Geologic Map of the Craters of the Moon 30′ x 60′ Quadrangle, Idaho

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Conversion Factors

To convert	Multiply by	To obtain
feet (ft)	0.3048	meter (m)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
square kilometer (km^2)	0.3861	square mile (mi^2)

Note: Measurements in this report are in metric except for elevations, which are in feet on topographic base.

Introduction

Pleistocene and Holocene Basaltic Volcanism in the Eastern Snake River Plain and the Area of this Map

Basaltic volcanism was a dominant geologic process in the eastern Snake River Plain (ESRP) in Holocene time, as attested by the fact that eight, predominantly Holocene (<15 ka) lava fields cover about 13 percent of the ESRP (Kuntz, Covington, and Schorr, 1992). Three of the eight lava fields, Craters of the Moon (COM), Kings Bowl, and Wapi, are located along the Great Rift volcanic rift zone. The Great Rift volcanic rift zone is an 85-km-long and 2- to 15-km-wide belt of lava fields of various sizes, tephra cones, lava cones, shield volcanoes, eruptive fissures, associated tephra deposits, and non-eruptive fissures. The Craters of the Moon (COM), Kings Bowl, and Wapi lava fields and the volcanic structures of the Great Rift volcanic rift zone are in the Craters of the Moon 30′ × 60′ quadrangle and the north half of the Lake Walcott 30′ × 60′ quadrangle (fig. 1). The northern nine-tenths of the COM lava field is in the Craters of the Moon 30′ × 60′ quadrangle; the southern one-tenth and the Kings Bowl and Wapi lava fields are in the north half of the Lake Walcott 30′ × 60′ quadrangle (fig. 1).

Because widespread loess deposition essentially terminated at the end of the late Pleistocene (≈10,000 ^{14}C yr B.P.), probably owing to abrupt climate change associated with retreat of continental and alpine glaciers, the predominantly Holocene lava fields are essentially loess free and they appear as dark objects (blackbody radiators) in Landsat imagery (fig. 1).

Craters of the Moon Lava Field

The COM lava field is the largest, predominantly Holocene lava field in the conterminous United States. It has been described by Kuntz and others (1982), Kuntz, Spiker, and others (1986), Kuntz, Champion, and others (1986), Kuntz, Lefebvre, and Champion (1989a, b), Champion and others (1989), Kuntz, Covington, and Schorr (1992), and Kuntz and others (2004). The COM lava field contrasts with most other lava fields in the ESRP because it is a composite, polygenetic field composed of at least 60 flows erupted from at least 25 tephra cones and at least eight eruptive fissure systems aligned along the Great Rift volcanic rift zone. Most other lava fields in the ESRP represent single, monogenetic eruptions from vents widely scattered in space during Pliocene and younger time.

The COM field covers about 1,600 km^2 and contains about 30 km^3 of lava flows and associated vent deposits. Stratigraphic relationships, paleomagnetic studies, and radiocarbon ages (Kuntz, Spiker, and others, 1986) indicate that the field formed during eight eruptive periods designated as H, the oldest, to A, the youngest. Each eruptive period was several hundred years or less in duration and separated from other eruptive periods by non-eruptive recurrence intervals of several hundred to about 3,000 yr. The first eruptive period began about 15,000 ^{14}C yr ago and the latest one ended about 2,100 ^{14}C yr ago. Because the present interval of dormancy has lasted about 2,100 yr, it is likely that another eruptive period will occur within the next 1,000 yr.

Craters of the Moon National Monument

President Coolidge established the Craters of the Moon National Monument on May 2, 1924. Since 1924, the monument has been expanded through five presidential proclamations. The most recent and largest expansion of the monument occurred November 9, 2000, when President Clinton signed a proclamation enlarging the monument 13-fold, from 55,000 acres to 715,000 acres. The expanded monument assures the protection of the entire Great Rift volcanic zone. It encompasses all of the COM lava field as well as remote areas that include the Kings Bowl lava field, Wapi lava field, and the proximal parts of the Bear Trap lava tube. The National Park Service and the Bureau of Land Management manage the monument cooperatively. The National Park Service has primary authority over the portion of the monument that includes the predominantly Holocene lava fields (COM, Kings Bowl, and Wapi). The Bureau of Land Management manages the remaining part of the monument. An excellent visitor center and camping facilities are provided by the National Park Service at the north end of the monument, located off Highway 20-26-93 between Arco and Carey, Idaho.

Evolution, Purpose, and Use of this Map

The detailed geology of the northern part of the COM lava field was previously depicted in a geologic map of the COM, Kings Bowl, and Wapi lava fields and the Great Rift volcanic rift zone (Kuntz and others, 1988). The Craters of the Moon 30′ × 60′ map was published previously as a USGS Open-File Report (Kuntz and others, 1994). The latter map contained the detailed geology of the COM lava field, but all pre-Holocene lava fields surrounding the COM lava field were identified simply as Pleistocene and Pliocene lava fields of the Snake River Group because little accurate and precise radiometric dating had been completed for them. With the advent of the expansion of the Craters of the Moon National Monument in 2000, funds became available from the National Park Service and the Bureau of Land Management for detailed paleomagnetic studies and ^{40}Ar/^{39}Ar dating of the pre-Holocene lava fields. The details of the volcanic geology of the pre-Holocene lava fields shown on this map could not have been obtained without this valuable support.

The field, paleomagnetic, and ^{40}Ar/^{39}Ar data from the previous and newer studies are incorporated in this map. These data give detail to the volcanic history of the pre-Holocene lava fields that surround and lie within kipukas of the COM

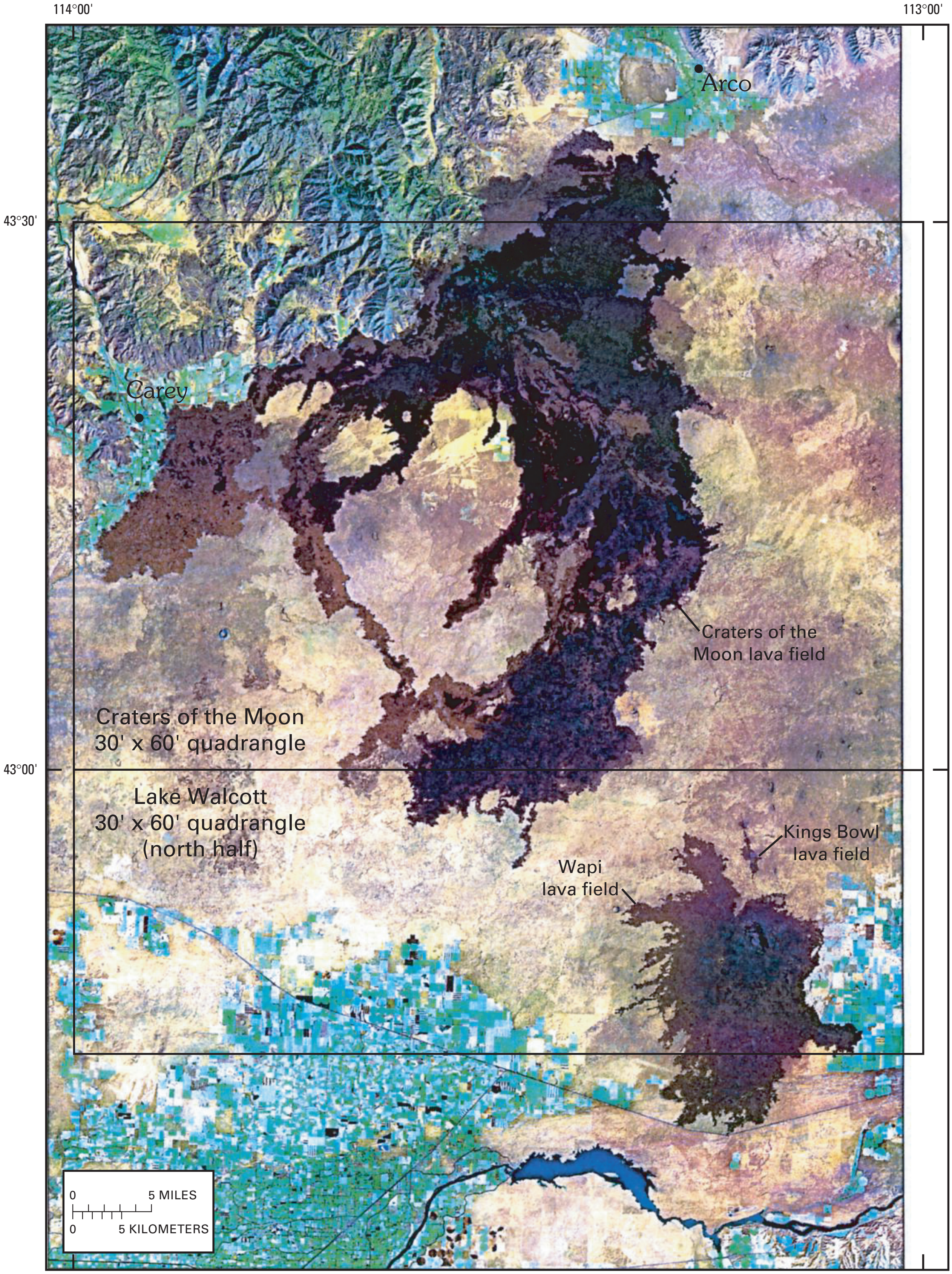

Figure 1. Landsat 7 image of the Craters of the Moon, Kings Bowl, and Wapi lava fields showing the location of the Craters of the Moon 30′ x 60′ quadrangle and the north half of the Lake Walcott 30′ x 60′ quadrangle. Image prepared by John Dohrenwend, Southwest Satellite Imaging, Inc., Teasdale, Utah.

lava field. In addition, these studies now permit a detailed analysis of the time scales for basaltic magmatism for an important part of the ESRP. In a sense, these data can be used to determine the "pulse rate" for basaltic volcanism for the COM lava field and lava fields that surround the COM field. These data show that a major volcanic rift zone, the Borkum rift zone, which contains vents at Sand Butte and Broken Top Butte, was active about 50 ka on the western margin of the COM lava field. A second region of young basaltic volcanism was active about 65–12 ka in the Arco–Big Southern Butte and Rock Corral Butte volcanic rift zones that lie east of the Craters of the Moon lava field. Beginning about 15,000 ^{14}C yr ago, basaltic volcanism was concentrated along the Great Rift volcanic rift zone and the complex COM lava field was formed.

This map and a forthcoming map of the north half of the Lake Walcott 30′ × 60′ quadrangle will provide field, geochronologic, paleomagnetic, and petrographic data not previously available to scientists. These data will contribute to management and preservation of the expanded Craters of the Moon National Monument, and to broad-scale understanding of the basaltic evolution of the ESRP.

Geochronology

Radiocarbon Ages of Lava Flows of the Craters of the Moon Lava Field

The radiocarbon ages of lava flows of the COM lava field listed in table 1 and given in the Description of Map Units were determined using charcoal from tree molds and charcoal and carbon-bearing matter in sediments buried by lava flows. We assume that the carbon-bearing matter was formed by combustion of sagebrush, grass, and humic-rich sediment when they were overridden by lava flows (see Kuntz, Spiker, and others, 1986, for details of radiocarbon studies). Sediment samples were obtained by backhoe excavation beneath flows along the margins of the COM lava field. Radiocarbon ages were obtained for only one or a few flows in each eruptive period; thus accurate durations of eruptive periods are uncertain.

All samples for radiocarbon dating were probably contaminated by young organic material, chiefly modern roots. All samples treated for removal of young organic material gave older ages than untreated samples. Thus, the oldest radiocarbon age for a suite of untreated and treated samples is considered to be the most accurate estimate of the age of the flow. The ages of charcoal and carbon-bearing material from sediments buried by flows are of variable accuracy, thus the "true" maximum ages of those sediments are older than the measured ages for their respective flows. All radiocarbon ages listed in table 1 and in the Description of Map Units are given in conventional ^{14}C yr B.P.; they have not been corrected for isotopic fractionation.

$^{40}Ar/^{39}Ar$ Studies of Pre-Holocene Lava Fields

Methods

All samples were examined petrographically to determine which were sufficiently fresh and had the least amount of glass in the groundmass. Those deemed suitable for dating were crushed and sieved to varying size fractions (100–200 μ to 300–500 μ, depending on the sample) and ultrasonically cleaned in de-ionized water. Standard magnetic separation techniques and hand picking were used to concentrate groundmass concentrates. Splits of each sample, ranging from 50 to 200 mg, were then encapsulated in copper packets and loaded into a sealed quartz vial interspersed with packaged flux monitors. Vials were irradiated in a cadmium-lined tube at the TRIGA reactor at Oregon State University for 20 min. Samples were then analyzed by incremental heating in a Staudacher-type resistance furnace (Gans, 1997). For all samples, we analyzed groundmass concentrates of holocrystalline rocks. From 6 to 15 step-heating experiments were conducted for each sample. Twenty-four new age determinations are summarized in table 2. All errors given for our estimated (preferred) ages, as reported throughout the text and in table 2, are ±2 sigma (95 percent confidence). The flux monitor used for all irradiations was Taylor Creek Rhyolite with an assigned age of 27.92 Ma (Dalrymple and Duffield, 1988). For comparison, we obtained an age of 27.60 Ma on Fish Canyon Tuff sanidine (another widely used standard) when we used Taylor Creek Rhyolite as our flux monitor.

Results of $^{40}Ar/^{39}Ar$ Dating

Virtually all of the samples yielded consistent, well-behaved $^{40}Ar/^{39}Ar$ data with easily interpretable ages and uncertainties. Most of the samples yielded fairly flat age spectra having well-defined plateaus or "pseudo plateaus." Individual spectra range from "hump-shaped" to "U-shaped" to "L-shaped"—a range of spectral types that is typical of these rock suites and is readily explainable in terms of the combined effects and variable contributions of reactor-induced recoil, low-temperature argon loss, and a non-atmospheric "trapped" component (that is, excess argon). In general, the flattest and most reliable parts of the individual spectra were associated with the gas released at intermediate temperatures. Typical confidence estimates range from 10 to 50 ka. The order of laboratory-determined ages of the rocks agreed with stratigraphic order of the rocks determined independently by geologic mapping and field relations.

The new $^{40}Ar/^{39}Ar$ geochronologic data reveal a fairly complete and continuous record of basaltic volcanism in the Craters of the Moon 30′ × 60′ quadrangle for the last 500

Table 1. Selected conventional radiocarbon ages of lava flows in the Craters of the Moon and Quaking Aspen Butte lava fields, Craters of the Moon 30′ x 60′ quadrangle, Idaho.

[Sample pretreatment methods: ca, charcoal leached with dilute hydrochloric acid only; caaa, charcoal pretreated by acid-alkali-acid method; sa, charred sediment pretreated by sieving and acid leaching only; saaa, charred sediment pretreated by sdda method and by acid-alkali-acid pretreatment; sdda, charred sediment pretreated by disaggregation-deflocculation-acid method. Field number K79-C5 is located beyond map area. Laboratory number: W refers to samples analyzed at USGS Radiocarbon Laboratory, Reston, Va. Radiocarbon measurements were made by standard acetylene gas counting method at USGS Radiocarbon Laboratories, Reston, Va., and Menlo Park, Calif. Sample activities were not corrected for isotope fractionation by a ^{13}C measurement. Ages were calculated relative to the U.S. National Bureau of Standards oxalic acid standard activity (Stuiver and Polach, 1977). See Kuntz, Spiker, and others (1986) for details of radiocarbon dating methods and the entire suite of radiocarbon samples. See Kuntz and others (1988) for locations of all radiocarbon samples and radiocarbon ages]

Eruptive period and lava flow	Sample pretreatment	Field number	Laboratory number or reference	^{14}C age (yr B.P.)	Map unit symbol
			Craters of the Moon lava field		
Eruptive period A					
Blue Dragon	caaa	K79-C5	W-4578	2,030±80	Qcfa2
Trench Mortar Flat	caaa	K79-C6	W-4581	2,180±70	Qcfa3
Big Craters	ca	K80-C1	W-5342	2,400±300	Qcfa5
Eruptive period B					
Deadhorse	sdda	K78-S55	W-4259	4,300±60	Qcfb2
Devils Caldron	saaa	K78-S56	W-4339	3,660±60	Qcfb3
Minidoka	saaa	K78-C7	W-4447	3,590±70	Qcfb4
Rangefire	saaa	K78-S58a	W-4742	4,510±100	Qcfb6
Eruptive period C					
Sawtooth	saaa	K78-S67	W-4370	6,020±160	Qcfc3
Eruptive period D					
Carey Kipuka	saaa	K78-S64	W-4592	6,600+60	Qcfd2
Little Park	saaa	K78-S66	W-4587	6,500±60	Qcfd3
Eruptive period E					
Grassy	saaa	K79-C12	W-4488	7,360±60	Qcfe1
Laidlaw Lake	saaa	K79-C9	W-4511	7,470±80	Qcfe2
Lava Point	saaa	K78-S68	W-4497	7,840±140	Qcfe3
Eruptive period F					
Pronghorn	saaa	K78-S73	W-4586	10,240±120	Qcff1
Heifer Reservoir	saaa	K78-S54	W-4583	10,670±150	Qcff2
Bottleneck Lake	sdda	K78-S71	W-4305	11,000±100	Qcff3
			Quaking Aspen Butte lava field		
Quaking Aspen Butte	sa	K77-C5	W-3918	>40,000	Qsbb19

Table 2. $^{40}Ar/^{39}Ar$ and K-Ar ages and analytical data for samples from the Craters of the Moon 30′ x 60′ quadrangle.

$^{40}Ar/^{39}Ar$ data for basaltic lava fields of the Snake River Group

[All ages in ka, unless otherwise noted. Analyses by P.B. Gans, University of California, Santa Barbara, Calif.]

Geographic location	Field number	Weighted mean preferred age	Isochron age	Total fusion age	Preferred age (±2σ)	Map unit symbol
Basalt of lower Little Wood River.	SRP-100	4.18±0.02 Ma	4.22±0.04 Ma	4.22 Ma	4.20±0.02 Ma	Tsbf2
Wagon Butte	SRP-101	117±20	177±52	162	120±25	Qsbb13
Broken Top Butte	SRP-102				<50	Qsbb5
Spud Butte	SRP-103	57±30	32±28	126	57±30	Qsbb7
The Blowout	SRP-104	116±12	117±22	110	116±15	Qsbb11
West Wildhorse Butte	SRP-105				<50	Qsbb8
Bear Den Butte	SRP-106	58±10	61±32	67	58±10	Qsbb3
Laidlaw Butte	SRP-107	422±14	452±32	376	425±20	Qsbd3
Snowdrift Crater	SRP-108	482±42	470±120	415	480±50	Qsbd4
Big Blowout Butte	SRP-109	208±12	303±104	216	210±15	Qsbc8
Mule Butte	SRP-110	106±8	108±16	100	106±10	Qsbb27
Horse Butte	SRP-111	73±16	86±82	66	75±20	Qsbb26
Mosby Butte	SRP-112	263±30	288±110	278	265±30	Qsbc52
Rock Lake	SRP-113	295±48	274±90	277	290±50	Qsbc54
Split Top	SRP-114	114±6	110±14	121	113±10	Qsbb28
Packsaddle Butte	SRP-115	336±10	346±18	333	340±15	Qsbc63
Antelope Butte	SRP-116	465±22	480±40	458	470±25	Qsbd5
Pratt Butte	SRP-150	260±18	269±38	260	263±20	Qsbc35
Serviceberry Butte	SRP-151	119±10	120±26	127	120±12	Qsbb22
Rock Corral Butte	SRP-152	59±10	44±32	87	55±12	Qsbb16
East Wildhorse Butte	SRP-153	326±10	325±12	323	325±10	Qsbc38
Fingers Butte	SRP-154	57±20	53±406	79	57±20	Qsbb18
Coyote Butte	SRP-156	64±16	64±46	95	64±20	Qsbb20

$^{40}Ar/^{39}Ar$ data for Idavada Volcanics (Tiv)

[All ages in Ma. Analyses by L.W. Snee, U.S. Geological Survey, Denver, Colo.]

Geographic location	Field number	Weighted mean or plateau age	Total gas age	Material analyzed	Map unit symbol
East of Road Canyon	L87-74	9.13±0.15	10.11±0.34	Plagioclase	Tiv
Scribbin Draw	LH-127	11.22±0.10	11.72±0.09	Sanidine	Tiv
Queen's Crown	LH-142	8.77±0.07	8.51±0.13	Glass	Tiv
Road Canyon	LH-132	8.81±0.04	8.75±0.01	Glass	Tiv

K-Ar data

[Analyses by M.A. Kuntz, U.S. Geological Survey, Denver, Colo., and G.B. Dalrymple and J.C. von Essen, U.S. Geological Survey, Menlo Park, Calif. $K_2$0 analyses by S.T. Prebble, U.S. Geological Survey, Menlo Park, Calif.]

Geographic location	Field number	Laboratory number	[1]$K_2$0 weight percent	$^{40}Ar_{rad}$ (10^{-13} mol/g)	$^{40}Ar_{rad}$ percent	[2, 3]Calculated age (10^3 yr)	Map unit symbol
Sand Butte	92KS5	941096A	0.841±0.005	0.415	0.518	34±29	Qsbb6
Rock Lake vent	92KS10A	941112A	0.702±0.003	1.893	0.422	182±172	Qsbc54
Vent 5252	92KS12A	941110A	0.667±0.002	2.008	1.766	209± 47	Qsbb30
Big Southern Butte, (aphanitic rhyolite).	76G022	77A045	5.195±0.019	22.03	37.3	294±15	Qsr1
Big Southern Butte, (obsidian).	76G021	77A009	4.747±0.025	21.16	45.750	[2]309±10	Qsr2
South Fork Muldoon Creek	92KS17	941102A	0.336±0.001	2.098	2.428	433±78	Qsbd1
Valley of Little Wood River	92KS6	941100A	0.505±0.006	0.259	10.858	3.55± 0.13 Ma	Tsbf1

[1]Mean and standard deviation of four measurements.

[2]Pooled mean age of two argon measurements.

[3] λ_ε=0.581 x $10^{-10}yr^{-1}$; λ_β=4.962 x $10^{-10}yr^{-1}$; $^{40}K/K$=1.167 x 10^{-4} mol/mol. Errors are estimates of standard deviation of analytical precision.

ky. In detail, however, our ages cluster into age groupings at *~30 ka* (Broken Top Butte [Qsbb5] and west Wildhorse Butte [Qsbb8]); *50–70 ka* (Rock Corral Butte [Qsbb15], Fingers Butte [Qsbb18], Bear Den Butte [Qsbb2], Coyote Butte [Qsbb20], and Horse Butte [Qsbb25]); *100–125 ka* (Mule Butte [Qsbb27], Split Top [Qsbb28], The Blowout [Qsbb10], Seviceberry Butte [Qsbb22], and Wagon Butte [Qsbb13]); *260–290 ka* (Pratt Butte [Qsbc35], Mosby Butte [Qsbc52], and Rock Lake [Qsbc54]); *320–340 ka* (east Wildhorse Butte [Qsbc38] and Packsaddle Butte [Qsbc63]); and *475 ka* (Antelope Butte [Qsbd5] and Snowdrift Crater [Qsbd4]). There are apparent periods of ≈30–60 ky duration when little or no volcanic activity took place between groups. More work will be required to determine whether this episodicity is real or an artifact of incomplete sampling.

Whole Rock Potassium-Argon Studies

Four samples of Idavada Volcanics from the Lake Hills and eight samples of pre-Holocene lava flows in this quadrangle were dated by the potassium-argon (K-Ar) method (table 2). Five of the eight pre-Holocene samples were redated by the $^{40}Ar/^{39}Ar$ method. K-Ar dating of the pre-Holocene lava flows was hampered by the low K_2O contents of the flows (typically less than 0.8 percent), the relative youth of the flows, and mass spectrometric and electronic limitations.

Paleomagnetic Studies

Magnetic polarity and remanent inclination and declination directions (table 3) were determined for basaltic lava flows from surface samples. All lava flows in the quadrangle have normal magnetic polarity; they were emplaced during the Brunhes Normal-Polarity Chron and are younger than 780,000 yr. Secular variation of the geomagnetic field occurs at a geologically rapid rate (≈4° per century; Champion and Shoemaker, 1977), which allowed us to group lava flows having similar paleomagnetic directions. Conversely, dissimilar paleomagnetic directions indicated that two lava flows erupted at different times. With these two ideas as guides and by incorporating the new $^{40}Ar/^{39}Ar$ ages, we used directions of remanent magnetization to correlate and approximately date lava flows and lava fields for this map.

Paleomagnetic site-average data are ordered from youngest to oldest in each of five geographic groups for the Craters of the Moon 30′ x 60′ quadrangle in table 3. The first and largest group represents sites in lava flows of the COM lava field. The COM data are further organized into eight eruptive periods. Within the eruptive periods, paleomagnetic site averages are calculated for some lava flows. These data were first described by Kuntz and others (1986) and the presentation in table 3 follows their descriptions.

The other four geographic groups are sites in pre-Holocene lava flows in the northwestern, southwestern, northeastern, and southeastern parts of the quadrangle. Some of the paleomagnetic sites listed in table 3 are not within the boundaries of the COM 30′ x 60′ quadrangle, but are from adjoining quadrangles. These sites were used to establish the large extents of some of the lava flows.

Adjacent lava fields, with or without additional petrographic correlations, may have similar directions of remanent magnetization. This similarity may indicate that the two lava fields erupted simultaneously during a short span of time, on the order of about 100 yr. When the similar remanent magnetizations have a distinctive steep or shallow inclination, or a distinctive east or west declination, the temporal correlation of the lava fields is probable. When the similar remanent magnetizations have no such distinctions, and are close to low-60° inclination and near 0° declination (the time-averaged paleomagnetic direction for the Snake River Plain), then no strong correlation can be drawn. The stratigraphic order of the paleomagnetic sites in each of the groups in table 3 is compatible with the known chronologic and stratigraphic data in hand. Because the chronologic and stratigraphic data for this map are incomplete, the stratigraphic order of the lava fields depicted on the map may be revised based on future paleomagnetic and radiometric studies.

Paleomagnetic correlations between different lava fields or flows that are not in contact with one another have been used to establish the stratigraphy of the lava fields as shown in the Correlation of Map Units. For example, The Blowout lava field (Qsbb10) is paleomagnetically correlated to the Serviceberry Butte (Qsbb22) and Vent 5206 (Qsbb23) lava fields. Although these lava fields are tens of kilometers apart, they share remanent directions (12° to 14° east declinations and low-60° inclinations). Additionally, two of the lava fields have similar $^{40}Ar/^{39}Ar$ ages. Based on these data, these three lava fields are interpreted to have erupted during a very short interval of time, perhaps 100 yr.

Nine lava fields in the Paddelford–Little Laidlaw Park area are correlated temporally on the basis of paleomagnetic data, even though they do not have, in most cases, the same remanent directions. Five of the sites have remanent directions that are not typical of the “normal” magnetic polarity of the Brunhes Chron. The paleomagnetic directions form an open, counterclockwise loop through very steep southerly directions, to easterly and then northeasterly directions, before returning to “normal” remanent directions. Also, samples from the nine lava fields possess weak natural remanent magnetization and they did not group well after alternating-field demagnetization. Owing to the weak natural remanent magnetization, these samples have larger uncertainties in paleomagnetic directions than is typical for samples from the Snake River Plain. The nine lava fields are interpreted to record an excursion of the geomagnetic field at about 210 ka, spanning a time interval of a few centuries to perhaps 1,000 yr.

Table 3. Paleomagnetic data for the Craters of the Moon 30′ x 60′ quadrangle, Idaho.

