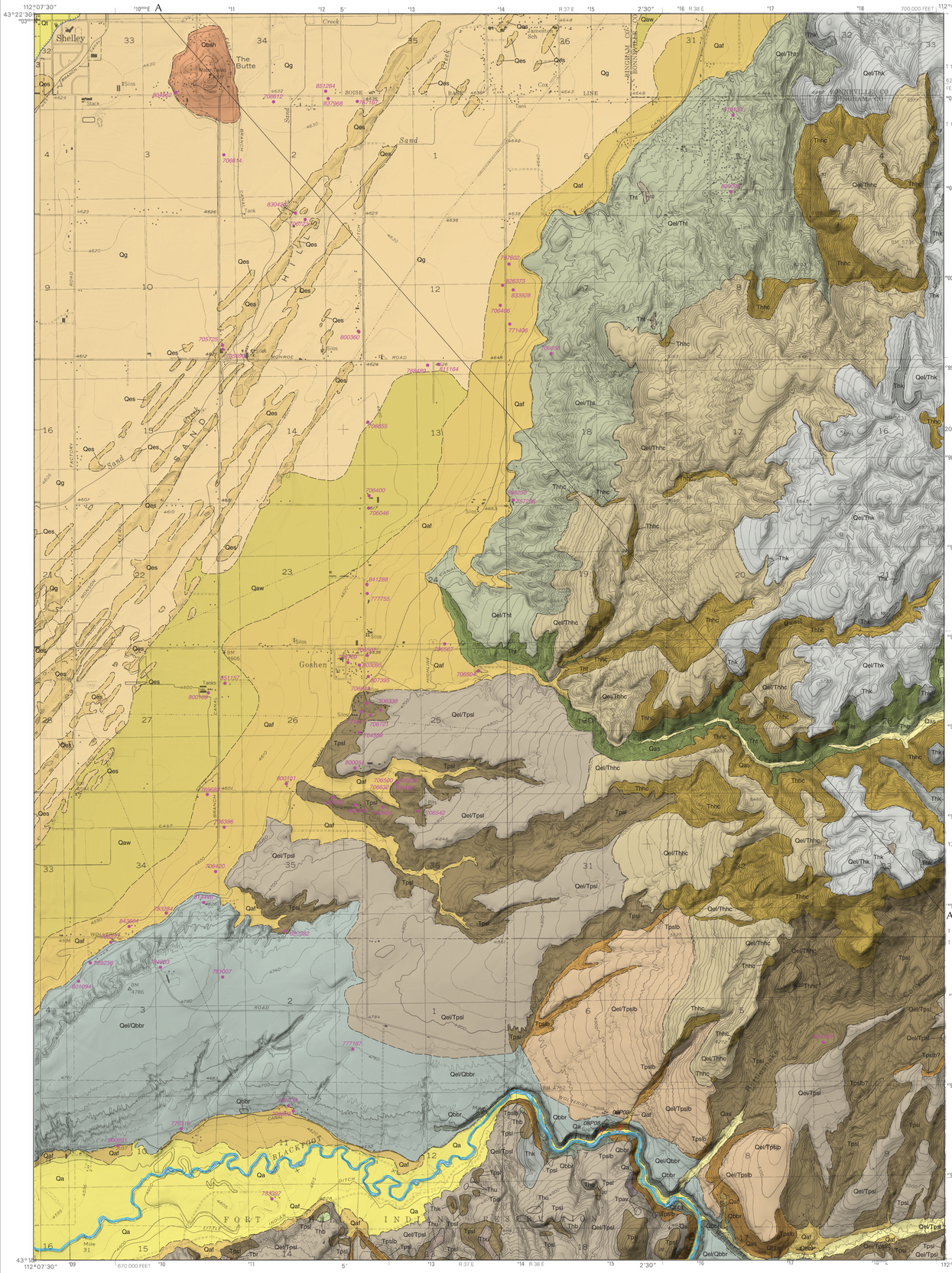
Geologic Map of the Goshen Quadrangle, Bingham and Bonneville Counties, Idaho

William M. Phillips and John A. Welhan

2013



Base map compiled from scanned USGS film positive, 1998 (NAD 1983) and paper copy of the 1952 edition (NAD 1927).

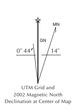
Shaded elevation from 10 m DEM.

