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Overview for Geologic Field-Trip Guides to Mount Mazama, Crater Lake Caldera, and Newberry Volcano, Oregon

Scientific Investigations Report 2017–5022–J

U.S. Department of the Interior
U.S. Geological Survey

Cover (top photo): View east-northeast from Garfield Peak on the south rim of Crater Lake caldera. Peak on skyline is 8,929 feet (2,722 meters) Mount Scott, an ~420 thousand years before present (ka) dacite stratovolcano considered to be part of Mount Mazama, the volcano that collapsed during the caldera-forming eruption ~7,700 years ago. The caldera walls in this view expose Mazama lava flows and fragmental deposits from as old as ~400 ka at Phantom Cone, adjacent to tiny Phantom Ship island, to as young as ~27 ka at Redcloud Cliff, the V-shaped face at the top of the wall left of center. The beheaded glacial valley of Kerr Notch, the low point on the caldera rim, is seen between Phantom Ship and Mount Scott. Photograph by Carly McLanahan.

Cover (bottom photo): Newberry Volcano, Oregon, is the largest volcano in the Cascades volcanic arc. This north-facing view taken from the volcano's peak, Paulina Peak (elevation 7,984 feet), encompasses much of the volcano's 4-by-5-milewide central caldera, a volcanic depression formed in a powerful explosive eruption about 75,000 years ago. The caldera's two lakes, Paulina Lake (left) and the slightly higher East Lake (right), are fed in part by active hot springs heated by molten rock (magma) deep beneath the caldera. The Central Pumice Cone sits between the lakes. The mostly treeless, 1,300-year-old Big Obsidian Flow, youngest lava flow on the volcano, is surrounded by forest south of the lakes. Photograph by Robert Jensen.

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Preface

The North American Cordillera is home to a greater diversity of volcanic provinces than any comparably sized region in the world. The interplay between changing plate-margin interactions, tectonic complexity, intra-crustal magma differentiation, and mantle melting have resulted in a wealth of volcanic landscapes. Field trips in this series visit many of these landscapes, including (1) active subduction-related arc volcanoes in the Cascade Range; (2) flood basalts of the Columbia Plateau; (3) bimodal volcanism of the Snake River Plain-Yellowstone volcanic system; (4) some of the world's largest known ignimbrites from southern Utah, central Colorado, and northern Nevada; (5) extension-related volcanism in the Rio Grande Rift and Basin and Range Province; and (6) the spectacular eastern Sierra Nevada featuring Long Valley Caldera and the iconic Bishop Tuff. Some of the field trips focus on volcanic eruptive and emplacement processes, calling attention to the fact that the western United States provides opportunities to examine a wide range of volcanological phenomena at many scales.

The 2017 Scientific Assembly of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) in Portland, Oregon, marks the first time that the U.S. volcanological community has hosted this quadrennial meeting since 1989, when it was held in Santa Fe, New Mexico. The 1989 field-trip guides are still widely used by students and professionals alike. This new set of field guides is similarly a legacy collection that summarizes decades of advances in our understanding of magmatic and tectonic processes of volcanic western North America.

The field of volcanology has flourished since the 1989 IAVCEI meeting, and it has profited from detailed field investigations coupled with emerging new analytical methods. Mapping has been enhanced by plentiful major- and trace-element whole-rock and mineral data, technical advances in radiometric dating and collection of isotopic data, GPS (Global Positioning System) advances, and the availability of lidar (light detection and ranging) imagery. Spectacularly effective microbeam instruments, geodetic and geophysical data collection and processing, paleomagnetic determinations, and modeling capabilities have combined with mapping to provide new information and insights over the past 30 years. The collective works of the international community have made it possible to prepare wholly new guides to areas across the western United States. These comprehensive field guides are available, in large part, because of enormous contributions from many experienced geologists who have devoted entire careers to their field areas. Early career scientists are carrying forward and refining their foundational work with impressive results.

Our hope is that future generations of scientists as well as the general public will use these field guides as introductions to these fascinating areas and will be enticed toward further exploration and field-based research.

