Geologic Maps of the Moody, White Owl Butte, and Wright Creek Quadrangles, Madison and Teton Counties, Idaho

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Idaho Geological Survey
Third Floor, Morrill Hall
University of Idaho
Moscow, Idaho 83843-3014

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INTRODUCTION

The southern margin of the Eastern Snake River Plain near Rexburg, Idaho consists of a gently rolling, loess-covered plateau known locally as the Rexburg Bench. The first detailed geologic maps of this area were published in the 1970s at scales of 1:125,000 (Prostka and Hackman, 1974) and 1:48,000 (Prostka and Embree, 1978). Unpublished mapping was also conducted by D. Doherty. The mapping presented in this report provides the first published 1:24,000-scale geologic maps of much of the Rexburg Bench. The mapping was conducted intermittently between about 1978 and 2014.

Thick loess deposits blanket over 99% of bedrock in the map area, obscuring a sequence of basalt eruptive units underlain by the rhyolitic Huckleberry Ridge Tuff. Using isolated outcrops, we have distinguished and correlated basalt units based upon petrology and petrography, remanent magnetization, composition, and $^{40}Ar/^{39}Ar$ ages. Additional constraints on the extent of individual flow fields, flow-vent correlations, and relative ages were obtained with water well logs (Idaho Department of Water Resources, 2016) and vertically exaggerated hillshades of 10-m digital elevation models (Moore and Embree, 2014). The basalts were erupted from small shield volcanos (Bitters Butte, Canyon Creek Butte, and White Owl Butte) and from the Sommers Butte volcanic rift that we interpret as an extension of the Grand Valley normal fault (Piety and others, 1992).

The geologic maps are displayed in Plates 1 through 3. Cross sections are shown on Plate 4. The age relationships of units are indicated on the Correlation Diagram (Figure 1). Full-scale map and cross section plates are available as digital (PDF format) files at www.idahogeology.org. Simplified map explanations are used on the map plates. More detailed unit descriptions are given below. Unit descriptions are modified after Prostka and Embree (1978) with additional details taken from 1:24,000-scale maps of several adjacent quadrangles where the same units are exposed. The southeastern portion of the Wright Creek quadrangle was mapped by Price and Rodgers (2010) and is not included in this work.

1. Department of Geology, Brigham Young University–Idaho, Rexburg, ID 83460–0510
2. Idaho Geological Survey, University of Idaho, Moscow, ID 83844-3014
3. U.S. Geological Survey (deceased)

