred feet of orange pumice fall (**dcp**) from the initial phase of the Pumice Castle eruption. The large V-shaped center of the cliff is Redcloud rhyodacite (**re**, 27 ka), which fills a 1000-foot-deep explosion crater (EC) from the initial phase of the Redcloud eruption. The vent for this eruption was below Hill 7960, near the Cloudcap Overlook. The north section of Redcloud Cliff is **re** lava that overflowed the explosion crater and then continued down the northeast slope of Mount Mazama for another mile. Pumice Castle (P) is **dcp** pumice that was altered and indurated by heat and fluids from a nearby dike. The top of Redcloud Cliff is covered by thick deposits of the Plinian pumice fall (**cp**) and proximal ash flows (**cb, cu**) of the CE. **0.3**

RD 20.4a Redcloud Cliff and Pumice Castle, from Pumice Castle Overlook.



RD 20.4b Redcloud Cliff is formed from two overlapping lava flows, the Redcloud rhyodacite (re, 27 ka) and dacite of Pumice Castle (dc, 72 ka). The re vent is below Hill 7960 and the dc vent is below Cloudcap. Pumice Castle (P) is altered and indurated pumice (dcp) from the initial phase of the Pumice Castle eruption. Older volcanic rocks (OVR) are andesite and dacite, 240-335 ka. Redcloud Cliff is covered with thick pumice fall (cp) and proximal ash flows (cb, cu) of the CE. View is from west rim.

RD 20.4c Pumice Castle is dcp pumice that was altered and indurated by hot silica-rich gasses and fluids from a nearby dike. The floors of the castle are alternating layers of unwelded and welded tuff and the altered rocks are more deeply colored and erosion-resistant than the adjacent unaltered beds. Telephoto view from Pumice Castle Overlook.

<u>South Rim.</u> The south side of the caldera is built from Mount Mazama's oldest volcanic rocks, mainly andesite and dacite lava flows that erupted from 200 to 400 ka. The most extensive of these eruptions is the andesite of Applegate Peak (aa, ~240 ka), and most of the south side of Mount Mazama is covered with a thick blanket of these lava flows. Three major glacial valleys — Kerr, Sun, and Munson — cut into these older volcanic rocks on the south side of Mount Mazama, and Rim Drive travels across all of these valleys. Kerr Valley and Sun Valley have deep, U-shaped notches in the wall of the caldera, and Stops 10 and 11 are in these notches. During the ring-vent phase of the CE, pyroclastic flows poured down all of Mount Mazama's glacial valleys, leaving thick deposits of scoria, pumice and ash along their path. One of the best places to see these deposits is on the side trip to the Pinnacles Overlook.

