U.S. DEPARTMENT OF THE INTERIOR
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PRELIMINARY GEOLOGIC MAP OF CRATERS OF THE MOON 30- x 60-MINUTE QUADRANGLE, IDAHO

By

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CRATERS OF THE MOON 1:100,000 QUADRANGLE

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Ql **Lacustrine deposits (Holocene)**—Silt, clay, and minor sand and gravel; good sorting; thin, parallel beds: present in former sites of drained reservoirs in the northwest corner of quadrangle. Thickness generally less than 1 m

Qmf **Deposits of modern flood plains (Holocene)**—Silt, sand, and clay, minor gravel; humic in poorly drained areas; poor to moderate sorting; overlies sandy gravel of cut terraces or mainstream alluvium. Subject to high water tables, poor drainage, and periodic flooding. Paludal deposits of Carey Lake of Scott (1982). Thickness generally 1-3 m, locally thicker in abandoned channels

Qta **Alluvium of tributary streams (Holocene and late Pleistocene)**—Silty sand to clayey silt, minor angular to round gravel, locally humic; nonbedded to parallel bedded; overlies pebble and cobble gravel; parallel bedding and large- and small-scale crossbedding. Includes fan alluvium and colluvium (Qfac) along valley margins. Lower lying areas subject to periodic flooding, high water tables, and poor drainage. Locally includes lacustrine deposits of Fish Creek Reservoir. Unit description largely from Scott (1982). Maximum exposed thickness about 8 m

Qls **Landslide deposits (Holocene to middle Pleistocene)**—Pebble to boulder gravel commonly contains silty sand to silty clay matrix; also includes largely intact slide blocks of bedrock; nonsorted to poorly sorted; clasts generally angular to subangular; nonbedded to crudely bedded. Includes deposits of avalanches, slumps, earthflows, debris flows, and mudflows of local derivation. Common on volcanic units. Characterized by hummocky undrained topography. Subject to major mass movements and small landslides. Unit description largely from Scott (1982)

Qfac **Fan deposits of alluvium and colluvium (Holocene to middle Pleistocene)**—Pebble to boulder gravel, contains matrix of silty sand to clayey silt; poorly sorted; locally derived clasts are mostly angular to subround; nonbedded to crudely bedded. Forms fans at mouths of drainage basins that have areas of generally less than 2-6 km^2. Unit description largely from Scott (1982)

Qp **Playa deposits (Holocene and early Pleistocene)**—Silty sand to clayey silt; minor gravel and scattered boulders of basalt along margins. Fills small depressions along contacts between lava flows; deposited along low-gradient, ephemeral streams and in ephemeral lakes. Thickness 0-10 m

Qc **Colluvium (Holocene and Pleistocene)**—Variably textured colluvium derived from nearby bedrock. Includes: (1) nonbedded to crudely bedded coarse, angular to subrounded, gravel-size clasts containing variable amounts of fine-grained matrix material composing colluvial cones and fans, rock-glacier deposits, and taluses in rugged terrain on hard bedrock, and (2) sand, silt, and minor, angular to subrounded fine gravel containing variable amounts of fine-grained matrix; nonbedded to crudely bedded; occurs as unsorted taluses and slumps in gentle terrain formed on volcanic and intrusive rocks; includes some rubbly colluvium along canyon walls. Unit description modified from Scott (1982). Thickness generally 1-3 m, but exceeds 10 m at base of slopes and in colluvial cones and fans

Qmp **Deposits along mainstreams of Pinedale age (late Pleistocene)**—Pebble and cobble gravel to pebbly sand; poor to moderate sorting, clasts subround to round; parallel bedding and large-scale crossbedding; thin to thick beds. Upper 0.5-2 m generally sand, silt, and clay of eolian and/or alluvial origin. Unit commonly gravelly where less than 1 m thick. Includes fans at mouths of major basins. Upper part of deposits are of Pinedale age based on degree of soil development and relation to outwash of Pinedale age. Unit description modified from Scott (1982). Total thickness of fills, including buried older mainstream deposits and thin deposits of modern flood plains ranges from a few meters to several tens of meters

Qfy **Younger fan alluvium (late Pleistocene)**—Pebble to cobble gravel, locally bouldery near fan heads; contains variable amounts of sand to silty sand as matrix; some lenses of sand and silty sand, most common on distal portions of fans; unit is poorly to moderately sorted; subangular to round clasts, chiefly of detritus derived from Copper Basin Formation (Mississippian). Unit shows parallel bedding, large-scale crossbedding, and locally crude bedding in medium to thick beds. Stones have discontinuous to continuous calcium carbonate coats on bottoms. Also includes aprons of rhyolite debris on steep basal slopes of Big Southern Butte. Local areas near active stream channels subject to flash flooding, flooding from rapid snow melt, and debris-flow and mudflow activity. Degree of soil development and relation to moraines and outwash of Pinedale age suggest this unit is also of Pinedale age. Total thickness of fans ranges from a few meters to several hundred meters

Qt **Travertine (Pleistocene)**—Pale-orange to white, dense algal limestone; forms small ledge about 1 m high about 1½ km northeast of Carey Lake; no evidence of Holocene hot spring activity

Qfo **Older fan alluvium (middle and early(?) Pleistocene)**—Pebble to cobble gravel, locally bouldery near fan heads, contains variable amounts of sand to silty sand matrix, some lenses of sand and silty sand; poor to moderate sorting; subangular to round clasts composed of a large component of Copper Basin Formation detritus and minor amounts of felsic to basic volcanic rock fragments; parallel bedding and large-scale crossbedding, locally crudely bedded, medium to thick beds. Forms inclined fan remnants in upper drainage basin of Little Fish Creek and near mouth of Fish Creek, and isolated remnants along and above South Fork of Muldoon Creek. Differentiated from younger fan alluvium (Qfy) by topographically higher position, better-developed soil, and 2 to 10-mm-thick caliche coat on clasts. Includes pediment gravel. Unit description modified from Scott (1982). Topographic position suggests a Bull Lake age for most of unit, but pediment gravel may be early Pleistocene. Unit as much as 100 m thick

Qgo **Glacial morainal and outwash deposits (middle Pleistocene)**—Boulder to pebble gravel, contains variable amounts of sand to silty sand matrix; moderate to good sorting; clasts, largely subround, are as much as 95 percent detritus from the Copper Basin Formation and minor amounts of intermediate and felsic volcanic rock fragments. Size of clasts generally diminishes to south from cobbles and boulders 12.5-26.4 cm in diameter west of Friedman Creek and north of the South Fork of Muldoon Creek to pebbles and cobbles north of the former Cameron Reservoir. Unit locally crudely bedded. Beds are medium to thick. Forms dissected high-level east-trending ridges, minor upland basin fill, and isolated remnants in the northwest corner of the quadrangle. Deposits as much as 110 m thick rest on strata as young as Pliocene basalt. The extensive erosion and original large volume of the morainal deposits suggest a Bull Lake age

QTf **Older fan gravels (Pleistocene and Pliocene)**—Fan-shaped deposit of large subrounded to angular boulders and cobbles of the Copper Basin Formation derived from outcrop at altitude of 6700-7100 ft on the north flank of Pine Mountain; overlies ash-flow tuffs of Idavada Volcanics. Thickness 1-2 m

BASALTIC LAVA FLOWS OF THE SNAKE RIVER GROUP

Rock names assigned to lava flows in the Craters of the Moon lava field ("basalt," "hawaiite," "trachyandesite") are those suggested by Cox and others (1979). The classification is based on the weight percentages of the $Na_20 + K_2O$ versus SiO_2. Chemical compositions of lava flows in the Craters of the Moon lava field and older basaltic rocks of the Snake River Group are given in Kuntz and others (1975, 1992). Colors and numerical designation of hues for basaltic lava flows were assigned by using the Rock Color Chart of the Geological Society of America (1975). Colors of rocks in cinder cones and volcanic-ash deposits are extremely variable, thus general terms are used to describe the colors of these deposits. Compositions of olivine and plagioclase were determined by standard optical methods.

LAVA FLOWS OF THE CRATERS OF THE MOON LAVA FIELD

Lava flows and related cinder-cone and eruptive-fissure deposits of eruptive-period A

Qcfa1 **Broken Top pahoehoe basalt flow (Holocene)**—Surface- and tube-fed-pahoehoe basalt flow from obscure vents on the east and southeast sides of Broken Top cinder cone (Qcca1). Glassy surfaces of flow are highly vesiculated and are typically olive gray (5Y4/1) to medium dark gray (N4). Flow is more massive and dark gray (N3) in interior. Vents are short fissures, arcuate cracks, and small spatter vents that are largely covered by tephra that has been eroded from higher parts of Broken Top cinder cone. Flows are hummocky, rough surfaced, and cut by widely spaced joints. A lighter color on aerial photographs and a greater abundance of grass and low bushes distinguish the Broken Top flow from underlying Blue Dragon Flow (Qcfa2). Unit includes slabs of lava, as much as 10 m thick, that rest on the east and south flanks of Broken Top cinder cone. Rock is aphyric and holocrystalline; all crystals are typically <0.2 mm. Olivine (about Fa_{45}) crystals are euhedral; plagioclase (An_{45-50}) crystals range from slender needles to stout laths; and intersertal clinopyroxene spindles are intergrown with an acicular, feathery, opaque mineral

Qcca1 **Broken Top basaltic cinder cone (Holocene)**—Black to brown lapilli and coarse ash. West flank of cone is mantled by agglutinated spatter from younger eruptive fissure on west side of cone. Slabs of basalt lava of the Broken Top flow (Qcfa7), as thick as 10 m, lie on the east, southeast, and south sides of cone. Cone is cut by northwest-trending fissures and normal faults of small (< 1 m) displacement. Bulk of cone may have been formed by eruptions from fissure on west side of cone, possibly at same time as eruptions that were occurring from fissures (Qcea2) in Trench Mortar Flat (Kuntz and others, 1982). Arcuate scarps on east and south sides of cone are roughly concentric with apex of cone and may have formed by collapse of cone during eruption of Broken Top flow. Cone is 115 m high and 1 km in diameter

Qcfa2 **Blue Dragon pahoehoe and a'a basalt-hawaiite flows (Holocene)**—Tube- and surface-fed pahoehoe and a'a basalt-hawaiite flows that are characterized by fresh, iridescent, dark- to light-blue (5PB3/2-5B7/6), glassy, vesicular crusts. Interiors of flows are more massive and medium dark gray (N4). Flows erupted from fissure-controlled vents (Qcea1) at south end of Big Craters cinder cone (Qcca2). Fissure system is marked by spatter cones and pit craters. Lava tubes, skylights, and rootless vent complexes define tube systems that fed eastern and western lobes of unit. Lava ponds rimmed by levees are perched above openings on the tube system between Big Craters cinder cone (Qcca2) and Broken Top cinder cone (Qcca1). Pressure ridges, pressure plateaus, and collapse depressions, common morphologic features on the surface of these flows, indicate a high-volume, short-duration eruption. Blue Dragon flows lie on top of the Trench Mortar Flat flows (Qcfa3) and the Big Craters flows (Qcfa5) but are probably younger in age by only a few tens of years on the basis of paleomagnetic studies. The spectacular examples of pahoehoe toes, cascades of ropy pahoehoe lava, skylights, and lava tubes in Craters of the Moon National Monument are in the Blue Dragon flow. Mean age of four radiocarbon samples of charcoal from tree molds and carbon-bearing material from sediment buried by unit is 2,076 ± 45 years. Rock is fine grained (<0.3 mm), dense, mostly holocrystalline, and partly diktytaxitic. Olivine (about Fa_{50-60}) crystals are euhedral to subhedral and many form aggregates of several crystals; plagioclase (about An_{35-50}) occurs as slender and stout laths <0.2 mm; and clinopyroxene occurs as poorly formed slender needles or granules. Opaque minerals occur in equant, partly skeletal crystals as large as 0.25 mm, in granules (<0.02 mm) in the matrix, and in aggregates of feathery crystals

Qcca2 **Big Craters basaltic cinder cone (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, and coarse ash. Cone consists of at least nine nested cones that indicate a complicated eruptive history. Inner walls of southernmost crater are mantled by thin flows and agglutinated spatter. Cone is 100 m high, 800 m long, and 500 m wide. Vents at base of the south flank of cones were sources for some of the earlier Blue Dragon flows (Qcfa2). Fissures (Qcea3) on north flank of cone were source vents for Big Craters flows (Qcfa5)

Qcea1 **Blue Dragon basaltic eruptive-fissure deposits (Holocene)**—Fissure system at south end of Big Craters cinder cone (Qcca2). Fissure defined by spatter cones and pit craters. Fissure system is source vent for Blue Dragon flow (Qcfa2)

Qcfa3 **Trench Mortar Flat pahoehoe and a'a basalt-hawaiite flows and near-vent tephra deposits (Holocene)**—Chiefly fountain- and surface-fed, medium-dark-gray (N4), thin, shelly, pahoehoe basalt-hawaiite flows. Unit consists of several flows that were erupted from various parts of the Trench Mortar Flat set of eruptive fissures (Qcea2) between Big Cinder Butte (Qccc1) and The Watchman (Qcca3) cinder cones. The a'a flow to the east of The Watchman cinder cone flowed from eruptive fissures on the northwest and southeast flanks of The Watchman cinder cone. Pahoehoe flows of unit that traveled more than about 1 km from source vents broke up into slab pahoehoe and a'a flows. Flows of unit lie on and flowed around cinder cones that are adjacent to eruptive fissures. Mean radiocarbon age of nine samples of charcoal from tree molds in unit is 2,205±25 yrs. Rock is typically fine grained, holocrystalline to hypocrystalline; contains microphenocrysts, as large as 1 mm, of olivine, plagioclase, and an equant opaque mineral. The microphenocrysts are set in a pilotaxitic to trachytic matrix of these minerals, patches of subophitic spindles of clinopyroxene that are <0.25 mm, and opaque-charged, brown glass