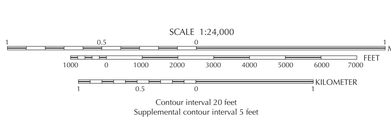
Topography compiled 1946. Planimetry derived from imagery taken in 1998.

Projection: Idaho coordinate system, east zone (Transverse Mercator). 1927 North American Datum.sssssss

10,000-foot grid ticks based on Idaho coordinate system, east zone.

1000-meter Universal Transverse Mercator grid ticks, zone 12 (NAD 83 on north, east, and south map boundaries).





Field work conducted 2008.

This geologic map was funded in part by the U.S. Geological Survey National Cooperative Geologic Mapping Program, USGS award no. 08HQAG0054.

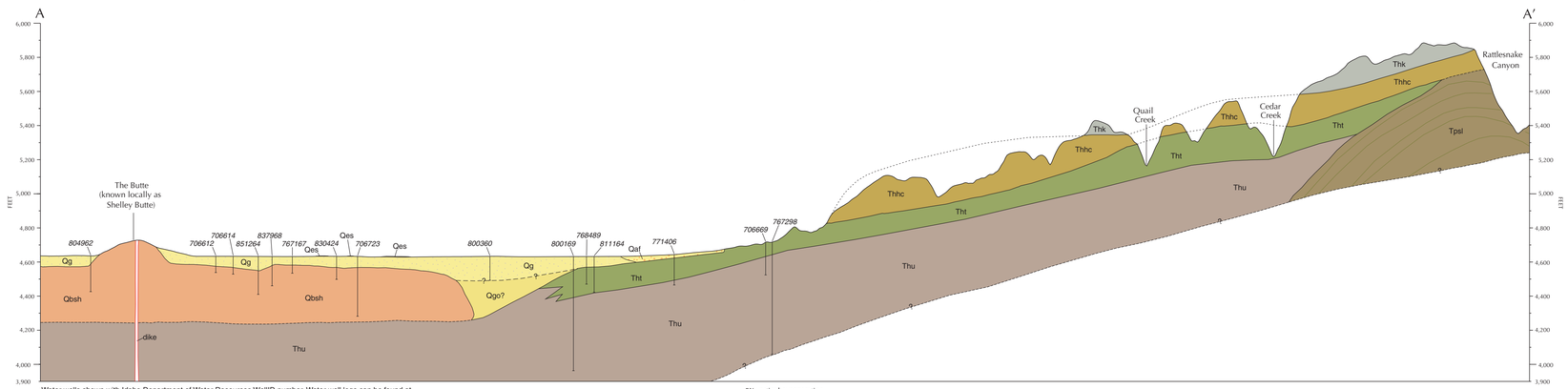
Digital cartography by Collette Gantenbein and Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.

Technical review status: Authors only.

Editorial review by Alyson R. Kral.

Map version 10-16-2013.

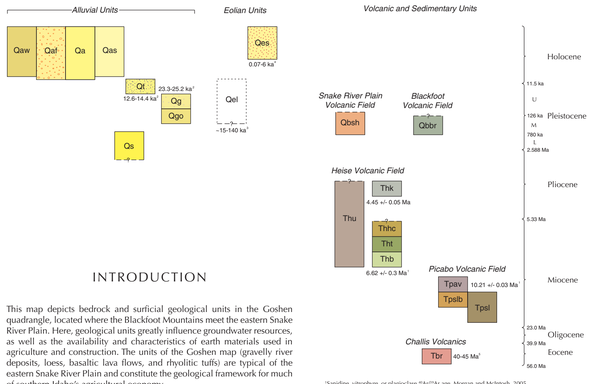
PDF (Acrobat Reader) map may be viewed online at www.idahogeology.org.



Water wells shown with Idaho Department of Water Resources WellID number. Water well logs can be found at http://www.idwr.idaho.gov/apps/appswell/RelatedDocs.asp?WellID=xxxxxx where "xxxxxx" is the six-digit WellID.

5X vertical exaggeration.

CORRELATION OF MAP UNITS



*Sanidine, vitrophyre, or plagioclase $^{40}Ar/^{39}Ar$ age, Morgan and McIntosh, 2005.
†Range of single aliquot quartz OSL ages, Phillips and others, 2009a.
‡Range of OSL and TL ages, Phillips and others, 2009a; Pierce and others, 2003.
§Dugan and others, 2007.
#Range of OSL ages from unit, Pearce and Rittenour, 2009.