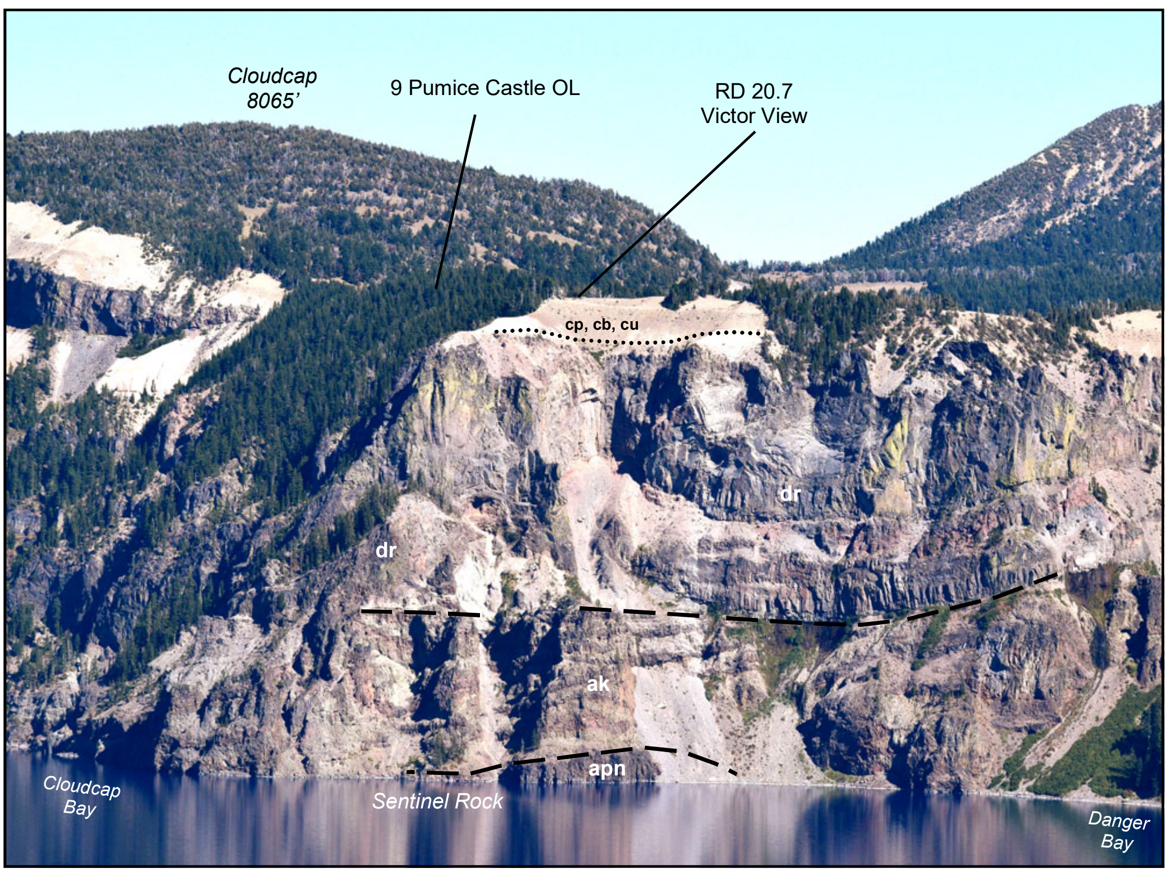
RD 20.7 Victor View, right, is at the top of Sentinel Rock, which juts out into Crater Lake between Cloudcap Bay and Danger Bay. This prominent rock is formed from two thick lava flows of the dacite of Sentinel Rock (**dr**, 320 ka) that fill a glacial valley in older volcanic rocks (photo). The **dr** lava flows are capped with Plinian ash fall (**cp**) and proximal ash flows (**cb, cu**) of the of the CE, and the overlook is built on these deposits. **0.9**

RD 21.8 After leaving Victor View, Rim Drive turns away from the caldera as it begins to cross a broad ridge of aa lava flows, and these lava flows are exposed in the roadcut on right. Most of the **aa** lava along the ridge is covered with deposits of the CE. After crossing this ridge, Rim Drive turns toward the caldera and descends into Kerr Notch at the head of Kerr Valley. **0.7**

RD 22.5 Roadcut in **aa** lava flows. **0.4**

RD 22.9 Park at Phantom Ship Overlook for Stop 10.

RD 20.7 Victor View is at the top of Sentinel Rock, a massive 1,200-foot promontory that juts into Crater Lake between Cloudcap Bay and Danger Bay. The rock is formed from two thick lava flows of the dacite of Sentinel Rock (dr, 320 ka) that fill a glacial valley in lava flows of the dacite of Kerr Notch (ak, 335 ka). Below the ak lava, at lake level, is an isolated outcrop of the andesite of Phantom Cone (apn, 400 ka). Sentinel Rock is covered by thick deposits of Plinian pumice fall (cp) and proximal ash flows (cb, cu) of the CE, and these deposits are well exposed below the overlook. Telephoto view from Rim Village.