Qcca3 **The Watchman cinder cone (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, and coarse ash. Northwest and southeast sides of cone are cut by fissure vents that were sources for Trench Mortar Flat flow (Qcfa3). Fissure vents are flanked by spatter ramparts. Cone is 95 m high and about 0.8 km in diameter

Qcea2 **Trench Mortar Flat basaltic eruptive-fissure deposits (Holocene)**—A set of eruptive fissures in Trench Mortar Flat between the east flank of Big Cinder Butte cinder cone (Qccc1) and The Watchman cinder cone (Qcca3). Fissures are open cracks and furrows mantled by thin lava flows, agglutinated spatter, and tephra. Spatter ramparts as much as 10 m high and as much as 100 m wide flank some fissures. Fissures were source vents for Trench Mortar flat flows (Qcfa3)

Qcfa4 **North Crater pahoehoe basalt-hawaiite flow (Holocene)**—Surface-fed, medium-dark-gray (N4), bulbous, pahoehoe basalt-hawaiite flow that extends north and east from vent in North Crater cinder cone (Qcca4). Flow diverges into two lobes around the margins of high-standing Big Craters flow (Qcfa5). Flow has iridescent, light- to dark-blue (5PB3/2-5B7/6), highly vesicular, glassy crust. Unit is youngest flow near North Crater, but its age relations with Broken Top (Qcfa1), Blue Dragon (Qcfa2), and Trench Mortar Flat (Qcfa3) flows are unknown. Rock is mostly very fine grained (<0.1 mm), hypocrystalline, and contains a few microphenocrysts of olivine, an equant opaque mineral, and rare plagioclase, all <0.5 mm. Olivine (about Fa_{50-60}) crystals are typically euhedral and partly skeletal; plagioclase (An_{35-50}) occurs as small (<0.10 mm) crystals in matrix; clinopyroxene occurs as small (<0.05 mm), intergranular blades, spindles, and granules. An equant opaque mineral in the matrix is <0.01 mm, and brown glass is charged with small crystals of an equant opaque mineral

Qcca4 **North Crater basaltic cinder cone (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, and ash. Crater is open to north as a result of cone collapse and rafting of remnants of crater walls by viscous lava flows. North side of cone is cut by northwest-dipping normal faults that bound slump blocks. Most of cone is believed to have formed and collapsed during eruption of Devils Orchard (Qcfa9) and Serrate (Qcfa8) flows. A few cinders contain inclusions of gneissic rocks, partly fused dacitic to rhyolitic rocks, and holohyaline clots of silicic pumice. Cone is 130 m high and 1 km in diameter. Crater in center of cone was source vent for North Crater flow (Qcfa4)

Qcfa5 **Big Craters pahoehoe and a'a hawaiite flows (Holocene)**—Mainly surface- and fountain-fed pahoehoe hawaiite flows that extend east, west, and southwest from eruptive fissure (Qcea3) and cinder cone vents at the north end of Big Craters cinder cone (Qcca2). Unit also includes a'a and slab pahoehoe. Flows are characterized by dark-greenish-gray (5GY4/1) glassy crusts and elongated, stretched vesicles. Rock is denser and medium dark gray (N4) in interior. Flows are overlain by Blue Dragon (Qcfa2) and North Crater (Qcfa4) flows but lie on Serrate (Qcfa8), Devils Orchard (Qcfa9), and Highway (Qcfa10) flows. Rock is fine grained (mostly <0.10 mm), hypocrystalline, and partly diktytaxitic and contains a few microphenocrysts of olivine, an equant opaque mineral, and rare plagioclase. Olivine (about Fa_{50-70}) occurs as large (as much as 1 mm) crystals that are typically skeletal and euhedral and have glass and opaque inclusions and as smaller equant granules (<0.05 mm) in the matrix; plagioclase (An_{40-50}) crystals are mainly stubby to elongated laths (<0.2 mm) in the matrix; clinopyroxene occurs in the matrix as granules, blades, and subophitic spindles that are <0.05 mm. Glass is brown and charged with granules of opaque minerals. Opaque minerals occur as larger, skeletal, equant crystals and as equant <0.002 mm granules in the matrix

Qcea3 **Big Craters basaltic eruptive-fissure deposits (Holocene)**—Spatter ramparts along a 30-m-long fissure at northwest base of Big Craters cinder cone (Qcca2). Fissure and craters at northwest part of Big Craters cinder cone were source vents for Big Craters flow (Qcfa5)

Qcfa8 **Serrate block and a'a latite flow (Holocene)**—Surface-fed, olive-gray (5Y4/1) to medium-dark-gray (N4), jagged, block and a'a latite flow that extends about 11 km east-northeast from a presumed source vent at or near North Crater cinder cone (Qcca4). Flow fronts are steep and as high as 5 m. Unit contains prominent flow ridges that are perpendicular to and convex toward the direction of flow movement. Flow also contains longitudinal furrows and cracks that are roughly parallel to the direction of flow movement. Flow contains rafted blocks (monoliths) of bedded cinders and ash derived from a shattered cinder cone (probably North Crater; unit Qcca4) that were rafted on the surface of the moving flow. Rafted blocks have lengths and widths of as much as 150 m and exposed heights of <30 m. Bulbous lobes of lava, squeezed out at the edges of the flow ("squeeze-outs"), have black (N2), filamented, glassy crusts and are common along flow margins. Flow is overlapped on south by Blue Dragon flow (Qcfa2), and proximal parts are overlapped by Big Craters flow (Qcfa5). Flow is similar to Devils Orchard (Qcfa9) and Highway (Qcfa10) flows in terms of petrographic, chemical, and field characteristics, but age relations with these units are unknown. Rock is fine grained (mostly <0.10 mm) and hypocrystalline, has rounded xenocrysts of anorthoclase, plagioclase, and green clinopyroxene that are each as large as 2 mm. Xenocrysts of anorthoclase have wormy, corroded rims and, commonly, corroded cores. Rock also contains xenolithic clots, as large as 3 mm, that consist of anorthoclase, plagioclase (An_{35-55}), green clinopyroxene, an equant opaque mineral, rare olivine (about Fa_{75-90}), and rare zircon. The matrix of the rock consists of plagioclase (An_{10-40}) laths, spindles and subophitic blades and needles and green clinopyroxene, granules of olivine, and opaque-charged, brown glass

Qcfa9 **Devils Orchard block and a'a latite flow (Holocene)**—Surface-fed, olive-gray (5Y4/1) to medium-dark-gray (N4), block and a'a latite flow. Flow fronts are steep and as high as 5 m. Flow extends about 7 km east from a presumed source vent at or near North Crater cinder cone (Qcca4). Flow is rough surfaced and contains rafted blocks of bedded cinders and ash, derived from a cinder cone (probably North Crater, Qcca4). Rafted blocks have lengths and widths of as much as 100 m and heights of 20 m. Squeeze-outs having black (N2), filamented, glassy crusts are common along flow margins. Flow immediately east of Paisley Cone (Qcc) is covered by a thin (< 10 cm) layer of ash and cinders. Exact age relations of unit with Serrate (Qcfa8) and Highway (Qcfa10) flows are unknown. Rock is fine grained (mostly <0.05 mm) and hypocrystalline having xenocrysts of anorthoclase, plagioclase, and green clinopyroxene that are each as large as 2 mm in longest dimension. Xenocrysts of anorthoclase have corroded rims and, commonly, corroded cores. Rock also contains xenolithic clots, as large as 3 mm that consist of anorthoclase, plagioclase (about An_{20-40}), green clinopyroxene, an equant opaque mineral, and rare zircon. The matrix of the rock consists of plagioclase (about An_{20}) laths, rounded crystals of olivine (about Fa_{10}), spindles of green clinopyroxene, and opaque-charged, brown glass

Qcfa10 **Highway block, a'a, and pahoehoe latite flows (Holocene)**—Surface-fed, steep-sided, bulbous, olive-gray (5Y4/1) to medium-dark-gray (N4), block and a'a latite flow that extends 1 km north from a presumed source vent at or near North Crater cinder cone (Qcca4). Flow is extremely rough-surfaced and contains furrows, spires, and blocks that produce a local relief of as much as 10 m. Bulbous, steep-sided flow fronts are as high as 15 m. Flow is 2-10 m thick where exposed in cross section on an arcuate scarp about 0.25 km north of North Crater cinder cone. Thin (< 1 m), black, glassy-surfaced, pahoehoe trachyandesite flow in the area of the campground at Craters of the Moon National Monument is included in the map unit. Exact age relations of unit with Serrate (Qcfa8) and Devils Orchard (Qcfa9) flows are unknown. Xenoliths of gneissic rock as large as 30 cm are rare in outcrop. Rock is fine grained (mostly <0.2 mm), hypocrystalline, and commonly contains xenocrysts of corroded anorthoclase, rounded, green clinopyroxene, an equant opaque mineral, and rare zircon, all 0.5-2.0 mm in longest dimension. The matrix of the rock consists of slender, skeletal olivine (about Fa_{80}), spindles and needles of greenish-brown clinopyroxene, slender laths of plagioclase (An_{15-25}), and rare apatite needles, all 0.2 mm in longest dimension, and opaque-charged, brown glass

Lava flows and related cinder-cone and eruptive-fissure deposits of eruptive-period B

Qcfb1 **Vermillion Chasm pahoehoe basalt flow and near-vent tephra deposits (Holocene)**—Chiefly fountain- and surface-fed, dark-gray (N3), pahoehoe basalt flow from eruptive fissures (Qceb1) at Vermillion Chasm and from eruptive fissures that extend as far as 1 km southeast of Vermillion Chasm. Unit consists of thin (mostly <1 m), shelly flows near source vents and thicker, more dense pahoehoe flows in distal parts. Unit also includes red, brown, and black, partly agglutinated spatter, bomb, and cinder deposits that form ramparts and low mounds that flank eruptive fissures. Flows of unit overlie Deadhorse flows (Qcfb2), but both units are probably part of the same episode of fissure eruptions. Unit is cut by noneruptive fissures in the area between Devils Cauldron and Vermillion Chasm. Rock is microporphyritic and hypocrystalline, and has abundant euhedral, partly skeletal phenocrysts of olivine (about Fa_{50-70}) and abundant laths of plagioclase (An_{40-50}), both as large as 1 mm in longest dimension. The phenocrysts are set in a fine-grained (<0.05 mm) matrix of olivine, plagioclase, intergranular clinopyroxene, an equant opaque mineral, and clear glass

Qceb1 **Vermillion Chasm basaltic eruptive-fissure deposits (Holocene)**—A set of fissures flanked by large (20 m high and 200 m wide) spatter ramparts and low spatter and cinder mounds. Fissures are now marked by tephra-mantled furrows as much as 10 m wide and 10 m deep. Fissures were source vents for Vermillion Chasm flow (Qcfb1)

Qcfb2 **Deadhorse pahoehoe basalt flows (Holocene)**—Chiefly fountain-fed, shelly, thin (<1 m), pahoehoe basalt flows from eruptive fissures (Qceb2) northwest and southeast of Black Top Butte cinder cone (Qccb1). Thin, glassy crusts are decomposed and broken into small fragments. Color of weathered, glassy crust is brownish gray (5YR4/1); rock in interior of flows is medium dark gray (N3). Unit also includes deposits of partly agglutinated, red, brown, and black cinders and ash that form low ramparts on flanks of eruptive fissures. Age of unit, on the basis of a single radiocarbon analysis of untreated carbon-bearing material from sediment buried by flow, is $4{,}300 \pm 60$ years, an age that is believed to be too old on the basis of its stratigraphic relations with the Devils Cauldron flow (Qcfb3). Rock is hypocrystalline and porphyritic and has a fine-grained (mostly <0.2 mm) matrix. Contains common phenocrysts of euhedral, partly skeletal olivine (about Fa_{50-70}) and plagioclase (An_{40-50}) laths having maximum dimensions of 1.5 mm. The matrix is intergranular and consists of plagioclase, olivine, clinopyroxene(?), an equant opaque mineral, and clear glass

Qceb2 **Deadhorse basaltic eruptive-fissure deposits (Holocene)**—A set of en echelon eruptive fissures and related open cracks that indicate offset in a right-lateral sense. Fissure system has a length of about 11 km and extends from southeast margin of Vermillion Chasm flow (Qcfb1), through Black Top cinder cone (Qccb1), to the southeast margin of the Craters of the Moon lava field. Fissures are flanked by low (<3 m) spatter ramparts. Fissures were source vents for Deadhorse flows (Qcfb2)

Qcfb3 **Devils Cauldron pahoehoe basalt-hawaiite flow (Holocene)**—Surface- and tube-fed, medium-dark-gray (N4), pahoehoe basalt-hawaiite flow erupted from a low, broad lava dome (Devils Cauldron) that contains two lava-filled craters. Flows are hummocky and have prominent ridges and depressions. Unit is cut by noneruptive fissures in an area 1-2 km northeast of Devils Cauldron. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 3,660±60 years. Rock is medium grained and has crystals of partly skeletal olivine (about Fa_{50-70}), needles and laths of plagioclase (An_{40-50}), and a skeletal, equant opaque mineral, all 0.1-0.4 mm in longest dimension. Smaller (<0.1 mm) crystals of olivine, plagioclase, an equant opaque mineral, and subophitic clinopyroxene constitute the matrix. Some rocks are microporphyritic and have phenocrysts of olivine and plagioclase (as large as 0.4 mm) set in a matrix of brown glass and small (<0.05 mm) crystals of olivine and plagioclase