COMBINED CORRELATION OF MAP UNITS FOR THE MOODY, WHITE OWL BUTTE, AND WRIGHT CREEK QUADRANGLES

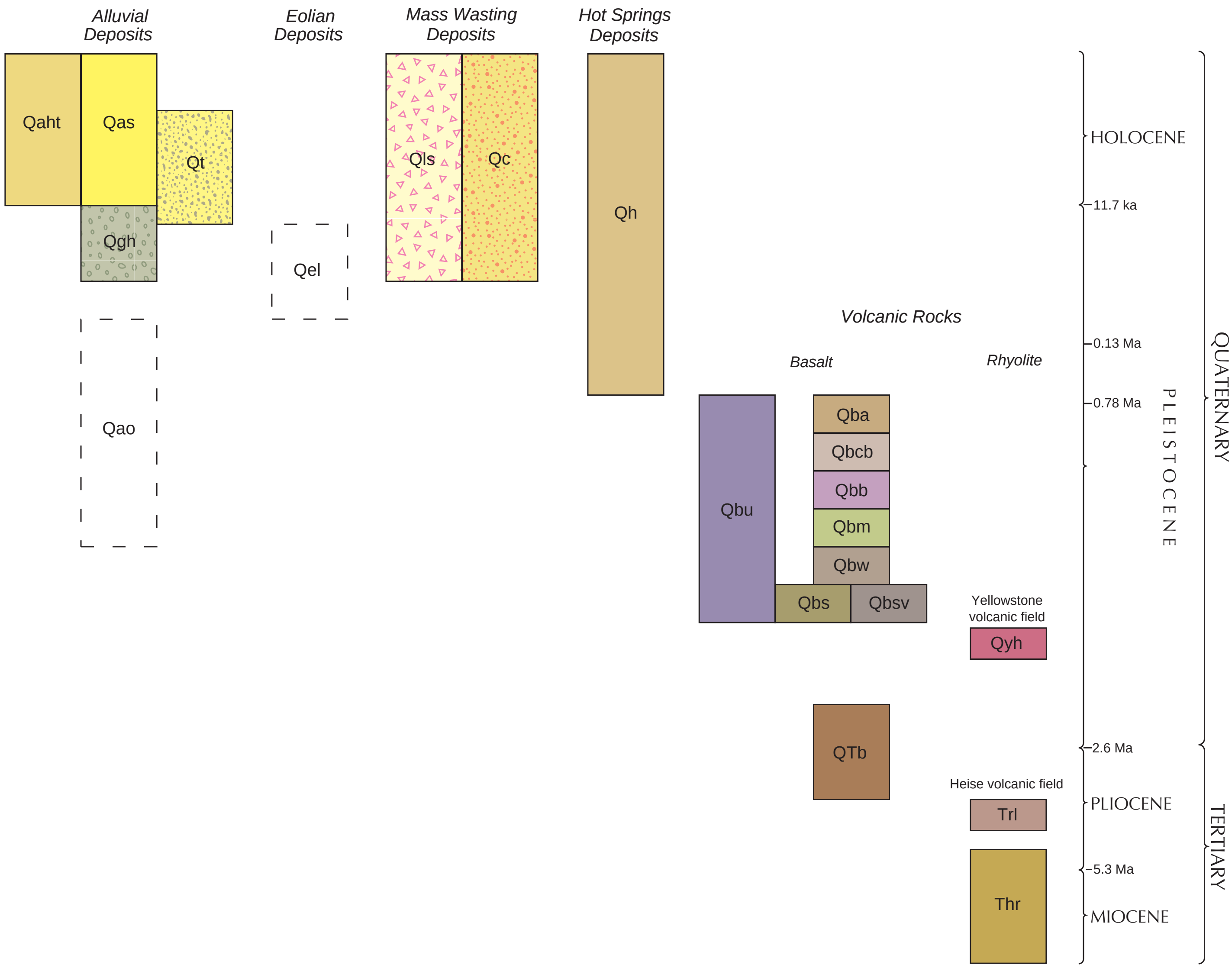

Figure 1. *Combined correlation of map units for the Moody, White Owl Butte, and Wright Creek quadrangles.*

DESCRIPTION OF MAP UNITS

SEDIMENTARY AND MASS MOVEMENT DEPOSITS

ALLUVIAL DEPOSITS

Qaht—Alluvium of South Fork Teton River (Holocene)—Gravel, sand, silt and clay of the active floodplain of the South Fork Teton River. Gravel clasts consist of rhyolite, basalt, quartzite, gneiss, and obsidian. Thickness is generally <9 m (<30 ft). Also consists of thin, unmapped deposits from the 1977 Teton Dam failure (Scott, 1977; Phillips, 2012). Subject to seasonal flooding and standing water.

Qas—Alluvium of Moody Creek, Canyon Creek, and unnamed side streams (Holocene)— Basaltic and rhyolitic gravel, sand, and silt; thickness generally <3 m (<10 ft).

Qt—Stream terraces (Holocene-Late Pleistocene)—Sand, clay, and gravel in terraces separated by 1.5 to 3 m (5 to 10 ft) scarps from active floodplains. Thickness generally <3m (<10 ft) in Moody quadrangle and as much as 30 m (100 ft) in the Wright Creek quadrangle.

Qgh—Gravelly outwash of the Henrys Fork and South Fork Teton River (Late Pleistocene)— Massive to thickly bedded, well-rounded cobble to pebble gravel, with an open-framework filled by subangular sand. Gravel clasts consist of rhyolite, basalt, quartzite, gneiss, and obsidian. Beds of thinly cross-bedded, coarse to medium, sub-angular sand commonly separate gravels. Sand is composed of obsidian, quartz and feldspar derived from rhyolite phenocrysts, muscovite, and fragments of basalt, rhyolite, and quartzite (Phillips and others, 2016). Thickness of gravels above basalt in water well logs is 20 to 63 m (60 to 190 ft;). The gravels are braided stream outwash from glaciation of the headwaters of the Henrys Fork and Teton River (Scott, 1982).

Qao—Older Alluvium of the Teton River (Late Pleistocene-Middle Pleistocene)—Poorly exposed loess, gravel, sand, and clay. Water well logs indicate thickness is about 5 to 14 m (16 to 45 ft; Phillips, 2012).

EOLIAN DEPOSITS

Qel—Loess (late Pleistocene)—Massive, light gray to light brownish gray silt, clay, and very fine sand; calcareous except where leached; carbonate-silica duripan locally present. Thickness is <1.5 m to >10 m (<5 ft to >32 ft). Thin loess (not mapped) also covers parts of *Qao*, *Qgh*, and *Qt*. Derived from deflation of fine-grained sediment from outwash deposits along the Henrys Fork and Teton River by northeast directed winds during glaciation of the Snake River headwaters (Phillips and others, 2016; Scott, 1982). Several depositional units of loess separated by buried soils are present in the eastern Snake River Plain (Pierce and others, 1982) and may be present in map area. Ages derived from luminescence dating indicate regional loess deposition occurred between 25 to15 ka, 46 to 36 ka, ~79 to 68 ka, and ~140 to 130 ka (Pierce and others, 2011; Phillips and others, 2009).