Geologic time scale from Gradstein, F.M. and others 2004.

INTRODUCTION

This map depicts bedrock and surficial geological units in the Goshen quadrangle, located where the Blackfoot Mountains meet the eastern Snake River Plain. Here, geological units greatly influence groundwater resources, as well as the availability and characteristics of earth materials used in agriculture and construction. The units of the Goshen map (gravelly river deposits, loess, basaltic lava flows, and rhyolitic tuffs) are typical of the eastern Snake River Plain and constitute the geological framework for much of southern Idaho's agricultural economy.

SOURCES OF INFORMATION AND METHODS

The following sources were compiled and/or consulted. Major stratigraphic and structural features of the Blackfoot Mountains, particularly for Tertiary rhyolitic rocks and sediments assigned to the Salt Lake Formation, were outlined by Mansfield (1952) in his map of the Ammon 15-minute quadrangle. Rember and Bennett (1979) mapped the region at a scale of 1:250,000. Their map identified major outcrops of rhyolite, tuff and sediments, the intercanyon basalt flow along the Blackfoot River, gravelly Snake River alluvium, loess, and sand dunes. Allmendinger (1980, 1982) mapped the Wolverine and Bone 7.5-minute quadrangles east and northeast of the Goshen quadrangle. His work separated rhyolitic units from the Salt Lake Formation and correlated them with upper Miocene and Pliocene deposits of the Heise volcanic field described by Prostka and Embree (1978) about 50 km (30 mi) north of Goshen. He also presented a structural model for deformation and uplift of the Blackfoot Mountains. Hladky and others (1992) mapped the Fork Hall Indian Reservation south of the Blackfoot River at 1:50,000. This work and subsequent geochemical studies (Kellogg and others, 1994) defined the upper Miocene Starlight Formation and clarified relationships between units formerly assigned to the Salt Lake Formation. Studies of regional ignimbrites in the northeastern Snake River Plain placed rhyolitic units into the context of a migrating Yellowstone hot spot (Morgan and McIntosh, 2005, and references therein). Surficial units of the Snake River Plain were mapped at a scale of 1:250,000 by Scott (1982). Soil mapping (Salzmann and Harwood, 1973; Miles, 1981) assisted with descriptions of sand dunes, alluvial fans, and loess deposits. Water well logs (IDWR, 2009) provided information on the subsurface extent and thickness of units.

Field work was conducted in 2008 to 2009. A fluxgate magnetometer was used to determine magnetic polarities of rhyolitic rocks. Characteristic remanent magnetization was determined for basalts with oriented drill cores and a spinner magnetometer (Table 1). Major and trace elements were determined for basalts with whole rock XRF analyses (Table 2). No field work was conducted on the Fort Hall Indian Reservation south of the Blackfoot River.

STRUCTURAL AND STRATIGRAPHIC RELATIONSHIPS

The map lies on the western flank of the Blackfoot Mountains. These mountains have been affected by both Basin and Range faulting and Yellowstone-Snake River Plain hotspot volcanism and deformation. About 1 to 5 km (0.6 to 3 mi) east of the map, north-northwest trending normal faults (i.e. Gateway Fault of Allmandinger, 1982) separate Mesozoic and Paleozoic strata of Taylor Mountain from upper Miocene-Pliocene volcanic rocks with about 775 to 1000 m (2540 to 3280 ft) of throw. These Basin-and-Range-style faults were most active in the late Miocene at ~10 Ma, ceasing motion by about 4.45 Ma. Rhyolitic rocks erupted from calderas on the Snake River Plain, and sediments eroded from the footwall accumulated in the downthrown block (Allmandinger, 1982). Deposits from two Yellowstone-Snake River Plain caldera centers, the ~10.2 Ma Picabo Volcanic Field, and the 6.62 to 4.45 Ma Heise Volcanic Field, are present. The Blackfoot River, following probable northwest and east-west trending fault structures, defines an approximate boundary between Picabo deposits to the south and Heise deposits to the north. Subsequent deformation consisted of downwarping of the Snake River Plain following the passage of the Yellowstone hotspot. As a result, upper Miocene-Pliocene rhyolitic deposits dip northwest or west into the plain, where they are obscured by Pleistocene basalt flows, and glacial outwash (see cross section).

SYMBOLS

Contact: dashed where approximately located.