Qcfb4 **Minidoka pahoehoe basalt flow (Holocene)**—Tube- and surface-fed, medium-dark-gray (N4), pahoehoe basalt flows having hummocky, billowy surfaces. Lava tube systems, having rootless vents, carried lava as far as 35 km southwest from an obscure, lava-filled vent complex about 3 km east of New Butte. Unit is cut by noneruptive fissures about 2 km southeast of New Butte. Pressure ridges, pressure plateaus, tumuli, and collapse depressions are common morphologic features on this flow and indicate a high-volume, short-duration eruption. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 3,590±70 years. Rock is hypocrystalline and contains microphenocrysts of olivine (about Fa_{50}), plagioclase (about An_{40}), and an equant opaque mineral, all as large as 0.4 mm. The larger crystals are set in a fine-grained (<0.05 mm) matrix of olivine, plagioclase, clinopyroxene, an equant opaque mineral, and brown glass

Qcfb5 **Larkspur Park pahoehoe hawaiite flow (Holocene)**—Surface- and tube(?)-fed, medium-dark-gray (N4), pahoehoe hawaiite flow having hummocky, billowy surface. Field relations, petrographic similarities, and paleomagnetic data suggest that unit may be an earlier phase of the Minidoka flow (Qcfb4). Rock is fine to medium grained and hypocrystalline, and has laths of plagioclase (about An_{50}) that are 0.2-0.6 mm long and subhedral to euhedral olivine (about Fa_{50}) crystals that are 0.05-0.20 mm long. The larger crystals are set in a matrix of plagioclase, olivine, and clinopyroxene spindles; an equant opaque mineral, all <0.1 mm in longest dimension, and opaque-charged, brown glass

Qcfb6 **Rangefire pahoehoe hawaiite-latite flows (Holocene)**—Surface- and tube(?)-fed, dark-gray (N3), pahoehoe hawaiite-latite flows. Exposed in patches around and beneath the southern and eastern margins of the Devils Cauldron (Qcfb3) flows and margins of Minidoka (Qcfb4) flows. Flows are cut by noneruptive fissures about 5 km south-southeast and about 5 km east-southeast of New Butte. Source vent is uncertain, but flow directions suggest a source at or near Black Top Butte cinder cone (Qccb1). Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 4,510±100 years. Rock is fine grained and hypocrystalline. Euhedral to subhedral crystals of olivine (about Fa_{50-70}), plagioclase (An_{35-50}), and an equant opaque mineral, all 0.1-0.6 mm in longest dimension, are set in a matrix of olivine, plagioclase, clinopyroxene, and an equant opaque mineral, all 0.05-0.10 mm, and opaque-charged, brown glass

Qcfb7 **Black Top Butte pahoehoe hawaiite flow (Holocene)**—Surface-fed, thin (<2 m), medium-gray (N4), pahoehoe hawaiite flow from vents at the south end of Black Top Butte cinder cone (Qccb1). Mostly covered by Deadhorse (Qcfb2) and Devils Cauldron (Qcfb3) flows. Rock is hypocrystalline and microporphyritic and contains euhedral crystals of olivine (about Fa_{50}), plagioclase (An_{40-50}), and an equant, partly skeletal opaque mineral, all 0.2-0.8 mm in longest dimension. The microphenocrysts are set in a matrix of olivine, plagioclase, slender needles and patches of clinopyroxene, an equant opaque mineral, and a feathery, needle-like opaque mineral, all 0.05-0.2 mm in longest dimension, and opaque-charged, brown glass

Qccb1 **Black Top Butte basaltic cinder cone (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, and ash. Cone consists of at least three nested cones that indicate a complicated eruptive history. Craters are filled by lava lakes and indented by collapse pits. Southeast flank of cone cut by fissures and explosion craters of the Deadhorse fissure system (Qceb2). Cone is 75 m high, 600 m wide, and 1 km long. Cone is source vent for Black Top flow (Qcfb7)

Lava flows and related cinder-cone and eruptive-fissure deposits of eruptive-period C

Qcfc1 **Indian Wells North a'a latite flow (Holocene)**—Surface-fed, bulbous, steep-sided, medium-dark-gray (N4), a'a latite flow that contains numerous lobes having steep fronts. Lobes are defined by flow ridges that are perpendicular to and convex toward the direction of flow movement and by longitudinal furrows and cracks that are roughly parallel to the direction of flow movement. Flow contains rafted blocks of bedded cinders that are as much as 100 m in width and length and 15 m high. Squeeze-outs, having filamented- and sharkskin-textured glassy crusts, are common along flow margins. Flow lines suggest a source vent at or near the northwest side of Big Cinder Butte cinder cone (Qccc1). Rock is fine grained and hypocrystalline and has rounded, partly corroded xenocrysts of alkali feldspar (anorthoclase?), plagioclase, and green clinopyroxene that are 0.5-1.5 mm in longest dimension. Matrix consists of plagioclase (about An_{30-40}) laths, elongated crystals of olivine (about Fa_{70-80}), and granules of an equant opaque mineral, all 0.01-0.10 mm, and opaque-charged, brown glass

Qcfc2 **Indian Wells South a'a latite flow (Holocene)**—Surface-fed, bulbous, steep-sided, brownish-gray (5YR4/1) to medium-dark-gray (N4), a'a latite flow having flow fronts as high as 20 m. Flow contains numerous lobes having steep fronts and flow ridges that are perpendicular to and convex toward the direction of flow movement and longitudinal furrows and cracks that are roughly parallel to the direction of flow movement. Flow contains rafted blocks of bedded cinders that are as much as 100 m in width and length and as much as 15 m high. Squeeze-outs, having filamented- to sharkskin-textured, glassy crusts, are common along flow margins. Unit may be an early phase of the Indian Wells North a'a flow (Qcfc1). Flow lines suggest a source at or near Big Cinder Butte cinder cone (Qccc1). Unit is petrographically similar to Indian Wells North a'a flow

Qcfc3 **Sawtooth a'a latite flow (Holocene)**—Surface-fed, long (21 km), steep-sided, brownish-gray (5YR4/1) to medium-dark-gray (N4), a'a latite flow that contains numerous lobes having steep fronts. Flow ridges are perpendicular to and convex toward the direction of flow movement in proximal parts, and longitudinal furrows and cracks are roughly parallel to flow direction in proximal and distal parts of flow. Tephra as much as 2 m thick mantles proximal parts. Flow contains rafted blocks of bedded cinders that are as much as 100 m in width and length and as much as 15 m high and blocks (as large as 10 m) of broken a'a. Squeeze-outs, having filamented, glassy crusts, are common along flow margins. Source vent is at south end of Big Cinder Butte cinder cone (Qccc1). Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is $6{,}020 \pm 160$ years. Rock is fine grained, hypocrystalline, and partly diktytaxitic and has microphenocrysts of skeletal olivine (about $Fa_{60\text{-}80}$) and euhedral plagioclase (about $An_{30\text{-}40}$) as much as 0.5 mm in longest dimension. Rock also contains scattered xenocrysts and xenolithic clots of anorthoclase, plagioclase, green clinopyroxene, and an equant opaque mineral that are as large as 2 mm. The microphenocrysts, xenocrysts, and xenoliths are set in a matrix of slender plagioclase laths, olivine granules, subophitic clinopyroxene, and an equant opaque mineral, all <0.10 mm in longest dimension, and brown glass

Qcfc4 **Big Cinder Butte NW a'a latite flow (Holocene)**—Surface-fed, short (<1 km), blocky, medium-dark-gray (N4), a'a latite flow on northwest flank of Big Cinder Butte cinder cone (Qccc1). Flow largely covered by cinders and lapilli in its proximal parts. Distal parts of flow covered by Blue Dragon flow (Qcfa2). Age relations with Sawtooth flow (Qcfc3) are unknown but units are believed to be roughly equivalent in age because both are known to have been erupted from Big Cinder Butte (Qccc1). Rock is hypocrystalline and partly diktytaxitic having microphenocrysts of olivine (about $Fa_{60\text{-}75}$) as much as 0.5 mm in longest dimension. Also contains xenocrysts of anorthoclase and plagioclase as long as 1 mm, and xenoliths, as much as 2 mm in maximum dimension, that consist of clear clinopyroxene, an equant opaque mineral, plagioclase, anorthoclase, and zircon. The matrix of the rock is identical to the matrix of the Sawtooth a'a flow (Qcfc3)

Qccc1 **Big Cinder Butte basaltic cinder cone (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, coarse ash, and interbedded, thin (<1 m), frothy lava flows. Tephra is coarser on steep eastern and northern flanks of cone than on western flanks. Inner walls of crater are mantled by agglutinated spatter and thin lava flows. Cone is 240 m high, 1 km wide, and 3 km long, and has a volume of about 0.2 km^3. Stearns (1928, p. 5) reported that "Big Cinder Butte ranks among the largest, purely basaltic cinder cones in the world." East and southeast flank of cone are cut by alined, elongated, and circular craters that are part of Trench Mortar Flat eruptive fissures (Qcea2). Cone is open to southeast. Cone is source vent for Sawtooth (Qcfc3) and Big Cinder Butte NW (Qcfc4) flows and possible source vent for Indian Wells North (Qcfc1) and Indian Wells South (Qcfc2) flows

Qcfc5 **South Echo pahoehoe basalt flow (Holocene)**—Fissure-fed, dark-gray (N3), mostly thin (<1 m), pahoehoe basalt flow that is largely covered by ash and lapilli. Flow erupted from fissures (Qcec1) about 1 km southeast of Echo Crater cinder cone. Rock ranges from glassy to holocrystalline. In typical samples, microphenocrysts of skeletal olivine (about $Fa_{40\text{-}50}$) and plagioclase (about An_{40}) are set in a microcrystalline matrix of opaque crystals, brown to orange glass, small plagioclase laths, and rare needles and blades of clinopyroxene

Qcec1 **South Echo basaltic eruptive-fissure deposits (Holocene)**—Eruptive fissures located between South Echo cinder cone (Qcc) and The Sentinel cinder cone (Qccc4). Fissures largely covered by tephra and vegetation. Fissures were source vents for South Echo flow (Qcfc5)

Qcfc6 **Sheep Trail Butte pahoehoe and a'a basalt flow (Holocene)**—Channel- and tube-fed, dark-gray (N3), pahoehoe and a'a basalt flows that extend as much as 17 km south from source vents at Sheep Trail Butte cinder cone (Qccc2). Flows are predominantly hummocky, billowy pahoehoe in proximal parts and both pahoehoe and a'a in distal parts. Isolated exposure of unit 3-9 km south-southwest of Black Top Butte cinder cone (Qccb1) is correlated with main part of unit on the basis of similarity in flow characteristics, petrography, and paleomagnetic data. Rock is typically hypocrystalline; microphenocrysts are skeletal, euhedral olivine (about Fa_{40-50}), plagioclase (about An_{50}) laths, and a skeletal, equant opaque mineral. The microphenocrysts, as large as 1.5 mm, are typically set in a matrix of opaque-charged, brown glass

Qccc2 **Sheep Trail Butte basaltic cinder cone (Holocene)**—Black, brown, and red cinders, lapilli, and coarse ash. Cone consists of five nested cinder cones and associated craters that indicate a complicated eruptive history. Cone is 30 m high, 750 m long, and 800 m wide. Cone is source vent for Sheep Trail Butte flows (Qcfc6)

Qcfc7 **Fissure Butte pahoehoe and a'a basalt flow (Holocene)**—Surface- and fountain-fed, dark-gray (N3), pahoehoe and a'a basalt flows erupted from crater at Fissure Butte cinder cone (Qccc3) and from eruptive fissure (Qcec2) northwest of Fissure Butte. Flows largely mantled by lapilli and ash. Rock is medium to fine grained and holocrystalline and has microphenocrysts of olivine (Fa_{40-50}) and rare plagioclase (about An_{40}) as large as 0.6 mm. The microphenocrysts are set in an intergranular matrix of olivine, plagioclase, an equant opaque mineral, and rare clinopyroxene, all <0.2 mm in longest dimension

Qccc3 **Fissure Butte basaltic cinder cone (Holocene)**—Black, brown, and red cinders, lapilli, and coarse ash. Cone elongated to east; northern parts of cone join with spatter ramparts that lie along Fissure Butte eruptive fissure (Qcec2). Cone is 150 m high, 2.5 km long, and 1 km wide. Cone is source vent for Fissure Butte flow (Qcfc7)

Qcec2 **Fissure Butte basaltic eruptive-fissure deposits (Holocene)**—Eruptive fissure extends about 2 km northwest of Fissure Butte cinder cone (Qccc3). Fissure is flanked by low (<5 m) spatter ramparts. Fissure and ramparts are largely covered by tephra. Eruptive fissure and Fissure Butte cinder cone (Qccc3) were source vents for Fissure Butte flow (Qcfc7)

Qcfc8 **The Sentinel pahoehoe and a'a basalt flow (Holocene)**—Surface- and channel-fed, dark-gray (N3), pahoehoe and a'a basalt flow from craters and vents at the base of The Sentinel cinder cone (Qccc4). Flow is dominantly pahoehoe in proximal parts and partly a'a in distal parts. Flow is mantled by lapilli and ash near vents. Rock is hypocrystalline and contains large (0.2-0.8 mm) crystals of olivine (about Fa_{40-50}), plagioclase (about An_{50}), and a skeletal, equant opaque mineral. The large crystals are set in a finer (0.05-0.2 mm) matrix of the same minerals plus clinopyroxene and small amounts of opaque-charged, brown glass

Qccc4 **The Sentinel basaltic cinder cone (Holocene)**—Black, brown, and red cinders, lapilli, and coarse ash. Cone is a composite of at least four smaller cinder cones, which indicates a complicated eruptive history. Cone is 65 m high and 1 km long. Cone is the source vent for The Sentinel flows (Qcfc8)