MASS MOVEMENT DEPOSITS

Qc—Colluvium (Holocene-late Pleistocene)—Blocky talus derived from *Qyh* mixed with *Qel*. Thickness estimated at <5 m (<16 ft).

Qls—Landslide (Holocene-late Pleistocene)—In Canyon Creek of the Wright Creek quadrangle, consists of rotational failures of *Qyh* over unmapped sediments. Springs are present along this contact. Thickness of landslides estimated at 35 m (115 ft). No active scarps or scars visible on aerial imagery. In the Moody quadrangle, consists of active small slumps <3 m (10 ft) thick along stream cutbanks.

HOT SPRINGS DEPOSITS

Qh—Travertine (Holocene-middle Pleistocene?)—Travertine forming the hot springs mound of Pincock (now called Green Canyon) Hot Springs. Estimated thickness is about 40 m (130 ft). Temperature reported to be 44°C (Dansart and others, 1994). Lime for use in mortar for construction of sugar factory in Sugar City, Idaho was reportedly produced from "limestone" at the Pincock Hot Springs in 1903. Hot springs discharge was "about five cubic feet/sec at mouth of the spring" in 1898 (Neibaur, 2003).

VOLCANIC ROCKS

BASALTS

Qba—Basalt of Ards Farm (early Pleistocene)—Light- to medium-gray fine-grained basalt with rare plagioclase phenocrysts <2 mm and patchy areas of diktytaxitic texture. Shown as *Qel/Qba* where concealed by loess. Thickness ranges from 3 to 10 m (10 to 32 ft). Erupted from concealed north-south trending fissure vent in the adjacent Drummond quadrangle (sec. 31, T. 7 N., R. 44 E; Feeney and others, 2014). Normal magnetic polarity. The thick loess cover away from canyon edges and presence on both sides of the Teton River canyon suggest eruption prior to major stream incision during the Olduvai normal subchron at 1.79-1.95 Ma, rather than during the Brunhes normal chron after 0.78 ka. The name 'Ard Farms' was first applied to this unit by Prostka and Embree (1978); it does not appear on U.S Geological Survey 1:24,000-scale topographic maps.

Qbcb—Basalt of Canyon Creek Butte (early Pleistocene)—Dark-gray, fine-grained diktytaxitic basalt with (1-3 mm) phenocrysts of plagioclase and olivine composing 5 to 10 percent of the rock (Proskta and Embree, 1978). Shown as *Qel/Qbcb* where concealed by loess. Water well logs indicate thickness of 8 to 20 m (27 to 67 ft). Reversed magnetic polarity.

Qbb—Basalt of Bitters Butte (early Pleistocene)—Flows and cinder deposits lithologically similar to unit *Qbs* (Prostka and Embree, 1978). Shown as *Qel/Qbb* where concealed by loess. Bitters Butte has maximum relief of 27 m (89 ft). It has an asymmetrical cross-section with the steep side on the northeast, suggesting influence by regional northeast-directed winds. Water well logs indicate that flows range in thickness from 9 to 26 m (30 to 84 ft) with cinders present both above and below flows. Reversed magnetic polarity.

Qbm—Basalt of Moody (early Pleistocene)—Medium-gray, fine-grained, locally diktytaxitic basalt with sparse phenocrysts of plagioclase as much as 5 cm in length and 7 to 10 percent olivine (Prostka and Embree, 1978). Shown as *Qel/Qbm* where concealed by loess and *Qao/Qbm* where concealed by older alluvium of Teton River. Flow thickness ranges between about 18 m to 43 m (60 ft to 140 ft). Concealed fissure vent in the White Owl Butte quadrangle (lat. 43.7977° N., long. 111.5593°W.) is a narrow ridge trending north-south. Reverse magnetic polarity.

Qbw—Basalt of White Owl Butte (early Pleistocene)—Medium- to dark-gray, aphantic to fine-grained, locally diktytaxitic basalt with locally abundant phenocrysts of plagioclase 1-2 mm and sparse phenocrysts of olivine <1mm (Prostka and Embree, 1978). Shown as *Qel/Qbw* where concealed by loess. Thickness in vent area from water well logs is about 25 m (82 ft). Reversed magnetic polarity.

Qbs—Basalt of Sommers Butte volcanic rift zone (early Pleistocene)—Dark greenish-gray basalt, fine-grained, dense to vesicular with abundant reddish-brown olivine 0.25-0.5 mm. Shown as *Qel/Qbs* where concealed by loess. Erupted from vents along a 22 km (13 mi) volcanic rift. Extent of flows mostly mapped with water well logs and geomorphic criteria. Basalt is generally thicker within the rift graben where it is up to 98 m (320 ft) thick and occurs with black and red cinders. Basalt thins away from the rift graben to about 20 to 6 m (70 to 20 ft). Basalt from multiple vents flowed down Lyons Creek in the adjacent Heise quadrangle where it interacted with the Snake River to form phreatomagmatic deposits (Phillips and others,2016). Reverse magnetic polarity. Dated by whole rock step-heated $^{40}Ar/^{39}Ar$ analyses at about 2.0 Ma.

