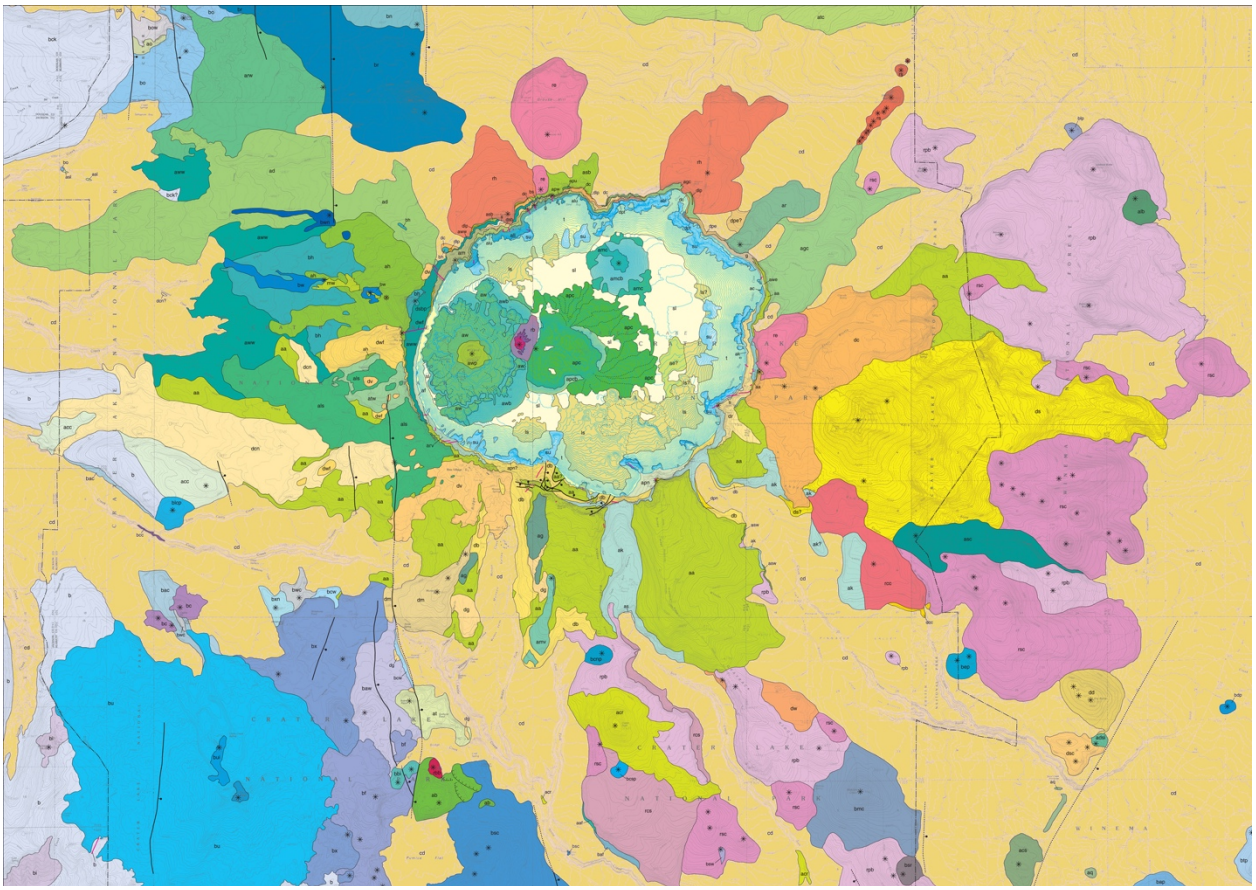
Geologic History of Crater Lake

This overview is published by the National Park Service Geologic Resources Division and describes the rocks and unconsolidated deposits that appear on the digital geologic map of Crater Lake National Park, the environment in which those units were deposited, and the timing of geologic events that formed the present landscape.

The geologic history of Crater Lake National Park is an explosive one. Bacon (2008) mapped 111 eruptive units underlying, building up, and ejected out of Mount Mazama, not to mention the Mazama ash that blew out of the volcano and was transported by wind far across the landscape. From least to most explosive, the eruptive units include five basalt, 32 basaltic andesite, 46 andesite, 19 dacite, and 9 rhyodacite. Since the climactic eruption, five additional postcaldera units—four andesite and one rhyodacite—vented onto the floor of Crater Lake caldera. While the mountain was active, glaciers moved down its slopes and across the landscape.



