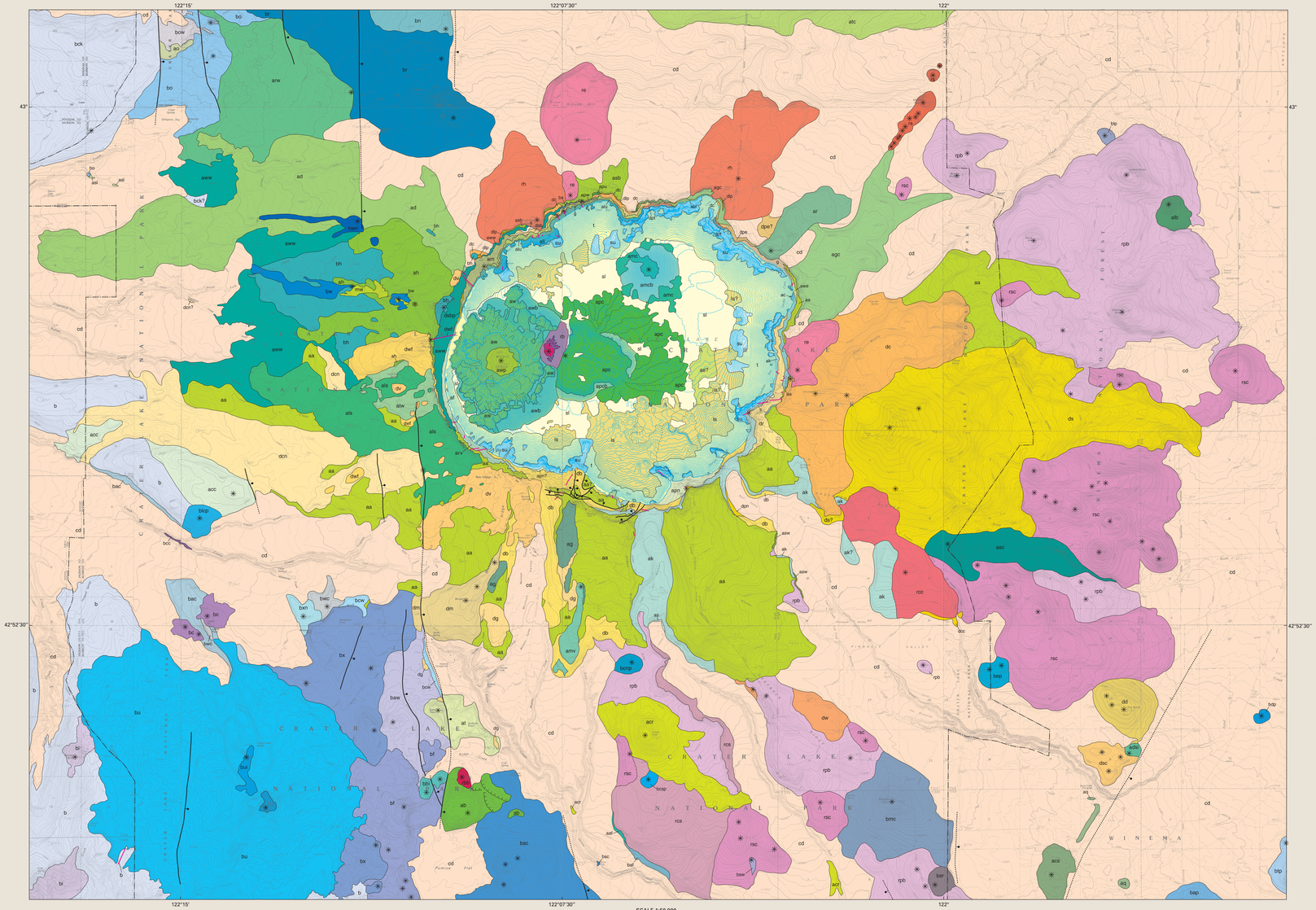
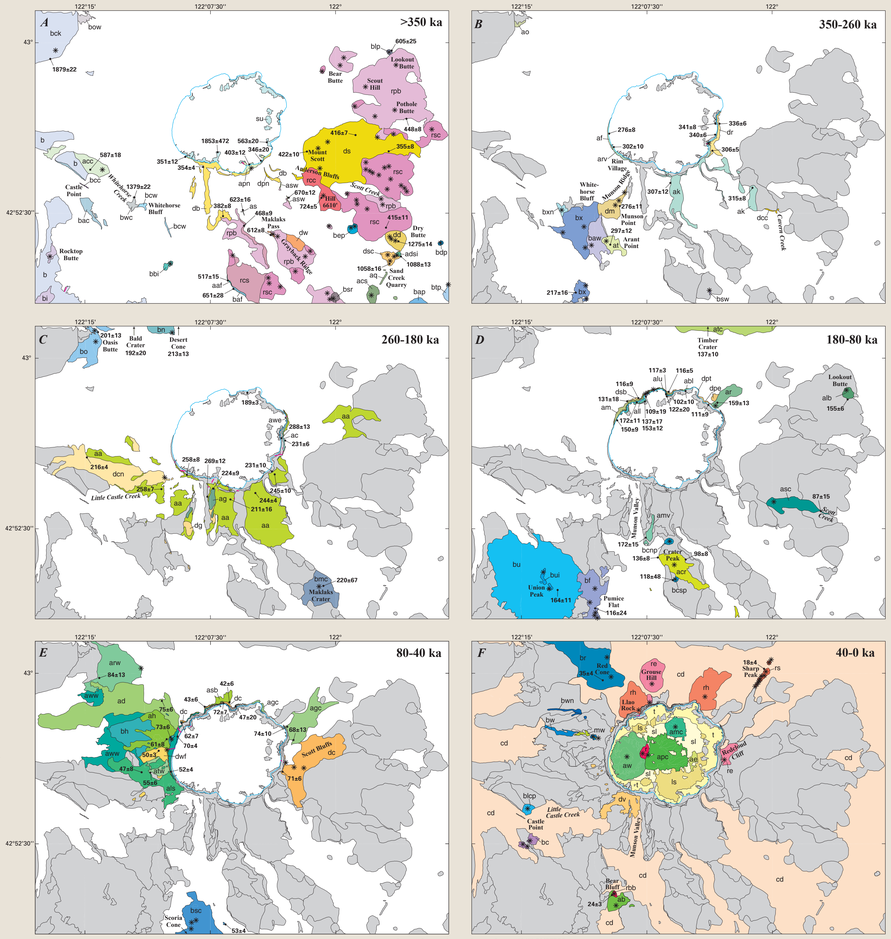
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY