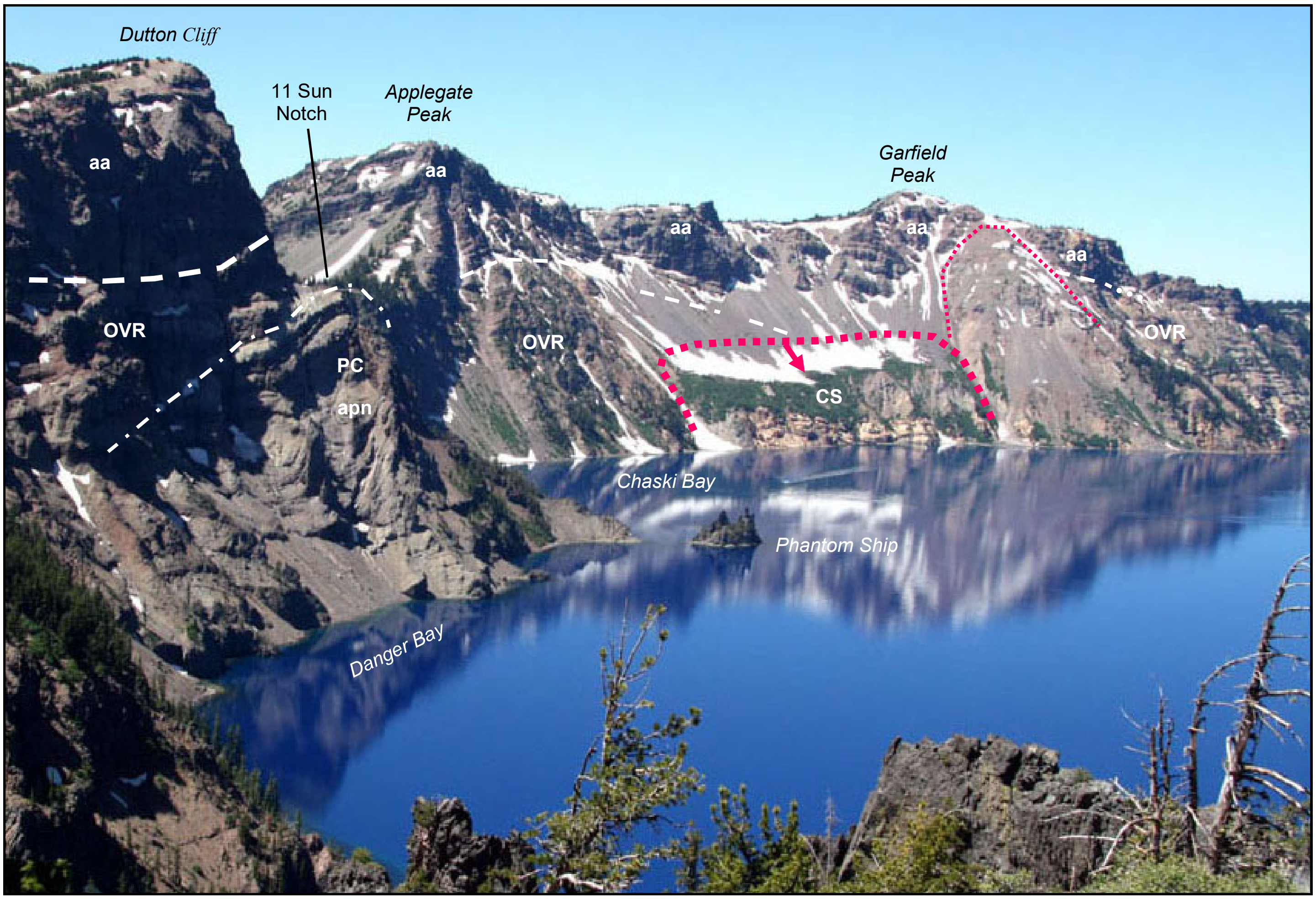


RD 22.9 Stop 10, Phantom Ship Overlook

Phantom Ship Overlook is in Kerr Notch, at the head of Kerr Valley. From here there is a good view of the south wall of the caldera, and some of the oldest rocks of Mount Mazama are exposed along this wall of the caldera. Most of these rocks erupted from 200,000 to 400,000 years ago, and the oldest rocks are at Phantom Cone on the lower half of Dutton Cliff. This large steep-sided cone is formed from near-vent ash fall, breccias, lava flows and intrusives of the andesite of Phantom Cone (**apn**, 400 ka). Some of these rocks have been altered and indurated by silica-rich fluids, so that Phantom Cone stands out from the wall of the caldera and forms a large point of land between Danger Bay and Chaski Bay.

From Dutton Cliff to Garfield Peak the south wall of the caldera is rimmed by thick, multiple lava flows of the andesite of Applegate Peak (**aa**, 240 ka). These are the most abundant and widespread lava flows of Mount Mazama, and the **aa** eruptions came from multiple vents on the south side of the mountain over a long period of time (210 ka to 270 ka).