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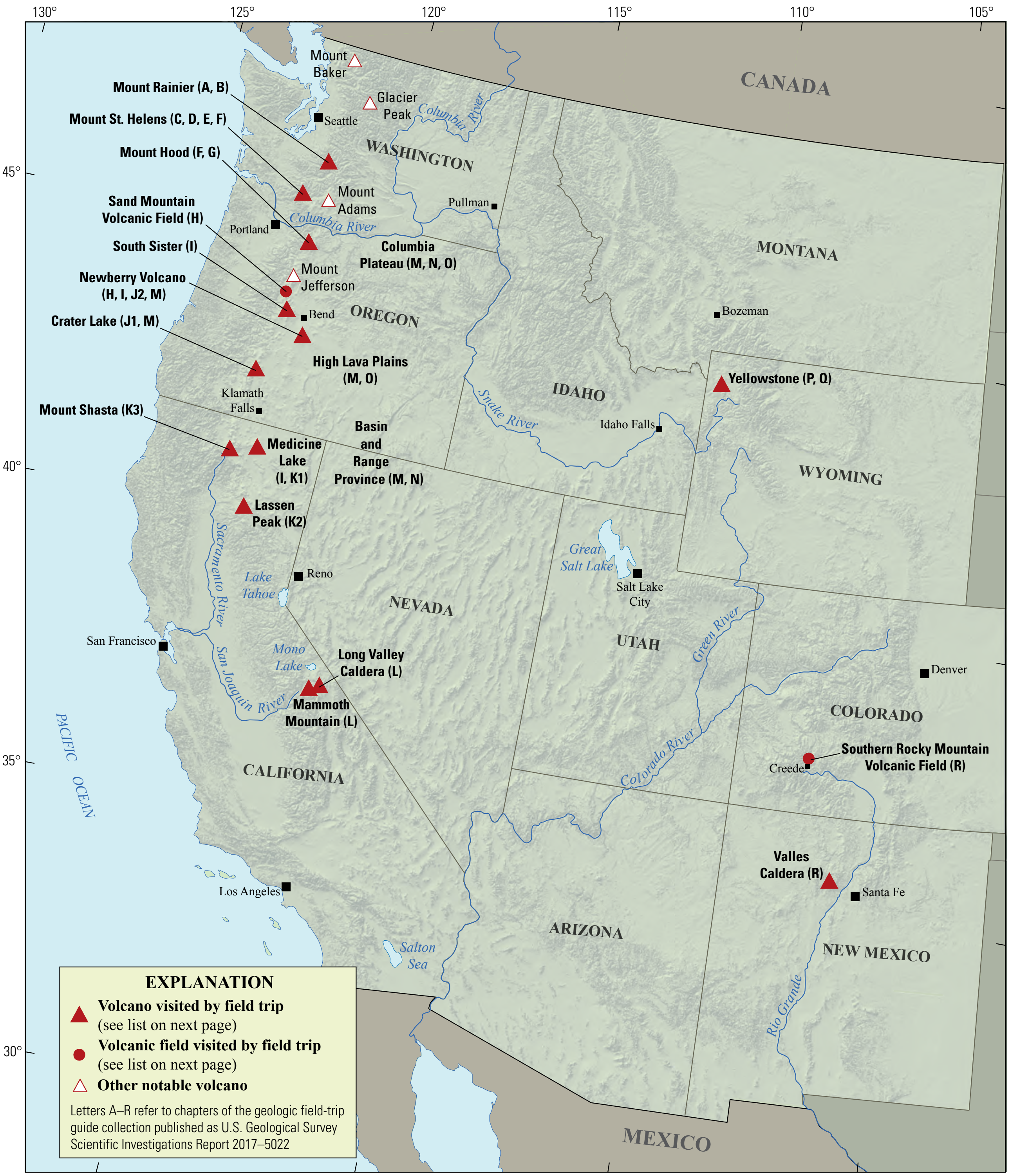
Field-trip committee, IAVCEI 2017



Map of the western United States showing volcanoes and volcanic fields visited by geologic field trips scheduled in conjunction with the 2017 meeting of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) in Portland, Oregon, and available as chapters in U.S. Geological Survey Scientific Investigations Report 2017–5022. Shaded-relief base from U.S. Geological Survey National Elevation Dataset 30-meter digital elevation model data.