Rock units listed on back page

Pre-Mazama Volcanism

Bacon and Lanphere (2006) referred to the rocks and volcanoes that predate Mount Mazama as “pre-Mazama volcanics” or “pre-Mazama volcanoes.” Bacon (2008) referred to them as “pre-Mazama silicic rocks.” Silicic rocks such as dacite and rhyodacite, which make up the pre-Mazama volcanoes. These rocks include the dacites of Dry Butte, Sand Creek, and west of the Pinnacles, which erupted 1.3 million, 1.1 million, and 612,000 years ago, respectively; the 724,000-year-old rhyodacite dome west of Cavern Creek; and the rhyodacites of Scott Creek, Crater Peak, and Pothole Butte, which erupted between 460,000 and 410,000 years ago. These 400,000-year-old and older lava flows are known from various sources, including exposures in deep canyons on the southern flank of Mount Mazama, samples retrieved from submerged caldera walls, and cores from two geothermal exploration wells (Bacon 2008).

Regional Volcanism

Mount Mazama and now Crater Lake caldera are situated among regional volcanoes that are characterized by dominantly basaltic andesitic lava flows. Cones and shields that partly surround Mount Mazama are manifestations of regional volcanism spreading northwest, southwest, and east of Crater Lake caldera. Lava flows of regional volcanoes interfinger with some distal Mazama lavas and overlie others (Bacon 2008). Regional volcanism probably has been active for at least the last 700,000 years, with episodic activity since 200,000 years ago (Bacon 2008). Between 100,000 and 40,000 years ago, regional volcanism experienced a less-active stage but became voluminous while Mount Mazama's magma chamber was growing about 40,000–7,700 years ago. Bacon (2008) identified more than 40 vents for regional lavas in the Crater Lake area. Notable among these are Crater Peak, Red Cone, Williams Crater, and three vents that sit astride Castle Point, which are less than about 16,000–14,000 years old and comprise the youngest regional volcano near Crater Lake caldera.

Buildup of Mount Mazama

Mount Mazama began to erupt and build about 420,000 years ago, starting with the andesite of Phantom Cone. The buildup of Mount Mazama encompasses 47 named units, including lava, breccia, and pyroclastic material of primarily andesite and low-silica dacite, fed mostly by low fountains of lava. The 35,000-year-old mingled lava of Williams Crater represents the youngest unit produced during this constructional phase.