Chaski Slide (CS) is a large landslide between Applegate Peak and Garfield Peak where a thick slab of the caldera wall moved downslope over 1000 feet. Within the slide block, thick **aa** lavas that were once on the rim of the caldera are now at mid slope, and rocks in the lower part of the slide block cover the floor of Chaski bay for up to two miles from shore. **0.1**



RD 22.9 South wall of caldera. Phantom Cone (PC), on lower half of Dutton Cliff, is steeply dipping lava flows, intrusives, breccias and ash fall of the andesite of Phantom Cone (apn, 400 ka). Phantom Ship is apn lava flows that were altered and indurated by silica-rich fluids from a nearby dike. The south rim of caldera from Dutton Cliff to Garfield Peak is dominated by thick multiple lava flows of the andesite of Applegate Peak (aa, 240 ka). At Chaski Slide (CS), a half-mile-long section of the caldera wall slid over 1,000 feet down the wall of the caldera. Older volcanic rocks (OVR) along the south rim include dacite of Sentinel Rock (300 ka), andesite of Kerr Notch (335 ka), and dacite of Chaski Bay (350 ka). View from Phantom Ship Overlook.

RD 23.0	Intersection with Pinnacles Road. Stay on Rim Drive. Just beyond this intersection, Rim Drive turns south and climbs up the west side of Kerr Valley toward the broad ridge of **aa** lava between Kerr Valley and Sun Valley. Roadcuts near the floor of Kerr Valley are andesite of Kerr Notch (**ak**, 335 ka) and roadcuts along the rim are thick **aa** lava flows. **0.8**

RD 23.8	Turnout with good views of Kerr Valley and Kerr Notch (photo). After climbing onto the broad ridge of aa lava, Rim Drive turns west toward Sun Valley and travels across the aa lava flows and overlying pumice fall (cp) and proximal ash flows (**cb, cu**) of the CE. **1.1**

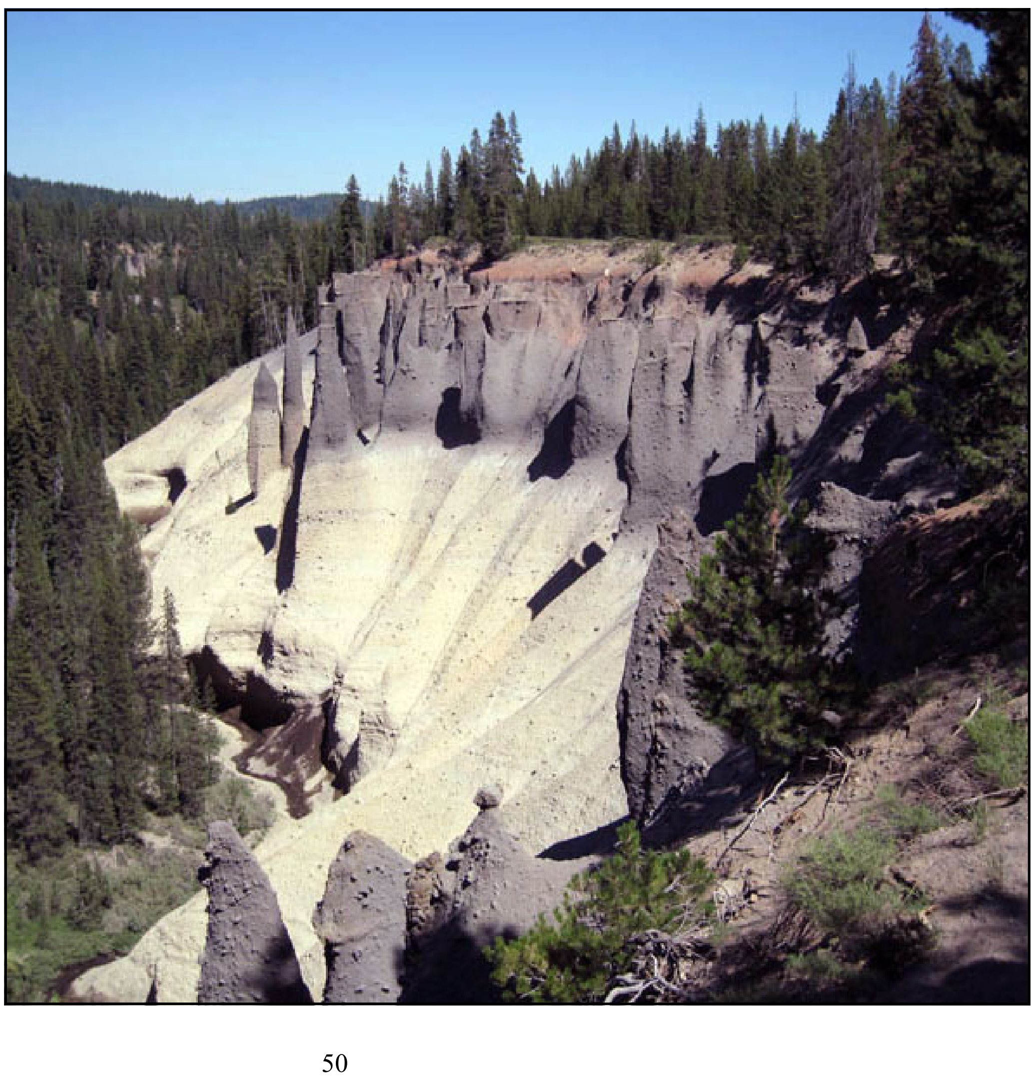
RD 24.9	View of the Klamath Lakes from paved turnout (photo). These lakes lie within in a large down-faulted block of the Basin and Range geologic province. The Annie Spring fault is a major boundary fault of this province, and Mount Mazama lies within the northwestern part of this geologic province. **0.6**