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Contents

Figure

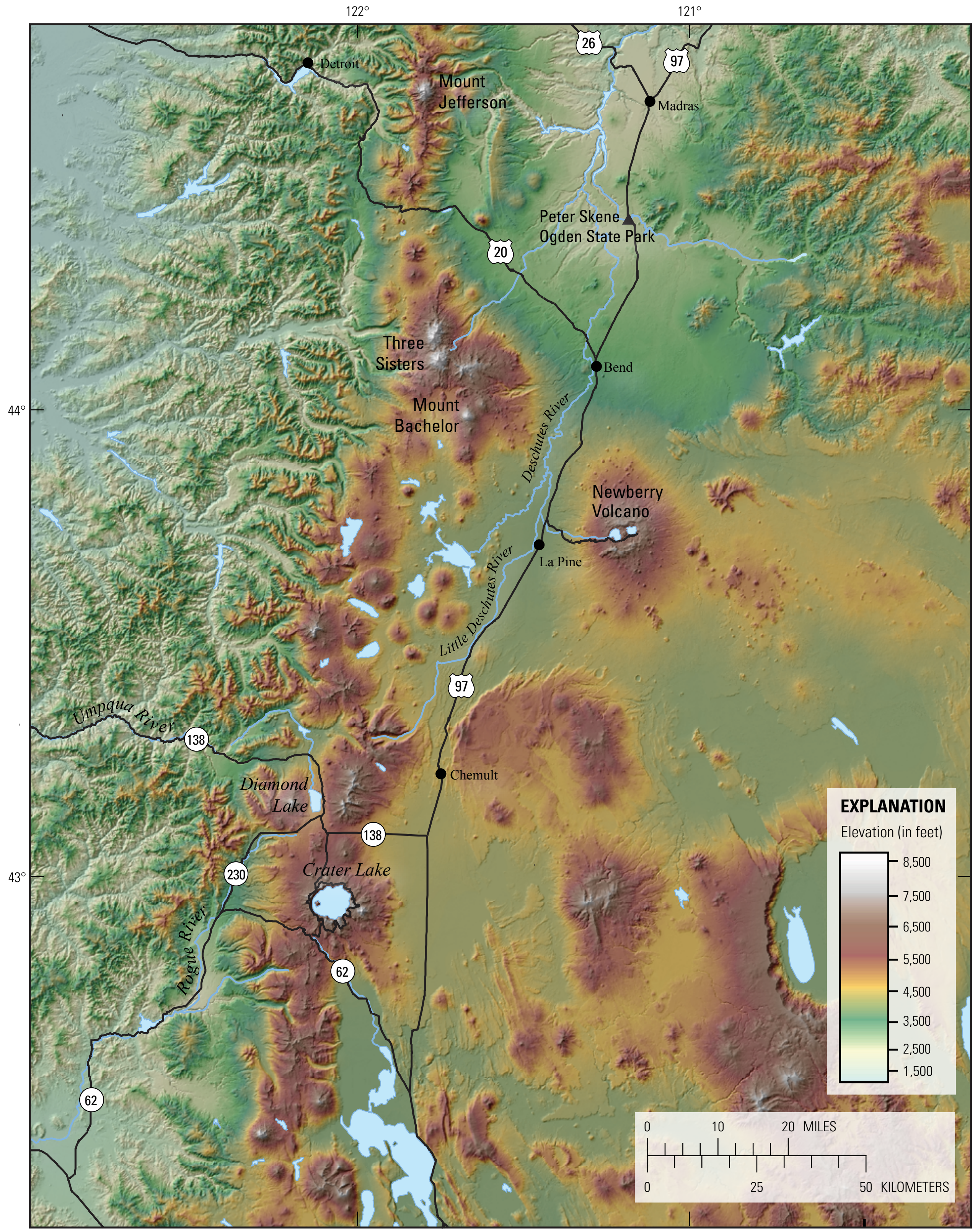
Overview for Geologic Field-Trip Guides to Mount Mazama, Crater Lake Caldera, and Newberry Volcano, Oregon