Lava flows and related cinder cone deposits of eruptive-period D

Qcfd1 **Silent Cone a'a latite flow (Holocene)**—Surface-fed, medium-dark-gray (N4) a'a latite flow having bulbous lobes. Lobes contain flow ridges oriented perpendicular to and convex toward the direction of flow movement and longitudinal furrows and cracks that are roughly parallel to direction of flow movement. Flow contains rafted blocks of bedded cinders that are typically 100 m in longest dimension and as high as 30 m. Proximal parts of flow are mostly covered by Big Craters flow (Qcfa5), but small (unmapped) kipukas of unit are present on west and north sides of the source vent, Silent Cone cinder cone (Qccd1). Rock is hypocrystalline and locally vitrophyric, and has large crystals of skeletal olivine (about Fa_{50-70}), plagioclase (about An_{40}), and a skeletal, equant opaque mineral that are all typically 0.2-0.8 mm in longest dimension. The largest crystals are set in a matrix of tiny (<0.05 mm) crystals of plagioclase, olivine, trellis-like clinopyroxene, and opaque-charged, brown glass. The rock contains rare xenocrysts of anorthoclase

Qccd1 **Silent Cone basaltic cinder cone (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, coarse ash, and interlayered, thin lava flows. Cone consists of three nested craters that indicate a complicated eruptive history. Cone is collapsed, faulted, and open to the northwest, the direction of exit for the Silent Cone flow (Qcfd1). Cone is 150 m high and 1.5 km wide. Cone may have been source vent for Carey Kipuka (Qcfd2), Little Park (Qcfd3), and Little Laidlaw Park (Qcfd4) flows

Qcfd2 **Carey Kipuka a'a hawaiite flow (Holocene)**—Surface-fed, medium-dark-gray (N4) a'a hawaiite flow having lobes and steep, bulbous flow fronts as high as 10 m. Lobes contain prominent flow ridges that are perpendicular to and convex toward the direction of flow movement and longitudinal furrows and cracks that are roughly parallel to direction of flow movement. Only distal parts of flow are exposed, proximal parts are covered by Blue Dragon flow (Qcfa2). Source vent is unknown but may be Silent Cone cinder cone (Qccd1). Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 6,600±60 years. Rock is hypocrystalline, fine grained, and contains microphenocrysts of euhedral, partly skeletal olivine (about Fa_{50}) as large as 0.6 mm set in an intergranular matrix of plagioclase (about An_{40}), olivine, a skeletal, equant opaque mineral, and clinopyroxene, all <0.02 mm, and opaque-charged, brown glass

Qcfd3 **Little Park a'a hawaiite flow (Holocene)**—Surface-fed, medium-dark-gray (N4), blocky a'a hawaiite flow having lobes and steep, bulbous flow fronts as high as 10 m. Lobes are defined by prominent flow ridges that are perpendicular to and convex toward the direction of flow movement. Lobes also contain longitudinal furrows and cracks that are roughly parallel to direction of flow movement. Flow contains rafted blocks of bedded cinders as much as 100 m in longest dimension and as much as 30 m high. Only distal part of flow is exposed, proximal part is covered by younger flows. Source vent is unknown but may be Silent Cone cinder cone (Qccd1). Age of flow, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by the flow, is 6,500±60 years. Rock is hypocrystalline and contains microphenocrysts of euhedral, partly skeletal olivine (about Fa_{60}) as much as 0.6 mm in longest dimension. The microphenocrysts are set in an intergranular matrix of plagioclase (about An_{40}), granules of olivine and clinopyroxene, and an equant, partly skeletal opaque mineral, all less than 0.2 mm, and brown glass

Qcfd4 **Little Laidlaw Park a'a hawaiite flow (Holocene)**—Surface-fed, medium-dark-gray (N4), blocky a'a hawaiite flow having lobes and steep, bulbous flow fronts as high as 10 m. Lobes are defined by prominent flow ridges that are perpendicular to and convex toward the direction of flow movement and longitudinal furrows and cracks that are roughly parallel to direction of flow movement. Flow contains rafted blocks of bedded cinders as much as 100 m in longest dimension and as much as 30 m high. Source vent is unknown but may be Silent Cone cinder cone (Qccd1). Rock is fine grained, hypocrystalline, and partly diktytaxitic, and contains microphenocrysts of skeletal, euhedral olivine (about Fa_{50-60}) as large as 0.4 mm. The microphenocrysts are set in a matrix of olivine granules and plagioclase (about An_{30}) laths, both <0.10 mm. Scattered patches of subophitic clinopyroxene as large as 0.2 mm occur in brown glass. The rock also contains rare xenocrysts and xenoliths of rounded, corroded anorthoclase as large as 2 mm

Lava flows and related cinder cone deposits of eruptive-period E

Qcfe1 **Grassy pahoehoe and a'a basalt flow (Holocene)**—Surface- and tube-fed, dark-gray (N3), pahoehoe basalt flow. Flow surface is hummocky and flow has pressure plateaus, collapse depressions, and flow ridges. Flow contains large amounts of a'a in collapsed areas and where lava flowed over steep slopes. Larger areas of a'a are lobate and contain flow ridges that are perpendicular to and convex toward the direction of flow movement and longitudinal furrows and cracks that are roughly parallel to direction of flow movement. Flow is covered by black, brown, olive, and red tephra having a maximum thickness of about 1 m within 1 km of the source vent at Grassy Cone cinder cone (Qcce1). Pressure ridges, pressure plateaus, tumuli, and collapse depressions are common morphologic features of this flow and indicate a high-volume, short-duration eruption. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is $7{,}360 \pm 60$ years. Rock is holocrystalline to hypocrystalline and partly diktytaxitic. Porphyritic varieties contain phenocrysts of euhedral olivine (about Fa_{50}), plagioclase (about An_{50}), and a skeletal, equant opaque mineral, all as large as 1 mm. The phenocrysts are set in an intergranular to subophitic matrix of the same minerals plus clinopyroxene, a feathery opaque mineral, and brown glass. Clear to brown apatite crystals as long as 1 mm are a common accessory mineral

Qcce1 **Grassy Cone basaltic cinder cone (Holocene to latest Pleistocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, coarse ash, and interlayered, thin lava flows. Cone consists of five nested craters that indicate a complicated eruptive history. Cone is 110 m high and 1.5 km wide. Cone is known source vent for Grassy flow (Qcfe1) and the probable source vent for Laidlaw Lake flow (Qcfe2)

Qcfe2 **Laidlaw Lake pahoehoe and a'a basalt flows (Holocene)**—Chiefly surface- and tube(?)-fed, dark-gray (N3), pahoehoe basalt flows possibly from source vent(s) at Grassy Cone (Qccc1). Pahoehoe is hummocky, has pressure plateaus, collapse depressions, and flow ridges. Isolated exposure of unit about 5 km south of Huddles Hole is correlated with main part of unit based on similarities in field, petrographic, and paleomagnetic characteristics. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 7,470±80 years. Rock is hypocrystalline, partly diktytaxitic, and nonporphyritic. Crystals of euhedral olivine (about Fa_{50}), plagioclase (about An_{50}), intergranular to subophitic clinopyroxene, and an equant opaque mineral are 0.05-0.6 mm in longest dimension. A feathery to bladed opaque mineral and an equant opaque mineral occur in cloudy, brown glass. Brown apatite crystals as long as 0.2 mm are a common accessory mineral

Qcfe3 **Lava Point a'a basalt flows (Holocene)**—Surface-fed, medium-dark-gray (N4), a'a basalt flows having steep, bulbous flow fronts and rough, corrugated surfaces. Flow fronts are as high as 10 m. In proximal parts of units, lobes are defined by flow ridges that are perpendicular to and convex toward the direction of flow movement. Longitudinal furrows and cracks are roughly parallel to the direction of flow movement. Squeeze-outs, having filamented, glassy crusts, are common along flow margins. Southwestern (main) lobe contains rafted blocks of bedded cinders as long as 100 m and as high as 20 m. Exposures of unit north, west, and south of Purple Butte are correlated with main lobe at Lava Point on the basis of similarities in field, petrographic, and paleomagnetic characteristics. Isolated exposure south of Huddles Hole is correlated with unit on the basis of paleomagnetic data and similarity of petrographic and field characteristics. Only distal parts of flows are exposed; source vent is unknown. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow is 7,840±140 years. Rock is fine grained, hypocrystalline, and contains a few euhedral, partly skeletal phenocrysts of olivine (about Fa_{50}) as large as 1 mm set in an intergranular to subophitic matrix of plagioclase (about An_{50}) laths, olivine granules, an equant opaque mineral, and feathery, subophitic clinopyroxene, all <0.2 mm in longest dimension. A feathery to bladed, opaque mineral and an equant opaque mineral occur in brown glass

Lava flows of eruptive-period F

Qcff1 **Pronghorn pahoehoe and a'a basalt flow (latest Pleistocene)**—Surface and tube(?)-fed, medium-dark-gray (N4) pahoehoe basalt flows. Flows contain areas of a'a that consist of broken plates of pahoehoe where flows collapsed or moved over steep slopes. Exposed mainly in two contiguous but stratigraphically distinct flows; the western flow is younger. Only distal parts of flows are exposed; source vent is unknown. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 10,240±120 years. Rock is hypocrystalline, partly diktytaxitic, and contains scattered phenocrysts of euhedral, partly skeletal olivine (about Fa_{50}) as large as 0.8 mm. The phenocrysts are set in a matrix of crystals that are all <0.3 mm. Crystals in the matrix are granular olivine, plagioclase (An_{40-50}) laths, blades of clinopyroxene and subophitic clinopyroxene both intergrown with a feathery opaque mineral, an equant opaque mineral, and opaque-charged, brown glass

Qcff2 **Heifer Reservoir pahoehoe basalt flows (latest Pleistocene)—** Surface and tube(?)-fed, medium-dark-gray (N4) pahoehoe basalt flows. Flows covered by thin (<5 cm), discontinuous deposits of eolian sand near edges. Exposures south of Huddles Hole are correlated with exposure near Pratt Butte on the basis of similarity in field and paleomagnetic characteristics. Only distal parts of flows are exposed; source vent is unknown. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 10,670±150 years. Rock is hypocrystalline, nonporphyritic, medium grained, and consists of euhedral olivine (about Fa_{50}), tabular to lath-like plagioclase (An_{40-50}), an equant opaque mineral, and intergranular to subophitic blades of clinopyroxene intergrown with a feathery to needle-like opaque mineral. Opaque-charged, brown glass is also present

Qcff3 **Bottleneck Lake pahoehoe and a'a basalt flows (latest Pleistocene)**—Chiefly surface- and tube(?)-fed, medium-dark gray (N4) pahoehoe basalt flows. Flows contain areas of a'a that consist of broken plates of pahoehoe where flows collapsed or moved over steep slopes. Units exposed in two isolated locations; flows west of Bear Park are correlated with main part of unit on the basis of similarities of field, petrographic, and paleomagnetic characteristics. Only distal parts of flows are exposed; source vent is unknown. The oldest age from four radiocarbon analyses on both pretreated and untreated samples of carbon-bearing material from sediment buried by flow is 11,000±100 years. Rock is hypocrystalline and diktytaxitic, and contains rare phenocrysts of euhedral olivine (about Fa_{50}) as much as 0.8 mm in longest dimension, and an equant opaque mineral. The phenocrysts are set in an intergranular matrix of plagioclase (An_{40-50}) laths, olivine granules, subophitic clinopyroxene that is interlayered with a feathery opaque mineral, and brown, opaque-charged glass. All minerals in the matrix are <0.3 mm

Lava flows and related cinder-cone deposits of eruptive-period G

Qcfg1 **Sunset pahoehoe and a'a basalt-hawaiite flows (latest Pleistocene)**—Chiefly surface- and tube(?)-fed, hummocky, medium-dark-gray (N4) pahoehoe basalt-hawaiite flows. Flows of main part of unit are covered by a thin (<2 m) layer of olive, orange, and brown lapilli as far as 3 km northeast from the source vent at Sunset Cone cinder cone (Qccg1). Southeasternmost flow is from a low source vent southeast of Sunset Cone cinder cone and is correlated with the main part of the units on the basis of similarity in paleomagnetic data. A'a lava occurs where pahoehoe flows collapsed or moved over steep slopes. Pressure ridges, pressure plateaus, and collapse depressions are common morphologic features on the surface of these flows and indicate high-volume, short-duration eruptions. Age of unit, on the basis of a single radiocarbon analysis of charcoal excavated from beneath the flow, is 12,010±150 years. Rock is hypocrystalline and porphyritic and contains microphenocrysts of euhedral olivine (about Fa_{40-50}), plagioclase (An_{40-50}) laths, and an equant, skeletal opaque mineral, all 0.2-0.8 mm in longest dimension. The microphenocrysts are set in an intergranular matrix of the same minerals plus blades and patches of spindly clinopyroxene and opaque-charged, brown glass

Qcfg2 **Carey pahoehoe and a'a basalt-hawaiite flows (latest Pleistocene)**—Chiefly surface- and tube(?)-fed, hummocky, medium-dark-gray (N4) pahoehoe basalt-hawaiite flows. Flow contains conspicuous ridges, plateaus, collapse pits, and depressions of various sizes, which are characteristic of high-volume, short-duration eruptions. Isolated exposures about 1-5 km west of Big Cinder Butte cinder cone (Qccc1) are correlated with main unit farther west on the basis of similarity in paleomagnetic directions. Carey flows are believed to have been erupted simultaneously with Sunset flows (Qcfg1) on the basis of similarities of field, petrographic, paleomagnetic, and chemical characteristics. Sunset Cone cinder cone (Qccg1) is believed to be source vent for flows of unit. Rock is hypocrystalline, medium to fine grained (mostly <0.2 mm), diktytaxitic, and microporphyritic. In typical samples, crystals of euhedral olivine (about Fa_{40-50}), laths of plagioclase (An_{40-50}), and an equant, skeletal opaque mineral are as large as 0.8 mm. The phenocrysts are set in a matrix of the same minerals plus a feathery, bladed opaque mineral, blades and patches of spindly, subophitic clinopyroxene, and granules of an equant opaque mineral, all 0.05-0.2 mm, and opaque-charged, brown glass