[Site is alphanumeric identifier of location; asterisk prefix indicates site is not located within quadrangle. Lat/Long are latitude and longitude in degrees north and east of site location; longitude indicated in degrees east of Greenwich prime meridian. N/No is number of cores used compared with number originally taken at site. Exp is strength of peak alternating field in milliTeslas; NRM equals the natural remanent magnetization and signifies all samples in site did not require alternating field cleaning treatment. I and D are remanent inclination and declination. ∝95 is 95 percent confidence limit about the mean direction. k is estimate of Fisherian precision parameter. R is length of resultant vector. Plat/Plong are location north and east of virtual geomagnetic pole (VGP) calculated from site mean direction]

Unit name	Site	Lat	Long(+)	N/No	Exp	I	D	∝95	k	R	Plat	Plong
CRATERS OF THE MOON LAVA FIELD												
Eruptive-period A												
Broken Top flow	8A105	43.432°	246.465°	11/12	20	66.2°	344.1°	1.3°	1196	10.99164	77.8°	187.0°
	BufI	43.426°	246.454°	12/12	10	63.7°	349.8°	1.4°	987	11.98887	82.5°	174.3°
	8A165	43.426°	246.458°	12/12	20	65.2°	348.5°	1.2°	1342	11.99180	81.1°	185.5°
Blue Dragon flows	HudI	43.465°	246.663°	12/12	20	64.2°	355.5°	2.4°	332	11.96687	86.0°	196.2°
	BDWI	43.326°	246.326°	9/12	NRM	65.2°	352.5°	1.8°	860	8.99070	83.4°	194.9°
	RsBI	43.283°	246.708°	24/24	NRM	63.9°	351.6°	1.5°	409	23.94372	83.6°	180.8°
Trench Mortar Flat flow	TmFI	43.415°	246.473°	12/12	NRM	64.9°	357.1°	2.3°	352	11.96872	86.0°	217.3°
The Watchman flow	WchI	43.387°	246.507°	13/13	NRM	64.4°	350.9°	1.9°	489	12.97546	83.0°	183.4°
North Crater flow	NoCI	43.456°	246.443°	23/24	NRM	65.4°	352.4°	2.1°	213	22.89672	83.3°	196.5°
Big Craters flow	BCSI	43.430°	246.452°	12/12	10	63.1°	349.5°	2.5°	295	11.96275	82.4°	168.5°
	BNwI	43.447°	246.411°	12/12	30	62.1°	353.3°	2.4°	338	11.96744	85.1°	158.0°
Serrate flow	SerI	43.479°	246.482°	10/11	10	59.2°	353.1°	2.2°	486	9.98150	83.8°	124.6°
	8A153	43.477°	246.485°	12/12	NRM	65.1°	10.5°	1.6°	754	11.98540	81.8°	306.8°
Highway flow	HwyI	43.462°	246.432°	12/12	10	65.9°	358.1°	3.1°	194	11.94336		
Eruptive-period B												
Vermillion Chasm flow	8A366	43.320°	246.631°	11/12	10	56.4°	350.6°	0.9°	2392	10.99582	80.4°	118.6°
	8A426	43.347°	246.571°	12/12	20	60.1°	349.8°	1.6°	708	11.98446	82.1°	142.4°
Deadhorse flow	DdHI	43.245°	246.719°	12/12	NRM	57.0°	352.6°	1.3°	1089	11.98992	82.0°	114.1°
	8A048	43.253°	246.715°	11/12	NRM	57.9°	353.1°	1.4°	1121	10.99108	83.0°	117.2°
	8A390	43.284°	246.629°	12/12	10	59.5°	349.7°	1.1°	1474	11.99254	81.8°	139.0°
Devils Caldron flow	QtnI	43.244°	246.719°	11/12	20	57.8°	359.0°	2.1°	479	10.97916	85.2°	76.4°
	8A438	43.297°	246.626°	12/12	NRM	58.9°	356.3°	0.6°	5409	11.99797	85.4°	105.1°
Minidoka flow	*MnTI	42.934°	246.516°	12/12	NRM	60.5°	355.7°	1.9°	505	11.97822	86.5°	132.6°
	MnEI	43.203°	246.724°	12/12	NRM	59.3°	359.9°	1.7°	698	11.98427	86.9°	67.7°
	MnWI	43.093°	246.467°	13/13	NRM	58.9°	357.8°	1.7°	640	12.98127	86.2°	92.5°
Larkspur Park flow	LarI	43.019°	246.374°	11/12	NRM	63.1°	0.3°	2.3°	407	10.97546	88.4°	254.7°
Rangefire flow	8A060	43.256°	246.705°	24/24	10	58.1°	357.7°	1.6°	365	23.93706	85.2°	88.7°
	8A072	43.180°	246.709°	16/21	10	56.2°	359.4°	1.9°	365	15.95885	83.6°	70.8°
	8A294	43.206°	246.625°	11/12	10	57.6°	355.2°	2.0°	539	10.98143	83.8°	103.9°
Black Top Butte flow	8A306	43.200°	246.617°	10/11	10	59.6°	354.8°	1.4°	1155	9.99221	85.3°	123.0°
	8A402	43.284°	246.628°	12/12	20	60.0°	354.8°	0.7°	3944	11.99721	85.5°	127.4°
	8A414	43.285°	246.626°	11/12	20	61.2°	353.3°	0.8°	3150	10.99682	85.0°	147.5°

Table 3. Paleomagnetic data for the Craters of the Moon 30′ x 60′ quadrangle, Idaho.—Continued

Unit name	Site	Lat	Long(+)	N/No	Exp	I	D	∝95	k	R	Plat	Plong
CRATERS OF THE MOON LAVA FIELD—Continued												
Eruptive-period C												
Indian Wells South flow	InWI	43.356°	246.422°	12/12	5	70.1°	359.4°	2.4°	329	11.96662	79.3°	244.5°
Indian Wells North flow	8A545	43.363°	246.444°	11/12	10	70.9°	356.6°	1.7°	723	10.98618	77.9°	237.1°
Sawtooth flow	8A225	43.269°	246.505°	23/24	NRM	67.8°	355.3°	1.9°	266	22.91743	81.8°	225.2°
Sheep Trail Butte flow	8A318	43.255°	246.549°	12/12	10	69.1°	355.6°	0.7°	3616	11.99696	80.3°	230.5°
	8A450	43.236°	246.611°	10/12	20	70.1°	358.5°	1.9°	665	9.98646	79.1°	242.0°
Fissure Butte flow	8A617	43.361°	246.519°	12/12	20	69.8°	356.2°	1.1°	1451	11.99242	79.5°	234.2°
The Sentinel flow	8A462	43.315°	246.535°	12/12	10	75.2°	7.6°	0.9°	2178	11.99495	70.7°	257.4°
	8A533	43.363°	246.556°	11/12	10	72.6°	14.3°	1.5°	998	10.98998	73.0°	273.2°
Eruptive-period D												
Silent Cone flow	8A569	43.419°	246.402°	9/12	10	57.6°	7.8°	2.2°	532	8.98495	82.2°	14.9°
Carey Kipuka flow	CyKI	43.310°	246.340°	12/12	10	55.2°	5.4°	2.0°	461	11.97614	81.4°	35.8°
Little Park flow	8A201	43.278°	246.346°	24/24	10	52.2°	14.6°	1.7°	292	23.92115	74.5°	13.8°
Little Laidlaw Park flow	8A213	43.312°	246.462°	24/24	10	53.8°	16.1°	1.9°	255	23.90974	74.6°	6.7°
	8A117	43.444°	246.425°	8/12	NRM	55.3°	14.0°	3.1°	318	7.97802	76.8°	6.8°
Eruptive-period E												
Grassy Cone flow	GrCI	43.443°	246.403°	23/25	30+	59.7°	353.5°	1.1°	817	22.97306	84.4°	127.7°
	GrSI	43.122°	246.350°	9/12	10	59.1°	353.0°	1.9°	758	8.98945	83.8°	127.5°
	GsWI	43.319°	246.278°	11/12	NRM	59.0°	353.0°	1.1°	1612	10.99382	83.7°	124.7°
	WndI	43.344°	246.278°	5/8	20	59.3°	348.1°	2.6°	874	4.99543	80.5°	140.2°
	8A177	43.402°	246.377°	8/12	10+	60.6°	350.1°	2.5°	481	7.98543	82.5°	146.1°
Lava Point flow	8A237	43.215°	246.486°	20/24	10+	53.6°	8.9°	1.8°	315	19.93963	78.6°	26.4°
	8A249	43.200°	246.515°	11/12	20	54.7°	2.0°	1.2°	1389	10.99280	81.9°	55.1°
	8A330	43.285°	246.532°	10/12	20	54.4°	5.0°	2.1°	522	9.98276	80.8°	40.1°
	8A342	43.266°	246.559°	10/12	20	56.7°	10.8°	2.0°	588	9.98470	79.8°	9.2°
	8A509	43.404°	246.650°	12/12	20	56.9°	4.3°	2.6°	277	11.96022	83.2°	36.4°
Eruptive-period F												
Pronghorn flow	PhRI	43.098°	246.419°	11/12	10	58.1°	14.0°	1.4°	1155	10.99137	78.6°	354.2°
	RfRI	43.130°	246.522°	9/12	40	58.1°	10.2°	2.0°	651	8.98772	81.2°	2.6°
	BDLI	43.179°	246.527°	10/12	20	59.4°	13.5°	2.2°	479	9.98121	79.6°	348.3°
	8A474	43.173°	246.566°	10/12	10+	59.2°	13.0°	1.3°	1392	9.99353	79.8°	350.6°
	8A486	43.174°	246.567°	11/11	10	58.5°	10.6°	2.5°	323	10.96908°	81.1°	359.7°
	8A497	43.130°	246.544°	12/12	10	57.8°	15.6°	1.5°	872	11.98738	77.3°	352.9°
	8A641	43.228°	246.581°	9/12	30	59.5°	16.4°	1.4°	1340	8.99403	77.4°	344.4°
Heifer Reservoir flow	HfrI	43.330°	246.729°	12/12	10	57.0°	356.8°	1.7°	671	11.98363	83.7°	90.9°

	FgBI	43.407°	246.703°	12/12	30+	56.9°	355.9°	1.6°	775	11.98581	83.4°	95.8°
Bottleneck Lake flow	BnLI	43.077°	246.388°	11/12	10	64.3°	341.9°	1.4°	1159	10.99140	76.8°	175.6°
	8A270	43.202°	246.621°	9/12	30	67.1°	338.2°	1.7°	898	8.99109	73.7°	188.0°
	8A282	43.202°	246.621°	11/12	20	65.4°	341.6°	1.3°	1189	10.99159	76.4°	181.3°
	8A593	43.226°	246.660°	10/12	30	67.1°	345.6°	1.7°	791	9.98862	78.1°	195.5°
	8A605	43.204°	246.649°	12/12	30	65.8°	344.8°	1.9°	505	11.97822	78.3°	186.3°
Eruptive-period G												
Sunset flow	*SneI	43.562°	246.531°	18/18	20+	59.7°	21.1°	1.1°	1012	17.98320	74.1°	340.1°
	8A141	43.475°	246.460°	10/12	40	59.2°	26.6°	2.7°	320	9.97190	69.9°	337.5°
	CpCI	43.380°	246.280°	12/12	NRM	59.9°	20.9°	1.4°	911	11.98794	74.3°	338.8°
	CrTI	43.320°	246.185°	12/12	NRM	60.2°	16.7°	1.2°	1311	11.99163	77.5°	340.7°
	LrxI	43.326°	246.238°	12/12	5	59.6°	18.1°	2.2°	407	11.97302	76.3°	342.5°
	LvLI	43.321°	246.192°	6/6	NRM	60.5°	16.1°	2.8°	566	5.99116	78.0°	339.5°
	8A189	43.315°	246.172°	11/12	20	60.5°	17.2°	1.1°	1820	10.99450	77.2°	338.6°
	8A261	43.243°	246.211°	19/21	20+	60.7°	19.9°	1.2°	816	18.97794	75.3°	335.3°
	8A557	43.390°	246.409°	7/12	30	62.3°	23.3°	1.8°	1073	6.99441	73.2°	327.5°
Eruptive-period H												
Kimama flow	KmaI	43.026°	246.365°	12/12	10	58.2°	0.8°	1.3°	1141	11.99038	85.8°	57.8°
Crescent Butte flow	2B576	43.412°	246.496°	14/14	30+	57.9°	338.9°	3.0°	173	13.92482	73.4°	146.9°
Bear Den Lake flow	BrDI	43.186°	246.502°	12/12	10	48.9°	359.1°	1.7°	699	11.98428	76.6°	70.0°
Baseline flow	8A521	43.400°	246.655°	10/12	10	48.1°	358.9°	2.2°	502	9.98207	75.7°	70.7°
Little Prairie flow	8A581	43.382°	246.558°	11/12	10	49.7°	8.5°	1.1°	1812	10.99448	75.5°	35.9°
Lost Kipuka flow	LsKI	43.282°	246.704°	9/12	10+	53.0°	1.4°	1.6°	990	8.99192	80.2°	59.7°
No Name flow	8A378	43.320°	246.631°	11/12	10	54.4°	9.8°	0.9°	2336	10.99572	78.7°	21.5°
Brown flow	8A081	43.179°	246.709°	10/12	20	46.5°	3.9°	1.7°	844	9.98934	74.3°	53.8°
NORTHWESTERN PART OF QUADRANGLE												
Bear Den Butte lava field	570B2	43.168°	246.501°	8/8	20	66.0°	358.4°	1.1°	2439	7.99713	84.8°	234.6°
Vent 5168 lava field	834B2	43.263°	246.458°	8/8	20	63.8°	357.3°	1.2°	1984	7.99647	87.1°	205.9°
Lava Butte lava field	562B2	43.207°	246.488°	7/8	Pl	53.5°	3.3°	2.7°	512		80.5°	49.7°
Paddelford Flat lava field	722B2	43.288°	246.206°	4/4	20	62.7°	359.6°	1.8°	2636	3.99886	89.2°	224.0°
Little Park lava field	746B2	43.293°	246.324°	7/8	Pl	69.0°	308.1°	2.8°	462		54.8°	190.0°
Purple Butte cinder cone	8A629	43.227°	246.582°	9/12	30	51.7°	344.3°	1.9°	710	8.98873	73.6°	120.4°
Hollow Top Butte lava field	778B2	43.320°	246.415°	8/8	Pl	71.0°	348.2°	5.2°	132		75.7°	218.4°
Vent 5129 lava field	738B2	43.310°	246.298°	8/8	Pl	64.6°	37.9°	6.7°	267	.	63.2°	316.2°
Vent 5074 lava field	714B2	43.320°	246.218°	7/8	Pl	56.7°	353.1°	4.5°	161		82.0°	109.6°
Turnbull Butte lava field	786B2	43.266°	246.420°	6/8	30+	55.5°	324.6°	3.1°	482	5.98963	62.0°	153.6°
Big Blowout Butte lava field	770B2	43.295°	246.403°	7/8	Pl	21.2°	41.9°	2.2°	633		41.5°	5.3°
Vent 5237 lava field	794B2	43.273°	246.433°	6/8	30+	59.0°	112.8°	2.5°	711	5.99297	12.8°	293.1°
Bullshot Reservoir lava field	802B2	43.279°	246.456°	8/8	Pl	77.3°	162.7°	1.4°	1484		19.8°	253.9°
Blowout Reservoir lava field	810B2	43.291°	246.450°	8/8	Pl	76.8°	173.2°	2.8°	395		18.3°	249.5°
Bowl Crater lava field	826B2	43.270°	246.479°	8/8	Pl	82.2°	169.6°	2.5°	755		28.2°	249.6°

Table 3. Paleomagnetic data for the Craters of the Moon 30' x 60' quadrangle, Idaho.—Continued

Unit name	Site	Lat	Long(+)	N/No	Exp	I	D	∝95	k	R	Plat	Plong
NORTHWESTERN PART OF QUADRANGLE—Continued												
Vent 5136 lava field	754B2	43.268°	246.342°	6/8	20	53.1°	351.1°	6.1°	121	5.95851	78.1°	105.3°
Ant Butte lava field	762B2	43.259°	246.363°	8/8	Pl	57.2°	20.3°	4.4°	232		73.7°	349.0°
Corral Butte lava field	842B2	43.242°	246.381°	8/8	Pl	71.0°	354.8°	2.3°	513		77.3°	232.8°
Laidlaw Butte lava field	850B2	43.200°	246.380°	8/8	Pl	61.6°	344.0°	3.8°	182		78.3°	159.7°
Snowdrift Crater lava field	818B2	43.307°	246.447°	8/8	Pl	48.1°	10.0°	1.0°	3068		73.7°	33.7°
SOUTHWESTERN PART OF QUADRANGLE												
Broken Top Butte lava field	610B2	43.177°	246.148°	8/8	30	66.0°	7.1°	2.0°	768	7.99089	82.9°	287.5°
Sand Butte lava field	626B2	43.084°	246.181°	7/8	30+	66.2°	358.6°	1.5°	1664	6.99639	84.4°	236.9°
Spud Butte lava field	618B2	43.169°	246.173°	8/8	30	62.7°	0.4°	1.6°	1254	7.99442	89.0°	264.0°
West Wildhorse Butte	594B2	43.071°	246.257°	8/8	20	57.8°	20.1°	2.0°	807	7.99133	74.1°	346.5°
lava field.	*605B3	42.954°	246.251°	7/8	30+	62.4°	18.7°	2.3°	719	6.99166	76.4°	326.6°
Monument Butte lava field	602B2	43.160°	246.056°	7/8	Pl	54.5°	15.6°	1.3°	2106		75.5°	4.8°
The Blowout lava field	586B2	43.150°	246.221°	8/8	20	61.7°	11.5°	2.2°	640	7.98907	81.6°	334.6°
Wagon Butte lava field	730B2	43.236°	246.213°	8/8	20+	83.3°	101.3°	1.7°	1023	7.99316	39.3°	263.2°
Black Ridge Crater lava field	554B2	43.025°	246.044°	8/8	30+	63.0°	346.8°	2.4°	522	7.98658	80.4°	169.4°
Vent 4645 lava field	578B2	43.075°	246.329°	7/8	30	61.3°	355.7°	2.3°	709	6.99153	86.8°	146.3°
NORTHEASTERN PART OF QUADRANGLE												
Rock Corral Butte	4B991	43.334°	247.059°	10/12	40+	80.6°	2.3°	1.1°	2052	9.99561	61.7°	248.6°
lava field.	493B3	43.263°	246.908°	8/8	20	83.3°	15.5°	1.8°	923	7.99242	55.9°	253.2°
Vent 5494 lava field	4B979	43.377°	246.951°	12/12	40	54.7°	1.4°	1.7°	621	11.98228	81.8°	59.0°
Fingers Butte lava field	*378B2	43.429°	246.734°	8/8	20	48.6°	345.1°	1.9°	846	7.99172	71.7°	112.1°
Quaking Aspen Butte	*4B655	43.551°	246.985°	12/12	20+	63.6°	344.8°	1.1°	1493	11.99263	79.0°	170.9°
lava field.	386B2	43.410°	246.774°	7/8	20	64.1°	342.9°	0.8°	6248	6.99904	77.6°	173.7°
Serviceberrry Butte lava field	418B2	43.309°	246.800°	8/8	20	62.5°	14.1°	1.7°	1065	7.99343	79.8°	329.0°
Vent 5206 lava field	*4B583	43.507°	247.111°	12/12	30+	63.9°	12.6°	1.1°	1655	11.99335	80.8°	319.7°
Vent 5328 lava field	426B2	43.304°	246.848°	8/8	30+	59.0°	8.8°	1.5°	1388	7.99496	82.6°	2.2°
Cruthers Butte lava field	370B2	43.433°	246.701°	8/8	30	61.6°	329.7°	2.3°	599	7.98832	68.0°	165.4°
Pratt Butte lava field	410B2	43.319°	246.737°	8/8	Pl	56.2°	3.4°	3.6°	277		82.9°	44.0°
East Wildhorse Butte lava field.	354B2	43.471°	246.739°	8/8	20	66.2°	6.6°	1.4°	1558	7.99551	83.2°	286.6°
Huddles Hole lava field	362B2	43.458°	246.649°	8/8	20+	67.9°	3.2°	2.3°	600	7.98834	82.2°	261.8°
Sixmile Butte lava field	*4B955	43.522°	246.735°	9/12	30+	51.0°	347.6°	1.7°	895	8.99106	74.7°	110.4°
Vent 5575 lava field	394B2	43.426°	246.795°	8/8	Pl	50.7°	353.0°	1.3°	1731		76.8°	93.9°
Vent 5609 lava field	4B967	43.465°	246.760°	8/12	30+	51.4°	343.1°	2.3°	562	7.98754	72.5°	121.8°
Tin Cup Butte lava field	402B2	43.463°	246.801°	8/8	Pl	74.6°	66.2°	2.2°	560		48.1°	288.1°

Antelope Butte lava field	442B2	43.244°	246.874°	8/8	Pl	62.1°	4.3°	1.6°	1347		86.9°	333.3°
Vent 5221 lava field	434B2	43.250°	246.836°	8/8	Pl	59.8°	3.1°	1.7°	1170		86.5°	24.1°
SOUTHEASTERN PART OF QUADRANGLE												
Horse Butte lava field	530B2	43.028°	246.769°	8/8	40+	48.9°	4.7°	1.5°	1296	7.99460	76.2°	49.5°
	501B3	43.082°	246.762°	8/8	20	51.5°	2.0°	1.0°	2906	7.99759	79.0°	58.1°
Bear Trap lava tube	*533B3	42.993°	246.671°	8/8	30	48.2°	0.7°	1.2°	2187	7.99680	76.2°	64.1°
Vent 4946 lava field	514B2	43.099°	246.689°	8/8	30	60.3°	339.6°	1.9°	822	7.99148	75.8°	156.5°
Mule Butte lava field	522B2	43.081°	246.647°	8/8	20	60.2°	359.2°	1.4°	1647	7.99575	88.0°	83.4°
Split Top lava field	482B2	43.158°	246.956°	8/8	30	66.5°	351.7°	1.3°	1915	7.99634	81.8°	205.4°
Vent 5252 lava field	506B2	43.201°	246.775°	8/8	Pl	57.1°	358.1°	3.0°	303		84.3°	82.1°
Rock Lake lava field	498B2	43.098°	246.915°	8/8	20+	69.5°	16.8°	2.3°	566	7.98763	75.0°	288.8°
Vent 5317 lava field	490B2	43.119°	246.947°	8/8	30	63.2°	344.7°	1.0°	3401	7.99794	78.9°	170.6°
Vent 5365 lava field	546B2	43.050°	246.914°	8/8	20	65.4°	337.2°	1.4°	1534	7.99544	73.4°	180.4°
Mosby Butte lava field	538B2	43.055°	246.820°	8/8	Pl	40.2°	18.0°	2.2°	539		64.9°	24.6°
Vent 5358 lava field	458B2	43.240°	246.949°	8/8	30	61.4°	25.0°	2.0°	799	7.99124	71.7°	330.5°
Vent 5358 lava field	466B2	43.246°	246.946°	8/8	30	57.0°	27.4°	1.3°	1715	7.99592	68.5°	342.9°
Vent 5374 lava field	474B2	43.204°	246.925°	8/8	20	47.7°	19.9°	1.6°	1137	7.99384	68.5°	12.5°
Packsaddle Butte lava field	450B2	43.235°	246.924°	8/8	Pl	62.8°	11.6°	1.2°	4163		81.6°	326.3°

Nomenclature, Mapping and Petrographic Conventions, and Thickness of Lava Flows

Notes on Rock Names and Rock Colors in the Description of Map Units

Rock names (for example, basalt, hawaiite, latite) used for lava flows of the COM lava field are based on chemical compositions of flows (Kuntz and others, 1985). They follow the nomenclature of Cox and others (1979) and are based on the weight percentages of Na_2O, K_2O, and SiO_2. Because of the uniformity in chemical composition of pre-Holocene lava flows of the map area and elsewhere in the ESRP (Kuntz, Covington, and Schorr, 1992), the pre-Holocene flows of this map are all classified as olivine basalts. In the Description of Map Units, these flows are simply referred to as "basaltic lava flows."

Some of the flows in the COM lava field have unique colors. Most basalt and hawaiite pahoehoe flows have glassy crusts that are blue or olive green. Black, glassy crusts are typical of latite flows. Colors and numerical designation of hue, value, and chroma that are used to describe flows in the Description of Map Units are taken from the Rock Color Chart of the Geological Society of America (1975). Because the glassy crusts have been removed by erosion from flow surfaces of the pre-Holocene lava fields, they are typically dark or medium gray. No attempt was made to further quantify the color and they are simply referred to as "dark gray" or "medium gray."

Rocks in cinder cones and eruptive-fissure deposits are typically oxidized and intensely weathered. For this reason, they were not studied in thin section. Colors of cinder-cone and eruptive-fissure deposits are also highly variable and are described only in general terms.

Notes on Petrographic Descriptions in the Description of Map Units

Standard petrographic examination of thin sections was used to prepare the petrographic descriptions of lava flows in the Description of Map Units. For COM flows, the composition of olivine was determined by the curvature of the isogyre, and thus the compositions are only approximate. The composition of plagioclase was determined by measurement of extinction angles in crystals in which both (010) and (001) crystallographic planes were oriented vertically. Microprobe determinations of the composition of minerals in some flows of the COM lava field are given by Leeman and others (1976), Stout and Nicholls (1977), and Stout and others (1994).

The petrographic characteristics of olivine basalts of the ESRP are remarkably similar. Almost all rocks consist of olivine and plagioclase microphenocrysts that are 1–3 mm in longest dimension. Typically, the microphenocrysts are set in a matrix of olivine, plagioclase, intersertal clinopyroxene, opaque minerals, and, in some samples, intersertal glass. The largest crystals in the matrix are mostly <1 mm. Compositions of minerals in olivine basalts of the Snake River Plain were reviewed by Kuntz, Covington, and Schorr (1992). Briefly, olivine basalts typically contain olivine phenocrysts that are $Fo_{70–90}$; olivine crystals in the matrix that are $Fo_{55–70}$; plagioclase phenocrysts that are $An_{70–90}$; plagioclase crystals in the matrix that are $An_{30–50}$; a single clinopyroxene that is augite to ferroaugite; equant titanomagnetite; elongated to needle-like ilmenite; and various amounts of brown glass. Compositions of minerals in the pre-Holocene lava flows were not determined by optical methods.

The kinds of minerals are mostly constant in all samples, but their sizes and proportions vary and textures of the rocks are often unique. Therefore, these characteristics are described in some detail in the petrographic descriptions. Most flows are hypocrystalline, but some are holocrystalline. Glass that is free of inclusions of opaque minerals and (or) translucent minerals is extremely rare in Snake River Plain basalt flows. Typically, the glass contains small areas of pink and tan clinopyroxene and discrete microlites of opaque minerals that are mostly <0.2 mm in longest dimension. The glass is mainly intersertal in most samples and rarely does it line vesicle walls.

Common textures of basaltic lava flows are microporphyritic to porphyritic, cumulophyric, and diktytaxitic. Microporphyritic rocks contain olivine and plagioclase crystals <1 mm in a groundmass (matrix) consisting of crystals typically <0.5 mm. Porphyritic rocks contain crystals of olivine and plagioclase that are typically 1–4 mm in a groundmass containing crystals typically <0.5 mm. Many basalt flows have a cumulophyric (also termed glomerophyric) texture in which phenocrysts in the rock are clustered together in irregular groups, or clots, of two to as many as 30 crystals. The clots typically consist entirely of plagioclase crystals (termed "plagioclase + plagioclase" in the text); entirely of olivine crystals (termed olivine + olivine in the text); or plagioclase and olivine crystals (termed "olivine + plagioclase" in the text). In diktytaxitic rocks, open spaces separate the main minerals; the open spaces are mostly <1 mm. A distinctive texture observed in some flows, termed "starburst" texture, is a rare type of cumulophyric texture. It is clots of plagioclase + plagioclase or plagioclase + olivine crystals that radiate from a crystallization center. Another distinctive texture, "waist" texture, refers to plagioclase crystals that radiate upward and downward, but not to the side, of a central olivine crystal. Syntaxial bundles of plagioclase are clusters in which several plagioclase crystals adhere to one another along similar crystallographic surfaces, typically (010) surfaces.

