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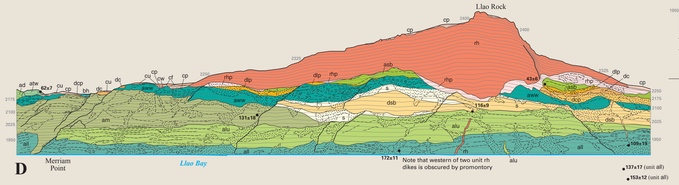
SCIENTIFIC INVESTIGATIONS MAP 2832
SHEET 4 of 4
Pamphlet and CD-ROM accompany map



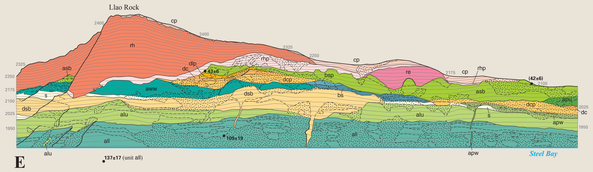
Aerial view to west-southwest of Llao Rock from Steel Bay (Panorama E). Note the thick, light-colored wedge of bedded, near-vent pumice-fall deposit (unit **rhp**) under the right extent of the Llao Rock lava flow (unit **rh**). Pumice-fall deposit decreases in thickness to east and also is present lining the explosion crater under the Llao Rock lava flow, where it has been compacted and fused to form dark, dense vitric tuff for several meters thickness against the overlying lava. Two dikes can be traced upward into dacite of Steel Bay lava (unit **dsb**; 116±5 ka); the more obvious dike stands out from the caldera wall, casting a shadow in the lower right corner of the photo.



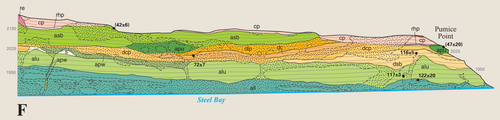
The great cliff at Llao Rock (Panorama D), which dominates this aerial view looking northwest, slices into Holocene rhyodacite lava (unit **rh**) that filled and overflowed the explosion crater formed in the early stages of the same eruption. Ash from the explosive phase of this eruption (unit **rhp**), which occurred 100–200 years before the caldera-forming climactic event, is found as far away as northern Nevada and northeastern California. Climactic pumice fall (unit **cp**) rests on the craggy top of the lava flow but was stripped from its lower flanks by pyroclastic flows of the ring-vent phase of the climactic eruption. Several lava and pyroclastic units exposed in the caldera wall below Llao Rock range in age from unit **all** (~140–170 ka) to unit **asb** (43±6 ka here). The broad shield volcano (lowest third of wall), composed of units **all** and **alu**, and the thick wedge of unit **am** (left) are clearly visible.



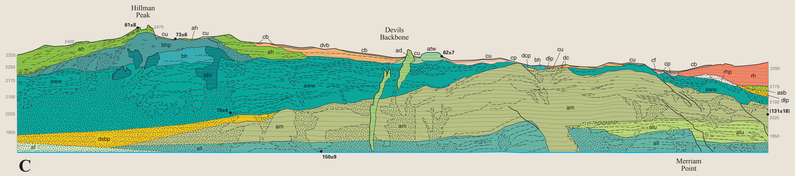
D



E



F



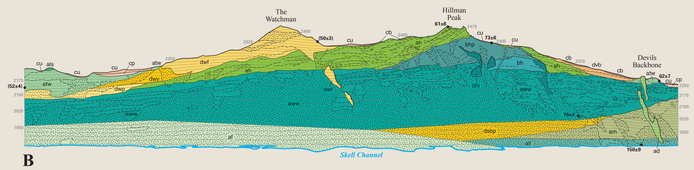
C



View northwest shows the two segments of the Devils Backbone dike that cut all four visible lava units (Panorama C): lower andesite below Llao Rock (unit **all**; 150±9 ka here), andesite of Merriam Point (unit **am**; 131±18 ka), andesite of the west wall (unit **aww**; 70±4 ka), and andesite south of The Watchman (unit **atw**, the lava cliff on the caldera rim to the right of upper dike segment; 62±7 ka here). Lava flows correlated with the Devils Backbone dike (unit **ad**; ca. 40–50 ka) extend as far as 11 km west of the caldera rim. Highest slope to the left of left dike segment is underlain by dacite of Munson Valley pyroclastic flow (unit **dvb**; ~35 ka).