24 Strike and dip of eutaxitic foliation in rhyolite or bedding in unwelded tuff.

08P08 Paleomagnetic sample.

824339 Water well and permit number.

UNIT DESCRIPTIONS

ALLUVIAL SEDIMENTS

Qaf **Alluvial fans (Holocene and upper Pleistocene)**—Grayish-brown silt, very fine sand, and clay derived from reworking of loess and tuffaceous deposits. Deposited along the geomorphic contact between uplands of Neogene volcanic rocks and lowlands underlain by sand and gravel of the Snake River Plain. Also includes smaller fans along the Blackfoot River. Water well logs indicate average thickness of 6 to 9 m (20 to 30 ft). At Goshen, in sec. 24, T. 1 S., R. 37 E., the thickness of the Cedar Creek alluvial fan is as much as 30 m (100 ft). Forms the parent material for the Ammon soil series (Salzmann and Harwood, 1973; Miles, 1981). Lack of pedogenic carbonate (Bk) or clay (Bt) soil horizons in this unit suggests continuing depositional activity during the Holocene.

Qaw **Alluvium of Willow Creek (Holocene)**—Reddish brown, stratified sand and silt derived from weathered rhyolite and Mesozoic rocks of the Blackfoot Mountains. Thickness generally 1.5 to 3 m (5 to 10 ft). Paesl and Paul soils are developed on this unit (Miles, 1981). Willow Creek is a Yazoo-type stream that flows parallel to the Snake River upon entering the Snake River Plain near Ririe, Idaho. Discharge is much diminished in Willow Creek because of irrigation water diversion and development of Ririe Dam. Most discharge on Willow Creek presently reaches the Snake River through an incised channel that flows through the city of Idaho Falls. Another former flow path of Willow Creek, as indicated by distinctive reddish brown alluvium, was between uplands and sand dunes.

Qas **Alluvium of side streams (Holocene)**—Sand, silt and minor gravel deposits along Cedar Creek, Rattlesnake Canyon, and Wolverine Creek. Consists of reworked loess and tuffaceous sediment. Thickness <3 m (<10 ft).

Qa **Alluvium of the Blackfoot River (Holocene and upper Pleistocene)**—Dark grayish-brown, stratified silt and sand with lesser gravels of basalt, rhyolite, sandstone and limestone. Thickness 1.8 to 6 m (6 to 20 ft). Poorly drained with water table within 1.2 m (4 ft) of the surface in the spring. Subject to seasonal flooding.

Qt **Alluvium of Snake River terraces (upper Pleistocene)**—Well-rounded, pebble and cobble gravel with lesser sand; similar to unit *Qg*. Forms gently southwest dipping fill-cut terraces along the Snake River. Separated from unit *Qg* by a scarp 3 to 6 m (10 to 20 ft) high in sec. 33, T. 1 N., R. 37 E. Covered by 50 to 150 cm (20 to 60 in) of loess-derived loam soils of the Bannock and Bock soil series (Salzmann and Harwood, 1973; Miles, 1981). Correlative deposits in the Idaho Falls area yielded OSL ages of 14.4 ± 0.8 ka and 12.6 ± 0.7 ka (Phillips and others, 2009).

Qg **Gravelly alluvium of the Snake River (upper Pleistocene)**—Well-rounded, pebble and cobble gravel, clast-supported with a sandy matrix. The gravel is massive to parallel bedded, with minor cross-bedded coarse- to medium-grained sand. Gravel is dominated by pink, gray, and purple quartzite with lesser sandstone, limestone, granitic rocks, porphyritic igneous rocks, and basalt. Sand grains are composed of subangular obsidian, quartzite, phenocrysts of quartz and feldspar, muscovite, and fragments of basalt and rhyolite. This unit is part of the outwash plain deposited by the Snake River during the last glaciation (Pinedale) of the river's headwaters (Scott, 1982). Forms a broad, gently southwest sloping surface. Water wells show gravels to be as much as 67 m (220 ft) thick in the Goshen quadrangle. Some of the deeper gravels are partially cemented and fines-rich and may be correlative with *Tpsl*. However, these deposits cannot be reliably separated from *Qg* in most water well logs. Covered by 0.6 to 1.8 m (2 to 6 ft) of loess-derived soils of the Bannock and Bock soil associations (Salzmann and Harwood, 1973; Miles, 1981). Correlative deposits in the Idaho Falls area yielded OSL ages of 25.2 ± 1.5 and 23.3 ± 1.5 ka (Phillips and others, 2009).