General terms such as "stout," "intermediate," and "elongated" are used to describe the shape of plagioclase crystals. These terms refer to the length:width ratios of the crystals. For elongated crystals, the ratio is typically 10:1; for intermediate crystals, the ratio is typically 5:1; and for stout crystals, the ratio is typically 3:1.

The petrographic character of a lava flow or lava field is also a function of where the sample for the thin section was collected. Surface samples are typically fine grained and contain varying amounts of glass. Samples collected several centimeters to several meters beneath the flow surface are typically coarser grained and contain smaller amounts or lack glass. The reader is cautioned that the petrographic descriptions given for flows or lava fields are for a sample collected locally. The descriptions may not reflect crystal sizes, proportions, or textures that may be obtained for a sample of the same lava flow or lava field collected elsewhere.

Notes on Names and Unit Labels Given to Lava Fields and Lava Flows

Craters of the Moon Lava Field

The descriptive names for lava flows, all of which are informal, in the COM lava field (for example "Blue Dragon flow") in the Description of Map Units mostly follow terminology of Stearns (1928) and Murtaugh (1961). However, new informal names have been assigned to many flows (Kuntz, Champion, and others, 1986; Kuntz and others, 1988). The map unit symbols used for COM flows, as they appear in the Description of Map Units and on the map, consist of letters and numbers arranged in the following system: the first letter, "Q" or "T," refers to the age (Quaternary or Tertiary, respectively) of the unit. The second letter, "c," references flows of the Craters of the Moon lava field. The third letter refers to the type of deposit (f=flow, c=cinder deposits, e=eruptive fissure deposit). The fourth letter refers to the eruptive period ("a" for the youngest, through "h" for the oldest) to which the deposit belongs. The number suffix refers to the stratigraphic order of deposits assigned to an eruptive period (1 designates the youngest deposit, 2 designates the next youngest deposit, and so on), based on stratigraphic relations. Because radiocarbon ages are available for only a few of the COM flows, the numbers should not be inferred to imply absolute relative age relations of lava flows assigned to an eruptive period.

Pre-Holocene Lava Fields Surrounding and Within Kipukas of the Craters of the Moon Lava Field

The descriptive names for some lava fields on this map are taken from names of prominent vents and buttes near vents as they appear on U.S. Geological Survey 1:24,000-scale topographic map quadrangles that cover parts of this map. In the absence of named landmarks, spot elevations, mostly at high points at vents and or nearby buttes, are used to identify various basaltic lava fields. For example, Qsbb1 is the Vent 4895 lava field and Qsbc2 is the Vent 5074 lava field. The map unit symbols used for pre-Holocene lava fields, as they appear in the Description of Map Units and on the map, consist of letters and numbers arranged in the following system: "Q" or "T" refer to the age (Quaternary or Tertiary, respectively) of the unit. The second letter "s" refers to flows that are part of the Snake River Group. The third letter "b" refers to basalt. The fourth letter (for example, "b," "c," "d," and so on) refers to arbitrary divisions of Pleistocene and Pliocene time, as described in the subsequent section. The number suffix identifies lava fields in lava-field age units, based on stratigraphic data where available. However, because radiometric ages are available for only a few pre-Holocene lava fields, the numbers do not imply absolute relative age relations of lava fields.

Thickness of Lava Flows

In the area of this map, there is little if any erosion of lava flow; thus the thickness of lava flows cannot be determined by direct measurement. In addition, there are few logged wells or coreholes for the area of this map for which thickness of lava flows can be determined. For this reason, thickness of lava flows and lava fields are not given in the Description of Map Units. However, from the study of coreholes at the Idaho National Engineering and Environmental Laboratory, it has been determined that pahoehoe flows range from 10 to 39 m and average about 20 m thick (Champion and others, 2002). From analysis of topographic maps, it can be determined that lava flows may accumulate to thicknesses of as much as 200 m around a vent and on top of underlying lava flows. A'a flows are typically 15–30 m thick (Kuntz, Champion, and others, 1986).

Geologic Time Designations

Subdivisions of Holocene, Pleistocene, and Pliocene Time Used for Basaltic Lava Flows and Lava Fields of this Map

For purposes of this map, Holocene time is the period from the present to 10,000 ^{14}C yr or 11,680 calibrated or sidereal yr. Flows of the COM lava field having conventional radiocarbon ages from 15,100 ^{14}C yr B.P. to 12,010 ^{14}C yr B.P. (table 1) are late Pleistocene in age. These flows are included in the age class "predominantly Holocene" used elsewhere on this map. Lava fields having radiometric or stratigraphically assumed ages between 11,680 ^{14}C yr and 128,000 sidereal yr are designated as late Pleistocene in age; the first four letters of unit labels are "Qsbb." Lava fields having radiometric ages or stratigraphically assumed ages of 128,000–400,000 sidereal years are designated as late middle Pleistocene in age; the first four letters of unit labels are "Qsbc." Lava fields having radiometric ages or stratigraphically assumed ages of 400,000–780,000 sidereal yr are designated as early middle Pleistocene in age; the first four letters of unit labels are “Qsbd.” Lava fields having radiometric ages or stratigraphically assumed ages of 1.806–5.3 Ma are designated as Pliocene in age; the first four letters of unit labels are “Tsbf.”

Paleozoic and Tertiary Rocks of the Northwestern Part of the Map Area

Older rocks in the northwestern part of the map area range in age from Tertiary (Miocene) to Paleozoic (Ordovician). These rocks provide evidence that this part of Idaho was tectonically active since at least latest Devonian time. Paleozoic and Mesozoic compressional fold and thrust events include the Antler and Sevier orogenies. Compression was followed by major extension and faulting in Tertiary (Eocene through Miocene) time, accompanied by voluminous volcanism represented by the Challis Volcanic Group. Basin-and-Range faulting followed in Neogene time, and continues today.

During the Early Mississippian Antler orogeny, Ordovician through Devonian mudstone, siltstone, and chert deposited in an oceanic environment were thrust eastward over coeval shelf carbonate rocks. Both of these sequences are exposed in tilted, raised fault blocks in the Fish Creek Reservoir area. The western oceanic sequence is overlain unconformably by basinal marine sandy limestone and calcareous sandstone of the Pennsylvanian and Permian Wood River Formation. The coeval eastern carbonate shelf rocks are conformably overlain by clastic rocks of the Mississippian Copper Basin Group. Some of the detritus of the Copper Basin Group was derived from western emergent oceanic sequences. All of these Paleozoic rocks, and possibly some Mesozoic sedimentary rocks, were then folded and transported eastward on thrust plates and emplaced during the Late Cretaceous to Paleocene Sevier orogeny. The partly buried Sevier Pioneer thrust fault that trends north-northwest across the map area juxtaposes the two different Paleozoic sequences. The Pioneer fault probably has some later normal movement, down to the west.

Following Sevier compression, the area has been characterized by extension and volcanism. Middle Eocene (49–47 Ma) intermediate extrusive rocks of the Challis Volcanic Group are widespread. In places, the extrusive rocks are intruded by roughly coeval stocks and dikes. The Challis rocks were then faulted and partly eroded prior to eruption of the Miocene (12–8 Ma) rhyolitic ash-flow tuffs of the Idavada volcanic field. The ash-flow tuffs dip gently southward (15°–25°) toward the Snake River Plain and record the passing of the Yellowstone hotspot (Pierce and Morgan, 1992) and the downwarp of the Snake River Plain. Early Pliocene (4.2–3.5 Ma) intracanyon basalt flows along the Little Wood River near the northwest margin of the Snake River Plain presumably had sources on the plain, but they have been subsequently tilted gently (<5°) toward the Snake River Plain. This indicates that downwarping of the plain has continued through late Neogene and Quaternary time. Basin-and-Range north-northwest trending normal faults cut all of the rock units discussed above. Offsets on the Basin-and-Range faults in the area of this map are much less than offsets on the Basin-and-Range faults in east-central Idaho.

DESCRIPTION OF MAP UNITS

UNCONSOLIDATED SURFICIAL DEPOSITS

Ql **Lacustrine deposits (Holocene)**—Silt, clay, and minor sand and gravel. Well sorted. Thin, parallel beds. Present in former sites of two drained reservoirs in northwest corner of quadrangle. Thickness generally <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; 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; parallel bedding and large- and small-scale crossbedding common. Overlies pebble and cobble gravel. Includes fan alluvium and colluvium (Qfac) along valley margins. Low areas subject to periodic flooding, high water tables; 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 early middle Pleistocene)**—Pebble to boulder gravel; matrix commonly silty sand to silty clay. Nonsorted to poorly sorted; nonbedded to crudely bedded. Clasts generally angular to subangular. Includes largely intact slide blocks of bedrock. Includes avalanche, slump, earthflow, debris flow, and mudflow deposits of local derivation. Commonly overlies bedrock volcanic units. Characterized by hummocky undrained topography. Subject to major slow mass movement and small landslides. Unit description largely from Scott (1982)

Qfac **Fan deposits of alluvium and colluvium (Holocene to early middle Pleistocene)**—Pebble to boulder gravel. Matrix is silty sand to clayey silt; poorly sorted. Nonbedded to crudely bedded. Locally derived clasts are mostly angular to subrounded. Forms fans at mouths of drainage basins that have areas generally smaller than 2–6 km^2. Unit description largely from Scott (1982)

Qp **Playa deposits (Holocene to 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 to early Pleistocene)**—Variably textured colluvium derived from nearby bedrock. Includes (1) nonbedded to crudely bedded, coarse, angular to subrounded, gravel-size clasts and variable amounts of fine-grained matrix 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 and variable amounts of fine-grained matrix. Nonbedded to crudely bedded. Present as nonsorted talus and slump deposits in gentle terrain on volcanic and intrusive rocks. Includes some rubbly colluvium along canyon walls. Unit description modified from Scott (1982). Thickness generally 1–3 m, but >10 m at base of slopes and in colluvial cones and fans

Qmp **Deposits along main streams of Pinedale age (late Pleistocene)**—Pebble and cobble gravel to pebbly sand. Poor to moderate sorting. Clasts subrounded to rounded. 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. Commonly gravelly where <1 m thick. Includes fan deposits at mouths of major basins. Upper part of deposits is of Pinedale age, based on degree of soil development and relation to outwash of Pinedale age. Unit description modified from Scott (1982). Thickness of fills, including buried older main-stream deposits and thin deposits of modern flood plains, ranges from a few meters to several tens of meters

Qafy **Younger fan alluvium (late Pleistocene)**—Pebble to cobble gravel, locally bouldery near fan heads. Contains variable amounts of sand to silty sand as matrix. Lenses of sand and silty sand. Common on distal parts of fans. Poorly to moderately sorted.

Subangular to rounded clasts, chiefly of detritus derived from Copper Basin Group (Mississippian). Parallel bedding, large-scale crossbedding, and, locally, crude bedding in medium to thick beds. Stones have discontinuous to continuous calcium carbonate coats on bottoms. Includes aprons of rhyolite debris on steep basal slopes of Big Southern Butte. Local areas near active stream channels are subject to flash flooding, flooding from rapid snowmelt, and debris-flow and mudflow activity. Degree of soil development and relation to moraines and outwash indicate unit is of Pinedale age. Thickness in fans ranges from a few meters to several hundred meters

Qt **Travertine (Pleistocene)**—Pale-orange to white, dense algal limestone. Forms small ledge 1 m high about 1.5 km northeast of Carey Lake. No evidence of Holocene hot-spring activity

Qafo **Older fan alluvium (late middle Pleistocene to early Pleistocene(?))**—Pebble to cobble gravel; locally bouldery near fan heads. Matrix contains variable amounts of sand to silty sand; some lenses of sand and silty sand. Poor to moderate sorting. Subangular to rounded clasts composed of a large component of Copper Basin Group detritus and minor amounts of felsic to basic volcanic rock fragments. Size of clasts in gravel generally diminishes southward 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. Gravel locally crudely bedded; beds medium to thick. Forms dissected, high-level, east-trending ridges, minor upland basin fill, and isolated remnants in northwest corner of quadrangle. 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 fan remnants along and above South Fork of Muldoon Creek. Differentiated from younger fan alluvium (Qafy) by topographically higher position, better developed surface soil, and 2- to 10-mm-thick caliche coats on clasts. Includes pediment gravel. Unit description modified from Scott (1982). Topographic position indicates a Bull Lake age for most of unit, but pediment gravel may be early Pleistocene. Unit as thick as 100 m

QTf **Older fan gravel (Pleistocene and Pliocene)**—Fan-shaped deposit at altitude of 6,700–7,100 ft on north flank of Pine Mountain. Consists of large, subrounded to angular boulders and cobbles of Copper Basin Group and Idavada Volcanics. Overlies ash-flow tuffs of Idavada Volcanics. Thickness 1–2 m

HOLOCENE AND LATE PLEISTOCENE BASALTIC LAVA FLOWS AND RELATED CINDER CONE AND ERUPTIVE-FISSURE DEPOSITS OF THE SNAKE RIVER GROUP

Craters of the Moon lava field

Eruptive-period A

Qcfa1 **Broken Top pahoehoe basalt flow (Holocene)**—Surface- and tube-fed pahoehoe basalt flow from obscure vents on east and southeast sides of Broken Top cinder cone (Qcca1). Glassy surfaces of flow are highly vesiculated and 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 was eroded and transported from higher parts of Broken Top cinder cone. Flows are hummocky, rough surfaced, and cut by widely spaced joints. A lighter tone on aerial photographs and a greater abundance of grass and low bushes distinguish the Broken Top flow from the older, underlying Blue Dragon flow (Qcfa2). Unit includes slabs of lava, as thick 10 m, on 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 acicular, feathery ilmenite

Qcca1 **Broken Top basaltic cinder cone deposits (Holocene)**—Black to brown lapilli and coarse ash. West flank of cone is mantled by agglutinated spatter from younger eruptive fissures on west side of cone. Slabs of basalt lava of the Broken Top flow (Qcfa1), as thick as 10 m, are on 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 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 slab-pahoehoe basalt-hawaiite flows characterized by fresh, iridescent, dark- to light-blue (5PB3/2-5B7/6), glassy, vesicular crusts. Interiors of flows are medium dark gray (N4) and more massive. 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 overlie the Trench Mortar Flat flows (Qcfa3) and the Big Craters flows (Qcfa5), but are probably only a few tens of years younger in age on the basis of paleomagnetic studies. The most 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 samples of charcoal from tree molds and carbon-bearing material from sediment buried by unit is 2,076±45 ^{14}C yr (table 1). Carbon-bearing material from sediment buried by the Blue Dragon flow yielded a radiocarbon age of 2,030±80 ^{14}C yr. (table 1). 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}) crystals are slender and stout laths <0.2 mm; clinopyroxene is poorly formed, slender needles or granules. Opaque minerals are equant, partly skeletal crystals of magnetite as large as 0.25 mm, granules of magnetite (<0.02 mm) in matrix, and aggregates of feathery ilmenite(?) crystals

Qcca2 **Big Craters basaltic cinder cone deposits (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, and coarse ash. Big Craters cone complex 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 south flank of cone complex were sources for some of the older Blue Dragon flows (Qcfa2). Fissures (Qcea3) on north flank of cone complex 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 complex (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 slab-pahoehoe 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 erupted from several parts of the Trench Mortar Flat set of eruptive fissures (Qcea2) between Big Cinder Butte (Qccc1) and The Watchman (Qcca3) cinder cones. Pahoehoe flows that traveled more than about 1 km from source vents fragmented into slab pahoehoe flows. For example, slab-pahoehoe flow east of The Watchman cinder cone flowed from eruptive fissures on northwest and southeast flanks of The Watchman cinder cone. Flows of unit lie on and flowed around cinder cones that are adjacent to eruptive fissures. Average radiocarbon age of nine samples of charcoal from tree molds in unit is 2,205±25 yr (table 1). Rock is typically fine grained and holocrystalline to hypocrystalline. Contains microphenocrysts of olivine, plagioclase, and equant magnetite as large as 1 mm. Microphenocrysts are set in a pilotaxitic to trachytic matrix of these minerals and in patches of subophitic spindles of clinopyroxene that are ≤0.25 mm. Rock also contains opaque-charged, brown glass

Qcca3 **The Watchman cinder cone deposits (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). Spatter ramparts flank fissure vents. Includes cinder mounds 0.5–2.0 km east of Coyote Butte. Cone is 95 m high and about 0.8 km in diameter

Qcea2 **Trench Mortar Flat basaltic eruptive-fissure deposits (Holocene)**—Deposits from eruptive fissures in Trench Mortar Flat between 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 high as 10 m high and as wide as 100 m 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 margins of Big Craters flow (Qcfa5). Flow has iridescent, light- to dark-blue (5PB3/2–5B7/6), 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), and hypocrystalline. It contains a few microphenocrysts of olivine, equant magnetite, and rare plagioclase, all ≤0.5 mm. Olivine (about $Fa_{50–60}$) crystals are typically euhedral and partly skeletal; plagioclase crystals ($An_{35–50}$) are small (<0.10 mm); clinopyroxene crystals are small (≤0.05 mm), intergranular blades, spindles, and granules. Magnetite crystals in matrix are ≤0.01 mm, and brown glass is charged with small crystals of equant magnetite

Qcca4 **North Crater basaltic cinder cone deposits (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 interpreted 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 and 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 slab-pahoehoe hawaiite flows (Holocene)**—Mainly surface- and fountain-fed pahoehoe hawaiite flows that extend east, west, and southwest from an eruptive fissure (Qcea3) and cinder cone vents at north end of Big Craters cinder cone (Qcca2). Unit includes slab-pahoehoe flows near vent. Flows are characterized by dark-greenish-gray (5GY4/1) glassy crusts and elongated, stretched vesicles. Rock is more dense and medium dark gray (N4) in interior. Flows are overlain by Blue Dragon (Qcfa2) and North Crater (Qcfa4) flows, but overlie Serrate (Qcfa8), Devils Orchard (Qcfa9), and Highway (Qcfa10) flows. Rock is fine grained (mostly ≤0.10 mm), hypocrystalline, and partly diktytaxitic. Rock contains a few microphenocrysts of olivine, magnetite, and rare plagioclase. Olivine (about $Fa_{50–70}$) crystals as large as 1 mm are typically skeletal and euhedral. They contain glass and opaque inclusions. Olivine granules in the matrix are typically ≤0.05 mm. Plagioclase ($An_{40–50}$) crystals are mainly stubby to elongated laths (≤0.2 mm) in the matrix. Clinopyroxene crystals in matrix are present as granules, blades, and subophitic spindles ≤0.05 mm. Glass is brown and charged with granules of opaque minerals. Opaque minerals are present as larger, skeletal, equant crystals of magnetite and as equant ≤0.02 mm granules of magnetite in the matrix. Radiocarbon age of flows is 2,400±300 ^{14}C yr (table 1)

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 northwestern 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 8 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, Qcca4) that were rafted on surface of 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 edges of 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. It 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, of anorthoclase, plagioclase ($An_{35–55}$), green clinopyroxene, equant magnetite, rare olivine (about $Fa_{75–90}$), and rare zircon. Matrix of rock is plagioclase ($An_{10–40}$) laths; spindles and subophitic blades and needles of 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 (≤1 m) 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; xenocrysts of anorthoclase, plagioclase, and green clinopyroxene 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, of anorthoclase, plagioclase (about $An_{20–40}$), green clinopyroxene, equant magnetite, and rare zircon. Matrix of rock is 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 flow (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). A source vent near north end of flow cannot be ruled out. 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 (Qcca4). Thin (≤2 m), black, glassy-surfaced, pahoehoe trachyandesite flow in area of the campground at Craters of the Moon National Monument is included in 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) and hypocrystalline. It commonly contains xenocrysts of corroded anorthoclase; rounded, green clinopyroxene; magnetite; and rare zircon, all 0.5–2.0 mm in longest dimension. Matrix of 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

Qcca5 **Cinder mound deposits (Holocene)**—Irregular-shaped, low mounds, less than 8 m high and less than 100 m in diameter. Origin of deposit unknown; possibly related to eruptions during collapse of North Crater cinder cone (Qcca4)

Eruptive-period B

Qcfb1 **Vermillion Chasm pahoehoe basalt flows 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); both units were probably emplaced during the same episode of fissure eruptions. Unit is cut by non-eruptive fissures in the area between Devils Caldron and Vermillion Chasm. Rock is microporphyritic and hypocrystalline. It 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. Phenocrysts are set in a fine-grained (≤0.05 mm) matrix of olivine, plagioclase, intergranular clinopyroxene, magnetite, and clear glass

Qceb1 **Vermillion Chasm basaltic eruptive-fissure deposits (Holocene)**—Eruptive 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 wide as 10 m and 10 m deep. Fissures were source vents for Vermillion Chasm flow (Qcfb1)

Qcfb2 **Deadhorse pahoehoe basalt flows (Holocene)**—Chiefly fountain-fed, shelly, thin (≤2 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 includes deposits of partly agglutinated, red, brown, and black cinders and ash that form low ramparts on flanks of eruptive fissures. 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. Matrix is intergranular and consists of plagioclase, olivine, clinopyroxene(?), magnetite, and clear glass. Age of unit, on the basis of a single radiocarbon analysis of untreated carbon-bearing material from sediment buried by flow, is 4,300±60 ^{14}C yr (table 1). That age is too old on the basis of stratigraphic relations with the Devils Caldron flow (Qcfb3)

Qceb2 **Deadhorse basaltic eruptive-fissure deposits (Holocene)**—Left-stepping, en-echelon eruptive fissures and related open cracks. Fissure system is about 11 km long and extends from southeast margin of Vermillion Chasm flow (Qcfb1), through Black Top Butte cinder cone (Qccb1), to the southeast margin of the COM lava field. Fissures are flanked by low (≤3 m) spatter ramparts. Fissures were source vents for Deadhorse flows (Qcfb2)

Qcfb3 **Devils Caldron 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 Caldron) that contains two lava-filled craters. Flows are hummocky and have prominent ridges and depressions. Unit is cut by non-eruptive fissures in an area 1–2 km northeast of Devils Caldron. Rock is medium grained; crystals are partly skeletal olivine (about $Fa_{50–70}$), needles and laths of plagioclase ($An_{40–50}$), and skeletal magnetite, all 0.1–0.4 mm in longest dimension. Smaller (≤0.1 mm) crystals of olivine, plagioclase, magnetite, 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. 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 ^{14}C yr (table 1)

Qcfb4 **Minidoka pahoehoe basalt flows (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 non-eruptive 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. Rock is hypocrystalline and contains microphenocrysts of olivine (about Fa_{50}), plagioclase (about An_{40}), and magnetite, all as large as 0.4 mm. The larger crystals are set in a fine-grained (≤0.05 mm) matrix of olivine, plagioclase, clinopyroxene, magnetite, and brown glass. 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 ^{14}C yr

Qcfb5 **Larkspur Park pahoehoe hawaiite flows (Holocene)**—Surface- and tube(?)-fed, medium-dark-gray (N4), pahoehoe hawaiite flow having a hummocky, billowy surface. Field relations, petrographic similarities, and paleomagnetic data indicate that unit may be an early 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. Larger crystals are set in a matrix of plagioclase, olivine, clinopyroxene spindles, and magnetite, 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 southern and eastern margins of Devils Caldron (Qcfb3) flows and margins of Minidoka (Qcfb4) flows. Flows are cut by non-eruptive fissures about 5 km south-southeast and about 5 km east-southeast of New Butte. Source vent is uncertain; flow directions indicate a source at or near Black Top Butte cinder cone (Qccb1). Rock is fine grained and hypocrystalline. Euhedral to subhedral crystals of olivine (about Fa_{50-70}), plagioclase (An_{35-50}), and magnetite, all 0.1–0.6 mm in longest dimension, are set in a matrix of olivine, plagioclase, clinopyroxene, and magnetite, all 0.05–0.10 mm, and opaque-charged, brown glass. 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 ^{14}C yr (table 1)

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

Qccb1 **Black Top Butte basaltic cinder cone deposits (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, and ash. Cone complex 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 Butte flow (Qcfb7)

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 many 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 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 indicate a source vent at or near northwest side of Big Cinder Butte cinder cone (Qccc1). Rock is fine grained and hypocrystalline. It 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 equant magnetite, 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 many lobes having steep fronts, flow ridges that are perpendicular to and convex toward the direction of flow movement, and also longitudinal furrows and cracks that are roughly parallel to the direction of flow movement. Flow contains rafted blocks of bedded cinders as much as 100 m in width and length and as high as 15 m. 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 indicate a source at or near Big Cinder Butte cinder cone (Qccc1). Unit is petrographically similar to Indian Wells North a'a flow (Qcfc1)

Qcfc3 **Sawtooth a'a latite flows (Holocene)**—Surface-fed, long (21 km), steep-sided, brownish-gray (5YR4/1) to medium-dark-gray (N4), a'a latite flows that contain many 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 the flow direction in proximal and distal parts of flow. Tephra as thick as 2 m mantles proximal parts. Flow contains rafted blocks of bedded cinders as much as 100 m in width and length and as high as 15 m, 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). Rock is fine grained, hypocrystalline, and partly diktytaxitic. It has microphenocrysts of skeletal olivine (about $Fa_{60–80}$) and euhedral plagioclase (about $An_{30–40}$) as large as 0.5 mm in longest dimension. Rock contains scattered xenocrysts and xenolithic clots of anorthoclase, plagioclase, green clinopyroxene, and equant magnetite as large as 2 mm. Microphenocrysts, xenocrysts, and xenoliths are set in a matrix of slender plagioclase laths, olivine granules, subophitic clinopyroxene, and equant magnetite, all <0.10 mm in longest dimension, and brown glass. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 6,020±160 ^{14}C yr (table 1)

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 is largely covered by cinders and lapilli in its proximal parts. Distal parts of flow are covered by Blue Dragon flow (Qcfa2). Age relations with Sawtooth flow (Qcfc3) are unknown; units are interpreted to be roughly coeval because both erupted from Big Cinder Butte (Qccc1). Rock is hypocrystalline and partly diktytaxitic, having microphenocrysts of olivine (about $Fa_{60–75}$) as much as 0.5 mm in longest dimension. Contains xenocrysts of anorthoclase and plagioclase as long as 1 mm. Also contains xenoliths as large as 2 mm in maximum dimension of clear clinopyroxene, equant magnetite, plagioclase, anorthoclase, and zircon. Matrix of rock is identical to matrix of Sawtooth a'a flow (Qcfc3)

Qccc1 **Big Cinder Butte basaltic cinder cone deposits (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) stated, “Big Cinder Butte ranks among the largest, purely basaltic cinder cones in the world.” East and southeast flank of cone are cut by aligned, 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 (Qcc). Rock ranges from glassy to hypocrystalline. In typical samples, microphenocrysts of skeletal olivine (about $Fa_{40–50}$) and plagioclase (about An_{40}) are set in a microcrystalline matrix of magnetite and ilmenite, brown to orange glass, small plagioclase laths, and rare needles and blades of clinopyroxene

Qcec1 **South Echo basaltic eruptive-fissure deposits (Holocene)**—Eruptive fissures 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 flows (Holocene)**—Channel- and tube-fed, dark-gray (N3), pahoehoe and a'a basalt flows that extend as far 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. Rock in an 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 skeletal, equant magnetite. 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 deposits (Holocene)**—Black, brown, and red cinders, lapilli, and coarse ash. Cone complex 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 flows (Holocene)**—Surface- and fountain-fed, dark-gray (N3), pahoehoe and a'a basalt flows erupted from a crater at Fissure Butte cinder cone (Qccc3) and from an eruptive fissure (Qcec2) northwest of Fissure Butte. Flows are largely mantled by lapilli and ash. Rock is medium to fine grained and holocrystalline. It contains microphenocrysts of olivine ($Fa_{40–50}$) and rare plagioclase (about An_{40}) as large as 0.6 mm. Microphenocrysts are set in an intergranular matrix of olivine, plagioclase, equant magnetite, and rare clinopyroxene, all ≤0.2 mm in longest dimension