Aerial view toward southwest of The Watchman (left) and Hillman Peak (right) from near Devils Backbone (Panorama B). Light-colored exposure at bottom right is pyroclastic-flow deposit (unit **dsbp**) correlated with dacite of Steel Bay (unit **dsb**; 116±5 ka). Thick package of many lava flows is andesite of the west wall (unit **aww**; 70±4 ka). Gray scree slopes above unit **aww** lavas are near-vent fall deposit of hornblende basaltic andesite of Hillman Peak (unit **bhp**) on either side of crags composed of lithified breccia (**bhp**) and intrusive rock (unit **bh**; 73±6 ka). Andesite of Hillman Peak (unit **ah**; 61±8 ka) forms the summit of its namesake. The Watchman is a glaciated horn sculpted from a thick dacite lava flow (unit **dwf**, 50±3 ka) whose feeder dike forms sail-like outcrops on the caldera wall. Slope above unit **aww** lava at caldera rim on extreme right is supported by dacite of Munson Valley pyroclastic flow (unit **dvf**; ~35 ka).



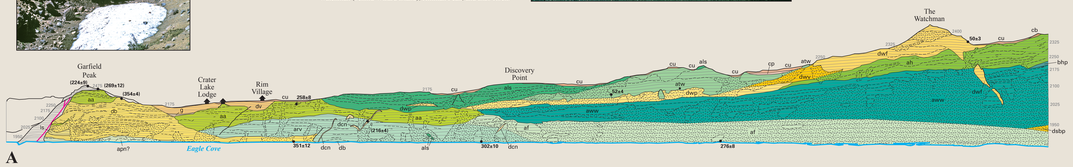
B



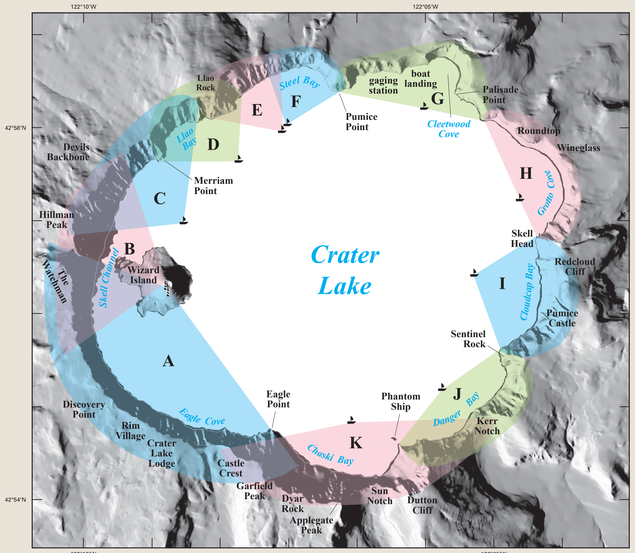
View to west from Garfield Peak trail at approximately 7,700 ft elevation, showing caldera-facing normal fault scarp interpreted as headwall of incipient landslide that formed in response to caldera collapse. This is the southernmost fault recognized in a set of similar faults below Garfield and Applegate Peaks.



Aerial view of Crater Lake caldera looking west-northwest from area above Scott Creek. Mount Scott (8,928 ft elev) in right foreground, composed entirely of dacite lava and pyroclastic rubble (unit **ds**; ~420 ka), has a mantle of climactic pumice (unit **cp**), long buff-colored scar descending to left apparently was formed by snow avalanche(s). Pyroclastic flows of ring-vent phase of climactic eruption left proximal lithic-rich ignimbrite (unit **cb**) in saddle on summit ridge of Mount Scott. From left to right, high points on caldera rim (8,013–8,151 ft elev) are Dutton Cliff (above Kerr Notch), Applegate and Garfield Peaks, The Watchman (behind Wizard Island), Hillman Peak, and Llao Rock.