Qs **Older alluvium of the Blackfoot River (lower Pleistocene)**—Well-rounded gravels and sand, and massive silt beneath lava flows of intercanyon basalt (*Qbbr*). Gravels include clasts of Mesozoic and Paleozoic lithologies. Best exposed along the Wolverine Road in NE¼ sec. 17, T. 2 S., R. 38 E., and in the Blackfoot River gorge in NE¼, sec. 7, T. 2 S., R. 38 E.

Qgo **Older gravelly alluvium of the Snake River (middle Pleistocene?)**—Shown in cross section only; schematically represents gravelly outwash deposits of older glaciations in the Snake River headwaters. In the Jackson Hole area, glacial deposits more extensive than the Pinedale glaciation are dated by cosmogenic ^{10}Be as correlative with the Bull Lake (~140-150 ka) Rocky Mountain glaciation (Licciardi and Pierce, 2008). For this reason, outwash of Bull Lake age may be locally present in the shallow subsurface along the Snake River.

EOLIAN SEDIMENTS

Qes **Sand dunes (Holocene to upper Pleistocene)**—Light brownish-gray, fine- to medium-grained, cross-bedded sand; well-sorted and loose. Many dunes contain buried A and weakly developed Bt soil horizons, suggesting several periods of dune mobilization and stability. Forms active to partially vegetated, linear parabolic and hairpin parabolic dunes that trend northeast, parallel to prevailing winds from the southwest. Also includes sand sheets and small hummocky dunes along the terrace scarp separating *Qt* and *Qg*. Some dunes visible on older topographic maps and air photos have been removed by agricultural activities. Thickness of dunes ranges from <3 m to >9 m (<10 ft to >30 ft). The parabolic dunes and sand sheets thicken and become more numerous toward the southwest. These dunes are part of a system of mostly relic sand dunes extending 155 km (96 mi) from Rupert to Idaho Falls, toward a source region identified by Scott (1982) as deposits of the ~18 ka Bonneville flood. OSL dating of dune sand bracketed by paleosols shows that dunes in the Idaho Falls area were active between ~6 ka and as recently as 80 to 140 yr (Pearce and Rittenour, 2009; Rittenour and Pearce, 2011). Forms parent material for the Wolverine soil series (Salzmann and Harwood, 1973).

Qel **Loess (upper to middle Pleistocene)**—Massive, grayish-brown to light-gray silt, very fine sand, and clay; composed of quartz, feldspars, carbonate, and clay minerals (smectite, illite, and kaolinite; Lewis and Fosberg, 1982). Loess that has not been reworked generally contains a pedogenic carbonate-silica (Bk) horizon at 20 to 22 cm (8 to 13 in) with carbonate morphology stage II (Salzmann and Harwood, 1973). Water well logs indicate thickness of 1.8 m to >15 m (6 ft to >50ft) in secs. 1-4, T. 1 S., R. 37 E. Derived predominantly from deflation of fines from braided stream alluvium (unit *Qg*) during glaciation of the Snake River headwaters. Regionally consists of several depositional units separated by buried soils (Lewis and Fosberg, 1982; Pierce and others, 1982, 2011; Scott, 1982). Undated in the map area but probably contains beds deposited between 15 to 25 ka, 35 ka, 46 ka, and ~68 to 79 ka (Phillips and others, 2009; Pierce and others, 2011). Forms parent material for the Newdale soil series (Salzmann and Harwood, 1973).

VOLCANIC AND SEDIMENTARY UNITS

Qel/Qbrr/Qbrr **Basalt of Blackfoot River (middle Pleistocene?)**—Dark gray, dense, very fine-grained basalt. Where covered by loess, shown as *Qel/Qbbr*. Contains rare olivine phenocrysts as much as 0.25 mm in length and abundant plagioclase microlites. Basalt has normal magnetic polarity (Table 1). In roadcut along Wolverine Road in NE¼ sec. 17, T. 2 S., R. 38 E., a ~9 m (~30 ft) thick flow with basal pillows and breccia, columnar center, and upper entablature overlies fluvial sediments. At least three flows and steep contacts with an older basalt (*Tsltb*) and fluvial and eolian sediments (*Qs*) are exposed in Blackfoot River gorge near the stream gaging station in NE¼, sec. 7, T. 2 S, R. 38 E. Water wells indicate that basalt 3 to 21 m (10 to 68 ft) thick underlies secs. 1-4, T. 2 S., R. 37 E. This basalt is interpreted as intercanyon flows that spread out onto the Snake River Plain upon exiting the Blackfoot River canyon. Vents for these flows have not been precisely identified but probably lie within the Blackfoot-Gem volcanic field east of the map. Undated; normal polarity, intercanyon character, and thick loess cover suggest age of >140 ka and <780 ka.