Rhyodacite Domes and Flows

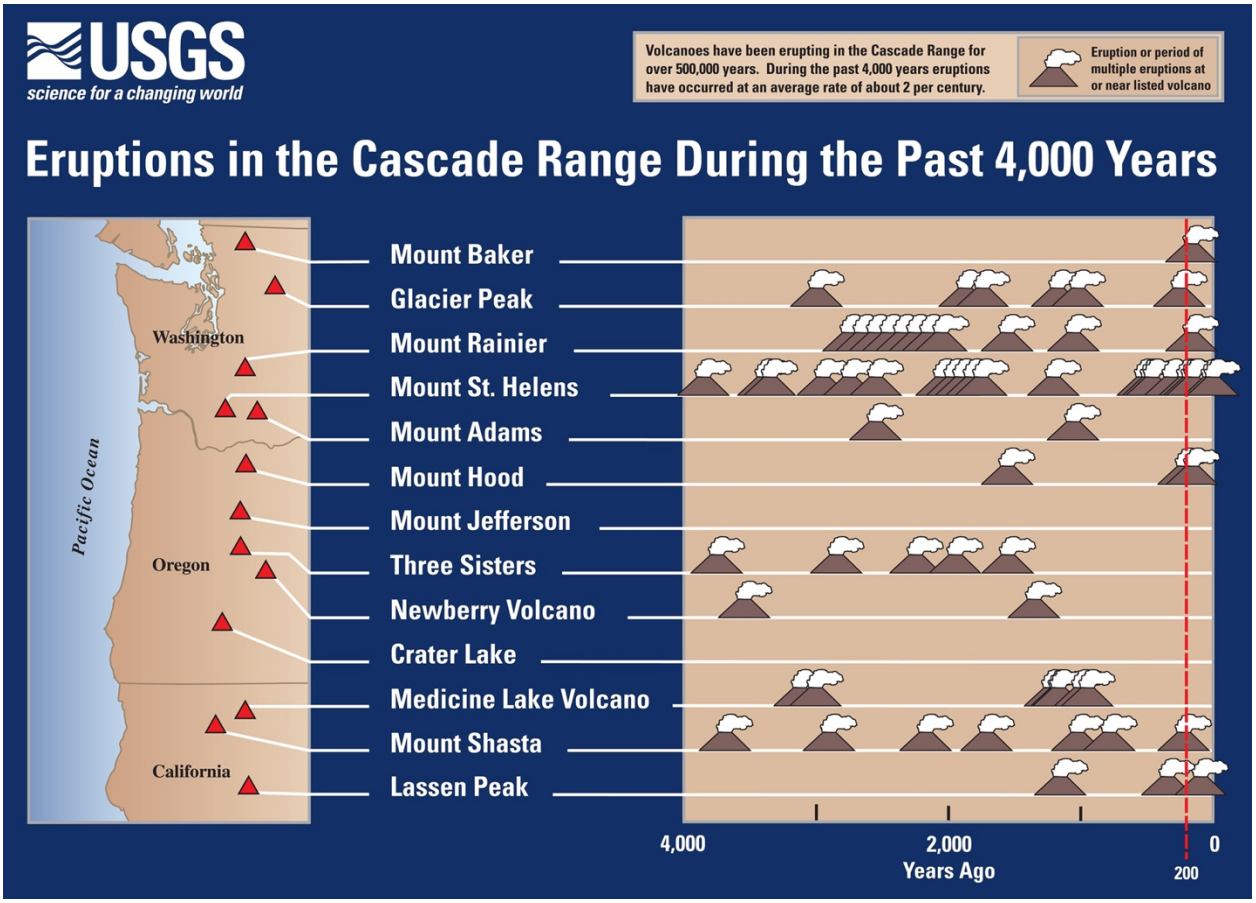
In addition to these 47 units, some rhyodacite lava domes and flows erupted between about 30,000 and 7,700 years ago. These eruptions preceded the caldera-forming eruption, and represent early leaks from the top of the climactic magma chamber as it grew (Druitt and Bacon 1988). Bacon (2008) divided these rhyodacite deposits into four map units: (1) evolved Pleistocene preclimactic rhyodacite, which includes the Grouse Hill and Redcloud flows; (2) a small dome consisting of rhyodacite of Bear Bluff; (3) rhyodacite of Sharp Peak; and (4) Holocene preclimactic rhyodacite, which includes the Cleetwood and Llao Rock flows.