Qbsv—Vents of Basalt of Sommers Butte volcanic rift zone (early Pleistocene)—Small lava and cinder cones 11 to 45 m (36 to 150 ft) high contained with rift graben. Most vents have asymmetrical cross-sections with steep sides on the northeast, suggesting influence by regional northeast-directed winds during eruptions. Includes poorly exposed red to brown cinders and ash adjacent to vents. Dated by whole rock step-heated $^{40}Ar/^{39}Ar$ analyses at about 2.0 Ma.

Qbu—Basalt, unnamed and undivided (Pleistocene)—Dark-gray unnamed basalt lava flows limited areal extent and uncertain correlation; post-*Qyh* in age.

QTb—Basalt, undivided (early Pleistocene-Pliocene)—Dark-gray columnar-jointed lava flows of massive and diktytaxitic basalt containing phenocrysts of plagioclase and olivine. May be correlative to the Pliocene basalt of Rexburg which is exposed in the nearby Rexburg and Ririe quadrangles (Phillips and others, 2016; Phillips and others, 2014).

RHYOLITES

Qyh—Huckleberry Ridge Tuff (early Pleistocene)—Light-gray to grayish pink, densely welded devitrified rhyolite tuff with well-developed eutaxitic texture. Shown as *Qel/Qyh* where concealed by loess. Major phenocrysts are sanidine and quartz with lesser plagioclase and pyroxene.

Phenocrysts are more abundant (20 to 30 percent) in lower part of unit, becoming smaller and less numerous (<5 percent) near the top. Maximum exposed thickness is about 100 m (328 ft). Locally present above the major unit is thin (<5 m, <16 ft) crystal-rich vitric welded tuff, with unflattened white and pink pumice, and distinctive black shards in an orange matrix (Prostka and Embree, 1978). Excursional magnetic polarity with subhorizontal inclination (Reynolds, 1977). Three Huckleberry Ridge Tuff members (A, B, and C) were erupted from the Big Bend Ridge caldera in the Yellowstone volcanic field (Christiansen, 2001). Most exposures in the mapped area are probably Member A (Colin Wilson, written commun., 2015) except for the uppermost unit, which may be Member B. Recently measured ages from single-crystal laser-fusion $^{40}Ar/^{39}Ar$ analyses of sanidine range from 2.123 ± 0.006 Ma (Ellis and others, 2012) to 2.0794 ± 0.0046 (Rivera and others, 2014).

Trl—Rhyolite of Long Hollow (Pliocene)—Rhyolite lava flow consisting of red and black perlitic vitrophyre with abundant phenocrysts (10 to 20 percent of rock) of sanidine, quartz, plagioclase, and pyroxene (Prostka and Embree, 1978). Shown as *Qel/Trl* where concealed by loess. Contains zones of flow breccia consisting of black clasts in red matrix. Flow banding and lithophysae zones are commonly oriented near-vertically. Locally, rhyolite is devitrified and highly contorted, with white and dark gray flow banding. Near top of unit, grades into pink tuff with black shards and vitrophyre clasts. Maximum thickness about 140 m (460 ft). Dated at 3.5 ± 0.4 Ma by fission track on zircons (Morgan and others, 1984); and at 4.28 ± 0.18 Ma by U-Pb in zircons (Bindeman and others, 2007).

Thr—Heise volcanic field rhyolites (Pliocene-Late Miocene)—Welded and unwelded tuffs, lava flows, and intercalated fluvial and lacustrine sediments (Morgan and McIntosh, 2005). Not exposed in mapped area; shown only in cross sections. Minimum thickness beneath the Rexburg Bench of about 960 m (3150 ft) is based on the Madison County geothermal well (Kunze and Marlor, 1982). Thickness could be much greater if calderas are present.

TABLES

Table 1. Paleomagnetic data of basalts from the Moody, White Owl Butte, and Wright Creek quadrangles. Unit *Tbr* is the basalt of Rexburg (Phillips and others, 2016; Phillips and others, 2014).