Qccc3 **Fissure Butte basaltic cinder cone deposits (Holocene)**—Black, brown, and red cinders, lapilli, and coarse ash. Cone is elongate to east; northern parts of cone join with spatter ramparts 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 predominantly 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 skeletal, equant magnetite. Large crystals are set in a finer (0.05–0.2 mm) matrix of same minerals, plus clinopyroxene and small amounts of opaque-charged, brown glass

Qccc4 **The Sentinel basaltic cinder cone deposits (Holocene)**—Black, brown, and red cinders, lapilli, and coarse ash. Cone complex 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 source vent for The Sentinel flows (Qcfc8)

Eruptive-period D

Qcfd1 **Silent Cone latite a'a flow (Holocene)**—Surface-fed, medium-dark-gray (N4), latite a'a flow having bulbous lobes. Flow fronts as high as 30 m. Lobes contain flow ridges oriented perpendicular to and convex toward the direction of flow movement, and also longitudinal furrows and cracks that are roughly parallel to the 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 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 skeletal, equant magnetite that are all typically 0.2–0.8 mm in longest dimension. Largest crystals are set in a matrix of small (≤0.05 mm) crystals of plagioclase, olivine, trellis-like clinopyroxene, and opaque-charged, brown glass. Rock contains rare xenocrysts of anorthoclase

Qccd1 **Silent Cone basaltic cinder cone deposits (Holocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, coarse ash, and interlayered, thin lava flows. Cone complex 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 hawaiite a'a flow (Holocene)**—Surface-fed, medium-dark-gray (N4), hawaiite a'a 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 also longitudinal furrows and cracks that are roughly parallel to the direction of flow movement. Only distal parts of flow are exposed; proximal parts are covered by Blue Dragon flow (Qcfa2). Source vent may be Silent Cone cinder cone (Qccd1). Rock is hypocrystalline and fine grained. It 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; skeletal, equant magnetite; and clinopyroxene, all ≤0.02 mm; and opaque-charged, brown glass. 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 ^{14}C yr (table 1)

Qcfd3 **Little Park hawaiite a'a flows (Holocene)**—Surface-fed, medium-dark-gray (N4), blocky, hawaiite a'a flows having lobes and steep, bulbous flow fronts as high as 10 m. Lobes are characterized 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 the direction of flow movement. Flows contains rafted blocks of bedded cinders as much as 100 m in longest dimension and as high as 30 m. Only distal parts of flows are exposed; proximal parts are covered by younger flows. Source vent may be Silent Cone cinder cone (Qccd1). Rock is hypocrystalline and contains microphenocrysts of euhedral, partly skeletal olivine (about Fa_{60}) as long as 0.6 mm. Microphenocrysts are set in an intergranular matrix of plagioclase (about An_{40}); granules of olivine and clinopyroxene; and equant, partly skeletal magnetite, all less than 0.2 mm; and brown glass. Age of flows, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by the flow, is 6,500±60 ^{14}C yr (table 1)

Qcfd4 **Little Laidlaw Park hawaiite a'a flow (Holocene)**—Surface-fed, medium-dark gray (N4), blocky hawaiite a'a flow having lobes and steep, bulbous flow fronts as high as 10 m. Lobes are characterized by prominent 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 as much as 100 m in longest dimension and as much as 30 m high. Source vent may be Silent Cone cinder cone (Qccd1). Rock is fine grained, hypocrystalline, and partly diktytaxitic. It contains microphenocrysts of skeletal, euhedral olivine (about Fa_{50-60}) as large as 0.4 mm. 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, are present in brown glass. Rock contains rare xenocrysts and xenoliths of rounded, corroded anorthoclase as large as 2 mm

Eruptive-period E

Qcfe1 **Grassy pahoehoe and collapse-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 also longitudinal furrows and cracks that are roughly parallel to the 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 source vent at Grassy Cone cinder cone (Qcce1). Pressure ridges, pressure plateaus, tumuli, and collapse depressions are common morphologic features of this flow, and they indicate a high-volume, short-duration eruption. Rock is holocrystalline to hypocrystalline and partly diktytaxitic. Porphyritic varieties contain phenocrysts of euhedral olivine (about Fa_{50}); plagioclase (about An_{50}); and skeletal, equant magnetite; all as large as 1 mm. Phenocrysts are set in an intergranular to subophitic matrix of same minerals plus clinopyroxene, feathery ilmenite, and brown glass. Clear to brown apatite crystals as long as 1 mm are a common accessory mineral. Age of unit, on the basis of a single radiocarbon analysis of pretreated carbon-bearing material from sediment buried by flow, is 7,360±60 ^{14}C yr (table 1)

Qcce1 **Grassy Cone basaltic cinder cone deposits (Holocene to latest Pleistocene)**—Black, brown, and red cinders, agglutinated spatter, lapilli, coarse ash, and interlayered, thin lava flows. Cone complex 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 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 (Qcce1). Pahoehoe is hummocky and has pressure plateaus, collapse depressions, and flow ridges. Rock is hypocrystalline, partly diktytaxitic, and nonporphyritic. Crystals of euhedral olivine (about Fa_{50}), plagioclase (about An_{50}), intergranular to subophitic clinopyroxene, and equant magnetite are 0.05–0.6 mm in longest dimension. Feathery to bladed ilmenite and equant magnetite are present in cloudy, brown glass. Brown apatite crystals as long as 0.2 mm are a common accessory mineral. 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 ^{14}C yr (table 1)

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 characterized 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. Flows north, west, and south of Purple Butte are correlated with flows of main lobe at Lava Point on the basis of similarities in field, petrographic, and paleomagnetic characteristics. Flow in 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. Rock is fine grained and hypocrystalline. It contains sparse 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; equant magnetite; and feathery, subophitic clinopyroxene; all <0.2 mm in longest dimension. Feathery to bladed ilmenite and equant magnetite are present in brown glass. 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 ^{14}C yr (table 1)

Eruptive-period F

Qcff1 **Pronghorn pahoehoe and a'a basalt flows (late Pleistocene)**—Surface- and tube(?)-fed, medium-dark-gray (N4), pahoehoe basalt flows. Flows contain areas of a'a-like lava that consists of broken plates of pahoehoe where flows collapsed or moved over steep slopes. Rock is 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. Rock is hypocrystalline, partly diktytaxitic, and contains scattered phenocrysts of euhedral, partly skeletal olivine (about Fa_{50}) as large as 0.8 mm. Phenocrysts are set in a matrix of crystals that are all ≤0.3 mm. Crystals in matrix are granular olivine; plagioclase ($An_{40–50}$) laths; blades of clinopyroxene and subophitic clinopyroxene, both intergrown with feathery ilmenite; equant magnetite; and opaque-charged, brown glass. 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 ^{14}C yr (table 1)

Qcff2 **Heifer Reservoir pahoehoe basalt flows (late Pleistocene)**—Surface- and tube(?)-fed, medium-dark-gray (N4), pahoehoe basalt flows. Flows in exposures south of Huddles Hole are correlated with flows in 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. Rock is hypocrystalline, nonporphyritic, and medium grained. It consists of euhedral olivine (about Fa_{50}), tabular to lath-like plagioclase ($An_{40–50}$), equant magnetite, and intergranular to subophitic blades of clinopyroxene intergrown with a feathery to needle-like opaque mineral (ilmenite?). Opaque-charged, brown glass is also present. Flows covered by thin (<5 cm), discontinuous deposits of eolian sand near edges. 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 ^{14}C yr (table 1)

Qcff3 **Bottleneck Lake pahoehoe and a'a basalt flows (late Pleistocene)**—Chiefly surface- and tube(?)-fed, medium-dark gray (N4) ,pahoehoe basalt flows. Flows contain areas of a'a-like lava that consists of broken plates of pahoehoe where flows collapsed or moved over steep slopes. Unit is 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. Rock is hypocrystalline and diktytaxitic. It contains rare phenocrysts of euhedral olivine (about Fa_{50}) as much as 0.8 mm in longest dimension, and equant magnetite. Phenocrysts are set in an intergranular matrix of plagioclase ($An_{40–50}$) laths, olivine granules, subophitic clinopyroxene that is interlayered with feathery ilmenite, and brown, opaque-charged glass. All minerals in matrix are <0.3 mm. The oldest of four radiocarbon ages on both pretreated and untreated samples of carbon-bearing material from sediment buried by flow is 11,000±100 ^{14}C yr (table 1)

Eruptive-period G

Qcfg1 **Sunset pahoehoe and slab-pahoehoe basalt-hawaiite flows (late 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 main part of unit on the basis of similarity in paleomagnetic data. Slab pahoehoe is present where pahoehoe flows collapsed or moved over steep slopes. Pressure ridges, pressure plateaus, and collapse depressions, common morphologic features on the surface of these flows, indicate high-volume, short-duration eruptions. Rock is hypocrystalline and porphyritic. It contains microphenocrysts of euhedral olivine (about $Fa_{40–50}$); plagioclase ($An_{40–50}$) laths; and equant, skeletal magnetite, all 0.2–0.8 mm in longest dimension. Microphenocrysts are set in an intergranular matrix of same minerals plus blades and patches of spindly clinopyroxene, and opaque-charged, brown glass. Age of unit, on the basis of a single radiocarbon analysis of charcoal excavated from beneath the flow, is 12,010±150 ^{14}C yr (table 1)

Qcfg2 **Carey pahoehoe and slab-pahoehoe basalt-hawaiite flows (late Pleistocene)**—Chiefly surface- and tube(?)-fed, hummocky, medium-dark-gray (N4) pahoehoe basalt-hawaiite flows. Flows contain conspicuous ridges, plateaus, collapse pits, and depressions of various sizes, which are characteristic of high-volume, short-duration eruptions. Flows in 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 interpreted 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 interpreted 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 equant, skeletal magnetite are as large as 0.8 mm. Phenocrysts are set in a matrix of same minerals plus feathery, bladed ilmenite, blades and patches of spindly, subophitic clinopyroxene, and granules of equant magnetite, all 0.05–0.2 mm, and opaque-charged, brown glass

Qccg1 **Sunset Cone basaltic cinder cone deposits (late 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 complex are mantled by fine tephra. Cone complex is 140 m high and 1.5 km in diameter. Cone complex is the known source vent for Sunset flow (Qcfg1) and the probable source vent for 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

Eruptive-period H

Qcfh1 **Kimama pahoehoe basalt flow (late Pleistocene)**—Surface-fed, medium-dark-gray (N4), hummocky, pahoehoe basalt flow. Only distal part of flow is exposed. Source vent is unknown. Rock is hypocrystalline, diktytaxitic, and microporphyritic. Microphenocrysts are rare euhedral crystals of olivine (about Fa_{45}) and equant, skeletal magnetite as long as 1 mm. Microphenocrysts are set in a matrix of plagioclase ($An_{45–55}$) laths, olivine granules, blades of clinopyroxene, and equant magnetite, all <0.2 mm, and brown glass charged with feathery to bladed ilmenite and equant magnetite. Flow is covered by thin, discontinuous mantle of loess and eolian sand. The older of two radiocarbon ages from pretreated samples of carbon-bearing material from sediment buried by flow, is 15,100±160 ^{14}C yr

Qcfh2 **Bear Den Lake pahoehoe basalt flows (late Pleistocene)**—Surface-fed, medium-dark-gray (N4), pahoehoe basalt flows. Flows are present in two main exposures and in nearby isolated exposures that are surrounded by younger flows. All exposures are correlated on the basis of 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, equant magnetite, and laths of plagioclase ($An_{45–55}$), each as long as 1 mm. Phenocrysts are set in a matrix of same minerals plus ophitic, light-brown clinopyroxene, blades and bundles of subophitic clinopyroxene, equant magnetite, all <0.2 mm, plus opaque-charged, brown glass. A thin, discontinuous mantle of loess and eolian sand covers flows

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

Qcfh4 **Little Prairie pahoehoe and a'a basalt flows (late Pleistocene)**—Surface- and tube-fed, medium-dark-gray (N4), pahoehoe basalt flows. Low shrubs and grass cover flows. Eastern and southern margins 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, equant magnetite, and acicular to bladed ilmenite, all <0.4 mm, and opaque-charged, brown glass. Unit is mantled by a thin blanket of tephra on its western margin and by fine tephra and loess on eastern margin

Qcfh5 **No Name pahoehoe basalt flow (late Pleistocene)**—Surface- and tube-fed, medium-dark-gray (N4), pahoehoe basalt flow. Unit is possibly correlative with Little Prairie flows (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. A thin, discontinuous mantle of loess and eolian sand covers flow

Qcfh6 **Lost Kipuka pahoehoe basalt flow (late Pleistocene)**—Surface-fed, medium-dark-gray (N4), pahoehoe basalt flow. Unit is possibly correlative with Little Prairie flows (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. It consists of euhedral, mostly equant crystals of olivine (about Fa_{50}); plagioclase (about An_{40}) laths; blades and subophitic patches of clinopyroxene; acicular to feathery ilmenite; and equant, partly skeletal magnetite; all <0.4 mm; and opaque-charged, brown glass. Low shrubs and grass and a thin discontinuous mantle of loess and eolian sand cover flow

Qcfh7 **Crescent Butte pahoehoe basalt flow (late 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

Qcch1 **Crescent Butte basaltic cinder cone deposits (late 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 Crescent Butte flow (Qcfh7)

Qcfh8 **Brown pahoehoe basalt flow (late 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 non-eruptive fissures

Qcc **Basaltic cinder cones, undivided (Holocene and late Pleistocene)**—Cinder cones that have no identified, associated lava flows. Cones consist of black, brown, and red cinders, agglutinated spatter, lapilli, and coarse ash. Age of cones encompasses nearly the entire time span of the COM lava field. Unit includes Paisley Cone, Inferno Cone, Half Cone, Echo Crater, South Echo, Split Butte, Two Point Butte, New Butte, and other unnamed cinder cones

PRE-HOLOCENE BASALTIC LAVA FIELDS AND ASSOCIATED FLOWS, VENTS, AND ERUPTIVE-FISSURE DEPOSITS OF THE SNAKE RIVER GROUP

[Units are grouped geographically here, whereas they are organized chronologically in Correlation of Map Units]

Basaltic lava fields of northwestern part of map area

Paddelford Flat, Carey, and Little Wood River areas

Qsbb1 **Basaltic pahoehoe flows and pyroclastic deposits of Vent 4895 lava field (late Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows erupted from a north-south-trending, fissure-dominated, cinder cone vent at spot elevation 4895 ft in southwestern part of Paddelford Flat. Vent area is a north-trending, 730-m-long eruptive fissure and cinder cone at north end of fissure. Cone is 300 m long and 20 m high. Cone consists of reddish, oxidized, and black cinders and fine ash. Proximal flows have smooth surfaces; local relief ≤2 m. Medial and distal flows have relief of ≤5 m. Unit is correlated temporally with Wagon Butte flows (Qsbb13) on basis of alignment and closeness of vents. Flows mantled by ≤1 m loess and eolian sand

Qsbc1 **Basaltic pahoehoe flows and pyroclastic deposits of Paddelford Flat lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray pahoehoe basalt flows erupted from a N. 55° W.-trending, 1.2-km-long, cinder cone vent in northeastern part of Paddelford Flat. Vent has high cone walls, approximately 50 m high, at northwest and southeast ends. Walls of vent are of red, oxidized cinders and agglutinated spatter. Lava channel about 100–150 m wide, having conspicuous levees ≤5 m high, is present in medial parts of flow. Flows on margins of leveed channel are smooth. Distal flows have rougher topography; local relief about 8 m. A very fine grained rock examined petrographically has a unique characteristic: the largest crystals are subhedral, subophitic clinopyroxene ≤0.8 mm in longest dimension. Rare subhedral, poorly formed plagioclase microphenocrysts ≤0.8 mm and rare euhedral granules of olivine ≤0.15 mm are set in a matrix of plagioclase and olivine crystals ≤0.1 mm and subophitic clinopyroxene. Abundant equant magnetite crystals ≤0.1mm are present in much greater volume than elongated ilmenite crystals, which are also ≤0.1 mm long. Medial and distal parts of flow are covered by loess ≤1 m thick

Qsbc2 **Basaltic pahoehoe flows and pyroclastic deposits of Vent 5074 lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows and associated near-vent pyroclastic deposits. Flows erupted from a N. 35° W.-trending, 500-m-long, fissure-controlled cinder mound. Northwest and southeast ends of fissure-vent are covered by Carey flows (Qcfg2). Flows in medial area are smooth and covered by thin deposits of loess, some of which are farmed. Distal parts of flows have local relief of about 6 m. Unit is correlated temporally with other flows in Little Park and Laidlaw Park that have similar anomalous paleomagnetic directions (table 3); the inferred age is approximately 210 ka

Qsbc3 **Basaltic pahoehoe flows (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows from unknown source vents. Unit includes several kipuka exposures of older flows that are mostly surrounded by Carey flows (Qcfg2). Flows are mantled discontinuously by loess and eolian sand ≤3 m thick

Qsbd1 **Basaltic pahoehoe flows of Campbell Reservoir–South Fork Muldoon Creek area (early middle Pleistocene)**—Medium-gray, intracanyon, pahoehoe basalt flows. Vent area unknown. Flows fill broad, low area near Campbell Reservoir and South Fork Muldoon Creek. Flows dip about 4° NW. Flows in and near valley of South Fork Muldoon Creek are tilted as much as 4° by small normal faults. Unit not studied petrographically. K-Ar age is 433±78 ka (table 2)

Qsbd2 **Basaltic pahoehoe flows and pyroclastic deposits of Fish Creek Reservoir (inferred to be early middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows from vent area south of Fish Creek Reservoir. Vent is largely obscured by water in Fish Creek Reservoir, lacustrine deposits, and (or) alluvial gravel. Flows are confined to valley of Fish Creek. Medial and distal flows are partly covered by loess and eolian sand and by alluvial deposits along Fish Creek and Huff Creek

Tsbf1 **Basaltic pahoehoe flows of upper Little Wood River and South Fork Muldoon Creek areas (early Pliocene)**—Dark-gray to medium-gray, intracanyon, pahoehoe basalt flows along Little Wood River about 6.7 km north of Carey, and along northern bank of South Fork Muldoon Creek, where unit is faulted. Source vents unknown, may be in Snake River Plain. K-Ar age of flow along upper Little Wood River is 3.55±0.13 Ma (table 2)

Tsbf2 **Basaltic pahoehoe flows of lower Little Wood River area (early Pliocene)**—Dark-gray to medium-gray, intracanyon, pahoehoe basalt flows along Little Wood River 0.8 km north of Carey. Source vent unknown, probably in Snake River Plain. Flow is cut by normal fault having displacement of 5–7 m down to west. Unit is tilted about 3° SE. $^{40}Ar/^{39}Ar$ age of unit is 4.20±0.02 Ma (table 2)

Little Park area

Qsbc4 **Basaltic pahoehoe flows and pyroclastic deposits of Little Park lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-dark-gray, pahoehoe basalt flows and associated near-vent pyroclastic deposits. Flows were derived from three ~N. 45° W.-trending vents along a 3.5-km-long eruptive fissure in northeastern part of Little Park, and from vents near spot elevation 5247 ft. Southeasternmost vent is a small cinder cone about 15 m high, indented by a small crater. Central and northwesternmost vents are mostly covered on their northeastern flanks by Carey Kipuka a'a flows (Qcfd2). Vent deposits are red, oxidized cinders, agglutinated spatter, and fine ash. Two conspicuous channels about 50 m wide, bordered by low levees, are present in proximal and medial parts of flow. Unit is covered by thin (≤2 m) deposits of loess and eolian sand

Qsbc5 **Basaltic pahoehoe flows and pyroclastic deposits of Vent 5129 lava field (late middle Pleistocene)**—Surface- and tube(?)-fed, medium-dark-gray, pahoehoe basalt flows and associated near-vent pyroclastic deposits. Flows were derived from a northwest-trending fissure vent in northern part of Little Park near spot elevation 5129 ft. Vent area is mostly covered by Carey Kipuka a'a flows (Qcfd2). Rock is porphyritic, having plagioclase lath phenocrysts as long as 1.5 mm in a matrix of plagioclase, olivine, and clinopyroxene crystals that are all ≤1 mm in longest dimension. Cumulophyric clots of plagioclase + plagioclase and plagioclase + olivine are common. Equant, euhedral to subhedral crystals of olivine ≤0.75 mm; plagioclase laths ≤1.0 mm; subophitic to ophitic, anhedral crystals of clinopyroxene <1 mm; abundant equant magnetite crystals ≤0.03 mm; and rare elongated needles of ilmenite ≤0.3 mm constitute the matrix. Unit is correlated temporally with other flows in Paddelford Flat and Laidlaw Park that have similar anomalous paleomagnetic directions (table 3); inferred age is approximately 210 ka (see tables 2 and 3)

Laidlaw Park and Little Laidlaw Park areas

Qsbc6 **Basaltic pahoehoe flows and pyroclastic deposits of Hollow Top lava field (late middle Pleistocene)**—Surface-fed, dark-gray to medium-gray, pahoehoe basalt flows and red, oxidized, and black, pyroclastic, near-vent deposits. Flows erupted from a N. 40° W.-trending, broad, low vent area at Hollow Top. A shallow, N. 40° W.-trending trench, which represents an eruptive fissure, lies atop Hollow Top. Trench is mantled by cinders and ash ≤10 cm in diameter. Proximal flows are smooth and covered by ≤1 m of loess and eolian sand. Rock is porphyritic, containing long, slender phenocrysts of plagioclase laths ≤2 mm, and euhedral, equant crystals of olivine ≤1 mm, in a fine matrix of plagioclase, olivine, clinopyroxene, and opaque minerals, all of which are ≤0.15 mm in longest dimension. Waist texture is common. Many large plagioclase crystals are moderately zoned. Intergranular, anhedral crystals of clinopyroxene in matrix are ≤0.15 mm. Matrix contains abundant opaque minerals ≤0.075 mm; magnetite is more abundant than ilmenite. Unit is correlated temporally with other flows in Paddelford Flat, Little Park, Little Laidlaw Park, and Laidlaw Park that all have similar anomalous paleomagnetic directions (table 3); inferred age is approximately 210 ka

Qsbc7 **Basaltic pahoehoe flows and pyroclastic deposits of Turnbull Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows and red, oxidized, near-vent, pyroclastic deposits. Flows vented from a N. 25° W.-trending eruptive fissure that extends for about 700 m southeast from Turnbull Butte. Turnbull Butte is a 350-m-long cinder mound, about 25 m high, at north end of eruptive fissure. Red, oxidized cinders and ash are present on flanks of Turnbull Butte and along eruptive fissure. Proximal flows are smooth surfaced; medial and distal flows are more rough surfaced. Rock is microporphyritic, containing subhedral, poorly formed laths of plagioclase ≤2.1 mm, and equant to rectangular crystals of olivine ≤0.6 mm as phenocrysts. Matrix is plagioclase, olivine, granular clinopyroxene, and opaque minerals, all of which are ≤0.15 mm. Magnetite exceeds ilmenite in volume. Flows are covered by veneer of loess and eolian sand ≤2 m thick. Unit is correlated temporally with other flows in Paddelford Flat, Little Park, Little Laidlaw Park, and Laidlaw Park that all have similar anomalous paleomagnetic directions (table 3); inferred age is approximately 210 ka (table 2)

Qsbc8 **Basaltic pahoehoe flows and pyroclastic deposits of Big Blowout Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray to medium-gray, pahoehoe basalt flows and red, oxidized, and black, pyroclastic near-vent deposits. Flows erupted from a N. 25° W.-trending, 500-m-long vent at Big Blowout Butte. Vent is surrounded by ramparts and cinder mounds of well-bedded, red, oxidized, and black cinders, agglutinated spatter, and ash. Cinder mound on north side of Big Blowout Butte is about 55 m above vent depression. A leveed lava lake about 750 m long extends southeast from vent depression. Two major channels extend away from vent area. A 1,500-m-long, 70-m-wide channel extends westward from vent and a 3,700-m-long, approximately 70-m-wide channel extends southward from lava lake. Proximal flows near vent and lava lake are smooth surfaced, having local relief of 1–3 m; medial and distal flows are rougher surfaced, having local relief of about 4–5 m. Flows form a shield volcano about 80 m above surrounding, older flows; slopes of shield are steep near vent area. Rock is mostly even grained; largest olivine crystals are ≤2 mm and largest plagioclase crystals are ≤1.5 mm; crystals in matrix are typically ≤0.5 mm. Cumulophyric clots of as many as six olivine crystals are common. Subhedral to euhedral, equant olivine crystals are altered to reddish-brown material on crystal surfaces, which are locally overgrown by unaltered olivine. Plagioclase crystals are subhedral, have ragged edges and ends, and are relatively uniform in size. Some crystals are moderately zoned. Intergranular clinopyroxene granules are ≤0.3 mm. Equant magnetite crystals exceed elongated and needle-shaped ilmenite crystals in volume. Both magnetite and ilmenite crystals are ≤0.2 mm. Flows are mantled by <2 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 210±15 ka (table 2). Paleomagnetic directions are anomalous and similar to those of flows in other lava fields in Paddelford Flat, Little Park, Little Laidlaw Park and Laidlaw Park (table 3)

Qsbc9 **Basaltic pahoehoe flows and pyroclastic deposits of Vent 5237 lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, near-vent pyroclastic deposits. Flows erupted from a N. 25° W.-trending, approximately 2.2-km-long, eruptive-fissure system. Cinder cones are absent. Low mounds of red, oxidized cinders and ash ≤5 m high mantle the eruptive fissure. Flows are remarkably smooth surfaced. Rock is strongly porphyritic, containing plagioclase and olivine phenocrysts in a fine matrix of same minerals plus clinopyroxene and opaque minerals. Plagioclase crystals are as long as 2.5 mm, subhedral, and have ragged edges. Olivine crystals are subhedral, mostly equant, and ≤0. 5 mm. Clinopyroxene is present as intergranular, subhedral crystals ≤0.2 mm. Equant magnetite crystals exceed elongated ilmenite crystals in volume. Both magnetite and ilmenite crystals are ≤0.1 mm long. Flows are mantled by ≤2 m of loess and eolian sand. Unit is correlated with other flows in Paddelford Flat, Little Park, Little Laidlaw Park, and Laidlaw Park that have similar anomalous paleomagnetic directions (table 3); inferred age is approximately 210 ka (table 2)

Qsbc10 **Basaltic pahoehoe flows and pyroclastic deposits of Bullshot Reservoir lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, near-vent pyroclastic deposits. Flows erupted from a N. 25° W.-trending, approximately 500-m-long, eruptive-fissure system. Cinder cones are absent. Low mounds of red, oxidized cinders and ash <3 m high mantle eruptive fissure. Flows mantled by a thin (≤2 m) veneer of loess and eolian sand. Unit is correlated temporally with other flows in Paddelford Flat, Little Park, Little Laidlaw Park, and Laidlaw Park that all have similar anomalous paleomagnetic directions (table 3); inferred age is approximately 210 ka (table 2)

Qsbc11 **Basaltic pahoehoe flows and pyroclastic deposits of Blowout Reservoir lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, near-vent pyroclastic deposits. Flows erupted from a N. 30° W.-trending, approximately 750-m-long, eruptive-fissure system. Cinder cones are absent. Low mounds of red, oxidized cinders and ash <8 m high mantle eruptive fissure. Proximal flows are smooth surfaced; local relief is ≤2 m. Medial and distal flows have local relief of ≤5 m. Rock is mostly equigranular and contains rare phenocrysts of plagioclase and olivine. Subhedral to euhedral laths of plagioclase are as large as 3 mm; subhedral to euhedral, equant olivine phenocrysts are as large as 1.5 mm. Matrix of rock is olivine crystals ≤0.4 mm; plagioclase crystals ≤0.75 mm; intergranular, mostly equant crystals of clinopyroxene ≤0.4 mm; moderate amounts of magnetite granules ≤0.5 mm; and rare, elongated crystals of ilmenite ≤0.5 mm. Flows are mantled by ≤2 m of loess and eolian sand. Unit is correlated temporally with other flows in Paddelford Flat, Little Park, Little Laidlaw Park, and Laidlaw Park that have similar anomalous paleomagnetic directions (table 3); inferred age is approximately 210 ka (table 2)