Qbsh **Basalt of Shelley Butte (middle Pleistocene?)**—Dark gray to reddish, dictytaxitic, vesicular basalt with olivine phenocrysts as much as 5 mm in length. Includes thin pahoehoe flows, spatter, breccia, and cinder indicating that edifice is a vent. Produced at least two flows traceable in subsurface with water well logs. Normal magnetic polarity (Table 1). Basalt boulders as much as 1 m (3 ft) in length on slopes were probably detached from outcrop by periglacial processes. These boulders are commonly coated with white carbonate and silica. Draped by loess that is thickest on north and northeast sides. Some outcrops and large boulders have ventifacts with lineations between 45°- 60°. Undated but position in the Snake River Plain rather than in uplands suggests that age is younger than early Pliestocene-Pliocene. If true, then normal magnetic polarity suggests age is <0.78 Ma. Locally thick loess cover and relatively thick pedogenic carbonate and silica coatings suggest pre-late Pleistocene age.

Heise Volcanic Field

Qel/Thk/Thk **Kilgore Tuff (Pliocene)**—Densely welded, rhyolitic, relatively crystal-poor ignimbrite containing 2% to 10% crystals of plagioclase, quartz, sanidine, augite, magnetite, and zircon. Where covered by loess, shown as *Qel/Thk*. In the Goshen map, most exposures consist of resistant, ridge-capping, rounded outcrops 1 to 1.5 m (3 to 5 ft) thick of brown welded tuff with 1 to 3 cm lithophysae, locally overlain by several decimeters of pink, platy, devitrified welded tuff, and a black vitrophyre. Maroon pumice fragments are locally present in upper part of unit. Reversed magnetic polarity. The Kilgore Tuff is the youngest ignimbrite erupted from the Heise volcanic field and is widely distributed in the upper Snake River Plain. Dated by $^{40}Ar/^{39}Ar$ on sanidine at 4.45 ± 0.05 Ma (Morgan and McIntosh, 2005).

Qel/Tht/Tht **Tuff (upper Miocene)**—Unwelded lapilli pumice containing abundant black obsidian, and pink, gray, and brown devitrified welded tuff with moderately abundant phenocrysts of plagioclase, sanidine and quartz. In SE¼, sec. 6, T. 1 S., R. 38 E., consists of about 0.5 m (1.6 ft) thick black vitrophyre capped by a brown to pink welded tuff with normal magnetic polarity that is about 2 m (6.6 ft) thick. Limited exposures suggest thickness of >60 m (>196 ft). Correlated with thick pumice deposits and a thin phenocryst-poor welded tuff lying between units *Thk* and *Thb* in the adjacent Ammon and Idaho Falls South quadrangles (W.M. Phillips, unpublished mapping, 2012; Phillips and Welhan, 2011). The *Tht* stratigraphic interval may contain both the 5.59 Ma tuff of Wolverine Creek and the 6.27 Ma Walcott Tuff (ages from Morgan and McIntosh, 2005). East of Goshen in SE¼, sec. 24, T. 1 S., R. 37 E., and in SW¼, sec. 19, T. 1 S., R. 38 E., consists of rounded boulders and cobbles of welded tuff in sandy matrix. Former landfill at Goshen placed within this deposit. Monitoring wells for the former Goshen landfill and nearby water wells in secs. 35 and 36, T. 1 S., R. 37 E., indicate that unit consists of at least 60 to 90 m (200 to 300 ft) of silt, clay, sand, and partially cemented gravel.