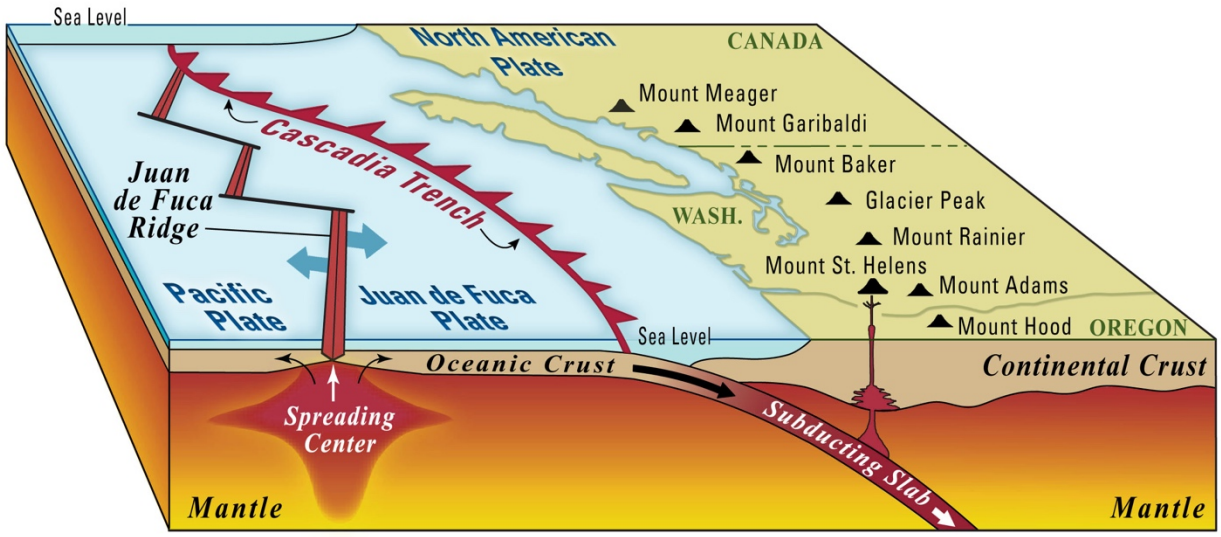
Climactic Eruption of Mount Mazama

Crater Lake caldera formed 7,700 years ago as a result of a climactic eruption of approximately 50 km^3 (12 mi^3) of magma from Mount Mazama. The eruption can be divided into two phases—a single-vent phase and a ring-vent phase. The single-vent phase produced a Plinian pumice-fall deposit and pyroclastic flows of the Wineglass Welded Tuff. During the single-vent phase, approximately half of the magma erupted as air-fall pumice and ash that covered the Pacific Northwest and southwestern Canada as "Mazama ash." Lack of support from the roof of the magma chamber caused the caldera to collapse, which ended the single-vent phase. During collapse and resultant ring-vent phase, multiple vents around the subsiding caldera floor generated a compositionally zoned pyroclastic flow deposit, including ignimbrite and lithic breccia. Violent pyroclastic flows deposited pumiceous ignimbrite in stream valleys, and coarse lithic breccia near the caldera. Additionally, finegrained lithic- and crystal-rich ignimbrite overlies lithic breccia on the slopes and interfluves of Mount Mazama or grades laterally into lithic breccia or ignimbrite in valleys. Most of the erupted volume was hydrous rhyodacitic pumice (70.4% SiO_2); minor amounts of basaltic to andesitic scoria compose the upper part of the ring-vent-phase ignimbrite.

Postcaldera Volcanism and Basin Filling

The basin that now contains Crater Lake is the collapsed caldera of Mount Mazama. In a matter of only a few hundred years, the 1,200-m- (3,900-ft-) deep caldera was partially filled. Initially, hundreds of meters of debris accumulated as the caldera subsided and its walls failed inward. Afterward, renewed volcanic activity vented lava onto the floor of Crater Lake caldera and deposited the andesites of east basin, central platform, Merriam Cone, and Wizard Island. Bacon (2008) provisionally identified the andesite of the east basin on the basis of bathymetry and acoustic backscatter, as investigators do not have a sample of this submerged lava flow. This andesite makes up a probable lava flow extending 1.7 km (1 mi) south of east basin in Crater Lake. Postcaldera andesite volcanoes divide the lake floor into three basins: northwest, southwest, and the largest and deepest east basin. Venting of these andesite volcanoes was completed within 500 years of the climactic eruption, that is, by 7,200 years ago. East basin likely erupted first, followed by Wizard Island and the central platform; Wizard Island continued venting after the central platform. The timing and duration of the Merriam Cone eruption is uncertain, but probably occurred more than 300 years after the caldera collapsed. The youngest postcaldera eruption produced a subaqueous dome on the northeastern flank of Wizard Island about 4,800 years ago. This eruption deposited rhyodacite lava and breccia.


USGS
science for a changing world
Volcanoes have been erupting in the Cascade Range for over 500,000 years. During the past 4,000 years eruptions have occurred at an average rate of about 2 per century.
Eruption or period of multiple eruptions at or near listed volcano
Eruptions in the Cascade Range During the Past 4,000 Years
Pacific Ocean
Washington
Oregon
California
Mount Baker
Glacier Peak
Mount Rainier
Mount St. Helens
Mount Adams
Mount Hood
Mount Jefferson
Three Sisters
Newberry Volcano
Crater Lake
Medicine Lake Volcano
Mount Shasta
Lassen Peak
4,000
2,000
Years Ago
0
200


Sea Level
North American Plate
CANADA
Mount Meager
Mount Garibaldi
Mount Baker
Glacier Peak
Mount Rainier
Mount St. Helens
Mount Adams
Mount Hood
OREGON
WASH.
Cascadia Trench
Juan de Fuca Ridge
Pacific Plate
Juan de Fuca Plate
Sea Level
Oceanic Crust
Continental Crust
Spreading Center
Subducting Slab
Mantle
Mantle

LIST OF MAP UNITS

[List of map units shown on maps and (or) panoramas]

SURFICIAL DEPOSITS

- sl — Sediment gravity-flow deposits (Hol.)
- t — Talus (Hol. and Pleist.)
- ls — Landslide deposits (Hol.)
- g — Glacial deposits, undivided (Pleist.)
- s — Sedimentary deposits, undivided (l. and m. Pleist.)