Unit	Site	Lat. (N)	Long. (E)	*P*	*I*	*D*	N/N_0	α_{95}	*k*
Qba	3659B	43.854°	-111.446°	n	334.5°	66.1°	8/8	3.6°	240
Qba	3739B	43.899°	-111.461°	n	344.7°	64.1°	7/8	1.8°	1162
Qba	8629B	43.883°	-111.304°	n	336.1°	63.1°	8/8	3.3°	314
Qba	8709B	43.852°	-111.263°	n	329.5°	63.1°	7/8	2.4°	330
Qbcb	3579B	43.829°	-111.509°	r	147.7°	-66.4°	8/8	1.4°	1642
Qbcb	RBKF11#	43.856°	-111.563°	r	142.3°	-69.3°	8/8	7.6°	263
Qbcb	RBLH11#	43.816°	-111.546°	r	170.4°	-67.1°	8/8	4.3°	171
Qbb	3189B	43.863°	-111.370°	r	175.2°	-58.6°	8/8	2.5°	585
Qbm	3499B	43.904°	-111.567°	r	157.5°	-69.3°	8/8	2.2°	640
Qbm	RBCC11#	43.857°	-111.478°	r	150.7°	-65.6°	8/9	1.7°	1124
Qbm	RBMC11#	43.831°	-111.639°	r	172.1°	-71.1°	7/8	2.3°	667
Qbw	3899B	43.764°	-111.560°	r	160.3°	-64.8°	8/8	2.9°	415
Qbs	3979B	43.798°	-111.719°	r	163.7°	-79.4°	7/8	3.1°	508
Qbs	4379B	43.682°	-111.739°	r	130.3°	-86.2°	8/8	3.1°	373
Qbsv	4059B	43.797°	-111.708°	r	117.0°	-77.5°	7/8	2.8°	357
Tbr	4139B	43.798°	-111.773°	r	194.1°	-60.3°	6/8	6.4°	80
Tbr	4219B	43.761°	-111.804°	r	191.1°	-64.6°	8/8	1.7°	1014
Tbr	4299B	43.720°	-111.751°	r	194.1°	-61.6°	6/8	2.8°	672
Tbr	08P02 #	43.729°	-111.761°	r	194.0°	-61.5°	8/8	2.3°	587
Tbr	08P03 #	43.773°	-111.693°	r	201.2°	-56.4°	7/8	6.5°	88

Notes: Characteristic component of Natural Remanent Magnetization (ChRM) determined by line fit on vector component diagrams in response to alternating-field demagnetization. Site is field site identification number. Multiple oriented cores were drilled at each site and analyzed to obtain: mean site P, polarity (n-normal or r-reversed); mean I and D, inclination and declination; N/N_0, number of samples averaged/number of samples collected; α_{95}, angular radius of 95% confidence; and k, precision parameter. Samples marked by "#" were analyzed by V. Thornton and W. Phillips in 2012 at the Idaho Geological Survey; other samples were measured by D. Champion in 2012 at the United States Geological Survey, Menlo Park, CA.

Table 2. Whole-rock compositions of basalts from the Moody, White Owl Butte, and Wright Creek quadrangles. X-ray fluorescence analyses conducted at BYU, Provo, Utah; LOI and major oxides (wt %); trace elements (ppm). Unit Tbr is the basalt of Rexburg (Phillips, and others, 2016; Phillips and others, 2014).

Unit	Qbs/Qbsv		Qbw	Qbm				Qbb	Qbcb	Qba.	Tbr			
Sample	RB-7	RB-1	RB-3	3499B	TC-001	TC-002	TC-003	RB-2	RB-4	RB-5	4139B	4219B	4299B	RB-6
Lat. (N.°)	43.797	43.682	43.764	43.904	43.905	43.905	43.905	43.863	43.829	43.899	43.798	43.761	43.720	43.716
Long. (E.°)	111.708	111.739	111.560	111.567	111.569	111.569	111.569	111.589	111.509	111.461	111.773	111.807	111.751	111.749
SiO_2	49.31	49.39	49.88	45.07	45.63	45.92	46.32	45.80	48.22	47.75	47.17	47.09	46.77	48.08
TiO_2	3.63	3.52	2.28	3.81	4.17	4.14	4.20	4.42	3.63	2.51	1.90	1.98	2.97	2.15
Al_2O_3	14.13	14.35	15.85	14.16	15.13	14.86	14.60	13.68	14.18	16.04	16.91	16.76	14.94	16.37
FeO_t	15.39	15.02	11.62	15.81	14.44	14.56	14.83	16.84	15.13	14.43	12.36	12.63	14.52	12.86
MnO	0.28	0.27	0.18	0.23	0.24	0.24	0.24	0.28	0.25	0.24	0.18	0.19	0.21	0.20
MgO	4.24	4.40	6.28	6.62	5.86	5.57	5.13	5.92	5.32	6.52	7.96	7.80	6.76	7.28
CaO	8.23	8.31	10.87	9.39	9.94	10.02	9.16	9.72	9.40	9.86	10.02	10.06	10.03	10.27
Na_2O	1.85	1.90	2.28	2.75	2.86	2.83	3.01	1.48	1.80	1.89	2.85	2.86	3.01	2.11
K_2O	1.73	1.70	0.41	0.80	0.68	0.78	1.07	0.82	1.10	0.37	0.32	0.31	0.41	0.37
P_2O_5	1.20	1.12	0.34	1.35	1.05	1.09	1.44	1.04	0.98	0.39	0.31	0.33	0.38	0.30
TOTAL	99.41	99.08	101.21	99.20	95.71	96.03	95.15	99.17	99.35	99.80	99.28	99.40	99.35	99.27
LOI	-0.59	-0.92	1.21	-0.80	-1.01	-0.72	-1.08	-0.83	-0.65	-0.20	-0.72	-0.60	-0.65	-0.73
V	157	167	255	310	321	318	313	298	248	319	272	278	327	275
Cr	11	22	244	153	168	142	74	91	70	65	77	84	58	80
Ni	3	11	60	69	65	61	45	43	44	95	107	99	78	90
Ga	27	27	24	21	20	20	18	23	25	22	20	20	23	23
Rb	34	32	4	14	10	12	17	10	18	1	5	4	7	4
Sr	341	348	442	303	278	284	280	279	297	273	278	275	255	259
Y	67	68	38	56	57	61	67	62	78	40	28	30	37	32
Zr	501	488	203	442	417	452	530	447	584	198	155	162	198	166
Nb	46	45	22	46.9	43.4	47.5	57.2	46	60	21	13.9	15.3	18.3	16
Ba	1286	1220	820	656	633	641	750	723	877	510	227	252	288	287
La	55	55	31	55	49	53	66	50	70	22	19	16	19	18
Ce	101	104	65	120	87	95	112	88	138	46	35	40	42	36
Nd	55	54	31	60	39	42	42	52	62	27	18	20	24	23