Qccg1 **Sunset Cone basaltic cinder cone (latest Pleistocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, coarse ash, and interlayered, thin lava flows. Cone is a complex of eight nested cones that indicate a complicated eruptive history. Flanks of cone are mantled by fine tephra. Cone is 140 m high and 1.5 km in diameter. Cone is known source vent for Sunset flow (Qcfg1) and the probable source vent for the Carey flow (Qcfg2). Sunset flow vented from northeast base of cone; flow northwest of Sunset Cone vented from obscure, tephra-covered vents on northwest flank of Sunset Cone. Vent to southeast of Sunset Cone is a low lava cone covered by black lapilli from Sunset Cone

Lava flows and related cinder-cone deposits of eruptive-period H

Qcfh1 **Kimama pahoehoe basalt flow (latest Pleistocene)**—Surface-fed, medium-dark-gray (N4), hummocky, pahoehoe basalt flow. Flow is covered by thin, discontinuous mantle of loess and eolian sand. Only distal part of flow exposed. Source vent is unknown. The oldest of two radiocarbon ages from pretreated samples of carbon-bearing material from sediment buried by flow is $15,100 \pm 160$ years. Rock is hypocrystalline, diktytaxitic, and microporphyritic. Microphenocrysts are rare euhedral crystals of olivine (about Fa_{45}) and an equant, skeletal opaque mineral as much as 1 mm in longest dimension. The microphenocrysts are set in a matrix of plagioclase (An_{45-55}) laths, olivine granules, blades of clinopyroxene, and an equant opaque mineral, all <0.2 mm, and brown glass charged with a feathery to bladed opaque mineral and an equant opaque mineral

Qcfh2 **Bear Den Lake pahoehoe basalt flows (latest Pleistocene)**—Surface-fed, medium-dark-gray (N4), pahoehoe basalt flows. Flows are covered by a thin, discontinuous mantle of loess and eolian sand. Flows occur as two main exposures and in nearby isolated patches that are surrounded by younger flows. All exposures are correlated with one another by similarity in field and petrographic characteristics. Source vent is unknown. Rock is hypocrystalline and porphyritic to aphyric. Porphyritic varieties contain euhedral single crystals of olivine (about Fa_{45}), clots of several crystals of olivine, an equant opaque mineral, and laths of plagioclase (An_{45-55}), each as long as 1 mm. The phenocrysts are set in a matrix of these same minerals plus ophitic, light-brown clinopyroxene, blades and bundles of clinopyroxene, an equant opaque mineral, all less than 0.2 mm, plus opaque-charged, brown glass

Qcfh3 **Baseline pahoehoe basalt flows (latest Pleistocene)**—Surface- and tube(?)-fed, medium-dark-gray (N4), hummocky, pahoehoe basalt flows. Both exposures are covered by a thin, discontinuous mantle of loess and eolian sand. Source vent is unknown. Rock is hypocrystalline, partly diktytaxitic, and porphyritic, and contains phenocrysts of euhedral, partly skeletal olivine (about Fa_{50}) and an equant, skeletal opaque mineral 0.2-1.0 mm in longest dimension. The phenocrysts are set in a matrix of the same minerals plus plagioclase (about An_{40}) laths, granules and blades of clinopyroxene, an acicular to bladed opaque mineral, all <0.2 mm, plus opaque-charged, brown glass

Qcfh4 **Little Prairie pahoehoe and a'a basalt flows (latest Pleistocene)**—Surface- and tube-fed, medium-dark-gray (N4) pahoehoe basalt flows. Flows are covered by low shrubs and grass. Unit is mantled by a thin blanket of tephra on its western margin and by fine tephra and loess on eastern margin. Eastern and southern margin of unit represent older a'a lobes of main unit. Source vent is unknown. Rock is hypocrystalline, diktytaxitic, intergranular, and aphyric. Consists of skeletal, euhedral olivine (about Fa_{50}), plagioclase (about An_{40}) laths, intergranular blades and patches of clinopyroxene, an equant opaque mineral, and an acicular to bladed opaque mineral, all <0.4 mm, and opaque-charged, brown glass

Qcfh5 **No Name pahoehoe basalt flow (latest Pleistocene)**—Surface- and tube-fed, medium-dark-gray (N4), pahoehoe basalt flow. Flow is covered by a thin, discontinuous mantle of loess and eolian sand. Unit is possibly correlative with Little Prairie flow (Qcfh4) on the basis of similarities in rock type, paleomagnetic data, and distribution of units with respect to the Great Rift. Source vent is unknown. Unit not studied petrographically

Qcfh6 **Lost Kipuka pahoehoe basalt flow (latest Pleistocene)**—Surface-fed, medium-dark-gray (N4) pahoehoe basalt flow. Flow is covered by low shrubs and grass and a thin discontinuous mantle of loess and eolian sand. Unit is possibly correlative with Little Prairie flow (Qcfh4) on the basis of similarities in rock types, paleomagnetic data, and distribution of units with respect to the Great Rift. Source vent is unknown. Rock is hypocrystalline, intergranular, diktytaxitic, and aphyric. Consists of euhedral, mostly equant crystals of olivine (about Fa_{50}), plagioclase (about An_{40}) laths, blades and subophitic patches of clinopyroxene, an acicular to feathery opaque mineral, and an equant, partly skeletal opaque mineral, all <0.4 mm, and opaque-charged, brown glass

Qcfh7 **Crescent Butte pahoehoe basalt flow (latest Pleistocene)**—Small, surface-fed, medium-dark-gray (N4), pahoehoe basalt flow that vented from crater in Crescent Butte cinder cone (Qcch1). Flow is vegetated and thinly mantled by colluvium. Unit not studied petrographically

Qcch1 **Crescent Butte basaltic cinder cone (latest Pleistocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, coarse ash, and interlayered, thin lava flows. Cone has a single crater. Western flank of cone is mantled by tephra from Trench Mortar Flat eruptive fissures (Qcea2). Cone is 120 m high and 1 km in diameter. Cone is source vent for the Crescent Butte flow (Qcfh7)

Qcfh8 **Brown pahoehoe basalt flow (latest Pleistocene)**—Surface- and tube(?)-fed, medium-dark-gray (N4) pahoehoe basalt flow. Exposed as distal parts of a larger flow that is covered by Rangefire (Qcfb6) and Minidoka (Qcfb4) flows. Flow is cut by many noneruptive fissures. Flow not studied petrographically

Qcc **Basaltic cinder cones, undifferentiated (Holocene and latest Pleistocene)**—A group of cinder cones that have no identifiable, associated lava flows. Cones of unit consist of black, brown, and red cinders, agglutinated spatter, lapilli, and coarse ash. Age of cones encompasses nearly the entire time span of the Craters of the Moon lava field. Unit includes Paisley Cone, Inferno Cone, Half Cone, Echo Crater, Split Butte, Two Point Butte, and other unnamed cinder cones

BASALTIC LAVA FLOWS AND ASSOCIATED VENT AND ERUPTIVE-FISSURE DEPOSITS AND RHYOLITIC ROCKS OF THE SNAKE RIVER GROUP

Qbsb **Basaltic lava flows and pyroclastic deposits (late Pleistocene—estimated 15-100 ka)**—Dark-gray to black, unweathered to slightly weathered, pahoehoe and a'a lava flows, and bedded, moderately oxidized scoria, cinders, and ash near vents. Flows are locally covered by as much as a meter of eolian sand and loess. Unit includes Broken Top Butte, Sand Butte, Quaking Aspen Butte, Split Top Butte, The Blowout, Fingers Butte, and Rock Corral Butte lava fields. Normal magnetic polarity

Qbsc **Basaltic lava flows and pyroclastic deposits (late and middle Pleistocene—estimated 100-200 ka)**—Light- to dark-gray, slightly to moderately weathered pahoehoe and a'a lava flows, and bedded, moderately to strongly oxidized scoria, cinders, and ash near vents. Flows are locally covered by as much as several meters of eolian sand and loess. Unit includes Serviceberry Butte, Horse Butte, Wildhorse Butte, (Butte County), Wildhorse Butte (Lincoln County), Mule Butte, and Laidlaw Butte lava fields. Normal magnetic polarity

Qbec **Eruptive-fissure deposits (middle Pleistocene—estimated 200-400 ka)**—Eruptive fissures and associated spatter ramparts, cinder mounds, and tephra-mantled furrows. Deposits locally masked by tephra and thin (< 1 m) sheets and patches of eolian sand. Unit extends southeastward for about 8 kms about 5 km south of Pratt Butte. Includes Rattlesnake Butte. Normal magnetic polarity

Qbsd **Basaltic lava flows and pyroclastic deposits (middle Pleistocene—estimated 400-730 ka)**—Light- to dark-gray and reddish (oxidized), slightly to strongly weathered pahoehoe and a'a lava flows and bedded, moderately to deeply oxidized scoria, cinders, and ash near vent areas. Flows locally covered by as much as several meters of loess and eolian sand. Unit includes Monument Butte, Snowdrift Crater, Bowl Crater and Mosby Butte lava fields. Flows in and near valley of South Muldoon Creek tilted as much as 4° in various directions by local normal faults. Normal magnetic polarity

Qr **Rhyolite flows, breccia, and obsidian (middle Pleistocene—about 300 ka)**—Chiefly pink to tan, flow-laminated, 1 to 10-m-thick rhyolite lava flows and minor amounts of rhyolitic-flow and vent breccia and banded obsidian. Unit forms rhyolite dome of Big Southern Butte. Big Southern Butte consists of two coalesced cumulo domes. Southeastern dome consists of lavender-gray, aphyric rhyolite containing abundant devitrification spherulites. Flow-layered rhyolite grades upward into white, sugary-textured rhyolite. The northwestern dome consists chiefly of massive, aphyric, white rhyolite that lacks spherulites. Petrology and structure of Big Southern Butte discussed more fully by Spear and King (1982)

QTb **Basaltic lava flows (early Pleistocene and Pliocene)**—Light- to dark-gray, tan, and reddish (oxidized), slightly to strongly weathered and locally hydrothermally altered pahoehoe lava flows. Flows of unit locally covered by as much as several meters of loess, eolian sand and alluvial deposits. Most exposures are along edges of valley of Little Wood River between Carey and Campbell Reservoir and along Muldoon Creek northeast of Campbell Reservoir. Flows near edge of Snake River Plain tilted south by as much as 5°. Source vents unknown

VOLCANIC ROCKS ALONG NORTHWEST MARGIN OF EASTERN SNAKE RIVER PLAIN

Tiv **Rhyolite ash-flow tuff (Miocene)**—Vitric-crystal, crystal-vitric, and lithic-crystal tuffs and minor interbedded polymictic alluvial gravel. Ash-flow tuffs are grayish red, moderate reddish brown, moderate brown, dark yellowish brown, and black, weather to similar colors; are densely welded to nonwelded, porphyritic to glomeroporphyritic, contain 2-15 percent phenocrysts of feldspar, including sanidine and plagioclase, chiefly oligoclase-andesine, pyroxene, opaque iron oxides, and rare hornblende, biotite, and quartz; black vitrophyre zones locally are perlitic; lithic-rich layers contain pumiceous and non-pumiceous vitric clasts. A minimum of five emplacement units consist of multiple cooling units from coeval vents on the Snake River Plain (Moye and others, 1988). They are thick bedded to platy, have common zones of lithophysal cavities as much as 30 cm in length, have local flow lineations defined by elongation of vesicles, display rheomorphic flow features, and vary in thickness from 0-150 m. Thin (<4 m) polymictic alluvial gravel composed of angular to rounded pebble- to boulder-sized clasts derived chiefly from the Copper Basin Formation (Mississippian) and a lesser component of volcanic rocks from the Challis Volcanic Group are cemented by an ash matrix. Gravel grades upwards into light-gray or light-olive-gray bedded ash deposits locally present between cooling units and at base (unit Tig). Radiometric (Ar^{40}-Ar^{39}) ages on sanidine and volcanic glass range from $8.77 \pm .07$ Ma to $11.72 \pm .09$ Ma for rhyolite ash-flows; sample localities shown on map; data included in Snee and Moye (in press). Locally, springs issue from the unconformable basal contact with the Challis Volcanic Group. Younger tuffs at Queen's Crown and vicinity, along west margin of quadrangle west of Little Wood River, are coextensive with the Picabo tuff of Schmidt (1962)

Tig **Gravel**—Pebble- to boulder-sized polymictic alluvial gravel at base and within lower part of rhyolite ash-flow tuff unit (Tiv) mapped separately west of Long Canyon, northwest of Watercress Spring, and east of the South Fork of Muldoon Creek

Tj **Jasperoid (Oligocene? and Eocene?)**—Medium-gray to black aphanitic to fine-grained silica formed by secondary silicification of Paleozoic mudstone. One outcrop mapped southeast of Payne Creek

Tg **Gossan (Pre-Miocene and Post-Permian)**—Dark-yellowish-brown, moderate-brown-weathering, massive laminated hematite, limonite, silica, and plumbojarosite containing laminations of quartz sand, silt, and clay; forms ledges and irregular knobs; as much as 15 m thick (Bruce Otto, consultant, Boise, Idaho, written commun., 1992). Interpreted to be chiefly alteration product of impure limestone of Hailey Member of Wood River Formation. Source of sulphides and iron may have been magmatic fluids injected along normal faults. Biotite granite of probable Tertiary age was encountered at 61 m below the surface in drill hole in Long Canyon (Bruce Otto, consultant, Boise, Idaho, written commun., 1991)

CHALLIS VOLCANIC GROUP (EOCENE)