Qsbc12 **Basaltic pahoehoe flows and pyroclastic deposits of Bowl Crater lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, near-vent pyroclastic deposits. Flows erupted from a N. 35° W.-trending, approximately 350-m-long, 20-m-deep crater at Bowl Crater in northern part of Little Laidlaw Park. Crater is surrounded by a cinder cone 60 m above crater floor. Crater consists of red, oxidized, and black, coarse cinders, agglutinated spatter, and ash in prominent layers. Major lava exits from crater were from vent at northwest base of cone and from open slot in southeast corner of cone. Proximal flows are smooth surfaced; local relief ≤2 m. Medial and distal flows have local relief of ≤5 m. Rock examined is very fine grained, containing rare microphenocrysts of plagioclase ≤0.45 mm, and rare, skeletal microphenocrysts of olivine ≤0.3 mm. Phenocrysts are set in a matrix of plagioclase laths, subophitic to ophitic clinopyroxene, olivine granules, abundant magnetite euhedra, and rare ilmenite needles, all of which are ≤0.2 mm in longest dimension. Flows are mantled by a thin (≤2 m) veneer of loess and eolian sand; some areas are dry farmed for hay. Unit is correlated temporally with other flows in Paddelford Flat, Little Park, and Laidlaw Park that have similar anomalous paleomagnetic directions (table 3); inferred age is approximately 210 ka (table 2)

Qsbc13 **Pyroclastic deposits of North Laidlaw Butte cinder cone complex (inferred to be late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits that constitute the N. 15° W.-trending North Laidlaw Butte cinder cone complex. Tallest cinder cone is 110 m high. Cinder cone complex consists of two cones, each having remnants of a vent depression on their east sides. North Laidlaw Butte is unique in that cinder cones formed on west or southwest sides of vent depressions, a direction opposite to the prevailing southwesterly to northeasterly wind direction. Vent depressions are mostly infilled by Sawtooth a'a flows (Qcfc3). No flows are exposed; they are covered by Sawtooth a'a flows (Qcfc3). Rock examined is porphyritic, containing rare phenocrysts of long, slender plagioclase ≤3.3 mm and rare, equant, partly skeletal crystals of olivine ≤0.8 mm. Phenocrysts are set in a very fine matrix in which crystals are ≤0.5 mm. Olivine phenocrysts typically contain inclusions of glass. Matrix consists of plagioclase laths, equant olivine crystals, small intergranular crystals of clinopyroxene ≤0.1 mm, and abundant opaque minerals. Relatively large crystals of equant magnetite are as large as 0.5 mm. Most magnetite crystals are ≤0.1 mm. Magnetite greatly exceeds ilmenite in volume. Unit is correlated temporally with Bowl Crater lava field (Qsbc12) on the basis of similar petrographic characteristics and geographic alignment of vents

Qsbc14 **Basaltic pahoehoe flows and pyroclastic deposits of Potter Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, near-vent pyroclastic deposits. Flows erupted from a N. 15° W.-trending, 300-m-long, low (≤25 m) cinder mound at Potter Butte. Cinder mound is red, oxidized cinders and ash. Rock examined is coarse grained, containing abundant, subhedral, poorly formed plagioclase phenocrysts as long as 2.5 mm and rare olivine phenocrysts ≤1.2 mm. Cumulophyric clots containing two or three olivine crystals are common. Matrix is subhedral plagioclase laths, granules of olivine, intergranular clinopyroxene, equant crystals of magnetite, and elongated ilmenite crystals that are all ≤0.75 mm. Magnetite exceeds ilmenite in volume; most ilmenite is confined to very fine grained parts of matrix, where it is intergrown with clinopyroxene

Qsbc15 **Pyroclastic deposits of Vent 5370 (late middle Pleistocene)**—Red, oxidized, near-vent pyroclastic deposits. Flows erupted from a N. 40° W.-trending, 575-m-long, 40-m-high cinder cone at spot elevation 5370 ft. Cinder cone is almost completely surrounded by Little Park a'a flows (Qcfd3). Flows at south end of cinder cone are mostly covered by Hollow Top pahoehoe flows (Qsbc6). Included in unit are two cinder cone vents about 0.8 km southeast of cinder cone at spot elevation 5370 ft. Cinder cones are red, oxidized cinders and ash

Qsbc16 **Basaltic pahoehoe flows and pyroclastic deposits of Vent 5136 lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Flows erupted from a N. 15° W.-trending, 300-m-long, low (25 m) cinder cone at spot elevation 5136 ft. Cinder cone is red, oxidized, and black cinders and ash. Proximal flows are smooth surfaced; local relief <4 m. Distal flows are rougher surfaced; local relief ≤6 m. Rock examined is porphyritic, containing phenocrysts of subhedral, poorly formed laths of plagioclase ≤2.1 mm, and euhedral, mostly equant olivine crystals ≤1.1 mm. Rock contains cumulophyric clots of plagioclase + plagioclase, olivine + olivine, and starburst plagioclase. Plagioclase crystals are characterized by swallow-tail ends and abundant glassy inclusions, and they are weakly zoned. Matrix is plagioclase, olivine, granules of clinopyroxene, and abundant opaque minerals, all of which are ≤0.25 mm. Magnetite greatly exceeds ilmenite in volume. Flows mantled by ≤2 m of loess and eolian sand

Qsbc17 **Basaltic pahoehoe flows and pyroclastic deposits of Ant Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Flows erupted from a N. 15° W.-trending, 700-m-long, 25-m-high cinder cone at Ant Butte. Cinder cone consists of red, oxidized cinders and ash, which are excavated as a local source of road metal. Proximal flows are smooth surfaced; local relief ≤2 m. Distal flows are more rough surfaced; local relief ≤4 m. Rock examined is strongly porphyritic, containing phenocrysts of mostly subhedral, moderately zoned laths of plagioclase ≤3.3 mm, and euhedral to subhedral, mostly equant olivine ≤0.6 mm. Cumulophyric clots of olivine + olivine are present. Phenocrysts are set in a matrix of plagioclase; olivine; anhedral, subophitic clinopyroxene; and abundant opaque minerals, all of which are ≤0.3 mm. Magnetite exceeds ilmenite in volume. Flows are mantled by ≤2 m of loess and eolian sand

Qsbc18 **Basaltic pahoehoe flows and pyroclastic deposits of Corral Butte lava field (late middle Pleistocene)**—Surface-fed, medium-gray, pahoehoe basalt flows and red, oxidized, near-vent pyroclastic deposits. Flows erupted from a N. 10° W.-trending, 250-m-long, 10-m-high cinder mound at Corral Butte. Cinder mound is red, oxidized cinders and ash. Proximal flows are smooth surfaced; local relief ≤2 m. Medial and distal flows are covered by younger flows from Big Blowout Butte (Qsbc8). Rock examined is fine grained, containing plagioclase laths ≤0.6 mm and olivine crystals ≤0.8 mm as the largest crystals. Rock contains cumulophyric microclots as large as 0.5 mm, of as many as 10 olivine crystals. Plagioclase, olivine, intergranular clinopyroxene, and abundant magnetite and ilmenite crystals ≤0.2 mm constitute remainder of rock

Qsbc19 **Carey Kipuka cinder cone deposits (late middle Pleistocene)**—Red, oxidized, near-vent pyroclastic deposits. Carey Kipuka consists of a N. 20° E.-trending, 1,200-m-long cinder cone. Cone is 25 m high. Cinder cone is surrounded by, and all flows from cinder cone are covered by, Carey Kipuka (Qcfd2) and Little Park (Qcfd3) a'a flows. Unit is correlated temporally with other late middle Pleistocene units on the basis of youthful appearance of pyroclastic deposits

Qsbc21 **Basaltic pahoehoe flows and pyroclastic deposits (Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows and reddish, oxidized, and black, near-vent pyroclastic deposits. Unit appears as kipuka exposures that are surrounded mainly by flows of COM lava field. Flows are covered by variable amounts of loess and windblown sand, thus they are older than Holocene. No radiometric or paleomagnetic data exist for unit, thus definitive age designation cannot be given. Source vents are known for some units, unknown for others. Unit occurs throughout map area

Qsbd3 **Basaltic pahoehoe flows and pyroclastic deposits of Laidlaw Butte lava field (early middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe flows, and red, oxidized, and black, near-vent pyroclastic deposits. Flows erupted from a N. 30° W.-trending, deep vent atop Laidlaw Butte. Vent is 1,000 m long and 30 m deep. Laidlaw Butte is one of the largest, highest, and most imposing shield volcanoes in the eastern Snake River Plain; it is 160 m above surrounding, younger lava flows on its north flank and 275 m above surrounding, younger flows on its south flank. Rock is characterized by extremely coarse crystal size, containing plagioclase laths as large as 3 cm. Large crystal size may have contributed to relatively high viscosity of Laidlaw Butte flows and, along with high volume and rapid effusion rate, caused formation of a high shield volcano having steep flanks. Crater walls are characterized by well-layered, shelly pahoehoe flows, red, oxidized, and black cinders, agglutinated spatter, and ash. Lava rings on margins of crater walls are evidence of lava-lake activity. Proximal, medial, and distal flows are all rough surfaced; local relief is 5 m. Rock examined is coarse. Plagioclase crystals are subhedral, have rough edges, are stubby to intermediate in shape, and are weakly zoned. Syntaxial clots of as many as 10 plagioclase crystals are common. Subhedral, mostly equant olivine crystals are typically 1–2 mm in longest dimension, and cumulophyric clots of as many as 10 olivine crystals are common. Clinopyroxene is present as anhedral, intergranular crystals that are typically intergrown with needles of ilmenite and skeletal, equant crystals of magnetite. Locally, the abundance of magnetite and ilmenite crystals in clinopyroxene renders intergranular areas of rock opaque. Distal and medial flows are mantled by as much as 2 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 425±20 ka (table 2)

Qsbd4 **Basaltic pahoehoe flows and pyroclastic deposits of Snowdrift Crater lava field (early middle Pleistocene)**—Surface-, channel-, and tube-fed, basaltic pahoehoe flows, shelly pahoehoe flows, and dark-gray and red, oxidized, and black, near-vent pyroclastic deposits. Flows erupted from a N. 45° W.-trending, large, deep vent atop Snowdrift Crater. Vent area is 1,500 m long and consists of two craters; northern crater is circular and 35 m deep, southern crater is elongated northwest and 55 m deep. Crater walls are well-layered, shelly pahoehoe flows and red, oxidized, and black cinders, agglutinated spatter, and ash. Locally, walls are veneered by thin lava flows. Remnants of lava rings in craters are evidence of lava-lake activity. A roughly circular lava lake, about 700 m in diameter, is present at southeast end of vent depression. Proximal and medial flows are smooth surfaced and are mantled by ≤3 m of loess and eolian sand. Rock examined is mostly even grained, but contains rare phenocryst laths of plagioclase as long as 2.5 mm in a matrix of other crystals that are ≤1.5 mm. Cumulophyric clots of six to eight olivine crystals and as many as eight plagioclase crystals are common. Subhedral to euhedral, mostly equant crystals of olivine ≤0.8 mm are confined to the matrix. Subhedral, poorly formed crystals of plagioclase having ragged edges and ends that are ≤1.5 mm are in the rock matrix. Intergranular, subophitic clinopyroxene ≤0.75 mm, which is intergrown with ilmenite crystals, is also confined to the matrix. Elongated crystals of ilmenite ≤0.4 mm are more abundant than equant magnetite crystals ≤0.15 mm. $^{40}Ar/^{39}Ar$ age is 480±50 ka (table 2)

Basaltic lava fields of southwestern part of map area

Qsbb2 **Basaltic pahoehoe flows and pyroclastic deposits of Bear Den Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, basaltic pahoehoe flows and near-vent pyroclastic deposits. Flows erupted from a ~N. 35° W.-trending vent and lava-lake complex at Bear Den Butte. Vent is a roughly circular depression about 200 m in diameter and 20 m deep. Vent is nearly completely surrounded by a cinder cone of red, oxidized cinders and agglutinated spatter-ash deposits that rise as high as 80 m above vent depression. Cone is breached on southeast flank, where channel leads to a 900-m-long lava lake having confining levees as high as 10 m. A 5-km-long channel–lava-tube system leads southwest from distal part of lava pond. Flows near channel-tube system are smooth and of low relief. Flows form a broad shield that rises about 130 m above surrounding, older flows. Slopes near vent are steep. Medial and distal flows are more rough surfaced; local relief is ~7 m. Unit includes flows and vent deposits from cinder cone at spot elevation 5022 ft, 2 km north-northwest of Bear Den Butte, based on similarity in hand-sample petrology. Flows from vent at 5022 not studied petrographically. Rock from Bear Den Butte flows is fine grained and contains microphenocrysts of plagioclase and olivine. Both stout and slender laths of plagioclase phenocrysts are ≤1.5 mm. Olivine phenocrysts are ≤0.6 mm.

Most crystals of plagioclase, olivine, and clinopyroxene that constitute the matrix are ≤0.3 mm. Cumulophryric clots of as many as five olivine crystals are common. Anhedral, subophitic crystals of clinopyroxene are as large as 0.8 mm, most are ≤0.3 mm. Equant crystals of magnetite greatly exceed elongated crystals of ilmenite in volume. Both magnetite and ilmenite are ≤0.2 mm. Age of unit, based on $^{40}Ar/^{39}Ar$ analysis, is 58±10 ka (see table 2)

Qsbb3 **Basaltic pahoehoe flows and pyroclastic deposits of Vent 5168 lava field (late Pleistocene)**—Surface-fed, medium-dark-gray, pahoehoe basalt flows and associated near-vent pyroclastic deposits. Vent area is a low, ~N. 25° W.-elongated hill having a slot-shaped, eruptive-fissure depression approximately 200 m long. Red, oxidized cinders and ash are present on flanks of eruptive fissure within 300 m of vent. Pahoehoe flows are smooth and covered by ≤1 m of loess and eolian sand. Unit correlated temporally with Bear Den Butte lava field (Qsbb2) on basis of similar paleomagnetic directions (see table 3); inferred age is 58±10 ka

Qsbb4 **Basaltic pahoehoe flows and pyroclastic deposits of Lava Butte lava field (late Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt lava flows and red, oxidized, near-vent, pyroclastic deposits. Flows are derived from a 1-km-long, N. 25° W.-elongated eruptive fissure and cinder cone vents. Cinder cones at each end of eruptive fissure are cinders, agglutinated spatter, and fine ash. Flows are smooth surfaced near vent. Rock is distinctly porphyritic, containing euhedral, well-formed plagioclase laths 2–3 mm in longest dimension and euhedral to subhedral olivine, 0.6–0.9 mm, as phenocrysts in a very fine grained matrix in which most crystals are 0.1–0.5 mm. Cumulophyric clots of olivine and plagioclase phenocrysts are common. Matrix is plagioclase and olivine crystals; intergranular to subophitic, anhedral clinopyroxene ≤0.75 mm; abundant equant, skeletal magnetite crystals; and elongated ilmentite crystals. Opaque minerals are ≤0.2 mm and magnetite greatly exceeds ilmenite in volume. Larger crystals of magnetite adhere to surfaces of olivine crystals

Qsbb5 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Broken Top Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray to medium-gray, pahoehoe basalt flows, shelly-pahoehoe flows, and red, oxidized, and black, near-vent pyroclastic deposits. Flows erupted from a north-south-trending, 830-m-long, 47-m-deep, slot-shaped vent at Broken Top Butte. Proximal, medial, and distal flows are characterized by rough surfaces; lava mounds, tumuli cut by cracks, and tilted plates of lava are common. Local relief as much as 8 m. Prominent lava tube having several skylights extends about 1.5 km east of vent area. Narrow (≤10 m) channels are present near vent area and on east side of Sand Butte. Lava field forms a broad, low shield about 75 m above surrounding, older flows. Walls of vent are veneered by thin, shelly pahoehoe flows; local areas of shelly pahoehoe present near vent. Lava terraces in vent indicate a complicated, piston-like filling and draining history. Red, oxidized, and black, well-layered cinders, agglutinated spatter, and ash are present locally in vent walls. Rock examined is porphyritic, containing moderately elongated to elongated laths of plagioclase as long as 3.2 mm, and subhedral, rounded, mostly equant olivine crystals that are ≤1.0 mm. Cumulophyric clots of plagioclase + plagioclase and plagioclase + olivine (typical clots consist of about 8 olivine and 10 plagioclase crystals) are common, as is waist texture. Phenocrysts are set in a fine, intergranular matrix of plagioclase crystals, typically ≤0.75 mm long; equant olivine crystals ≤0.25 mm; elongated olivine crystals ≤0.15 mm; intergranular clots of clinopyroxene intergrown with needle-like ilmenite crystals; moderate amounts of intersertal, yellow and tan glass; and ubiquitous, small (≤0.05 mm) crystals of opaque minerals. Ilmenite exceeds magnetite in volume. Flows covered by little (<1 m) or no loess or eolian sand. Unit has paleomagnetic directions that are similar to directions for Sand Butte (Qsbb6) and Spud Butte (Qsbb7) (table 3). $^{40}Ar/^{39}Ar$ age is <50 ka (table 2)

Qsbb6 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Sand Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray to medium-gray, pahoehoe basalt flows, and red, oxidized, and black cinders, ash, and palagonitized-sideromelane, near-vent pyroclastic deposits. Vent area is a circular tephra cone about 1,400 m in diameter. Cone has a north-south elongated depression about 700 m in diameter. Cone walls are about 100 m high. Cone is well-bedded, locally agglutinated ash and palagonitized sideromelane deposited by hydrovolcanic eruptions during later stages of volcanic activity at Sand Butte. Cone is open on north rim. A satellite vent at base of south rim of cone leads to a north-south-trending, 1,850-m-long lava channel having levees as high as 15 m. Proximal flows are smooth surfaced; local relief ≤2 m. Medial and distal flows have more rough surfaces; local relief ≤5 m. Rock examined is weakly porphyritic; olivine and plagioclase phenocrysts ≤1.8 mm are in a matrix of crystals that are ≤0.7 mm. Olivine phenocrysts are euhedral and mostly equant; some contain inclusions of glass. Plagioclase phenocrysts are long and slender; some contain cloudy, corroded cores that are filled with minute crystals of opaque minerals. Cumulophyric clots of as many as 12 olivine crystals as large as 2 mm are common. Matrix consists of small (≤0.05 mm) granules of olivine and equant to slender plagioclase crystals ≤0.7 mm. Clinopyroxene and opaque minerals ≤0.05 mm form cloudy parts of matrix. Flows are locally covered by ≤1 m of loess and eolian sand; most flows lack surficial cover. K-Ar age is 34±29 ka (table 2). Geographic alignment with Broken Top Butte (Qsbb5), and similarity in paleomagnetic directions for Broken Top Butte (Qsbb5), Spud Butte (Qsbb7), and Sand Butte (Qsbb6) indicate that age is approximately 50±10 ka (tables 2 and 3)

Qsbb7 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Spud Butte lava field (late Pleistocene)**—Surface-fed, medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 40-m-high cinder cone at Spud Butte. Cone is red, oxidized cinders and ash. Cone is nearly completely surrounded by flows from Broken Top Butte vent (Qsbb5). Flows on south and west sides of cone are smooth; local relief ≤1 m. Rock examined is weakly porphyritic, having small phenocrysts of plagioclase ≤1.6 mm and olivine ≤1.2 mm set in a matrix of crystals ≤0.5 mm. Cumulophyric clots of olivine and plagioclase, containing about 10 crystals of each mineral, are as large as 5 mm. Olivine phenocrysts are euhedral to subhedral and mostly equant. Plagioclase phenocrysts are intermediate to elongated and are weakly zoned. Matrix is olivine granules, intermediate-shape plagioclase, intergranular to subophitic clinopyroxene intergrown with needle-like ilmenite, and equant magnetite crystals, all of which are ≤0.5 mm. Ilmenite exceeds magnetite in volume. Flows are locally covered by <1 m of loess and eolian sand; most flows lack surficial cover. ^{40}Ar/^{39}Ar age is 57±30 ka (table 2). Similarity in paleomagnetic directions for Broken Top Butte (Qsbb5) and Sand Butte (Qsbb6) indicate age is about 50±10 ka (tables 2 and 3)

Qsbb8 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of west Wildhorse Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray to medium-gray, pahoehoe basalt flows, shelly-pahoehoe flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a relatively flat, broad dome about 1,500 m wide indented by a shallow, northwest-elongated vent depression that is about 10 m deep. A satellite or rootless(?) vent is present about 1.6 km south of main vent depression. Orientation of feeder-dike system, based on configuration of satellite vent and main vent, is north-south. Vent walls are chiefly of shelly-pahoehoe flows. Cinders, ash, and agglutinated spatter exposed locally in walls of vent depression. Near-vent area is covered by thin, shelly pahoehoe flows that represent overflow from vent depression. Slopes of broad dome are steep, especially on west, south, and east flanks. Flows form a shield volcano that rises 150 m above surrounding, younger flows from Sand Butte (Qsbb6). Medial and distal flows have rough surfaces; local relief ≤5 m. Flows characterized by many tumuli and pressure plateaus. Flows in western part of lava field are cut by many north-south-trending fissures that are parallel to vents for Broken Top Butte (Qbb5) and Sand Butte (Qbb6) lava fields. Rock examined is coarse, containing anhedral to subhedral plagioclase phenocrysts as long as 4 mm and subhedral, rounded, equant olivine phenocrysts as long as 2.2 mm. Phenocrysts are set in fine matrix of crystals ≤0.5 mm. Cumulophyric clots of olivine + olivine as large as 2 mm, plagioclase + plagioclase as large as 3.5 mm, and plagioclase + olivine as large as 3.5 mm are common. Syntaxial bundles of as many as 10 crystals of plagioclase are also common. Matrix is equant olivine, intermediate plagioclase, and equant and elongated, intergranular clinopyroxene crystals, all of which are ≤0.5 mm. Elongated ilmenite and equant magnetite crystals ≤0.25 mm are intergrown with clinopyroxene. Ilmenite exceeds magnetite in volume. Flows are covered by little or no loess or eolian sand. $^{40}Ar/^{39}Ar$ age is <50 ka (table 2). Unit is correlated temporally with Monument Butte lava field (Qsbb9) on the basis of similarity in paleomagnetic directions (table 3)

Qsbb9 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Monument Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray to medium-gray, pahoehoe basalt flows, shelly-pahoehoe flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 300-m-long, N. 10° W.-trending depression about 20 m deep, atop a broad summit dome. Summit dome has steep flanks on north and east sides. Flows form a broad shield that rises about 70 m above surrounding, younger Broken Top Butte flows (Qsbb5) and Carey flows (Qcfg2). Walls of vent are shelly-pahoehoe flows and well-bedded, red, oxidized, and black cinders, agglutinated spatter, and ash. Proximal flows are smooth; medial and distal flows have rougher surfaces. Prominent lava-tube–skylight system extends for about 3 km northwest from vent area. Lava channel, about 10 m wide and 1.2 km long, extends southwest from vent area. Rock examined is relatively coarse, containing phenocrysts of plagioclase ≤2.5 mm and euhedral to subhedral, mostly equant olivine that are ≤1.5 mm. Cumulophyric clots of as many as 5 olivine crystals ≤1.75 mm and as many as 10 plagioclase crystals ≤2.5 mm are common, as is waist texture. Matrix is olivine and plagioclase crystals ≤0.5 mm, and elongated, intergranular crystals of clinopyroxene ≤0.25 mm. Elongated crystals of ilmenite ≤0.15 mm exceed equant crystals of magnetite ≤0.25 mm in volume. Flows are mantled by loess and eolian sand ≤1 m. Age not determined by $^{40}Ar/^{39}Ar$ methods. Unit is correlated temporally with dated (<50 ka) flows of west Wildhorse Butte (Qsbb8) on the basis of similarity in petrographic characteristics and paleomagnetic directions (table 3); inferred age is <50 ka (table 2)

Qsbb10 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of The Blowout lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, medium-gray, pahoehoe basalt flows, shelly-pahoehoe flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a circular, 70-m-deep, 300-m-wide depression (The Blowout), which is the main vent, and a steep-walled, 1,670-m-long lava lake, which extends south and southeast of The Blowout. Walls of the lava lake are as high as 30 m. Walls of vent are chiefly thin (<1 m) layers of shelly pahoehoe. Pyroclastic deposits are present locally in vent walls. A 300-m-wide lava channel, having leveed walls as high as 10 m, extends for 2.5 km north and west of The Blowout. A 100-m-wide, 4.3-km-long lava channel extends east-southeast from the lava lake. Proximal flows are very smooth; local relief ≤1 m. Medial and distal flows have more rough surfaces; local relief ≤3 m. Rock examined is extremely fine grained; largest crystals are olivine and plagioclase, both of which are ≤0.75 mm. Olivine crystals have a unique habit; they are elongated, having length:width ratios of 6:1. Olivine and plagioclase crystals in matrix are ≤0.25 mm. Slender, euhedral, log-shaped crystals of clinopyroxene are as long as 1.2 mm. Magnetite granules and elongated ilmenite crystals are ≤0.05 mm; magnetite exceeds ilmenite in volume. Flows are mantled by loess and eolian sand ≤1 m thick. $^{40}Ar/^{39}Ar$ age is 116±15 ka (table 2). Unit is correlated temporally with Serviceberry Butte (Qsbb22) and Vent 5206 (Qsbb23) lava fields on the basis of similarity in paleomagnetic directions (table 3)

Qsbb11 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 4792 lava field (late Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows, shelly-pahoehoe flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 5° W.-trending, 475-m-long, shallow (≤10 m), fissure-dominated, slot-shaped depression atop a north-south-elongated lava cone. Flows in and near vent are mainly shelly pahoehoe. Medial and distal flows have relatively smooth surfaces; local relief ≤3 m. Flows are mostly free of loess and eolian sand; locally mantled by ≤2 m of these surficial deposits. Unit is correlated temporally with flows from The

Blowout lava field (Qsbb10) on the basis of geographic alignment of fissure-dominated vent areas for both lava fields

Qsbb12 **Basaltic pahoehoe flows and near-vent pyroclastic deposits near spot elevation 4673 ft (late Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits and surface-fed, medium-gray, pahoehoe basalt flows. Vent area is a north-south-trending, 1-km-long eruptive fissure on west side of Vent 4792 (Qsbb11) lava field. Near-vent pyroclastic deposits along eruptive fissure are 10 m above surrounding younger flows. Flows are locally mantled by ≤2 m of loess and eolian sand

Qsbb13 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Wagon Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 750-m-long, north-south trending, flat-topped dome having a shallow (≤8 m) vent depression. Flows in and near vent are mainly shelly pahoehoe. Pyroclastic deposits are present locally in vent area. Flanks of dome are steep on north side. Medial and distal flows are characterized by many tumuli and pressure plateaus; local relief ≤8 m. $^{40}Ar/^{39}Ar$ age is 120±25 ka (table 2). Flows are mostly free of loess and eolian sand; locally mantled by ≤2 m of these surficial deposits