Qel/Thhc/Thhc **Rhyolite of Henry Creek (upper Miocene?)**—Gray to pinkish gray rhyolite lava flow with abundant phenocrysts of plagioclase, quartz, sanidine, and an altered greenish-brown prismatic mineral (augite?) generally surrounded by brown alteration products. Shown as *Qel/Thc*: where covered by loess. Many outcrops display flow banding and platy partings, with attitudes that do not reflect regional structure. A 6 to 9 m (20 to 30 ft) thick, dark gray basal vitrophyre is present in NE¼ NW¼ sec. 30, T. 1 S., R. 38 E. Unit generally lacks eutaxitic textures characteristic of ash flow tuffs. Normal magnetic polarity. Thickness ranges from about 100 to 240 m (328 to 787 ft). Exposures in the Goshen quad are correlated here with the unit named by Allmendinger (1980, 1982) for exposures along Henry Creek in the Ammon and Wolverine 7.5-minute quadrangles. Undated; position beneath Kilgore Tuff indicates eruption before 4.45 Ma and position over *Tht* suggests an age younger than 5.59 Ma. The juxtaposition of a large rhyolitic lava flow adjacent to a steeply faulted contact with pre-Tertiary strata may mark the location of a Heise-age caldera margin.

Thb **Blacktail Creek Tuff (Upper Miocene)**—Light gray, rhyolitic, relatively crystal-rich ignimbrite with 10% to 20% total crystals of plagioclase, quartz, sanidine, augite, opaque oxides and zircon. Base consists of black or dark brown, densely welded vitrophyre about 0.5 m (20 in) thick. Normal magnetic polarity. Along Cedar Creek in sec. 28, T. 1 S., R. 38 E., consists of ledge-forming welded tuff with abundant phenocrysts that weathers with distinctive gray and white "speckles." South of Blackfoot River, rock commonly fractures into plates less than 10 cm (4 in) thick (Hladky and others, 1992). Total thickness in map is > 8 m (26 ft). The Blacktail Tuff is the oldest of Heise volcanic field units with a sanidine $^{40}Ar/^{39}Ar$ mean age of 6.62 ± 0.03 Ma (Morgan and McIntosh, 2005).

Thu **Heise volcanic field, undivided (upper Miocene-Pliocene)**—Densely welded ash-flow tuffs, rhyolite lava flows, and unwelded pumice; poor exposures suggest correlation with units of the Heise volcanic field (Hladky and others, 1992). In cross section, schematically indicates Heise-age deposits of unknown character.

Picabo Volcanic Field

Tpav **Arbon Valley Tuff, Middle Member, Starlight Formation (Miocene)**—Tan, pumiceous, relatively crystal-rich rhyolitic ignimbrite with phenocrysts of plagioclase, bipyramidal quartz, clinopyroxene and biotite. The Arbon Valley Tuff is the only tuff in the eastern Snake River Plain-Yellowstone region containing biotite. Upper part is pumiceous, poorly welded, and poorly exposed. Middle part is welded and columnar jointed and about 185 to 200 ft (56 to 61 m) thick (Hladky and others, 1992). Kellogg and others (1994) show the Arbon Valley Tuff as extending into the southeastern portion of the Goshen quadrangle. However, biotite-bearing tuff has not yet been located north of the Blackfoot River. The most northern known exposures of the unit are in SE¼ sec. 7, T. 2 S., R. 38 E. Source vents are in the Picabo volcanic field (Kellogg and others, 1994; Morgan and McIntosh, 2005). Sanidine $^{40}Ar/^{39}Ar$ mean age is 10.21 ± 0.03 Ma (Morgan and McIntosh, 2005).

Qel/Tpslb/Tpslb **Basalt of Lower Member, Starlight Formation (Miocene)**—Dark gray to dark brown, medium-grained, open-textured basalt with abundant olivine phenocrysts 0.25 to 0.5 mm. Where covered by loess, shown as *Qel/Tpslb*. White secondary minerals fill some pore spaces. Thickness is about 36 m (120 ft). Along Blackfoot River gorge, well-developed cooling columns are characteristic and indicate that the unit is inclined and consists of at least two flows. Overlies tuffaceous sediments and gravels of *Tpsl* in the Blackfoot River gorge but pinches out to the north. Undated, with reversed magnetic polarity (Table 2).