RD 25.5	Rim Drive turns north and descends from Dutton Ridge into Sun Valley and Sun Notch. The thick **aa** lava flows of Dutton Ridge are exposed in many roadcuts along this section of Rim Drive. **0.4**

RD 25.9	Turnout with views of Sun Valley and Sun Notch (photos). **1.1**

RD 27.0	Park at Sun Notch parking area for Stop 11.

**RD 23.0	Pinnacles Overlook is a 12-mile (RT) side trip on Pinnacles Road from this intersection. At Pinnacles Overlook there are good views of numerous pinnacles along the steep sides of a canyon that cuts into distal ash flows (cf) of the CE. Pinnacles Road follows these ash flows as they grade from coarse lithic breccia (cb) near Kerr Notch to rhyodacite pumice (cf) at the overlook. These deposits also grade vertically from light tan on the lower wall to medium gray on the upper wall. The light-colored deposits are from the earlier ash flows and the darker deposits include andesitic and gabbroic scoria from the later ash flows. The pinnacles occur where ash flow deposits were altered by hot fumarolic fluids and gasses escaping from the ash flow.**



RD 23.8 Kerr Notch (KN), looking north from turnout. North wall of caldera and Mount Thielsen (T) can be seen through the notch. Large cliff, right, is andesite of Kerr Valley (ak). Pinnacles Road (P) is below turnout.

RD 24.9 South slope of Mount Mazama. Upper Klamath Lake (K) lies within a down-faulted block of the Basin and Range geologic province, a large area of extensional faulting that extends over much of Nevada, California, Oregon and Utah.

RD 25.9 View from turnout looking north toward Sun Notch (SN) as Rim Drive descends from Dutton Ridge into Sun Valley (left). The west wall of the caldera can be seen through the notch. Applegate Peak, left, is capped by thick lava flows of the andesite of Applegate Peak (aa, ~240 ka), and the roadcut, right, is aa lava flows on Dutton Ridge.