By Charles R. Bacon, Julie M. Donnelly-Nolan, Robert A. Jensen, and Heather M. Wright

These field-trip guides were written for the occasion of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) quadrennial scientific assembly in Portland, Oregon, in August 2017. The guide to Mount Mazama and Crater Lake caldera is an updated and expanded version of the guide (Bacon, 1989) for part of an earlier IAVCEI trip to the southern Cascade Range. The guide to Newberry Volcano describes the stops included in the 2017 field trip. Locations of the two volcanoes are shown on figure 1. Crater Lake and Newberry are the two best-preserved and most recent calderas in the Cascades Volcanic Arc. Although located in different settings in the arc, with Crater Lake on the arc axis and Newberry in the rear-arc, both volcanoes are located at the intersection of the arc and the northwest corner region of the extensional Basin and Range Province.

The overarching theme that connects the two volcanic centers is possession of similar-sized 6- to 10-kilometer (km)-diameter collapse calderas, common in volcanic arcs but relatively small in the spectrum of caldera size and erupted volume (Smith, 1979; Lipman, 1997). Few Quaternary calderas are known or implied to exist in the Cascades Arc (Hildreth, 2007; Nathenson and others, 2012). Youngest is Crater Lake caldera that collapsed ~7,700 years ago during the ~50 cubic kilometer (km^3) climactic eruption of Mount Mazama, the volcanic edifice at Crater Lake (Bacon and Lanphere, 2006). Newberry caldera, formed ~75 thousand years ago (ka) (Donnelly-Nolan and others, 2011) during a ≤50 km^3 explosive eruption, is the youngest of three calderas at Newberry. Two additional calderas nearby are inferred on the basis of ash-flow tuffs erupted ~300 and ~170 ka, northwest of Newberry Volcano from the arc axis where the Three Sisters volcanoes sit atop the arc crest. Another caldera dates from ~180 ka at the Medicine Lake rear-arc volcano (Donnelly-Nolan, 2010) 100 miles (160 km) south of Crater Lake, also where Basin and Range extension impinges on the arc.

Both Mount Mazama and Newberry volcanoes have existed since at least 400 ka and have erupted a diversity of magma types. Mazama eruptive products range from basaltic andesite to rhyodacite (Bacon and Lanphere, 2006), whereas Newberry lava compositions range from basalt to rhyolite (Jensen and others, 2009). Abundance of andesite and dacite resulted in a Mazama edifice composed of overlapping stratocones whereas a dominance of basaltic andesite led to more shield-like Newberry. The presence of mafic eruptive products with diverse geochemical signatures in the vicinity of both volcanoes is evidence for nearly dry and more hydrous mantle melt-generation processes (for example, high-alumina olivine tholeiite [HAOT] and typical arc basalt/basaltic andesite). Subduction-related flux melting dominates at Crater Lake (Bacon, 1990) but is also an important process at Newberry (Till and others, 2013; Mandler and others, 2014). McCrory and others (2012) project the depth to the Juan de Fuca slab to be ~75 km beneath Mazama and ~100 km under Newberry, although few recorded earthquake hypocenters constrain slab depth in this part of the arc. Nevertheless, both volcanoes illustrate aspects of arc volcanism and are worthy subjects for IAVCEI and other geological field excursions.



Hillshade base derived from U.S. Geological Survey National elevation dataset 30-meter digital elevation model

Figure 1. Shaded-relief map of central Oregon showing Crater Lake and Newberry Volcano as well as place names and principle roads relevant to IAVCEI 2017 field trip.

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