A



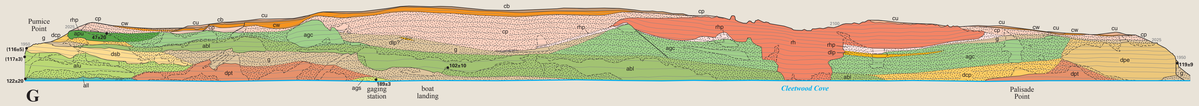
Geologic Panoramas of Crater Lake Caldera Walls

The geology of the caldera walls was mapped on photographs taken from Crater Lake, Wizard Island, and helicopter. This information was transferred to panoramic views made from photomosaics. Topographic contours (15-m contour interval) for each photograph were computed from a DEM. Computer-generated contour overlays for photos were superimposed on photomosaics and re-drafted by hand. Elevations in the DEM were accurate to approximately 5 m for points on a grid with 30-m spacing. As a result of the relatively large horizontal distance between data points, contours generalize the morphology of the caldera wall surface. They are primarily intended as a guide to thicknesses of map units in panoramic views of varying scale.

EXPLANATION

[Unit labels and colors correspond with those on geologic map (sheet 1)]

- **Covered areas**—Shows where rock units are covered by talus or vegetation
- **Contact**—Short dashes where concealed
- **Internal contact**—Indicates base or margin of lava flow or pyroclastic deposit within unit
- **Fault**—Short dashes where concealed (Panoramas A and K only)
- **Visual boundary**—Shows horizon and visual boundary clarifying three-dimensional surface
- **Lake surface**—At time photos were taken in 1979
- **Camera site**—Approximate location where photographs were taken
- **Dated sample**—Location and age (ka) of sample dated by K-Ar or $^{40}Ar/^{39}Ar$ methods. Ages in parentheses denote hidden sample localities that have been projected to panorama surfaces. Samples plotted below Panoramas D and E represent approximate locations of subsurface samples collected from the caldera wall by manned submersible
- **Computer-generated contour**—Accurate to approximately 5 m
- **Building**



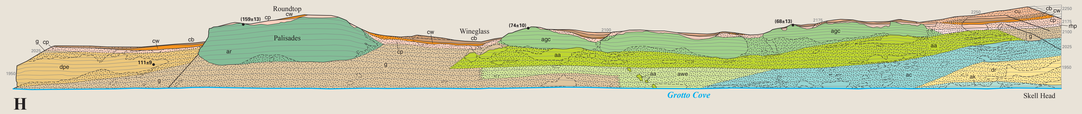
G

Aerial view of northeast caldera wall (Panorama H). The Palisades, the tall cliff above talus in center, is the ice-bounded lava flow, andesite of Roundtop (unit **ar**; 159±13 ka), that rests on thick glacial till and fluvial deposits largely obscured by talus. Below the lake surface, these permeable deposits rest on glaciated andesite of Cloudcap Bay (unit **ac**); seepage through these deposits apparently prevented Crater Lake from filling significantly higher than present elevation (Bacon and others, 2002). To the right of the Palisades is the scree chute known as the Wineglass. The bowl of the glass is scree from the three Holocene pumice-fall deposits (units **rhp** and **cp**) and the overlying Wineglass Welded Tuff and proximal ignimbrite (units **cw** and **cb**, respectively), the stem of the glass crosses subglacial and subaerial andesite of Applegate Peak (unit **aa**; ca. 210–270 ka) lying on glacial till obscured by talus. The cliff at the caldera rim to the right of the Wineglass is ice-bounded andesite of Grotto Cove (unit **agc**; 74±10 ka here). On the left end of the panorama, the Palisade flow (Williams, 1942) forms a cliff that reaches the lakeshore (unit **dpe**; 111±9 ka), fills a glacial paleovalley to the left of Roundtop, and is overlain by glacial till, the Holocene pumice-fall deposits, Wineglass Welded Tuff that thickens to the right toward the topographic low point on the rim, and proximal ignimbrite. Walker Rim, approximately the northeastern distal limit of climactic ignimbrite, is visible in the distance 46 km beyond the Wineglass.