Td **Dikes**—Light- to medium-gray, pinkish gray, very pale orange and light- to medium-brownish-gray porphyritic to glomeroporphyritic rhyolite contains 5-25 percent phenocrysts (0.25-5 mm) of twinned euhedral to subhedral plagioclase, largely oligoclase, sanidine, locally as much as 2.5 cm in length and locally altered to clay, and anhedral quartz, partly resorbed, commonly smoky; subordinate smaller, partly chloritized phenocrysts of biotite, amphibole, and clinopyroxene; sedimentary rock xenoliths rare to common; groundmass is fine- to medium-grained mixture of potassium feldspar and quartz. Hornblende leucogranite porphyry, found chiefly in Big Cottonwood Creek area, contains phenocrysts of rounded embayed phyric quartz as much as 20 mm in diameter, sericitized orthoclase, plagioclase, hornblende, and minor biotite, in a fine-grained groundmass of quartz and potassium feldspar (description partly from Sidle, 1979). Granite pegmatite and aplite dikes, restricted to area of Little Cottonwood Creek, are orange pink and moderate pink, coarsely crystalline to aphyric, and composed of quartz, orthoclase, biotite, and magnetite (Sidle, 1979). Dikes weather light gray, yellowish gray, light orange, light greenish gray, and light to medium brownish gray. Chilled, black, glassy margins, locally brecciated, present in places. Dikes commonly form resistant ridges oriented north to northeast. Dikes are extensive in Mississippian sedimentary rocks and also intrude volcanic rocks of Challis Volcanic Group (unit Tcv), and locally cut the biotite granite of Big Cottonwood Creek (unit Tgc) and the hornblende diorite of Little Cottonwood Creek (unit Thd) along north border of quadrangle (Sidle, 1979)

Tbg **Biotite granite of Big Cottonwood Creek**—Pale-red-purple, pinkish-gray, and grayish-orange-pink, medium- to coarse-grained, typically equigranular, locally granophyric granite composed of weakly sericitized and argillitized orthoclase, anhedral quartz, subordinate plagioclase (An_{5-20}), chloritized biotite, and opaque iron oxides; chloritized hornblende reported by Anderson (1929, p. 23). Weathers very light gray and pale pink; spheroidal weathering common. Locally in fault contact with Copper Basin Formation (Mcc). Intrudes volcanic rocks (unit Tcv) of Challis Volcanic Group, and is intruded by a hornblende leucogranite porphyry dike (Td) (Sidle, 1979)

Thd **Hornblende diorite of Little Cottonwood Creek**—Very light gray, pinkish-gray to greenish-gray, coarse-grained porphyritic diorite composed of 50 percent or more sericitized plagioclase phenocrysts as much as 2.5 mm in length, largely unaltered augite crystals, chloritized biotite pseudomorphs after hornblende and pyroxene, and magnetite in a matrix of quartz, feldspar, and epidote. Petrographic description based on single thin section. Rock weathers yellowish gray, pale greenish yellow, and light gray. Stock has been described as a porphyritic hornblende granite (Anderson, 1929, p. 24), a hornblende quartz monzonite (Sidle, 1979, p. 31-32), and as hornblende quartz monzonite (Kuntz and others, 1989a). Stock intrudes volcanic rocks (unit Tcv) of Challis Volcanic Group and is cut by granite pegmatite dikes (unit Td) (Sidle, 1979)

Tcv **Dacitic and andesitic volcanic rocks**—Dacitic biotite-rich ash-flow tuffs and airfall tuffs including the tuff of Stoddard Gulch (Skipp, 1989), at top; mixed biotite-rich dacite lava flows, lithic-crystal tuffs, tuff breccias, and interbedded volcaniclastic sedimentary rock in the middle; and pyroxene-rich andesite lava flows, tuff breccias, and interbedded volcaniclastic sedimentary rocks in the lower part make up a generalized stratigraphic sequence. Biotite-rich, very light gray to light-olive-gray ash-flow and airfall tuffs are well exposed high in the cliffs east of the Little Wood River valley just beneath the rhyolite ash-flow tuff unit (Tiv) and along the central northern border of sec. 34, T. 1 N., R. 21 E. where they form a conspicuous white outcrop visible north of Highway 93. Reddish-brown lithic-rich biotite ash-flow tuff, correlated with the tuff of Stoddard Gulch, contains grayish-black perlitic vitrophyres and small lithophysal cavities in the Lake Hills and on the ridge above Scribbin Draw. Biotite- and hornblende-bearing, purplish, reddish and greenish-gray dacitic lava flows, tuff breccia, lithic-crystal tuff, and interbedded volcaniclastic rocks make up most of the Lake Hills and large parts of the ridges between Muldoon Creek and Fish Creek. Black, dark-gray and greenish-gray andesite lava flows and tuff breccia weather reddish brown and brownish gray, and contain abundant pyroxene and hornblende, rare olivine, and rare to common plagioclase phenocrysts. The flows locally are interbedded with biotite-rich volcaniclastic sedimentary rocks, and are common in the area north of Craters of the Moon National Monument and on the ridges in the Fish Creek drainage area, and are less common in the Lake Hills and Long Canyon areas. Thickness of unit ranges from 0 to about 425 m. Volcanic units in this area were erupted about 49-47 Ma (Snider and Moye, 1989), and do not include representatives of the third and final phase of Challis volcanism identified by Moye and others (1988) and Snider and Moye (1989) in more northern parts of the southeastern Challis volcanic field

Tcc **Basal conglomerate**—Pebble to boulder conglomerate containing minor interbeds of very coarse- to granule-sized quartz sandstone. Conglomerate, light-gray to medium-gray; weathers moderate brown to dark yellowish brown; clasts locally derived chiefly from Copper Basin Formation, are rounded, commonly 6-10 cm in diameter, and consist of 70-80 percent fine- to medium-grained, medium-gray to very light-gray quartzite, 5-15 percent moderate-yellowish-brown and pale-brown argillite, and 10 percent medium-light-gray siltstone; matrix is coarse-grained, silica-cemented quartz and chert sand that also makes up sandstone interbeds. Unit is thick bedded to poorly bedded; cementation variations cause clasts to break out of unit in places and to break across clasts in others. Outcrops locally weather to form pillars and tunnels. Unconformably overlies Paleozoic rocks and is disconformably overlain by volcanic rocks (unit Tcv). Description largely from Larson (1974). Thickness ranges from 0 to 33 m (Larson, 1974). Present as erosional remnants between Fish Creek and Blizzard Mountain. Inferred to have been deposited in an alluvial fan environment (Paull, 1974; Burton and Blakely, 1988)

SEDIMENTARY ROCKS
SUN VALLEY GROUP

Wood River Formation (lower Permian to middle Pennsylvanian)

Pww **Wilson Creek Member (lower Permian)**—Siliceous fine-grained sandstone and siltstone, dark-gray to light-brown, thin-bedded, laminated, graded bedding, convolute bedding. Found only in subcrop surrounded by basalt and in one small ledge of jasperoid next to Pleistocene travertine (unit Qt) 1½ km northeast of Carey Lake; thickness unknown. Type section of formation in Pioneer Mountains to north of quadrangle exceeds 800 m in thickness (Mahoney and others, 1991)

Eagle Creek Member (lower Permian to middle Pennsylvanian)

PPweu and PPwem — **Upper part (lower Permian to upper Pennsylvanian)**—Siliceous sandstone, calcareous sandstone and sandy limestone, and minor conglomerate and siltstone. Siliceous sandstone, light-brown, very light to medium- gray, very fine to medium-grained (0.04 to 0.4 mm in diameter); consists of angular to subrounded quartz grains with concavo-convex to sutured contacts, and accessory chert, sericite, zircon, amphibole, and altered feldspar; weathers moderate brown, medium gray, and light olive gray, and is medium to thick bedded; locally laminated and brecciated; sedimentary breccias dominate, but tectonic breccias common. Calcareous sandstone and sandy limestone, brown to medium-gray, fine-grained; consist of subrounded grains of quartz and accessory components similar to siliceous sandstone in a fine- to medium-grained, chiefly bioclastic, calcite matrix containing minor sericite and cryptocrystalline quartz; weathers brown and reddish brown; medium to thick bedded. Conglomerate interbedded with siliceous sandstone only east of Fish Creek in lower 150 m of unit; contains granule- to pebble-sized clasts of chert, quartz, and quartzite as much as 1.5 cm in diameter in a siliceous or sericitic matrix; beds are graded, laminated, and internally deformed. Distinctive rare siltstone is light greenish gray and platy. Gradational lower contact. No diagnostic fossils have been recovered from unit in this area. Unit forms ledges and talus-covered slopes. More than 600 m thick in Fish Creek area. Correlates with unit 5 and unit 6 of the Wood River Formation of Hall and others (1974) and with upper part of Eagle Creek Member of (Mahoney and others (1991). Description modified from Skipp and Hall (1975) and Larson (1974)

Pwel — **Lower part (upper to middle Pennsylvanian)**—Interbedded sandy limestone, calcareous sandstone, and granule to pebble conglomerate in upper part, and calcareous siltstone and mudstone, and noncalcareous mudstone in lower part. Limestone and calcareous sandstone of upper part, medium-gray to medium-dark-gray and weather same colors; contain very fine to coarse-grained angular to rounded quartz grains, lithic fragments, and accessory feldspar, zircon, sericite, and hornblende in a micritic or bioclastic limestone matrix; commonly laminated; medium to thick bedded; graded beds common. Conglomerate, medium-gray; clasts are angular to subrounded fragments of black, gray, and yellow chert, light-gray quartzite, spicular limestone, and minor dark-gray and yellow argillite, as much as 5 cm in diameter but mostly smaller, in a limestone or siliceous sandstone matrix; clast-supported textures common; forms lowest part of graded sequences; medium to thick bedded; forms ledges and slopes. Conglomerate composes as much as 40 percent of this part of the Eagle Creek member east of Fish Creek; and less than 10 percent of the same unit west of Fish Creek (Skipp and Hall, 1975). Siltstone and mudstone of lower part of the member are pale red and pale reddish purple; thin to medium bedded, form slope; measured thickness in NE1/4 sec. 22, T. 1 N., R. 22 E. is 61 m; conformable contact with underlying Hailey member (Pwh). Unit contains fusulinids, and pelmatozoan, bivalve, molluscan, bryozoan, and coralline debris; correlates with units 3 and 4 of the Wood River Formation of Hall and others (1974) and lower part of Eagle Creek Member (Mahoney and others, 1991). Estimated total thickness 350 m

Pwh **Hailey member (middle Pennsylvanian)**—Limestone, sandy limestone, and calcareous sandstone, interbedded conglomerate, and minor thin beds of dark-gray mudstone that weathers pale reddish purple. Limestone, medium-gray to medium-dark-gray, weathers the same colors; micrite and fine- to medium-grained oolite-intraclast grainstone to packstone. Sandy limestone and calcareous sandstone are similar to rocks described in lower part of Eagle Creek Member (unit Pwel). Conglomerate is similar to that in unit Pwel except clasts are generally larger, as much as 10 cm in diameter, and graded beds are absent. Unit is thin to thick bedded; forms cliffs and low ledges; contains sparse fusulinids and other fossils; correlates with units 1 and 2 of Wood River Formation of Hall and others (1974). Estimated total thickness 200 m

Copper Basin formation (Mississippian)

Mcc **Upper clastic member (upper and lower Mississippian)—** Chiefly proximal and distal turbidites and interturbidites consisting of interbedded quartzite, argillite, siltite, and conglomerate, in order of decreasing abundance (Larson, 1974; Skipp and Hall, 1975). Quartzite, very light to medium-gray on fresh surfaces, weathers moderate to dark yellow brown, light olive gray, and pale brown; fine to coarse grained, commonly medium grained and well sorted; grains are angular to subrounded quartz (50-80 percent) and lithic fragments, chiefly chert and siltstone (10-40 percent) in a dominantly siliceous or sericitic matrix containing minor amounts of opaque iron oxides and carbonaceous material; quartz grains have common silica overgrowths, concavo-convex to sutured borders, and penetrate less competent lithic fragments. Quartzite is medium to thick bedded; locally graded, laminated, and crossbedded; load casts, sole markings, and ripple marks common; well-developed fracture cleavage; common gradational upper contacts; forms ledges and steep slopes. Argillite and siltite, dark-gray to medium-gray, weathers light olive gray, moderate brown, and grayish brown; consist of 40-80 percent clay commonly altered to sericite, locally carbonaceous, 20-60 percent silt and fine-grained angular quartz clasts, and 5-15 percent very fine grained chert clasts; laminated to thin bedded; locally contains trace fossils on bedding surfaces, two brachiopod collections from site (F-1) in a mudflow high in the section in N1/2NE1/4SE1/4 sec. 33, T. 2 N., R. 22 E., (USGS collections 25409-PC and 27118-PC), contain *Rhipidomella* cf. *R. arkansana* Girty, *Orthotetes* cf. *O. kaskaskiensis* (McChesney), *Quadratia* sp., *Flexaria* sp., *Anthracospirifer* spp., *Dimegelasma* cf. *D. eurekensis* (Lintz and Lohr), and *Eumetria* sp. suggestive of a late Meramecian or early Chesterian age (J.T. Dutro, Jr., written communs., 1978, 1993) (Larson, 1974); conodonts from site F-2 were identified as of late Kinderhookian age (C.A. Sandberg, U.S. Geological Survey, personal commun., 1994); forms slope except where locally silicified to jasperoid (unit Tj). Conglomerate, light- to dark-gray, weathers pale brown, moderate brown, and grayish red; granule- to cobble-sized clasts as much as 20 cm in diameter, in descending order of abundance, varicolored (light to dark gray, light olive gray, grayish orange, dark yellowish orange), angular to subangular chert, subangular medium- dark-gray, light-gray, and grayish-orange argillite, light-brownish-gray siltstone, and subrounded to rounded light-gray quartzite, consistently the largest clasts; matrix forms as much as 50 percent of rock and is medium- to fine-grained quartz sand, subangular to rounded chert, and argillaceous material cemented by silica and clay. Local 30-50 cm blocks of laminated argillite in random orientation indicate slumping; thick to very thick bedded, common graded bedding; gradational contact with Drummond Mine Limestone Member (unit Mcd) below; forms ledges and steep slopes; comprises Scorpion Mountain and Muldoon Canyon Formations and Brockie Lake Conglomerate of Larson (1974) in ascending order. Estimated minimum thickness 2185 m (Larson, 1974)