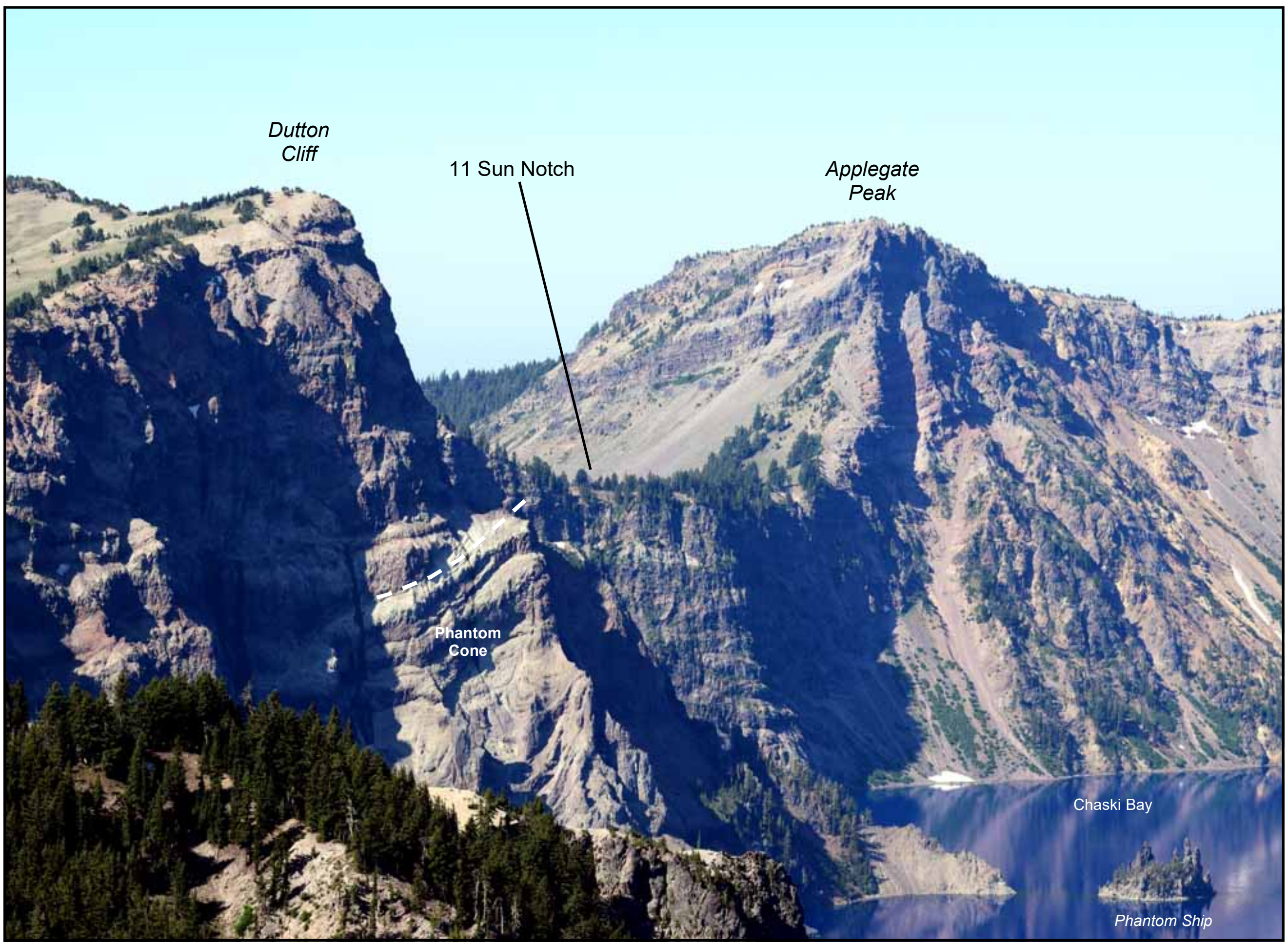
RD 25.9 View from turnout looking west across Sun Valley. Sun Notch is beyond right edge of photo. Applegate Peak and Vidae Ridge are multiple, thick aa lava flows, and the lower wall and floor of the valley is andesite of Kerr Notch (ak, 235 ka). After leaving Sun Notch, Rim Drive travels along west side of Sun Valley, then crosses Vidae Ridge (RD 28.8) on its way to Munson Valley.

RD 27.0 Stop 11, Sun Notch.

Sun Notch is the deepest and most prominent notch on the wall of the caldera, and the steep sides of the notch are reinforced by the thick, hard **aa** lava flows at Applegate Peak and Dutton Cliff. The notch is at the head of Sun Valley, a classic U-shaped glacial valley that extends down the south slope of Mount Mazama for over ten miles toward Klamath Lakes. During the late stage of the CE, the uppermost section of Sun Valley collapsed into the caldera, and pyroclastic ash flows poured through this notch and used Sun Valley as a pathway south toward Klamath Lakes. Deposits from these ash flows now cover much of the floor of Sun Valley, and extend southward as far as the Klamath Lakes.