BEDROCK GEOLOGIC MAP AND VOLCANIC HISTORY

The bedrock geologic map (left; 1:50,000 scale) shows interpreted probable extents of map units that commonly are largely obscured by pyroclastic and other fragmental deposits on the 1:24,000-scale geologic map (sheet 1). Thick pyroclastic deposits in major valleys and low-lying areas are mapped as undivided deposits of the climactic eruption (unit **cd**). Large areas of talus, landslide, and sedimentary deposits within the caldera also are shown. Some bedrock units have been generalized for clarity.

A series of six maps (above) based on the bedrock geologic map depicts the interpreted volcanic history of the area during intervals selected to highlight pulses of volcanism: *A*, >350 ka; *B*, 350-260 ka; *C*, 260-180 ka; *D*, 180-80 ka; *E*, 80-40 ka; and *F*, 40-0 ka. Colored units in each figure indicate units emplaced during the interval represented by that figure, while gray units indicate those that are older. White area is regional rock in place before Mount Mazama volcanism. Unit areas are bounded by present exposures and have not been reconstructed to their original form. In many cases, only small patches represent units that clearly once were far more extensive. Because not every unit has been radiometrically dated, some age assignments may prove to be incorrect. See unit descriptions in Description of Map Units (pamphlet).

View from the south-southwest rim of Crater Lake caldera showing the caldera wall from Hillman Peak on the west to Cleetwood Cove on the north. Crater Lake fills half of the 8- by 10-km-diameter caldera formed during the climactic eruption of Mount Mazama volcano approximately 7,700 years ago. Volcanic rocks exposed in the caldera walls and on the flanks record over 400,000 years of eruptive history. The exposed cinder cone and andesite lava flows on Wizard Island represent only 2 percent of the total volume of postcaldera volcanic rocks that is largely covered by Crater Lake. Beyond Wizard Island, the great cliff of Llao Rock, rhyodacite lava emplaced 100-200 years before the caldera-forming eruption, dominates the northwest caldera wall where andesite lava flows at the lakeshore are approximately 150,000 years old.

Deposits of the climactic eruption exposed in road cut on Rim Drive above Cleetwood Cove. Well-bedded and sorted climactic pumice fall (unit **cp**) is light gray to white on left but becomes increasingly oxidized reddish and compacted (fused) stratigraphically downward where layers drape the underlying craggy top of the Cleetwood rhyodacite flow. The oxidation resulted from trapping of air and its reaction at high temperature with iron in the pumice through addition of heat from the lava, which also softened the pumice and caused it to compact. Because the climactic pumice-fall deposit is affected in this way only on the surface of the Cleetwood flow, these features are evidence that this lava was still hot at the time of the climactic eruption. The rhyodacite lava crops out below the bedded pumice at the lower left and at the lower right corner of the photograph. Boulders at top of left half of road cut and the large block to right of person are clasts in lithic breccia (unit **cb**) that here rests on the pumice fall without intervening Wineglass Welded Tuff. The lithic breccia and accompanying mafic scoria clasts were deposited by pyroclastic flows of the ring-vent phase of the climactic eruption, during collapse of Crater Lake caldera. The channel in unit **cp** in which the large lithic block occurs may have been cut by the same pyroclastic flows. Pumice lapilli and crystal-rich ash migrating downslope obscure part of the road cut exposure.

Aerial view east-northeast over Williams Crater cinder cone (basaltic andesite, unit **bw**; ca. 35 ka) and Hillman Peak (andesite, unit **ah**; 61±8 ka) on the west rim of Crater Lake caldera. Mingled basaltic andesite and dacite lava (unit **mw**; forested) issued from west (left) base of cinder cone, crater, and a tiny dome near Rim Drive. Treeless ground is mainly underlain by fine-grained, lithic- and crystal-rich ignimbrite (unit **cu**) and proximal lithic breccia (unit **cb**) of the climactic eruption. Buff-colored slope on top of rhyodacite flow of Llao Rock (unit **rh**; upper left) is the pumice-fall deposit of the climactic eruption (unit **cp**). Three rounded, forested hills beyond caldera rim in center distance are pre-Mazama rhyodacite domes: left to right, Bear Butte, Lookout Butte, and Scout Hill (unit **rpb**).

Northeast aerial view of Cleetwood Cove showing cliffs in rhyodacite lava of the Cleetwood flow at caldera rim on either side of tongue of remobilized lava (backflow) that oozed down the fresh caldera wall immediately following collapse of the caldera during the climactic eruption (Panorama G). Tree-covered mesa immediately beyond Rim Drive is the surface of the Cleetwood flow. Brick-red outcrops along Rim Drive are lava and climactic pumice-fall deposit where they oxidized atop the Cleetwood flow, which was still hot when the climactic eruption began. Moored light-blue tour boats and trail to boat landing and lake gauge visible at left and Palisade Point at right. Forested slope on left in middle distance is southeast flank of Timber Crater shield volcano.

View of Mount Scott looking southeast from Rim Drive, where the road traverses the southern of two thick flows of andesite of Grotto Cove (unit **agc**) near a picnic area. Mount Scott is a stratovolcano composed entirely of dacite (unit **ds**; ca. 420 ka) erupted from low lava fountains. Its hydrothermally altered interior is exposed in the cirque on right. Smooth dark cliff in foreground is vitrophyric north flank of the Redcloud Cliff rhyodacite flow (unit **re**; ca. 27 ka), where lava chilled against glacial ice and was subsequently sculpted by glacial action. Forested mesa in middle distance between Mount Scott and the Redcloud Cliff flow is Scott Bluffs, a coulee of dacite of Pumice Castle (unit **dc**; 71±5 ka, weighted mean).