Mcd **Drummond Mine limestone member (lower Mississippian)**—Chiefly limestone turbidites (Nilsen, 1977) interbedded with calcareous sandstone and quartzite above Fish Creek Reservoir (Skipp and Hall, 1975) and argillite and chert near the head of the East Fork of Fish Creek (Larson, 1974). Limestone, medium- to dark-gray, pale-red, and yellowish-brown, weathers dark yellow orange, pale yellowish brown, medium light gray, and light olive gray; aphanitic to conglomeratic, micrite including spiculite and biomicrite, and as much as 40 percent argillaceous and carbonaceous material, and intramicrite containing clasts of micrite as much as 7 mm in diameter and fossil fragments in a lime mud matrix; thin to medium bedded (0.2-0.8 m). Sandstone, medium-gray to light-brown, calcareous, fine-grained, and quartzite, dark-gray, laminated, 1.5 m thick near base of unit above Fish Creek Reservoir. Argillite, grayish-black to dark-gray, interlaminated with chert, light-gray, silty, argillaceous; together they weather grayish orange to very pale orange where exposed in lower part of member on East Fork of Fish Creek. Limestone above Fish Creek Reservoir and in the East Fork of Fish Creek yielded Kinderhookian conodonts and foraminifers (Larson, 1974; Skipp and Hall, 1975). In addition, a new collection from site F-3 contained upper Kinderhook conodonts identified by C.A. Sandberg, U.S. Geological Survey (personal commun., 1994). Gradational basal contact with Little Copper Member (unit Mcl). Forms low ledges. Total measured thickness 34 m above Fish Creek Reservoir (Skipp and Hall, 1975). Minimum measured thickness 107 m, but base not exposed, at head of East Fork of Fish Creek (Larson, 1974)

Mcl **Little Copper member (lower Mississippian)**—Chiefly turbidites consisting of interbedded light- to medium-dark-gray quartzite, grayish-black, brown, and pale-red mudstone and siltstone, and minor granule to cobble conglomerate, in decreasing order of abundance. Sandstone is fine grained to conglomeratic, laminated (alternating concentrations of dark chert and light quartz grains), locally graded, common load casts and scour-and-fill structures; grains are angular to well rounded and consist of quartz, chert, carbonaceous claystone, quartzite, and rare mica and epidote in a carbonaceous clay matrix containing opaque iron oxides and common siliceous cement; weathers light gray, light brown, and pale yellowish brown; thin to thick bedded (0.3-0.9 m); forms ledges. Mudstone and siltstone, weather light gray and light brown, calcareous in places, thin bedded to laminated; *Helmenthoides* feeding trails, flattened coiled ammonoid, gastropod, and woody plant impressions rare on bedding surfaces. Ammonoids from near base probably Early Mississippian in age (McKenzie Gordon, Jr. *in* Skipp and Hall, 1975). Conglomerate, light- to dark- gray, weathers pale brown and moderate brown; clasts as much as 8 cm in diameter, of subangular to subround, chert, quartz, and quartzite in a matrix of rounded quartz sand grains, commonly silicified; medium to thick, graded beds. Unit forms a thickening and coarsening upward sequence. Forms slopes and ledges. Disconformable lower contact with Picabo Formation north of Fish Creek Reservoir is part of regional unconformity (Skipp and Bollmann, 1992). Measured thickness 372 m above Fish Creek Reservoir (Skipp and Hall, 1975)

DSs **Siltstone (Devonian? and Silurian)**—Medium-gray, brownish-gray, and light-olive-gray dolomitic and calcareous siltstone, very fine grained sandstone, and minor sandy limestone; weathers moderate brown, light brownish gray, and grayish red; thin bedded and laminated; commonly bedding obscured by well-developed cleavage nearly parallel or at a low angle to bedding; weathers to slabs containing abundant trace fossils or "worm trails"; no other fossils recovered. Unit closely resembles buff-weathering, limy to dolomitic siltstone with wispy laminations part of Dover's (1981) unnamed Silurian and Devonian unit in the Pioneer Mountains about 40 km northwest of Fish Creek Reservoir; estimated thickness 200 m but neither base nor top exposed. Present only in Long Canyon-Mints Canyon area

St **Trail Creek formation (Silurian)**—Sandstone and siltstone. Medium- to fine-grained, pale-yellowish-brown to medium-dark-gray quartzose sandstone; quartz grains chiefly subangular to subrounded; iron oxide grains and cement common, silica and (or) calcareous cement also common; banded, darker bands have higher iron oxide content than light bands; unfossiliferous. Sandstone ledges form lenses or tectonic slices in gray shaly siltstone. Outcrop veined with quartz. Lower contact conformable with medium-gray-weathering shaly siltstone assigned to Phi Kappa Formation. Estimated minimum thickness 20 m. Overlain unconformably by Hailey Member (unit Pwh) of Wood River Formation. Mapped only on ridge between Long and Mints Canyons

SOp **Phi Kappa formation (middle to lower Silurian? and upper to lower Ordovician)**—Chiefly dark-gray argillite, locally silicified, chert, siltstone, sandstone, minor granule conglomerate and silicified limestone. Upper part chiefly dark-gray argillite and siltstone but includes chert, conglomerate, and silicified limestone. Argillite and siltstone, chiefly dark-gray, carbonaceous, locally oxidized to light gray; weathers pale brown and moderate brown, local silvery phyllitic sheen; thin bedded to banded; local load casts, graded beds, crossbeds; tightly folded, cleavage subparallel to bedding; locally graptolitic; poorly preserved graptolites identified by Claire Carter (U.S. Geological Survey, written communs., 1988, 1991) include *Climograptus* sp., *Glyptograptus*? sp., *Orthograptus*? sp., and *Glossograptus*? sp. of probable Middle Ordovician age collected from mine dump on east side of Long Canyon, and *Orthograptus* cf. *O. amplexicaulis* (Hall), *Climograptus* cf. *C. tubuliferus* Lapworth, *C.* cf. *C. hastatus* T.S. Hall, *Glyptograptus*? sp., and *Amplexograptus*? sp. of probable Late Ordovician age collected from float on west side of Long Canyon. Limestone, silicified, banded medium-light-gray to dark-gray; weathers grayish orange, thin bedded; rare on slope beneath Trail Creek Formation (unit St). Chert, ferruginous chert, and siliceous argillite, dark-gray, grayish-red, and moderate-brown; weathers same colors or light to yellowish gray, laminated or thin bedded to thick bedded; forms cliffs; blocky to chippy talus; locally highly foliated dark-gray argillite in bottom of Long Canyon exhibits abundant small, tightly folded quartz veins. Unit also contains stratigraphically controlled gossans associated with thin- to thick-bedded chert (units Og and Oc of Zieg and Otto, in press). Sandstone, medium-dark-gray; weathers medium dark gray to moderate brown; very fine to medium grained, siliceous cement, thick bedded; forms ledges. Granule conglomerate, medium-gray; weathers brown, interbedded with siliceous sandstone. Sandstone and granule conglomerate resemble basal Basin Gulch Member of Phi Kappa Formation (Dover, 1981, 1983). Base not exposed; unit intruded by biotite granodiorite 61 m below surface in Long Canyon (Zieg and Otto, in press). Gradationally overlain by Trail Creek Formation or unconformably overlain by Hailey Member of Wood River Formation. Entire unit folded both megascopically and microscopically. Estimated minimum thickness 210 m

Dp **Picabo formation (upper Devonian)**—Interbedded dolomitic sandstone, sandy dolomite, sandy dolomite-pebble conglomerate, and minor calcareous sandstone. Dolomitic sandstone and sandy dolomite, medium-light- to dark-gray, pale-yellowish-brown; weathers pale yellowish brown, mediuin dark gray to light gray, and light olive gray; chiefly fine grained; laminated, and medium- to thick-bedded; load casts common, crossbedding rare; forms ledges and steep slopes. Sandy dolomite-pebble conglomerate, medium-light-gray to pale-yellowish-brown; weathers chiefly pale yellowish brown; dolomite pebbles bimodal; larger pebbles well rounded, subtabular, as much as 12.5 cm in diameter; smaller pebbles average 6 mm in diameter, subrounded; both sizes are light gray to grayish black, aphanitic to coarsely crystalline (derived from underlying Jefferson Formation (unit Dj) and Carey Dolomite (unit Dc); matrix of conglomerate is fine- to medium-grained dolomitic quartz sandstone; thick bedded (2-3 m); forms ledges and steep slopes. Calcareous sandstone, light-gray to pale-red; weathers pale yellowish brown; very fine to fine grained, thin bedded, partly laminated, locally present at top of formation. Conodonts from near top of formation at Timbered Dome (Skipp and others, 1990) about 10 km northeast of Fish Creek Reservoir confirm a Late Devonian (Famennian) age (Sandberg and others, 1989). Measured thickness at type section on ridge above north edge of Fish Creek Reservoir is 57.6 m (Skipp and Sandberg, 1975)

Dj **Jefferson formation (upper and middle Devonian)**—Dolomite and a basal dolomite breccia and sandy dolomite conglomerate. Dolomite, medium-gray to grayish black, pale-yellowish-brown, light-brownish gray; weathers light olive gray, light gray to grayish black, and dark yellowish orange to pale yellowish brown; finely to coarsely crystalline, locally sandy and silty, locally laminated, locally vuggy, fossiliferous (conodonts, corals, brachiopods, stromatoporoids, and boney fish). Formation divided into six units (not unmapped here), in descending order: 1) Yellow vuggy dolomite, 2) banded dolomite, 3) black dolomite, 4) blue dolomite, 5) silty dolomite, deposited in fluctuating intertidal and subtidal environments, and 6) basal dolomite breccia and sandy dolomite conglomerate, medium-gray; weather light gray to light olive gray; breccia clasts as much as 0.6 m in diameter; breccia merges along strike into undisturbed laminated dolomite and interbedded rounded dolomite-cobble conglomerate containing clasts, resembling Carey Dolomite (unit Dc), as large as 12.7 cm in diameter in a quartz sand matrix. Formation deposited in tidal flat to shallow subtidal marine environments. Medium to thick bedded; forms ledges and steep slopes; unconformable basal contact. Composite measured thickness 245 m on north side of Fish Creek Reservoir (Skipp and Sandberg, 1975)

Dc **Carey dolomite (middle to lower Devonian)**—Light-gray to medium-dark-gray dolomite and minor dolomite sandstone and granule to pebble conglomerate; weathers light gray, yellowish gray, and olive gray; medium to thick bedded (0.3-3.0 m); finely crystalline to aphanitic; common algal-mat laminae, birdseye porosity, mud chip conglomerate, rare quartz sand and silt grains; sparsely fossiliferous (conodonts, corals, brachiopods, and crinoid ossicles). Early Middle Devonian (Eifelian) conodont faunas recovered from lower beds (Skipp and Sandberg, 1975); deposited chiefly in intertidal and supratidal, locally low subtidal marine environments. Forms steplike ledges; base not exposed. Partial measured thickness of 147.8 m at type section on north side of Fish Creek Reservoir (Skipp and Sandberg, 1975)

DSrm **Robert Mountains formation (lower Devonian and upper Silurian)**—Limestone and phenoplast conglomerate interbedded with calcareous siltstone and silty limestone. Upper part consists of phenoplast conglomerate or intraformational sedimentary limestone breccia composed of subangular to subrounded fragments, as much as 25 cm in diameter, of bioclastic limestone and encrinite; weather medium gray, in yellowish-orange-weathering fossiliferous lime-mud matrix; medium bedded. Middle part is interbedded coral-reef limestone, silty limestone, and calcareous siltstone. Coralline patch-reef limestone, medium-gray, medium- to coarse-grained; medium-bedded; siltstone, yellowish-brown; weathers dark yellowish orange and light brown; irregularly dolomitized, platy. Lower part is coralline limestone, as above, interbedded with limestone encrinite, medium-dark-gray, coarse- to very coarse grained, thin bedded. Formation is fossiliferous (corals, conodonts, gastropods, tentaculitids, trilobites, brachiopods, primitive calcareous foraminifers, and calcareous blue-green algae). Formation forms ridge on east side of Fish Creek Reservoir; base and top faulted. Partial estimated thickness 200 m (Skipp and Sandberg, 1975)

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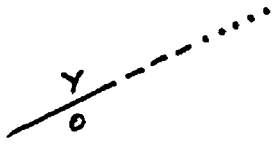
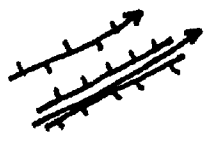
MAP SYMBOLS



Contact—Dashed where approximately located, particularly between lava flows that are veneered by thin deposits of eolian sand and loess. Letters Y and O denote younger and older flows along contact. Dash-dot contact separates flows erupted from the same vent

Flow line—Linear flow features and lava tubes; arrows show flow direction. Open circles on flow lines are locations of skylights in lava tubes



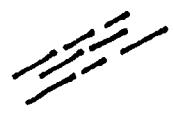
Lava channel—Arrow shows direction of flow within lava channel
Narrow—channels < 5 m wide
Wide—channels > 10 m wide

Crater—Outline of crater rim on volcanic vent, barbs point toward central depression. Barbs not shown on smaller craters