Qsbb14 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Black Ridge Crater lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, shelly-pahoehoe flows, pahoehoe basalt flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a broad lava dome indented by a N. 10° .W-trending, shallow vent depression 700-m-long and about 20 m deep. Lava dome is about 75 m above younger flows from Sand Butte (Qsbb6). Vent area is mantled by shelly-pahoehoe flows. Near-vent pyroclastic deposits are exposed locally. Prominent lava-tube and skylight systems are present on north and south flanks of lava dome. Proximal flows have smooth surfaces; local relief ≤1 m. Medial and distal flows have rougher surfaces; local relief ≤5 m. Flows are characterized by many tumuli, pressure ridges, and pressure plateaus. Flows are mantled by ≤2 m of loess and eolian sand; many areas are free of loess and eolian sand. Age of unit is based on near lack of cover by loess and eolian sand and youthful appearance similar to that of nearby lava flows of late Pleistocene age

Qsbc20 **Basaltic pahoehoe flows and pyroclastic deposits of Vent 4708 lava field (late middle Pleistocene)**—Surface-, channel-, and tube (?)-fed, medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a small cinder mound 15 m above surrounding, younger flows. Cinder mound is mainly red, oxidized, and black, near-vent pyroclastic deposits. Rock examined is porphyritic, containing subhedral phenocrysts of plagioclase ≤2 mm and euhedral phenocrysts of olivine ≤1.5 mm. Cumulophyric clots of olivine + olivine, olivine + plagioclase, and plagioclase + plagioclase are common. Phenocrysts are set in a matrix of crystals of plagioclase and olivine that are ≤0.15 mm and anhedral, ophitic clinopyroxene that is ≤0.75 mm. Equant, partly skeletal magnetite crystals are ≤0.15 and elongated crystals of ilmenite are ≤0.2 mm. Flows are mantled by ≤2 m of loess and eolian sand

Qsbc22 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 4645 lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 5° W.-trending, fissure-dominated, 1-km-long, slot-shaped, shallow (≤15 m deep) depression atop a broad lava cone that is about 50 m above surrounding, younger flows. Vent area mantled by red, oxidized cinders and ash. Proximal and medial flows have smooth surfaces; local relief ≤2 m. Rock examined is unique: olivine phenocrysts are larger (≤3 mm) than plagioclase phenocrysts (≤1.5 mm). Phenocrysts are set in a fine matrix of crystals ≤0.5 mm. Cumulophyric clots of as many as 4 olivine crystals and clots of as many as 20 plagioclase and 20 olivine crystals are common. Most large olivine crystals are euhedral, ≤1.5 mm, and many are skeletal, containing vacuoles filled by glass. Matrix is olivine granules, plagioclase laths, and equant granules of clinopyroxene. Magnetite crystals ≤0.05 mm exceed elongated ilmenite crystals ≤0.05 mm in volume. Flows are mantled by ≤2 m of loess and eolian sand. Prominent, N. 20° W.-trending linear features, probably representing loess-filled fissures, are present north and south of vent depression

Qsbc23 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 4550 lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 25° W.-trending cinder cone about 50 m above surrounding flows. Cone is indented by a circular vent depression about 160 m in diameter and ≤10 m deep. Cone is red, oxidized, and black cinders, agglutinated spatter, and ash. Flows have relatively smooth surfaces near vent, and are mantled by ≤2m of loess and eolian sand. Rock examined is strongly porphyritic and contains large phenocrysts of plagioclase (≤5 mm) and olivine (≤2 mm) in a medium to fine matrix (≤0.8 mm). Cumulophyric clots of plagioclase + plagioclase and plagioclase + olivine are common. One clot examined contains about 20 plagioclase and 7 olivine crystals. Olivine phenocrysts are mostly equant and euhedral to subhedral; some are skeletal, containing inclusions of plagioclase. Plagioclase phenocrysts are subhedral, having scalloped edges and ratty ends; weakly zoned. Matrix is granules of olivine, equant to intermediate laths of plagioclase, and equant, intergranular crystals of clinopyroxene, all of which are ≤0.5 mm. Magnetite crystals ≤0.15 mm exceed elongated crystals of ilmenite ≤0.4 mm in volume

Qsbc24 **Near-vent pyroclastic deposits and minor basaltic pahoehoe flows of Vent 4430 lava field (late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits and minor, surface-fed, medium-gray, pahoehoe basalt flows. Vent area consists of a low lava cone that rises about 20 m above surrounding, younger flows. Cone indented by vent depression about 200 m in diameter and ≤10 m deep. Red, oxidized, and black cinders, agglutinated spatter, and ash make up cone. Flows have relatively smooth surfaces near vent and are mantled by ≤2 m of loess and eolian sand. Unit not studied petrographically

Qsbc25 **Minor basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 4626 lava field (late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits and minor surface-fed, medium-gray, pahoehoe basalt flows. Vent area is a low lava cone about 25 m above surrounding, younger flows. Cone is indented by a circular vent depression about 140 m in diameter and ≤10 m deep on east side of cone. Cone is red, oxidized, and black cinders, agglutinated spatter, and ash. Flows have relatively smooth surfaces near vent, and are mantled by ≤2 m of loess and eolian sand

Qsbc26 **Basaltic pahoehoe flows (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows from unknown source vents. Unit includes several kipuka exposures of older flows that are between younger lava fields. Flows are mantled by loess and eolian sand ≤2 m thick

Basaltic lava fields of northeastern part of map area

Qsbb15 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Rock Corral Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, shelly-pahoehoe flows, pahoehoe basalt flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 800-m-long, north-south-trending lava dome indented by a shallow vent depression 500 m long and about 20 m deep. Shelly-pahoehoe-mantled ramparts as high as 15 m form walls of central part of vent area. Vent walls are mantled chiefly by shelly-pahoehoe flows; pyroclastic deposits are present locally within vent area. Proximal flows have relatively rough surfaces; local relief ≤3 m. Medial and distal flows are characterized by many tumuli, pressure ridges, and pressure plateaus; local relief ≤5 m. Rock examined has a distinctive two-part texture. Part of rock is coarse, consisting of subhedral plagioclase laths as long as 3.5 mm; subhedral, equant, olivine granules ≤0.75 mm; and anhedral, subophitic logs of clinopyroxene ≤1.5 mm. Cumulophyric clots of as many as eight olivine crystals are common. Syntaxial bundles of as many as 10 plagioclase crystals are also common. Other parts of rock are distinctly porphyritic, containing large phenocrysts of plagioclase ≤3.5 mm in a matrix of olivine, plagioclase, and clinopyroxene crystals that are all ≤0.4 mm. Needles and blades of ilmenite as long as 1.2 mm are in approximately equal abundance to equant crystals of magnetite that are ≤0.3 mm. Flows are mantled by ≤1 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 55±12 ka (table 2)

Qsbb16 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5438 lava field (late Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 300-m-long, north-south-trending lava dome indented by a shallow vent depression 200 m long and about 20 m deep. Red, oxidized, and black, near-vent pyroclastic deposits are present in walls of vent. Proximal flows have smooth surfaces; local relief ≤1 m. Medial and distal flows are covered by flows from Rock Corral Butte lava field (Qsbb15). Unit includes a vent area 2.5 km south, on the basis of closeness and alignment of vents. Rock examined has petrographic characteristics that are similar to those of Rock Corral Butte lava field. Rock contains subhedral, rounded olivine phenocrysts as long as 3.5 mm and subhedral plagioclase phenocrysts as long as 3 mm in a fine matrix of plagioclase, olivine granules, intergranular clinopyroxene, and crystals of magnetite and ilmenite that are all <0.5 mm. Flows are mantled by ≤1 mm of loess and eolian sand. Unit correlated temporally with flows of Rock Corral Butte lava field (Qsbb15) on the basis of similarity in petrographic characteristics and closeness and alignment of vents

Qsbb17 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5494 lava field (late Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 300-m-long, N. 55° W.-trending lava dome indented by a shallow vent depression 200 m long and about 20 m deep. Red, oxidized, and black, near-vent pyroclastic deposits are present in walls of vent. Proximal flows have smooth surfaces; local relief ≤1 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Flows are mantled by ≤1 m of loess and eolian sand

Qsbb18 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Fingers Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 750-m-long, N. 30° W.-trending lava dome indented by a shallow vent depression 500 m long and about 30 m deep. Shelly-pahoehoe-mantled ramparts as high as 15 m form walls of southern part of vent area. Red, oxidized, and black, near-vent pyroclastic deposits are present locally in walls of vent. A prominent channel, about 2 km long, extends northeast from vent area. Proximal flows are relatively smooth; local relief ≤2 m. Medial and distal flows have rougher surfaces; local relief ≤4 m. Flow fronts as high as 3 m are present in lobe of lava field west of Sunset Ridge. Rock examined is coarse and porphyritic, containing subhedral to euhedral laths of plagioclase as long as 6.5 mm and subhedral, typically elongated crystals of olivine as long as 3 mm. Matrix of rock is plagioclase, olivine, and intergranular clinopyroxene crystals that are all ≤0.75 mm. Rock contains round areas, approximately 1–2 mm in diameter, that contain cloudy clinopyroxene having inclusions of ilmenite needles as long as 0.5 mm. Ilmenite exceeds magnetite in volume. Flows are mantled by loess and eolian sand ≤1 m thick. $^{40}Ar/^{39}Ar$ age is 57±20 ka (table 2)

Qsbb19 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Quaking Aspen Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows and shelly-pahoehoe basalt flows. Vent area is an approximately 1-km-diameter, roughly circular, flat-topped lava dome that is indented by an oblong, ~N. 40° W.-trending vent depression that is approximately 10 m deep. Lava dome has steep flanks on west, north, and east sides and is about 30 m above medial parts of lava field. Shape of lava dome indicates repeated, piston-like draining and filling of vent area. Walls and top surfaces of lava dome and vent depression are mantled chiefly by shelly-pahoehoe flows. Pyroclastic deposits are rare in vent area. Medial and distal flows are characterized by many tumuli, pressure ridges, and pressure plateaus. Rock examined is coarse and even grained. It contains euhedral crystals of plagioclase and olivine as large as 2.5 mm and anhedral, subophitic to ophitic crystals of clinopyroxene, also as large as 2.5 mm. Equant and skeletal magnetite crystals and elongated ilmenite crystals are ≤0.4 mm. Magnetite and ilmenite are approximately equal in abundance. Flows are mantled by ≤1 m of loess and eolian sand. Age of unit is bracketed by $^{40}Ar/^{39}Ar$ ages of younger flows that cover Quaking Aspen Butte flows [Fingers Butte (Qsbb18), 57±20 ka], and flows that are covered by Quaking Aspen Butte flows [Coyote Butte (Qsbb20), 64±20 ka]. Age is approximately 60 ka (see table 2)

Qsbb20 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Coyote Butte lava field (late Pleistocene)**—Surface-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 50° W.-trending, 1.9-km-long eruptive fissure and associated cinder cones and spatter ramparts. Coyote Butte is a 400-m-long, 20-m-high cinder cone on central and northwestern parts of eruptive fissure. Cone consists of well-bedded, red, oxidized, and black cinders, agglutinated spatter, and ash. Medial and distal flows are relatively smooth; local relief ≤2 m. Distal flows are mantled by ≤1 m of alluvial and lacustrine deposits. $^{40}Ar/^{39}Ar$ age is 64±20 ka (table 2)

Qsbb21 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5159 lava field (late Pleistocene)**—Surface-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly-pahoehoe flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a low lava dome along east boundary of map area. Vent area is mantled by shelly-pahoehoe flows and minor amounts of red, oxidized, and black, near-vent pyroclastic deposits

Qsbb22 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Serviceberry Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows and shelly-pahoehoe basalt flows. Vent area is a N. 40° W.-trending, 1-km-long lava dome indented by a 300-m-long, oblong vent depression that is approximately 15 m deep. Vent area is mantled chiefly by shelly-pahoehoe flows; pyroclastic deposits are present locally. A 200-m-long lava tube and skylight system extends northwest and west from vent area. Proximal flows are smooth; local relief ≤1 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Rock examined is porphyritic, containing subhedral to euhedral phenocrysts of plagioclase as long as 3 mm and smaller phenocrysts of subhedral to euhedral, mostly equant crystals of olivine ≤0.8 mm. Cumulophyric clots of olivine + olivine, olivine + plagioclase, and syntaxial bundles of plagioclase crystals are common. Phenocrysts are set in a fine matrix of plagioclase, olivine, and equant, intergranular clinopyroxene, all of which are ≤0.5 mm. Intersertal yellow to clear glass is also present. Equant magnetite ≤0.6 mm and elongated ilmenite ≤1.0 mm are present in approximately equal volumes. Flows are mantled by ≤2 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 120±12 ka (table 2). Unit correlated temporally with Vent 5206 (Qsbb23) and The Blowout (Qsbb10) lava fields on the basis of similar paleomagnetic directions

Qsbb23 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5206 lava field (late Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area consists of four vent depressions aligned along a N. 60° W.-trending, 3.7-km-long eruptive-fissure system about 5.5 km north of Big Southern Butte. Two shallow vent depressions, 1,705 m and 250 m in diameter, are present along the eruptive-fissure system near spot elevation 5206 ft A third vent is present about 2.5 km southeast, at spot elevation 5149 ft. Each vent depression is ≤5 m deep. Vent depressions are atop lava cones that are draped with shelly pahoehoe and minor amounts of red, oxidized, and black pyroclastic deposits. A roughly east-west-oriented, 350-m-long lava pond is present at northwest end of eruptive fissure. Proximal flows are smooth; local relief <2 m. Medial and distal flows have rougher surfaces; local relief ≤5 m. Flows are characterized by tumuli, pressure ridges, and pressure plateaus of moderate relief. Rock examined is coarse. Phenocrysts of plagioclase as long as 4.8 mm and equant, subhedral crystals of olivine ≤1.5 mm are in a matrix of olivine, plagioclase, and intergranular to subophyitic, brown clinopyroxene that are all ≤0.6 mm. Cumulophyric clots of as many as 10 olivine crystals and syntaxial bundles of plagioclase phenocrysts are common. Rare phenocrysts of green clinopyroxene about 1 mm long are present. Clinopyroxene in matrix is charged with needles of ilmenite ≤0.5 mm long. Ilmenite exceeds magnetite in volume. Flows are mantled by ≤2 m of loess and eolian sand. Age is <200 ka on the basis of geologic and paleomagnetic correlation with K-Ar dated flows sampled in cores at the Idaho National Laboratory (Kuntz and others, 1994). Unit is correlated with Serviceberry Butte (Qsbb22) and The Blowout (Qsbb10) lava fields on the basis of similar paleomagnetic directions; inferred age is ~120 ka

Qsbc27 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5328 lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 20° W.-trending, 500-m-long, shallow (<10 m) vent depression atop a low lava cone. A small (150 m in diameter) lava lake is present on north margin of vent area. A prominent tube and skylight system (not mapped) is present on northwest flank of cone. All flows have relatively low local relief, ≤3 m. Rock examined is medium coarse grained. It contains plagioclase laths as long as 2.3 mm and olivine crystals ≤0.75 mm. Rock displays a unique texture: plagioclase crystals wrap around cumulophyric clots of olivine crystals. Syntaxial bundles of plagioclase are common. Clinopyroxene is present as intergranular crystals ≤0.5 mm. Flows are mantled by ≤2.5 m of loess and eolian sand

Qsbc28 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5359 lava field (late middle Pleistocene)**—Surface- and channel-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is an oblong, 200-m-long, <10-m-deep vent depression atop a N. 35° W.-trending lava dome. Dome is mantled chiefly by shelly pahoehoe and by minor pyroclastic deposits. Proximal flows have smooth surface; local relief ≤1 m. Medial and distal flows largely covered by younger flows from Vent 5494 lava field (Qsbb17). Rock examined is weakly porphyritic. Euhedral to subhedral, moderately zoned laths of plagioclase ≤3 mm and euhedral to subhedral, equant crystals of olivine ≤1.75 mm are set in a matrix of crystals ≤1.5 mm. Syntaxial bundles of plagioclase crystals and cumulophyric clots of as many as six olivine crystals are common. Matrix is plagioclase laths ≤1.5 mm, olivine granules ≤0.25 mm, and mostly equant, intergranular to subophitic clinopyroxene ≤0.6 mm. Elongated crystals of ilmenite ≤0.8 mm exceed equant crystals of magnetite ≤0.3 mm in volume. Flows and lava dome are covered by ≤2 m of loess and eolian sand

Qsbc29 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5119 lava field (late middle Pleistocene)**—Surface- and channel-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is two oblong vent depressions, each about 300 m long and <20 m deep, aligned atop a N. 10° W.-trending lava dome. Dome is mantled chiefly by shelly pahoehoe and by minor pyroclastic deposits. Proximal flows have smooth surface; local relief ≤1 m. Proximal flows are smooth; local relief ≤1 m. Medial and distal flows are covered by flows of Vent 5494 lava field (Qsbb17)

Qsbc30 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5244 lava field (late middle Pleistocene)**—Surface-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a small vent at spot elevation 5244 ft and a shallow vent depression 125 m long aligned along a N. 60° W.-trending lava cone. Lava cone is draped by shelly pahoehoe and minor amounts of red, oxidized, and black pyroclastic deposits. Proximal flows are smooth; local relief ≤2 m. Medial and distal flows have rougher surfaces; local relief ≤4 m. Flows are mantled by ≤2 m of loess and eolian sand

Qsbc31 **Basaltic pahoehoe flows (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray, pahoehoe basalt flows. Flows erupted from vents now covered by flows of COM lava field

Qsbc32 **Near-vent pyroclastic deposits and pahoehoe basalt flows of Vent 5149 and Rattlesnake Butte eruptive fissures (late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits and minor, surface-fed, pahoehoe basalt flows. Vent area is N. 40°

W.-trending, eruptive fissures and associated spatter ramparts and small cinder cones. Eruptive fissures are exposed over a distance of at least 11 km, extending from four small (<20,000 m^2) kipuka exposures surrounded by Blue Dragon flows (Qcfa2) about 3.5 km west and southwest of Pratt Butte, to approximately 1.5 km southeast of Rattlesnake Butte. Cinder cones and spatter ramparts along the eruptive-fissure system are as high as 40 m. Cones and ramparts are of red, oxidized, and black cinders, agglutinated spatter, and ash. Proximal flows have smooth surfaces; local relief ≤2 m. Proximal flows largely covered by as much as 1.5 m of cogenetic cinders and ash. Medial and distal flows largely covered by younger flows. Rocks examined are strongly porphyritic, containing subhedral to euhedral, stubby to intermediate phenocrysts of plagioclase ≤4 mm, and subhedral to euhedral, partly skeletal, mostly equant phenocrysts of olivine ≤1.3 mm. Cumulophyric clots of olivine + olivine, plagioclase + plagioclase, and plagioclase + olivine are common. Phenocrysts and cumulophyric clots are set in a fine matrix of plagioclase, olivine, and intergranular clinopyroxene, all of which are ≤0.2 mm. Individual and compound crystals of magnetite are ≤0.3 mm and elongated ilmenite crystals are ≤0.2 mm

Qsbc33 **Near-vent pyroclastic deposits and pahoehoe basalt flows of Saddle Butte lava field (late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits and surface-fed, medium-gray, pahoehoe basalt flows. Vent area is a N. 55° W.-trending, 5.8-km-long eruptive-fissure system of small cinder cones and spatter ramparts. Remnants of spatter ramparts are present as kipuka exposures northwest of Saddle Butte, surrounded by Blue Dragon flows (Qcfa2). Saddle Butte is a 55-m-tall cinder cone indented by a 15-m-deep crater that is open on the northwest end. Cones and ramparts are red, oxidized, and black cinders, agglutinated spatter, and ash; locally well bedded in crater walls. Proximal flows are mantled by ≤2 m of fine cinders, ash, loess, and eolian sand. Rocks examined are porphyritic, containing euhedral to subhedral, stout to elongated plagioclase phenocrysts as long as 2.5 mm and euhedral, mostly equant olivine phenocrysts ≤1.5 mm. Phenocrysts are set in a matrix of crystals that are all <0.3 mm. Cumulophyric clots of olivine + olivine, plagioclase + plagioclase, and plagioclase + olivine + magnetite crystals are present. Waist texture is common. Matrix is plagioclase; olivine; very small granules of clinopyroxene (≤0.03 mm); equant, skeletal magnetite ≤0.3 mm; and minor elongated ilmentite crystals ≤0.03 mm

Qsbc34 **Near-vent pyroclastic deposits and pahoehoe basalt flows of Cruthers Butte lava field (late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits and surface- and channel-fed, dark-gray and medium-gray, pahoehoe basalt flows. Vent area is a N. 15° W.-trending, 850-m-long, eruptive-fissure system. Major feature of eruptive-fissure system is a 500-m-long and 250-m-wide explosion crater that is about 35 m deep. A roughly circular, 850-m-wide and 30-m-high cinder cone is present on west side of explosion crater. Basalt flows, each about 10 m thick, are exposed in walls of explosion crater. Cinder cone is red, oxidized, and black cinders and ash. A 1.5-km-long channel extends north and west from northern part of explosion crater and ends in a lava lake that is partly covered by Blue Dragon flows (Qcfa2). Proximal flows have very smooth surfaces; local relief ≤1 m. Smooth surfaces are due to surface-fed nature of flows from channel and lava lake, and to mantle of cinders, ash, loess, and eolian sand ≤1.5 m thick. Rock examined is porphyritic, containing euhedral crystals of olivine ≤1.3 mm and minor, anhedral to subhedral laths of plagioclase ≤1.5 mm. Olivine and plagioclase phenocrysts are set in a matrix of olivine granules and plagioclase laths that are ≤0.5 mm, and anhedral, ophitic crystals of clinopyroxene that are ≤1.2 mm. Equant magnetite crystals (≤0.5 mm) greatly exceed crystals of ilmenite (≤0.2 mm) in volume

Qsbc35 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Pratt Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a nearly circular, 700-m-long depression that is 15–30 m deep. Depression is at top of a N. 45° W.-trending, elongated, broad lava dome 1 km in diameter. Vent area mantled by shelly-pahoehoe flows and minor amounts of pyroclastic deposits. Pratt Butte forms a large shield volcano about 100 m above surrounding, younger lava fields. Proximal and medial flows have smooth surfaces; local relief ≤2 m. Distal flows largely covered by flows of younger lava fields. Rock examined is coarse; it contains subhedral, stubby to intermediate crystals of plagioclase as large as 4 mm, and subhedral to euhedral, equant to elongated crystals of olivine as large as 1.5 mm. Plagioclase crystals are seriate in size, ranging from crystals 0.2 mm long to crystals ≤4 mm long, and they are moderately zoned. Olivine crystals are also seriate; smallest crystals are about 0.1 mm. Clinopyroxene crystals are intergranular and ≤0.5 mm. Skeletal, equant magnetite crystals ≤1.0 mm and elongated ilmenite crystals ≤0.8 mm are present in approximately equal abundance. Flows are mantled by ≤2 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 263±20 ka (table 2)

Qsbc36 **Near-vent pyroclastic deposits of China Cup cinder cone (late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits. Vent is a circular, 530-m-diameter cinder and tuff cone having a circular vent depression 300 m in diameter and about 25 m deep. Surface of vent depression and cone flanks are mantled by red, oxidized, and black cinders, agglutinated spatter, bombs, and ash. Cone is completely surrounded by flows from Rock Corral Butte lava field (Qsbb15). Rock Corral Butte flows have steep flow fronts about 5 m high around cinder cone, forming a moat on west, south, and east sides of cone. Unit includes small vent summits 1.6 and 3.8 km northwest of China Cup. Cinder examined contains euhedral, partly skeletal, mostly equant crystals of olivine ≤0.6 mm in a glassy to very fine matrix in which all crystals are <0.05 mm. Many olivine crystals have glass inclusions, and cumulophyric clots of as many as four olivine crystals are common. Matrix contains fine, dusty opaque minerals

Qsr1 **Massive, aphyric, white rhyolite of Big Southern Butte (late middle Pleistocene)**—Massive, aphyric, white rhyolite that lacks spherulites. Big Southern Butte consists of two coalesced cumulo domes. Massive, aphyric rhyolite forms western dome. Unit locally contains autoclastic breccia. Forms smooth slopes. Unit forms an arcuate outcrop pattern around western and southwestern margins of devitrified, flow-banded, rhyolite flows and sugary-textured rhyolite (Qsr2) that forms main part of Big Southern Butte. Unit description modified from Spear and King (1982). K-Ar age is 294±15 ka (table 2; Kuntz and others, 1994)

Qsr2 **Devitrified, flow-banded rhyolite flows, and sugary-textured rhyolite of Big Southern Butte (late middle Pleistocene)**—Chiefly lavender-gray, pink to tan, flow-laminated, 1- to 10-m-thick rhyolite lava flows and minor amounts of rhyolitic-flow and vent breccia, banded obsidian, and aphyric rhyolite containing abundant devitrification spherules. Big Southern Butte consists of two coalesced cumulo domes. Eastern dome is composed of lavender-gray, aphyric rhyolite containing abundant devitrification spherulites. Flow-layered rhyolite grades upward into white, sugary-textured rhyolite. Autoclastic breccia is present locally above sugary-textured rhyolite. Unit forms most of northern, eastern, and southeastern parts of Big Southern Butte. Unit forms varied topography and rugged slopes. Unit description modified from Spear and King (1982). K-Ar age is 310±11 ka (table 2; Kuntz and others, 1994)

Qsbc37 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5571 lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 1.1-km-long set of four small vents along an eruptive fissure that trends N. 35° W. Vents are atop a broad lava cone that is 20 m above surrounding flows. Vent area mantled chiefly by shelly-pahoehoe flows and minor red, oxidized, cinders, and ash near vents. Proximal flows have smooth surfaces; local relief ≤1 m. Medial and distal flows also have relatively smooth surfaces; local relief <2 m. Flows are mantled by ≤2 m of loess and eolian sand. Unit is correlated temporally with flows of East Wildhorse Butte (Qsbc38) due to parallel alignment and closeness of vents of the two lava fields; inferred age is approximately 325±10 ka

Qsbc38 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of east Wildhorse Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 35° W.-trending, 750-m-long lava dome indented by a shallow (≤5 m deep), 450-m-long vent depression. Lava dome caps a broad shield volcano that is about 130 m above surrounding flows. Vent area mantled chiefly by shelly-pahoehoe flows; pyroclastic deposits present locally. Proximal flows have local relief of ≤2 m; medial and distal flows have local relief of ≤5 m. Major rootless vent is present along a lava-tube system about 2.75 km south of vent depression. Rock examined is porphyritic, containing subhedral phenocrysts of plagioclase ≤2.4 mm and subhedral to euhedral, mostly equant phenocrysts of olivine ≤1.0 mm. Cumulophyric clots of olivine + olivine, plagioclase + plagioclase, and plagioclase + olivine are common. Waist texture is present. Phenocrysts are set in a matrix of crystals that are all ≤0.4 mm and most are ≤0.1 mm. Matrix is olivine and plagioclase crystals ≤0.4 mm and granules of clinopyroxene ≤0.1 mm. Magnetite crystals ≤0.15 mm and ilmenite crystals ≤0.25 mm are present in about equal volumes. Flows are mantled by ≤2 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 325±10 ka (table 2). Unit is correlated temporally with Huddles Hole lava field (Qsbc39) on the basis of similarity in paleomagnetic directions (table 3)

Qsbc39 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Huddles Hole lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a narrow, N. 50° W.-trending, 900-m-long, ≤125-m-wide, shallow (≤5 m) vent depression. Vent depression is atop a broad lava dome that is the summit of a large shield volcano. Shield volcano is now a kipuka exposure, completely surrounded by Blue Dragon flows (Qcfa2). Vent area mantled chiefly by shelly-pahoehoe flows; pyroclastic deposits are present locally. Proximal flows have local relief of ≤2 m; medial flows have local relief of ≤4 m. Rock examined is moderately coarse grained; it contains olivine crystals as large as 3 mm. Some large olivine crystals are skeletal and have bands of wavy extinction. Cumulophyric clots of as many as seven olivine crystals are common. Plagioclase crystals are mostly euhedral, have stout to intermediate shapes, and range from 1 to 2.5 mm. Clinopyroxene crystals are intergranular, ≤1 mm, and intergrown with parallel crystals of ilmenite ≤0.3 mm. Magnetite crystals are ≤0.25 mm. Flows are mantled by ≤2.5 m of loess and eolian sand. Unit is correlated temporally with flows of east Wildhorse Butte (Qsbc38) on the basis of similarity in paleomagnetic directions (table 3); inferred age is about 325±10 ka (table 2)