VOLCANIC ROCKS

Mount Mazama

- r* — Rhyodacite of the postcaldera dome (Hol.)
- aw — Andesite of Wizard Island (Hol.)
- amc — Andesite of Merriam Cone (Hol.)
- apc — Andesite of the central platform (Hol.)
- ae — Andesite of the E basin (Hol.)
- cd — Deposits of the climactic eruption (Hol.)
- Hol. preclimactic rhyodacite (Hol.)
  - rh/ — Lava
  - rhp* — Pyroclastic
- rs* — Rhyodacite of Sharp Peak (l. Pleist.)
- ab — Andesite S of Bear Bluff (l. Pleist.)
- rbb* — Rhyodacite of Bear Bluff (l. Pleist.)
- re — Evolved Pleist. preclimactic rhyodacite (l. Pleist.)
- mw — Mingled lava of Williams Crater (l. Pleist.)
- dv — Dacite of Munson Valley (l. Pleist.)
- als*/ — Andesite of Lightning Spring (l. Pleist.)
- asb* — Andesite of Steel Bay (l. Pleist.)
- apu* — Andesite of Pumice Point (l. Pleist.)
- ad*/ — Andesite of Devils Backbone (l. Pleist.)
- atw* — Andesite S of The Watchman (l. Pleist.)
- Dacite of The Watchman (l. Pleist.)
  - dwf*/ — Lava
  - dwp — Pyroclastic-flow deposits
- ah* — Andesite of Hillman Peak (l. Pleist.)
- dlp — Dacite below Llao Rock (l. Pleist.)
- agc* — Andesite of Grotto Cove (l. Pleist.)
- bh* — Basaltic andesite of Hillman Peak (l. Pleist.)
- Dacite of Pumice Castle (l. Pleist.)
  - dc*/ — Lava
  - dcp — Pyroclastic
- bs — Basaltic andesite of Steel Bay (l. Pleist.)
- apw/ — Andesite W of Pumice Point (l. Pleist.)
- aww* — Andesite of the W wall (l. Pleist.)
- arw* — Andesite W of Red Cone (l. Pleist.)
- su — Submerged caldera wall outcrops, undiv. (Pleist.)
- abl* — Andesite of the boat landing (l. Pleist.)
- dpe* — Dacite E of Palisade Point (l. Pleist.)
- Dacite of Steel Bay (l. Pleist.)
  - dsb*/ — Lava
  - dsbp — Pyroclastic
- am* — Andesite of Merriam Point (l. Pleist.)
- alu*/ — Andesite of Llao Bay, upper unit (l. Pleist.)
- dpt — Dacite of Palisade Point (l. or m. Pleist.)
- all* — Andesite of Llao Bay, lower unit (m. Pleist.)
- ar* — Andesite of Roundtop (m. Pleist.)
- amv* — Andesite E of Munson Valley (m. Pleist.)
- ags* — Andesite of the gaging station (m. Pleist.)
- dcn*/ — Dacite N of Castle Creek (m. Pleist.)
- ag* — Andesite of Garfield Peak (m. Pleist.)
- dg — Dacite S of Garfield Peak (m. Pleist.)
- aa* — Andesite of Applegate Peak (m. Pleist.)
- awe — Andesite E of Wineglass (m. Pleist.)
- ac*/ — Andesite of Cloudcap Bay (m. Pleist.)
- dm* — Dacite of Munson Ridge (m. Pleist.)
- af* — Andesite W of Fumarole Bay (m. Pleist.)
- arv* — Andesite below Rim Village (m. Pleist.)
- dr* — Dacite of Sentinel Rock (m. Pleist.)
- ak* — Andesite of Kerr Notch (m. Pleist.)
- db* — Dacite of Chaski Bay (m. Pleist.)
- dpn — Dacite of Phantom cone (m. Pleist.)
- ds* — Dacite of Mount Scott (m. Pleist.)
- dcc — Dacite of Cavern Creek (m.? Pleist.)
- apn* — Andesite of Phantom cone (m. Pleist.)