Table 3. Estimated ages of volcanic units from the Moody, White Owl Butte, and Wright Creek quadrangles.

Unit	Age (Ma)	Type	Reference
Qba	1.77 - 1.95	normal magnetic polarity correlated with Olduvai normal subchron at 1.77-1.95 Ma	Cohen and Gibbard (2011, paleomagnetic timescale)
Qbcb	1.77 - 2.05	stratigraphic and magnetic; lower bound, age of Qyh; upper bound, age of Qba	
Qbb	1.77 - 2.05	stratigraphic and magnetic; lower bound, age of Qyh; upper bound, age of Qba	
Qbm	0.440 ± 0.05*	magnetic separates of whole rock, step-heated $^{40}Ar/^{39}Ar$	B. Turrin (2012, written comm.) for sample TC-002
Qbw	1.77 - 2.05	stratigraphic and magnetic; lower bound, age of Qyh; upper bound, age of Qba	
Qbs	2.07 ± 0.08	whole rock, step-heated $^{40}Ar/^{39}Ar$	B. Turrin (2012, written comm.)
Qbsv	2.09 ± 0.08	whole rock, step-heated $^{40}Ar/^{39}Ar$	B. Turrin (2012, written comm.)
Qyh	2.053 ± 0.096	laser fusion single-crystal sanidine $^{40}Ar/^{39}Ar$	M.A. Lanphere (2000, written comm., in Christensen, 2001, p. G59)
QTb	3.29 ± 0.02	magnetic separates of whole rock, step-heated $^{40}Ar/^{39}Ar$	B. Turrin (2012, written comm.) for sample 08-372A. Unit correlated with Rexburg basalt, *Tbr* (Phillips, and others, 2016; Phillips and others, 2014)
Trl	3.5 ± 0.4 4.28 ± 0.18	zircon fission track zircon U-Pb concordia	Morgan and others (1984) Bindeman and others (2007)

*Age inconsistent with polarity and stratigraphic position. Sample is TC-002 (see Table 2 for location).