To reach Sun Notch, take the short loop trail (0.8 mi., easy) from the parking area. Turn right where the trail splits and go to the north end of the notch where there are good views of Dutton Cliff, Phantom Cone and Phantom Ship. The prominent brick-red layers on Dutton Cliff are the altered brecciated tops and bottoms of the **aa** lava flows. Phantom Cone, on the lower half of Dutton Cliff, is built from steeply-dipping, near-vent, silica-rich lava flows, intrusives, breccias and ash of the andesite of Phantom Cone (**apn**, 400 ka). Phantom Ship is **apn** lava flows that were altered and indurated by heat and silica-rich fluids from a nearby dike associated with Phantom Cone. From the Phantom Ship viewpoint, follow the trail along the lip of Sun Notch toward Applegate Peak, then complete the loop and return to the parking area. Most of the Sun Notch trail travels across lithic breccia (**cb**), and the best place to see these deposits is in the roadcuts at the parking area. **1.4**

After leaving the parking area, Rim Drive travels down the west side Sun Valley. The floor and lower slopes of the valley are lava flows of the andesite of Kerr Valley (**ak**, 335 ka) and these lava flows are mostly covered with proximal ash flows (**cb**, **cu**) of the CE. **0.4**



RD 27.0a Sun Notch (SN) is at the upper end of Sun Valley, a major glaciated valley on the south side of Mount Mazama. The valley cuts into some of Mount Mazama's oldest volcanic rocks and was shaped by ice age glaciers over the last 240,000 years. Telephoto view from Cloudcap Overlook.

RD 27.0b The upper half of Dutton Cliff is multiple lava flows of the andesite of Applegate Peak (aa, 240 ka) and the lower half is Phantom Cone, the vent for the eruption of andesite of Phantom Cone (apn, 400 ka). A buttress of indurated near-vent rocks reaches out from Phantom Cone toward Phantom Ship. View from Sun Notch.

RD 27.0c Phantom Ship is apn lava flows that have been altered and indurated by heat and silica-rich fluids from a nearby dike. The island is about 170 feet high and 500 feet long. View from Sun Notch.

RD 27.0d Sun Notch trail (T) travels along the lip of the notch, with views of Crater Lake and the south rim of caldera. Photo from east end of notch.

RD 27.0e Sun Notch parking area, with roadcuts in lithic breccia. Inset is close-up of lithic breccia.

RD 28.4 Pullout with view of Vidae Falls (photo). This hanging waterfall cascades down a glaciated ledge of **ak** lava. The falls are fed by Vidae Creek, which drains broad ledge of **ak** lava above the waterfall.

RD 28.8 Roadcut in **aa** lava flows (photo), where Rim Drive turn west and cuts through Vidae Ridge on its way to Munson Valley. For the next mile, Rim Drive continues across **aa** lava flows on the broad divide between Sun Valley and Munson Valley, then Rim Drive turns north and descends into Munson Valley. **1.5**

RD 30.3 Glacial deposits in roadcuts, right, are the lateral moraine of the Munson Valley glacier. **0.7**

RD 31.0 Castle Crest Wildflower Trail, right (0.4 mi., loop, easy). This trail travels across meadows and wet areas (photo) with seasonal wildflowers. The water comes from year-round springs sourced from glacial deposits on the east side of Munson Valley. The wet areas occur where runoff from these springs are partly blocked by a large bedform of lithic breccia (**cb**). **0.3**

RD 31.3 Intersection of East Rim Drive and Munson Valley Road (MV 3.9). End of road log. Turn right for Park Headquarters (0.1 mi.) and Rim Village (2.8 mi.), or left for Highway 62 (3.9 mi.).

RD 28.4 Vidae Falls descends 100 feet down a series of glacially carved ledges of the andesite of Kerr Notch (335 ka).

RD 28.8 Thick aa lava flows in roadcut as Rim Drive crosses Vidae Ridge. View east toward Sun Valley.

RD 31.0 Spring-fed Creek along Castle Crest Wildflower Trail. The trail is well-known for abundant wildflowers that depend on springs for their livelihood.

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Crater Lake Institute

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