Regional Volcanism, East

- asc* — Andesite of Scott Creek (l. Pleist.)
- acr* — Andesite of Crater Peak (l. Pleist.)
- bcsp* — Basaltic andesite S of Crater Peak (l. Pleist.)
- bcnp* — Basaltic andesite N of Crater Peak (m.? Pleist.)
- alb* — Andesite S of Lookout Butte (m. Pleist.)
- bsw — Basalt W of Sun Creek (m. Pleist.)
- bmc* — Basaltic andesite of Maklaks Crater (m. Pleist.)
- bsr — Basalt of Sand Ridge (m. Pleist.)
- btp — Basaltic andesite NE of Boundary Butte (m. Pleist.?)
- rpb* — Rhyodacite of Pothole Butte (m. Pleist.)
- rcs — Rhyodacite S of Crater Peak (m. Pleist.)
- rsc* — Rhyodacite of Scott Creek (m. Pleist.)
- aq — Andesite of Sand Creek quarry (m.? Pleist.)
- aaf* — Andesite NE of Annie Falls (m. Pleist.)
- bep — Basaltic andesite E of Cavern Creek (m.? Pleist.)
- acs — Andesite S of Sand Creek (m.? Pleist.)
- bdp — Basaltic andesite E of Dry Butte (m.? Pleist.)
- bap — Basaltic andesite of Boundary Butte (m.? Pleist.)
- as* — Andesite of Sun Creek (m. Pleist.)
- dw* — Dacite W of The Pinnacles (m. Pleist.)
- blp* — Basaltic andesite N of Lookout Butte (m. Pleist.)
- asw* — Andesite W of Sand Creek (m. Pleist.)
- baf* — Basaltic andesite E of Annie Falls (m. Pleist.)
- rcc* — Rhyodacite W of Cavern Creek (m. Pleist.)
- dsc* — Dacite of Sand Creek (e. Pleist.)
- adsi* — Andesite S of Dry Butte (e. Pleist.)
- dd* — Dacite of Dry Butte (e. Pleist.)

Regional Volcanism, Northwest

- bwn — Basaltic andesite NW of Williams Crater (l. Pleist.)
- bw — Basaltic andesite of Williams Crater (l. Pleist.)
- br* — Basaltic andesite of Red Cone (l. Pleist.)
- atc* — Andesite of Timber Crater (l. or m. Pleist.)
- bo* — Basaltic andesite of Oasis Butte (m. Pleist.)
- bn — Basaltic andesite N of Red Cone (m.? Pleist.)
- ao — Andesite SW of Oasis Butte (m. Pleist.)
- bow — Basaltic andesite W of Oasis Butte (m.? Pleist.)
- bck* — Basaltic andesite N of Crater Creek (e. Pleist.)

Regional Volcanism, Southwest

- bc — Basalt of Castle Point (e. Hol.)
- blcp — Basaltic andesite N of Little Castle Ck. (l. Pleist.)
- bsc* — Basaltic andesite of Scoria Cone (l. Pleist.)
- bf* — Basaltic andesite NW of Pumice Flat (l. Pleist.)
- Basaltic andesite of Union Peak (m. Pleist.)
  - bu* — Lava
  - bui — Intrusive
- bx* — Basaltic andesite of Whitehorse Bluff (m. Pleist.)
- at* — Andesite of Arant Point (m. Pleist.)
- bxn — Basalt NW of Whitehorse Bluff (m.? Pleist.)
- baw — Basaltic andesite W of Arant Point (m. Pleist.)
- bbi — Basaltic andesite W of Bear Bluff (m.? Pleist.)
- bcw — Basaltic and. W of Mazama Campgr. (m.? Pleist.)
- bwc — Basaltic andesite of Whitehorse Ck. (m.? Pleist.)
- acc* — Andesite N of Castle Creek (m. Pleist.)
- bcc — Basalt of Castle Creek (m. or e. Pleist.)
- bac — Basaltic andesite of Castle Point (e.? Pleist.)
- Basaltic andesite, undivided (Pleist. or Plio.)
  - b — Lava
  - bi/ — Intrusive

Contact

Dike

Fault—Dottted where concealed; bar and ball on downthrown side

Volcanic vent—Does not include dikes feeding lava flows

244±4 — Dated sample—Location and age (ka) of sample dated by K-Ar or $^{40}Ar/^{39}Ar$ methods

MZI-11A — Geothermal exploration well