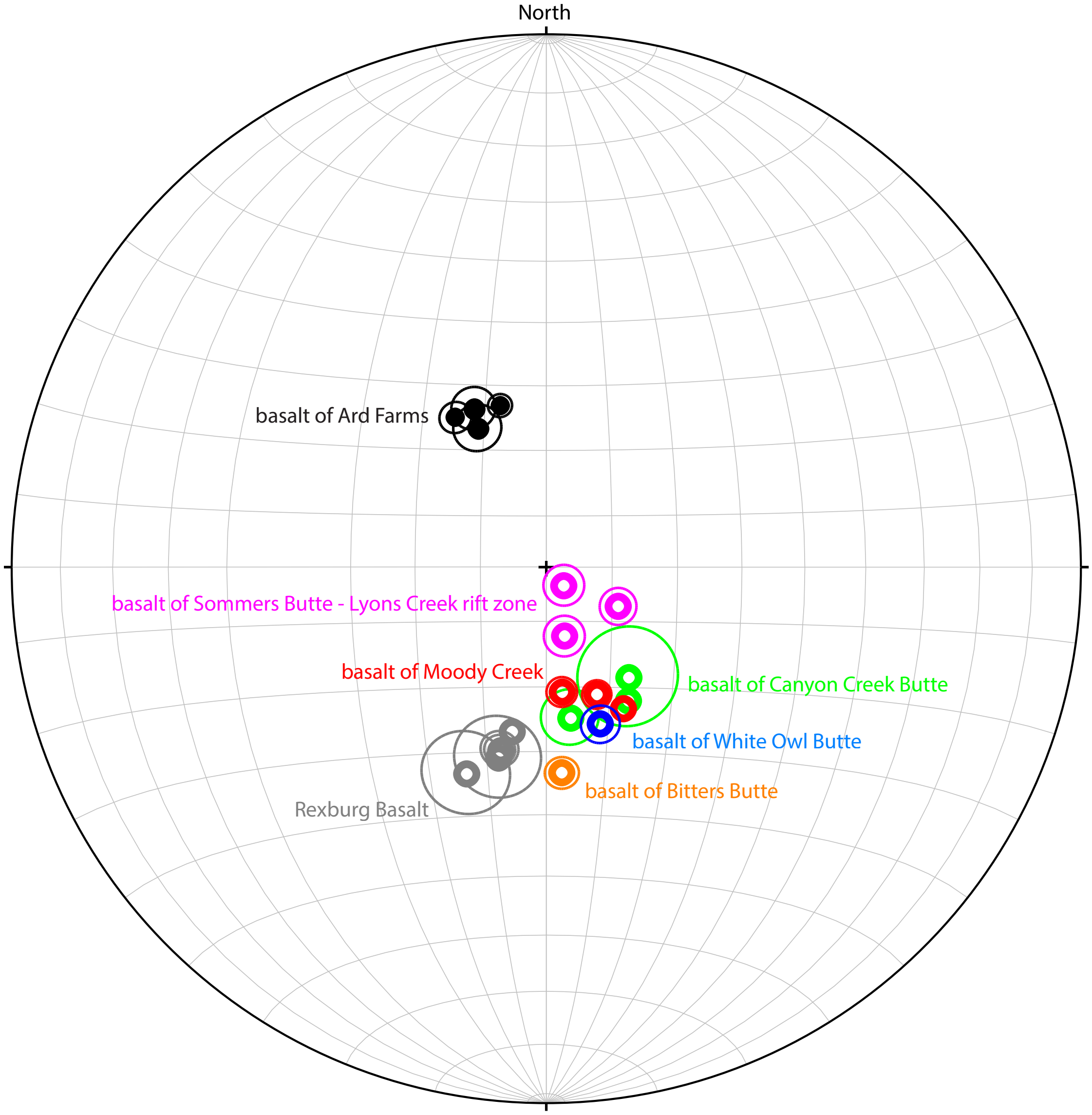

Figure 2. *Equal-area projection of paleomagnetic results from basalts of the Moody, White Owl Butte, and Wright Creek quadrangles. Filled circles are site mean ChRM directions with positive inclination and open circles are site mean ChRM with negative inclination; surrounding circles show α_{95} confidence limits. The Rexburg basalt (Phillips and others, 2016) is correlated to unit QTb.*