Qsbc40 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of southeast Wildhorse Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a low lava dome 2.5 km south of vent for east Wildhorse Butte (Qsbc38) lava field. Vent area is mantled chiefly by shelly-pahoehoe flows; pyroclastic deposits are present locally. Proximal flows have local relief of ≤2 m; medial and distal flows have local relief of ≤5 m. Flows are mantled by ≤2 m of loess and eolian sand

Qsbc41 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5549 lava field (late middle Pleistocene)**—Surface-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a shallow (≤10 m deep) depression atop a broad lava dome. Vent area is surrounded on north and west sides by a lava plateau, which indicates broad overflow of vent by piston-like draining and filling. Vent area covered chiefly by shelly-pahoehoe flows. Pyroclastic deposits are present locally in vent area. A leveed channel about 20 m wide extends south and east from vent for distance of about 1.5 km. Proximal flows are smooth; local relief ≤2 m. Medial and distal flows are largely covered by younger flows. Rock examined is very fine grained, having small phenocrysts of mostly euhedral, equant olivine ≤1.3 mm and subhedral plagioclase ≤1.3 mm. These small phenocrysts are set in a matrix of olivine, plagioclase, intergranular clinopyroxene, and opaque minerals, all of which are ≤0.4 mm. Equant magnetite ≤0.15 mm greatly exceeds elongated ilmenite crystals ≤0.05 mm in volume. Flows are mantled by ≤2 m of loess and eolian sand

Qsbc42 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5575 lava field (late middle Pleistocene)**—Surface-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a complex of eight separate vents in an area 2.7 km long and 3.3 km wide. Aligned vents trend N. 25° W. Vents range from craters 150 m long to aligned, small vents on eruptive fissures. Many flows from vents are identified, but all flows are inferred to be about the same age. Vent areas are mainly shelly-pahoehoe flows; pyroclastic deposits are present at some vents. Flows are surrounded by younger flows from Quaking Aspen Butte (Qsbb19) on south side, by Fingers Butte flows (Qsbb18) on west and north sides, and by flows from Vent 5549 lava field (Qsbc41) on east side. Rock examined is very coarse grained. It contains subhedral to euhedral, moderately zoned, stubby to intermediate phenocrysts of plagioclase as long as 10 mm, and rare, subhedral to euhedral, mostly equant phenocrysts of olivine ≤2 mm. Phenocrysts are set in a matrix of olivine crystals ≤0.3 mm, plagioclase laths ≤1 mm, and intergranular, anhedral crystals of clinopyroxene ≤1 mm. Syntaxial bundles of plagioclase phenocrysts and cumulophyric clots of as many as 10 olivine crystals are common. Olivine phenocrysts are altered to iddingsite along crystal surfaces and cleavages. Clinopyroxene is intergrown with ilmenite. Small patches of ilmenite-charged glass are also characteristic of the rock. Equant crystals of magnetite ≤0.3 mm and elongated blades and spindles of ilmenite ≤0.3 mm are present. Flows are mantled by ≤2 m of loess and eolian sand. Unit is correlated temporally with flows of Vent 5609 (Qsbc43) on the basis of similarity in paleomagnetic directions (table 3)

Qsbc43 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5609 lava field (late middle Pleistocene)**—Surface-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a shallow (≤5 m deep), N. 35° W.-trending vent depression atop a broad lava dome. Vent area covered chiefly by shelly-pahoehoe flows. Pyroclastic deposits are present locally in vent area. Proximal flows are smooth; local relief ≤2 m. Medial and distal flows have rougher surfaces; local relief ≤4 m. Rock examined is coarse. It contains subhedral to euhedral, stout to intermediate phenocrysts of plagioclase ≤4.8 mm, and rare, subhedral phenocrysts of olivine ≤1.8 mm. Cumulophyric clots of plagioclase + plagioclase crystals as long as 6 mm. Phenocrysts are set in a matrix of olivine crystals, plagioclase laths, and clinopyroxene crystals, all ≤1.5 mm. Clinopyroxene crystals range from intergranular crystals ≤0.3 mm to subophitic-ophitic crystals as large as 1.5 mm. Equant crystals of magnetite ≤0.6 mm exceed elongated crystals of ilmenite ≤0.8 mm in volume. Flows are mantled by ≤2 m of loess and eolian sand. Unit is correlated temporally with flows of Vent 5575 (Qsbc42) on the basis of similarity in paleomagnetic directions (table 3)

Qsbc44 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5337 lava field (late middle Pleistocene)**—Surface-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 35° W.-trending, oblong depression that is 600 m long, 270 m wide, and ≤15 m deep. Walls of vent depression are mantled by shelly pahoehoe and minor amounts of pyroclastic deposits. Only proximal flows are exposed; medial and distal flows are covered by flows from Vent 5609 lava field (Qsbc43) on south and by flows from east Wildhorse Butte (Qsbc38) on north

Qsbc45 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Tin Cup Butte lava field (late middle Pleistocene)**—Surface-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a shallow (≤10 m deep) lava lake that overlies a N. 40° W.-trending eruptive fissure. A small vent is present at northwest corner of lava lake. Shelly pahoehoe covers much of vent area; pyroclastic deposits are present locally in vent area. Proximal flows are very smooth; local relief ≤1 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Rock examined is porphyritic, containing subhedral to euhedral phenocrysts of plagioclase ≤5 mm, and euhedral to subhedral, mostly equant phenocrysts of olivine ≤1.5 mm. Rock is characterized by syntaxial bundles of plagioclase crystals, cumulophyric clots of plagioclase + plagioclase, plagioclase + olivine, olivine + olivine, starburst texture, and waist texture. Matrix of rock is crystals of olivine, laths of plagioclase, equant granules of clinopyroxene, and intersertal glass containing inclusions of clinopyroxene and opaque minerals. All minerals in matrix are ≤0.5 mm. Equant crystals of magnetite ≤0.25 mm are present in matrix; elongated crystals of ilmenite are ≤0.3 mm. Flows are mantled by ≤2 m of loess and eolian sand

Qsbc46 **Basaltic pahoehoe flows of Sixmile Butte lava field (late middle Pleistocene)**—Tube-fed, medium-black and medium-gray, pahoehoe basalt flows of Sixmile Butte lava field. Vent area is 1.8 km north of boundary of map. Medial flows are relatively smooth; local relief ≤2 m. Flows are mantled by ≤3 m of loess and eolian sand

Qsbc47 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Teakettle Butte lava field (late middle Pleistocene)**—Surface- and channel-fed, dark-gray and medium-gray, pahoehoe basalt flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 1-km-long, N. 50° W.-trending, slot-shaped vent depression that is ≤5 m deep. A small cinder cone vent is at northwest end of elongated vent depression. Vent depression is atop a 100-m-high eruptive fissure–cinder cone complex having steep slopes. Much of vent area mantled by red, oxidized, and black, near-vent pyroclastic deposits and shelly-pahoehoe flows. Proximal and medial flows have relatively rough surfaces; local relief ≤2 m. Rock examined is porphyritic, containing phenocrysts of plagioclase and olivine in a dense matrix. Stubby to intermediate, subhedral phenocrysts of plagioclase are ≤2.5 mm; subhedral, mostly equant phenocrysts of olivine are ≤2.4 mm. Cumulophyric clots of as many as 10 plagioclase crystals and as many as 40 plagioclase + olivine crystals are common. Fine-grained matrix of rock, in which all crystals are ≤0.4 mm, is of olivine, plagioclase, and intergranular clinopyroxene. Opaque minerals are present in matrix as tiny crystals intergrown with clinopyroxene. Flows are mantled by ≤2 m of loess and eolian sand

Qsbc48 **Basaltic pahoehoe flows (late middle Pleistocene)**—Dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, and black, near vent pyroclastic deposits. Vents are two small cinder cones that rise ≤8 m above surrounding flows

Qsbc49 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5128 lava field (late middle Pleistocene)**—Surface- and channel-fed, dark-gray and medium-gray, pahoehoe basalt flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 1.5-km-long, N. 50° W.-trending, eruptive fissure. Four small cinder cones are aligned along fissure. Much of vent area is mantled by red, oxidized, and black, near-vent pyroclastic deposits, and shelly-pahoehoe flows. Proximal and medial flows have relatively rough surfaces; local relief ≤2 m. Flows are mantled by ≤2 m of loess and eolian sand

Qsbc50 **Near-vent pyroclastic deposits and shelly-pahoehoe basalt flows of Shadow cinder cone (late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits. Vents are two N. 45° W.-trending cinder cones on north flank of Big Southern Butte. Cones are approximately 75 m high. Surfaces mantled chiefly by pyroclastic deposits and minor shelly pahoehoe. Only near-vent deposits are exposed; medial and distal flows are covered by younger colluvial deposits on flank of Big Southern Butte. Unit covered by ≤3 m of loess and eolian sand

Qsbc51 **Near-vent pyroclastic deposits and shelly-pahoehoe basalt flows of Vent 5265 cinder cone (late middle Pleistocene)**—Red, oxidized, and black, near-vent pyroclastic deposits. Cinder cone, 40 m high, is on north side of Big Southern Butte. Surfaces mantled chiefly by pyroclastic deposits and minor shelly pahoehoe. Only near-vent deposits are exposed; medial and distal flows are covered by colluvium on flanks of Big Southern Butte. Rock studied has a seriate texture; largest olivine crystals are ≤3.3 mm and largest plagioclase crystals are ≤3.5 mm. Olivine and plagioclase crystals range from 3.5 mm to about 0.5 mm. Cumulophyric clots of as many as 20 plagioclase + olivine and as many as 8 olivine + olivine crystals are common. Clinopyroxene is present as intergranular sheaves and bundles of elongated crystals that are as large as 1 mm. Clinopyroxene crystals are typically intergrown with spindles and needles of ilmenite that are ≤1.0 mm. Equant crystals of magnetite are ≤0.5 mm. Ilmenite exceeds magnetite in volume. Unit is covered by ≤3 m of loess and eolian sand

Qsbd5 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Antelope Butte lava field (early middle Pleistocene)**—Surface- and channel-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a double-crowned lava dome about 70 m above surrounding, younger flows. Two lava cones at summit of Antelope Butte may be vents. A shallow depression south of two lava cones, open to the south, may also be a vent. Isolated exposures at top of lava dome are largely shelly pahoehoe; pyroclastic deposits are present locally. A leveed channel extends for about 1 km from westernmost lava cone. Proximal flows have very smooth surfaces; local relief ≤1.5 mm. Only vent and near-vent area are exposed. Medial and distal flows are covered by younger, surrounding flows. Rock examined is coarse grained, but not porphyritic. Plagioclase laths are as long as 4.1 mm. Largest olivine crystals are subhedral, mostly equant, and ≤1.5 mm. Cumulophyric clots of olivine + olivine crystals are present. Plagioclase and olivine crystals range from 1.5 mm to about 0.4 mm. Anhedral to subhedral crystals of clinopyroxene are intergranular to subophitic and ≤1.2 mm. Magnetite crystals are ≤0.3 mm and ilmenite crystals are ≤0.6 mm. Flows are mantled by extensive loess and eolian sand ≤3 m thick. $^{40}Ar/^{39}Ar$ age is 470±25 ka (table 2). Unit is correlated temporally with Vent 5221 lava field (Qsbd6) on the basis of similarity in paleomagnetic directions (table 3)

Qsbd6 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5221 lava field (early middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, medium-gray, pahoehoe basalt flows, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 600-m-long eruptive fissure, trending N. 20° W. Eruptive fissure caps a low (~40 m high) lava cone. Rock examined is medium coarse. It contains a few very large, subhedral, moderately zoned plagioclase phenocrysts ≤4.5 mm. Cumulophryric clots of olivine + olivine, bundles of syntaxial plagioclase crystals, and crosses of plagioclase are common. Largest olivine crystals are ≤2.0 mm; most are 0.5–1.0 mm, and small crystals are ≤0.3 mm. Clinopyroxene is present as intergranular laths and blades ≤0.3 mm. Ilmenite crystals (≤0.4 mm) exceed equant magnetite crystals (≤0.3 mm) in volume. Vent area mantled by pyroclastic deposits. Proximal, medial, and distal flows have surfaces with ≤3 m relief. Flows are mantled by ≤3 m of loess and eolian sand. Unit is correlated temporally with Antelope Butte lava field (Qsbd5) on the basis of similarity in paleomagnetic directions (table 3); inferred age is ~470 ka

Qsbd7 **Basaltic lava flows on north face of Big Southern Butte (late middle and early middle Pleistocene)**—Olivine basalt, trachybasalt, and trachybasalt pyroclastic rocks, trachydacite lava flows, and local interbedded sediments of eolian or alluvial origin. Flows, pyroclastic deposits, and interbedded sediments are exposed in a hinged structural block that was uplifted and tilted 45°–60° to the north during intrusion of the rhyolite laccolith of Big Southern Butte. Flows, pyroclastic deposits, and interbedded sediments have a minimum thickness of 900 m. Trachydacite lava flows about 50 m thick at top of section are correlated with trachydacite flows of Cedar Butte, about 9 km east of Big Southern Butte (Fishel, 1993). K-Ar age of flows at Cedar Butte is 400±19 ka (Kuntz and others, 1994)

Basaltic lava fields of southeastern part of map area

Qsbb24 **Basaltic pahoehoe flows of Vent 5108 lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, medium-gray, pahoehoe basalt flows. Vent area is 2.5 km south of Horse Butte and 1.5 km south of southern boundary of map. In hand specimen, flows are dark gray. They contain abundant plagioclase ≤3 mm, abundant olivine crystals ≤1.5 mm, and clots of plagioclase and olivine crystals as large as 4 mm

Qsbb25 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Horse Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a north-south-trending 1.1-km-long, 700-m-wide, 90-m-deep crater at top of a very large shield volcano. Vent crater is one of the largest and deepest in the eastern Snake River Plain. Walls of crater are steep to vertical. Crater contains several nearly horizontal terraces, indicating that piston-like filling and draining and lava-lake activity occurred during later stages of vent development. A 500-m-diameter, leveed lava lake is at south end of crater. Many shelly-pahoehoe flows are exposed in crater walls; pyroclastic deposits are present locally between shelly-pahoehoe flows and also at several sites around margins of crater. Three slot-shaped vents, each about 300 m long and 10–30 m wide, and a 700-m-long eruptive fissure extend for about 2.5 km north-northwest of main eruptive crater. Several lava tube–skylight–rootless vent systems occur in lava field; most prominent lava tube–skylight–rootless vent system is the Bear Trap lava tube that extends at least 13 km north and west from crater to southern boundary of map. Bear Trap lava-tube system extends at least 18 km farther south and west, into the Lake Walcott 1:100,000-scale quadrangle. Proximal flows have significant relief (≤3 m). Medial and distal flows are characterized by many tumuli, pressure ridges, and pressure plateaus; local relief ≤4 m. Flows from rootless vents along lava-tube systems are extremely smooth; local relief <0.5 m. Rock examined is porphyritic, containing phenocrysts of subhedral, stout to elongated crystals of plagioclase as long as 5.5 mm, and subhedral, mostly equant crystals of olivine ≤1.8 mm. Cumulophyric clots containing as many as 15 crystals of plagioclase + olivine and cross-shaped clots of plagioclase are common. Many plagioclase phenocrysts have corroded cores containing glass and opaque inclusions. Matrix of rock is plagioclase laths and granules of olivine, both ≤1 mm; intergranular clinopyroxene ≤0.15 mm; intersertal brown glass contains plagioclase microlites, and small, opaque minerals. Blades and needles of ilmenite are ≤1 mm; equant crystals of magnetite are ≤0.5 mm. Flows are mantled by ≤2 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 75±20 ka (table 2)

Qsbb26 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 4946 lava field (late Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray to medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 30° W.-trending, 400-m-long, shallow vent depression that is ≤10 m deep. Vent depression is at top of a very low lava dome that is about 20 m high. Pyroclastic deposits are widely distributed in vent area. Proximal flows are chiefly shelly pahoehoe. Rock examined is coarse, containing large plagioclase and small olivine phenocrysts in a very fine matrix. Subhedral to euhedral plagioclase laths are ≤6.6 mm; some are moderately zoned and some have corroded cores containing blebs of opaque-charged glass. Euhedral, mostly equant olivine phenocrysts are ≤1.6 mm. Most olivine phenocrysts are altered to opaque minerals on crystal surfaces, cleavages, and fractures. Cumulophyric clots of as many as 22 olivine and 25 plagioclase crystals are present. Matrix is olivine, plagioclase, and elongated, intergranular clinopyroxene crystals, all of which are ≤0.3 mm, and abundant brown glass. Composite, partly skeletal crystals of magnetite are ≤0.6 mm and elongated, blade-like crystals of ilmenite are ≤0.7 mm. Ilmenite is mostly confined to brown glass. Flows are mantled by ≤2 m of loess and eolian sand. Unit is correlated temporally with flows of Mule Butte (Qsbb27) on the basis of similarity in paleomagnetic directions; inferred age of unit is approximately 100 ka (table 2)

Qsbb27 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Mule Butte lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a north-south-trending, 730-m-long, 220-m-wide, 75-m-deep crater. A 300-m-long by 150-m-wide, 60-m-deep alcove is present on east side of crater. Walls of crater and alcove are steep to vertical. Walls are mainly shelly-pahoehoe flows that are 0.1–2 m thick. Pyroclastic deposits are present locally around margins of vent area. Only proximal flows are exposed; medial and distal flows are covered by Minidoka pahoehoe basalt flows (Qcfb4) on west side, by flows of Vent 4946 (Qsbb26) on north and east sides, and by flows from Horse Butte (Qsbb25) on south side. Proximal flows characterized by relatively smooth surfaces; local relief ≤2 m. Rock examined is porphyritic, containing relatively small phenocrysts of plagioclase and olivine in a fine, ophitic matrix. Subhedral, weakly zoned plagioclase phenocrysts having corroded cores are ≤3.3 mm. Subhedral, mostly equant phenocrysts of olivine are ≤1 mm. Syntaxial bundles of plagioclase and cumulophyric clots of as many as 15 plagioclase crystals are common. Olivine and plagioclase crystals in matrix are ≤0.3 mm. Ophitic clinopyroxene crystals are as large as 1 mm. Magnetite crystals are ≤0.6 mm and ilmenite crystals are ≤0.4 mm. $^{40}Ar/^{39}Ar$ age is 106±10 ka (table 2)

Qsbb28 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Split Top lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 1.8-km-long, north-south trending complex of two vent craters and an eruptive fissure atop a broad shield volcano. Shield is about 110 m high. Central (main) crater vent is 500 m long, 230 m wide, and about 30 m deep. Walls of main crater are shelly-pahoehoe flows that are 0.3–3 m thick. A 500-m-long eruptive fissure is present about 1 km south of main crater. Red, oxidized, and black, near-vent pyroclastic deposits mantle eruptive fissure. Several rootless vents and lava tube–skylight systems are present in and near vent area. A lava channel 1.5 km long is present on southeast flank of shield. Proximal, shelly-pahoehoe flows are smooth; local relief <1 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Medial and distal flows are characterized by many tumuli, pressure plateaus, and pressure ridges. Rock examined is porphyritic, containing plagioclase and olivine phenocrysts in a fine matrix. Subhedral, moderately zoned plagioclase phenocrysts are ≤3 mm and equant, partly skeletal olivine phenocrysts are ≤1.5 mm. Cumulophyric clots of plagioclase + plagioclase, plagioclase + olivine, and olivine + olivine are common. Matrix is olivine, plagioclase, and subophitic clinopyroxene crystals that are all ≤0.5 mm. Magnetite crystals are ≤0.45 mm and ilmenite crystals are ≤0.7 mm. Flows are mantled by ≤2 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 113±0 ka (table 2)

Qsbb29 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5317 lava field (late Pleistocene)**—Surface- and channel-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a small lava cone about 3.7 km southeast of main crater at Split Top shield volcano. Lava-cone vent may be a rootless vent on a lava-tube system of Split Top lava field. However, age relationships between flows from the two vents suggest that this is a separate vent. Lava-cone vent is almost entirely shelly pahoehoe; pyroclastic deposits are present locally in vent area. Proximal flows are smooth; local relief ≤2 m. Flows are mantled by ≤2 m of loess and eolian sand. Similarity in paleomagnetic directions suggests unit is related temporally to Split Top lava field (Qsbb28)

Qsbb30 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5252 lava field (late Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 1.3-km-long, slot-shaped depression that is about 100 m wide and 10 m deep. Elongated vent overlies a N. 30° W.-trending eruptive fissure. Vent area mantled by red, oxidized, and black, near-vent cinders, agglutinated spatter, and ash. Shelly pahoehoe is present as proximal flows. Southeast flank of vent area is covered by younger flows of Split Top lava field (Qsbb28). Proximal flows are smooth to rough; local relief 1–2 m. Rock examined is mostly equigranular. Stubby to intermediate, subhedral plagioclase crystals are as large as 3.5 mm; most are about 2 mm long; size range is 0.5–3.5 mm. Mostly equant olivine crystals are as large as 1 mm; most are 0.5–0.8 mm. Syntaxial bundles of plagioclase crystals are common. Subophitic blades and granules of clinopyroxene are ≤1 mm. Magnetite crystals are ≤0.5 mm; ilmenite crystals are ≤0.1 mm. Flows are mantled by ≤2 m of loess and eolian sand. K-Ar age is 209±47 ka (table 2)

Qsbb31 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 4902 lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a shallow (≤15 m) depression atop a low (<25 m high) lava cone. Red, oxidized, and black, near-vent pyroclastic deposits and minor amounts of shelly pahoehoe characterize the vent area. Pyroclastic deposits in vent area are cut by many non-eruptive fissures. Proximal flows are smooth; local relief ≤1.5 m. A major channel extends for about 1.5 km southwest of vent depression. Flows are mantled by ≤2 m of loess and eolian sand

Qsbb32 **Basaltic pahoehoe flows (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows. Vent area unknown. Flows are smooth to rough; local relief 2–3 m. Flows are mantled by ≤3 m of loess and eolian sand. Flows are cut by many non-eruptive fissures

Qsbb33 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 4892 lava field (late middle Pleistocene)**—Surface-, and channel-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Main vent area is a 485-m-long, 250-m-wide, shallow (≤10 m deep) vent depression atop a low (≤35 m high) cinder cone. Vent is elongated north-south. Vent area mantled by and red, oxidized, and black, near-vent pyroclastic deposits. Proximal flows are smooth; local relief ≤1.5 m. Cinder cone is surrounded by younger flows; only near-vent pyroclastic deposits and proximal flows are exposed. Unit is mantled by ≤2 m of loess and eolian sand

Qsbb34 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5329 lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Main vent area is a 135-m-long, slot-shaped depression that is about 50 m wide and ≤10 m deep. Elongated vent overlies a N. 5° W.-trending eruptive fissure. Main vent is at top of a lava cone that is 65 m above surrounding, younger flows. Vent depression is mantled by pyroclastic deposits and shelly-pahoehoe flows. Proximal flows have a relatively rough surface; local relief ≤3 m. Included in unit is a small outcrop associated with a N. 5° W.-trending, 145-m-long eruptive fissure about 2.2 km north of main vent area. Outcrop of eruptive-fissure deposits is separated from Vent 5329 area by a flow lobe of Horse Butte (Qsbb22) lava field. Eruptive-fissure area is mantled by red, oxidized, and black, near-vent cinders, agglutinated spatter, and ash. Flows and near-vent deposits are mantled by ≤3 m of loess and eolian sand

Qsbb35 **Basaltic pahoehoe flows (late middle Pleistocene)**—Surface- and channel-fed, medium-gray, pahoehoe basalt flows. Flows underlie Vent 5317 (Qsbb29) flows. Flows are mantled by ≤2 m of loess and eolian sand

Qsbb36 **Near-vent pyroclastic deposits and basaltic pahoehoe flows (Pleistocene)**—Chiefly red, oxidized, and black, near-vent pyroclastic deposits and shelly pahoehoe flows, and minor surface-, channel-, and tube-fed, dark-gray to medium-gray, pahoehoe basalt flows. Flows and pyroclastic deposits are covered by variable amounts of loess and windblown sand, thus unit is older than Holocene. No radiometric or paleomagnetic data exist for unit, thus definitive age designation cannot be given. Exposed in kipukas within COM lava field. Includes large kipukas such as New Butte (Qcc) and Bear Park in southeast quadrant of map, but also includes smaller kipukas in central part of COM lava field near Sheep Trail Butte (Qccc2) in northeast quadrant of map

Qsbb37 **Basaltic pahoehoe flows (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray to medium-gray, pahoehoe basalt flows. Source vents unknown. Present as isolated kipuka exposures of loess- and eolian sand-covered flows surrounded by Minidoka flows (Qcfb4) flows

Qsbc52 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Mosby Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray to medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a poorly defined, 700-m-long crater at top of a broad shield volcano. Vent depression is very shallow (<5 m). Vent area contains interlayered, oxidized, and black pyroclastic deposits and thin shelly-pahoehoe flows. Two short segments of a north-trending eruptive fissure, each about 100 m long, extend about 1.3 km north of the shallow vent depression. Vent area elongated north-south. Shield is about 160 m high. All flows are characterized by fairly rough surfaces; local relief ≤3 m. Distal flows are characterized by many tumuli, pressure plateaus, and pressure ridges. Proximal flows are smooth; local relief ≤2 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Rock examined is porphyritic, containing euhedral to subhedral phenocrysts of plagioclase ≤5 mm and subhedral to euhedral, mostly equant phenocrysts of olivine ≤1.4 mm in a fine matrix in which crystals are ≤0.3 mm. Cumulophyric clots of as many as 20 olivine crystals, olivine + plagioclase crystals, and waist texture are common. Olivine, plagioclase, and intergranular clinopyroxene ≤0.2 mm constitute matrix. Magnetite and ilmenite crystals are ≤0.4 mm; magnetite exceeds ilmenite in volume. Flows are mantled by ≤2.5 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 265±30 ka (table 2)

Qsbc53 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5083 lava field (late middle Pleistocene)**—Surface- and channel-fed, medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a low, roughly circular depression about 300 m in diameter and ≤5 m deep. A 200-m-wide channel extends for about 1.5 km northeast from vent area. Vent area is difficult to identify due to cover by alluvial deposits. Flows mostly covered by alluvial deposits, loess, and eolian sand

Qsbc54 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Rock Lake lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a roughly circular crater about 700 m in diameter and about 30 m deep atop a broad lava cone. Cone is about 50 m high. A slight elongation to the crater indicates that it overlies a N. 30° W.-trending eruptive fissure. Walls of crater are steep to vertical. Walls are mainly shelly-pahoehoe flows that are 0.1–2 m thick. Pyroclastic deposits are present locally around margins of vent area. Two prominent lava tube–skylight–rootless vent systems extend eastward from crater to eastern edge of map. Proximal flows and flows near rootless vents are smooth; local relief ≤2 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Rock examined is porphyritic, containing euhedral, partly skeletal phenocrysts of olivine as large as 4 mm. Cumulophyric clots of olivine + olivine are common. Matrix is subhedral, moderately zoned plagioclase laths ≤1.5 mm; subhedral, mostly equant crystals of olivine ≤0.5 mm; and intergranular to subophitic blades of clinopyroxene ≤2.5 mm. Magnetite crystals are ≤0.8 mm; ilmenite crystals are ≤0.1 mm. Ilmenite greatly exceeds magnetite in volume. Flows are mantled by ≤2.5 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 290±50 ka. K-Ar age is 182±172 ka (table 2)