Aerial view of Cleetwood Cove, looking northwest from above Palisade Point (Panorama G). Boat landing and lake gauge (gaging station) at left; Palisade Point at right. Holocene rhyodacite of the Cleetwood flow (Williams, 1942; unit **rh**) forms cliff at caldera rim above the arcuate cove; tongue of lava descending to lake edge is rhyodacite of the Cleetwood flow, remobilized from the party interior of the lava flow after the caldera collapsed. This and other evidence indicates that the Cleetwood flow was emplaced shortly before the climactic eruption, probably at most a few years earlier. Scalloped form of Cleetwood Cove is typical of topographic walls of collapse calderas that enlarge beyond the bounds of a subsiding central block by landsliding during and immediately following a caldera-forming eruption. In the caldera wall beneath the Cleetwood flow are near-vent, pumice-fall deposits from the onset of the Cleetwood eruption lying on pumice from the Llao Rock vent (collectively unit **rhp** here), underlain by andesite of Grotto Cove (unit **agc**; 71±5 ka) and andesite of the boat landing (unit **abl**; 102±10 ka). Trail to the boat landing traverses partly welded Wineglass Welded Tuff (unit **cw**), then descends forested scree slope on thick climactic pumice fall with interbedded nonwelded pyroclastic flows (unit **cp**), approximately 1-m thickness each of Cleetwood and Llao Rock pumice falls, and glacial till before dropping through and along base of the unit **abl** lava flow. Units visible in middle distance beyond caldera rim are forested northeast portion of the Grouse Hill rhyodacite flow (unit **rg**; ~27 ka), Pumice Desert (unit **cf**), and Timber Crater shield volcano (unit **atc**; 137±10 ka). Mounts Bailey and Thielsen are to left and right, respectively, of Diamond Lake in the distance.



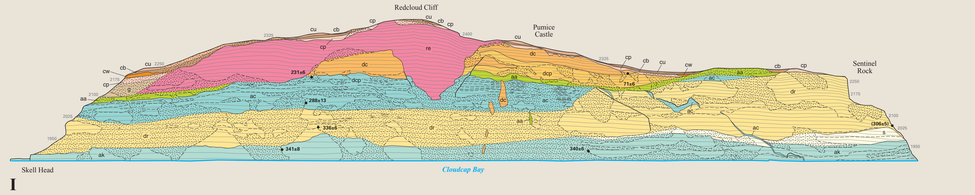
H

Redcloud Cliff dominates this view of the east wall of the caldera (Panorama I). The Redcloud Cliff flow of rhyodacite lava fills the V-shaped vent crater from which it issued. This flow and its kin (unit **rr**; ~27 ka), the Grouse Hill flow and dome and a small dome above Steel Bay (Panorama E), were emplaced when thick glacial ice was present on Mount Mazama. Also prominent are the cliff-forming lava (unit **dc**; 71±5 ka, weighted mean) and pumice-fall deposit (unit **dcp**) of dacite of Pumice Castle beneath the Redcloud Cliff flow. Below these are comparatively thin andesite of Applegate Peak (unit **aa**; ca. 210–270 ka), the lava shield of andesite of Cloudcap Bay (unit **ac**; est. 287±10 ka, weighted mean), pyroclastic flows and lava of dacite of Sentinel Rock (unit **dr**; 336±6 ka here), and andesite of Kerr Notch (unit **ak**; >340 ka here). Dikes of units **dr** (at right end of Panorama I), **ac**, **aa**, and **dc** cut units older than their respective extrusive equivalents. Climactic pumice fall (unit **cp**) and proximal ignimbrite (unit **cb**) are found at the caldera rim, but Wineglass Welded Tuff (unit **cw**) is absent except for a small outcrop at a low point to the right of photo.