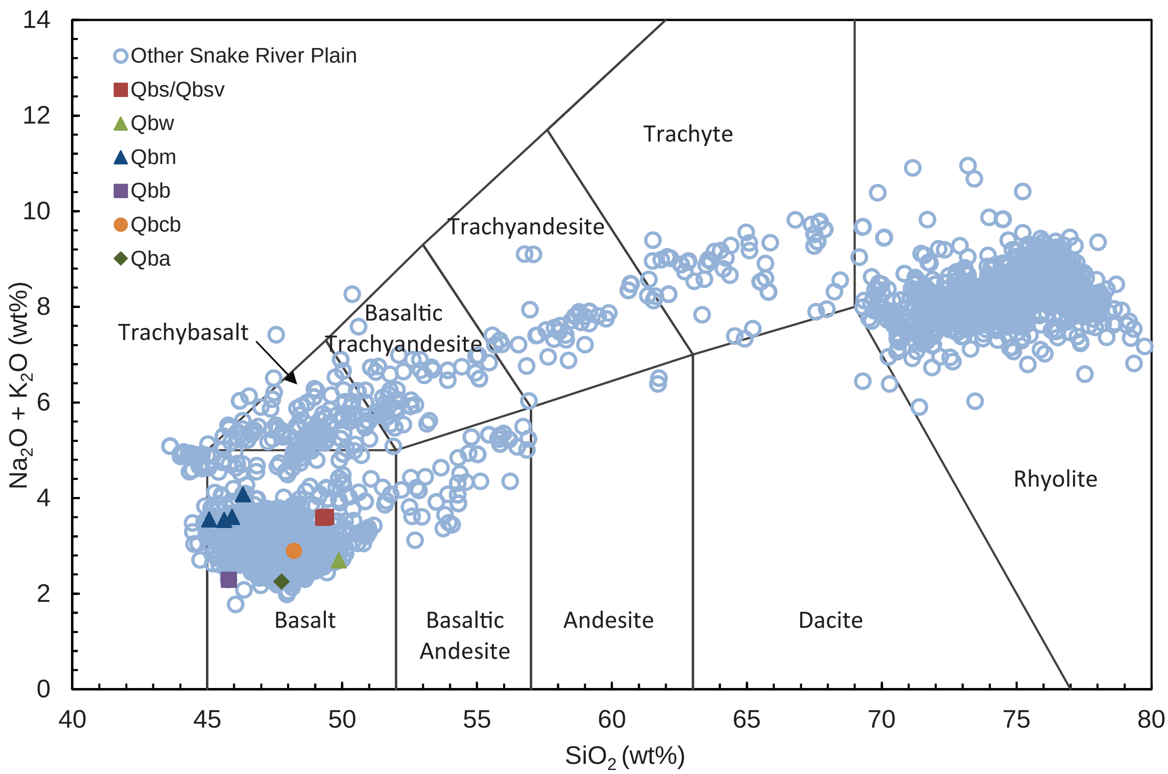

Figure 3. *Total alkali-silica diagram for basalts of the Moody, White Owl Butte, and Wright Creek quadrangles compared with other volcanic rocks of the Eastern Snake River Plain (light blue circles); modified from Christiansen and McCurry, 2008). Analyses are from Table 4.*

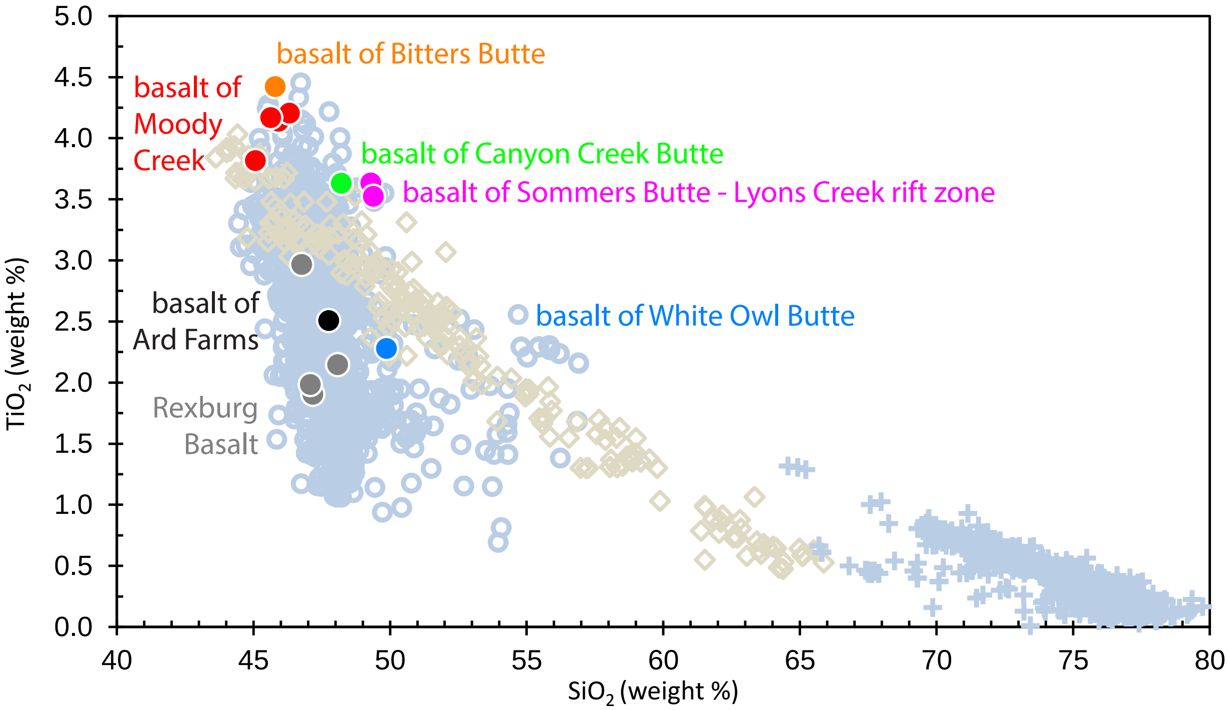

Figure 4. *Compositional data for basalts of the Moody, White Owl Butte, and Wright Creek quadrangles compared with other volcanic rocks of the Eastern Snake River Plain. Light brown circles, Craters of the Moon and Cedar Butte; light blue circles, olivine tholeiites; light blue crosses, rhyolites (modified from Christiansen and McCurry, 2008).*

PLATES

Plate 1. Geologic map of the Moody 7.5-minute quadrangle, Madison county, Idaho.

Plate 2. Geologic map of the White Owl Butte 7.5-minute quadrangle, Madison county, Idaho.

Plate 3. Geologic map of the Wright Creek 7.5-minute quadrangle, Madison and Teton counties, Idaho.

Plate 4. Geologic cross sections of the Moody, White Owl, and Wright Creek 7.5-minute quadrangles, Madison and Teton counties, Idaho.

Full-scale map and cross section plates are available as digital (PDF format) files at www.idahogeology.org.

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