Qsbc55 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5179 lava field (late middle Pleistocene)**—Surface- and channel-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a small vent at top of a lava/cinder cone about 1 km north of Gasten Beattie Well. Cone is about 30 m above surrounding flows. Vent is mantled by red, oxidized, and black, near-vent pyroclastic deposits and shelly-pahoehoe flows. All flows have relatively smooth surfaces; local relief ≤3 m. Flows mantled by ≤3 m loess and eolian sand. Unit is correlated temporally with Vent 5365 (Qsbc57) and Gasten Beattie (Qsbc56) vent flows because the three vents are on same north-south trend

Qsbc56 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Gasten Beattie lava field (late middle Pleistocene)**—Surface- and channel-fed, dark-gray and medium-gray, pahoehoe basalt flows and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a small vent at top of a lava/cinder cone. Cone is 30 m above surrounding flows. Vent is mantled by red, oxidized, and black, near-vent pyroclastic deposits and shelly-pahoehoe flows. All flows have relatively smooth surfaces; local relief ≤3 m. Flows are mantled by ≤3 m of loess and eolian sand. Unit is correlated temporally with Vent 5365 (Qsbc57) and Vent 5179 (Qsbc55) flows because the three vents are on same north-south trend

Qsbc57 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5365 lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a shallow (≤10 m deep), 160-m-long crater vent atop a lava cone. Crater is mantled by red, oxidized, and black, near-vent pyroclastic deposits and shelly-pahoehoe flows. A prominent lava tube–skylight system extends for about 700 m northeast of vent area. All flows have relatively smooth surfaces; local relief ≤3 m. Flows are mantled by ≤3 m of loess and eolian sand. Unit is correlated temporally with Vent 5179 (Qsbc55) flows and Gasten Beattie (Qsbc56) vent flows because all three vents are on same north-south trend

Qsbc58 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Mosby Well lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a 30-m-deep, nearly circular crater that is approximately 350 m in diameter. Crater is slightly elongated in a north-south direction. A 200-m-diameter, leveed lava lake is present at south end of crater. Crater walls are steep to vertical. Shelly-pahoehoe flows 0.5–3 m thick are exposed in crater walls. Near-vent pyroclastic deposits are exposed locally around vent area. Only proximal flows are exposed. Medial and distal flows are covered by flows from younger, nearby lava fields. Flows have relatively smooth surfaces; local relief ≤2.5 m. Rock examined is porphyritic, containing plagioclase and olivine phenocrysts in an ophitic matrix. Euhedral to subhedral, partly skeletal, mostly equant phenocrysts of olivine are ≤3.9 mm, and euhedral to subhedral, equant to intermediate laths of plagioclase are ≤3.6 mm. Cumulophyric clots of olivine + plagioclase, plagioclase + plagioclase, and cross-shaped plagioclase crystals are common. Matrix is olivine and plagioclase crystals mostly ≤0.5 mm, and anhedral, ophitic crystals of clinopyroxene that are ≤1.2 mm. Magnetite crystals are ≤0.5 mm and ilmenite crystals are ≤0.7 mm. Flows are mantled by ≤3 m of loess and eolian sand

Qsbc59 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Streifling lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a nearly circular crater that is approximately 180 m in diameter. Crater walls are shallow; vent is ≤10 m deep. Near-vent pyroclastic deposits are exposed locally around vent area. Flows have relatively smooth surfaces; local relief ≤2.5 m. Flows are mantled by ≤3 m of loess and eolian sand

Qsbc60 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5358 lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a nearly circular crater that is approximately 300 m in diameter and ≤10 m deep. Vent crater is elongated in a N. 35° E. direction. Crater is at top of a lava cone. Lava cone is about 65 m above surrounding flows. Crater walls expose shelly-pahoehoe flows 0.5–3 m thick. Near-vent pyroclastic deposits are exposed locally around vent area. Proximal flows have relatively smooth surfaces; local relief ≤2 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Rock examined is porphyritic, containing phenocrysts of euhedral, mostly equant olivine and subhedral plagioclase, both of which are ≤2 mm. Cumulophyric clots of olivine + olivine, olivine + plagioclase, and waist texture are common. Matrix of rock is olivine and plagioclase crystals that are both ≤0.5 mm; intergranular crystals of clinopyroxene ≤0.15 mm; and equant magnetite ≤0.15 mm. Flows are mantled by ≤3 m of loess and eolian sand

Qsbc61 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5374 lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 30° E.-elongated crater that is about 650 m long, 400 m wide, and about 15 m deep. Crater is at top of a lava cone. Lava cone is about 65 m above surrounding flows. Shelly-pahoehoe flows 0.5–3 m thick are exposed in crater walls. Near-vent pyroclastic deposits are exposed locally around vent area. Proximal flows have relatively smooth surfaces; local relief ≤2 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Lava field is characterized by two lava tube–skylight systems that lead to east, as far as 4 km from vent area. Rock examined is porphyritic, containing phenocrysts of stubby to intermediate, subhedral plagioclase ≤0.3 mm and euhedral, mostly equant, partly skeletal olivine ≤1.8 mm. Cumulophyric clots of olivine + plagioclase, and cross texture are common. Matrix is olivine and plagioclase crystals that are both ≤0.4 mm; intergranular crystals of clinopyroxene ≤0.3 mm; equant magnetite ≤0.25 mm; and elongated ilmenite ≤0.25 mm. Flows are mantled by ≤3 m of loess and eolian sand

Qsbc62 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Vent 5183 lava field (late middle Pleistocene)**—Surface-, channel-, and tube-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a N. 35° E.-trending, slightly elongated crater that is about 435 m long and ≤10 m deep. Crater is at top of a lava cone. Cone is about 45 m above surrounding younger flows from Vent 5374 (Qsbc61) lava field. Red, oxidized, and black, near-vent pyroclastic deposits are exposed widely around vent area. Shelly pahoehoe flows 0.5–3 m thick are locally exposed in crater walls. Proximal flows have relatively smooth surfaces; local relief ≤2 m. Medial and distal flows have rougher surfaces; local relief ≤3 m. Flows are mantled by ≤3 m of loess and eolian sand

Qsbc63 **Basaltic pahoehoe flows and near-vent pyroclastic deposits of Packsaddle Butte lava field (late middle Pleistocene)**—Surface-, channel-, and tube(?)-fed, dark-gray and medium-gray, pahoehoe basalt flows, shelly pahoehoe, and red, oxidized, and black, near-vent pyroclastic deposits. Vent area is a nearly circular crater that is approximately 585 m in diameter and approximately 30 m deep. Crater lies at top of a low (<30 m high) lava cone. Shelly-pahoehoe flows 0.5–3 m thick are exposed in crater walls. Near-vent pyroclastic deposits are exposed locally around vent area. Flows have relatively smooth surfaces; local relief ≤2 m. Only proximal flows are exposed; medial and distal flows are covered by younger flows that completely surround vent area. Rock examined is porphyritic, containing phenocrysts of subhedral to euhedral plagioclase ≤3.0 mm and euhedral to subhedral olivine ≤1.7 mm in a fine matrix of crystals ≤0.3 mm. Cumulophyric clots of as many as 10 olivine crystals, as many as 10 olivine + plagioclase crystals, and syntaxial clots of plagioclase crystals are common. Matrix is plagioclase and olivine crystals ≤0.3 mm; intergranular crystals of clinopyroxene ≤0.15 mm; equant, partly skeletal magnetite ≤0.3 mm; and elongated ilmenite crystals ≤0.4 mm. Flows are mantled by ≤3 m of loess and eolian sand. $^{40}Ar/^{39}Ar$ age is 340±15 ka (table 2)

VOLCANIC ROCKS ALONG NORTHWEST MARGIN OF EASTERN SNAKE RIVER PLAIN

Tiv **Idavada Volcanics (Miocene)**—Rhyolitic-crystal and lithic-crystal ash-flow tuffs and minor interbedded polymictic alluvial gravel. Ash-flow tuffs are grayish red, moderate red brown, moderate brown, dark yellowish brown, light gray, and black; weathers to similar colors. Tuff is densely welded to nonwelded and porphyritic to glomeroporphyritic. It contains 2–15 percent phenocrysts of feldspar, including sanidine and plagioclase (chiefly oligoclase-andesine), pyroxene, opaque iron oxides, and rare hornblende, biotite, and quartz. Local black vitrophyre zones are perlitic; lithic-rich layers contain rare pumiceous and common non-pumiceous vitric clasts. At least six emp1acement units are observed as multiple cooling units from coeval vents on the Snake River Plain (Moye, Leemann, and others, 1988; Lisa Morgan, USGS, oral commun., 1995). Cooling units are thick bedded to platy, have common zones of lithophysal cavities as long as 30 cm, have local flow lineations defined by elongation of vesicles, display rheomorphic flow features, and vary in thickness from 0 to150 m. Thin (<4 m) polymictic alluvial gravel, composed of subrounded to rounded pebble- to boulder-size clasts derived chiefly from the Copper Basin Group (Mississippian) and a lesser component of volcanic clasts derived from the Challis Volcanic Group, is cemented by an ash matrix. Gravel grades upward into light-gray or light-olive-gray, bedded ash deposits that are locally present between cooling units and at base (Tig). $^{40}Ar/^{39}Ar$ ages from sanidine and volcanic glass range from 8.77±0.07 Ma to 11.22±0.10 Ma for rhyolite ash flows (table 2). Sample localities shown on map. Locally, springs issue from the unconformable basal contact with the underlying Challis Volcanic Group. Tuffs at Queens Crown and vicinity, along west margin of quadrangle west of Little Wood River, are coextensive with the Picabo tuff of Schmidt (1962). Estimated thickness 0–260 m

Tig **Gravel (Miocene)**—Pebble- to boulder-size polymictic alluvial gravel at base of, and within, lower part of rhyolite ash-flow tuff unit (Tiv); mapped separately west of Long Canyon, northwest of Watercress Spring, and east of South Fork of Muldoon Creek. Thickness 0–20 m

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

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-shaped knobs as thick as 15 m (Bruce Otto, consultant, Boise, Idaho, written commun., 1992). Gossan on this map is interpreted to be a Tertiary(?) alteration product of impure limestone of the Hailey Member of the Wood River Formation. An Ordovician age is proposed by Otto and Zieg (2003), who considered the gossan to be related to mineralized layers in the Phi Kappa Formation (SOp) affected by alteration-related top intrusion of a Tertiary(?) biotite granite that was encountered at 61 m below the surface in a drill hole in Long Canyon

Challis Volcanic Group (Eocene)

Tcd **Rhyolite, leucogranite, and granite pegmatite and aplite dikes**—Light- to medium-gray, pinkish-gray, very pale orange, and light- to medium-brownish-gray, porphyritic to glomeroporphyritic rhyolite dikes. 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; and rare to common sedimentary rock xenoliths. Groundmass is fine- to medium-grained mixture of potassium feldspar and quartz. Hornblende leucogranite porphyry dikes, identified chiefly in Cottonwood Creek area, contain phenocrysts of rounded embayed phyric quartz as large 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 composed of orange-pink and moderate-pink, coarsely crystalline to aphyric quartz, orthoclase, biotite, and magnetite (Sidle, 1979).

Rocks weather light gray, yellowish gray, light orange, light greenish gray, and light to medium brownish gray. Chilled, black, glassy margins, locally brecciated, are present locally. Dikes commonly form resistant ridges oriented north to northeast. Dikes intrude Mississippian sedimentary rocks (Mca, Mcd, Mcl), and volcanic rocks of Challis Volcanic Group (Tcv), and locally they cut the biotite granite of Cottonwood Creek (Tcbg) and the hornblende diorite of Little Cottonwood Creek (Tchd) along north border of quadrangle (Sidle, 1979). Width of dikes is typically 1–2 m

Tcbg **Biotite granite of 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 described by Anderson (1929, p. 23). Weathers very light gray and pale pink; spheroidal weathering is common. Locally in fault contact with Copper Basin Group. Intrudes volcanic rocks (Tcv) of Challis Volcanic Group, and is intruded by a hornblende leucogranite porphyry dike (Tcd) (Sidle, 1979)

Tchd **Hornblende diorite of Little Cottonwood Creek**—Very light gray and pinkish-gray to greenish-gray, coarse-grained porphyritic diorite composed of 50 percent or more sericitized plagioclase phenocrysts as long as 2.5 mm; largely unaltered augite crystals; chloritized biotite pseudomorphs after hornblende and pyroxene; and magnetite, all in a matrix of quartz, feldspar, and epidote. Petrographic description is based on a single thin section. Rock weathers yellowish gray, pale greenish yellow, and light gray. Stock has been described as porphyritic hornblende granite (Anderson, 1929, p. 24), hornblende quartz monzonite (Sidle, 1979, p. 31–32), and hornblende quartz monzonite

(Kuntz and others, 1989a). Stock intrudes volcanic rocks (Tcv) of Challis Volcanic Group and is cut by granite pegmatite dikes (Tcd) (Sidle, 1979)

Tcv **Dacitic and andesitic volcanic rocks**—Dacitic, biotite-rich ash-flow tuffs and ash-fall tuffs, including the tuff of Stoddard Gulch (Skipp, 1989) at top; mixed biotite- and hornblende-rich dacite lava flows, lithic-crystal tuffs, tuff breccias, and minor interbedded volcaniclastic sedimentary rock in the middle; and pyroxene-rich andesite lava flows, tuff breccias, ash-flow tuffs, and interbedded volcaniclastic sedimentary rocks in the lower part form a generalized stratigraphic sequence. Biotite-rich, very light gray to light-olive-gray ash-flow and ash-fall tuffs are well exposed high in the cliffs east of the Little Wood River valley 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 north of Highway 93. Reddish-brown, lithic-rich, biotite ash-flow tuff, correlated temporally 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, purple, red, and greenish-gray dacitic lava flows, tuff breccia, ash-flow tuff, lithic-crystal tuff, and minor interbedded volcaniclastic rocks make up most of the Lake Hills and large parts of the ridges between South Fork Muldoon Creek and Fish Creek. Black, dark-gray, and greenish-gray andesitic lava flows, tuff breccia, and ash-flow tuff contain abundant pyroxene and hornblende, rare olivine, and rare to common plagioclase phenocrysts.

Andesitic rocks weather red brown and brownish gray. They are common in area north of Craters of the Moon National Monument, on ridges in the Fish Creek drainage area, and in Mints Canyon area; they are less common in the Lake Hills. Locally, andesites are interbedded with biotite-rich tuffs and volcaniclastic sedimentary rocks. Volcanic units in this area, erupted about 50–47 Ma (Snider and Moye, 1989; Snider 1995), do not include representatives of the third and final phase of Challis volcanism identified by Moye, Hackett, and others (1988), Snider and Moye (1989), and Snider (1995) in more northern parts of the southeastern Challis volcanic field. Maximum thickness of unit is about 425 m

Tcc **Basal conglomerate**—Light-gray to medium-gray, pebble to boulder conglomerate containing minor interbeds of very coarse to granule-size quartz sandstone; conglomerate weathers moderate brown to dark yellowish brown. Clasts, locally derived chiefly from Copper Basin Group, are rounded, commonly 6–10 cm in diameter, and 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 make 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; disconformably overlain by volcanic rocks (Tcv). Description is largely from 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). Maximum thickness ranges from 0 to 33 m (Larson, 1974)

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. Identified only in subcrop surrounded by basalt and in one small ledge of jasperoid adjacent to a Pleistocene travertine (Qt) 1.5 km northeast of Carey Lake. Thickness in this quadrangle is unknown. Unit I type section of formation in Pioneer Mountains north of quadrangle is more than 800 m thick (Mahoney and others, 1991)

Eagle Creek Member (Lower Permian to Middle Pennsylvanian)

PˈPweu **Upper part (Lower Permian to Upper Pennsylvanian)**—Siliceous sandstone, calcareous sandstone, sandy limestone, and minor conglomerate and siltstone. Siliceous sandstone is light brown and very light to medium gray; very fine grained to medium-grained particles are 0.04–0.4 mm in diameter; 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; medium to thick bedded; locally laminated and brecciated; sedimentary breccias are more abundant; tectonic breccias common. Calcareous sandstone and sandy limestone are brown to medium gray and fine grained; rocks consist of subrounded grains of quartz and accessory components similar to grains in siliceous sandstone, in a fine- to medium-grained, chiefly bioclastic, calcite matrix containing minor sericite and cryptocrystalline quartz; weathers brown and red brown; medium to thick bedded. Conglomerate is interbedded with siliceous sandstone only east of Fish Creek, in lower 150 m of unit; contains granule- to pebble-size clasts of chert, quartz, and quartzite as large 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.

Unit has gradational lower contact. No diagnostic fossils have been recovered from unit in this area. Unit forms ledges and talus-covered slopes. Correlated with units 5 and 6 of the Wood River Formation of Hall and others (1974) and with upper part of the Eagle Creek Member of Mahoney and others (1991). Description modified from Skipp and Hall (1975) and Larson (1974). More than 600 m thick in Fish Creek area

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.

Upper part: Limestone and calcareous sandstone are medium gray to medium dark gray and weather to same colors; rock contains very fine to coarse, 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 is 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 large as 5 cm in diameter but mostly smaller, in a limestone or siliceous sandstone matrix; clast-supported textures common; medium to thick bedding; forms lowest part of graded sequences; forms ledges and slopes. Conglomerate forms 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).

Lower part: Siltstone and mudstone are pale red and pale reddish purple. Thin to medium bedded; forms steep slopes. 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 pelmatazoan, 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 the Eagle Creek Member of Mahoney and others (1991). Estimated total thickness 350 m

ℙwh **Hailey Member (Middle Pennsylvanian)**—Limestone, sandy limestone, calcareous sandstone, interbedded conglomerate, and minor thin beds of dark-gray mudstone that weather pale reddish purple; limestone is medium gray to medium dark gray and weathers the same colors; limestone is micrite and fine- to medium-grained oolite-intraclast grainstone to packstone. Sandy limestone and calcareous sandstone are similar to rocks in lower part of the Eagle Creek Member (ℙwel).

Conglomerate is similar to that in unit ℙwel, except clasts are generally larger, as large 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. Correlated with units 1 and 2 of the Wood River Formation of Hall and others (1974). Estimated total thickness 200 m

Copper Basin Group (Mississippian)

Mca **Argosy Creek Formation (Upper and Lower Mississippian)**—Chiefly proximal and distal turbidites and interturbidites of interbedded quartzite, argillite, siltite, and conglomerate, in order of decreasing abundance (Larson, 1974; Skipp and Hall, 1975).

Quartzite is very light to medium gray on fresh surfaces and 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 predominantly siliceous or sericitic matrix containing minor amounts of opaque iron oxides and carbonaceous material. Quartz grains have common silica overgrowths and concavo-convex to sutured borders, and penetrate less competent lithic fragments. Medium to thick bedded; locally graded, laminated, and crossbedded; load casts, sole markings, and ripple marks are common; well-developed fracture cleavage. Common gradational upper contacts; forms ledges and steep slopes.

Argillite and siltite are dark gray to medium gray and weather light olive gray, moderate brown, and grayish brown. They 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-2), in a mudflow deposit high in the section in N1/2, NE1/4, SE1/4 sec. 33, T. 2 N., R. 23 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. *Dimelaglasma D. eurekensis* (Lintz and Lohr), and *Eumetria* sp.; indicating a late Meramecian or early Chesterian age (J.T. Dutro, Jr., U.S. Geological Survey, written commun., 1978, 1993; Larson, 1974). Conodonts from site F-1 were identified as late Kinderhookian in age (C.A. Sandberg, U.S. Geological Survey, written commun., 1994). Forms slopes except where locally silicified to jasperoid (Tj).

Conglomerate is light gray to dark gray and weathers pale brown, moderate brown, and grayish red. Granule- to cobble-size clasts are as large as 20 cm in diameter. In descending order of abundance, largest clasts are varicolored light- to dark-gray, light-olive-gray, grayish-orange, and dark-yellowish-orange, angular to subangular chert; medium-dark-gray, light-gray, and grayish-orange, subangular argillite; light-brownish-gray siltstone; and subrounded to rounded light-gray quartzite. 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- to 50-cm blocks of laminated argillite in random orientation indicate post-depositional slumping. Thick to very thick bedded; common graded bedding. Gradational contact with underlying Drummond Mine Limestone Member (Mcd). Forms ledges and steep slopes.

Comprises the Scorpion Mountain and Muldoon Canyon Formations and Brockie Lake Conglomerate of Larson (1974). Estimated minimum thickness 2,185 m (Larson, 1974)

Mcd **Drummond Mine Limestone (Lower Mississippian)**—Chiefly limestone turbidite lenses (Nilsen, 1977) interbedded with calcareous sandstone and quartzite above Fish Creek Reservoir (Skipp and Hall, 1975) and argillite and chert near head of East Fork of Fish Creek (Larson, 1974).

Limestone is medium to dark gray, pale red, and yellowish brown and weathers dark yellow orange, pale yellowish brown, medium light gray, and light olive gray. Limestone is aphanitic to conglomeratic micrite, including spiculite and biomicrite; as much as 40 percent argillaceous and carbonaceous material; and intramicrite containing clasts of micrite as large as 7 mm in diameter and fossil fragments in a lime mud matrix. Thin to medium bedded (0.2–0.8 m).

Sandstone is medium gray to light brown, calcareous, and fine grained. Quartzite is dark gray and laminated; 1.5 m thick near base of unit above Fish Creek Reservoir. Argillite is grayish black to dark gray, interlaminated with light-gray, silty, argillaceous chert. 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 East Fork of Fish Creek yielded Kinderhookian conodonts and foraminifers (Larson, 1974; Skipp and Hall, 1975). A new collection from site F-3 contained upper Kinderhook conodonts (C.A. Sandberg, U.S. Geological Survey, written commun., 1994). Gradational basal contact with Little Copper Formation (Mcl). Forms low ledges. Total measured thickness of unit is 34 m above Fish Creek Reservoir (Skipp and Hall, 1975). Minimum measured thickness is 107 m at head of East Fork of Fish Creek (Larson, 1974), but base not exposed

Mcl **Little Copper Formation (Lower Mississippian)**—Chiefly turbidites consisting of, in decreasing order of abundance, interbedded light- to medium-dark-gray quartzite; grayish-black, brown, and pale-red mudstone and siltstone; and minor granule to cobble conglomerate. Quartzite 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 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 some places; thin bedded to laminated. *Helmenthoides* feeding trails, flattened coiled ammonoid, gastropod, and woody plant impressions are present but rare on bedding surfaces. Ammonoids from near base are probably Early Mississippian in age (McKenzie Gordon, Jr., U.S. Geological Survey, written commun., *in* Skipp and Hall, 1975).

Conglomerate is light to dark gray and weathers pale brown and moderate brown. Clasts, as large as 8 cm in diameter, of subangular to subrounded 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 the Picabo Formation north of Fish Creek Reservoir is part of a regional unconformity (Skipp and Bollmann, 1992). Measured thickness above Fish Creek Reservoir is 372 m (Skipp and Hall, 1975)

Dp **Picabo Formation (Upper Devonian)**—Interbedded dolomitic sandstone, sandy dolomite, sandy dolomite-pebble conglomerate, and minor calcareous sandstone. Dolomitic sandstone and sandy dolomite are medium light gray to dark gray and pale yellowish brown. Weathers pale yellowish brown, medium dark gray to light gray, and light olive gray. Chiefly fine grained. Laminated and medium to thick bedded; load casts common, crossbeds rare. Forms ledges and steep slopes.

Sandy dolomite-pebble conglomerate is medium light gray to pale yellowish brown; weathers chiefly pale yellowish brown. Dolomite pebbles are bimodal; larger pebbles are well rounded, subtabular, as large as 12.5 cm in diameter. Smaller pebbles are subrounded and average 6 mm in diameter. Both clast sizes are light gray to grayish black and aphanitic to coarsely crystalline; clasts were derived from underlying Jefferson Formation (Dj) and Carey Dolomite (Dc). Matrix of conglomerate is fine- to medium-grained dolomitic quartz sandstone. Thick bedded (2–3 m); forms ledges and steep slopes.

Calcareous sandstone is 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 near top of formation at Timbered Dome (Skipp and others, 1990), about 10 km northeast of Fish Creek Reservoir, indicate a Late Devonian (Famennian) age (Sandberg and others, 1989). Covered lower contact with Jefferson Formation (Dj). 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. Formation is divided into six units (not mapped here), in descending order: (1) yellow vuggy dolomite, (2) banded dolomite, (3) black dolomite, (4) blue dolomite, (5) silty dolomite, and (6) basal dolomite breccia and sandy dolomite conglomerate; units 1–5 deposited in fluctuating intertidal and subtidal environments.

Dolomite is medium gray to grayish black, pale yellowish brown, and 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; local vugs. Fossiliferous (conodonts, corals, brachiopods, stromatoporoids, and boney fish).

Basal breccia is medium gray; weathers light gray to light olive gray. Breccia clasts are as large 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 (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 with Carey Dolomite (Dc). 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, and mud-chip conglomerate; rare quartz sand and silt grains. Sparsely fossiliferous (conodonts, corals, brachiopods, and crinoid ossicles). Early Middle Devonian (Eifelian) conodonts recovered from lower beds (Skipp and Sandberg, 1975). Deposited chiefly in intertidal and supratidal (and, 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 **Roberts Mountains Formation (Lower Devonian and Upper Silurian)**—Limestone and phenoplast conglomerate interbedded with calcareous siltstone and silty limestone. Upper part is phenoplast conglomerate or intraformational sedimentary limestone breccia composed of subangular to subrounded fragments, as large as 25 cm in diameter, of bioclastic limestone and encrinite; intraformational clasts 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 is medium gray, medium grained to coarse grained, and medium bedded; siltstone is 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)

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 is obscured by well-developed cleavage that is 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 that is part of Dover's (1981) unnamed Silurian and Devonian unit in the Pioneer Mountains about 40 km northwest of Fish Creek Reservoir. Present only in Long Canyon–Mints Canyon area. Estimated minimum thickness 200 m, but neither base nor top exposed

St **Trail Creek Formation (Middle to Lower 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. No fossils known. Sandstone ledges form lenses or tectonic slices in gray shaly siltstone. Outcrops are veined with quartz. Lower contact conformable with medium-gray-weathering shaly siltstone assigned to Phi Kappa Formation (SOp). Overlain unconformably by Hailey Member (ℙwh) of Wood River Formation. Mapped only on ridge between Long and Mints Canyons. Estimated minimum thickness 20 m

SOp **Phi Kappa Formation (Middle Silurian to Lower Ordovician)**—Chiefly dark-gray argillite; locally silicified chert, siltstone, sandstone, minor granule conglomerate, and silicified limestone.

Upper part is chiefly dark-gray argillite and siltstone, but includes chert, conglomerate, and silicified limestone. Argillite and siltstone are chiefly dark gray and carbonaceous. Locally oxidized light gray; weathers pale brown and moderate brown; local silver phyllitic sheen. Thin bedded to banded; local load casts, graded beds, and 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., *Glytograptus?* 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 is silicified, banded, and medium light gray to dark gray; weathers grayish orange; thin bedded; poorly exposed on slopes beneath Trail Creek Formation (St). Chert, ferruginous chert, and siliceous argillite are dark gray, grayish red, and moderate brown; weather same colors or light gray to yellowish gray; laminated or thin bedded to thick bedded; forms cliff; blocky to chippy talus on slopes below outcrops. Unit contains stratigraphically controlled gossans associated with thin- to thick-bedded chert (units Og and Oc of Otto and Zieg, 2003).

Lower part is sandstone and granule conglomerate. Sandstone is medium dark gray; weathers medium dark gray to moderate brown; very fine to medium grained, siliceous cement; thick bedded; forms ledges. Granule conglomerate is 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 is intruded by biotite granodiorite 61 m below surface in Long Canyon (Otto and Zieg, 2003). Gradationally overlain by Trail Creek Formation (St) or unconformably overlain by Hailey Member of Wood River Formation (ℙwh). Entire unit folded, both megascopically and microscopically. Estimated minimum thickness 210 m

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