View looking northeast of Pumice Castle, the orange outcrop in the center of the photo, from overlook on Rim Drive (Panorama I). Light-colored, bedded pumice at right is the same unit that forms Pumice Castle, Pliman fall deposit (unit **dcp**). Darker layers are incipiently to densely welded, more intensely to the left closer to vent. Cliff above pumice is lava unit of dacite of Pumice Castle (unit **dc**; 71±5 ka, weighted mean), which compressed and fused underlying pumice, and is overlain by climactic pumice fall (unit **cp**), proximal ignimbrite (unit **cb**), and a wind-reworked, pumice-rich deposit (restricted to caldera rim, included in unit **cu**). Skyline cliff at left is the Redcloud Cliff flow (unit **re**).



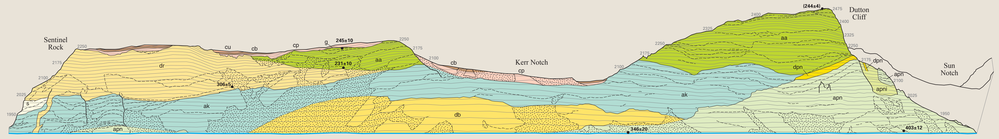
I



View northeast of Sentinel Rock from offshore from Kerr Notch (Panorama J). Two thick flows of dacite of Sentinel Rock (unit **dr**; 336±5 ka here) fill a glacial valley carved in thinner flows of andesite of Kerr Notch (unit **ak**; 340±6 ka near here, Panorama I). Outcrop at lake level, left center, is andesite of phantom cone (unit **apn**; 346±20 and 403±12 ka near here).



View southwest of nearly 600 m of relief and approximately 200,000 years of history in caldera wall between Kerr Notch (left) and Dutton Cliff (right; Panorama J). At right, light and dark bands dipping to left are flow-top and pyroclastic breccias and dense lava flow interiors, respectively, of phantom cone (Williams, 1942; unit **apn**; 346±20 and 403±12 ka). Hydrothermal alteration and oxidization of pyrite results in yellowish-tan breccias. The highest band is dacite of phantom cone (unit **dpn**). Overlying units are dacite of Chaski Bay (**db**) and andesite of Kerr Notch (**ak**), both hydrothermally altered to some degree at this location, and andesite of Applegate Peak (**aa**).



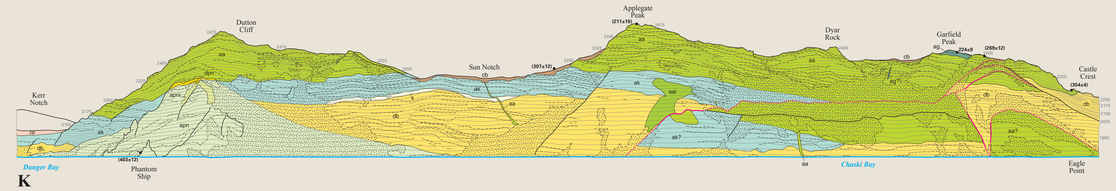
J

Aerial view of Phantom Ship island and unnamed point in phantom cone (Williams, 1942). All visible rock is lava and breccia of the andesite of phantom cone (unit **apn**; 403±12 ka here). Phantom Ship tops a buttress on the submerged caldera wall, whose southwest side appears to be bounded by a northwest-trending dike (Bacon and others, 2002). The beach at the point becomes much more extensive at times of low lake level and indicates that the surface elevation of Crater Lake has varied within only a few meters for a considerable time (Bacon and others, 2002).



View southwest of Garfield Peak and Eagle Crags above Chaski Bay (Panorama K). Cliffs at caldera rim are andesite of Applegate Peak (unit **aa**; ca. 210–270 ka), overlain by two thin flows of andesite of Garfield Peak at top center (unit **ag**; 224±9 ka). Talus rests on flat top of massive slide block that consists of altered lavas of units **aa**, **ak**(?), and **db**(?). Informally known as Chaski slide, the block was displaced downward from high on the caldera wall; an extensive debris-avalanche deposit lies on the caldera floor below Chaski Bay (Bacon and others, 2002). Several normal faults parallel to the caldera wall cut altered lavas below Garfield Peak, to the right of Chaski slide above Eagle Point. Yellowish-tan color results from oxidation of pyrite that is most evident in relatively permeable, flow-top breccias.





K

Geologic Map of Mount Mazama and Crater Lake Caldera, Oregon

By
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2008

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