Small cone—Small lava cone, cinder cone, or spatter cone

Rootless vent—Secondary source of lava not directly related to conduit to deep magma reservoir, most are openings in lava tubes

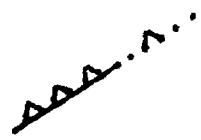
Lava pond—Basalt-filled depression surrounded by levees, shown by hachured line



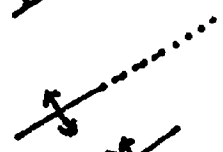
Noneruptive fissures—Fractures in rock through which lava has not erupted. Width generally less than 1 m

Normal or oblique-slip fault—Dashed where approximately located, dotted where concealed; bar and ball on downthrown side where relative motion is known; arrow indicates relative lateral movement

Thrust fault of Antler age (post-Devonian to pre-Middle Pennsylvanian)—Solid teeth on upper plate



Thrust fault of Mesozoic age—Dotted where concealed. Open teeth on upper plate



Anticlinal axis—Dashed where approximately located; dotted where concealed

Overturned anticlinal axis

Synclinal axis—Dashed where approximately located; dotted where concealed

Strike and dip of beds in sedimentary rocks and tuffs in volcanic rocks
Inclined
Vertical
Horizontal

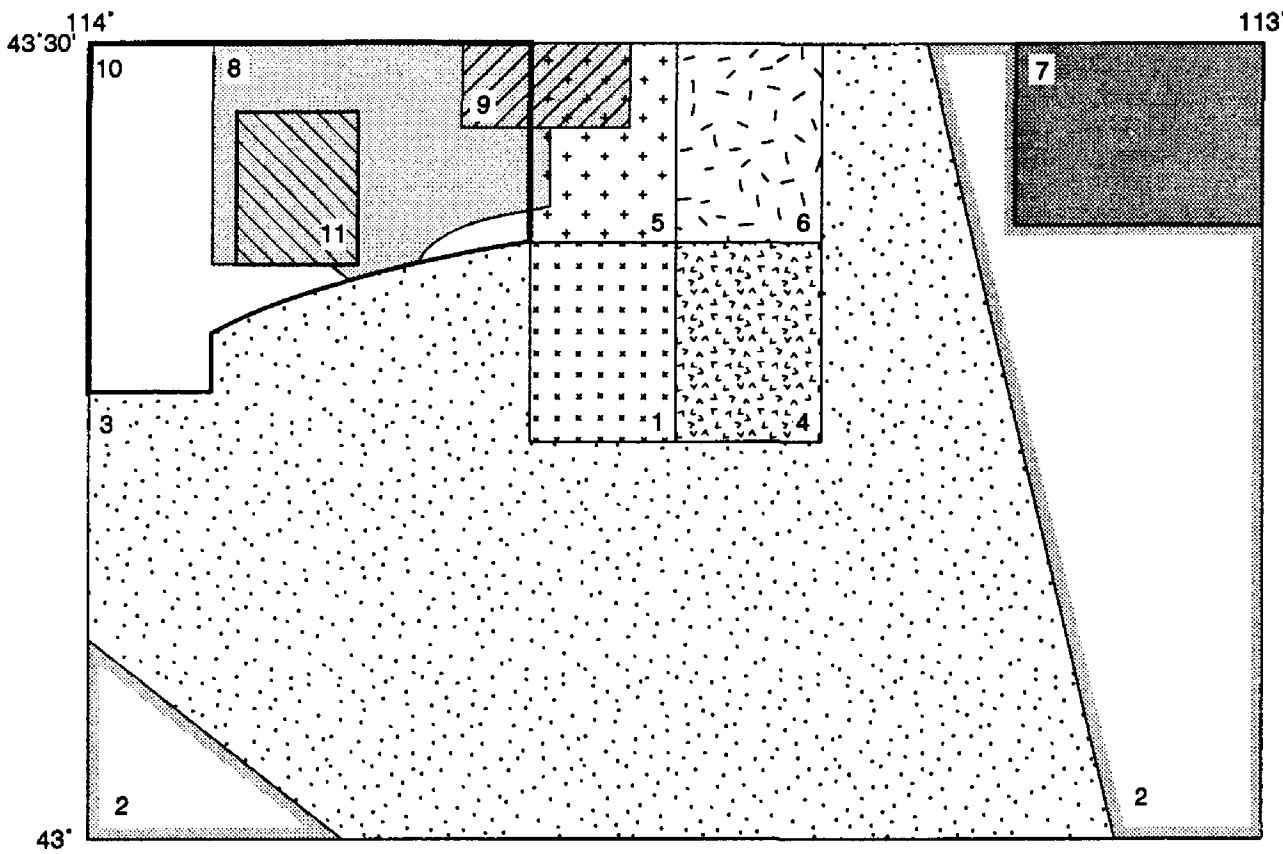
Strike and dip of eutaxitic structures in welded ash-flow tuffs
Inclined

X F-1 **Fossil locality**

• 9.13 ± 0.15 **Sample locality**—$^{40}Ar/^{39}Ar$ age determination (Ma) on sanidine and (or) volcanic glass from rhyolite ash-flow tuff

⊙ 92KS17 **Sample locality**—K-Ar age determinations (Ma or ka) on whole rock samples. Upper number is field number, lower number is age.
433 ± 78 ka

• W-4497 **Sample locality**—Locality of charcoal or carbon-bearing sediment sample for radiocarbon analysis. Laboratory number shown



Map showing sources of geologic data. Numbered sources are identified in References Cited.

KUNTZ- FIGURE ? - FILE: SOURCDWG.AI

Table 1. Potassium-argon ages and analytical data for basalt samples from the Craters of the Moon 1:100,000-scale quadrangle

[Argon analyses by J.C. von Essen and M.A. Kuntz; K_20 analyses by S.T. Prebble.]

Geographic location	Field number	Laboratory number	[1]K_20 wt. percent	$^{40}Ar_{rad}$ (10^{-13} mol/g)	$^{40}Ar_{rad}$ percent	[3]Calculated (10^3 yr)
Spud Butte	92KS3	94I111A	0.563±0.004	1.299	0.826	160± 77
Sand Butte	92KS5	94I096A	0.841±0.005	0.415	0.518	34± 29
Valley of Little Wood River	92KS6	94I100A	0.505±0.006	0.259	10.858	3.55± 0.13 Ma
Rock Lake	92KS10A	94I112A	0.702±0.003	1.839	0.422	182±172
Vent 5252	92KS12A	94I110A	0.667±0.002	2.008	1.766	209± 47
Split Top	92KS13	94I099A	0.811±0.003	0.790	1.419	68± 25
Laidlaw Butte	92KS15	94I105A	0.259±0.002	0.652	1.312	175± 72
Snowdrift Crater	92KS16	94I116A	0.608±0.001	2.946	1.961	337± 68
Muldoon Creek	92KS17	94I102A	0.336±0.001	2.098	2.428	433± 78
Big Southern Butte (obsidian)	76G021	77A009, 77A010	4.747±0.025	[2]21.16	[2]45.750	[2]310±11
Big Southern Butte (aphanitic rhyolite)	76G022	77A045	5.195±0.019	22.03	37.3	294±15

[1]Mean and standard deviation of four measurements.

[2]Pooled mean age of two argon measurements.

[3]$\lambda_\varepsilon=0.581\times10^{-10}yr^{-1}$, $\lambda_\beta=4.962\times10^{-10}yr^{-1}$, $^{40}K/K=1.167\times10^{-4}mol/mol$. Errors are estimates of the standard deviation of analytical precision.

Table 2. Radiocarbon ages of lava flows in the Craters of the Moon and Quaking Aspen Butte lava fields of the eastern Snake River Plain, Idaho.

[Type of sample: sa = charred sediment pretreated by sieving and acid leaching only; sdda = charred sediment pretreated by dissaggregation-deflocculation-acid method; saaa = charred sediment pretreated by sdda method *and* by acid-alkali-acit pretreatment; ca = charcoal leached with dilute HCI acid only; caaa = charcoal pretreated by acid-alkali-acid method. For lab number, prefit Tx refers to University of Texas (*Valastro et al., 1972*); prefix W refers to samples analyzed at the USGS Radiocarbon Laboratory, Reston, Va. Prefix USGS refers to samples analyzed at the USGS Radiocarbon Laboratory, Menlo Park, Calif. Radiocarbon measurements were made by the standard acetylene gas counting method at the USGS Radiocarbon Laboratories, Reston, Va., and Menlo Park, Calif. Sample activities were not corrected for isotope fractionation by a ^{13}C measurement. The ages were calculated relative to the U.S. National Bureau of standards oxalic acid standard activity (*Stuiver and Polach, 1977*). See Kuntz and others (1986) for details of radiocarbon dating methods and data.]

Lava fields, lava flows, and eruptive periods	Sample pretreatment	Field number	Lab number or reference	^{14}C date (yr B.P.)	Mean or oldest age (yr B.P.)
			CRATERS OF THE MOON LAVA FIELD		
Eruptive period A					
Broken Top				Undated	
Blue Dragon	ca	K79-C5	[1]W-4466	1,670 ± 60	
	caaa	K79-C5	[1]W-4578	2,030 ± 80	
	caaa	—	Tx-899	2,110 ± 90	
	caaa	—	Tx-900	2,050 ± 80	2,076 ± 45
	caaa	—	Tx-901	2,200 ± 130	
Trench Mortar Flat	caaa	—	Tx-1157	2,210 ± 80	
	caaa	—	Tx-1158	2,240 ± 80	
	caaa	—	Tx-1159	2,250 ± 80	
	caaa	—	Tx-1160	2,310 ± 70	2,205 ± 25
	caaa	—	Tx-1161	2,130 ± 80	
	caaa	—	Tx-1162	2,270 ± 80	
	caaa	—	Tx-1163	2,140 ± 60	
	ca	K79-C3	W-4413	2,100 ± 60	
	caaa	K79-C6	W-4581	2,180 ± 70	
North Crater				Undated	
Big Craters	ca	K80-C1	W-5342	2,400 ± 300	2,400 ± 300
Serrate				Undated	
Devils Orchard				Undated	
Highway				Undated	
Eruptive period B					
Vermillion Chasm				Undated	
Deadhorse	sdda	K78-S55	W-4259	4,300 ± 60	4,300 ± 60
Devils Cauldron	sdda	K78-S56	W-4287	2,820 ± 90	
	saaa	K78-S56	W-4339	3,660 ± 60	3,660 ± 60
Minidoka	sdda	K78-S58b	W-4267	2,650 ± 50	
	saaa	K78-C7	W-4447	3,510 ± 100	4,510 ± 100
Black Top				Undated	
Eruptive period C					
Indian Wells north				Undated	
Indian Wells south				Undated	
Sawtooth	saaa	K78-S67	W-4370	6,020 ± 160	6,020 ± 160
South Echo				Undated	
Sheep Trail Butte				Undated	
Fissure Butte				Undated	
Sentinel				Undated	

Table 2. Radiocarbon ages of lava flows in the Craters of the Moon and Quaking Aspen Butte lava fields of the eastern Snake River Plain, Idaho.--Continued

Lava fields, lava flows, and eruptive periods	Sample pretreatment	Field number	Lab number or reference	^{14}C date (yr B.P.)	Mean or oldest age (yr B.P.)
Eruptive period D					
Silent Cone				Undated	
Carey Kipuka	sdda	K78-S64	W-4310	3,860 ± 120	
	saaa	K78-S64	W-4592	6,600 ± 60	6,600 ± 60
Little Park	sdda	K78-S66	W-4260	3,960 ± 90	
	saaa	K78-S66	W-4587	6,500 ± 60	6,500 ± 60
Little Laidlaw Park				Undated	
Eurptive period E					
Grassy Cone	saaa	K78-S60	W-4385	6,670 ± 100	
	saaa	K79-C12	W-4488	7,360 ± 60	7,360 ± 60
Laidlaw Lake	saaa	K79-C9	[1]W-4511	7,470 ± 80	7,470 ± 80
Lava Point	saaa	K78-S68	W-4497	7,840 ± 140	7,840 ± 140
Eruptive period F					
Pronghorn	sdda	K78-S73	W-4271	6,820 ± 60	
	saaa	K78-S73	W-4586	10,240 ± 120	10,240 ± 120
Bottleneck Lake	sdda	K78-S72	W-4291	5,230 ± 110	
	saaa	K78-S72	W-4343	7,900 ± 100	
	sdda	K78-S71	W-4280	9,330 ± 120	
	sdda	K78-S71	W-4305	11,000 ± 100	11,000 ± 100
Heifer Reservoir	sdda	K78-S53b	W-4306	9,330 ± 120	
	saaa	K78-S54	W-4583	10,670 ± 150	10,670 ± 150
Eruptive period G					
Sunset	sdda	K78-S58c	[1]W-4270	3,270 ± 80	
	sdda	K76-C4A	[1]W-3674	11,120 ± 120	
	ca	K78-S77	[1]W-4296	12,010 ± 150	12,010 ± 150
Carey	sdda	K78-S62	W-4235	4,310 ± 80	
	sdda	K78-S61c	W-4301	6,500 ± 110	(~12,000)
Lava Creek	saaa	K79-C11	[1]W-4478	11,970 ± 120	
	saaa	K79-C10	[1]W-4476	12,760 ± 150	12,760 ± 150
Eruptive period H					
Kimama	saaa	K78-S75	[1]W-4387	13,900 ± 400	
	saaa	K79-C8	[1]W-4473	15,100 ± 160	15,100 ± 160
Bear Den Lake				Undated	
Baseline				Undated	
Little Prarie				Undated	
Lost Kipuka				Undated	
No Name				Undated	
Brown Flow				Undated	
		QUAKING ASPEN BUTTE LAVA FIELD			
Quaking Aspen Butte	sa	K77-C5	W-3918	>40,000	>40,000

[1]Sample locations beyond borders of this map are shown on Kuntz and others (1988).