Morning aerial view looking northwest up the valley of Sun Creek. Applegate Peak caps the prominent rock wall of the west side of Sun Notch at the caldera rim. Northwest caldera wall is visible on opposite side of Crater Lake through Sun Notch. Grayback Ridge in foreground is thick lava of pre-Mazama rhyodacite (unit **rpb**; ca. 410–460 ka). Forested valley wall on left consists of a thick unit **rcs** lava flow overlain by a unit **rpb** lava flow. Upper slopes of Mount Mazama are underlain by andesite of Applegate Peak (unit **aa**; ca. 210–270 ka), which onlaps unit **rpb** at Maklaks Pass between Grayback Ridge and Dutton Ridge in right center of middle distance. Flat floor of the broad glacial valley is underlain by at least 60 m of ignimbrite of the climactic eruption (unit **cf**), incised by Sun Creek.

Ignimbrite of the climactic eruption (unit **cf**) at Godfrey Glen (left center) on Munson Creek where it meets Annie Creek (below photograph), viewed from turnout on Highway 62. Deposit (~100 m thick) is compositionally zoned: juvenile blocks are uniform rhyodacite pumice in lower part, andesitic and gabbroic scoria in upper part, with a mixed zone in between. Color reflects emplacement temperature and compositional zonation of particulate matrix; stratigraphically higher and hotter material is dark gray. Thin, light-colored layer at top is the pyroclastic-flow deposit where it has been bleached by fumarolic alteration beneath a 1- to 2-m-thick layer of fine ash. Pinnacle landforms in middle portion of ignimbrite are relatively erosion resistant tuff indurated by precipitation of silica and other minerals in pore spaces near gas-escape fractures and chimneys during cooling. High points on skyline are Garfield (left) and Applegate (right) Peaks on south caldera rim 6 km north-northeast of photographer.

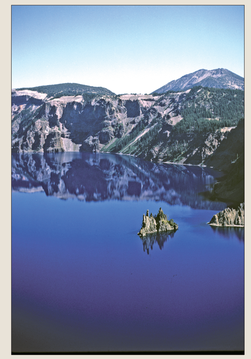
View northeast of deposits of the climactic eruption above Skell Head, the most complete section on the caldera rim (right mid of Panorama H). Climactic pumice fall (unit **cp**) forms pinkish-white slope and two prominent beds beside and above geologist. Horizontal boundaries between the four flow units of Wineglass Welded Tuff (Williams, 1942; unit **cw**) that make up the orange to brown cliff are marked by recesses and by relatively abundant, dark lithic fragments. The lower three flow units are partly welded and the highest flow is densely welded, grading up into black vitrophyre. Above the vitrophyre is a dark-colored slope of debris on proximal, lithic-rich climactic ignimbrite (unit **cb**).

View of southeast caldera wall (Panoramas J and K) from southwest shore of Crater Lake. Mount Scott is on the skyline at left, Kerr Notch in center, and Sun Notch at right. The notches are glacial valleys that were beheaded when the caldera collapsed during the climactic eruption ~7,700 yr ago. Dutton Cliff, between the notches, and the notch walls expose andesite of Applegate Peak (unit **aa**; ca. 210–270 ka). Andesite of Kerr Notch (unit **ak**; ~300–340 ka), dacite of Chaski Bay (unit **db**; ~350–380 ka), and andesite of phantom cone (unit **apn**; 403±12 ka) are exposed on either side of the talus below Dutton Cliff. Andesite of phantom cone is the oldest unit exposed in the caldera walls above lake level.