Qel/Tpsl/Tpsl **Lower Member, Starlight Formation (Upper Miocene)**—North of the Blackfoot River, consists of silt, volcanic ash, diamict, gravel with clasts of Mesozoic and Paleozoic strata, and welded tuff. South of Blackfoot River, similar deposits contain travertine (Hladky and others, 1992). Where covered by loess, shown as *Qel/Tpsl*; south of Blackfoot River, *Qel/Tpsl* may include some Thu beneath the loess cover. Generally poorly exposed. Interbedded at top with *Tpslb*. Along Rattlesnake Canyon in NE¼ sec. 8, T. 2 S., R. 38 E., unit is predominantly sandy tuffaceous sediment interbedded with a pink platy welded tuff. South of Blackfoot River, thickness is locally as much as 610 m (1000 ft). Similar deposits to east were mapped by Mansfield (1952) as Miocene Salt Lake Formation. Allmendinger (1980, 1982) also mapped these deposits as Salt Lake Formation, but emphasized the relationship of Basin and Range faulting to coarse clastic facies within the unit. South of the Blackfoot River, Hladky and others (1992) place similar deposits into the lower member of the Starlight Formation. Here, we provisionally adopt the nomenclature of Hladky and others (1992) for tuffaceous sediments and overlying basalt north of the Blackfoot River. Undated; lies below the 6.62 Ma Blacktail Creek Tuff and below the 10.21 Ma Arbon Valley Tuff. Unit is poor producer of groundwater, with some 30 m (100 ft) deep wells yielding as little as 12 gpm. Landfill at Rattlesnake Canyon placed within the deposit.

Challis Volcanics

Tbr **Andesite breccia (Eocene)**—Reddish-brown to gray planar-bedded laharic breccia with angular blocks of andesite as large as 4 m (13 ft) in lower part. Andesitic clasts contain abundant hornblende needles. Upper 0.5 m (1.6 ft) of individual lahar flows consist of andesitic gravel less than 2.5 cm (1 in) in sandy, clayey matrix. Unit gives K-Ar ages of 40 and 47 Ma (Armstrong, 1972) and is lithologically and temporally similar to Challis Volcanics (Hladky and others, 1992). Total thickness more than 2000 ft (610 m).

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ACKNOWLEDGMENTS

Thanks to the Thompson family and other land owners for permitting access to their property. D. Garwood and J. Tullis assisted with field work.

Table 1. Paleomagnetic data for the Goshen quadrangle.

Sample number	Unit name	Latitude	Longitude	n	D	I	α_{95}	κ	Polarity	Demag Level (mT)
08P08	Qbbr	43.26299	-112.04750	6	310	67	3.79	312	N	30
08P09*	Tpslb	43.26307	-112.04573	7	198	-48	1.94	973	R	60
07P00	Qbsh	43.36835	-112.10066	6	5	57	3.45	378	N	60

n = number of cores used / number of cores measured.
D = site mean declination of characteristic remanent magnetization (ChRm).
I = site mean inclination of characteristic remanent magnetism.
α_{95} = confidence limit for the mean direction at the 95% level.
κ = precision parameter.
Polarity: N = normal; R = reverse.
Demag Level: alternating field demagnetization used to isolate ChRM.
*Not corrected for tectonic rotation.

Table 2. Major oxide and trace element chemistry of samples collected in the Goshen quadrangle.

Sample number	Latitude	Longitude	Unit name	Map unit	Major elements in weight percent											Trace elements in parts per million														
					SiO_2	TiO_2	Al_2O_3	FeO*	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	SO_3	Sum	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th	Nd	U
08P08	43.26299	-112.04750	Blackfoot R. basalt	Qbbr	46.24	3.05	15.59	14.40	0.20	6.01	9.28	2.70	1.38	0.76	-0.24	0.25	99.62	52	20	27	311	788	32	392	261	37	28	22	27	150	5	31	69	0	38	0
08P09	43.26307	-112.04573	Starlight Fm. Basalt	Tpslb	50.40	1.57	16.60	10.63	0.16	6.34	10.23	2.83	0.42	0.20	0.69	0.19	100.25	70	70	29	232	248	6	349	120	23	13	20	36	101	4	15	32	1	18	0
07P06	43.36835	-112.10066	Shelley Butte basalt	Qbsh	45.73	2.88	13.91	13.56	0.21	6.91	10.94	2.52	0.50	0.70	nm	0.17	98.02	74	197	30	305	409	10	319	254	39	20	21	30	139	3	22	63	1	35	2

* Total Fe expressed as FeO.
LOI: Loss On Ignition at 900° C.
SO_3: Minimum value of SO_3 after fusion at 1000° C.
All analyses by XRF, performed at Washington State University GeoAnalytical Laboratory, Pullman, Washington.

Published and sold by the Idaho Geological Survey
University of Idaho, Moscow, Idaho 83844-3014