View of Pumice Point looking northwest (Panoramas F and G). Lowest cliff is upper unit of andesite below Llao Rock (unit **alu**; 117±3 ka), which rests on glaciated surface of lower unit of andesite below Llao Rock (unit **all**, obscured by talus; 122±20 ka here). Middle cliff is dacite of Steel Bay (unit **dsb**; 116±5 ka). Highest cliff to right of pumice slope is andesite of Pumice Point (unit **apu**; 47±20 ka) that fills small paleovalley cut in fall deposit of dacite of Pumice Castle (unit **dcp**; 71±5 ka, weighted mean) resting on glaciated surface of unit **dsb**. The higher, broader part of the pumice slope consists of 6 m of pumice fall from the nearby Llao Rock vent (unit **rhp**) lying on glaciated units **dcp** and **apu**, overlain by 31 m of climactic pumice fall and interbedded nonwelded ignimbrite (unit **cp**), then truncated by 1 m of Wineglass Welded Tuff (unit **cw**; barely visible at top of pumice) that grades upward into 2 m of proximal-facies, lithic-rich climactic ignimbrite (unit **cb**).

View southwest of Applegate Peak and 280-m-high cliff below Sun Notch from phantom cone (Panorama K). Hydrothermally altered flow-top breccia weathers tan; whereas, dense lava flow interiors are dark, giving cliffs a horizontally striped appearance. Lava outcrop at lake level is andesite of phantom cone (unit **apn**; 403±12 ka nearby). Lava flows above phantom cone and below prominent buff-colored sedimentary layer near top of cliff are dacite of Chaski Bay (unit **db**; ~350–380 ka). Highest lava flows are andesite of Kerr Notch (unit **ak**; ~300–340 ka). Slope below rim at Sun Notch is proximal lithic-rich climactic ignimbrite (unit **cb**) overlying a few meters of climactic and Llao Rock pumice-fall deposits (units **cp** and **rhp**; not visible). Andesite of Applegate Peak (unit **aa**; ca. 210–270 ka) lava flows and breccia form their namesake and high cliffs at right. Two steep gullies in shadows below Applegate Peak follow traces of caldera-wall-parallel normal faults. Talus forming slope in lower foreground was shed from Dutton Cliff.

View north of spectacular columnar joints in andesite of Applegate Peak vitrophyre (unit **aa**; ca. 210–270 ka) below Wineglass (note geologist at lower right; Panorama H). Columns formed perpendicular to cooling surface as meltwater penetrated solidifying lava along growing fractures (joints) as a result of lava flowing against or beneath glacial ice. Cliff in distance is southeast margin of andesite of Roundtop (unit **ar**; 159±13 ka), also an ice-bounded lava flow.



Aerial view northeast of Phantom Ship, a small island remnant of andesite of phantom cone (unit **apn**; 403±12 ka nearby). Resistant, hydrothermally altered lava flows that form Phantom Ship are the top of a buttress on the submerged caldera wall whose southwest side appears to be bounded by a northwest-trending dike (Bacon and others, 2002). Caldera wall in distance features Sentinel Rock and Kerr Notch (Panorama J). Mount Scott (right) and Cloudcap (left) are on skyline.

Aerial view towards north over east-facing scarp of Annie Spring fault. Basaltic andesite northwest of Pumice Flat (unit **bf**; 116±24 ka) forms north-south ridge in foreground that marks a fissure-vent system and also a small shield volcano (with arcuate buff-colored exposure at top) bounding forested Pumice Flat (right center). Forested hill due east of shield is Bear Bluff and coeval tuya (units **rbb**, 24±3 ka, and **ab**, respectively). Dark hill in middle distance is Arant Point (unit **afl**; 297±12 ka), the glaciated intrusive core of a cinder cone that is truncated on the east by the Annie Spring fault and that grew above the source vent for a tuya of the same unit (**afl**) that forms a low mesa east of the fault. The Watchman, Hillman Peak, and Llao Rock are visible on the west and north walls of Crater Lake caldera; Mount Bailey is in the far distance. Between Arant Point and the caldera rim, in line with Llao Rock, is the source vent for dacite north of Castle Creek (unit **dcn**; 216±4 ka), cut and displaced down to the east by the Annie Spring fault.

Geologic Map of Mount Mazama and Crater Lake Caldera, Oregon

By
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